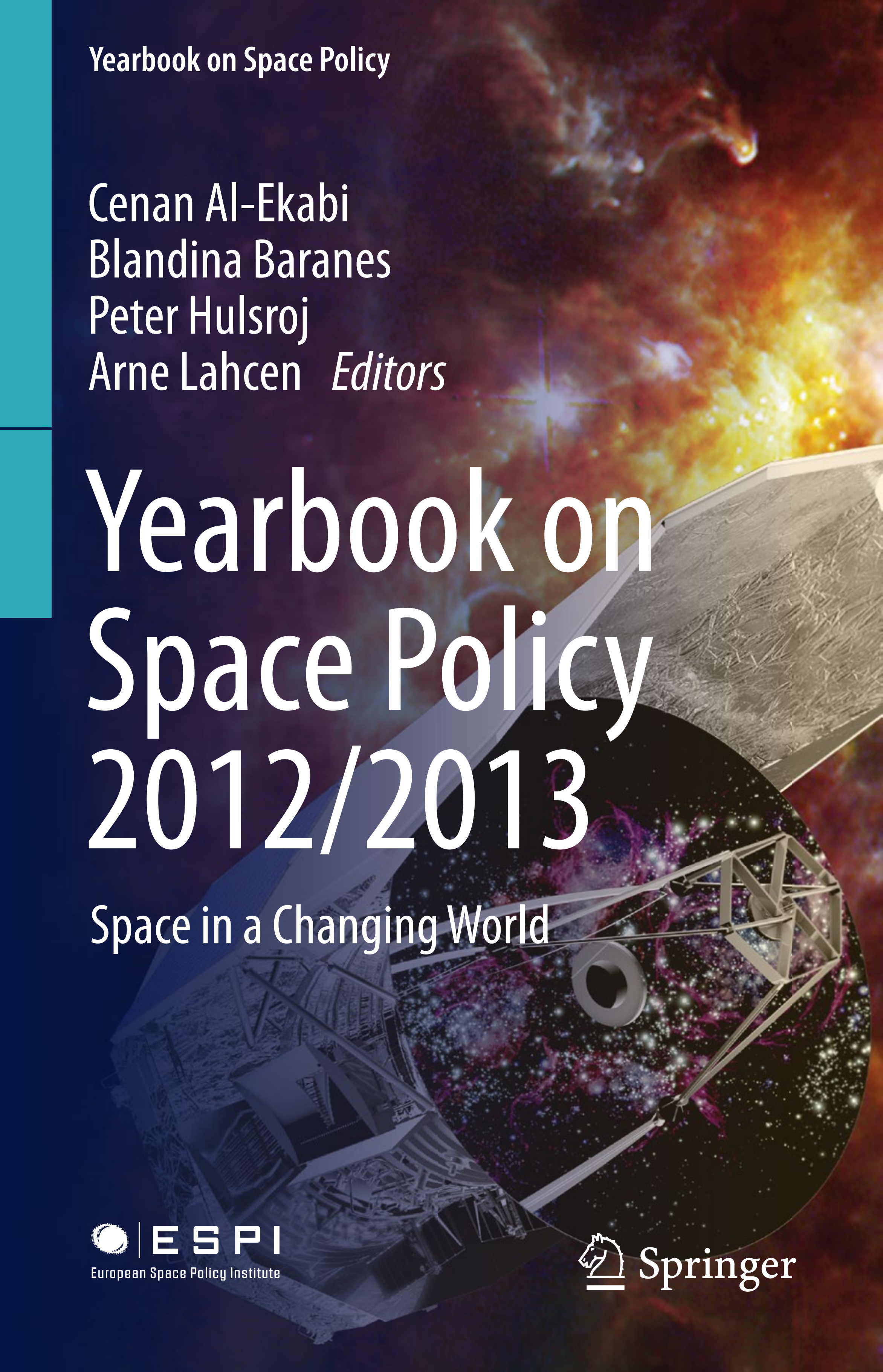

Yearbook on Space Policy

Cenan Al-Ekabi
Blandina Baranes
Peter Hulsroj
Arne Lahcen *Editors*

Yearbook on Space Policy 2012/2013

Space in a Changing World

ESPI
European Space Policy Institute

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Yearbook on Space Policy

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Preface ESPI Yearbook 2013

Space in a Changing World

In line with the nature of technological and social progress, the context in which space activities are embedded is subject to constant change. As a theme for the ESPI Yearbook 2013, we have chosen to focus specifically on the nature of these diverse changes, their driving forces and their future impacts. This choice is motivated not by the fact that changes to the space environment are novel per se, but because they are accelerating and their impact is starting to initiate a chain reaction of secondary effects that affects nearly all players and segments of space sector.

The changing dynamics currently affecting the space sector are noticeable in a number of fields and ways. A major element in this respect is the increased interest in space activities worldwide. Thanks to declining costs of space technologies and the ever increasing benefits space assets provide, many countries around the world are developing capabilities for the first time, while others are expanding their existing programmes. As a result, the amount of actors and activities in outer space increases. Although this increased involvement is a positive evolution, it will also require new ways to address and regulate, for instance, issues in terms of space utilisation, security and sustainability in the future. At the same time, space sectors and technologies are becoming more connected worldwide. This implies that established players have to revise their approaches in order to continue to best leverage their strengths in space. In addition, this tendency is making space technologies more subject to the laws that dictate other fields of the economy, and as a result, concepts like competitiveness and innovation are becoming much more relevant than in the past. From an overall perspective it seems that many of these changes are interconnected and thus self-reinforcing, furthering their impacts on governments, industry and society.

As the world around us is changing so is the nature of the yearbook, which will cover yearly time spans corresponding to calendar years from now onwards. We believe this to be simpler for the reader and will allow us to report on recent events with less time delay. What stays the same is the threefold structure of the yearbook.

Traditionally, the first part seeks to set out a comprehensive overview of the economic, political, technological and institutional trends that affect space activities. It is prepared in-house in ESPI, and while its perspective is European, it also provides a comparative analysis of space efforts around the world.

The second part of the ESPI Yearbook approaches the overall theme from a more analytical perspective. This year it includes eight external contributions that bring together the views of various professionals in the space field. To cover the worldwide changes affecting space in a sensible and comprehensive manner, the included contributions have a wide-ranging perspective. On the one hand, there is a focus on the geographical impact of change as illustrated by the rise of China, Russia's reorientation in space and the evolving programmes of India and a number of South American countries. On the other hand, some contributions focus on the structural implications of a changing world. This includes the evolution of major global trends, the future regulation of the outer space environment and the changing nature of security issues. Finally, one contribution analyses the interconnected nature of space from an overall perspective in order to assess what their implications for Europe will be. An important milestone in the idea forming behind the analysis offered in the second part was again the ESPI Autumn Conference, where authors met for an exchange on the content of their contributions. Having taken place in Vienna in September 2013, it provided a forum for constructive exchange and coordination of the contributions.

The third part of the Yearbook carries forward the character of the Yearbook as an archive of space activities. Again prepared in-house by ESPI, a bibliography, chronology and data about institutions are provided where readers of the now seven volumes of the Yearbook can identify statistical development and evolutions.

In closing, we would like to thank the contributors of the articles in Part II for their engagement in this publication, as well as the ESPI staff that has been instrumental for its production.

In particular, we are very grateful to Frances Brown, former editor-in-chief of Space Policy and member of the ESPI Advisory Council, for her support and inspiration as we prepared the ESPI Autumn Conference 2013.

Vienna, Austria

Cenan Al-Ekabi
Blandina Baranes
Peter Hulsroj
Arne Lahcen

List of Acronyms

ACE	Advanced Composition Explorer
ACS	Alcântara Cyclone Space
AEB	Brazilian Space Agency
AIA	Atmospheric Imaging Assembly
AIN	Arab Institute of Navigation
ALASA	Airborne Launch Assist Space Access
AO	Announcement of Opportunity
APL	Applied Physics Laboratory
Ariane 5 ME	Ariane 5 Midlife Evolution
ARM	Asteroid Redirect Mission
ASAT	Anti-Satellite Missile Test
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ATV	Automated Transfer Vehicle
BAFA	Federal Office of Economics and Export Control of Germany
BMD	Ballistic Missile Defence
CAA	Continuing Appropriations Act
CAGR	Compound Annual Growth Rate
CALT	China Academy of Launch Vehicle Technology
Caltech	California Institute of Technology
Casbaa	Cable and Satellite Broadcasting Association of Asia
CAST	China Academy of Space Technology
CBERS	Brazil Earth Resources Satellite
CCDev	Commercial Crew Development
CCiCap	Commercial Crew integrated Capability
CCL	Commerce Control List
CCP	Commercial Crew Programme
CCtCap	Commercial Crew Transport Capability
CD	Conference on Disarmament
CDI	Call for Declarations of Interest
CHF	Swiss franc

CHIRP	Commercially Hosted InfraRed Payload
CLA	Alcântara Launch Center
CMB	Cosmic Microwave Background
CME	Coronal Mass Ejection
CMG	Control Moment Gyroscope
CNES	Centre National d'Etudes Spatiales (French Space Agency)
CNSA	China National Space Administration
CONCORD	Conference on Coporate Research and Development
COROT	COnvention, ROtation and Planetary Transits
COTS	Commercial Orbital Transportation Services
CSA	Canadian Space Agency
CSO	Czech Space Office
CST	Commercial Space Transportation
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
CTS	Crew Transportation System
DARPA	Defense Advanced Research Project Agency
DARS	Digital Audio Radio Service
DBS	Direct Broadcast Services
DC4EU	Dream Chaser for European Utilization
Dextre	Special Purpose Dexterous Manipulator
DLR	Deutschen Zentrums für Luft-und Raumfahrt (National Aeronautics and Space Research Centre of the Federal Republic of Germany)
DoD	Department of Defense
DRDO	Defence Research and Development Organisation
DSCOVR	Deep Space Climate ObserVatoRy
DSM	Deep Space Manoeuvre
DTH	Direct To Home
DWSS	Defense Weather Satellite System
EAC	European Astronaut Centre
EADS	European Aeronautic Defence and Space Company
EAP	Environmental Action Programme
EC	European Commission
ECA	Evolution Cryotechnique type A
ECSAT	European Centre for Space Applications and Telecommunications
EDA	European Defence Agency
EDM	Entry, Descent and Landing Demonstrator Vehicle
EDRS	European Data Relay System
EELV	Evolved Expendable Launch Vehicle
EGNOS	European Geostationary Navigation Overlay Service
EIAST	Emirates Institution for Advanced Science and Technology
EJSM	Europa Jupiter System Mission
EO	Earth Observation

EPAA	European Phased Adaptive Approach
EPOXI	Extrasolar Planet Observations and characterisation/deep impact eXtended Investigation
EPS-SG	EUMETSAT Polar System—Second Generation
ERA	European Research Area
ESA	European Space Agency
ESOC	European Space Operations Center
ESPI	European Space Policy Institute
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUTELSAT	European Telecommunications Satellite Organization
EVA	Extravehicular Activity
EVE	EUV Variability Experiment
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FFC	Federal Communications Commission
FP8	Framework Programme Eight
FSS	Fixed Satellite Services
FY	Fiscal Year
GCSP	Global Collaborative Space Programme
GDP	Gross Domestic Product
GEO	Geostationary Orbit
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GERD	Gross domestic Expenditure on Research and Development
GLONASS	Global Navigation Satellite System
GLSV	Geosynchronous Satellite Launch Vehicle
GMES	Global Monitoring for Environment and Security
GNI	Gross National Income
GNSS	Global Navigation Satellite System
GPIM	Green Propellant Infusion Mission
GPS	Global Positioning System
GRAIL	Gravity Recovery and Interior Laboratory
GSLV	Geosynchronous Satellite Launch Vehicle
GTO	Geosynchronous Transfer Orbits
HDTV	High Definition Television
HFI	High Frequency Instrument
HMI	Helioseismic and Magnetic Imager
HoPS	Hostel Payload Solutions
HST	Hubble Space Telescope
HTV	H-II Transfer Vehicle
IBDM	International Berthing and Docking Mechanism
ICBM	Inter-Continental Ballistic Missile

ICG	International Committee on Global Navigation Satellite Systems
IGS	Information Gathering Satellite
IGS	Innovation and Growth Strategy
IHMC	Institute for Human and Machine Cognition
ILN	International Lunar Network
IMF	International Monetary Fund
IMO	International Maritime Organisation
Intelsat	International Telecommunications Satellite Consortium
IOV	In-Orbit Validation
IRGC	Islamic Revolution Guards Corps
IRIS	Interface Region Imaging Spectrograph
ISECG	International Space Exploration Coordination Group
ISPS	Innovative Space Propulsion Systems
ISR	Intelligence, Surveillance and Reconnaissance
ISRO	Indian Space Research Organisation
ISS	International Space Station
ITAR	International Traffic in Arms Regulation
ITU	International Telecommunication Union
JADE	Jovian Auroral Distributions Experiment
JAXA	Japan Aerospace Exploration Agency
JEDI	Jupiter Energetic Particle Detector Instrument
JEO	Jupiter Europa Orbiter
JIRAM	Jovian Infrared Auroral Mapper
JUICE	Jupiter Icy Moon Explorer
JWST	James Webb Space Telescope
KISS	Keck Institute for Space Studies
KSLV	Korea Space Launch Vehicle
LADEE	Lunar Atmosphere and Dust Environment Explorer
LAMP	Lyman Alpha Mapping Project
LEO	Low Earth Orbit
LFI	Low Frequency Instrument
LH2	Liquid Nitrogen
LRO	Lunar Reconnaissance Orbiter
LWS	Living With a Star
MAG	Magnetometer
MAVEN	Mars Atmosphere and Volatile Evolution
MDA	Missile Defense Agency
MDA	MacDonald, Dettwiler and Associates Ltd.
MDIS	Mercury Dual Imaging System
Melco	Mitsubishi Electric Corporation
MER	Mars Exploration Rover
MESSENGER	MErcury Surface, Space Environment, GEochemistry and Ranging
MetOp-SG	MetOp Second Generation

MEXT	Ministry of Education, Culture, Sports, Science and Technology
MFF	Multiannual Financial Framework
MFG	Meteosat First Generation
MHZ	Megahertz
MIRI	Mid-Infrared Instrument
MLA	Mercury Laser Altimeter
MMO	Mercury Magnetospheric Orbiter
MOIRE	Membrane Optical Imager for Real-Time Exploitation
MOM	Mars Orbiter Mission
MPCV	Multi-Purpose Crew Vehicle
MPLM	Multi-Purpose Logistic Module
MPO	Mercury Planetary Orbiter
MRO	Mars Reconnaissance Orbiter
MSG	Meteosat Second Generation
MSL	Mars Science Laboratory
MSS	Mobile Servicing System
MTG	Meteosat Third Generation
MWR	Microwave Radiometer
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NEO	Near-Earth Orbit
NEO	Near-Earth Object
NEXT	NASA’s Evolutionary Xenon Thurster
NGA	National Geospatial-Intelligence Agency
NGL	Next-Generation Launcher
NIAC	NASA’s Innovative Advanced Concepts
NIRSpec	Near-Infrared Spectrograph
NOAA	National Oceanic and Atmospheric Administration
NOFBX	Nitrous Oxide Fuel Blend
NRC	National Research Council
NRO	National Reconnaissance Office
NSA	National Security Agency
NSOAS	National Satellite Ocean Application Service
OECD	Organisation for Economic Co-operation and Development
OICT	Office of Information and Communications Technology
OMAC	Orbital Manoeuvring and Attitude Control
OMB	Office of Management and Budget
ONSP	Office of National Space Policy
OPEC	Organization of the Petroleum Exporting Countries
ORU	On-orbit Replacement Unit
OSTIn	Office for Space Technology and Industry
PCW	Polar Communications and Weather
PDV	Prithvi Defence Vehicle

PLA	People's Liberation Army
PMM	Permanent Multipurpose Module
PND	Portable Navigation Device
PPP	Public Private Partnership
PSLV	Polar Satellite Launch Vehicle
PTSS	Precision Tracking Space System
PWR	Pratt and Whitney Rocketdyne
QZSS	Quasi Zenith Satellite System
R&D	Research and Development
RCM	Radarsat Constellation Mission
REACH	Registration of Evaluation Authorization and Restriction of Chemicals
RHESSI	Reuven Ramaty High Energy Solar Spectroscopic Imager
RLV	Reuseable Launch Vehicle
RRM	Robotic Refuelling Mission
RSC	Rocket Space Corporation
SAC	Space Activities Commission
SAR	Synthetic Aperture Radar
SatDSiG	Germany's Satellite Data Security Act
SDO	Solar Dynamics Observatory
SecTelSat	Secure Telecom by Satellite
SHEFEX	Sharp Edge Flight Experiment
SIA	Satellite Industry Association
SLS	Space Launch System
SMEX	NASA Small Explorer
SMOS	Soil Moisture and Ocean Salinity
SNC	Sierra Nevada Corporation
SNSB	Swedish National Space Board
SOHO	SOlar and Heliospheric Observatory
SpaceX	Space Exploration Technologies Corporation
SPC	Space Programme Committee
SPOT	Satellite pour l'Observation de la Terre
SS/L	Space Systems/Loral
SSA	Space Situational Awareness
SSCB	Singapore Science Centre Board
SSCG	Swedish Space Corporation Group
SSN	Space Surveillance Network
SSO	Sun-Synchronous Orbit
SST	SpaceShipTwo
SSTA	Singapore Space and Technology Association
SSTO	Single Stage To Orbit
STEREO	Solar TErrestrial RElations Observatory
STFC	Science and Technology Facilities Council
TAA	Technical Assistance Agreement

TCBM	Transparency and Confidence Building Measures
TDM	Technology Demonstration Mission
TDRS	Tracking and Data Relay Satellite
TFEU	Treaty on the Functioning of the European Union
TG	Tiangong
TGO	Trace Gas Orbiter
TH	Tianhe
TRL	Technology Readiness Level
TZ	Tianzhou
UAE	United Arab Emirates
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UHF	Ultrahigh Frequency
UK	United Kingdom
ULA	United Launch Alliance
UN	United Nations
UN COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UN FCCC/ COP	United Nations Framework Convention on Climate Change / Conference of Parties
UN OOSA	United Nations Office of Outer Space Affairs
UN REDD	United Nations Programme on Reducing Emissions from Deforestation and forest Degradation
UN SAP	United Nations Programme on Space Applications
UN SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
UNCTAD	United Nations Conference on Trade and Development
UNGA	United Nations General Assembly
UNGIWG	United Nations Geographic Information Working Group
UNIDIR	United Nations Institute for Disarmament Research
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space
UNSDI	United Nations Spatial Data Infrastructure
US	United States
USAF	United States Air Force
USAT	Ultra Small Aperture Terminals
USML	United States Munitions List
UVS	Ultraviolet Imaging Spectrograph
VASIMIR	Variable Specific Impulse Magnetoplasma Rocket
VERTA	Vega Research and Technology Accompaniment
VIMS	Visual and Infrared Mapping Spectrometer
VLS-1	Brazil's Satellite Launch Vehicle
VSAT	Very Small Aperture Terminals
WGP	World Gross Product
WISE	Wide-field Infrared Survey Explorer

WMAP	Wilkinson Microwave Anisotropy Probe
WRC	World Radiocommunication Conference
WRS	World Radiocommunication Seminar
WT	Wentian
XT	Xuntian

Contents

Part I
The Year in Space 2013

Chapter 1
European Space Activities in the Global Context

Cenan Al-Ekabi

1.1 Global Political and Economic Trends

1.1.1 Global Economic Outlook

According to the United Nations' Annual Report "World Economic Situation and Prospects", the thread of this reporting period, covering 2012 and 2013, was the underperformance of the world economy, which was observed across almost all regions and major economic groups.[1]

The year 2012 was characterised by a considerable weakening of the world economy. Several developed nations, especially those in the Euro zone, experienced a double-dip recession, aggravated by sovereign debt crises and cumulating high unemployment, weak aggregate demand compounded by fiscal austerity, high public debt burdens, and financial fragility. These negative effects in turn spilled over to the developing nations and economies in transition through weaker demand for their exports and heightened volatility in capital flows and commodity prices. Some of the larger of these economies, including China, were not only affected externally, but also faced internal issues relating to weakened investment demand because of financing constraints in some sectors of their economies and excess production capacity elsewhere. The lower-end income countries had been shielded from these developments, but towards the end of 2012 they also started to be

[1] "World Economic Situation and Prospects 2014." 2014. United Nations 20 May 2014 http://www.un.org/en/development/desa/policy/wesp/wesp_current/wesp2014.pdf.

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affected by the effects of the slowdown in both the developed and major middle-income countries.[2]

In 2013, World Gross Product (WGP) is estimated to have grown by a subdued 2.1 %, lower than the 2.4 % that had been previously forecasted. This was mainly because most developed economies experienced the lingering effects of the financial crisis, grappling in particular with the challenges of taking appropriate fiscal and monetary policy actions.[3]

There were however signs of improvement, partly due to the Euro zone finally rising out of the recession. Western Europe showed a positive growth inclination from the second quarter of 2013 on, owing to stronger growth of two of Europe's economic motors, Germany and the United Kingdom. The return of growth in these countries in turn led to an improvement of the situation in Eastern Europe. Moreover, the crisis in Europe's southern periphery also seems to have toned down due to increased output. Ireland, Portugal and Spain, three of the five high-spread economies ended their recession in 2013, aided by strong export growth, with Italy and Greece easing their recession periods. Even though this seems to be the coming of a new dawn for the Euro zone, output has not yet caught up with pre-crisis levels, and is still up to 10 % or more below pre-crisis levels in those economies that were struck the hardest in the European economic area. Another significant challenge that will be high up on the agenda of the decision makers is youth and long-term unemployment which remain endemic. [4]

The economy of the United States of America continued to recover, although 2013 growth was significantly lower than in 2012, as a result of fiscal tightening and a series of political gridlocks over budgetary issues, culminating in the government shutdown of October 2013. Nevertheless, US GDP is expected to grow by 2.5 % and 3.2 % for 2014 and 2015 respectively. Although unemployment levels are at their lowest since 2008, employment rates have not yet reached pre-crisis levels—due to withdrawal from the labour force of retirees, but also because of large numbers of part-time workers. Even Japan, the third member of the major high-income economies, managed to end its decade-long deflation through a set of expansionary policy packages. A key driver of growth was investment in physical assets, with several construction projects financed by the government. GDP is forecast to moderate to 1.5 % in 2014.[5]

Despite tensions on financial markets and weaker momentum in the developed world, growth in the developing countries strengthened in the second half of 2013, after a period of feeble growth at the end of 2012 and a weak start to 2013. This recovery, however, has been uneven, with growth accelerations in China, India, Malaysia, Thailand and Mexico, offsetting the less well-off countries of

[2] "World Economic Situation and Prospects 2013." 2013. United Nations 20 May 2014 http://www.un.org/en/development/desa/policy/wesp/wesp_archive/2013wesp.pdf.

[3] "World Economic Situation and Prospects 2014." 2014. United Nations 20 May 2014 http://www.un.org/en/development/desa/policy/wesp/wesp_current/wesp2014.pdf.

[4] Ibid.

[5] Ibid.

South Africa, Turkey, Indonesia and the contracting Brazil.[6] Growth in the developing economies has been estimated to average 5.1 % in 2014 and 5.3 % in 2015.[7]

Overall, WGP is forecast to grow at a pace of 3.0 % and 3.3 % in 2014 and 2015, respectively. Even though 2013 was characterised by a subdued performance, some signs of improvement have emerged. Inflation remains tame worldwide, partly reflecting output gaps, high unemployment and a continued financial deleveraging in major developed economies. The global employment situation remains troublesome however, as a long-lasting problem that continues to weigh on the labour markets of many countries and regions, especially in the Euro zone.[8]

1.1.2 Political Developments

1.1.2.1 Geopolitics

The Arab Spring that saw its origins in Tunisia in December 2010, continued in 2012 while previously marginalised Islamist political forces were making dramatic gains. Parties that were once banned or fringed increasingly expanded their grip in Tunisia, Libya, and Egypt. In the case of Egypt, the Muslim Brotherhood saw its candidate Mohamed Morsi democratically elected as President, nevertheless triggering new protests by millions of Egyptians.[9] Morsi was accused of exploiting his position to consolidate the power of the Brotherhood and was removed from office by army chief Abdul Fatah el-Sisi. This move was again followed by another series of mass protests, polarizing Egyptian society between backers of Morsi and of Sisi. The outcome was a crackdown on the Muslim Brotherhood leaders and their supporters by the military-backed interim government, resulting in the solidification of power by Sisi and the new technocratic regime. Elections are planned for 2014 with Sisi running as candidate.[10]

In 2013, the African continent witnessed the rise of Islamist extremist-fuelled terrorism, leading to a hostage crisis at an Algerian oil field, repeated attacks by Boko Haram in Nigeria, and the assault by Al-Shabab on a mall in Nairobi. France

[6] "Global Economic Prospects | Coping with Policy Normalization in High-Income Countries." Jan. 2014. The World Bank 20 May 2014. http://www.worldbank.org/content/dam/Worldbank/GEP/GEP2014a/GEP2014a.pdf.

[7] "World Economic Situation and Prospects 2014." 2014. United Nations 20 May 2014. http://www.un.org/en/development/desa/policy/wesp/wesp_current/wesp2014.pdf.

[8] Ibid.

[9] "Top 10 Everything of 2012 | International News." 4 Dec. 2012. Time 19 May 2014. http://world.time.com/2012/12/04/top-10-international-news-lists/.

[10] "Top 10 International News Stories." 4 Dec. 2013. Time 19 May 2014. http://world.time.com/2013/12/04/world/slide/top-10-international-news-stories/.

also intervened and took up weapons by intervening in Mali, successfully pushing back Islamist forces.[11]

In the Middle East, Syria's civil war has shown no signs of abating. The war that has cost the lives of 100,000 people so far created the largest refugee crisis in years.[12] After a sarin gas attack on a Damascus suburb in August 2013, it was established that Syrian President Bashar Assad was behind the attack, killing at least 1,429 people. In a response to these worrying escalations, US President Barack Obama sought authorization to strike Syria's installations of chemical weapons, which was hailed as a major development by the rebels seeking to overthrow the regime since February 2011. However, with US public opinion dead set against another US military intervention in the Middle East, it never got to this point. Even though the Assad regime has reportedly been cooperating with UN inspectors aiming to eradicate the stockpile of chemical weapons, the civil war still rages on and few are optimistic that this horrifying chapter of Syria's history will soon come to an end.[13]

In Iran, new President Hassan Rouhani had a phone call with President Obama; historically noteworthy as it was the first official direct dialogue between the two states for three decades. This new rapprochement of the Islamic Republic with the Western world led to the signing of an agreement in November 2013 whereby Iran committed itself to curtailing its infamous nuclear activities in exchange for the waiving of sanctions costing billions of dollars.[14]

In the beginning of 2013, the world was gripped by the story evolving around the U.S. National Security Agency (NSA) whistle-blower Edward Snowden, with repercussions far outside the intelligence community. The cache of documents that Snowden exposed revealed the extent of US espionage operations in various parts of the world, thereby threatening to damage the relations between the US and some key international players. After fleeing to Hong Kong, the now-outcast Snowden was granted asylum by the Russian government which did little good for the ever-delicate relationship between Washington and Moscow.[15]

The United States also found itself in the first government shutdown since the mid-1990s which lasted more than two weeks in October 2013. Due to the inability to reach an agreement on federal spending levels, the federal bureaucracy ground to a halt, slowing economic growth at an estimated cost of around $24 billion according to Standard and Poor's credit agency.[16]

[11] Ibid.

[12] "Top 10 Everything of 2012 | International News." 4 Dec. 2012. Time 19 May 2014. http://world.time.com/2012/12/04/top-10-international-news-lists/.

[13] "Top 10 International News Stories." 4 Dec. 2013. Time 19 May 2014. http://world.time.com/2013/12/04/world/slide/top-10-international-news-stories/.

[14] Ibid.

[15] Ibid.

[16] Ibid.

Across the Atlantic, mass protests and strikes in 2012 became a common sight in Spain, Italy, Portugal, and elsewhere, as infuriated crowds voiced public discontent with the austerity measures resulting from bailouts that kept their countries away from bankruptcy.[17] The year 2013 showcased the resiliency of the euro, partially eliminating concerns over the survival of the European currency bloc. The economy of the Euro zone got itself on the right track towards recovery, even though government debts are precariously high and unemployment has only come down slowly, remaining painfully high in much of Southern Europe.[18] In this regard, long-term prospects look bleak with double digit unemployment among youth, reaching more than 50 % in Greece and Spain.[19]

In this reporting period, China found itself in ongoing disputes with Vietnam and the Philippines over maritime territory and the likely lucrative gas reserves that come with it. Even more intense was the situation with rival Japan, both nations contesting a string of islands that led to massive anti-Japan protests in China.[20] And in India, public anger was fuelled by waves of corruption scandals in which top politicians were accused of exploiting their positions for financial gain.

1.1.2.2 Environment

Space applications have an important role in the monitoring and protection of the environment. Space assets are uniquely positioned to offer a global perspective on climate change. They help to better manage disaster situations around the world, and are often a common multinational platform for collecting relevant meteorological and environmental data. These characteristics make them ideal promoters of international understanding and cooperation in this field. Satellite based systems are being used to gather information on climate change indicators e.g. the melting of the ice-caps, changes in the global sea level, and gathering data on regions most-affected by global warming. Remote sensing technologies can also be used to monitor deforestation and land use, and are important for better utilization of fresh water sources. There is no doubt that space technologies will play an important role in human and environmental security in the future, hence technical development of their capabilities is necessary.

Despite the financial crisis, climate change remains one of the commonly recognised agenda topics within the global political debate. Following the

[17] "Top 10 Everything of 2012 | International News." 4 Dec. 2012. Time 19 May 2014. http://world.time.com/2012/12/04/top-10-international-news-lists/.

[18] "Top 10 International News Stories." 4 Dec. 2013. Time 19 May 2014. http://world.time.com/2013/12/04/world/slide/top-10-international-news-stories/.

[19] "Youth Unemployment Could Prolong Eurozone Crisis, Christine Lagarde Says." 10 Dec. 2013. The Guardian 19 May 2014. http://www.theguardian.com/business/2013/dec/10/youth-unemployment-eurozone-crisis-christine-lagarde-imf.

[20] "Top 10 International News Stories." 4 Dec. 2013. Time 19 May 2014. http://world.time.com/2013/12/04/world/slide/top-10-international-news-stories/.

complicated acceptance and application of the 1997 Kyoto Protocol, which was set to expire in 2012, and the "Copenhagen Accord" of 2009 establishing voluntary emissions cuts,[21] new rounds of negotiations over the follow-up international agreement continued both in 2012 and 2013. The 18th Conference of Parties to the UN Framework Convention on Climate Change (UN FCCC/COP) took place in Doha, Qatar, from 26 November to 8 December 2012; it was followed by the 19th UN FCCC/COP in the next year, which was held in Warsaw, Poland, from 11 to 23 November 2013. In the 18th conference, a historic shift from previous meetings occurred, when the summit established for the first time that rich nations should consider compensating poor nations for losses and damages due to climate change.[22] Moreover, an agreement was reached to extend the life of the Kyoto Protocol to 2020; and the conference built on the previous Durban platform to develop a successor to the Kyoto Protocol by 2015 and enter it into force by 2020. While the Kyoto Protocol is the sole legally binding climate plan, obliging about 35 industrial nations to cut their emissions significantly, with the earlier withdrawal of Russia, Japan and Canada; the remaining backers, led by the European Union and Australia, now account for only 15 % of world greenhouse gas emissions.[23] The international community showed willingness to move away from the long lasting deadlock and towards real political solutions, despite varying degrees of reservation by the big players, the US, EU, and China, on levels of emission cuts and the wording of the 'Loss and Damage mechanism'. And traditional differences between the positions of developed and developing countries were significant and were stressed again during the conference, e.g. Russia, Ukraine and Belarus had hoped to be granted extra credit for the emissions cuts they had made when their industries collapsed, but that was ignored as an attempt to increase their emissions as other nations were obliged to cut theirs.

At the 19th conference, delegates continued negotiations towards a new global agreement on climate change. A potential deadlock emerged between industrialised and emerging nations on the limit on the level of emissions, with China giving deference to emerging nations for growth, while the US pushed for more accountability from the same in reducing emissions. The talks also led to the proposed 'Warsaw International Mechanism for Loss and Damage' that would provide expertise and some funds to help developing nations mitigate losses and damage from extreme environmental events (e.g. heat waves, droughts and floods), and

[21] "United Nations Climate Change Conference kicks off in Copenhagen." 7 Dec. 2009. United Nations Development Programme 20 Feb. 2012. http://content.undp.org/go/newsroom/2009/december/historic-united-nations-climate-change-conference-kicks-off-in-copenhagen.en.

[22] Harrabin, Roger. "UN climate talks extend Kyoto Protocol, promise compensation." 8 Dec. 2012. BBC 15 May 2014. http://www.bbc.com/news/science-environment-20653018.

[23] Doherty, Regan and Barbara Lewis. "Doha climate talks throw lifeline to Kyoto Protocol." 8 Dec. 2012. Reuters 15 May 2014. http://www.reuters.com/article/2012/12/08/us-climate-talks-idUSBRE8B60QU20121208.

imminent threats (e.g. rising sea levels, and land desertification).[24] Moreover, the Warsaw conference saw progress in the development of the Green Climate Fund, with the initial resource mobilization process expected to begin in the second half of 2014.[25] This fund, planned to be a major channel of financing for developing world action, will gather and distribute $100 billion (about 75.5 billion Euros) by 2020 to help developing countries handle the side effects of global warming and climate change. The other important outcome was the progress on the UN Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN REDD), where governments agreed on a set of measures to reduce emissions from deforestation and forest degradation, establishing the means for results-based payments if developing countries can demonstrate the protection of forests (backed by initial pledges of $280 million). Deforestation and soil degradation are well known, not only as the negative effect of global climate change, but also as a significant contributor to it. In sum, recent progress on global climate issues has shown that the gap between leading industrialised and emerging countries is slowly narrowing, with the upcoming 2015 replacement protocol expected to be applicable to all nations involved in the climate change discussion process.

Environmental and sustainable development issues continued to be important for both internal and external EU policies. For instance, just weeks before the 19th UN FCCC/COP Poland's insistence on its use of coal to generate 88 % of the country's electricity was seen to hold the EU back in its clean-energy goals intended to reduce the greenhouse gases linked to global warming.[26] Nevertheless, over the course of 2012 and 2013 several important initiatives regarding environmental issues were undertaken at the EU level.[27] Prior to the 18th UN FCCC/COP, the EU Council set out the EU position on climate change, in which in addition to stressing the urgency of establishing an ambitious international regime to solve global climate changes, it implemented its unilateral commitment to cut its emissions by at least 20 % of 1990 levels by 2020.[28] At the 19th UN FCCC/COP, the EU's stance focused on the proper implementation of existing decisions and advancing work under the Durban Platform for Enhanced Action by quickly closing the gap in the pre-2020 level of

[24] "Deadlock broken at UN climate talks." 24 Nov. 2013. Aljazeera 15 May 2014. http://www.aljazeera.com/news/europe/2013/11/deadlock-broken-at-un-climate-talks-20131123163641928770.html.

[25] "Warsaw Outcomes." United Nations Framework Convention on Climate Change 15 May 2014. http://unfccc.int/key_steps/warsaw_outcomes/items/8006.php.

[26] Hakim, Danny. "Poland, Wedded to Coal, Spurns Europe on Clean Energy Targets."

[27] Council of the European Union. The 318th Council Meeting: Environment. Press Release 15321/11 final of 10 Oct. 2011. Brussels: European Union.

[28] "Environment ministers set out EU position ahead of Doha Climate Conference." 25 Oct. 2012. Council of the European Union 16 May 2014. http://www.consilium.europa.eu/homepage/highlights/environment-ministers-set-out-eu-position-ahead-of-doha-climate-conference?lang=en.

mitigation ambition, and preparing the ground for adopting a new legally-binding global post-2020 climate agreement by 2015.[29]

During the Polish presidency, the EU Council adopted conclusions on the assessment of the EU's 6th Environmental Action Programme (EAP) 2002–2012. The conclusions proposed by the European Commission were seen as comprehensive and forward-looking, and took into account existing initiatives such as the Europe 2020 Strategy; the EU positions on the UN Conference on Sustainable Development (Rio +20); the post-2010 Biodiversity Strategy; and more. Regarding the 2012 Rio +20 UN Conference, the Polish Presidency significantly assisted in establishing the EU's general positions, mostly stressing the use of green energy in the context of sustainable development and poverty eradication, and the establishment of an institutional framework for sustainable development.[30]

Furthermore, on 20 November 2013 the European Parliament and European Council adopted a decision to establish the EU's 7th EAP to 2020 "living well, within the limits of our planet", which entered into force in January 2014. It identifies three key objectives: e.g. protection, conservation and enhancement of the EU's natural capital; turning the EU into a resource-efficient, green, and competitive low-carbon economy; and safeguarding the Union's citizens from environment-related pressures and risks to health and wellbeing. It also lists four 'enablers' that will facilitate these goals: better implementation of legislation; better information by improving the knowledge base; increased and wiser investment for environment and climate policy; and full integration of environmental requirements and considerations into other policies. Its two overarching horizontal priority objectives are to make the Union's cities more sustainable, and to help the Union address international environmental and climate challenges more effectively.[31]

1.1.2.3 Energy

While economic recovery was on the uptick in 2012 and 2013, the global energy map was undergoing revision with the increase in oil and gas production in the United States, along with a retreat from nuclear power in some countries, growth in the use of wind and solar technologies, and the spread of unconventional gas

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[29] "EU adopts its position for the UN climate change conference." 15 Oct. 2013. Council of the European Union 16 May 2014. http://www.consilium.europa.eu/homepage/highlights/eu-adopts-its-position-for-the-un-climate-change-conference?lang=en.

[30] Council of the European Union. Rio+20: Towards Achieving Sustainable Development by Greening the Economy and Improving Governance. Council Conclusion 15388/11.

[31] European Union. Decision of the European Parliament and of the Council on a General Union Environment Action Programmes to 2020 "Living Well, Within The Limits Of Our Planet". 20 Nov. 2013, European Parliament and Council Decision PE-CONS 64/1/13 REV 1 of 20 November 2013. Strasbourg: European Union. http://ec.europa.eu/environment/newprg/pdf/PE00064_en.pdf.

production. Roles are beginning to shift among major energy importers and exporters, as decision makers attempt to reconcile their state economic, energy and environmental objectives. The next stage in global energy development will require an awareness of the dynamics underpinning energy markets to anticipate how growth may be achieved and, with the rise of unconventional oil and gas and of renewables, map where the distribution of the world's energy resources will take root.

Another recurring trend during the review period was the increasingly strong role of emerging countries in determining energy market behaviour. The tide of energy demand is beginning to flow toward emerging economies, particularly China, India, and the Middle East, which have increased global energy use by one-third. While the US is projected to become the largest oil producer by 2020, moving toward meeting all its energy needs from domestic resources by 2035, North America is expected to shift toward becoming a net oil exporter by 2030.[32] On the other hand, China is poised to become the largest oil-importing country and India will be the largest importer of coal by the early 2020s, which should shift the majority of energy trade from the Atlantic region to the Asian-Pacific.[33] By 2030, China's oil consumption is expected to overtake the US, while the Middle East will do likewise with the EU, as the decline in oil use in OECD countries accelerates.[34] An important side effect of this trend is that significant investments in energy production and distribution will have to be made to respond to growing demand. By some estimates, as much as $38 trillion will have to be invested in related infrastructure by 2035, of which $20 trillion is to be for fossil fuel exploitation.[35] Yet energy price variations among regions are likely to affect industrial competitiveness, influencing investment decisions and company strategies. While the price of crude oil has remained high since 2011, the prices of other fuels have been subject to significant regional variations. It should be noted that energy-intensive sectors worldwide account for around one-fifth of industrial value addition, one-quarter of industrial employment and 70 % of industrial energy use.[36]

Despite the growth in renewable low carbon sources of energy, fossil fuels remain dominant in the global energy mix, supported by six times more subsidies than subsidies to renewables in 2011. In the long run, the share of fossil fuels in the global primary energy consumption mix is projected to fall slightly from 81 % in 2010 to approximately 75 % in 2035, though natural gas is expected to increase its relative share within the fossil fuel mix. At the same time, the problem of decreasing the environmental footprint of fossil fuel energy consumption remains unsolved. With the energy sector responsible for two-thirds of global greenhouse-gas emissions, it will be pivotal in determining whether or not climate change goals

[32] International Energy Agency. World Energy Outlook 2012. IAE: Paris, 2012.

[33] International Energy Agency. World Energy Outlook 2013. IAE: Paris, 2013.

[34] Ibid. at 4.

[35] International Energy Agency. World Energy Outlook 2011. IAE: Paris, 2011.

[36] International Energy Agency. World Energy Outlook 2013. IAE: Paris, 2013.

are achieved. In the current scenario, even with carbon abatement schemes announced by the EU, the US, China, and Japan to improve energy efficiency, support renewables, reduce fossil-fuel subsidies and, in some cases, to put a price on carbon, energy-related CO2 emissions are expected to still rise by 20 % by 2035.[37]

1.1.2.4 Resources

Space applications and Earth monitoring technologies play an important role in the area of resource management, as they can provide better control of and support for the utilisation of scarce natural resources. Likewise, satellite based technologies can perform indispensable tasks for international trade, e.g. by streamlining global business transactions and payments. Global navigation satellite systems (GNSS) are already relied on as an integral part of transportation and utilisation of natural, agricultural and industrial resources. And the use of meteorological and imaging satellites is making agricultural output bigger and more reliable, along with greater precision. For many developing countries the rationale for investment in space is improvement of the management of their agricultural and natural resources.

Between 2011 and the end of 2013, commodity prices continued to recede, though their effect on consumer price inflation varied between high-income and developing economies due to country-specific conditions. This tendency can be attributed to weaker global demand as a result of the economic crisis. Nevertheless, by the end of 2013, there were signs of a turning point in the global economy, as stronger growth was expected in high-income economies, which were beginning to match the growth of emerging economies that had been less scathed by the crisis. In this period, favourable weather conditions in several agriculture markets, as well as strong coal and metals production, led to price declines in these respective commodities. Oil prices eased by the end of 2013, due to the growing supply in the US and the easing of tensions surrounding Iran. Yet, there remains some uncertainty with regard to oil commodities, as potential political turmoil in the Middle East could result in substantial price increases, whereas the increase of crude-oil substitutions for other types of energy could result in the opposite outcome. Furthermore, currency fluctuations have affected domestic prices of commodities, sometimes increasing demand.[38]

While the rate of growth of international trade was expected to return to 7–8 % in 2011, it fell below that mark, reaching 5.3 % for that year; it decelerated even further to 1.7 % in 2012. However, the return of trade to pre-crisis levels has been uneven among economies, with developed, developing and transitioning economies all experiencing a slower rate of expansion in 2012 than experienced in the previous

[37] Ibid.

[38] The World Bank. Global Economic Prospects—Coping with policy normalization in high-income countries. Volume 8/January 2014. Washington DC: World Bank, 2014.

year. For instance, trade in Europe has been sluggish, due partly to the nominal growth of imports in addition to its extremely weak intra-EU trade that was responsible for nearly 90 % of the slowdown in Europe's exports. Japan has not fared much better in its exports following its 2011 earthquake, though it is beginning to increase its imports. However, the US is beginning to show signs of growth, with some increase in both its import and export volumes, despite signs of deceleration of the latter in 2013. Another example is the situation in the economies in transition. While figures remained positive for most transition economies, they have decelerated considerably with export volumes increasing by 1 % in 2012 from 4.2 % in 2011, and imports dropping to 3.9 % in 2012 from 15.7 % in 2011. Developing economies also experienced diminishing growth in 2012, though the change was not quite as severe, with import growth falling to 4.5 % in 2012 from 7.4 % in 2011, and exports displaying similar results at 3.6 % in 2012 from 6 % in 2011. It would appear that the previous crisis has altered trade patterns, with the volumes of trade of most developed regions remaining below their pre-crisis levels, while imports and exports in emerging economies have exceeded their pre-crisis peaks, though even that growth appears to be slowing down recently due to decreases in demand, hinting at a less favourable trade environment in the near future.[39]

Oil and mineral exporters experienced significant gains during the period. Oil prices remained high and relatively stable between 2012 and 2013, primarily because of decreases in production by members of the Organization of the Petroleum Exporting Countries (OPEC) in the last quarter of 2012, and geo-political tensions in Western Asia affecting oil supplies. Increased oil production in North America, and decelerating global demand growth in OPEC countries brought downward pressure on oil prices in 2013, though prices still increased at the start of the year based on expected improvement in economic conditions. To compare the situation with previous years, according to the figures of the United Nations Conference on Trade and Development (UNCTAD), crude oil market prices fluctuated in a $99–$111 band during the second half of 2012 and the first half of 2013, with an average price of $105.5 per barrel for the 12-month period. While in 2011 growth in the oil trade expanded by roughly 1 %, demand for crude oil marginally increased again by 1.5 % in 2012. For 2013, growth in the demand for oil was expected to come from non-OECD countries, while it was expected to fall for OECD countries.[40]

Additionally, non-oil commodity prices continued to exhibit some negative growth, due in part to improved supply conditions and a steep decline in global demand. However, there are signs of an uptick in the near future resulting in a minimal price growth in these commodities, with increasing demand coming from rapidly growing developing countries such as China. Nevertheless, whereas non-oil

[39] United Nations Conference on Trade and Development. Trade and Development Report, 2013. Geneva: UNCTAD, 2013. 1–10.

[40] Ibid. at 7–10.

commodity prices posted a 17.9 % increase in 2011, those prices decreased by 8.4 % in 2012, and showed a further reduction of 3.3 % in 2013.[41] Non-oil commodities prices are forecast to begin increasing by 2016.[42] As in previous years, uncertainty and instability have been the major distinguishing features of commodity markets, which is also reflected in the greater volatility of commodity prices. Looking at UNCTAD commodity price statistics, between the two periods 2003–2007 and 2008–2012, the simple measure of commodity groups showed medium levels of volatility in food commodity prices, with prices increases diminishing somewhat in the second period. On the other hand, vegetable oil seeds and oils, agricultural raw materials, minerals and metals and crude petroleum all showed higher levels of volatility.[43] Whereas metals and minerals prices rose steeply in the second half of 2010, and peaked during the first months of 2011 with relative stability in the following 18 months, prices in this market group declined sharply by mid-2013, with the index expected to decline almost 11 % in 2013. While gold, along with platinum and silver, have benefited from uncertainties about the global economy, the decline has marked a reversal from the previous 11 years of increasing precious metals prices. While still considered as safe havens, the indexes for gold, silver, and platinum declined by 15.5 %, 23.5 %, and 9.8 % respectively in 2013.[44] This is partially due to production and supply improvements, along with global recovery picking up pace, and the easing of financial tensions in Europe.[45]

1.1.2.5 Knowledge

There is no doubt that sustained education and knowledge improvement is one of the necessary conditions for successful space activities, as well as for the full exploitation of their societal benefits. In general, space technology and development, drawing on multiple scientific disciplines, is one of the most difficult and challenging fields in scientific and technical research. Therefore, coherent and sustainable strategies aimed at improving higher education and supporting technical and scientific activities are particularly relevant and necessary for space sector activities.

For Europe, the expansion of its pool of highly skilled and specialised scientists and professionals should be a constant priority if it is to remain a leading actor in the

[41] Ibid. at 9.

[42] The World Bank. Global Economic Prospects—Coping with policy normalization in high-income countries. Volume 8/January 2014. Washington DC: World Bank, 2014.

[43] Instability indices and trends of free-market commodity prices for selected periods, annual, 1983–2012. UNCTADstat 13 Apr. 2014. http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx.

[44] World Bank Group. Global Economic Prospects—Commodity Markets Outlook. 2014 / April. Washington DC: World Bank, 2014: 19.

[45] The World Bank. Global Economic Prospects—Less volatile, but slower growth. Volume 7 / June 2013. Washington DC: World Bank, 2013: 104.

field of space-related scientific and technological R&D. With other developed and emerging economies increasing investment in R&D in response to the financial crisis, for Europe to remain a leader in the global race for knowledge and excellence in space R&D current levels of financial spending and political commitment in this area will have to be increased, and not only simply maintained. For example, in 2013, 29 % of the European working age population (including all EU Member States except Bulgaria, Cyprus, Malta, Latvia, Lithuania, Romania, and Croatia) held a higher education degree compared to 42 % in the US, 46 % in Japan and 51 % in Canada.[46] While OECD figures tend to show that many European states can expect in the future a significant increase in the proportion of their population that attains a higher education degree, countries including Germany and Austria, and to a lesser extent Italy, Slovakia, Hungary, Czech Republic, and Greece are at risk of falling further behind the OECD average of 32 % of the working age population (between 25-to-64 years of age) with a higher education degree.[47]

Yet the crisis has reinforced the importance of a good education. Employment rates were the highest among people with a tertiary education with higher or specific skills, while low-skilled workers were more likely to find that their jobs had been automated.[48] According to a 2012 report of the European Centre for the Development of Vocational Training, the European skills forecast indicates that by 2020 around 38.2 % of jobs in the EU will require higher education qualifications, while medium qualification jobs would remain at about 46.5 %, and low qualification jobs would diminish to 15.3 % from 21.9 % in 2010.[49] By 2011, the share of the European population aged 30–34 having completed tertiary or equivalent education reached 37 %. When looking at graduation rates in tertiary education, it is likely that most European countries will achieve the EU's goal of 40 % of 30–34 year-olds completing higher education by 2020.[50] However, only 26 % of the overall working age population are qualified to this level today.[51] While the EU is several points short of its 40 % goal, it can identify three main challenges that are common to many Member States and have a direct impact on the ability of higher education systems to provide the number of highly qualified graduates a modern knowledge-based economy needs. These include the need to broaden access to higher education especially for states such as Bulgaria, Romania, the Czech Republic, Greece, and Hungary; to reduce drop-out rates and the time it takes to complete a degree, experienced mainly in Austria, Belgium, France, Greece, Hungary, Italy, the

[46] OECD. Education at a Glance 2013: OECD Indicators, OECD Publishing, 2013: 37. http://dx.doi.org/10.1787/eag-2013-en.

[47] Ibid. at 31.

[48] Ibid. at 74.

[49] European Centre for the Development of Vocational Training. Future skills supply and demand in Europe: Forecast 2012. CEDEFOP, 2012: 34.

[50] OECD. Education at a Glance 2013: European Union—Country Note. OECD Publishing, 2013: 8.

[51] National Priorities: Recent Trends & Future Developments—European Union. 1 May 2012. International Institute of Education 5 May 2014.

Netherlands, Poland Romania, Sweden, and Slovenia, and to improve the quality of higher education and make it more relevant.[52]

Encouragingly, the population of university and higher education students in Europe has been constantly increasing in recent years. Today, there are approximately 4,000 universities and other kinds of higher education institutions in Europe, with more than 19 million students. Nevertheless, this quantitative increase has not been accompanied by qualitative improvements in governance structures and proposed academic curricula, or by increases in funding. Although increasing in size, Europe's higher education system has not yet achieved an academic curricula distribution that will train scientists and professionals with the right kinds of skills to support economic growth and scientific excellence in new technologies. This is especially true for the space sector, which has a relatively limited human resources supply and demand chain.[53]

According to a European Commission report, the potential of European higher education institutions to fulfil their role in society and contribute to Europe's prosperity is not fully exploited. EU officials have pointed out that greater capacity for research and development could fuel innovation across all sectors of the economy, improving competitiveness and fostering job creation. The same report highlights the potential technological spin offs of innovation and their capacity to revitalise more traditional economic sectors and rural areas, multiplying their broader societal impact.[54] In this context, the role of space applications should be highlighted, as for example in the case of using communications satellites to improve broadband Internet connectivity in remote areas. Finally, the new strategy proposed by the European Commission identifies priority areas where EU countries need to do more to achieve shared education objectives and describes how the EU can support the modernisation of national higher education policies. According to the EC proposal, EU-level initiatives will include a multi-dimensional university ranking which will better inform students about university courses and support competition between universities.

The EU budget dedicated to funding programmes for education, training and youth was about 8.8 billion Euros for the period 2007–2013. In addition to this, the EU spent an additional 4.7 billion Euros on training, mobility and career development for researchers. For the 2014–2020 budget period the European Commission emphasises the priority of "smart growth" through knowledge creation, consequently allocating substantial funds to skills and knowledge creation. According to the budget proposal, a single funding programme for education, training and youth will receive 15.2 billion Euros in the 2014–2020 period, which means an

[52] Europe 2020 Target: Tertiary Education Attainment. Europa.eu 11 May 2014. http://ec.europa.eu/europe2020/pdf/themes/28_tertiary_education.pdf.

[53] Ibid.

[54] European Commission. Communication from the Commission. Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth. COM (2010) 2020 final of 3 Mar. 2010. Brussels: European Union.

increase of 73 % compared to the 2007–2013 period. The Commission has also proposed a 46 % rise in research funding under the planned Horizon 2020 strategy that will bring funding up to 80 billion Euros.[55]

Considering the shortcomings, it was not a surprise that initiatives in the scientific research and education fields were among the top priorities of the EU Council. For example, increasing continuous learning, as well as educational and professional mobility, and modernising higher education infrastructure and curricula were some of the key initiatives in this respect. The implementation of these priorities followed the broad lines of the Europe 2020 Strategy and its flagship initiative "Youth on the Move", for the creation of new skills and new jobs. In this context, the Council launched a comprehensive debate on learning and mobility issues in the framework of EU educational programmes, taking into account its international dimension and also including EU neighbours. These actions were further supported by the European Commission, which set the goal of doubling the number of EU grant recipients for studying and training abroad at 800,000 students by 2020. In addition to this, around 72.5 billion Euros was to be spent on education and training across Europe's regions until 2013, and this pace is expected to be maintained in the future.[56]

1.1.2.6 Mobility

Maritime commerce accounts for the bulk of global trade, whereas air traffic carries most of the world's passenger traffic. Space assets are indispensable to both, as they provide meteorological, navigation and communication services that make sea and air transport safer and cheaper. Maritime navigation and mobile communications are two of the upcoming sectors with significant financial interests in the development of new generations of satellite-based applications.

In the 2 years ending in December 2013, the transport sector, particularly in Europe, continued to suffer from the effects of the global financial crisis. As the principal facilitator of global commodity flows, the transport sector continued its steep decline in demand due to the crisis, and the subsequent slowdown in the demand for raw materials. Recovery has been uneven across regions, with the loss of momentum of trade growth affecting the rate of economic recovery among states at different speeds. In addition to a weaker world economy in 2011, trade was also affected by natural and political disasters that had the effect of disrupting supply chains and production processes in parts of Asia and North Africa. On top of those

[55] "An EU Strategy for Modernising Higher Education—Questions and Answers." 20 Sept. 2011. European Commission—Press Release. 1 Mar. 2012. http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/11/615&format=HTML&aged=0&language=EN&guiLanguage=fr.

[56] "Extra Funds for Education, Youth and Creativity Will Boost Jobs, says Commission." 11 June 2011. European Commission—Press Release. 29 Feb. 2012. http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/857&format=HTML&aged=0&language=EN&guiLanguage=fr.

economic uncertainties, the financial crisis brought with it a lack of trade finance, and an influx of protectionist measures that were additional factors that clouded the outlook for trade. Moreover, the tightening of lending by the banking sector also adversely affected transport, restraining necessary credit flows that facilitate international commerce transactions. Indeed, the collapse of confidence that accompanied the sovereign debt crisis in Europe had significant repercussions in the transport sector, with several banks refusing to issue letters of credit or accepting certain forms of collateral for loans. These effects continued into 2013, albeit with signs of marginal growth in all regions but the EU. The European Union has been slower to recover in global trade growth due in-part to constraints from austerity measures and rising unemployment, which resulted in a reduction of import demand.

Maritime transport is the most commonly used form of transport for international trade, representing the bulk of global trade transport (90 %). Consequently, it suffered the greatest blow from the continued crisis beginning in 2008. Indeed, the impact of the financial crisis terminated one of the longest uninterrupted growth periods in recorded maritime history, with vessel orders reaching 10,053 ships by the beginning of 2008, making the timing of the crisis particularly adverse. In the following 2 years, a great number of orders were cancelled, due to decreased maritime activity that led to an unprecedented level of distress demolitions (projected to have reached 15–18 % of world fleet capacity in 2010). In 2011, the total quantity of tonnage sold for demolition increased by 31 %, with a 356 % surge in the scrapping of many still sea-worthy dry-bulk ships that were sold rather than allowed to continue to generate financial losses due to energy inefficiencies.[57] The total tonnage sold for demolition increased by another 36.7 % in 2012, with similar results as the previous year.[58] However, orders for new vessel types are at a historical low, bringing a need for investors to place new orders or risk that all sectors of the maritime industry will reduce employment levels. Another medium-term consequence of the financial crisis with effects on sea trade could be the appearance of protectionist measures that would further hinder world trade.

Another challenge for the maritime industry was the increased number of piracy incidents, especially off the Somalia coast, the Gulf of Aden and the West Indian Ocean between 2005 and 2012. Although an increased international military presence in these regions improved security somewhat, piracy incidents persisted. Nevertheless, while the number of reported piracy incidents in 2011 increased by 11.3 % to 544, that number decreased by 37.3 % to 341 reported incidents in 2012. That number again decreased by 12.6 % to 298 reported piracy incidents in 2013, with the number of Somalia-based piracy incidents falling to 20, from the 78 inci-

[57] United Nations Conference on Trade and Development. Review of Maritime Transport 2012. Geneva: UNCTD, 2012. 49.

[58] United Nations Conference on Trade and Development. Review of Maritime Transport 2013. Geneva: UNCTD, 2013. 60.

dents reported in 2012. Still, there remain a high number of captives held ashore.[59] In its heyday, the surge in piracy in the Gulf of Aden generated considerable costs especially for Europe as 80 % of shipments that pass through the area come from or are going to this continent. Re-routing shipments around the Cape of Good Hope alone is estimated to have created over $7.5 billion of additional shipping costs annually with associated increased energy consumption. Coordinated measures were undertaken by the International Maritime Organisation (IMO) to face the deteriorating security environment in the area and provide security for ships navigating in these waters. In this context, it approved of ship owners voluntarily arming their vessels at their own expense, notably by hiring armed guards when passing through the region, and later drafted guidelines on the use of such personnel on board ships in the high risk area.[60]

1.1.3 Main Science and Technology Indicators Relevant for Space Activities

The space sector requires the continued input of cutting-edge technologies, facilitated by a centralised public sector that occasionally bets against unfavourable financial market conditions. In order to compete on a world scale while mitigating uncertain market conditions, a web of private and public technology development schemes interact with and complement each other at various levels and to different extents in the space industry and associated business domains. This interdependence likewise exists at the European Union level where knowledge and innovation are the key drivers of future economic and societal development in a broader context. This is also reflected in the continued development of the European Research Area (ERA), which consists of activities, programmes and policies that are designed and operated at regional, national, and European levels, and in which the space sector occupies an important place. Technological

[59] C.f. International Maritime Organization. Reports On Acts Of Piracy And Armed Robbery Against Ships: Annual Report 2012. MSC.4/Circ.193 of 2 Apr. 2013. London: IMO. http://www.imo.org/OurWork/Security/PiracyArmedRobbery/Reports/Documents/193_Annual2012.pdf; International Maritime Organization. Reports On Acts Of Piracy And Armed Robbery Against Ships: Annual Report 2013. MSC.4/Circ.208 of 1 Mar. 2013. London: IMO. http://www.imo.org/OurWork/Security/PiracyArmedRobbery/Reports/Documents/208_Annual_2013.pdf.

[60] International Maritime Organization. Revised Interim Guidance To Shipowners, Ship Operators And Shipmasters On The Use Of Privately Contracted Armed Security Personnel On Board Ships In The High Risk Area. Maritime Safety Committee. MSC.1/Circ.1405/Rev.2 of 25 May 2012. London: IMO. http://www.imo.org/OurWork/Security/PiracyArmedRobbery/Guidance/Documents/MSC.1-Circ.1405-Rev2.pdf; International Maritime Organization. Revised Interim Recommendations For Flag States Regarding The Use Of Privately Contracted Armed Security Personnel On Board Ships In The High Risk Area. Maritime Safety Committee. MSC.1/Circ.1406/Rev.1 of 16 September 2011. London: IMO. http://www.imo.org/MediaCentre/HotTopics/piracy/Documents/1406-Rev-1.pdf.

development and innovation is in fact a quantifiable activity, based on its input and output.[61]

1.1.3.1 Science and Technology Inputs

Science and technology inputs at the European level are constantly measured against the benefits they generate. In 2012 and 2013, in the wake of the global economic crisis, R&D investment underwent ambitious policy reforms with the aim of increasing efficiency and effectiveness and developing stronger R&D integration in broader industrial and macro-economic policies. This reporting period is measured by gross domestic expenditure on R&D (GERD), a statistical tool showing nominal changes in those expenditures.

Between 2009 and 2012, overall GERD as a percentage of GDP hovered between estimates of 2.00 % to 2.06 %, whereas between 2000 and 2009, the GERD had stayed at around 1.85 %.[62] While the EU's 2012 GDP increased to 12.971 trillion Euros in current price terms, its 2012 GERD was 267.19 billion Euros, amounting to a 4.1 % increase in GERD from the previous year.[63] Thus GERD itself increased from an estimated 2.04 % to 2.06 % between 2011 and 2012. In contrast, this performance stayed below Japan's and the United States' indicators from the most recent data available, albeit with signs that the intensity of investment of those frontrunners might be diminishing. Japan's 2011 GERD was estimated to be 3.4 %, amounting to about 144.42 billion Euros (about $187 billion); and the US saw an increase in its GERD from 2.3 % in 2010 to 2.8 % in the following year, amounting to around 312.46 billion Euros (about $404.6 billion).[64] With the financial crisis more of a recent memory, investment in innovation still has the potential for growth, especially in Asia which had the most funding growth

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[61] Godin, Benoit. "Science, Accounting and Statistics: the Input-Output Framework." Canadian Social Sciences and Humanities Research Council (2005): 5. http://www.csiic.ca/PDF/Godin_31.pdf.

[62] "Gross domestic expenditure on R&D (GERD)—% of GDP." Eurostat 28 Mar. 2014. http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&plugin=1&language=en&pcode=t2020_20; *see also* "R&D expenditure." Oct. 2012. European Commission—eurostat 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/R_%26_D_expenditure.

[63] "Gross domestic product at market prices | At current prices." Eurostat 28 Mar. 2014. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en. C.f. "National accounts—GDP." Oct. 2012. European Commission—eurostat 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/National_accounts_%E2%80%93_GDP.

[64] C.f."Chap. 4. Research and Development: National Trends and International Comparisons." Science and Engineering Indicators 2014 29 Mar. 2014. http://www.nsf.gov/statistics/seind14/index.cfm/chapter-4/c4h.htm#s2; and Grueber, Martin and Tim Studt. "2012 Global R&D Funding Forecast: R&D Spending Growth Continues While Globalization Accelerates." 16 Dec. 2011. R&D 29 Mar. 2014. http://www.rdmag.com/articles/2011/12/2012-global-r-d-funding-forecast-r-d-spending-growth-continues-while-globalization-accelerates.

among the regions, simultaneously lowering the US share in global R&D funding. On the national level, the top three European countries in terms of GERD kept their positions in 2012, with Finland (3.55 %), Sweden (3.41 %) and Denmark (2.99 %), while in 2012 ten European Member States, mainly in Central and Eastern Europe, reported expenditures under 1 %.[65]

A further breakdown of statistical data helps to underscore the impact of private R&D investment in Europe, when paired to publicly funded projects. As in 2011, countries with higher public investment in R&D also showed a generally high level of innovation investment within the private business sector; the top two in 2012 again being Finland (2.44 %) and Sweden (2.31 %); however, Slovenia (2.16 %) overtook Denmark (1.96 %), followed closely by Austria (1.95 %). From the data provided, it seems that countries with larger GDPs (such as Germany and France) tended to field similarly large government led investments in R&D, mostly through higher education research.[66]

In 2012, private sector funded R&D accounted for over 63.1 % of the EU's total GERD, as compared with the most recent figures for Japan (2010) at 76.6 % and the United States at 68.5 % in 2011. As shown above, the proportion of government expenditures in this field also varied significantly from one European region to the other, with the highest levels observed in Central and Eastern European countries.[67] The mixed approaches to R&D funding remain a challenge when planning appropriate policies at the European level.

1.1.3.2 Science and Technology Outputs

In contrast to R&D input, the outputs achieved from investments in innovation are harder to measure, due to the complex market dynamics within the private sector. While innovation offers a competitive edge to companies that are willing to invest and develop R&D projects, statistics such as the number of patents lodged by country, industrial sector and individual companies are merely indicative of output, as their effect on financial performance is also heavily dependent on external market competition and other factors. Based on the European Commission's 2013 EU Industrial R&D Investment Scoreboard, in 2012 approximately 2,000 companies worldwide each invested more than $29.9 million (22.6 million Euros) in R&D a 6.2 % increase from 2011. Total investment in R&D by leading companies amounted to 538.8 billion Euros; i.e. European companies account for 29.5 % (158.9 billion Euros) of that figure. Together with the US at 35.4 % and Japan at

[65] "Research and Innovation performance in EU Member States and Associated countries—2013" European Commission—Innovation Union 22 Apr. 2013: 5. http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2012/innovation_union_progress_at_country_level_2013.pdf.

[66] "Research and development expenditure, by sectors of performance.—% of GDP." Eurostat 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsc00001&language=en.

[67] Id.

18.9 %, they constitute 83.8 % of the companies surveyed. Companies realise they can gain a cutting edge by investing heavily in R&D when operating in highly competitive environments, as this action appears to have a linear link between investment and market performance. This trend might be the case with top performing companies, but it is highly dependent on the nature of the market, and would likely not hold true in every sector. What is clear however is that in 2012 the EU experienced increased growth (6.3 %) and that following the 2008 financial crisis the 2,000 companies surveyed began increasing their investments in R&D by an average of 6.2 % on a yearly basis, underlining the strategic importance of R&D during times of economic uncertainty.[68]

The uneven benefits of corporate innovation on a European scale are further demonstrated in the European Commission's bi-annual competitiveness assessment conferences, CONCORD. The 4th CONCORD meeting, held on 26–27 September 2013, focussed on financing innovation for company growth, and included themes on financial sources, growth strategies, and the role of public policies. It was concluded that financial constraints, such as internal lack of liquidity paired with high competition and lack of demand, are a major obstacle to innovation. Here, the reduction of information asymmetries can considerably lower the barriers to access financial resources, since open financial disclosures, patenting, and publication are positive information signals to investors, and have been proven to positively affect innovation and its growth rate. Access to funding can be supplemented through bank loans, venture capitalist investment, and perhaps crowd-funded external financing mechanisms. Here, a balance in financing needs to be established, since financial institutions might not have the scope and financial products to deal with long term investment in young firms, and venture capitalists might not see the desired short term returns. Remedial policy measures should be accurately designed and coordinated to fully utilize complementarities and synergies to maximize their effectiveness, considering that the impact of policies may depend on the size of firm, its growth phase, differences in low- and high- tech industry, and whether additional characteristics are to be taken into account. Especially in the space sector, it would seem that innovation-fuelled corporate performance greatly depends on the market sector's level of demand for cutting-edge technology. In general, the more high-tech a sector is, the greater and more robust the investment returns that can be expected from innovation. European policy reforms to increase efficiency and effectiveness began in 2011; that said, at a European level any horizontal measures taken to improve competitiveness through innovation would have to be accompanied by appropriate custom-made policies for the different market segments, corporate sizes and geographical regions of Europe.[69]

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[68] European Commission. "The 2013 EU Industrial R&D Investment Scoreboard." EU R&D Scoreboard 31 Mar. 2014. http://iri.jrc.ec.europa.eu/scoreboard13.html>; *see also* European Commission. "EU Industrial R&D Investment Scoreboard 2013." 18 Nov. 2013. Europa—Press releases database 31 Mar. 2014. http://europa.eu/rapid/press-release_MEMO-13-1000_en.htm.

[69] European Commission Joint Research Centre, Institute for Prospective Technological Studies. CONCORD-2013—4th European Conference on Corporate R&D and Innovation: Financing

1.2 Worldwide Space Policies and Strategies

1.2.1 The United Nations System

Various institutions within or associated with the United Nations are relevant for space policy. In this section, the UN General Assembly, its Committees, and other UN bodies and organs that deal with space activities are discussed.

1.2.1.1 United Nations General Assembly

The United Nations General Assembly (UNGA) passed two Resolutions in its 67th (2012–2013) session pertaining to the use and exploration of outer space. The first was Resolution A/RES/67/30 adopted on 3 December 2012, on the 'Prevention of an arms race in outer space'.[70] On 18 December 2012, the UNGA adopted its annual Resolution A/RES/67/113 on "International cooperation in the peaceful uses of outer space".[71] During the 68th (2013–2014) session with regard to the use and exploration of outer space, the UNGA passed four more Resolutions. The first of those instruments was Resolution A/RES/68/29 adopted on 5 December 2013, on the 'Prevention of an arms race in outer space'.[72] The second, adopted on the same day, was Resolution A/RES/68/50 on 'Transparency and confidence-building measures in outer space activities'.[73] The other two instruments, both adopted on 11 December 2013, were Resolution A/RES/68/74 on 'Recommendations on national legislation relevant to the peaceful exploration and use of outer space'[74];

R&D and innovation for corporate growth in the EU: Strategies, drivers and barriers—Summary Report. Dec. 2013. Seville, Spain. JRC Scientific and Technical Reports, 2013.

[70] United Nations General Assembly. Resolution adopted by the General Assembly—Prevention of an arms race—Sixty-Seventh Session. UN Doc. A/RES/67/30 of 11 Dec. 2012. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/67/30.

[71] United Nations General Assembly. Resolution adopted by the General Assembly—International cooperation in the peaceful uses of outer space—Sixty-Sixth Session. UN Doc. A/RES/67/113 of 14 Jan. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/67/113.

[72] United Nations General Assembly. Resolution adopted by the General Assembly—Prevention of an arms race—Sixty-Eighth Session. UN Doc. A/RES/68/29 of 9 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/29.

[73] United Nations General Assembly. Resolution adopted by the General Assembly—Transparency and confidence-building measures in outer space activities—Sixty-Eighth Session. UN Doc. A/RES/68/50 of 9 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/50.

[74] United Nations General Assembly. Resolution adopted by the General Assembly—Recommendations on national legislation relevant to the peaceful exploration and use of outer space—Sixty-Eighth Session. UN Doc. A/RES/68/74 of 16 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/74.

and Resolution A/RES/68/75 on 'International cooperation in the peaceful uses of outer space'.[75]

First, Resolution A/RES/67/30 adopted on 3 December 2012, and Resolution A/RES/68/29 adopted on 5 December 2013, both on the 'Prevention of an arms race in outer space' built on similar resolutions tabled in previous years. The instruments reaffirmed the importance of transparency and confidence building measures (TCBM) to avoid an arms race in space and additionally recognised, as stated in the report of the Ad Hoc Committee on the Prevention of an Arms Race in Outer Space, that the legal regime applicable to outer space by itself does not guarantee the prevention of an arms race in outer space, whilst acknowledging that the regime plays a significant role in the prevention of an arms race in that environment, and that there is a need to consolidate and reinforce the regime and enhance its effectiveness. Moreover, both instruments again recognised the importance of strict compliance with existing bilateral and multilateral agreements. The Conference on Disarmament (CD) was seen as the relevant multilateral disarmament forum for further discussions. In general, they also recognised the complementary nature of multilateral and bilateral efforts in this area.

Similarly, Resolution A/RES/67/113 adopted on 18 December 2012, and Resolution A/RES/68/75 adopted on 11 December 2013, both on 'International cooperation in the peaceful uses of outer space' were also very similar to the Resolution tabled in 2011. Welcoming the United Nations Conference on Sustainable Development, held in Rio de Janeiro, Brazil, from 20 to 22 June 2012, the instruments recognised the important role that space science and technology play in promoting sustainable development; the second instrument went on to note the progress on the establishment of a new regional centre for space science and technology education in Asia and the Pacific located at Beihang University in Beijing, as proposed by the Government of China, in particular the positive conclusion of an evaluation mission to Beihang University facilitated by the Office for Outer Space Affairs in September 2013.[76] Both noted the central aspects and challenges of the peaceful use of outer space and recalled the crucial importance of international cooperation to tackle all relevant issues. Also, the second instrument elaborated on its concern about the fragility of the space environment and the challenges to the long-term sustainability of outer space activities, in particular the impact of space debris, which is an issue of concern to all nations, yet made sure to note its satisfaction with the recommendations for an international response to the near-Earth object impact threat, endorsed by the Scientific and Technical Subcommittee at its fiftieth session and by the Committee at its fifty-sixth session. Moreover, both instruments urged all Member States to continue to contribute to the Trust Fund for the United Nations

[75] United Nations General Assembly. Resolution adopted by the General Assembly—International cooperation in the peaceful uses of outer space—Sixty-Eighth Session. UN Doc. A/RES/68/75 of 16 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/75.

[76] Ibid.

Programme on Space Applications in order to enhance the capacity of the Office for Outer Space Affairs of the Secretariat to provide technical and legal advisory services in its priority thematic areas; and provided an overview of the necessary steps that should be taken in this regard, including conferences, sessions of relevant entities and noteworthy progress in implementing corresponding programmes.

Resolution A/RES/68/50 adopted on 5 December 2013, on 'Transparency and confidence-building measures in outer space activities', building on the previous Resolution A/RES/65/68 adopted on 8 December 2010, reaffirmed the right of free exploration and use of outer space by all states in accordance with international law, and also reaffirmed that the prevention of an arms race in outer space was in the interest of maintaining international peace and security, in addition to fostering international cooperation in the exploration and use of outer space for peaceful purposes.[77] For that purpose, the resolution recognised the need for increased transparency and confirmed the importance of confidence-building measures as a means of reinforcing the objective of preventing an arms race in outer space, and referred the recommendations contained in the report to the Committee on the Peaceful Uses of Outer Space, the Disarmament Commission and the Conference on Disarmament as a way to further advance transparency and confidence-building measures in outer space.

Resolution A/RES/68/74 adopted on 11 December 2013, on 'Recommendations on national legislation relevant to the peaceful exploration and use of outer space', built on Resolution A/RES/59/115 of 10 December 2004 on the application of the concept of the "launching State", and on Resolution A/RES/62/101 of 17 December 2007 on recommendations on enhancing the practice of states and international intergovernmental organizations in registering space objects. With the increasing participation of non-governmental entities in space activities, the resolution observed that appropriate action at the national level is needed, in particular with respect to the authorization and supervision of non-governmental space activities. It went on to list elements to consider, as appropriate, by states when enacting regulatory frameworks for national space activities. Those suggested elements included: the scope of space activities to be targeted by national regulatory frameworks; the ascertainment of national jurisdiction for activities; the need for national authorization and clear procedures for space activities; authorization to be consistent with international obligations for the state; appropriate procedures for continued supervision to be available; a national registry of objects launched in space should be maintained; the establishment of recourse methods for liability for damage incurred by operators of space objects; and continuing supervision of the

[77] United Nations General Assembly. Resolution adopted by the General Assembly—Transparency and confidence-building measures in outer space activities—Sixty-Eighth Session. UN Doc. A/RES/68/50 of 9 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/50.

space activities of non-government entities in the case where ownership or control of a space object is transferred.[78]

1.2.1.2 UNGA Committees

UNGA has a number of committees that address space policy and associated matters. The main ones are discussed below.

The Disarmament and International Security Committee

The Disarmament and International Security Committee works in close cooperation with the United Nations Disarmament Commission and the Geneva-based Conference on Disarmament to deal with disarmament, global challenges and threats to peace that affect the international community, and seeks solutions to the challenges in the international security regime, including the prevention of an arms race in outer space.[79] In November 2012, the Disarmament and International Security Committee forwarded 53 draft resolutions and 6 draft decisions to UNGA for adoption, of which 58 were ultimately adopted by the General Assembly in December 2012.[80] In the next year, the Disarmament and International Security Committee submitted another 48 draft resolutions and 5 draft decisions to UNGA; by 5 December 2014, UNGA had adopted all 53 documents in an intensive session that revealed both common and divergent positions on issues covering nuclear disarmament and non-proliferation, implementing the Arms Trade Treaty, and broadening the scope of the United Nations Register of Conventional Arms.[81]

The Committee on the Peaceful Uses of Outer Space

The UN Committee on the Peaceful Uses of Outer Space (COPUOS) activities included the Committee's plenary sessions on 6–15 June 2012, and 12–21 June

[78] United Nations General Assembly. Resolution adopted by the General Assembly—Recommendations on national legislation relevant to the peaceful exploration and use of outer space—Sixty-Eighth Session. UN Doc. A/RES/68/74 of 16 Dec. 2013. Vienna: United Nations. http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/68/74.

[79] "Disarmament and International Security." General Assembly of the United Nation 12 Apr. 2013. http://www.un.org/en/ga/first/index.shtml.

[80] "FEATURE: The UN General Assembly's First Committee—disarmament and international security issues." 27 Dec. 2012. UN News Centre 31 Mar. 2014. http://www.un.org/apps/news/story.asp?NewsID=43849.

[81] "Capping Intensive Disarmament Committee Session, General Assembly Adopts 53 Texts on Wide Range of Pressing International Security Concerns." 5 Dec. 2013. United Nations General Assembly 31 Mar. 2014. http://www.un.org/News/Press/docs/2013/ga11463.doc.htm.

2013, and the annual sessions of its scientific and technical and its legal subcommittees on 11–22 February 2013 and 8–19 April 2013 respectively. At the 2012 plenary session, the Committee considered ways and means to maintain outer space for peaceful purposes, emphasizing that international, regional and interregional cooperation and coordination in the field of space activities were essential for strengthening the peaceful uses of outer space and assisting states in the development of their space capabilities; and considered how to implement the recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III). It also endorsed the findings and recommendations of its subcommittees from their 2012 preceding sessions, and considered the current status of spin-off benefits of space technology; space and society, space and water, space and climate change; the use of space technology in the United Nations system; the future role of the committee; and other related matters.[82] At the 2013 plenary session, the Committee expanded on previous years' matters, and it was informed by some delegations that the first open-ended consultations on the development of an international code of conduct for outer space activities had been held in Kiev, Ukraine on 16–17 May 2013, and that a second round of consultations was planned for late 2013.[83]

At the 2013 scientific and technical subcommittee meeting, discussions and presentations were made on a broad range of space related issues, including matters relating to remote sensing of the Earth by satellite (i.e. applications for developing countries and monitoring of the Earth's environment); space debris and the mitigation measures already implemented by some states; the further development of the space-system-based disaster management support programme (i.e. UN-SPIDER); recent developments in global navigation satellite systems; space weather for the purpose of understanding near-Earth space weather and to communicate that knowledge to interested parties; the use of nuclear power sources in outer space; near-Earth objects; long-term sustainability of outer space activities; along with additional space safety topics. The subcommittee also examined the physical nature and technical attributes of the geostationary orbit (GEO) and its utilisation and applications, including the field of space communications with particular note of the needs and interests of developing countries. The subcommittee received and considered information provided by the Member States on their activities in all these fields.[84]

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[82] United Nations General Assembly. Report of the Committee on the Peaceful Uses of Outer Space on its Fifty-fifth-session, Held in New York from 6–15 June 2012. UN Doc. A/67/20 of 29 June 2012. New York: United Nations. http://www.oosa.unvienna.org/pdf/gadocs/A_67_20E.pdf.

[83] United Nations General Assembly. Report of the Committee on the Peaceful Uses of Outer Space on its Fifty-sixth-session, Held in New York from 12–21 June 2013. UN Doc. A/68/20 of 5 July 2013. New York: United Nations. http://www.oosa.unvienna.org/pdf/gadocs/A_68_20E.pdf.

[84] United Nations General Assembly. Report of the Scientific and Technical Subcommittee on its fiftieth session, held in Vienna from 11 to 22 February 2013. UN Doc. A/AC.105/1038 of 7 March

The proceedings of the legal subcommittee focussed on the status and application of the five United Nations treaties on outer space, in addition to exchanging information on the activities of international governmental and non-governmental organizations related to space law. Ongoing issues on the definition and delimitation of outer space were considered particularly in reference to the sometimes conflicting interests of states that desired legal certainty while also insisting on a demonstrable need and practical basis prior to developing a conclusion on the delimitation/definition of outer space. The subcommittee also discussed items on the character and utilization of the geostationary orbit, including consideration of ways and means to ensure the rational and equitable use of the geostationary orbit without prejudice to the role of the International Telecommunication Union. National legislation relevant to the peaceful exploration and use of outer space was another agenda item; and in addition to considering a review and possible revision of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, the subcommittee also examined developments concerning the Protocol to the Convention on International Interests in Mobile Equipment on Matters specific to Space Assets, capacity-building in space law, and information and views on legal mechanisms relating to space debris mitigation measures.[85]

1.2.1.3 Other UN Bodies and Organs Monitoring Outer Space Activities

Beyond the UN General Assembly and its Committees, there are other UN bodies, programmes and organs related to space activities. The following discusses the ITU (a specialised agency of the UN), UN-SPIDER, the UN Programme on Space Applications, the International Committee on Global Navigation Satellite Systems (ICG), the United Nations Spatial Data Infrastructure (UNSDI), the Conference on Disarmament (CD) and UNIDIR.

International Telecommunication Union

The International Telecommunication Union (ITU) held its 2012 and 2013 Annual Council Meetings at its headquarters in Geneva from 4 to 12 July 2012 and 11 to 21 June 2013, respectively. The ITU held its biennial World Radiocommunication Seminar (WRS) in Geneva on 3–7 December 2012. During those meetings, a significant number of space related issues were advanced, including radio spectrum allocation and orbital slots procedures, emergency communications

2013. Vienna: United Nations. http://www.oosa.unvienna.org/pdf/reports/ac105/AC105_1038E.pdf.

[85] United Nations General Assembly. Report of the Legal Subcommittee on its fifty-second session, held in Vienna from 8 to 19 April 2013. UN Doc. A/AC.105/1045 of 23 April 2013. Vienna: United Nations. http://www.oosa.unvienna.org/pdf/reports/ac105/AC105_1045E.pdf.

standardisation, and the coordination of satellite networks. Also addressed in the Council meeting were the strategic plan and budget of the ITU and a review of the implementation of the objectives of the World Summit on the Information Society. At the Council meeting, the key issue regarding information and communication technology development was how to create the new digital highways needed to accommodate the massive increase in data traffic.[86] Another notable issue was the topic of specific frequency band allocations to member states to facilitate the development of terrestrial mobile broadband applications, which in turn could potentially impact mobile satellite service operators that had planned on using the same frequency for emergency and disaster relief radio communication.[87] These meetings provided a forum to exchange views on the associated technical, procedural and operational aspects of satellite communications and, particularly, technical issues related to technological advancements. The next World Radiocommunication Conference (WRC), which precedes the next WRS meeting, is scheduled to be held in Geneva from 2–27 November 2015.[88]

UN-SPIDER

The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) organised several workshops and regional meetings in 2012 and 2013. Set up by UNGA in 2006, the platform aims to provide universal access to all types of space-based information and services relevant to disaster management support. In this context, the International Charter on Space and Major Disasters was activated several times by the UN Office of Outer Space Affairs (UN OOSA) at the request of other UN entities. Key geopolitical events that activated the Charter included floods in Canada, India, the US, Africa, England and Pakistan; hurricanes and tropical storms in the US, Samoa, the French territories Wallis and Futuna, and Fiji; and earthquakes in Iran, China, and Guatemala in the 2012 reporting period. In 2013, the charter was activated for floods in Israel, Mozambique, Iraq, India, Nepal, Thailand, Japan, Myanmar, Sudan, China, Philippines, Russia, Pakistan, Senegal, the US, Cambodia, Oman, and the UK; hurricanes and tropical storms in the Republic of Seychelles, Madagascar, Bangladesh, India, and Vietnam; earthquakes in China, Pakistan, the Phil-

[86] "ITU Council meets to review strategies for ICT development—Increased data traffic demands high speed digital highways" 12 Oct. 2011. ITU 12 Apr. 2013. http://www.itu.int/net/pressoffice/press_releases/2011/CM15.aspx.

[87] Leite, Fabio. "World Radiocommunication Conference 2012 (WRC-12)." ITU 2 Apr. 2014. http://www.itu.int/en/ITU-R/seminars/rrs/Documents/Tutorial/WRC-12.pdf.

[88] Aubineau, Philippe. "WRC-15 Preparation." 7 Dec. 2012. ITU 2 Apr. 2014. http://www.itu.int/en/ITU-R/seminars/rrs/Documents/Tutorial/WRC-15.pdf.

ippines, and Japan; oil spills in Canada; wildfires in Argentina, and Australia; and volcanic activities affecting Peru, and Indonesia.[89]

UN Programme on Space Applications

The UN Programme on Space Applications (SAP) is concerned with cooperation in space science and technology. In the reporting period of the second half of 2012, and all of 2013, several activities were carried out under SAP's auspices dealing with topics such as: in 2012, workshops on climate change and human and basic space technologies in emerging countries, as well as space technology for economic development and for its socio-economic benefits.[90] In 2013, activities included workshops on the integrated use of space technology for food and water security, applications of GNSS, climate change, human space technology, space technology for economic development, and space technology applications for socio-economic benefits, in addition to symposiums on space weather data and on basic space technology.[91]

International Committee on Global Navigation Satellite Systems

The aim of the International Committee on Global Navigation Satellite Systems (ICG) is to promote cooperation in matters of satellite navigation. The UN OOSA serves as the Executive Secretariat of the ICG and the associated Providers' Forum. The seventh meeting of the ICG was organised by the Government of China, and took place in Beijing, China, on 5–9 November 2012. The eighth meeting of the ICG was organised by the Emirates Institution for Advanced Science and Technology (EIAST), and took place in Dubai, UAE, on 9–14 November 2013. Both meetings drew participants from industry, government, non-governmental officials and academia to review and discuss developments in global navigation systems.[92]

In 2012, throughout the sessions of its Plenary and working group meetings, presentations were made to update ICG Members, Associate Members, and Observers on matters of interest such as: professional, mass-market, and scientific applications; and recent developments with regard to GNSS services, applications

[89] "UN-SPIDER Monthly Updates." 7 Feb. 2014. UNOOSA 3 Apr. 2014. http://www.un-spider.org/about/updates.

[90] "United Nations Programme on Space Applications Activities Schedule: 2012." United Nations Office for Outer Space Affairs 03 Apr. 2014. http://www.oosa.unvienna.org/oosa/en/SAP/sched/2012.html.

[91] "United Nations Programme on Space Applications Activities Schedule: 2013." United Nations Office for Outer Space Affairs 03 Apr. 2014. http://www.oosa.unvienna.org/oosa/en/SAP/sched/2013.html.

[92] "ICG Meetings." United Nations Office for Outer Space Affairs 3 Apr. 2014. http://www.oosa.unvienna.org/oosa/en/SAP/gnss/icg/meetings.html.

and educational and capacity-building activities at the global, regional and national levels. Four working groups also met during the Plenary, covering compatibility and interoperability (led by Russia and the US); enhancement of performance of GNSS services (led by ESA); information dissemination and capacity-building (led by China and the UN OOSA); and reference frames, timing and applications (led by the International Federation of Surveyors, the International Association of Geodesy and the International Global Navigation Satellite System Service).[93] Within the Plenary, the ICG endorsed the decisions and recommendations of the working groups with regard to the implementation of the actions contained in its work plan (e.g open service information dissemination, service performance monitoring, and spectrum protection regarding interference detection and mitigation).[94]

The 2013 sessions of the ICG's Plenary and working group meetings built on the activities of the previous year, updating Members, Associate Members, and Observers on similar matters of interest. Of note were various new topics such as: the experience of utilizing GLONASS technologies in various fields of the Russian economy, Galileo's in-orbit-validation position results; position, navigation and timing assurance standards for GNSS receivers used in critical applications; Galileo and EGNOS applications; BeiDou application demonstration and experience campaign progress and BeiDou/GNSS applications; and BeiDou application for precision agriculture.[95] This time, issues on compatibility and interoperability were once again led by Russia and the US; while the enhancement of the performance of GNSS services was led by India and the ESA; information dissemination and capacity-building was led by the UAE and UN OOSA; and reference frames, timing and applications was led again by the International Federation of Surveyors, the International Association of Geodesy and the International Global Navigation Satellite System Service. Also, the Arab Institute of Navigation (AIN) and the European Space Policy Institute (ESPI) were granted observer status during the Plenary.[96] The ninth ICG meeting will take place in Prague, Czech Republic from 10 to 14 November 2014, on behalf of the European Union.

[93] United Nations General Assembly. Seventh Meeting of the International Committee on Global Navigation Satellite Systems—Note by the Secretariat. UN Doc. A/AC 105/1035 of 18 Dec. 2012. New York: United Nations. http://www.oosa.unvienna.org/pdf/icg/2012/icg-7/50STSC-1035_E.pdf.

[94] Ibid.

[95] United Nations General Assembly. Eighth Meeting of the International Committee on Global Navigation Satellite Systems—Note by the Secretariat. UN Doc. A/AC 105/1059 of 29 Nov. 2013. New York: United Nations. http://www.oosa.unvienna.org/pdf/icg/2013/icg-8/51STSC-1059_E.pdf.

[96] Ibid.

United Nations Spatial Data Infrastructure

The United Nations Geographic Information Working Group (UNGIWG) held its thirteenth annual Plenary Meeting in Istanbul, Turkey, on 27 February–1 March 2013. This year co-chaired by representatives from the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) and the Office of Information and Communications Technology (OICT), the UNGIWG functions as a network of UN cartography and geospatial information management science professionals that lay the foundations for the United Nations Spatial Data Infrastructure (UNSDI). The UNSDI contributes substantively to the mission of the United Nations by functioning as a comprehensive, decentralised geospatial information network to facilitate decision-making mechanisms between member states, regional organizations and partners that advance social, economic development, environmental and humanitarian agendas.[97]

Conference on Disarmament

The Conference on Disarmament (CD) is the key multilateral disarmament and arms control negotiating forum within the international community. The stalemate in its work regarding space security continued with several delegations reaffirming their respective positions in lengthy discussion on the issue of prevention of an arms race in outer space. The 2012 session ended on 14 September 2012, and the 2013 session was again conducted in three parts: first part on 21 January–29 March, second on 13 May–28 June, and third on 29 July–13 September 2013, with three informal plenary meetings on 4 June, 3 September, and 10 September 2013. Over the course of the 2012 and 2013 sessions, some of the topics that were addressed by the CD included the cessation of the nuclear arms race and nuclear disarmament, prevention of nuclear war including all related matters, and prevention of an arms race in outer space, prohibition of the development and manufacture of new types of weapons of mass destruction and new systems of such weapons, and effective international arrangements to assure non-nuclear-weapon states against the use or threat of use of nuclear weapons.[98]

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[97] "13th UNGIWG Plenary Meeting." UNGIWG 3 Apr. 2014. http://www.ungiwg.org/meetings/13th-ungiwg-plenary-meeting.

[98] Conference on Disarmament. Report of the Conference on Disarmament to the General Assembly of the United Nations. UN Doc. CD/1963 of 12 Sept. 2013. Geneva: United Nations. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/G13/630/38/PDF/G1363038.pdf?OpenElement.

United Nations Institute for Disarmament Research

The United Nations Institute for Disarmament Research (UNIDIR) conducts some projects that cover, both directly and indirectly, issues of space security. It seeks to review former proposals and to propose new options for breaking the deadlock in space weaponisation matters at the Conference on Disarmament (CD). In July 2013, the UNGA was informed of the activities of the UNIDIR for the period of August 2012 to July 2013. In the field of space security, the UNIDIR with the support of the EU was working to build international understanding of, and support for, a code of conduct for outer space activities through a series of regional meetings, background papers, expert consultations and support activities, for completion at the end of 2013. During its 2013 conference entitled "Space Security 2013: enhancing confidence, ensuring space stability", the UNIDIR gave a special briefing on space security to States Members of the African Group in Geneva, and started to develop the agenda for 2014.[99]

1.2.2 The Group on Earth Observation

The Group on Earth Observation (GEO) system-of-systems cooperation platform (GEOSS) is a voluntary partnership of governments and international organisations that facilitate the interlay of current and future Earth observing systems, while also providing coordinated and sustained data worldwide as a decision support tool for its users. In 2012 and 2013 GEO sought to further improve its governance mechanisms and operational capabilities, with a focus on improving and coordinating observation systems; advancing broad open data policies and practices; fostering increased use of Earth observation data and information; and building capacity. From 2011 until the end of 2013, the group strived to facilitate collaboration among developers and users of Earth observation data and information, with involvement in numerous conferences, forums, symposia, workshops and other gatherings. At the end of 2013, participation in the GEO Work Plan had expanded to almost 850 contributors from more than 340 organizations engaged in close to 60 individual Work Plan components. Its contributors were affiliated with 40 Member Governments, 35 Participating Organizations, 1 Observer organization and 7 other partners. Additionally, its annual three-day Work Plan Symposium attracts around 120 participants representing 40 Members and Participating Organizations.[100]

[99] United Nations General Assembly. United Nations Institute for Disarmament Research—Note by the Secretary General, on its Sixty-eighth session. UN Doc. A/68/182 of 23 July 2013. http://www.un.org/ga/search/view_doc.asp?symbol=A/68/182.

[100] Report on Progress: 2011–2013 Geneva Ministerial Summit. 17 Jan. 2014. Group on Earth Observations 7 Apr. 2014. http://www.earthobservations.org/documents/ministerial/geneva/MS3_GEO Report_on_Progress_2011_2013.pdf.

1.2.3 Europe

1.2.3.1 European Space Agency

Throughout 2012 and 2013, the European Space Agency continued its course of transition. With the Ministerial Council meeting successfully completed in Naples, Italy on 20–21 November 2012, the focus shifted to assessing the role of ESA in sustaining competitiveness and growth, in addition to securing the needed level of resources for ESA's mandatory activities between 2013–2017 covering science programmes and basic activities, renewal of ESA Member States contributions to the running costs of the Guiana Space Centre, in French Guiana, and initiating the process for the further evolution of ESA, with the aim of capitalising on ESA's competences and achievements, while taking full benefit of EU policies to ensure the continued success of ESA as the research and development space agency for Europe, Member States and the EU. With Ministers having approved funding for the next budgetary cycle, and having confirmed Europe's commitment to the exploitation of the ISS, the question left for the 2014 Ministerial Council will be the future of Europe's launcher system. In the 2 years that have followed the 2012 Ministerial Council, detailed definition studies have been underway for the development of a new launcher Ariane 6 and the continuation of the development of Ariane 5 ME, with the goal of developing as many commonalities as possible between the two launchers.

The period of review also witnessed the emergence of trends in ESA policies as a response to the rapidly changing geopolitical and economic conditions of our time. These included strong emphasis on international cooperation, as well as on the use of more flexible and purpose-specific funding mechanisms, capable of maximising investment returns on both the operational and industrial levels.

An example of this trend has been ESA's contribution to the development of public private partnerships (PPPs) in European space programmes. In 2012 and 2013, this mutually beneficial interaction between the public and private sectors continued its expansion on a European, as well as national level. In fact, on a national level, all major space faring countries are continuing to explore this sort of advantage, with the United Kingdom, Germany and France taking the lead. Especially in the United Kingdom, almost two thirds of all European PPPs are anchored.[101] Moreover, ESA has initiated the most important such partnerships on an institutional level, especially through its participation in satellite communications projects. Through its ARTES 33 Partner programme, ESA has provided the satcom industry with an efficient framework to bring innovative products and systems into the marketplace through industry-generated public–private partnerships, having already implemented several PPPs such as Amerhis, Alphasat,

[101] De Selding, Peter B. "Europe Knocked for Balking at Public-Private Satellite Venture." Space News, 20 June 2011: 7.

SmallGEO, Hylas-1 and EDRS.[102] In this context, ESA has also implemented a PPP-type financial arrangement for the development, launch and in-orbit validation of an electric-propulsion telecommunications satellite in the 3-ton mass range (Electra), offering power consumption and communication capabilities equal to those offered by larger mid-size satellites with a launch mass low enough for small launch vehicles, or increasing the size of the payload staying at the same launch mass to increase competitiveness and economic benefit.[103] With SES as Electra's prime contractor for the design phase, and OHB as SES's subcontractor, the first Electra flight is scheduled for 2018.[104]

Contrary to the uncertainty regarding the future of the Ariane launcher, the start of 2012 witnessed the successful development conclusion and inaugural launch of the European Soyuz and Vega rockets. The former is the European version of the Russian launcher, modified for operations from French Guiana. Having undergone improvements in safety, telemetry and tracking systems to qualify the rocket for launch from the European spaceport, in addition to naturally enhancing the launcher's lift capacity due to the spaceport's equatorial geographic location, the launcher's October 2011 inaugural flight carried Europe's first two Galileo satellites to orbit.[105] Prior to its inaugural launch, the rocket's development had met with a 3 year delay and a 36 % budget increase, mainly related to the completion of ground launch infrastructure.[106] Since its inaugural launch, the Europeanised Soyuz conducted a total of six launches by year-end 2013.[107] Arianespace's launcher family was completed by the accompaniment of the Italian-made Vega small-satellite launcher, whose maiden flight occurred on 13 February 2012. Its first launch under the Vega Research and Technology Accompaniment (VERTA) programme which aimed to demonstrate the flexibility of the Vega launch system took place on 7 May 2013.[108] By November 2013,

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102 "ARTES 33 Partner." 27 May 2013. ESA 15 Apr. 2014. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=32274&fareaid=64.

103 "Electra." 12 Feb. 2013. ESA 23 Apr. 2014. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=32275.

104 "SES Partners with European Space Agency, OHB To Build All-electric Satellite." 15 Oct. 2013. Space News 23 Apr. 2014. http://www.spacenews.com/article/satellite-telecom/37714ses-partners-with-european-space-agency-ohb-to-build-all-electric.

105 De Selding, Peter B. "European Soyuz Must Pass Final Exam Before October Debut." Space News 4 July 2011: 5; De Selding, Peter B. "Insiders Hard-pressed to Say Why European Soyuz Was Delayed." Space News 4 July 2011: 5.

106 De Selding, Peter B. "European Soyuz Must Pass Final Exam Before October Debut." Space News 4 July 2011: 5; *see also* De Selding, Peter B. "Insiders Hard-pressed to Say Why European Soyuz Was Delayed." Space News 4 July 2011: 5.

107 "Milestones." ESA 24 Apr. 2014. http://www.arianespace.com/launch-services-soyuz/milestones.asp.

108 "VERTA Programme." 20 Nov. 2013. ESA 24 Apr. 2014. http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Vega3/VERTA_programme.

10 more Vega launchers were commissioned, on top of the 5 VERTA demonstration launches ordered in 2010.[109]

Another example of the European Space Agency's efforts to position itself at the centre of international cooperation appeared in ESA's collaboration with Russia in the ExoMars space exploration mission. In October 2011, the Russian space agency Roscosmos was invited to participate as a full partner in the US-European endeavour, and to contribute a third of its budget. ESA's decision was partially dictated by a previous NASA budgetary tightening that prohibited it from committing to the originally set 2016 launch timeframe. Then by mid-2012, ESA's ExoMars project underwent a significant reorganization of support, with Russia's Roscosmos replacing NASA as ESA's main partner in launching the telecommunications orbiter, two landers and a rover to Mars in 2016 and 2018. Subsequently, in March 2013, ESA and Roscomos signed a formal agreement to work in partnership on the ExoMars programme with launches of the two missions planned for January 2016 and May 2018.[110] The ExoMars programme is expected to cost ESA around 1.2 billion Euros; however, ESA has only managed to raise about 850 million Euros—enough to secure funding for the 2016 mission. To secure the rest of the funding needed for the 2018 mission, ESA may need to channel the costs saved in launching its JUICE satellite to Jupiter on a Russian Proton rocket to the ExoMars mission.[111] On 17 October 2013, ESA's council approved the request to transfer entry fees from ESA's new members, Romania and Poland, to go to ExoMars.[112] Before this decision, the ExoMars Programme had been funded by 14 ESA Member States (Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK and Canada), of which Italy is the largest contributor and the UK the second largest.[113] Additional sources of funding that are being considered include: delaying construction on ESA's new headquarters building; soliciting funds from Europe's space science decision-making body; and trying to gain additional funds from ExoMars' current sponsors.[114]

US budgetary tightening took a toll on other cooperation already initiated between ESA and NASA on space science and exploration missions. Following the announcement of the US Planetary Science Decadal Survey, and changes in

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[109] "Stepping Up Vega Launcher Production." 20 Nov. 2013. ESA 24 Apr. 2014. http://www.esa.int/Our_Activities/Launchers/Stepping_up_Vega_launcher_production.

[110] "ExoMars 2016 Set to Complete Construction." 17 June 2013. ESA 28 Mar. 2014. http://exploration.esa.int/mars/51931-exomars-2016-set-to-complete-construction/.

[111] De Selding, Peter. "ESA, Roscosmos Fromalize ExoMars Pact." 14 Mar. 2013. SpaceNews 27 Apr. 2014. http://www.spacenews.com/article/civil-space/34153esa-roscosmos-formalize-exomars-pact.

[112] De Selding, Peter. "Entry Fees for New ESA Members Go to ExoMars." 18 Oct. 2013. SpaceNews 27 Apr. 2014. http://www.spacenews.com/article/civil-space/37747entry-fees-for-new-esa-members-go-to-exomars.

[113] "ExoMars: ESA and Roscosmos for Mars Missions." 14 Mar. 2013. ESA 28 Mar. 2014. http://exploration.esa.int/mars/51495-exomars-esa-and-roscosmos-set-for-mars-missions/.

[114] De Selding, Peter. "ExoMars Wins One-month Reprieve." SpaceNews 21 May 2012: 8.

NASA's budget in 2011, NASA withdrew from the JUICE mission, and would no longer provide the Jupiter Europa Orbiter (JEO) expected to perform flybys by four Jupiter moons prior orbiting Europa.[115] On the upside, however, budgetary constraints across the Atlantic could further increase the incentive for ESA to engage in international cooperation with various partners in this mission area. At the time of JUICE's selection by ESA's Space Programme Committee (SPC) in May 2012, an agreement had already been established with NASA as a minor payload contributor, and negotiations on an agreement with Russia concerning payload provision for the JUICE spacecraft and the Russian Ganymede lander were in progress.[116] In addition to the JUICE programme, ESA and Roscosmos are exploring an opportunity for European participation in Russia's planned Luna-25 (Luna-Glob lander in 2016), 26 (Luna-Resurs orbiter in 2018) and 27 (Luna-Resurs lander in 2019) missions to the Moon.[117]

Collaboration on the NASA/ESA/CSA James Webb Space Telescope (JWST) remained ongoing, with NASA responsible for the overall management and operations of the JWST mission. NASA will build the spacecraft, the telescope and the platform that will host the instruments, while ESA will provide the launch with an Ariane 5 ECA rocket, and the Near-Infrared Spectrograph (NIRSpec) on board instrument,[118] In September 2013, the NIRSpec was completed, taking the JWST a step further to completion, and its scheduled 2018 launch.[119]

China and ESA are also looking to cooperate in developing the expansion of China's manned Tiangong-1 space station, which could host European astronauts in addition to astronauts from China. In exchange for European astronauts aboard the station, ESA might build technologies for the station similar to ESA's International Berthing and Docking Mechanism (IBDM), which could overcome a problem China has experienced in using the current Russian system. ESA's IBDM system allows different countries' spacecraft to berth and dock, being compatible with the different designs. ESA has been cooperating with China on Earth observation since the 1990s and, since 2004, under the ongoing Dragon programs (joint ESA-China

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[115] "L1 Mission Reformulation: JUICE—JUpiter ICy moon Explorer | Technical & Programmatic Review Report." 18 Dec. 2012. ESA 24 Apr. 2014. http://sci2.esa.int/cosmic-vision/JUICE_technical_and_programmatic_review_report.pdf.

[116] "Forthcoming Announcement of Opportunity for Scientific Instrumentation Onboard the JUICE Spacecraft." 30 May 2012. ESA 27 Mar. 2014. http://sci.esa.int/juice/50400-forthcoming-announcement-of-opportunity-for-juice-scientific-instrumentation/.

[117] "European-Russian Luna Mission Speed Dating." 3 Dec. 2013. Spaceports 25 Apr. 2014. http://spaceports.blogspot.co.at/2013/12/european-russian-luna-mission-speed.html.

[118] "ESA and NASA Sign Agreement on James Webb Space Telescope and LISA Pathfinder." 18 June 2007. ESA 25 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/ESA_and_NASA_sign_agreement_on_James_Webb_Space_Telescope_and_LISA_Pathfinder.

[119] "ESA Completes Second Instrument for James Webb Space Telescope." 10 Sept. 2013. Space Daily 25 Apr. 2014. http://www.spacedaily.com/reports/ESA_completes_second_instrument_for_James_Webb_Space_Telescope_999.html.

Earth observation programmes).[120] ESA's Estrack network also provided critical support to China's Chang'e 3 mission throughout its journey to the Moon, recording radio signals as the spacecraft touched down, to aid China in pinpointing the lander's location with remarkable accuracy.[121]

Apart from cooperating on an international level in 2012 and 2013, ESA continued its efforts to strengthen its relations with other European institutional space stakeholders. For example, building on its shared objective with the European Defence Agency (EDA) in developing European dual use technologies and operational concepts, the two organizations agreed to pursue cooperation on such key policy topics relating to space and security as governmental satellite communications, navigation, or Intelligence, Surveillance and Reconnaissance (ISR). The first such project was a demonstration mission for the control of Unmanned Aerial Systems (UAS) by satellite under the DeSIRE programme, where satellite communications were used to pilot a Unmanned Aerial Vehicle (UAV) in general air traffic.[122]

And finally, as regards ESA's rapprochement with the EU, decisions on the direction of ESA's evolution (i.e. improved cooperation under the "status quo"; bringing ESA as an intergovernmental organisation under the authority of the European Union (following, to a certain extent, the model of the European Defence Agency); or transforming ESA into an EU agency (following the model of existing regulatory agencies); etc.) are expected to made at the next ESA Council at Ministerial level held in autumn 2014.

1.2.3.2 European Union

In 2012 and 2013, the European Union continued its efforts to position itself as a leading global actor in space activities. Yet significant challenges remained regarding the future of the European space policy and programmes heralded in the Lisbon treaty, especially from a budgetary point of view. The lasting effects of the economic crisis discussed earlier may have played a significant part in this state of affairs. In general, developments during the reporting periods 2012 and 2013 present a mixed picture and included considerable breakthroughs, despite some funding setbacks.

An example of these breakthroughs is in developments regarding the Copernicus programme (formerly known as the Global Monitoring for Environment and Security, or GMES) programme, and especially the efforts undertaken to resolve

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[120] "Europe May Work With China on Space Station." 26 Feb. 2013. Space.com 24 Apr. 2014. http://www.space.com/19960-china-space-station-europe-cooperation.html.

[121] "ESA Teams Ready for Moon Landing." 13 Dec. 2013. ESA 24 Apr. 2014. http://www.esa.int/Our_Activities/Operations/ESA_teams_ready_for_Moon_landing.

[122] "EDA-ESA bilateral at ESA's European Space Research and Technology Centre." 17 July 2013. EDA 24 Apr. 2014. http://www.eda.europa.eu/info-hub/news/2013/07/17/eda-esa-bilateral-at-esa-s-european-space-research-and-technology-centre.

outstanding budgetary and governance issues among the European Commission, the European Space Agency (ESA) and Member States. This hindrance first emerged in July 2011, when the European Commission announced that it did not intend to finance Copernicus through its next 7 year framework programme, instead proposing that the 5.8 billion Euros amount needed for Copernicus between 2014 and 2020 be provided on an à la carte basis by individual participating states. The proposal of the Commission was to create a funding mechanism outside the Multiannual Financial Framework (MFF), based on voluntary subscription based on GNI contributions from all Member States. While this had initially been an effort on the part of the EC to tighten its research and development budget in view of the ongoing economic crisis, that move put the entire programme at risk. By December 2012, the Commission had reinserted Copernicus into its MFF, yet indicated that it was willing to only spend about 3.786 billion Euros (in 2011 prices) on the programme over the 7-year period, 2 billion Euros less than originally proposed.[123] In July 2013, the 34.4 % budget cut was approved by the European Parliament, meaning that replacement satellites likely will not be built in time to take over for Sentinel satellites, if they are to have 7-year life spans.[124] In coordinating the evolution of the Copernicus Space Component, ESA has prepared a long-term plan for the content and associated funding needs, covering the operation of the Sentinels up to 2020, and the procurement of recurrent Sentinel satellites and instruments and access to data available from contributing missions up to 2028.[125] The first Sentinel-1A is expected to launch in spring 2014, with Sentinel-1B to follow in late 2015.[126]

In the development of the EU's FP8 programme, later renamed Horizon 2020, other space programmes were also detrimentally affected—albeit not to the same scale as Copernicus. By February 2013, the Galileo flagship GNSS programme faced a 10 % reduction in funding, in addition to a scaled-back space research package in Horizon 2020 that faced up to 25 % in budget reductions. Where previously, Galileo's system had been allocated 7 billion Euros over the 7-year period, the Commission allocated 6.3 billion Euros to the programme, or 900 million Euros each year.[127] On 22 November 2013, the European Parliament in its

[123] "For Europe's Embattled GMES, Good and Bad News." 7 Dec. 2012. SpaceNews 25 Apr. 2014. http://spacenews.com/article/civil-space/32717for-europe%E2%80 %99 s-embattled-gmes-good-and-bad-news.

[124] Cf. De Selding, Peter. "Copernicus Backers Worry EU Cuts Will Discourage Investment." 8 Feb. 2013. SpaceNews 30 May 2014. http://www.spacenews.com/article/civil-space/33564copernicus-backers-worry-eu-cuts-will-discourage-investment.

[125] "Green Light for GMES Copernicus." 4 July 2013. ESA 28 Apr. 2014. http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Green_light_for_GMES_Copernicus.

[126] "European Commissioner for Industry presented Sentinel—1A." 25 Nov. 2013. New Europe 25 Apr. 2014. http://www.neurope.eu/article/copernicus-satellite-will-launch-april-or-may.

[127] "Space Programs Facing Cuts in Seven-year EU Budget." 1 Feb. 2013. SpaceNews 25 Apr. 2014. http://spacenews.com/article/space-programs-facing-cuts-in-seven-year-eu-budget.

plenary approved the Galileo's programme's 7-year 6.3 billion Euros budget at 2011 prices.[128]

Galileo had its first milestone launch for the Galileo GNSS on 21 October 2011, when two Galileo satellites were placed to orbit on the inaugural flight of the European version of the Soyuz rocket, launched from the European spaceport in French Guiana. The successful launch signified the opening of the system's operational deployment phase, with the scheduled launch of 14 satellites out of a total of 30 required to achieve full operational capability. A further eight spacecraft were ordered on 2 February 2012.[129] Two more Galileo spacecraft were launched on 12 October 2012, meeting the requisite minimum number of 4 Galileo spacecraft in orbit needed to fix a position in three dimensions. In the next several months of in-orbit tests of the spacecraft, another milestone was achieved wherein the first position fix of longitude, latitude and altitude was conducted on 12 March 2013, with an accuracy of 10–15 m, as was expected due to the limited deployed infrastructure of the constellation.[130] In 2013, delays in ground testing of the next two Galileo satellites, in addition to production delays regarding separate issues related to the spacecraft' payload and platform, meant that the launch of the first fully operational Galileo spacecraft had to be pushed back to June 2014.[131] This delay might compromise the European Commission's goal to demonstrate initial Galileo services by year-end 2014.

In February 2013, funding for Horizon 2020, the EU's Research and Innovation programme which includes a large variety of space research efforts, was estimated to be at 1.4 billion Euros over the 7-year period, i.e. 200 million Euros per year.[132] However, as expected by European government and industry officials, by 10 December 2013 the actual amount allocated to space research under Horizon 2020 had fallen short of that estimate for at least 2014 and 2015. Under the Horizon 2020 Work Programme 2014–2015, the 2014 space research budget was 165.75 million Euros, while the 2015 indicative budget was slightly higher at 181.9 million Euros.[133]

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[128] "Galileo Funding: A 'Small' Difference of €700 Million." 22 Nov. 2013. The European Sting 25 Apr. 2014. http://europeansting.com/2013/11/22/galileo-funding-a-small-difference-of-e700-million/.

[129] De Selding, Peter "Galileo on Firmer Ground with New Satellite, Launch Deals." 2 Feb. 2012. SpaceNews 30 May 2014. http://www.spacenews.com/article/galileo-firmer-ground-new-satellite-launch-deals.

[130] "Galileo Fixes Europe's Position in History." 12 Mar. 2013. ESA 25 Apr. 2014. http://www.esa.int/For_Media/Press_Releases/Galileo_fixes_Europe_s_position_in_history.

[131] "Initial Operational Galileo Launch Pushed Well Into 2014." 26 Sept. 2013. SpaceNews 25 Apr. 2014. http://www.spacenews.com/article/launch-report/37397initial-operational-galileo-launch-pushed-well-into-2014.

[132] "Space Programs Facing Cuts in Seven-year EU Budget." 1 Feb. 2013. SpaceNews 25 Apr. 2014. http://spacenews.com/article/space-programs-facing-cuts-in-seven-year-eu-budget.

[133] Commission of the European Communities. Horizon 2020—Work Programme 2014–2015. Annex 8. European Commission Decision C(2013)XXX of 10 December 2013. Brussels:

Following the mandate in Article 189 of the Treaty on the Functioning of the European Union (TFEU) to establish any appropriate relations with ESA, on 4 April 2011, the European Commission presented a Communication to the Council, and European Parliament, inter alia, entitled 'Towards a Space Strategy for the European Union that Benefits its Citizens' wherein the Commission put forward initial ideas regarding the evolution of relations between EU and ESA.[134] On 14 November 2012, the Commission built on its previous Communication, issuing another one to the Council and the European Parliament on 'Establishing Appropriate Relations between the EU and the European Space Agency'.[135] Therein, it assessed the structural obstacles in current EU/ESA relations, highlighting the mismatch of financial rules, such as the conflict between geographic return in ESA financial procedures and EU Financial Regulation rules that embody the strict principle of 'best value'. It also noted membership asymmetry between the members of the EU and ESA, along with differing voting systems that might give non-EU members disproportionate leverage over matters that may affect the EU. Asymmetry also exists in terms of security and defence matters, due to the ESA membership including states that are not within the EU. Moreover, regarding international issues, there is no formal mechanism at policy level to ensure that initiatives taken within ESA are consistent with EU policies. And finally, it highlights an asymmetry regarding political accountability. Within the Communication, the Commission considered that a clear target date needed to be set between 2020 and 2025, on the evolution of ESA, wherein potential options for consideration might be: improved cooperation under the "status quo"; bringing ESA under the authority of the European Union (similar to the model of the European Defence Agency); or transforming ESA into an EU agency (following the model of existing regulatory agencies).[136] On 19 February 2013, the EU Competitiveness Council adopted a lighter version of the Commission's proposal, omitting references to security concerns with ESA's non-EU member states and lightly touching on differences in contract award procedures.[137]

European Union. http://ec.europa.eu/enterprise/policies/space/files/research/horizon-2020/h2020-leit-space-work-programme-2014-2015_en.pdf.

134 Commission of the European Communities. Towards a Space Strategy for the European Union that Benefits its Citizens. COM(2011) 152 final of 4 April 2011. Brussels: European Union. http://ec.europa.eu/enterprise/policies/space/files/policy/comm_pdf_com_2011_0152_f_communication_en.pdf.

135 Commission of the European Communities. Establishing Appropriate Relations between the EU and the European Space Agency. COM(2012) 671 final of 14 November 2012. Brussels: European Union. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0671:FIN:EN:PDF.

136 Ibid.

137 "Resolution Underscores Complications in ESA-EU Partnership." 19 Feb. 2013. SpaceNews 25 Apr. 2014. http://spacenews.com/article/resolution-underscores-complications-in-esa-eu-partnership.

1.2.3.3 European Organisation for the Exploitation of Meteorological Satellites

One of the key developments regarding the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) programmes was the progress made in the development of the organisation's next generation geo-stationary weather satellites. While the meteorological satellite organization had also been hindered by the sovereign-debt crisis in its pursuit of support for its second-generation European Polar System (EPS-SG), by July 2012 it had been fortunate enough to have 95 % of the funding needed to begin its preparatory programme. On 16 November 2012, Eumetsat successfully concluded the approval process for the EPS-SG Preparatory Programme with all 26 Member States having firmly committed themselves.[138] The EPS-SG sets of satellites will succeed the current MetOp three-satellite programme, and are expected to begin launching around 2020.

The MetOp Second Generation (MetOp-SG) is the space segment of EUMETSAT's EPS. In terms of funding for the MetOp-SG, ESA will spend about 800 million Euros on the design and construction of the first MetOp-SG models, while Eumetsat has budgeted the program at 3.4 billion Euros over more than 20 years, including operations of each successive pair of satellites. With nearly all of the funding for the MetOp-SG secured, the prime contractor for the spacecraft will be selected early in 2014.[139] Unlike its MetOp predecessor, which operated in a 3-satellite relay in SSO, MetOp-SG will feature six satellites, operating in three pairs, each carrying a different but complementary suite of instruments.[140] The launch of the first spacecraft is planned for 2020, with the programme lifetime expected to last 21 years.

Eumetsat's current METOP program consists of three identical satellites launched at 6-year intervals between 2006 and 2018, with operations running until 2023. The second polar-orbiting meteorological satellite, Metop-B, was successfully placed into orbit on 17 September 2012, where it began operating in tandem with Metop-A, which had launched in October 2006. The third identical Metop satellite, Metop-C, is expected to launch sometime between late 2016 and late 2018. The entire cost of the Metop program (including development of the three satellites, their launches and the related ground infrastructure) reached 3.2

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[138] "EUMETSAT, the European Organisation for the Exploitation of Meteorological Satellites, held its 77th Council meeting in Darmstadt, Germany, on 15 November." 16 Nov. 2012. EUMETSAT 29 Apr. 2014. http://www.eumetsat.int/website/home/News/DAT_2041274.html.

[139] "Addition of Debris-mitigation Measure Delays MetOp-SG Award." 18 Oct. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/37749addition-of-debris-mitigation-measure-delays-metop-sg-award.

[140] "MetOp-SG (MetOp-Second Generation Program)." eoPortal Directory 29 Apr. 2014. https://directory.eoportal.org/web/eoportal/satellite-missions/m/metop-sg.

billion Euros (at 2011 prices), with Eumetsat covering 75 % of the cost, and ESA covering the rest of the amount.[141]

On 24 February 2012, ESA entered into a $1.8 billion deal with Thales Alenia Space as prime contractor in partnership with OHB to build six satellites for its METEOSAT Third Generation (MTG) system, aimed at providing geostationary meteorological services for 20 years starting in 2018. ESA is covering 62 % of the cost of the six satellites while EUMETSAT will cover the other 38 % of the contract and is also funding more than two-thirds of the entire MTG programme (budgeted at about 2.4 billion Euros).[142] On 7 February 2013, a milestone in the programme's development was achieved with the signing of a contract for the development of four new lightning imagers for the spacecraft, providing the first fully operational lightning detection capability from GEO, with real-time data on lightning events across Earth, both day and night, and with a spatial resolution of better than 10 km.[143] And by 4 December 2013, contracts were signed with Thales Alenia Space for the development of the ground segment for the MTG programme, giving Thales Alenia the reigns in ensuring that optimal MTG performance is achieved.[144]

The existing Meteosat programmes consist of two generations of active satellites, i.e. the Meteosat First Generation (MFG) and the Meteosat Second Generation (MSG) operating in geostationary orbit over Europe and Africa. While only one satellite, Meteosat-7, remains under the MFG programme operating until 2016, the MSG programme has three satellites in operation, Meteosat -8 to -10, which are expected to end service in 2019, 2021, and 2022 respectively.[145]

By mid-2014, membership in Eumetsat is expected to grow from 26 member states to 30 member states and 1 cooperating state (i.e. Serbia).[146] Estonia was

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[141] "European Weather Satellite Launched after 4-Month Delay." 27 Sept. 2012. SpaceNews 28 Apr. 2014. http://spacenews.com/article/european-weather-satellite-launched-after-4-month-delay.

[142] De Selding, Peter B. "ESA Signs $1.8B Deal with Thales Alenia for Six Weather Sats." 24 Feb. 2012. Space News 15 May 2012. http://www.spacenews.com/article/esa-signs-18b-deal-thales-alenia-six-weather-sats.

[143] "Contract Signed for METEOSAT Third Generation Lightning Instruments." 7 Feb. 2013. ESA 28 Apr. 2014. http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Meteorological_missions/Contract_signed_for_Meteosat_Third_Generation_lightning_instruments.

[144] "Thales Alenia Wins Contract for METEOSAT Third Generation (MTG) Ground Segment." 4 Dec. 2013. Thales Group 28 Apr. 2014. https://www.thalesgroup.com/en/worldwide/space/press-release/thales-alenia-space-wins-contract-meteosat-third-generation-mtg-ground.

[145] "There are two generations of active Meteosat satellites, Meteosat First Generation (MFG) and Meteosat Second Generation (MSG), providing images of the full Earth disc, and data for weather...." Eumetsat 30 May 2014. http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Meteosat/index.html.

[146] See further "EUMETSAT is a user-governed operational organisation, formed in 1986, which serves the needs of its Member States." Eumetsat 30 May 2014. http://www.eumetsat.int/website/home/AboutUs/WhoWeAre/MemberStates/index.html.

welcomed as a member on 26 June 2013[147]; and Lithuania, Bulgaria, and Iceland are expected to become full members in 2014.[148] While their contributions are not expected to be substantial, the inclusion of these new members will have symbolic importance for the organization as it moves forward with its flagship programmes.[149] On the international level, on 27 August 2013, Eumetsat and the US National Oceanic and Atmospheric Administration (NOAA) formally extended their longstanding cooperation, reconfirming three decades of willingness to collaborate on space-based weather, ocean and climate monitoring.[150] Additionally, Eumetsat will cooperate with China's National Satellite Ocean Application Service (NSOAS), to provide NSOAS with data from its Metop satellites and from the US-European Jason-2 and Jason-3 ocean-monitoring satellites in exchange for similar scatterometer and altimetry data from the Chinese HY-1 and HY-2 ocean-colour satellites.[151]

1.2.3.4 National Governments

France

Several different issues emerged regarding France and its space activities during the reporting period. However the main discussion continued to relate mostly to launch issues, with France as a leading country in European space cooperation activities and one of the two biggest contributors to the ESA budget remaining vocal on its opinion following the ESA Ministerial Council meeting in November 2012. Further issues focused on the future of the ISS, and the development of relations between ESA and the EU.

On 4 September 2013, the French government created a joint government-industry grouping, 'Cospace' in the hope of facilitating a consensus opinion between the French space industry and CNES on the future of Europe's launcher development. Following the previous Ministerial Council meeting in Italy in

[147] "Estonia today became EUMETSAT's latest Member State, following the signature of the accession agreement on 14 December 2011 and the recent completion of the ratification process." 26 June 2013. EUMETSAT 29 Apr. 2014. http://www.eumetsat.int/website/home/News/DAT_2055722.html.

[148] "Eumetsat Welcoming New Members as Investments Loom." 30 Aug. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/37012eumetsat-welcoming-new-members-as-investments-loom.

[149] "Eumetsat Welcoming New Members as Investments Loom." 30 Aug. 2013. SpaceNews 28 Apr. 2014 http://spacenews.com/article/civil-space/37012eumetsat-welcoming-new-members-as-investments-loom.

[150] "NOAA, Eumetsat Extend Cooperation Accord." 28 Aug. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/36985noaa-eumetsat-extend-cooperation-accord.

[151] "Europe and China To Share Ocean-monitoring Sat Data." 25 Sept. 2012. SpaceNews 28 Apr. 2014. http://spacenews.com/article/europe-and-china-share-ocean-monitoring-sat-data.

November 2012, differing opinions on the direction of launcher development, i.e. Ariane 6 or Ariane 5 ME, had pitted French industry and CNES on opposite sides, in addition to the debate between France and Germany. French industry, particularly Airbus Defence & Space with production facilities in both France and Germany, saw the Ariane 5 ME as a job producer, while CNES sees the value of Ariane 5 diminishing with European governments turning to the European Soyuz to launch spacecraft. And Germany has the opinion that although Ariane 6 might do well in the international market of commercial telecommunications satellite operators, the billions of euros invested in launcher development are primarily for government missions allowing the launch of heavy exploration payloads out of the reach of Ariane 6. With Cospace, France hopes to attend the autumn 2014 Ministerial Council with a united view on the full development of either the Ariane 6 or the Ariane 5 ME, or both launchers.[152]

France also plans to increase its spending in ESA. Its 2014 spending in ESA will grow by 7.8 % to 854.4 million Euros to meet its commitments for the next generation launcher. Its spending will be offset by a decrease in France's non-ESA-related space activities. Thus overall spending at CNES will increase by only 1.3 % to 1.43 billion Euros for 2014.[153]

In the same vein, France is also reducing its contributions to the ISS, following an assessment that its current payments are much higher than the station-related contracts received by French industry. As a result of the 2012 ESA Ministerial Council meeting, France's ISS contribution is capped at 275 million Euros for the 2-year period 2013–2014, or 20.86 % of the total ESA programme (dropping from 27.1 % of the total) with constant annual payments through 2021. Moreover, while the life cycle of the ISS has been extended by another 5 years, with ESA looking for ways to supply a service module for NASA's Orion Multi-Purpose Crew Vehicle (MPCV), CNES' role will be limited to 20 % of the ATV-derivative programme, though France intends on reviewing that role at the upcoming 2014 ESA Ministerial Council meeting.[154]

Germany

In 2012 and 2013 Germany continued advancing its position as a European space technology leader by taking the lead in key European space technology development projects, both in the framework of the EU and ESA. At the same time, it

[152] "France Moves To Get Industry, Government on Same Page with Creation of Cospace Group." 5 Sept. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/37072france-moves-to-get-industry-government-on-same-page-with-creation-of.

[153] "France Favors CNES with Better-than-inflation Budget Bump." 26 Sept. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/37395france-favors-cnes-with-better-than-inflation-budget-bump.

[154] "France is Reducing Its Space Station Contributions." 20 Feb. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/33755france-is-reducing-its-space-station-contributions.

increased the visibility and public impact of its technological capabilities, both through its strong support for the International Space Station (ISS) and by initiating its own national programmes. The German space programme focuses on the following priorities: the completion of the Galileo and Copernicus (GMES) constellations; the full exploitation of ISS for as long as possible; the development of new or improved launch vehicles; and the realization of space exploration missions.[155]

While France has pushed for the development of a new Ariane 6 launcher as the way to go for Europe's step, Germany was not convinced.[156] The German DLR's chairman, Johann-Dietrich Woerner went as far as to say "Any hope that Europe one day would be launching its own astronauts would evaporate with Ariane 6."

In international initiatives, the DLR and OHB System AG signed an agreement on 13 November 2013, where the DLR agreed to direct funding from its budget to finance a study to explore possible uses of the US spacecraft Dream Chaser being developed by the US Sierra Nevada Corporation (SNC). The project, known as Dream Chaser for European Utilization (DC4EU), will explore ways in which the spacecraft can be used to cover German and European requirements for the transportation of payloads and astronauts to the ISS and for deployment as a manned or unmanned space vehicle allowing German and European scientists to conduct research under weightless conditions over extended periods of time. The study will also determine the extent to which Dream Chaser is able to launch satellites or remove decommissioned satellites from their orbits. This project will complement work conducted by SNC under NASA's Commercial Crew Program.[157]

In 2013, Germany's expertise in Earth observation had export potential in satellite manufacturing and imagery. Throughout the year, Russia's Ministry of Defence expressed its interest in purchasing two medium-resolution X-band radar Earth observation satellites from Astrium GmbH for use by Russia's military, resembling Germany's government-commercial TerraSAR-X and TanDEM-X spacecraft. Due to the special nature of the technology, its export requires the approval of the German government, which was still pending by the end of 2013. Should Germany accept the estimated 365 million Euros ($493 million) deal, consent from the US government would likely be needed as well, since some components used on both spacecraft are US-built and fall under US technology-

[155] De Selding, Peter. "Germany Reaffirms Commitment to $2B Ariane 5 Upgrade." Space News 31 Oct. 2011: 6.

[156] De Selding, Peter. "DLR's Woerner Remains Unconvinced Just-unveiled Ariane 6 Design Is Right Way To Go." 12 July 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/launch-report/36225dlr%E2%80 %99 s-woerner-remains-unconvinced-just-unveiled-ariane-6-design-is-right.

[157] "OHB System Launching Bilateral Partnership for the Commercial Provision of Supplies for ISS." 13 Nov. 2013. OHB System 28 Apr. 2014. https://www.ohb-system.de/press-releases-details/items/contract-signed-with-dlr-for-the-study-phase-for-the-utilization-of-us-company-sierra-nevada-corporations-dream-chaser-spacecraf.html.

export restrictions. In the scenario being considered, to avoid technology transfer by thorough inspection or reverse engineering by the Russian contracting team, Astrium would deliver the synthetic-aperture radar observing instruments as "black boxes", while KB Arsenal of St. Petersburg, Russia, would be the principal Russian company to handle the satellites' final integration in Russia.[158] And Astrium has been in talks with Russian organizations about the possible sale of a TerraSAR-X-type system for the Russian market, and has also invited other nations to join the new German-Spanish partnership to operate a constellation of X-band radar satellites.[159]

Moreover, the German government has put into place a two-step regulatory regime for commercial satellite EO imagery that subjects proposed sales of the most sensitive data to approval on a case-by-case basis. On 8 October 2013, Astrium announced that its current TerraSAR-X/TanDEM-X system had been upgraded and now could offer customers 4 by 3.7 square km, small scene size images at 25 cm resolution. Geospatial-imagery competitors in the US and France have government-imposed 50 cm resolution limits on commercial sales of their optical imagery. Germany's Satellite Data Security Act (SatDSiG) and related legislation sets the general ground rules for commercial satellite data sales, limiting the sale of commercial imagery from German satellites that would harm German security and foreign policy interests. Under the SatDSiG, requests from either commercial or scientific users for TerraSAR-X data are subject to a "sensitivity check". Where the sharpness, or the prospective customer, give the imagery special sensitivity, the sale would need to be accepted by a second organization, the Federal Office of Economics and Export Control (BAFA).[160]

Italy

Cooperative PPPs in developing space capabilities were highly relevant for Italy for civilian and defence purposes. In November 2012, Italy's Defence Ministry expressed its support for a proposal by the Italian Space Agency and the Italian space industry to launch two Ka-band communications satellites for civil and military use under a government-commercial partnership called the Sigma project. A portion of the construction of the military communication satellites Sicral 1B and Sicral 2 (under construction) will be financed by Italy's Telespazio in return for ownership of a portion of their capacity for resale. With Italy still overcoming the effects of the financial crisis, co-investing in Sigma for additional Ka-band capacity

[158] De Selding, Peter. "Russia Looking To Germany for Radar Reconnaissance Satellites." 22 Feb. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/military-space/33800russia-looking-to-germany-for-radar-reconnaissance-satellites.

[159] "Commercial Earth Observation | German Imagery Policy Sets No Hard Limits on Resolution." 14 Oct. 2013. SpaceNews 28 Apr. 2014. http://www.spacenews.com/article/civil-space/37666commercial-earth-observation-german-imagery-policy-sets-no-hard-limits-on.

[160] Ibid.

is an example of the government's interest in finding creative solutions beyond merely sharing expenses with ASI. UHF capacity on the open market (i.e. spot purchases by military forces needing short-term leases on bandwidth) can fetch as much as $3 million/year for a 25-kHz channel.[161] This project could also fulfil Italy's obligation to NATO should the 28-nation alliance decide to use its capacity post-2020; Italy along with Britain and France already provide satellite capacity to NATO under a contract that expires in 2019.

Another example of Italy's cooperation with the private sector is its stake in the Athena-Fidus Ka-band broadband satellite, scheduled to launch in early 2014. France and Italy are constructing the satellite, with ownership stakes held by CNES and ASI, and the two nations' military forces. Athena-Fidus has separate French and Italian Ka-band payloads, and an extremely high frequency Ka-band payload for Italian national coverage to be used by government emergency response forces. France will have operational control of Athena-Fidus.[162]

The United Kingdom

In 2012 and 2013, the United Kingdom (UK) continued to successfully develop its space activities and cooperation with other partners, related in part to its recently established UK Space Agency. On 9 November 2012, just days prior to the 2012 ESA Ministerial Council meeting, the United Kingdom pledged to increase its annual investment in ESA by 25 % for the next 5 years, 2013–2017. While the news was unanticipated, given the fact that the UK was dialling back spending in many other areas due to the crisis, increased investment in space is expected to have a multiplier effect on the nation's economy in addition to boosting the UK's international competitiveness. Thus, the UK's annual investment in ESA was increased to 301 million Euros ($383 million) per year through 2017, placing the UK fourth behind Germany, France, and Italy as ESA's biggest contributors. In that same period, ESA moved its telecommunications directorate from the European Space Research and Technology Centre in Noordwijk, Netherlands, to ESA's newest facility in Harwell, UK.[163] The European Centre for Space Applications and Telecommunications (ECSAT)[164] located in Harwell, UK, was officially unveiled on 14 May 2013, and will be active in telecommunications, climate change, technology, science and integrated applications.[165]

[161] De Selding, Peter. "Italian Defense Ministry Backs Sigma Ka-band Satellite Partnership." 29 Nov. 2012. SpaceNews 28 Apr. 2014. http://spacenews.com/article/italian-defense-ministry-backs-sigma-ka-band-satellite-partnership.

[162] Ibid.

[163] SpaceNews Editor. "Editorial | Britain Steps Up in Space." 19 Nov. 2012. SpaceNews 28 Apr. 2014 http://spacenews.com/article/editorial-britain-steps-up-in-space.

[164] "ECSAT." ESA 30 May 2014. http://www.esa.int/About_Us/Welcome_to_ESA/ECSAT.

[165] Press Releases. "N° 14–2013: ESA opens its doors in UK." 14 May 2013. ESA 30 May 2014. http://www.esa.int/For_Media/Press_Releases/ESA_opens_its_doors_in_UK.

In November 2013, the UK space sector published the UK Space Innovation & Growth Strategy 2014–2030: Space Growth Action Plan report, a follow-on to the Space Innovation and Growth Strategy (IGS) report, published in February 2010. The Action Plan report aims to deliver new jobs and growth for the sector, with the goal of increasing the UK share of the global space market to 8 % by 2020. In addition to proposing measures designed to enhance the UK's supportive business environment, including the development of a vibrant regional SME community spread across the UK, the report calls for stronger support for exports and an improved regulatory framework for space activity.[166] Its recommendations include: (1) Develop the high-value priority markets identified to deliver £30 billion per annum of new space applications by promoting the benefits of space to business and Government and engaging service providers; (2) Make the UK the best place to grow existing and new space businesses and attract inward investment by providing a regulatory environment that promotes enterprise and investment in the UK; (3) Increase the UK's returns from Europe by continuing to increase the UK's contributions to European Space Agency (ESA) programmes and securing greater influence in large European-funded programmes; (4) Support the growth of UK space exports from £2 billion to reach £25 billion per annum by 2030 by launching a National Space Growth Programme and defining an international policy that will improve collaboration with nations across the world, enhance the UK's competitive edge in export markets and enable targeted and market-led investments in leading edge technology; and (5) Stimulate a vibrant regional space SME sector by improving the supply of finance, business support, information, skills and industry support.[167]

On 5 December 2013, the UK Space Agency announced the beginning of its Five-year Global Collaborative Space Programme (GCSP), which will allow the space agency to increase its international portfolio by fostering projects of mutual interest with other countries, with £80 million ($131.3 million) in funding focused on using space to assist in social and economic development. On 10 December 2013, the UK Space Agency completed its first Memorandum of Understanding with the China National Space Administration (CNSA), beginning the process of identifying collaborative opportunities that have the potential to deliver real economic growth and social benefit for both the UK and China. International collaboration between UK industry and Russia, Brazil and Kazakhstan has also begun. Through this programme, the UK hopes these partnerships will play an important role in helping the UK space economy to be worth £40 billion/year by 2030. The GCSP will also address a key recommendation of the ambitious Space Innovation and Growth Strategy Action Plan, designed to enable the UK to develop an even

[166] Staff Writers. "Space Sector Calls for Action to Keep Britain Ahead in the Global Race." 18 Nov. 2013. Space Daily 28 Apr. 2014. http://www.spacedaily.com/reports/Space_sector_calls_for_action_to_keep_Britain_ahead_in_the_global_race_999.html.

[167] UK Space Innovation & Growth Strategy 2014–2030: Space Growth Action Plan. 14 Nov. 2013. Innovateuk.org 13 May 2014. https://connect.innovateuk.org/web/space/space-igs-2014-30.

more supportive business environment for space companies to deliver growth and other benefits to the national economy.[168]

1.2.4 The United States

From a policy perspective, 2012 and 2013 saw significant changes in US space initiatives. Funding for space programmes continued to be a major hurdle, resulting in the restructuring of priorities. During this time, concrete actions were undertaken to implement the new strategic orientations, amid political controversy over their declared objectives and how best to accomplish them. Nevertheless, concerns remained on such topics as changes to US regulations on EO satellites, hosted payloads, export reform, and the development of suborbital and in-orbit satellite service industries.

NASA has experienced difficulty in generating public interest in its human spaceflight programme while developing hardware with no deep-space mission anywhere in the agency's Five-year budget horizon. Lacking the impetus drawn from Cold War-era Moon expeditions, or the roar of the now-retired space shuttle launch, public dialogue on exploration, science, and technology seems to be stagnant. On 21 October 2013, NASA Administrator Charles Bolden—before a National Research Council panel evaluating NASA's human spaceflight goals—defended the agency's plan to build deep-space hardware before settling on a destination as being "the only realistic way to set the stage for a manned Mars mission given the current budget climate". The National Research Council is now awaiting a report from the Space Studies Board's Committee on Human Spaceflight due to be published in May 2014. This ad hoc committee was established in response to the NASA Authorization Act of 2010, which saw the Constellation Moon exploration programme cancelled by President Obama for being too costly given NASA's then expected budget. President Obama's 2014 budget request includes $17.7 billion for NASA, and proposes using the future Space Launch System to launch a crewed Orion to rendezvous with a small asteroid relocated near the Moon by a robotic tug sometime between 2021 and 2023. While NASA has not formally committed to this Asteroid Redirect Mission (ARM)—especially following the lukewarm response from Congress—should the mission proceed, it would use a solar-powered robotic spacecraft to push a 10-m asteroid into a deep retrograde orbit around the Moon. While no formal cost estimate for ARM has been determined, estimates put the mission cost at approximately $2.6 billion. To be

[168] "Going Global: UK Space Agency to Build International Partnerships Using UK Expertise." 12 Dec. 2013. UK Space Agency 28 Apr. 2014. http://www.bis.gov.uk/ukspaceagency/news-and-events/2013/Dec/going-global.

successful, it will need to fit within overall financial considerations, in addition to satisfying political interests.[169]

In NASA's FY2014 budget request, the ARM proposal was seen to be its most controversial aspect, being the stepping-stone toward President Obama's 15 April 2010 directive setting an asteroid as the next destination for the US human spaceflight programme. The earlier directive had similarly received little support in Congress and the broad space community, where it envisioned astronauts travelling for several months to visit an asteroid and study human adaptation to deep space missions as a step towards even longer missions to Mars. As a precursor to this mission, the Keck Institute for Space Studies (KISS) published a report in 2012 recommending that an asteroid be captured by a robotic spacecraft and tugged into lunar orbit for easier accessibility by astronauts who could return a large sample to Earth for study. While the White House adopted a variation of this plan in its FY2014 budget request, as a way to send humans to an asteroid more quickly and cost effectively, NASA faces opposition from the House Science, Space and Technology Committee while also struggling to define a mission concept.[170]

On 2 January 2013, President Obama signed into law the National Defense Authorization Act (NDAA) for Fiscal Year 2013 which repealed the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 that had placed satellites and related items on the United States Munitions List (USML). In response to allegations that China was improving its rocket capabilities through launches of US satellites, in 1998 the US Congress had put in place stricter export controls that were applied to all space-related hardware and services, transferring all items from the US Commerce Control List (CCL) regardless of sophistication or availability. Over the following decade, US satellite and component makers were placed at a competitive disadvantage due to export control laws; a 2012 Aerospace Industries Association report showed the US share of the global satellite manufacturing market having dropped from 65 % to as low as 30 % since 1999, in addition to $21 billion in lost revenues between 1999 and 2009, and a loss of 9,000 jobs annually. The new law gives the US President the discretion (with appropriate national security reviews) to place satellites and related items on the CCL, which contains dual-use items whose exports are regulated by the US Department of Commerce. Moreover, the new NDAA maintains a de facto ban on transferring US satellite hardware to China or North Korea, or countries deemed to be state sponsors of terrorism; i.e. should the US President seek a waiver to permit the launch of US satellite hardware aboard a Chinese or North Korean rocket, Congress is directed to meet that request with a presumption of denial. However, if companies want to launch US-built satellites on Russian or European

[169] Leone, Dan. "Bolden: Capabilities-based Approach Is All NASA Can Afford." 22 Oct. 2013. SpaceNews 29 Apr. 2014. http://www.spacenews.com/article/civil-space/37808bolden-capabilities-based-approach-is-all-nasa-can-afford.

[170] "NASA's FY2014 Budget Request." 17 Oct. 2013. Space Policy Online 29 Apr. 2014. http://www.spacepolicyonline.com/pages/images/stories/NASA%20FY2014%20Budget%20Request%20Oct%2017.pdf.

rockets, they still need a State Department license (i.e. a Technical Assistance Agreement, or TAA) to hold the discussions necessary to mate the two vehicles. Moreover, with the exception of launches of US hardware operated by close US allies, monitors from the US DoD are required to be present.[171]

With the NDAA signed, the next step was for the US government to draft implementing regulations for publication in the US Federal Register, to include categories of space technology proposed for transfer to the CCL. On 24 May 2013, the Obama administration published in the Federal Register its proposed new USML Category 15, including a list of those items that would move to the CCL. This proposed Category 15 list closely followed what had appeared in the April 2012 Section 1248 report.[172] Under the "1248 report" (invoked by Section 1248 of the National Defense Authorization Act for 2010), items recommended for transfer to the CCL include communications satellites that do not contain classified components, and some low-performing remote sensing satellites and components that may be treated as non-military technology for export purposes, without affecting national security. Items likely to remain on the USML include dedicated military payloads hosted aboard commercial satellites, most of which are owned by international companies and launched on foreign rockets, on the grounds that hosted military payloads may contain sensitive encryption and radiation-hardening technologies and thus sensitive from a security perspective. That is, there is no material change to restrictions imposed on spacecraft carrying DoD-funded secondary or hosted payloads, and specially designed parts and components.[173]

By December 2013, the Obama administration's export control reform efforts, including reviews of what should remain on the USML and what could be moved to the less restrictive CCL, were in their final phases. A 45-day public comment period had followed the publication of the administration's revised proposed new USML Category 15, which ended in July 2013. After that period, an interagency group began reviewing the nearly 400 pages of comments, including feedback from companies, trade organizations, and members of the general public. That review was completed on 10 December 2013, with the next step requiring the Commerce Department to begin the formal process of getting approval from the Office of Management and Budget (OMB). After approval, the final rules will then be reviewed by Congress in late March or April in 2014, taking effect 180 days later. It should be noted that changes may be expected to the section of the draft Category 15 rule that kept "man-rated sub-orbital, orbital, lunar, interplanetary or habitat" spacecraft on the USML, which could impact vehicle developers like

[171] "New Export Law Seen as Boon to U.S. Satellite, Component Makers." 4 Jan. 2013. SpaceNews 29 Apr. 2014. http://www.spacenews.com/article/civil-space/33047new-export-law-seen-as-boon-to-us-satellite-component-makers.

[172] "The ITAR Shift." 1 July 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/civil-space/36055the-itar-shift.

[173] "Proposed ITAR Changes a Mixed Bag for U.S. Satellite Industry." 14 June 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/satellite-telecom/35794proposed-itar-changes-a-mixed-bag-for-us-satellite-industry.

Virgin Galactic and XCOR Aerospace that plan to operate in spaceports being developed outside the US. Another mainly academic issue is on the definition of a 'defense service', where some critics have balked at its vagueness.[174] Moreover, the proposed changes on Earth observation satellites appear to be outdated, with new rules covering optical, radar and hyperspectral imaging satellites, and setting clear technical parameters for what will remain on the USML; however, many of the technologies the rules are designed to restrict are easily available outside the US, and are being integrated into satellites owned by many nations.[175]

Work on the final draft of the Obama administration's export reform regulations was delayed by the government shutdown in October 2013. Whereas originally the work was expected to be completed by the end of 2013, the government shutdown pushed estimates back to early 2014.[176] Beginning on 1 October 2013 when the US Senate and House couldn't agree on an emergency spending bill to keep the government funded, the 16-day shutdown forced huge numbers of federal employees home, including 97 % of NASA's 18,000-member workforce. During that time, a skeleton crew of 549 employees remained at their posts to protect the lives of the astronauts aboard the ISS and monitor currently operating scientific spacecraft to ensure their safety.[177] A further 1,566 employees were on call in the event of an emergency. While most of NASA had shut down, some projects were exempted, such as those in the middle of delicate tests or working in limited time windows. The main instrument for the $8.8 billion James Webb Space Telescope (expected to launch in 2018), had been undergoing cryogenic vacuum testing when the shutdown took effect, but was allowed to continue in-part due to the long-term implications that would arise otherwise; i.e. the instrument was kept cool, and in suspend-mode with a crew to monitor it so that the mission schedule could remain on track.

However, NASA suspended the Mars Atmosphere and Volatile Evolution (MAVEN) mission launch preparations on 1 October, sparking an outcry from Mars exploration advocates, due to the 26 month delay and millions of dollars of additional expense that would result if the 4-week launch window was missed. On 3 October, the orbiter was granted an emergency exemption on the grounds that the orbiter must launch this year to protect the rovers NASA already has at Mars by replacing Mars Odyssey (launched in 2001) and the Mars Reconnaissance Orbiter (launched in 2005) as a communications relay in order to be assured of continued

[174] "Export Control Reform Process is Wrapping Up." 15 Dec. 2013. Space Politics 29 Apr. 2014. http://www.spacepolitics.com/2013/12/15/export-control-reform-process-is-wrapping-up/.

[175] "Proposed ITAR Changes a Mixed Bag for U.S. Satellite Industry." 14 June 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/satellite-telecom/35794proposed-itar-changes-a-mixed-bag-for-us-satellite-industry.

[176] "Government Shutdown Delayed New Satellite Export Regulations." 19 Nov. 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/military-space/38245government-shutdown-delayed-new-satellite-export-regulations.

[177] "NASA Assessing Impacts of Government Shutdown." 18 Oct. 2013. Space.com 29 Apr. 2014. http://www.space.com/23253-nasa-government-shutdown-impacts.html.

communications with the Curiosity and Opportunity rovers. Missing that launch window, and launching in 2016 would have required MAVEN to use more fuel to reach the red planet, and would have limited the duration of MAVEN's core science mission of measuring the interaction of solar particles with the upper Martian atmosphere.[178] On 16 October, the Senate and House passed the Continuing Appropriations Act (CAA), which kept the government funded at its FY2013 levels until 15 January 2014; President Obama signed the bill into law early the next day.[179] The MAVEN mission launched on 18 November 2013.

1.2.5 Canada

In 2012, the Canadian Space Agency (CSA) appeared in need of clearly defined future space plans to keep Canadian aerospace from falling behind China, Russia and other countries, according to recommendations in a report by a Canadian aerospace review panel led by David Emerson (i.e. Emerson Report) presented on 29 November 2012. A notable improvement would be the use of yearly, minister-level reviews of its activities as well as some high-level advisory boards that could advise Canadian officials on space activities. Moreover, the panel said that the agency should hand off contracting responsibility to the Public Works department to better focus the work of the CSA; saying further that competition for contracts should be more open to foreign companies who pledge to include Canadian content. The recommendations were made in a revenue-neutral way, in an effort to remain in line with the government's goal of cutting back spending to try to balance the budget. Hence, if the CSA is to increase its activities, it will need to become more streamlined in order to do so, or look to other federal departments with an interest in space (e.g. defence or environment). The panel also emphasised that the CSA should rent out research space at its facilities, or form PPPs, to leverage additional funding from the private sector. To increase commercial space activity, the panel also proposed the use of regulatory changes to increase the opportunities to companies interested in suborbital and orbital launches, high-altitude tests and human spaceflight.[180]

On 2 December 2013, Canada's Industry Minister James Moore announced that Canada's new space plan would be made public early in 2014. Moore said that the Canadian government will examine all opportunities to work with the private sector and Canada's international partners to encourage innovation in the country's space

[178] "U.S. Government Shutdown | Most of NASA Idled but Mars Orbiter Gets Reprieve." 4 Oct. 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/civil-space/37561us-government-shutdown-most-of-nasa-idled-but-mars-orbiter-gets-reprieve.

[179] "NASA's FY2014 Budget Request." 17 Oct. 2013. Space Policy Online 29 Apr. 2014. http://www.spacepolicyonline.com/pages/images/stories/NASA FY2014 Budget Request Oct 17.pdf.

[180] "Canadian Space Agency Needs a Plan, Experts Say." 30 Nov. 2012. Space.com 29 Apr. 2014. http://www.space.com/18715-canadian-space-agency-future-plans.html.

activities. Moreover, a background paper said the plan will outline the government's strategic goals for its space activities, which include jobs and growth, sovereignty, security and the advancement of knowledge. As an additional result of the Emerson Report, the current support for the CSA's space technologies development program is expected to double to $20 million annually in the 2015–2016 period.[181]

By November 2013, the Canadian government had reduced its fees and coverage restrictions for satellite licensees, following requests by satellite operators and users. The government will also be more active in seeking orbital slots outside Canada's orbital arc to enhance the competitiveness of Canada's satellite sector. Whereas previously, Industry Canada had accepted incomplete or defective applications, and permitted a licensee to maintain their place in queue while the filing was corrected, now defective applications will be accorded first-come, first-served preference for assistance but will also be sent to the back of the queue. Also, a new fee structure imposed on licensees will permit Industry Canada to recoup its processing costs, and to reduce the number of spurious applications. In line with similar rules imposed by the US Federal Communications Commission (FCC), licensees will be required to meet development milestones to keep their licenses (i.e. demonstrate a signed satellite construction contract within 2 years, and operation within 5 years of license approval). The new policy also reduces the public service obligation of satellite license holders from spending 2 % down to 0.5 % of their adjusted gross income toward research and development. Also, while 50 % of the satellite capacity is still expected to be reserved for Canadian users, it is now only for the first 6-months of the satellite's operational life, unless a Canadian market exists. And the Canadian government has agreed to act as licensing authority for satellites to be operated outside the Canadian orbital arc of between 70° west and 130° west longitude in GEO.[182]

Also, by deciding to proceed with the Radarsat Constellation Mission, Canada will help to boost the MDA Corp.'s position in providing the international market with satellite data, and in attracting new customers because of the system's ability to conduct rapid revisits of specific locations. On 9 January 2013, the CSA and MDA Corp. signed a C$706 million contract to continue the development of the Radarsat Constellation Mission (RCM) of three satellites to be launched in 2018. With initial work beginning in 2005, Canada has already paid MDA Corp. C$269 million for its previous work on the programme, with this announcement raising the total contribution to C$975 million. The programme, led by the CSA, will be supported by its principal users, which are Canadian federal government departments, including the Department of National Defence, Fisheries and Oceans

[181] "Canada's New Space Plan Coming 2014." 2 Dec. 2013. CBC News 29 Apr. 2014. http://www.cbc.ca/news/politics/canada-s-new-space-plan-coming-2014-1.2448154.

[182] "Canada Revamps Satellite Regulations To Make Industry More Competitive." 7 Nov. 2013. SpaceNews 29 Apr. 2014. http://spacenews.com/article/satellite-telecom/38046canada-revamps-satellite-regulations-to-make-industry-more.

Canada, Agriculture and Agri-Food Canada, Environment Canada, Natural Resources Canada and Public Safety Canada. The programme will employ around 200 employees over a 6-to-7 year period.[183] The three satellites from the RCM mission will be launched on a single SpaceX Falcon 9 rocket in 2018.[184]

Lastly, the status of Canada's Polar Communications and Weather (PCW) mission remained uncertain near the end of 2013. While the CSA hopes to start work on the new polar-orbiting communications and weather satellite system as soon as November 2016; following a feasibility study on the project in 2008, in February 2013 the agency was looking for partners, including other Canadian government agencies and other nations, to help finance the system (expected to cost about C$600 million). The PCW would benefit Canada because GEO communications satellites face limitations for mobile services at far northern latitudes.[185]

1.2.6 Russia

Russia plans to spend an estimated 2.1 trillion roubles (around $63 billion, or $7.9 billion per year at 2013 exchange rates) including extrabudgetary sources, for the development of its national space activities in 2013–2020. In addition to enabling effective participation in forward-looking projects, such as the ISS, the study of the Moon, Mars and other celestial bodies in the solar system, the programme is designed to maintain Russia's leading position as a global space power, while also supporting its defence capability, and boosting economic and social development.[186] The government's decision to increase Russia's space budget will enable Russia to surpass China and reach spending parity with Europe. With only one-fifth of its domestic demand for geospatial imagery currently able to be met by Russia's own satellites and with Russian meteorological satellites being below international standards, this funding could help Russia to redress its past underinvestment in Earth observation and meteorology satellites.[187] In July 2013, an Audit Chamber released a statement finding Russia's Federal Space Program for 2006–2015 to be

[183] "Canada Recommits To Building Radarsat Constellation Mission." 9 Jan. 2013. SpaceNews 29 Apr. 2014. http://www.spacenews.com/article/civil-space/33100canada-recommits-to-building-radarsat-constellation-mission.

[184] "SpaceX Wins Contract to Launch Canadian Radar Satellites." 30 July 2013. Space.com 29 Apr. 2014. http://www.space.com/22178-spacex-launch-contract-canadian-satellites.html.

[185] "Weather, Communications Project Inches Ahead at CSA." 1 Nov. 2013. SpaceNews 29 Apr. 2014. http://www.spacenews.com/article/civil-space/37963weather-communications-project-inches-ahead-at-csa.

[186] "Russia Launches $70 Bln Space Program for 2013–2020." 27 Dec. 2012. RIA NOVOSTI 30 Apr. 2014. http://en.ria.ru/science/20121227/178432916/russia_launches.html.

[187] "Russia Boosting Space Budget To Surpass China, Equal Europe." 5 June 2013. SpaceNews 30 Apr. 2014. http://www.spacenews.com/article/civil-space/35638russia-boosting-space-budget-to-surpass-china-equal-europe.

ineffective, due largely to the poor management of space activities and budget funds allocated for space projects; in particular, it lacked a comprehensive management system in regard to space programs, projects, contracts and expenses, despite the increase in budget spending for space exploration by 2.5 times in the past 3 years. The Federal Space Program met only 40 % of its set goals in 2010, 66.7 % in 2011, and 73.3 % in 2012; and launched only 47.1 % of its planned number of satellites into orbit in 2010–2012.[188] The Audit Chamber attributed Roscosmos' lack of adherence to regulatory requirements and best practices in state procurement orders to be a cause of that state of affairs.

In September 2013, Russian, European, Japanese, Canadian and US space agencies were nearing the point where they could declare their respective parts of the ISS fit to fly through 2028 (marking the 30th anniversary of the station's first pressurised space module, Zarya, placed into orbit by Russia in 1998).[189] By the end of that month, engineers in Russia determined that the Zarya cargo module can last in orbit until about 2028 (twice its design service life) despite micro-cracks occurring in the aluminium hull during pressure and loads cycling of a test article on the ground. Some of the recertification work was based on the Komplast space-exposure experiment removed from Zarya's hull and returned to Earth after 12 years in space, which validated predictions of aging effects.[190]

1.2.7 Japan

On 20 June 2012, Japan passed legislation implementing a 2008 law that profoundly changes the organization of Japanese space activities, enabling the Prime Minister's Cabinet Office to take control of the planning and budgeting of Japan's government space program, and providing JAXA with the ability to pursue military space programs. Previously, JAXA had been wholly controlled by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and was overseen by a MEXT committee called the Space Activities Commission (SAC). MEXT no longer controls the direction of JAXA, and its SAC has now been abolished. In its place, the Prime Minister's Cabinet Office will set up a Space Strategy Office, which will be supported by a consultative Space Policy Commission of five to seven academics and independent observers. The next step of the Space Strategy Office will be to draft new laws and policies to shift Japan's space focus away from purely research and development programs to a more national, security-orientated

[188] "Russia's Space Program Is Ineffective—Audit Chamber." 4 July 2013. RIA NOVOSTI 30 Apr. 2014. http://en.ria.ru/russia/20130704/182063035.html.

[189] "U.S., Russia Close to Completing Technical Assessment of Flying ISS through 2028." 30 Sept. 2013. SpaceNews 30 Apr. 2014. http://www.spacenews.com/article/civil-space/37460us-russia-close-to-completing-technical-assessment-of-flying-iss-through.

[190] "Oldest ISS Element Cleared Until 2028." 24 Sept. 2013. Aviation Week 30 Apr. 2014. http://aviationweek.com/space/oldest-iss-element-cleared-until-2028.

approach, which is also expected to encourage the industrialization and commercialization of Japan's space industry.[191]

On 25 January 2013, Japan's Space Strategy Headquarters released the latest version of its Basic Plan that lays out the priorities for most of Japan's space development for the 5 years that started in April 2013. The Basic Plan has three main targets: national security and disaster management, development of industries, and space science.[192] Similar to the previous strategy, this 46-page document puts emphasis on continuing to fund the development and launch of the increasingly capable Information Gathering Satellites (IGS) system with the aim of maintaining a constellation of two optical and two radar imaging satellites. A long time in development (IGS was initiated following an August 1998 North Korean missile test that overflew Japan), with the launch of the IGS-Radar 4 spacecraft on 27 January 2013, Japan now has two functional radar satellites and an experimental optical satellite in orbit for disaster monitoring and national security purposes. In other respects, the new Basic Plan does not specify budgets for particular programs and essentially leaves the current structure intact.[193]

On 3 April 2013, Japan announced that Mitsubishi Electric Co. (Melco) would be tasked to complete Japan's Quasi-Zenith Satellite System (QZSS) meant to enhance the precision of the US GPS positioning, navigation and timing satellites over the Pacific Ocean region. The contract, valued at $539.4 million, will have Melco build one geostationary satellite and two spacecraft to be operated in highly elliptical orbit to complete the QZSS space architecture by 2017. Whereas GPS-only signals are available with precision only 90 % of the time in Japan, with the QZSS overlay in place, the signals will increase that percentage to 99.8 % of the time, and will carry six civil signals. That is, while the GPS-only L1S signal has a 10-m horizontal accuracy in Japan, the addition of the QZSS will refine that accuracy down to 2-m, in addition to being able to send short disaster-warning messages to mobile phone users.[194]

[191] Kallenar-Umezu, Paul. "Japan Passes Overhaul of Space Management Structure." 2 July 2012. SpaceNews 30 Apr. 2014. http://spacenews.com/article/japan-passes-overhaul-space-management-structure.

[192] "Profile | Naoki Okumura, President, Japan Aerospace Exploration Agency." 9 Dec. 2013. SpaceNews 30 Apr. 2014. http://spacenews.com/search?search_api_views_fulltext=Japan&sort_by=created&sort_order=DESC&page=2.

[193] "Japan Stays the Course on IGS under Latest Five-year Plan." 18 Feb. 2013. SpaceNews 30 Apr. 2014. http://www.spacenews.com/article/japan-stays-the-course-on-igs-under-latest-five-year-plan.

[194] "Melco To Build Three QZSS Navigation Satellites." 3 Apr. 2013. SpaceNews 30 Apr. 2014 http://spacenews.com/article/civil-space/34676melco-to-build-three-qzss-navigation-satellites.

1.2.8 China

Chinese space policy revolves around the country's Five-year economic development plans. The country's space programme is therefore meant to support its overall development objectives, while maintaining a comprehensive set of objectives for space activities. The main challenge for the Chinese programme is to achieve the right mix of national space capabilities and participation in international space cooperation. In December 2011, the Chinese government announced its latest Five-year plan for 2011–2016, in the form of a government White Paper entitled "China's Space Activities in 2011".[195] This document updates and extends the country's strategic and operational objectives in space, depicting the progress made since 2006 and laying down its short term plans, divided into four main activity areas: space transportation, satellite development, space applications and space science. In addition to this, it presents China's ambitions to play a pivotal role on the international scene and underpins the contribution of space activities to achieving this purpose.

China's principle policy objectives in space are all related to promoting the country's scientific, economic and social development, securing its national security and independence (in its broader sense) and improving its international influence by engaging in space cooperation. More specifically, it relates space activities to achieving the objectives of its scientific and technological innovation policies. At the same time, it stresses the importance of maintaining independent space capabilities, while carefully trying to balance this with an open approach to international cooperation and insistence on the peaceful exploitation of space. In a nutshell, the new Chinese space policy's principal axes are:

- Enhance space science and technology capabilities through innovation.
- Maintain technological and operational self-reliance across the board.
- Adopt an open and constructive attitude to international cooperation on the basis of mutual benefit.
- Oppose space weaponisation and protect the space environment.

All of the aforementioned policies converge to achieve the general national objectives of economic development, social progress and comprehensive national strength.

Apart from these general principles, China's new space policy recites in detail the country's achievements in space over the past 5 years and declares its programmatic intentions for the future. The level of operational and technological details provided is unprecedented for a Chinese document of this kind; combined with the clear description of future programmes, it implies a higher level of confidence and pride in the country's space capabilities than before. The Chinese Five-year space

[195] White Papers of the Government of China. "China's Space Activities in 2011." Beijing 29 Dec. 2011. 6 Mar. 2012. http://www.china.org.cn/government/whitepaper/node_7145648.htm.

programme focuses on four mission areas: transportation, satellites, spaceflight and applications.

On 29 June 2013, China successfully test-fired the rocket engine destined to power the next-generation heavy-lift launcher, Long March 5. The first engine test lasted roughly three minutes from ignition to shutdown. The Long March 5, with its larger carrying capacity, is being pursued in China's 12th Five-Year Plan period (2011–2015). Moreover, China is also drawing up plans for a medium-size Long March 7 launcher. On 13 November 2013, China successfully test-fired the booster engine for the Long March 7, with all systems working stably, and within the tests operating procedure. Both the Long March 5 and Long March 7 have been improved by using non-toxic and pollution-free propellant.[196] The Long March 5 is closely tied to the development of China's growing space station, in addition to its developing Moon exploration programme, in which it will be mainly used for the lofting of China's manned space station, with the capacity to carry an 18 metric tons payload to NEO. The Long March 7 will be able to launch 12 metric tons into NEO, and will be capable of launching a cargo spacecraft to the country's manned space station. That said, a new Tiangong 2 space laboratory is planned for launch into orbit by 2015, followed by an experimental core module of the larger space station in 2018, and by 2020, China's manned space station should be completed. Both the Long March 5 and Long March 7 launchers are expected to fly before the end of 2015, and will launch from China's Wenchang Satellite Launch Centre which is currently under construction on the North-Eastern coast of Hainan Island. Once in operation, the complex will host heavy GEO communication satellite launches, in addition to space station modules, and missions to the Moon. However, piloted space missions will continue to be conducted from the Jiuquan Satellite Launch Centre. The total cost of the new launch port is estimated to be cost around $810 million.[197]

China is also beginning to draw up preliminary designs for a Long March 9 Super-Heavy launcher which is planned to be more powerful than the Saturn V launcher of the Apollo missions, and match the lift capacity of NASA's planned SLS Block 2 launcher. China's CALT has studied configurations similar to those that NASA considered to lift 130 metric tons to LEO; though China aims to build the largest space launcher in history. Preliminary work is already underway for the intended engines, and at the International Astronautical Congress held in Beijing on 23–27 September 2013, the CALT published the main specifications of the two possible configurations. The first concept would have four YF-660 engines mounted in the core first stage and one in each of four side-mounted boosters. In the second concept, most of the initial thrust would come from four solid-propellant boosters, each generating 1,000 tons of thrust, while four YF-220 concept engines

[196] "Long March 7 Launch Vehicle Completed Booster Engine Firing Test." 26 Nov. 2013. China Manned Space Engineering 2 May 2014. http://en.cmse.gov.cn/show.php?contentid=1355.

[197] "Chinese Rocket Engine Test a Big Step for Space Station Project." 15 July 2013. Space.com 2 May 2014. http://www.space.com/21957-china-rocket-engine-test-space-station.html.

would be mounted in the first stage. While work is underway on the engines, the Chinese industry is still awaiting permission to begin developing the Long March 9.[198]

In the field of satellite development, the new Chinese space policy describes a comprehensive programme embracing all fields of satellite and spacecraft use. It calls for the development of improved weather and communications satellites, as well as of an entirely new Earth observation and electromagnetic monitoring satellite series. The key plank of this programme will be the development of a satellite fleet capable of all-weather 24-h operations worldwide, which would imply making significant advancements in space borne SAR and high resolution optical instrument technologies. Finally, the new policy reiterated China's goal of fielding a regional satellite navigation capability by the end of 2012 and completing the deployment of its entire 35 satellite Beidou GNSS constellation by 2020. On 27 December 2013, China announced that it expects to launch upgraded Beidou satellites by 2020, with accuracy expected to be upgraded to the meter or sub-meter level by that time. The Beidou system began providing positioning, navigation, timing and short message services to civilian users in China and surrounding areas in the Asia-Pacific region in December 2012, with accuracy to within 10 m.[199]

In the area of orbital spacecraft development and human spaceflight, China has made substantial headway in fulfilling the goals of its manned programme's three-step strategy (i.e. first perfecting its human spaceflight transportation system, then building a space station and moving on to a manned moon landing), so far demonstrating the program's ability to stage simple spacewalks and to navigate and dock in orbit. However, those capabilities will need to be even further expanded prior to attempting to assemble China's planned modules into a 60-ton space station staffed by taikonauts for months at a time. Following the launch of China's Shenzhou 10 mission in June 2013, which lasted more than 14 days and featured television transmissions from the three-person crew inside Tiangong 1, China has moved onto the next stage in station development focusing on the 2015 launch and operation of a larger space station testbed named Tiangong 2, followed by a more spacious experimental space station around 2018.[200]

On 31 October 2013, the names of China's future station and cargo ship were released, to be listed as follows: China's manned space station is named "Tiangong" (TG); the core module is "Tianhe" (TH); the Experimental Module-1 is "Wentian" (WT); Experimental Module-2 is "Xuntian" (XT); and the cargo

[198] "Chinese Super-Heavy Launcher Designs Exceed Saturn V." 30 Sept. 2013. Aviation Week 2 May 2014. http://aviationweek.com/awin/chinese-super-heavy-launcher-designs-exceed-saturn-v.

[199] "China's BeiDou Satellite System Expected to Achieve Global Coverage By 2020." 27 Dec. 2013. Xinhuanet 2 May 2014. http://news.xinhuanet.com/english/china/2013-12/27/c_133001847.htm.

[200] "Tests Loom in China's Next Decade of Human Spaceflight." 15 Oct. 2013. Spaceflight Now 2 May 2014. http://spaceflightnow.com/news/n1310/15shenzhou/.

spaceship is named "Tianzhou" (TZ).[201] The primary emphasis of research on the station will be life and physical sciences, with the former divided into five areas: fundamental biology, biotechnology, space radiation biology, fundamental studies on cells and interdisciplinary studies; and the latter including biological mechanics research and hypomagnetic biology. Planned to operate in orbit from 2022 to 2032, officials in China aim to provide opportunities to scientists in China and all the world.[202]

1.2.9 India

By tradition, Indian policy aims at achieving social and economic development through space activities. India's government approved the 12th Five-year plan (2012–2017) with the aim of achieving an annual average economic growth rate of 8.2 %, reduced from the 9 % envisaged earlier, in view of fragile global recovery.[203] However, India's space programmes are driven by a decade profile and directions for 2025. The broad directions for the space programme for the next decade include: (i) strengthening operational services in communications and navigation; (ii) developing enhanced imaging capability for natural resource management, weather and climate change studies; (iii) space science missions for better understanding of the solar system and the universe; (iv) planetary exploratory missions; (v) development of heavy lift reusable launch vehicles and (vi) a human space flight programme. Innovations in space-based communications and earth observations will be pursued to achieve faster delivery of information to remote areas and finer observations of earth. Overall, 58 missions are planned for realisation during the Twelfth Plan period which includes 33 Satellite missions and 25 Launch Vehicle missions.[204]

While a human spaceflight mission will not be conducted before the year 2017, there are funds in the 12th Five-year plan to continue with pre-project studies and to develop critical technologies associated with the proposed mission. However, India still lacks an operational GLSV needed to launch a two-member crew to LEO and have them return safely to Earth. While India's GSLV-Mk II (rocket) was proposed

[201] "China Manned Space Program Logo and Names of Space Station and Cargo Ship Officially Released." 31 Oct. 2013. China Manned Space Engineering 2 May 2014. http://en.cmse.gov.cn/show.php?contentid=1354.

[202] "China Unveils Space Station Research Plans." 12 Nov. 2013. SpaceNews 2 May 2014. http://spacenews.com/article/civil-space/38131china-unveils-space-station-research-plans.

[203] "Government Approves 12th Five Year Plan." 4 Oct. 2012. The Times of India 3 May 2014. http://timesofindia.indiatimes.com/business/india-business/Government-approves-12th-five-year-plan/articleshow/16672927.cms.

[204] "Twelfth Five Year Plan (2012–2017)." 10 May 2013. Planning Commission Government of India 3 May 2014: p.264. http://planningcommission.gov.in/plans/planrel/12thplan/pdf/12fyp_vol1.pdf.

to be used for the mission, it would be able to carry only the two-member crew; the GSLV-Mk III that is currently under development will have additional mass left for conducting scientific experiments in addition to hosting a two-member crew.[205]

1.2.10 Brazil

Despite long-standing obstacles for Brazil's space and R&D development, and the lack of expertise in its workforce, Brazil is becoming an important space player of the future due to its geographic position close to the equator, and its rapidly growing economy. Brazil released its 'National Program of Space Activities 2012–2021' in 2012, with the advancement of industry as its top priority. As part of its strategic guidelines the country plans to consolidate the Brazilian space industry by increasing its competitiveness and innovation capacity, also through the use of the state's purchasing power and partnerships with other countries. It will develop an intensive programme of critical technologies in order to foster capacity building in the space sector, with greater participation of academia, S&T governmental institutions and industry. Partnerships with other countries will be expanded, by prioritizing joint development of technological and industrial projects of mutual interest. It will also encourage funding of programs based on PPPs, and will promote greater integration of the space activities governance system in the country by increasing synergy and effectiveness of actions among its main players and the creation of the National Space Policy Council, run directly by the Presidency of the Republic. Legislation affecting space activities will be improved by encouraging and facilitating government purchases, allocating more funds for the Space Sectoral Fund, and decreasing taxes on industry. And Brazil will encourage the development of human resources by training of experts needed in Brazilian space activities, both domestically and abroad—in addition to promoting public awareness on the relevance of the study, use, and development of the space activities in Brazil. Overall, Brazil's space plan calls for expenditure of 9.1 billion reals ($4.6 billion) on its space programme through 2021, in which the budgeting of 900 million reals per year is considered to be essential to generate the necessary growth and sustainability of Brazil's space sector.[206] A total of 47 % of the budget is devoted to a series of satellite missions, while 26 % is for space infrastructure and 17 % for space access projects.[207]

Brazil has cultivated partnerships with space powers around the globe. With respect to China, the two nations have an ongoing global strategic partnership,

[205] "India Not to Undertake Human Space Flight Before 2017: ISRO." 17 Sept. 2012. The Economic Times 3 May 2014. http://articles.economictimes.indiatimes.com/2012-09-17/news/33902713_1_cryogenic-engine-gslv-mk-iii-radhakrishnan-today.

[206] "National Program of Space Activities 2012–2021." 15 Mar. 2013. AEB 3 May 2014. http://www.aeb.gov.br/wp-content/uploads/2013/03/PNAE-Ingles.pdf.

[207] "Brazil Scales Back Launch Vehicle Plans." 10 Feb. 2013. Parabolic Arc 3 May 2014. http://www.parabolicarc.com/2013/02/10/brazil-scales-back-launch-vehicle-plans/.

mainly developed from the China-Brazil Earth Resources Satellite (CBERS) project that began in 1988.[208] On 9 December 2013, a malfunction in the third stage of China's Long March 4B rocket resulted in the loss of the CBERS-3 Earth observation satellite. Nevertheless, the partners are continuing with the CBERS programme, already beginning development of the CBERS-4 satellite. The first CBERS-1 launched in 1999, with CBERS-2 following in 2003, and CBERS-2B in 2007.[209]

Brazil is also undertaking cooperative programs with Ukraine to build six Cyclone-4 rockets that could launch heavy satellites into low Earth orbit (LEO) and small communications satellites to geostationary transfer orbit. Brazil and Ukraine created the binational company "Alcântara Cyclone Space" (ACS), with financing divided equally, for commercial launches using the Ukrainian vehicle Cyclone-4 from the Alcântara Launch Center (CLA) whose proximity to the equator gives the launch vehicle more capacity to orbit than can be offered from Russian spaceports.[210] The launcher development program is estimated to cost 1.58 billion reals ($802.5 million) over the 10-year period. The Cyclone-4 program, listed as a separate budget item, is allocated an additional 459.8 million reals ($233.8 million) during the 10-year period. Moreover, around 1.9 billion reals ($970 million) has been allocated for space infrastructure improvements, mostly going toward development of the ALC. Brazil hopes to launch the Cyclone-4 rocket from the ALC in 2014.[211]

Russia will aid Brazil in its plans to become self-sufficient in launcher and space technology, following its delegation's visit to Brazil during a Latin American tour on 14–17 October 2013. While Brazil's Satellite Launch Vehicle (VLS-1) project was paused in 2003, following an explosion on the launch pad killing 21 people, development recently began again, albeit with a shortage of funding and trained personnel. Under a previous agreement between Roscosmos and the Brazilian Space Agency (AEB), Russia will provide launcher technology to help complete Brazil's VLS-1 project.[212]

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[208] Ibid.

[209] "China Blames Long March Failure on Third-stage Malfunction." 10 Dec. 2013. SpaceNews 3 May 2014. http://www.spacenews.com/article/launch-report/38585china-blames-long-march-failure-on-third-stage-malfunction.

[210] "News from the 64th International Astronautical Congress | Backers Insist Brazilian Spaceport Is Nearing Launch Readiness." 4 Oct. 2013. SpaceNews 3 May 2014. http://www.spacenews.com/article/launch-report/37550news-from-the-64th-international-astronautical-congress-backers-insist.

[211] "Brazil Scales Back Launch Vehicle Plans." 10 Feb. 2013. Parabolic Arc 3 May 2014. http://www.parabolicarc.com/2013/02/10/brazil-scales-back-launch-vehicle-plans/.

[212] "Russia Offers Brazil New Joint Space Projects." 20 Oct. 2013. RIA NOVOSTI 3 May 2014. http://en.ria.ru/russia/20131020/184250734.html.

1.2.11 Emerging Space Powers

On 30 January 2013, South Korea successfully launched its Naro-1 rocket (previously known as the Korea Space Launch Vehicle (KSLV)). It lifted the 100 kg Korean-built STSat-2C technology demonstration satellite to LEO orbit, to operate for 1 year taking measurements of the space radiation environment. This marked the first success of the launcher after two previous launch failures in 2009 and 2010, making South Korea the 11th nation to launch a rocket into space from its own territory. While this launcher uses a Russian built RD-151 engine that is a similar, less powerful version of the engine to be used in Russia's Angara launcher, South Korea expects to develop a more powerful indigenous NGL by 2021. A sum of 529 billion Korean won ($479 million) has been invested into the Naro vehicle by the Korean government since development began, with a total allocation of more than 1.5 trillion won dedicated to the launch vehicle program through 2021.[213] With hopes high for the development of the NGL, South Korea intends to launch the upgraded KSLV-2 launcher to the Moon, carrying a 10–20 kg lunar rover to search for rare minerals on the surface, sometime after 2020.[214]

South Korea remains one of the most active emerging space actors, especially in the field of space applications. The Kompsat-3/Arirang-3 was launched on 17 May 2012 on a SSO orbit, constituting Korea's first satellite at a sub-meter resolution. Its sister satellite, Kompsat-3R with additional infrared capability will be launched in 2014. The Kompsat-5/Arirang-5 X-band Synthetic Aperture Radar (SAR) spacecraft was placed into LEO on 22 August 2013, adding radar to South Korea's existing optical Earth observation satellite capacity.[215] This campaign brings the total number of Korean-built satellites in orbit to a total of five, significantly improving both ground resolution and operational flexibility. Although the satellites were poised to provide imagery for civilian and scientific purposes, their improved operational characteristics enable military use as well. It is noteworthy that Korean authorities opted for open commercial market procedures in awarding the programme's contract, because the same commercially oriented approach is expected to prevail in the distribution of the satellites' products.[216]

During the reporting period, Singapore emerged as another Southeast Asian country with significant space aspirations. Most international commercial space companies maintain offices in the country, encouraged by favourable tax laws. In

[213] "Third Time Lucky for South Korea with Satellite Launch Success." 31 Jan. 2013 SpaceNews 4 May 2014. http://spacenews.com/article/third-time-lucky-for-south-korea-with-satellite-launch-success.

[214] "South Korea Reveals Moon-lander plans." 13 Nov. 2013. Nature.com 4 May 2014. http://www.nature.com/news/south-korea-reveals-moon-lander-plans-1.14159.

[215] "Dnepr Rocket Launches S. Korean Radar Satellite." 23 Aug. 2013. SpaceNews 4 May 2014. http://spacenews.com/article/launch-report/36910dnepr-rocket-launches-s-korean-radar-satellite.

[216] Perrett, Bradley. "Seoul Pushes Ahead With Spacecraft Program." Aviation Week & Space Technology 24/31 Oct. 2011: 44.

February 2013, Singapore began taking formal steps to build its space-satellite industry by setting up the Office for Space Technology and Industry (OSTIn), as an Economic Development Board programme that comprises multiple Government agencies to plan and execute economic strategies in that pursuit.[217] Concurrently, the Singapore Space and Technology Association (SSTA) and the Singapore Science Centre Board (SSCB) have a memorandum of understanding with a hi-tech start-up, IN.Genius, which plans to develop a space science education programme and send the first Singaporean to space by 2015.[218]

In the Middle East region, Iran continued to establish itself as a strong regional space actor, through the implementation of a comprehensive space programme. In 2012, the focus of Iran's space activities was space applications. Iran conducted three launches in 2012, with two launches resulting in failure. While Iran's Navid-e Elm-o Sanat remote sensing satellite was successfully launched on 3 February 2012, Iran's other two satellites launched on 23 May 2012 and 22 September 2012, failed to reach orbit.[219] The Navid-e Elm-o Sanat is another Iranian designed and built satellite, and is considered to be a technology validation mission, in addition to being a telecom, measurement and scientific satellite whose records could be used in a wide range of fields.[220] In 2013, Iran's pursuit of human spaceflight was central. On 16 December 2013, the country announced that it had successfully launched a monkey into sub-orbital space for the second time in 2013, sending it to a 120 km apogee altitude, with a safe return to Earth after a 15-min ride aboard a Kavoshgar 5 rocket.[221] Earlier in the year, controversy arose when archive photos were used by a news agency instead of actual photos of the first space monkey's return, creating doubt as to the accuracy of the claims by Iranian officials.[222] Having reached a new milestone, launches of animals are expected to continue into 2014, helping scientists continue to develop space technology in the pursuit of sending a human to space by 2018.

[217] "Singapore's Journey to Space: Government Plans to Build up Space-Satellite Industry." 21 Feb. 2013. Asia One 4 May 2014. http://news.asiaone.com/News/Latest%2BNews/Science%2Band%2BTech/Story/A1Story20130221-403539/2.html.

[218] "A Singaporean in Space by 2015?" 22 Feb. 2013. Yahoo News 4 May 2014. https://sg.news.yahoo.com/a-singaporean-in-space-by-2015--060646737.html.

[219] Federal Aviation Administration. Commercial Space transportation: 2012 Year in Review. Washington DC: FAA, Jan. 2013: 32.

[220] "Iran Successfully Launches New Satellite into Orbit." 3 Feb. 2012. EU Times 5 May 2014. http://www.eutimes.net/2012/02/iran-successfully-launches-new-satellite-into-orbit/.

[221] "Iran Says It Launched a Second Monkey Into Space (Video)." 16 Dec. 2013. Space.com 4 May 2014. http://www.space.com/23979-iran-space-monkey-launch.html.

[222] "Let's Get the Facts Straight About Iran's Space Monkey." 3 Feb. 2013. The Guardian 4 May 2014. http://www.theguardian.com/world/iran-blog/2013/feb/03/iran-space-monkey.

1.3 Worldwide Space Budgets and Revenues

Worldwide national space budgets continued to increase in 2012, although funding decreased in 2013. In 2012, total world governmental expenditure on space programmes amounted to $78.44 billion from $72.77 billion in 2011, with much of the increase going toward military programmes.[223] Total government expenditures for civil space programs decreased from $44.92 billion in 2011 to $42.24 billion in 2012.[224] In 2013, total world governmental expenditure on space programmes amounted to $74.10 billion, a 1.7 % decrease in the respective funding prior to conversion into US currency for comparison, with the US government decreasing its funding by 9.4 %, while non-US government investment increased by 10.1 %.[225] Total government expenditure for civil space programs decreased slightly to $42.17 billion in 2013.[226] It should be mentioned that the rate of overall growth of these space budgets has decreased in intervals since 2010. In the entire space industry, including commercial revenues and government expenditure, the compound annual growth rate (CAGR) peaked in 2010 at 6.3 %; thereafter in 2011 it reduced to 5.7 %, dropping lower to 4.1 % in 2012, and settling at 4.0 % in 2013.[227] A more detailed analysis of institutional budgets is set out in the following section.

The Space Reports of 2013 and 2014 were used as guides for the commercial revenue of space activities, listing the 2012 total revenue of commercial satellite services at about $115.97 billion. These revenues were compiled from various activities including telecommunications, Earth observation and positioning services. This amount is a 4.9 % increase from the $110.53 billion in 2011. The revenue of space-related commercial infrastructure including manufacturing of spacecraft and in-space platforms, launch services as well as ground equipment is estimated to have reached around $109.90 billion (this diminished amount corresponds to the 7 % decrease in launch attempts numbering 78 in 2012, down from 84 in 2011). Overall, total commercial space revenue in 2012 reached $225.87 billion.[228] In 2013, total revenue of commercial satellite services grew by 5.7 % reaching $122.58 billion, while space-related commercial infrastructure grew by 6.9 % reaching $117.49 billion; i.e. total commercial space revenue reached $240.07 billion in 2013.[229]

[223] The Space Report 2013. Colorado Springs: The Space Foundation, 2013: 26.

[224] Ibid. at 40. The amount was calculated by subtracting the total military expenditure on space from the total world governmental expenditure on space (see supra footnote).

[225] Space Report 2014: 24.

[226] Ibid. at 40.

[227] Space Report 2014: 24.

[228] Space Report 2013: 26.

[229] Space Report 2014: 24.

1.3.1 Overview of Institutional Space Budgets

From the Space Report, total institutional spending on space programs in 2012, including that of intergovernmental organisations, can be estimated to have increased by 1.3 % (prior to conversion into US currency for comparison) to $78.44 billion in 2012 from $72.77 billion in 2011; these estimates do not fully depict the changes in budgetary spending cycles in all states that are considered, though.[230] This space spending was comprised of a reduced 53.9 % share in civil expenditure ($42.24 billion of the total) and an increased 46.1 % share in defence expenditure ($36.2 billion); this ratio changed by a factor of 7.8 percentage points from 2011. Total institutional spending on space programs in 2013 decreased by 1.7 % to $74.10 billion, with civil expenditure ($42.17 billion of the total) increasing its share to 56.9 %, while global defence expenditure ($31.93 billion) held a reduced share of 43.1 %.[231]

On the other hand, estimates by Euroconsult listed 2012 civil space expenditure to be $41.30 billion, while its estimates for government expenditure for defence space programmes reached $31.69 billion.[232] Here, the 2012 ratio of defence expenditure relative to civil expenditure experienced moderate change compared to 2011, with a 56.6 % share for civil expenditure and a 43.4 % share in defence expenditure compared to 52 % and 48 % respectively in 2011. In 2013, civil space expenditure reached $43.72 billion, while defence space programmes amounted to $28.43 billion; changing the civil-to-defence ratio to 60.6 % toward civil expenditure, while 39.6 % of funding went to defence purposes.[233]

The Space Report 2012 estimated worldwide defence related space expenditure to be $27.85 billion in 2011, with 95 % of this funding going toward US national defence purposes, the 2013 edition of this report showed the US share of defence related space expenditure to have diminished substantially. In 2012, while worldwide defence related space expenditure increased to $36.2 billion, US spending in defence increased to $27.47 billion, reaching a 75.9 % share of the total amount; in the following year, worldwide defence related space expenditure declined to $31.93 billion, the US share of that amount ($21.72 billion) amounted to 68.0 %. The funds in the US came from, *inter alia*, the Department of Defence (DoD), the National Reconnaissance Office (NRO), and the National Geospatial-Intelligence Agency (NGA). It should be noted that a degree of uncertainty exists regarding expenditures

[230] Cf. Space Report 2013: at 37 and The Space Report 2012. Colorado Springs: The Space Foundation, 2012: 43; note: Figures in this section are based on the Space Report 2013 data (USA, Russia, Japan, China, and France), while all other values in figures 2.1 & 2.2 come from the Euroconsult Report 2013—Profiles of Government Space Programs.

[231] Cf. Space Report 2014 at 40 and The Space Report 2013. Colorado Springs: The Space Foundation, 2013: 37; note: Figures in this section are based on the Space Report 2013 data (USA, Russia, Japan, China, and France), while all other values in figures 2.1 & 2.2 come from the Euroconsult Report 2013—Profiles of Government Space Programs.

[232] Profiles of Government Space Programs. Paris: Euroconsult, 2014: 9–12.

[233] Ibid.

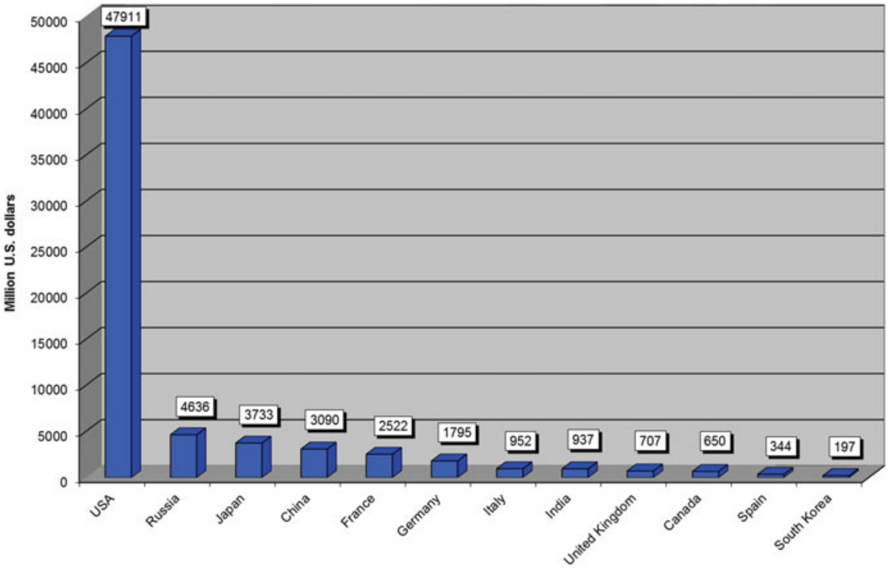

Fig. 1.1 Public space budgets of major space powers in 2012 (Based on Euroconsult and the Space Report 2013 data)

on defence space activities as not all relevant funding is made public. While the United States is still clearly a driving force in worldwide space activity, particularly in the defence area, its lead has begun to diminish while other states have continued to gain ground (Figs. 1.1 and 1.2).

The expenditure hierarchy among states remained unchanged in 2012, but saw significant reordering in 2013. The United States holds a strong lead position, with the largest space budget placing $20.44 billion toward civil purposes, and $27.47 billion toward defence; in 2013, $19.54 billion went toward civil purposes and $21.72 billion toward defence.[234] Russia's budget, though increasing by 12.5 % in 2012 and 18.2 % in 2013, is still considered as underestimated due to sparse information on its classified military launches, and its scientific programmes. In 2013, China took third position in funding, previously held by Japan. While France increased its spending in 2012 by 11.1 %, it was overtaken by Germany in 2013.[235] India and Italy reduced the gap for the 7th position, with India increasing its budget by 27.5 % in 2013, while Italy saw a 16.1 % increase in its space spending for civil and military purposes.

The European Space Agency maintained a relatively unchanged budget for 2012 of 4.02 billion Euros ($5.17 billion), nominally increasing the amount from 3.994 billion Euros ($5.33 billion) in 2011.[236] In 2012 the five biggest contributors were

[234] The Space Report 2014, 38.

[235] Ibid. at 47.

[236] "ESA Budget for 2012." ESA 15 May 2012.

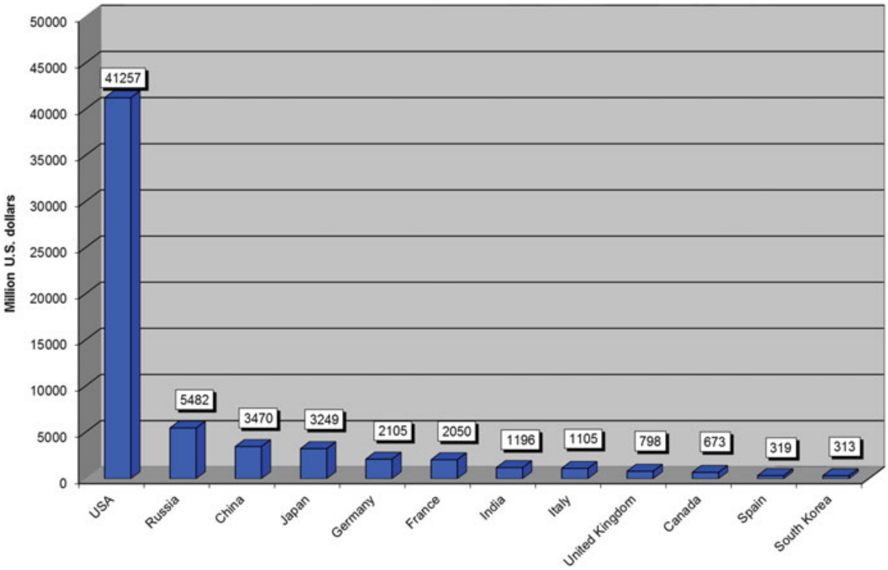

Fig. 1.2 Public space budgets of major space powers in 2013 (Based on Euroconsult and the Space Report 2014 data)

Germany 18.7 %, France 17.9 %, Italy 8.7 %, the UK 6.0 %, and Spain 4.6 %. The biggest ESA contributors in 2013 were Germany 18.0 %, France 17.5 %, Italy 9.3 %, the UK 7.0 %, and Spain 3.5 %.[237]

And while Japan's budget listed another reduction of 3.7 % in 2012, moving from ¥309.4 billion to ¥298.0 billion; its space budget increased by 8.1 % to ¥322.2, marking a shift from Japan's reduced spending immediately following its regional crisis and a change in its priorities.[238] The increasing civilian budgets of the Asian space powers, Japan, China, and India have helped to balance the world concentration of space expenditure, accounting for about 11.8 % of the whole, whereas the US, Europe (including ESA contributions), and Russia, generated around 82.9 % of that expenditure in 2013.[239]

When measuring the concrete effort of countries in the space sector it is necessary to put the figures into perspective in regard to GDP[240] (Figs. 1.3 and 1.4). Yet considering the absolute numbers alone will paint only a partial picture

[237] "ESA Budget 2013." 24 Jan. 2013. ESA 2 Feb. 2014. http://www.esa.int/About_Us/Welcome_to_ESA/Budget_as_presented_during_DG_press_conference_24_January_2013.

[238] The Space Report 2014, 52.

[239] Euroconsult 2014: 8.

[240] The data used is the nominal GDP converted to current U.S. dollars using the official exchange rates as indicated by the International Monetary Fund.

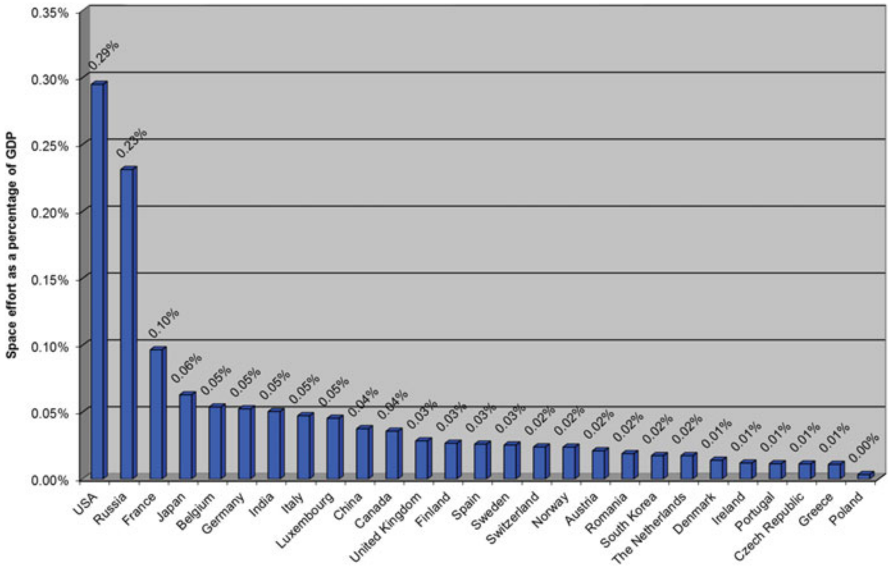

Fig. 1.3 Public space budgets (selection) as a share of nom. GDP in 2012 (source: Euroconsult/IMF)

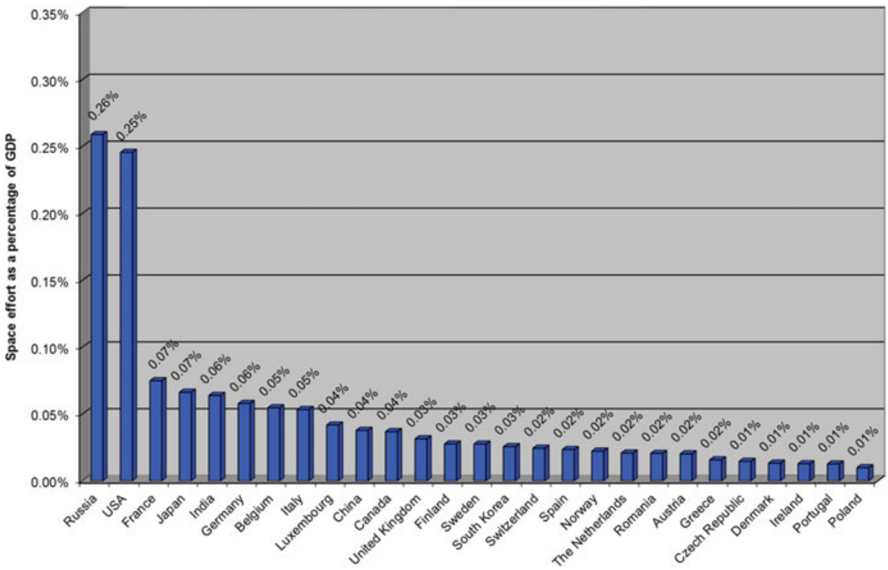

Fig. 1.4 Public space budgets (selection) as a share of nom. GDP in 2013 (source: Euroconsult/IMF)

since comparisons between countries with different economic conditions (e.g. purchase power parities or wage levels) can be misleading.

In 2012 and 2013, US space budget figures continued to diminish, falling to 0.29 % in 2012 from 0.31 % in the previous year; they dropped even further to 0.25 % in 2013. What is most revealing in this comparison is that while the US amount still evidences its strong engagement in the space field, in 2013 the US dropped to second position in terms of space budgets as a percentage of GDP. While the US seems to be tapering off its level of investment, Russia's space effort has continued to increase, moving up by 0.01–0.23 % in 2012, followed by an increase to 0.26 % in 2013, which surpassed the US for first position. France reclaimed its 3rd position spot relating to space efforts as a percentage of GDP for both 2012 and 2013 with 0.10 % and 0.07 % respectively, while Japan and India maintained their spending ratios at 0.07 % and 0.06 % respectively in 2013. In both 2012 and 2013, Germany, Belgium, and Italy invested 0.05 % of their GDP on space activities, while the other leading space countries in Europe continued to invest 0.05 % or less (Fig. 1.5 and 1.6).

While the US dominated per capita space expenditure in 2012 at $152.63 (an increase of 0.7 % from 2011), its lead dropped by 14.5 % to $130.48 in 2013. France's per capita space budget remained relatively unchanged between 2012 and 2013, staying at about $32 (a 10.5 % decrease from 2011). Luxembourg's per capita budget maintained second place with $50.00 for both years (a 13.6 % increase from 2011); Belgium's amount grew to $23.87 (barely increasing from $23.55 in 2011), with funding from both states directed toward participation in ESA (Luxembourg

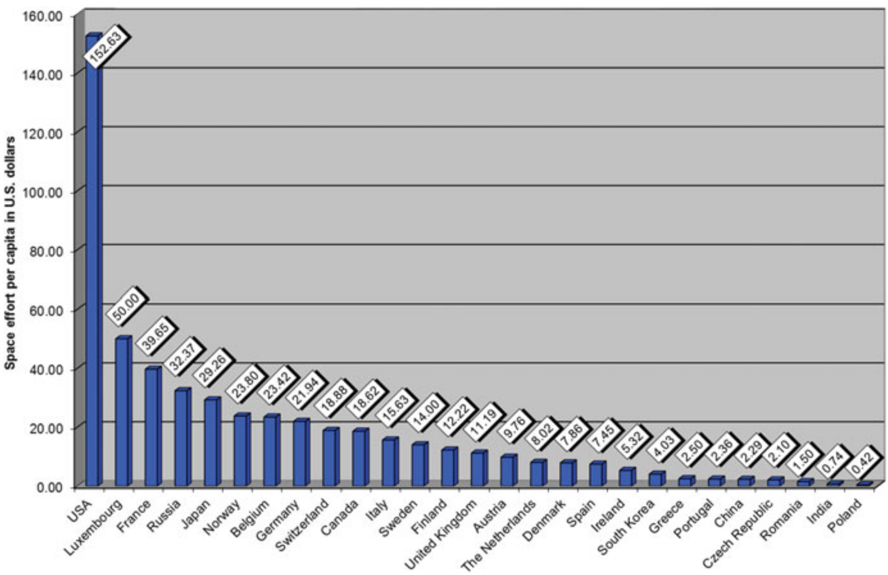

Fig. 1.5 Public space budgets per capita (selection) in 2012 (source: Space Report 2013/ Euroconsult/Population Reference Bureau)

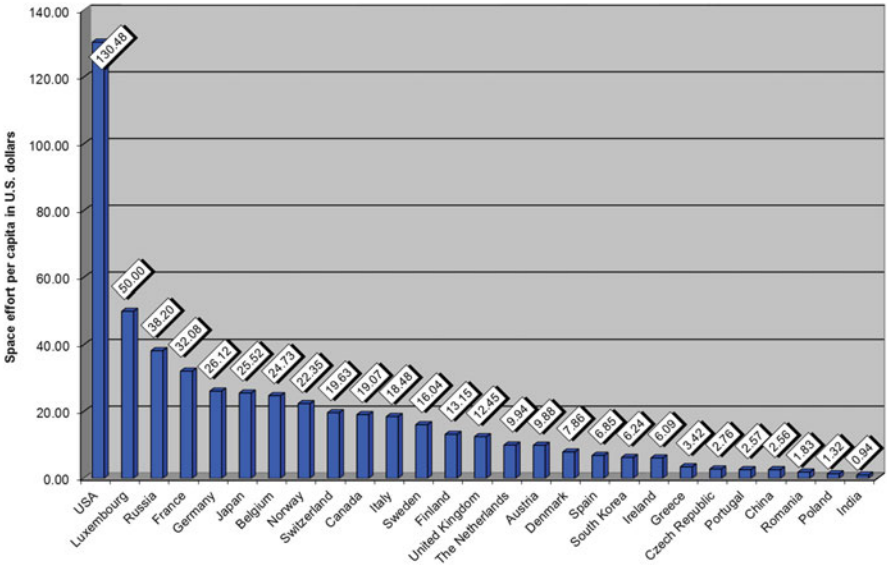

Fig. 1.6 Public space budgets per capita (selection) in 2013 (source: Space Report 2014/ Euroconsult/Population Reference Bureau)

contributed 0.37 %, and Belgium 4.2 % to ESA's 2012 Space Budget, and 0.35 % and 4.4 % respectively to the 2013 budget). While, Norway had advanced its position in its per capita space budget beyond Belgium and Germany, increasing its amount by 13.3 % to $23.8 in 2012, it was surpassed in the following year by both countries, spending a reduced $22.35 for 2013. And in 2012, Japan's per capita budget decreased by 2.4 % while also being overtaken by Russia's 12.2 % increase; the gap between the two expanded even further in 2013, though that is partially due to currency exchange discrepancies as both countries increased their spending significantly.[241] In 2012, the per capita space budgets of 11 European states decreased (including the Netherlands, Sweden, Denmark, Austria, Finland, Portugal, Ireland, Spain, Italy, Germany, and Belgium) with the most substantial decrease being that of the Netherlands, dropping by 30.9 %; the decrease of the other states mentioned did not exceed 13 %. Nevertheless, the same number of states have experienced an upswing in per capita space funding since 2011 (including Romania, Canada, the United Kingdom, Luxembourg, Norway, Russia, France, the Czech Republic, Greece, Switzerland, and the United States). Authoritative sources differ on the situation in India and China due in part to their socio-economic characteristics.

In 2013, while Luxembourg and Denmark showed little change from the previous year, a large majority of the states considered experienced growth in their per capita space funding. Poland had the most dramatic change at 216.3 %, along with

[241] The Space Report 2013: 52–53, and The Space Report 2014: 52–53.

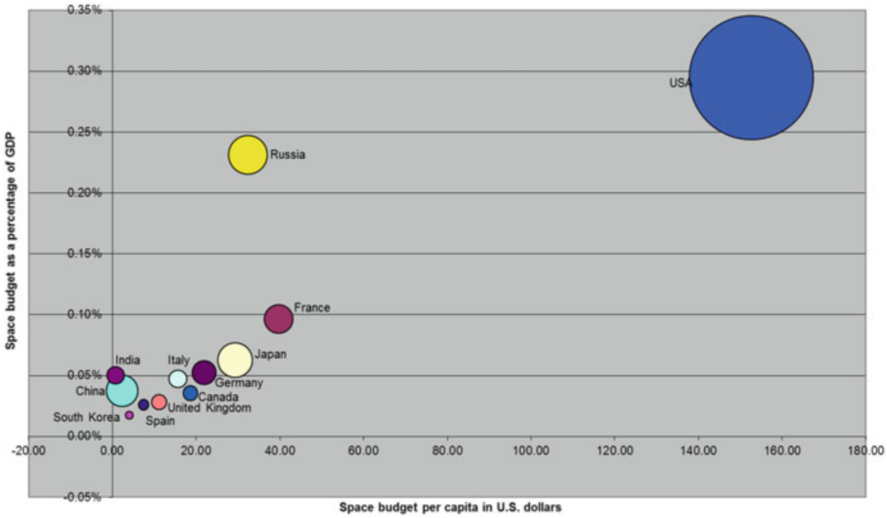

Fig. 1.7 Public space budgets as share of GDP mapped against space budgets per capita in 2012. The bubble size indicates the absolute space budget (Based on Space Report 2013 and Euroconsult data)

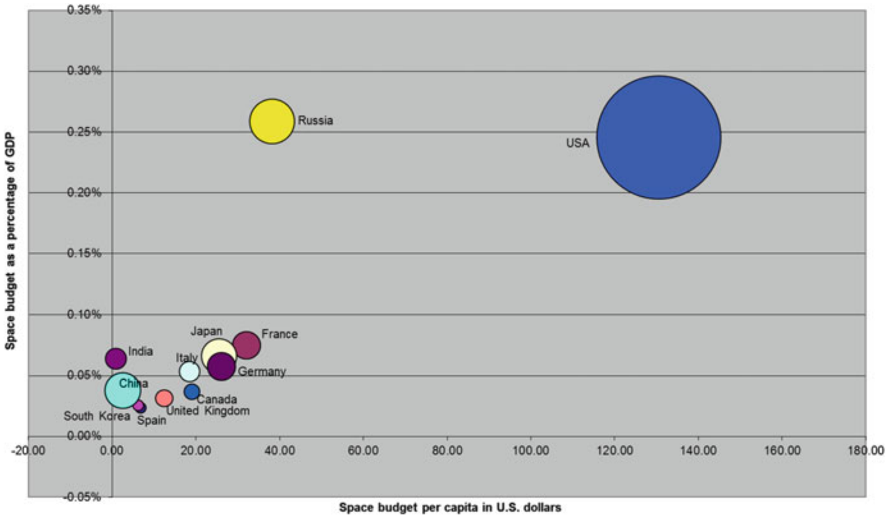

Fig. 1.8 Public space budgets as share of GDP mapped against space budgets per capita in 2013. The bubble size indicates the absolute space budget (Based on Space Report 2014 and Euroconsult data)

South Korea's strong increase of 54.8 %, and eight other European states saw growth of over 14 % (i.e. Greece, Czech Republic, the Netherlands, Romania, Germany, Italy, Sweden, and Ireland); the US had a 14.5 % reduction from the previous year, while France's decrease was an even larger 19.1 % (Figs. 1.7, 1.8, 1.9, and 1.10).

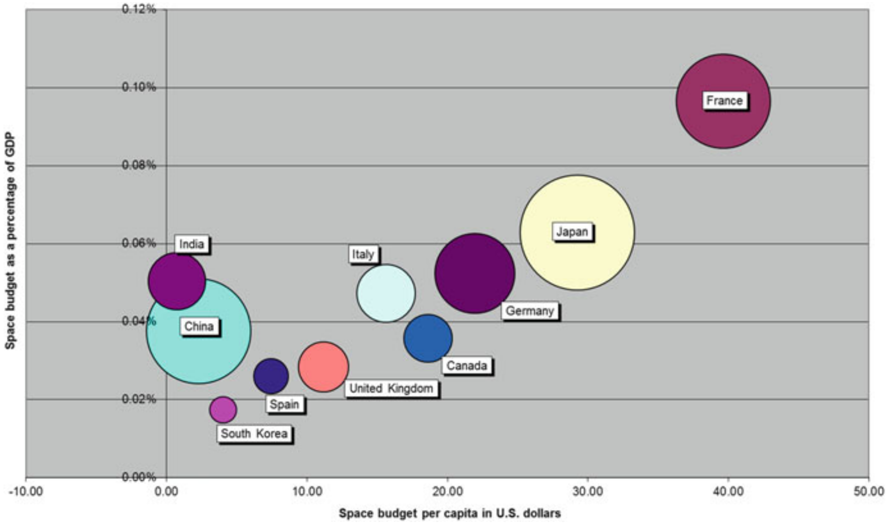

Fig. 1.9 Public space budgets as a share of GDP mapped against space budgets per capita in 2012, not including the U.S. and Russia. The bubble size indicates the absolute space budget (Based on Space Report 2013 and Euroconsult data)

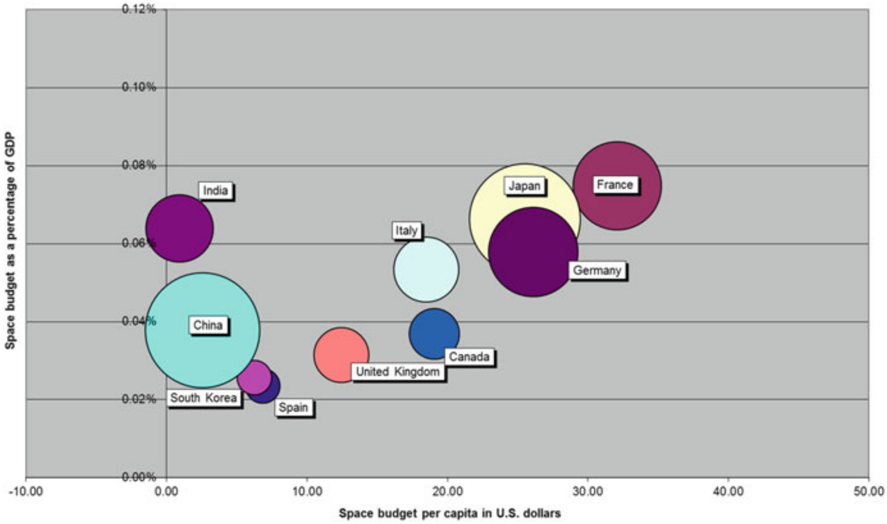

Fig. 1.10 Public space budgets as a share of GDP mapped against space budgets per capita in 2013, not including the U.S. and Russia. The bubble size indicates the absolute space budget (Based on Space Report 2014 and Euroconsult data)

1.3.2 Overview of Commercial Space Markets

In 2013, global industry revenues, including revenue from satellite services, satellite manufacturing, launch industry, and ground equipment continued to grow as shown in both Satellite Industry Association (SIA) and Space Report 2014 assessments. The SIA reported global satellite revenues at $177.4 billion in 2011, $189.5 billion in 2012, and $195.2 billion in 2013[242]; whereas the Space Report lists total commercial revenues for 2011, 2012, and 2013 to have been $216.99 billion, $225.87 billion, and $240.07 billion, respectively.[243] However, it must be clarified that these authorities appear to use different methods of assessment. In fact, total revenue is slowly on the uptick, with the SIA reporting continued growth following the industry bottoming out at 5 % in 2010. In 2010, the industry generated revenue of $168.0 billion; but revenue growth increased by 6 % in 2011 to generate $177.4 billion, and then by 7 % in 2012 to generate $189.5 billion.[244] As indicated in previous assessments, there is a discrepancy in the findings of SIA and the Space Report, amounting to a difference of $36.37 billion between the 2012 figures, and $30.67 billion in 2013 figures; a likely consequence of the different reporting methodologies. The following section presents key figures and data on commercial space activities divided by field of activity, based primarily on available SIA figures generated by the Tauri Group, in addition to previous Futron reports.

1.3.2.1 Satellite Services

A sustained expansion of satellite capacity and corporate revenue was fuelled by continued demand from emerging economies and developing regions. Worldwide satellite capacity jumped by 64 % from 900 36 MHZ transponder equivalents in 2011 to exceed 1,400 transponder equivalents in 2012.[245] However, in the following year, budget crunches in the US likely resulted in the reduction of orders for transponder equivalents to around 800 for the year 2013.[246] While growth appears to be slightly increasing in the satellite industry, satellite services have maintained a consistent share portion among the other segments, including satellite manufacturing, launch services, and ground equipment; maintaining a share portion of 59.9 % in 2012, a slight decrease from the 60.8 % share in 2011; the satellite services share portion returned to 60.8 % in 2013. Satellite services earned $107.8 billion in 2011, $113.5 billion in 2012, and $118.6 billion in 2013, due mostly to the increase in direct to home (DTH) satellite services. However, the rate of revenue growth for

[242] "State of the Satellite Industry Report." May. 2014. Satellite Industry Association and The Tauri Group 24 May 2014. http://www.sia.org/wp-content/uploads/2014/05/SIA_2014_SSIR.pdf.

[243] The Space Report 2012, 32; The Space Report 2013, 26; and The Space Report 2014, 24.

[244] State of the Satellite Industry Report, 4.

[245] Satellite Telecommunications Report—2012 Year-End Summary. Futron: 1.

[246] Satellite Telecommunications Report—2013 Year-End Summary. Futron: 1.

satellite services has continued to decrease, declining from 16 % growth in 2008, to rest at 5 % for both 2012 and 2013.[247]

Satellite services can further be deconstructed into their component parts, including consumer services (satellite radio (DARS), and consumer satellite broadband), fixed satellite services (e.g. transponder agreements, and managed services), as well as mobile services (voice and data), and remote sensing. The following is a breakdown of the industry's key developments and trends, according to the nature of the services provided.

1.3.2.2 Consumer Services

As mentioned above, consumer services are made up of satellite television, radio, and broadband services. Direct Broadcast Services (DBS) also include direct-to-home satellite television. This section of the industry showed considerable development in 2012 and 2013, fuelled by the quantitative expansion in emerging markets and the qualitative increase in new technologies and services in developed ones. While demand revenue increased from 2011, its rate of growth slipped from 9.5 % in 2011 to 5.3 % in 2012 and 4.8 % in 2013. While in 2011, DBS revenue was $84.4 billion, it increased by just 4.7 % to $88.4 billion in 2012, and by another 4.7 % to $92.6 billion in 2013. This growth was mainly attributed to the number of HDTV channels in recent years, i.e. this growth amounted to 3,853 channels or a 42 % increase by 2011, 4,768 channels or a 24 % increase by 2012, and around 6,246 channels or a 31 % increase by 2013.[248] In 2012 and 2013, consumer satellite television services accounted for about 78 % of total satellite services revenue, with the share of available HDTV channels servicing Europe and Asia increasing to 41 %, while the share of available HDTV channels in the Americas reduced from 70 % in 2011 to around 59 % by 2013. In fact, while the annual growth rate of DBS was expected to exceed that of the rest of the satellite services' sector with DBS replacing more traditional services such as video distribution, the growth rate of satellite radio and satellite broadband advanced in both 2012 and 2013.[249] By 2013, there were over 200 million satellite pay-TV subscribers worldwide, with 42 % of global revenues attributed to the US; satellite radio revenue grew from $3.0 billion in 2011 to increase by 13.3 % to $3.4 billion in 2012, and by another 11.8 % to reach $3.8 billion in 2013. Similarly, satellite broadband revenue grew by 25 %, from $1.2 billion in 2011 to $1.5 billion in 2012, and by 13.3 % to $1.7 billion in 2013.[250]

[247] 2014 State of the Satellite Industry Report: 11.

[248] Ibid.

[249] Ibid.

[250] Ibid.

Additionally, the majority of worldwide broadband satellite revenue continued to flow from the US, generating around 70 % of the revenue generated in 2013. All major satellite operators have increased their investments in new technologies and products in developed markets, while new services entered into operation by the end of 2013.

1.3.2.3 Fixed Satellite Services

Fixed Satellite Services (FSS) refers to the use of spacecraft that utilise land terminals in fixed positions to broadcast. Whereas Consumer Services covers satellite broadband Internet, communications and network televisions and radio broadcasts, FSS relates to commercial signal agreements, such as transponder agreements and managed network services. From 2011 to 2013 the FSS outlook remained positive, as operators continued to profit from previous investments in new capacity, as well as from the sustained demand for satellite TV, radio, and broadband services.

While some reports had anticipated a decrease in new satellite investment leading up to 2012–2013, the effect of the current boom in FSS is expected to continue throughout the decade. Industry-wide FSS revenue climbed by 4.7 % to $15.7 billion in 2011, by another 4.5 % to $16.4 billion in 2012; and remained unchanged at $16.4 billion in 2013. The growth is explained by the continued demand for video and broadband, mainly from the Americas, but with additional growth in Europe and Asia. The revenue generated by Eutelsat is a clear example of this upward trend with its 2012 revenue climbing to 1.222 billion Euros ($1.537 billion); these were increases of 4.6 % and 3.3 % from the previous year's revenues of 1.168 billion Euros and 926.4 million Euros, respectively.[251] By year-end 30 June 2013, Eutelsat's revenue increased by another 5.1 % to 1.284 billion Euros ($1.670 billion).[252]

To handle the increase in demand, coming especially from HDTV consumers, commercial operators invested in technological upgrades that let them meet the needs of consumers while still making significant profits. Transponder agreement revenue continued to expand in 2011 and 2013, with growth evident across multiple regions. Similarly, while the number of HDTV channels has jumped in successive

[251] Eutelsat Communications. "Eutelsat Communications—Solid Full Year 2011–2012 Results." 30 July 2012 Eutelsat 16 May 2014. http://www.eutelsat.com/home/investors/financial-information/financial-press-releases-2013-20/2011-2012/press-list-container/eutelsat-communications-solid.html.

[252] Eutelsat Communications. "Eutelsat Communications—Solid Full Year 2011–2012 Results." 30 July 2013 Eutelsat 16 May 2014. http://www.eutelsat.com/home/investors/financial-information/financial-press-releases-2013-20/2012-2013/press-list-container/eutelsat-communications-reports.html.

years from around 1,500 in 2009 to over 6,000 in 2013, with nearly 59 % serving the Americas, growth continues in Europe and Asia.[253]

1.3.2.4 Remote Sensing

Remote sensing refers to commercial companies that provide optical and radar images to the open market; however, they are mostly used by government entities that have been increasingly outsourcing such capabilities over the past few years. While commercial remote sensing revenue increased by 42.9 % in 2009, it stayed at the $1 billion benchmark throughout 2010, growing by 10 % to $1.1 billion in 2011, by 18.2 % to reach $1.3 billion in 2012, and by 15.4 % to $1.5 billion in 2013.[254] US government demand in addition to good industry performance were the dominant factors boosting remote sensing services providers' revenue over the course of 2011–2013.

A total of 12 civilian remote sensing satellites were launched in 2012; an increase of 20 % from the 10 remote sensing satellites launched in 2011 (not including government-built, university-built, or research satellites).[255] Additionally, 14 military surveillance satellites were launched in 2011; however, the number of military surveillance satellites launched in 2012 was 64.3 % less, amounting to five satellites for that year. In 2013, around 16 civilian remote sensing satellites were launched, in addition to 11 military surveillance satellites. While the total number of civilian and military remote sensing satellites in orbit increased in 2012 and 2013, the civil industry continues to outpace military spacecraft by a significant margin, indicating a shift in where government funding is directed, and suggesting that states are looking more toward PPPs in this field.

1.3.2.5 Mobile Satellite Services

Mobile satellite services offer both mobile data service and mobile voice service (including satellite phones). Over the course of 2011 and 2012, mobile satellite services earned revenue of $2.4 billion each year, thereafter increasing by 8.3 % to $2.6 billion in 2013. Within its segments, revenue earned by mobile voice services has remained relatively unchanged since 2009, staying at $700 million in 2012, and increasing to $800 in 2013; whereas mobile data services revenue has increased by $100 million increments since 2009, reaching $1.8 billion in 2012, and staying at

[253] "State of the Satellite Industry Report." Oct. 2013. Satellite Industry Association and The Tauri Group 24 May 2014: 11–14. http://www.sia.org/wp-content/uploads/2014/05/SIA_2014_SSIR.pdf.

[254] 2014 State of the Satellite Industry Report, 11.

[255] Ibid. at 17.

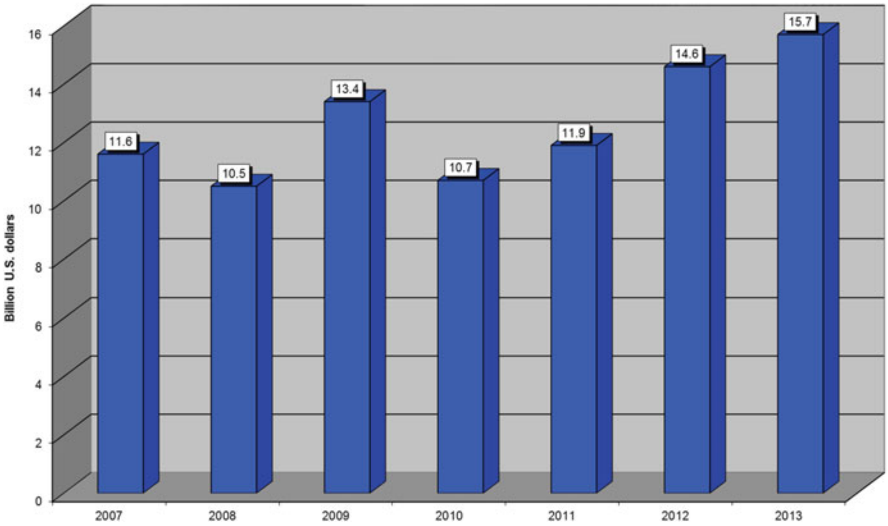

Fig. 1.11 World satellite manufacturing revenue (Source: SIA)

that level in 2013. The latter segment comprises nearly 70 % of all mobile satellite services revenue.[256]

1.3.2.6 Satellite Manufacturing

The total revenue of satellite manufacturers that built satellites both for governmental and commercial launches in 2011 amounted to $11.9 billion; midway between the revenues earned in the previous 2 years, and an increase of 11 % from 2010. Satellite manufacturing revenue increased by another 23 % in 2012, earning $14.6 billion; it increased by a further 7.5 % to reach $15.7 billion in 2013.[257] As displayed in Fig. 1.11, manufacturing revenue exceeded the growth trend forecasted by Futron in 2010, with actual revenue surpassing the $15 billion revenue expected to be reached in 2013.[258] It should be noted that the US earned 56.2 % of 2012 manufacturing revenue, amounting to $8.2 billion, with 61 % of those earnings coming from US government contracts.[259] In 2013, the US earned 69.2 % of 2013 manufacturing revenue, amounting to $10.9 billion, with 75 % of those earnings came from US government contracts.[260]

256 Ibid. at 11.

257 State of the Satellite Industry Report, 16.

258 2010 Futron Forecast of Global Satellite Services Demand: Executive Summary.

259 State of the Satellite Industry Report, 16.

260 2014 State of the Satellite Industry Report, 18.

1.3.2.7 Commercial Space Launch

The year 2012 ushered in a total of 20 successful commercial launches, with 27 commercial services payloads carried into orbit. These payloads made up 19.4 % of the 139 payloads launched in 2012 in 78 launch events. In 2012, US companies once again conducted commercial launches, whereas in 2011 none were conducted. Two of the 13 launches conducted by US launchers were commercial; amounting to 10 % of the total commercial launches of 2012. Russia had the most launches for 2012, with 7 out of its 24 launches conducted for commercial purposes; those launches held a 35 % share of total commercial launches for the year—20 percentage points lower than the share in 2011. Europe conducted ten launches for 2012, of which six were commercial; its share in commercial launches increased in 2012 to a 30 % share for the year. China's 2 commercial launches resulted in 10 % share of commercial activity, while the multinational Sea Launch AG had a 15 % share. The revenue from the 20 launches amounted to an estimated $2.4 billion, an increase of 25.2 % or $486 million from 2011. Following its absence from commercial launches in 2011, the US re-emerged in 2012 generating $108 million, 64.8 % lower than the $307 million commercial revenue it generated in 2010. Europe generated the lion's share of revenue, reaching $1,320 million (a 50.0 % increase from 2011), followed once again by Russian commercial launch revenue at approximately $595 million (another decrease amounting to 15.8 %). Multinational revenue took the next position, this time generating $300 million (a 50 % increase from 2011), and China's revenue amounted to $90 million (a decrease of 35.7 %). The 25.2 % increase in industry revenue was a result of the increase in net profits by European and multinational commercial launch service providers, along with US re-emergence in providing commercial launch services in 2012. However, these figures should only be considered as indicative of the sector as they do not depict current commercial launch contracts because contracts are typically prepaid 1–2 years prior to launch; instead they take into account the value of the activity conducted in 2012.[261]

In 2013, there were a total of 22 successful commercial launches, which carried 22 commercial services payloads into orbit; there was one launch failure of the Multinational Sea Launch AG to launch one satellite. Of the 114 payloads that were launched in 2013, when not considering the additional 98 cubesats launched in 2013, these commercial payloads made up 20.2 %. In 2013, the US conducted a total of 6 commercial launches, while an additional 13 were non-commercial. The US share of commercial launches amounted to 26.1 % of the total commercial launches of 2013; about 16.1 percentage points higher than its share in 2012. Russia again had the most launches for 2013, with 12 out of its 32 launches conducted for commercial purposes; those launches held a 52.2 % share of total commercial launches for the year—17.2 percentage points lower than the share it held in

[261] Federal Aviation Administration. Commercial Space transportation: 2012 Year in Review. Washington DC: FAA, Jan. 2013: 6.

2012. Europe conducted seven launches for 2013, of which four were commercial; its share in commercial launches decreased in 2013 to a 17.4 % share for the year. China had no commercial launches in 2013, while the multinational Sea Launch AG had a 4.3 % share, despite the fact that the company experienced a launch failure. The revenue from the 23 launches amounted to an estimated $1.91 billion, a decrease of 20.9 % or $504 million from the revenue generated in 2012. In 2013, the US generated $340 million in commercial launch revenues, more than tripling its earnings in 2012, returning revenue levels to previous levels. While Europe was in third position as to the number of launches in 2013, it generated the second largest amount of revenue, reaching $710 million (a 46.2 % decrease from the $1,320 million in 2012). In 2013, Russia generated the highest commercial launch revenue at approximately $759 million (increasing by 27.6 % from $595 million in 2012). Multinational revenue took the last position, this time generating $100 million in 2013 (a decrease of 66.7 % from the $300 million gained in 2012). This 20.9 % decrease in industry revenue can be seen from the reduced launches and net profits by European and multinational commercial launch service providers, along with the absence of commercial activity by China in 2013.[262]

When considering European launch activities in total, i.e. commercial and non-commercial, Arianespace reported a 31.2 % increase in revenue for 2012, following its windfall revenue that exceeded industry expectations in 2011.[263] In 2011, Arianespace earned 1.013 billion Euros ($1.340 billion), albeit with a subsidy of 145 million Euros ($191.4 million) from ESA to avoid losses for the year.[264] Revenues grew in 2012, with operating costs now spread among three launch systems (Ariane 5, Soyuz, and Vega), to amount to 1.329 billion Euros ($1.75 billion); this time, receiving a 70 million Euros contribution from ESA to generate a mere 1.7 million Euros ($2.25 million) profit. However Arianespace expected to report a decrease of 27.8 % amounting to around 960 million Euros ($1.32 billion) in revenue for 2013.[265] By the end of 2013, the company's backlog stood at 4.3 billion Euros ($5.92 billion) for its heavy-lift Ariane 5 series, medium-lift Soyuz 2 ST vehicles, and light Vega launch series; with plans to conduct 14 launches in the following year. In 2012, six European launches were carried out by Arianespace

[262] Federal Aviation Administration. Commercial Space transportation: 2012 Year in Review. Washington DC: FAA, Jan. 2013: 6.

[263] De Selding, Peter. "Arianespace Revenue Rose 31.5 Percent for 2012." 12 Apr. 2013. Space News 14 Feb. 2014. http://www.spacenews.com/article/financial-report/34824arianespace-revenue-rose-315-percent-for-2012.

[264] Messier, Doug. "Arianespace Makes Profit With Large ESA Subsidy." 25 Apr. 2012. Parabolic Arc 14 Feb. 2014. http://www.parabolicarc.com/2012/04/25/arianespace-makes-profit-with-large-esa-subsidy/.

[265] De Selding, Peter. "Cost Savings Minimal in Latest Ariane 5 Contract." 8 Jan. 2014. Space News 24 Feb. 2014. http://www.spacenews.com/article/financial-report/38985cost-savings-minimal-in-latest-ariane-5-contract.

onboard the Ariane 5 ECA launcher, one onboard the Ariane 5 ES-ATV launcher, along with two Soyuz-ST launches and one Vega launch from Kourou, French Guiana. Europe's Ariane 5 ES-ATV launcher made its third flight on 23 March 2012, carrying the ATV-3, Edoardo Amaldi; the ATV second launch occurred in February 2011, following the maiden flight in March 2008.[266] ESA's fourth ATV mission was launched on 5 June 2013, carrying the ATV-4, Albert Einstein to the international space station[267]; the final ATV-5, Georges Lemaître is slated for some time in 2014.[268] Following Arianespace's new ability to launch Soyuz spacecraft from the Guiana Space Centre in French Guiana, a milestone in cooperation between Europe and Russia, Arianespace launched 2 Soyuz 2 spacecraft in 2012. The Soyuz 2-ST launcher continued to be a hallmark of European and Russian commercial cooperation, launching the second pair of satellites for Europe's Galileo global navigation satellite system on 12 October 2012, 1 year following the launch of Galileo's first pair of in-orbit validation navigation satellites in October 2011.[269] The launcher also lifted CNES's Pleiades 1B satellite on 1 December 2012, its twin Pleiades 1A having been launched on 16 December 2011. Finally, Europe's Vega Launcher made its debut launch on 13 February 2012, carrying an assortment of European small and microsatellites geared for scientific and development purposes. Vega can carry a 1,500 kg satellite into a 700-km orbit, priced commercially at around 32 million Euros ($42 million) per launch, and is expected to be price-competitive with converted Russian ballistic missiles; if sufficient market demand exists, the price could drop to 22 million Euros ($28.5 million) (Figs. 1.12, 1.13, 1.14, and 1.15).[270]

1.3.2.8 Ground Equipment

Ground equipment revenue includes infrastructure elements, such as mobile terminals, gateways and control stations, and consumer equipment, such as very small

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[266] "ATV-3 launch." 23 Mar. 2012. ESA News 22 May 2012. http://www.esa.int/esaCP/SEM9UR2T00H_index_0.html.

[267] "ATV-4: Albert Einstein." 27 June 2013. ESA 14 Feb. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/ATV/ATV-4_i_Albert_Einstein_i.

[268] SpaceNews Staff. "Europe's ATV Poised To Launch to Space Station." 19 Mar. 2012. SpaceNews 14 Feb. 2014. http://www.spacenews.com/article/europes-atv-poised-launch-space-station.

[269] "One Soyuz Launcher, Two Galileo Satellites, Three Successes for Europe." 21 Oct. 2011. ESA—News. 24 Apr. 2012. http://www.esa.int/esaCP/SEM167GURTG_index_0.html.

[270] De Selding, Peter. "Vega Expected to be Price-competitive With Russian Rockets." 23 Jan. 2012. Space News 23 May 2012. http://www.spacenews.com/launch/012312-vega-expected-price-competitive-with-russian-rockets.html.

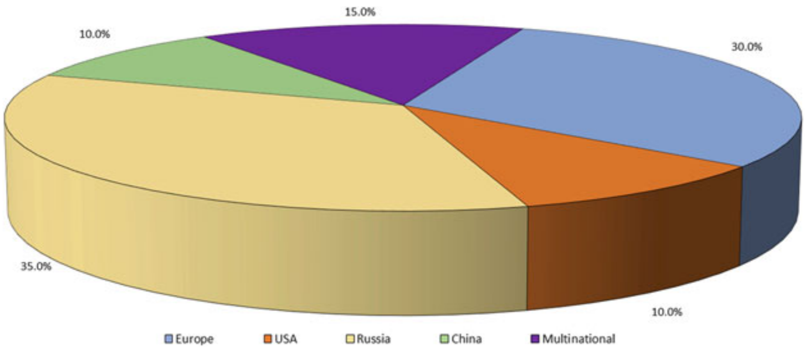

Fig. 1.12 Commercial Launch Activity by Country in 2012 (Source: FAA)

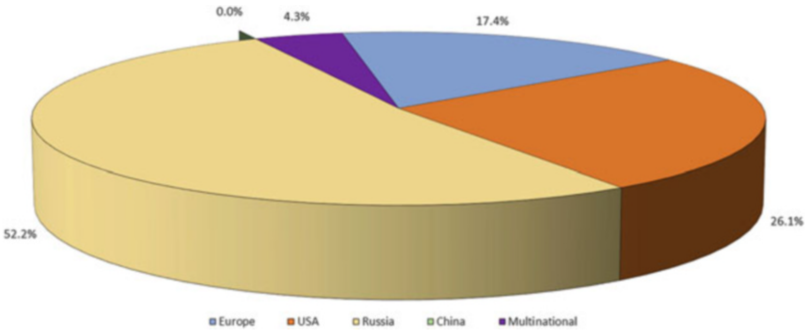

Fig. 1.13 Commercial Launch Activity by Country in 2013 (Source: FAA)

aperture terminals (VSAT), ultra small aperture terminals (USAT), DTH broadcast dishes, satellite phones and digital audio radio satellite (DARS) equipment. Portable Navigation Devices (PND) form one of the sub-segments of end-user electronics that incorporate GPS chip sets.

While the PND market has been in decline since 2008, marginal growth was gleaned in 2011 amounting to a 0.9 % increase from $31.9 billion in 2010; revenues held steady at $32.2 billion for both 2011 and 2012. In 2013, revenue dropped by 3 % to around $31.2 billion. This low growth can be attributed to the migration from standalone devices to embedded chipsets for devices such as smart phones.[271] While satellite navigation equipment represented a 58.8 % share of overall ground equipment revenue in 2012, that share dipped to 56.2 % in 2013. Overall ground equipment revenues continued their slow expansion albeit with lowered growth rates since 2008 (i.e. 2 % in 2011, following 3 % in 2010, and 8 % in 2009). In 2012, ground equipment revenue grew by 4 %, reaching $54.9 billion; thus the ground equipment segment held a 29 % share of the $189.5 billion in world satellite industry revenue in 2012. In 2013, ground equipment revenue grew by only

[271] State of Satellite Industry Report 2014, 27.

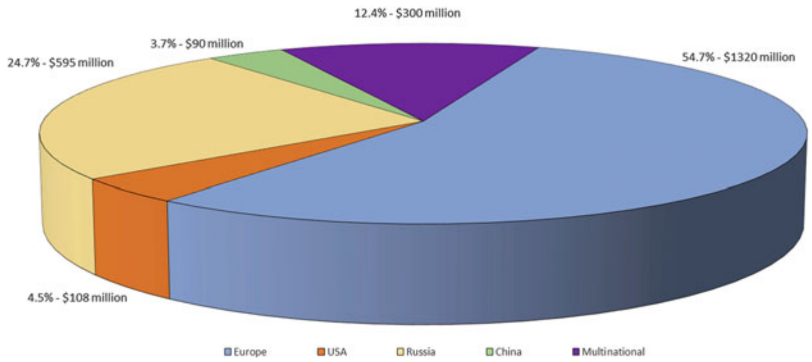

Fig. 1.14 Commercial Launch Revenues by Country in 2012 (Source: FAA)

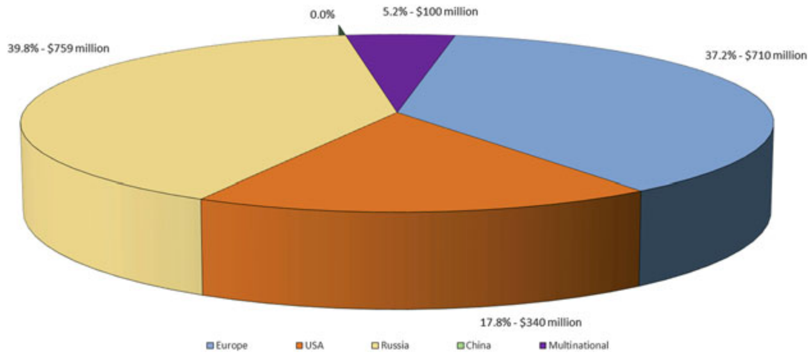

Fig. 1.15 Commercial Launch Revenues by Country in 2013 (Source: FAA)

1.1 % to $55.5 billion, representing a 28.4 % share of the $195.2 billion in world satellite industry revenue in 2013.

The revenue profiles for Garmin and TomTom, the two companies leading the PND market were dissimilar for both 2012 and 2013. Whereas both companies saw diminishing revenue in each consecutive year, the loss appeared to have affected Garmin less strongly. Garmin's total revenue for 2012 reached $2.716 billion, a 1.6 % decrease from the previous year; it decreased by another 3.1 % to $2.632 billion in 2013. TomTom's total revenue reached 1.057 billion Euros ($1.397 billion) in 2012, experiencing another decrease of 17.0 % from the 1.273 billion Euros ($1.648 billion) earned in 2011; it decreased by another 8.9 % to 963.454 million Euros ($1.326 billion) in 2013.[272]

[272] "TomTom Annual Report and Accounts 2012." TomTom 12 Feb. 2013. http://corporate.tomtom.com/common/download/download.cfm?companyid=TOMTOM&fileid=638911&filekey=86013D50-A248-483B-BDC2-7C8391123481&filename=TomTom_Annual_Report_2012.pdf.

1.3.2.9 Insurance Sector

Insurance costs have continued to decrease as the space industry has continued to demonstrate increased hardware reliability, low accident rates and promising growth in recent years.[273] More competition results from a safer market, which results in a change in consumer behaviour as well. Indeed, the perceived reliability spacecraft and launch services in recent years is likely to have led to SES's decision to authorize the shipment of its SES-8 satellite to Florida to be prepared for launch on SpaceX's Falcon 9 v1.1 launcher, despite insurance industry concerns about the Falcon 9's upper-stage engine not properly completing its second ignition as expected.[274] The SES-8 was successfully launched on 3 Dec. 2013, insured by SES for $200 million for the launch and first year of orbit. The biggest claim for 2013 was for the loss of Intelsat 27, following its launch failure on 1 Feb. 2013 due to loss of telemetry on board a commercial Sea Launch Zenit-3SL launcher.[275] Another $70 million claim was expected for a damaged solar array on South Korea's 7 year-old Koreasat 5 telecommunications satellite owned by KT Corp., launched in 2006.[276]

1.3.3 Developments in the Space Industry

1.3.3.1 Industrial Developments in Europe

The Arianespace commercial launch company expected to post a loss for 2013, following substantial gains in 2012. Whereas Arianespace had reported a final 2012 revenue of 1.329 billion Euros ($1.75 billion), a 31.2 % increase from the 1.013 billion Euros ($1.34 billion) earned in 2011[277]; it expected to report a decrease of

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[273] De Selding, Peter. "Insurance Premiums Stay Flat Despite W3B Satellite Failure." 20 May 2011. Space News 24 Apr. 2012. http://www.spacenews.com/satellite_telecom/110520-insurance-premiums-flat.html.

[274] De Selding, Peter. "SES Approves Satellite Shipment for Falcon 9 Launch Despite Questions." 4 Oct. 2013. Space News 17 Feb. 2014. http://www.spacenews.com/article/launch-report/37547ses-approves-satellite-shipment-for-falcon-9-launch-despite-questions.

[275] Clark, Stephen. "Sea Launch rocket, Intelsat satellite fall into Pacific." 1 Feb. 2013. Spaceflight Now 17 Feb. 2014. http://www.spaceflightnow.com/sealaunch/is27/130201failure/#.UwIIPi1wa70.

[276] De Selding, Peter. "SES Approves Satellite Shipment for Falcon 9 Launch Despite Questions." 4 Oct. 2013. Space News 17 Feb. 2014. http://www.spacenews.com/article/launch-report/37547ses-approves-satellite-shipment-for-falcon-9-launch-despite-questions.

[277] De Selding, Peter. "Arianespace Revenue Rose 31.5 Percent for 2012." 12 Apr. 2013. Space News 24 Feb. 2014. http://www.spacenews.com/article/financial-report/34824arianespace-revenue-rose-315-percent-for-2012.

27.8 % amounting to around 960 million Euros ($1.32 billion) in revenue for 2013.[278]

Eutelsat reported total revenue for the 12 months ending 30 June 2012 to be 1.222 billion Euros ($1.54 billion), a 4.6 % increase from the previous period. In the next 2012–to–2013 period, the total revenue increased by 5.1 %, amounting to 1.284 billion Euros ($1.67 billion).[279] Around 68 % of the revenues generated in both periods came from European regions. The Americas and the Middle East generated about 13.7 % and 11.7 % respectively, while Africa made up 5.3 %, and Asia averaged at 1.4 %.[280] For the last 6 months of 2013, the operator reported revenue of 647.4 million Euros ($891.2 million), up 2.2 % over the same period a year earlier.[281] These figures do not consider the impact of the acquisition of Satmex, which was due to close at the beginning of 2014. The acquisition of Satmex, financed with a 930 million Euros ($1.28 billion) 6-year bond issue in December 2013, is meant to enhance Eutelsat's presence in Latin America; over the next 2 years, Eutelsat aims to build additional capacity, mainly in video broadcasting, in the fastest growing regions (i.e. Latin America, Russia, the Middle East, and Africa).[282]

On 22 June 2012, it was revealed that Spanish telecommunications infrastructure provider Abertis Telecom was to sell a 7 % stake in Eutelsat through the sale of shares to the China Investment Corp. (CIC), based in Beijing, China. Formerly Eutelsat's largest shareholder, Abertis Telecom, had previously sold a 16 % share of Eutelsat to investors on 13 January 2012, in a transaction valued at about 1 billion Euros ($1.3 billion).[283] Desiring an industry leadership role, and greater financial consolidation, Abertis appears to be actively pursuing a controlling interest Hispasat. By 21 February 2012, Abertis had begun steps to purchase a 13.23 % equity stake in Hispasat from telecommunications operator Telefonica.[284] Upon approval from the Spanish government, that transaction would see Abertis' stake in

[278] De Selding, Peter. "Cost Savings Minimal in Latest Ariane 5 Contract." 8 Jan. 2014. Space News 24 Feb. 2014. http://www.spacenews.com/article/financial-report/38985cost-savings-minimal-in-latest-ariane-5-contract.

[279] Reference Document 2012–2013. Eutelsat Communications 25 Feb. 2014: 136. http://www.eutelsat.com/files/contributed/investors/pdf/reference-document-2012-2013.pdf.

[280] Ibid.

[281] Press Release. "Eutelsat Communications First Half 2013–2014 Results." 14 Feb. 2014. Eutelsat Communications 25 Feb. 2014. http://www.eutelsat.com/files/contributed/news/press/en/2014/PR1114-H12013-14.pdf.

[282] Ibid.

[283] De Selding, Peter. "Chinese Investment Firm Taking 7 Percent Stake in Satellite Fleet Operator Eutelsat." 22 June 2012. Space News 25 Feb. 2014. http://www.spacenews.com/article/chinese-investment-firm-taking-7-percent-stake-satellite-fleet-operator-eutelsat.

[284] De Selding, Peter. "Abertis Buys Out Telefonica To Increase Hispasat Stake." 22 Feb. 2012. Space News 25 Feb. 2014. http://www.spacenews.com/article/abertis-buys-out-telefonica-increase-hispasat-stake.

Hispasat grow to 46.6 %, with the other shareholders Eutelsat and the Spanish government having 27.7 % and 25.7 %, respectively.

Hispasat reported a 3.5 % increase in revenue in 2011 generating 187.5 million Euros ($249.4 million). Its revenue increased by another 6.9 % amounting to 200.3 million Euros ($264.7 million) in 2012.[285] By 2013, revenue edged upward by 0.57 % reaching 201.4 million Euros ($277.2 million). As observed by the Hispasat chairwoman, the company's focus on internationalisation has enabled it to grow and counteract the adverse exchange rate effect in its source markets; therefore sales efforts were intensified to reinforce its customer base with a more diversified quality offering for the coming years. Of the total revenue earned in 2013, 44.4 % was generated from clients in Europe and North Africa, while 55.6 % came from Latin America. In this period, Hispasat introduced new video, data and broadband services, in addition to providing services to telecommunications operators, audio-visual broadcasters, and to business and government sectors.[286]

Telenor Satellite Broadcasting of Norway reported a 1.80 % decrease in revenue for the year ending 2012, along with another decrease of 0.92 % in 2013, driving its recent decision to implement a programme to improve its operating efficiency. The Oslo-based satellite fleet operator had experienced a drop in revenue in the last quarter of 2012, following the retirement of its Thor 2 satellite.[287] At the end of that year, Telenor reported revenue of 980 million kroner ($175.4 million) for 2012. In 2013, Telenor reported revenue of 971 million kroner ($158.6 million).[288] Telenor plans to enhance its commercial broadcasting capacity with the launch of the Thor 7 satellite planned for late 2014.

In early November 2013, the imaging company RapidEye AG, a subsidiary of the Blackbridge group, officially changed its name to Blackbridge. Several subsidiaries had been absorbed into the parent company over a 2-year process, RapidEye's continuity of imagery products and geospatial solutions are considered to be secure. Aside from the name change, the business, staff, and products & services remained unaffected.[289] Having filed for bankruptcy protection after breaching several of its loan covenants, RapidEye AG was purchased in 2011;

[285] De Selding, Peter. "Hispasat Profit Down Despite Strong Showing in the Americas." 20 June 2013. Space News 20 Feb. 2014. http://www.spacenews.com/article/financial-report/35897hispasat-profit-down-despite-strong-showing-in-the-americas.

[286] Press releases 2014. "HISPASAT continues growing thanks to exports outside Europe." 5 Mar. 2014. Hispasat 6 Mar. 2014. http://www.hispasat.com/en/press-room/press-releases-2014/128/hispasat-sigue-creciendo-gracias-a-la-.

[287] De Selding, Peter. "Retirement of Thor 2 Takes Toll on Telenor's Revenue." 13 Feb. 2013. Space News 26 Feb. 2014. http://www.spacenews.com/article/retirement-of-thor-2-takes-toll-on-telenor%E2%80 %99 s-revenue.

[288] De Selding, Peter. "Telenor Revenue Down Slightly for Second Consecutive Year." 12 Feb. 2014. Space News 26 Feb. 2014. http://www.spacenews.com/article/financial-report/39471telenor-revenue-down-slightly-for-second-consecutive-year.

[289] Press Releases. "RapidEye is now BlackBridge." 6 Nov. 2013. BlackBridge 26 Feb. 2014. http://www.blackbridge.com/rapideye/news/pr/2013-blackbridge.htm.

thereafter in 2012, its main operations were moved to Berlin, Germany from Brandenburg.[290] While expecting to generate about $45 million in revenue in 2012, the company stated that the development and launch of a second-generation constellation would be affordable if annual revenue increased by another $5 million, to $50 million. RapidEye's initial constellation of five medium resolution satellites entered full commercial operations in early 2009 and are expected to function beyond 2018.[291]

Inmarsat reported a 2.2 % reduction in revenue in 2013, generating $1.25 billion as opposed to the $1.28 billion earned in 2012 (not including revenue derived from cooperation with LightSquared). Continued subscriber growth was seen in the company's FleetBroadband, XpressLink, and SwiftBroadband services. Inmarsat's FleetBroadband maritime product has been successful beyond Inmarsat's forecasts, with total active terminals exceeding 41,000 at the end of 2013, and its hand-held satellite telephone earned a 51 % increase in revenue reaching $21.6 million in 2013 from $14.3 million in the previous year, mainly due to the growing popularity of its ISatPhonePro hand-held device with over 84,000 active subscribers at the beginning of 2013.[292] Nevertheless, the low growth in total revenue is mainly attributed to reduced US government business for the use of 3rd party satellite sources in 2013, following the autumn budget crisis and prolonged US troop pull-out from Afghanistan.[293]

Europe's Astrium space hardware and services provider reported an increase of 17 % in revenue for 2012, with a corresponding increase in pre-tax profit, and a 13.6 % reduction in backlog rocket and satellite deliveries.[294] Astrium's revenue for 2012 totalled 5.82 billion Euros ($7.7 billion), up from 4.96 billion Euros ($6.4 billion) in 2011. Astrium's new orders reached nearly 3.8 billion Euros ($5.02 billion) in 2012, with its backlog reaching 12.7 billion Euros ($16.78 billion) by 31 December 2012. The acquisition of satellite solutions provider Vizada in December 2011 meant that Astrium needed more investment in research and development, along with integration charges in the following year. In 2013, Astrium generated about the same revenue as the previous year, earning 5.78 billion

[290] De Selding, Peter. "RapidEye Sats Assigned Longer Life Expectancy." 18 Jan. 2013. Space News 26 Feb. 2014. http://www.spacenews.com/article/civil-space/33241rapideye-sats-assigned-longer-life-expectancy.

[291] Ibid.

[292] Press Release. "Inmarsat plc Reports Preliminary Full Year Results 2013." 6 Mar. 2014. Inmarsat 6 Mar. 2014. http://www.inmarsat.com/wp-content/uploads/2014/03/Inmarsat_plc_Preliminary_Results_2013.pdf.

[293] De Selding, Peter. "Inmarsat Revenue Down as US Government Business Remains Weak." 7 Nov. 2013. Space News 6 Mar. 2014. http://www.spacenews.com/article/financial-report/38041inmarsat-revenue-down-as-us-government-business-remains-weak.

[294] De Selding, Peter. "Vizada Acquisition Fuels Astrium Growth in 2012." 27 Feb. 2013. Space News 26 Feb. 2014. http://www.spacenews.com/article/vizada-acquisition-fuels-astrium-growth-in-2012.

Euros, with new orders increasing by 62.3 % to 6.17 billion Euros, resulting in a book to bill ratio of 1.07.[295]

Astrium Services' revenue totalled 1.45 billion Euros ($1.92 billion) in 2012, up 68.3 % from 861.8 million Euros ($1.13 billion) in 2011, with revenue from Vizada, which accounted for 500 million Euros ($660.7 million) in 2012, exceeding estimates. In 2013, its revenue decreased by 4.5 % to 1.39 billion Euros ($1.91 billion). Astrium Satellites delivered nine spacecraft in 2012, with revenue reaching nearly 2.1 billion Euros ($2.78 billion), an increase of 9 % from revenue earned in 2011.[296] In 2013, Astrium Satellites reported a 3.3 % decrease in revenue, the total amounting to 2.02 billion Euros ($2.78 billion). Astrium Space Transportation reported revenue of 2.27 billion Euros ($3.0 billion), up 4.1 % from the 2.18 billion Euros ($2.86 billion) reported in 2011, after delivering seven Ariane 5 rockets during the year. In 2013, Astrium Space Transportation revenue increased by 4.4 % to 2.37 billion Euros ($3.26 billion). Additionally, the mentioned three divisions booked a combined total of 3.8 billion Euros ($5.02 billion) in new orders in 2012, up 8.6 % from the 3.5 billion Euros ($4.59 billion) generated in 2011; followed by another 62.3 % increase in orders reaching 6.17 billion Euros ($8.49 billion) in 2013.[297]

Responding to the steep reduction in European defence spending in 2013, EADS underwent major restructuring, renaming the group as Airbus, and consolidating its Cassidian, Astrium, and Military divisions into a single "Airbus Defence & Space" division by year end. On 10 December 2013, Astrium space hardware and services division then announced plans to eliminate 2,470 Astrium positions from its pool of 18,000 employees over the following 3 years. Described as a part of Astrium's streamlining effort, the 2015 goal is to create a company that is leaner in middle management and bureaucracy, eliminating jobs that do not directly contribute to Astrium's product and service portfolio. The job cuts were said to mainly involve negotiated voluntary departures and the non-replacement of retiring employees, to increase Astrium's competitiveness on world markets, and its profitability within the larger Airbus space group. Airbus Defence and Space on the whole was expected to shed some 5,800 jobs, including 1,300 employees now on non-renewable short-term contracts. Of the 4,500 full-time positions to be eliminated, 2,000 are in Germany, 1,260 in France, 557 in Spain, 450 in Britain, and

[295] De Selding, Peter. "New Orders Eclipsed Flat Revenue in 2013 at Airbus Space Division." 26 Feb. 2014. SpaceNews 19 May 2014. http://www.spacenews.com/article/financial-report/39626new-orders-eclipsed-flat-revenue-in-2013-at-airbus-space-division.

[296] De Selding, Peter. "Vizada Acquisition Fuels Astrium Growth in 2012." 27 Feb. 2013. SpaceNews 19 May 2014. http://www.spacenews.com/article/vizada-acquisition-fuels-astrium-growth-in-2012.

[297] De Selding, Peter. "New Orders Eclipsed Flat Revenue in 2013 at Airbus Space Division." 26 Feb. 2014. SpaceNews 19 May 2014. http://www.spacenews.com/article/financial-report/39626new-orders-eclipsed-flat-revenue-in-2013-at-airbus-space-division.

180 positions will be lost in other parts of the world.[298] The company will reinvest the 400 million Euros ($560 million) in annual savings resulting from employment streamlining into self-financed research and offering better prices to its customers. Astrium's Agile programme, an internal transformation programme designed to prepare the company to adapt to the competitive market, has been operating in an environment where, for instance, the currency exchange rate between the Euro and the Dollar has made it very hard for Europe's Ariane 5 rocket to make a profit, despite the launcher's consistent record.[299]

Astrium Services increased competition with its two US competitors, GeoEye and DigitalGlobe in 2012 and 2013 with its Pleiades 1A and Pleiades 1B high-resolution optical Earth observation satellites. The first satellite was launched on 17 December 2011, with its twin, Pleiades 1B launched a year later on 2 December 2012. In 2013, DigitalGlobe saw sharply lower year-end revenue than anticipated due to unexpected competition in the emerging market business, i.e. generating $613 million instead of the $635 million it had anticipated. Moreover, DigitalGlobe now expects to report $645 million for 2014 instead of the $699 million initially predicted.[300] Another reason for DigitalGlobe's shortfall was said to be due to the 2.5 month delay in the launch of its WorldView-3 satellite, now set for launch sometime in 2014. With the cost of developing the two-satellite Pleiades exceeding 650 million Euros ($850 million), covered around 90 % by CNES, the spacecraft now have an output of 450 images per day.[301] The other 10 % the bill was covered by Belgium, Spain, Sweden, and Austria, with a pro rata share of the remaining imagery and work for their respective national industries. The French Ministry of Defence has priority access to 50 images per day, while civil agencies have access to 40 % of the remaining output; Astrium Services gets the remaining 60 % share.[302] Moreover, Astrium Services has exclusive rights to sell Pleiades imagery commercially. Additional activities by Astrium include its investment of about 300 million Euros ($375 million) in the development and launch of the Spot 6 and Spot 7 medium-resolution satellites; Spot 6 was launched on 9 September 2012, and Spot 7 is scheduled for launch aboard India's PSLV rocket sometime in 2014.[303]

[298] De Selding, Peter. "EADS Restructuring To Eliminate Nearly 2,500 Astrium Jobs." 10 Dec. 2013. SpaceNews 19 May 2014. http://www.spacenews.com/article/financial-report/38588eads-restructuring-to-eliminate-nearly-2500-astrium-jobs.

[299] De Selding, Peter. "Astrium Efficiency Initiative to Eliminate 2,000 Positions by 2015." Space News 27 June 2011: 12.

[300] De Selding, Peter. "Unexpected Competition, Launch Delay Are Drag on DigitalGlobe Revenue." 27 Feb. 2014. SpaceNews 19 May 2014. http://www.spacenews.com/article/financial-report/39648unexpected-competition-launch-delay-are-drag-on-digitalglobe-revenue.

[301] De Selding, Peter. "Soyuz Launches French Pleiades Imaging Satellite." 7 Dec. 2012. SpaceNews 19 May 2014. http://www.spacenews.com/article/soyuz-launches-french-pleiades-imaging-satellite.

[302] De Selding, Peter. "With Pleiades in Orbit, Astrium Sets Sights on DigitalGlobe, GeoEye." Space News 9 Jan. 2012: 7.

[303] De Selding, Peter. "Indian Rocket Lofts Spot 6 Earth-observing Satellite." 17 Sept. 2012. SpaceNews 19 May 2014. http://www.spacenews.com/article/indian-rocket-lofts-spot-6-earth-observing-satellite.

Both satellites are designed to cover up to 6 million square km daily at a resolution of 1.5 m.[304]

Thales Alenia Space, owned 67 % by Thales and 33 % by Finmeccanica, has 7,500 employees in France, Italy, Spain, Belgium, Germany and the United States. The group posted a total revenue of 2.1 billion Euros ($2.78 billion) in 2012.[305] That revenue was reported to have grown in excess of 2 billion Euros in 2013.[306] Registered in both France (Thales Alenia Space SAS) and Italy (Thales Alenia Space Italia SpA),[307] Thales Alenia Space is a key supplier of satellite and orbital infrastructure solutions. Thales Alenia Space is thus a global market leader in telecommunications, navigation, space exploration and Earth observation.[308] In telecommunications, it competes in the commercial satellite market, producing its own satellites from its Spacebus platform dedicated to geostationary satellites, while supplying additional payloads for all the major contractors in the sector, and providing satellites for the low-orbit civilian constellation market including Globalstar, Iridium NEXT, and O3b satellites. The first four O3b high throughput MEO satellites were launched on 25 June 2013.[309] In the defence and security segment, it offers space segments and ground telecommunications systems (Syracuse, Sicral, COMSAT-BW), military observation systems (Helios, Pleiades, CSO—rest of Helios, SAR-LUPE), and also dual civilian and military systems (COSMO-SkyMed, Athena-Fidus, and Yahsat). Thales Alenia Space is also a major player in Earth observation and scientific missions, having been selected for the last three decades as the prime contractor for weather satellite programmes in Europe (METEOSAT) and for environmental missions in the context of GMES (Sentinel programmes) or space altimetry (i.e. SADKO, SWIM, and GFO-RA product lines). And for scientific missions, it developed Proteus, a multi-mission platform (class 500–700 kg), used in the SMOS, Jason, COROT and Calipso missions, in addition to being the prime contractor for the Herschel-Planck mission for ESA, and executing the Exomars programme. Thales Alenia Space also plays a major role in the Galileo programme, participating in the In-Orbit Validation (IOV) phase, as well as providing system support and the Mission Ground Segment for the full

[304] "SPOT 6 and SPOT 7 Satellite Imagery—Spot the Difference." Airbus Defence & Space 19 May 2014. http://www.astrium-geo.com/en/147-spot-6-7-satellite-imagery.

[305] "Eutelsat 3D Launch a Success Satellite Built by Thales Alenia Space for Eutelsat." 15 May 2013. Thales Alenia Space 27 Feb. 2014. https://www.thalesgroup.com/en/content/eutelsat-3d-launch-success-satellite-built-thales-alenia-space-eutelsat.

[306] "Martin Van Schaik appointed Thales Alenia Space Senior Vice President, Sales." 10 Mar. 2014. Thales Alenia Space 30 May 2014. https://www.thalesgroup.com/en/worldwide/space/press-release/martin-van-schaik-appointed-thales-alenia-space-senior-vice-president.

[307] 2012 Registration Document. Thales. 27 Feb. 2014: 141 https://www.thalesgroup.com/sites/default/files/asset/document/Thales 2012 registration document bookmarked pdf.pdf.

[308] Ibid. at 147.

[309] "First four O3b satellites successfully launched." 25 June 2013. Thales Alenia Space 27 Feb. 2014. https://www.thalesgroup.com/sites/default/files/asset/document/first_four_o3b_satellites_successfully_launched.pdf.

constellation. In manned space flight, Thales Alenia Space is a major contributor to the ISS, supplying more than 50 % of its pressurised volume (Nodes 2 and 3, MPLM, Cupola, PMM) and is significantly involved in the ATV vehicles for ESA.[310]

OHB Technology of Germany saw its total revenue rise to 632.73 million Euros ($836 million) in 2012; amounting to a 13.9 % increase from the 555.29 million Euros ($719 million) earned in 2011.[311] OHB forecast its full year revenue for 2013 to be over 700 million Euros ($945 million), an increase of 10.6 % from 2012.[312]

RUAG Space, the largest independent supplier of space technology in Europe, developing subsystems and equipment for satellites and launch vehicles, reported a 3.6 % increase in net sales for 2012, earning CHF 285 million ($311.8 million) compared to CHF 275 million ($292.6 million) in 2011.[313] Based in Switzerland, Sweden, and Austria, the company now employs 1,126 personnel.[314] Its launch vehicle structures and separation systems once again had the highest sales volume, with RUAG Space's payload fairings this time being used in 11 launches by the Atlas V 500, Ariane 5, and now the Vega launch vehicles.[315] The company was also involved in the production of two European weather satellites, Eumetsat's MSG-3 and Metop-B and provides the central onboard computers and solar array drive mechanisms for the Galileo navigation satellites.[316]

1.3.3.2 Industrial Developments in the United States

The US satellite prime commercial satellite manufacturer, Space Systems/Loral (SS/L), was acquired by Canada's MacDonald, Dettwiler and Associates Ltd. (MDA) on 2 November 2012.[317] With the transaction initially having been announced in mid-2012, MDA began pre-booking orders from the US Defense

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[310] See generally 2012 Registration Document. Thales. 27 Feb. 2014: 147. https://www.thalesgroup.com/sites/default/files/asset/document/Thales 2012 registration document bookmarked pdf.pdf.

[311] Annual Report 2012. OHB 22 Feb 2014: 2. http://www.ohb.de/tl_files/ohb/pdf/finanzberichte_hauptversammlung/2012/OHB_GB12_E.pdf.

[312] De Selding, Peter. "Galileo Prime Contractor Expects No Trouble Finding a Profit as European Navigation Satellites Encounter New Delays." 15 Nov. 2013. Space News 22 Feb. 2014. http://www.spacenews.com/article/financial-report/38168galileo-prime-contractor-expects-no-trouble-finding-a-profit-as.

[313] RUAG Annual Report 2012. RUAG 21 Feb 2014: 98. http://www.ruag.com/de/Konzern/Media/Geschaeftsberichte/2012/2012_e/RUAG_GFB_2012_E.pdf.

[314] Id. at 26.

[315] Id. at 24.

[316] Id. at 24, 25.

[317] Press Release. "MDA completes acquisition of Space Systems/Loral." 2 Nov. 2012. MDA Corporation 28 Feb. 2014. http://www.mdacorporation.com/corporate/news/pr/pr2012110206.cfm.

Advanced Research Projects Agency (DARPA) for robotic elements of a satellite-salvage program while awaiting regulatory approval of the purchase.[318] By November 2012, MDA assumed ownership of SS/L, closing the deal at $1.069 billion, with little resistance from US regulators. However, 75 % of the contracted work on the $30 million in contracts won from DARPA as part of preliminary work on a future in-orbit satellite servicing project would need to be done in the US.[319]

In the wake of the controversy created by the risk posed by LightSquared Inc.'s potential L-band interference with GPS signals, subsequently blocked by US regulators, the wireless-broadband company filed for Chapter 11 bankruptcy protection on 14 May 2012.[320] By 15 May 2013, interest in LightSquared's radio frequencies had attracted a $2.22 billion bid to purchase the company from Dish Network Corp. (a satellite TV provider from Englewood Colorado), a welcome offer by some awaiting creditors, including Boeing Network and Space Systems, owed $112 million for the construction of two LightSquared satellites, one of which is currently in orbit.[321] On 1 November 2013, LightSquared brought a suit against several GPS manufacturers regarding misrepresentations on the interference posed by LightSquared's signals on GPS receivers, preventing the timely launch of the wireless broadband network, and driving the company into bankruptcy.[322] On 24 December 2013, a new bankruptcy plan was submitted to the courts to avoid LightSquared's sale to Dish Network, consisting of a $2.5 billion exit loan and no less than 1.25 billion in new equity contributions.[323]

The Stratolaunch project, seeking to develop the largest air-launch system in the world, made some substantial headway in realizing its goal. Unveiled on 13 December 2011 by billionaire Microsoft co-founder Paul Allen, the company's aim is to bring airport-like operations to the launch of commercial and government payloads and eventually conduct human missions. While Stratolaunch initially planned to partner with SpaceX, utilizing a derivative of the Falcon 9 launch vehicle with fewer engines, the idea was amicably scrapped due to the significant

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[318] De Selding, Peter. "Canada's MDA Expects Space Systems/Loral Purchase To Close this Fall." 27 July 2012. Space News 27 Feb. 2014. http://www.spacenews.com/article/canadas-mda-expects-space-systemsloral-purchase-close-fall.

[319] De Selding, Peter. "With SS/L Purchase, MDA Corp. Finally Gains U.S. Foothold." 2 Nov. 2012 Space News 27 Feb. 2014. http://www.spacenews.com/article/satellite-telecom/32138with-ssl-purchase-mda-corp-finally-gains-us-foothold.

[320] SpaceNews Staff. "Troubled LightSquared Files for Bankruptcy." 21 May 2012. Space News 28 Feb. 2014. http://www.spacenews.com/article/troubled-lightsquared-files-bankruptcy.

[321] De Selding, Peter. "Boeing's Space Earnings Boosted by Commercial Satellite, NASA Revenue." 26 July 2013. Space News 28 Feb. 2014. http://www.spacenews.com/article/financial-report/36473boeing's-space-earnings-boosted-by-commercial-satellite-nasa-revenue.

[322] Rosenblatt, Joel. "LightSquared Sues GPS Manufacturers Over Alleged Broken Promises." 2 Nov. 2013. Bloomberg.com 28 Feb. 2014. http://www.bloomberg.com/news/2013-11-02/lightsquared-sues-gps-makers-over-alleged-broken-promises.html.

[323] Kary, Tiffany. "LightSquared Seeks Approval for New Plan With Fortress Bid (1)." 26 Dec. 2013. Bloomberg 28 Feb. 2014. http://www.businessweek.com/news/2013-12-26/lightsquared-seeks-to-update-bankruptcy-plan-with-fortress-offer.

modifications needed to accommodate Stratolaunch's designs, which needed an additional fin/chine configuration to help generate additional lift at supersonic speeds.[324] The contract was subsequently given to Orbital Sciences, the builder and operator of the now sparsely used Pegasus rocket. Released from its carrier aircraft, operating from a large airport or spaceport, the air-launched rocket is planned to boost up to 6,800 kg of payload to low Earth orbit, and smaller payloads to geostationary transfer orbit.[325] The Orbital Sciences rocket will have ATK Aerospace develop and produce the first two-stages of the three-stage rocket; the third-stage liquid-fuelled engine supplier was still being sought.[326]

After a period of uncertainty surrounding the funding of commercial Earth satellite imagery providers GeoEye's and DigitalGlobe's 10-year EnhancedView programme—a series of 9 1-year commitments with the US government—the solution came by unifying resources. On 22 June 2012, GeoEye was informed that the US government wished to cancel key elements of its portion of the $7 billion contract with the company, leaving GeoEye unclear how large such cuts would be.[327] Meanwhile, DigitalGlobe's contract remained unaltered. To mitigate the situation, GeoEye first tried to purchase DigitalGlobe, but was declined. On 23 July 2012, 2 months after the initial merger offer, the companies agreed that DigitalGlobe would purchase GeoEye; a move in the interest of both companies to enhance competitiveness against Europe's Astrium Services Earth observation service provider.[328] On 9 January 2013, the proposed merger received a Department of Justice decision that the transaction would not be challenged on antitrust grounds, with the acquisition taking place on 31 January 2013.[329] It would be business as usual for the duration of 2013, with DigitalGlobe's US government revenue rising 53 % from the previous year, while showing no signs of being

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[324] Leone, Dan. "Orbital Sciences Replaces SpaceX on Stratolaunch Project." 30 Nov. 2012. Space News 28 Feb. 2014. http://www.spacenews.com/article/launch-report/32591orbital-sciences-replaces-spacex-on-stratolaunch-project.

[325] Leone, Dan. "Orbital Tapped To Build Stratolaunch Rocket." 5 June 2013. Space News 28 Feb. 2014. http://www.spacenews.com/article/launch-report/35647orbital-tapped-to-build-stratolaunch-rocket.

[326] Leone, Dan. "ATK To Supply Stratolaunch Rocket Stages." 13 Aug. 2013. Space News 28 Feb. 2014. http://www.spacenews.com/article/launch-report/36764atk-to-supply-stratolaunch-rocket-stages.

[327] De Selding, Peter. "NGA Letters Cast Cloud Over GeoEye's EnhancedView Funding." 23 June 2012. Space News 3 Mar. 2014. http://www.spacenews.com/article/nga-letters-cast-cloud-over-geoeyes-enhancedview-funding.

[328] De Selding, Peter. "Astrium Services Girds for Competition with DigitalGlobe-GeoEye Combo." 15 Oct. 2012. Space News 3 Mar. 2014. http://www.spacenews.com/article/astrium-services-girds-competition-digitalglobe-geoeye-combo.

[329] Ferster, Warren. "DigitalGlobe Closes GeoEye Acquisition." 31 Jan. 2013. Space News 3 Mar. 2014. http://www.spacenews.com/article/digitalglobe-closes-geoeye-acquisition.

affected by the temporary government shutdown occurring in the first half of October 2013.[330]

Having upgraded its Falcon 9 rocket for missions to geostationary orbit, Space Exploration Technologies (SpaceX) expects to launch commercial telecommunications satellites, AsiaSat 6 and AsiaSat 8, in 2014. AsiaSat of Hong Kong ordered the development of the two satellites from Space Systems/Loral of Palo Alto, California, to increase the capacity of the current AsiaSat fleet in orbit. SpaceX debuted its more powerful Falcon 9 v1.1 launcher on 29 September 2013, launching the Cassiope experimental space-environment monitoring satellite to LEO for the Canadian Space Agency.[331] With an increase in length, new engines, and a larger-diameter fairing, the second launch of the Falcon 9 v1.1 lifted SES-8, its first commercial telecommunications satellite, to geostationary transfer orbit on 3 December 2013.[332] And with the further development of electric propulsion spacecraft, lowering the mass of normally heavier telecommunication satellites, SpaceX could become a bigger competitor in the telecommunications market. While having a one-launch track record only, following the launch of SES-8, SpaceX's backlog for the launch of commercial geostationary satellites is nearly $500 million.[333] SpaceX intends to develop a reusable first stage to reduce the cost of the Falcon 9 v1.1 launcher by up to 75 %; the first of its reusability tests was to be conducted on its next International Space Station cargo-supply mission, expected sometime in February 2014.[334] SpaceX will also launch the Iridium NEXT constellation of LEO communications satellites starting in 2014.[335]

SpaceX is planning to use a new launch pad at Vandenberg US Air Force Base to launch the standard Falcon 9 rocket and its upcoming heavy-lift variant. SpaceX currently launches its Falcon 9 only from Canaveral Air Force Station, whereas the new pad will be built to also accommodate the developmental Falcon 9 Heavy launch vehicle, now expected to debut in 2014.[336] The company will spend between $20–30 million to renovate the site, unused since 2005; the Titan 4 was the last

[330] De Selding, Peter. "Inmarsat Revenue Down as US Government Business Remains Weak." 7 Nov. 2013. Space News 6 Mar. 2014. http://www.spacenews.com/article/financial-report/38041inmarsat-revenue-down-as-us-government-business-remains-weak.

[331] Ferster, Warren. "Upgraded Falcon 9 Rocket Successfully Debuts from Vandenberg." 29 Sept. 2013. Space News 26 Mar. 2014. http://www.spacenews.com/article/launch-report/37450upgraded-falcon-9-rocket-successfully-debuts-from-vandenberg.

[332] De Selding, Peter. "SES-8 On Its Way to Geostationary Orbit Following SpaceX's Commercial Launch Debut." 3 Dec. 2013. Space News 26 Mar. 2014. http://www.spacenews.com/article/launch-report/38485ses-8-on-its-way-to-geostationary-orbit-following-spacexs-commercial.

[333] Ibid.

[334] Ferster, Warren. "Upgraded Falcon 9 Rocket Successfully Debuts from Vandenberg." 29 Sept. 2013. Space News 26 Mar. 2014. http://www.spacenews.com/article/launch-report/37450upgraded-falcon-9-rocket-successfully-debuts-from-vandenberg.

[335] De Selding, Peter B. "SpaceX To Launch Pair of Satellites for AsiaSat." 8 Feb. 2012. Space News 3 May 2012. http://www.spacenews.com/contracts/120208-spacex-launch-asiasat-sats.html.

[336] "SpaceX Breaks Ground on West Coast Launch Pad." Space News 25 July 2011: 8.

rocket launched from there. SpaceX will also update its launch facility in Cape Canaveral, enabling the heavy-lift rocket to launch from both coasts. SpaceX's Florida base is also undergoing general upgrades, additional hangars are being built to prepare its Falcon 9 rockets and customer payloads for launch. With an expected flight rate of 10–12 launches per year, the current facility (Space Launch Complex 40) will receive a 16,000 square-meter addition, including an unused Delta 2 processing building. SpaceX will receive $7.3 million from Space Florida, a state-funded agency, toward the upgrades. These upgrades include, *inter alia*, a clean room, a hazardous hypergolic fuelling facility and enough volumetric space to encapsulate a payload in a fairing in a vertical position.[337]

SpaceX launched its second Falcon 9 Dragon cargo run to the International Space Station (ISS) on 1 March 2013,[338] about 10 months following its maiden Falcon 9 ISS cargo launch on 22 May 2012.[339] While the latest launch was successful, a propulsion glitch on the Dragon capsule resulted in a delay of 1 day prior to docking onto the ISS on 3 March 2013. The Dragon capsule detached from the ISS on 26 March 2013, re-entering Earth's atmosphere, and alighting in the Pacific on the same day. This mission was the second of the twelve commercial resupply missions to the ISS SpaceX negotiated under the terms of a $1.6 billion 2008 contract with NASA; NASA being responsible for 40 % of the SpaceX manifest.[340]

Virgin Galactic successfully completed rocket-powered test flights of SpaceShipTwo (SST) on 29 April 2013 and 5 September 2013, with the spacecraft's hybrid rocket engines firing for a maximum of 20 s.[341] Prior to the first engine firing, the spacecraft had already performed more than 20 unpowered flight tests, involving drop tests where SST would glide back to a runway after being dropped in midair from its mother ship, WhiteKnightTwo, and performing a set of manoeuvres along with ballast checks.[342] Designed to be released from its carrier at an altitude of 15 km, its SSTs rocket engine will ignite to propel the craft at an apex altitude up to 110 km. Virgin Galactic expects be able to start flying customers in June or July

337 Klotz, Irene. "SpaceX Expanding Florida Facilities to Meet Launch Demand." Space News 28 Nov. 2011: 5.

338 Klotz, Irene. "SpaceX Stumbles on 2nd Cargo Run to the Space Station." 1 Mar. 2013. Space News 26 Mar. 2014. http://www.spacenews.com/article/spacex-stumbles-on-2nd-cargo-run-to-the-space-station.

339 Space News Staff. "SpaceX Delivers Falcon 9 to Orbit." 22 May 2012. Space News 23 May 2012. http://spacenews.com/launch/120522-spacex-falcon-delivers-dragon-orbit.html.

340 Kramer, Miriam. "SpaceX Dragon Capsule Returns to Earth After 2nd Paid Mission to ISS." 1 Apr. 2013. Space News 26 Mar. 2013. http://www.spacenews.com/article/launch-report/34664spacex-dragon-capsule-returns-to-earth-after-2nd-paid-mission-to-iss.

341 Klotz, Irene. "Firm Expanding Spaceship Test Flights To Hone 'Virgin Space Experience'." 7 Oct. 2013. Space News 5 Mar. 2014. http://www.spacenews.com/article/civil-space/37589firm-expanding-spaceship-test-flights-to-hone-'virgin-space-experience'.

342 Amos, Jonathan. "Sir Richard Bransonäs Virgin Galactic spaceship ignites engine in flight." 29 Apr. 2013. BBC News 5 Mar. 2013. http://www.bbc.com/news/science-environment-22344398.

2014. By 3 October 2013, more than 600 passengers had reserved a flight on the spacecraft, each at $250,000 per seat.[343] Among these customers are scientists along with their experiments and space tourists. Soon, other companies might also be able to provide similar suborbital space travel products, including *inter alia* XCOR Aerospace, Blue Origin and Armadillo Aerospace.[344]

Futhermore, having purchased Scaled Composite's 30 % stake in The Spaceship Company in October 2012, Virgin Galactic—in collaboration with Aabar Investments PJS of Abu Dhabi, UAE—is looking to enter the satellite launch business. In addition to providing customers access to several minutes of microgravity conditions and a superb view of Earth's curvature aboard SpaceShipTwo, Virgin Galactic also plans to develop a two-stage unmanned rocket, named LauncherOne, which is intended to carry small satellite payloads between 100 kg-to-225 kg into orbit with costs in the long-term of less than $10 million with regular operation.[345] For now, its SpaceShipTwo and LauncherOne activity will be localised at Spaceport America in New Mexico, USA, whose law shields spacecraft operators, manufacturers and suppliers from clients that sign liability waivers.[346] Virgin Galactic is also anchored to operate only in the US until it receives a specific waiver from the country's International Traffic in Arms Regulations (ITAR); thereafter, spaceports in the UAE, Sweden and possibly the UK are also envisioned.[347]

1.3.3.3 Industrial Developments in Russia

On 2 December 2013, Russia's President Vladimir Putin signed a decree ordering the creation of the United Rocket and Space Corporation, wherein several federal state-owned unitary space enterprises will be reorganised into open joint stock companies to be fully owned by the federal government. Next they will each contribute 100 % of shares minus one-share to the new corporation's authorised

[343] Boyle, Alan. "NBC teams up with Virgin Galactic for 'Space Race' reality TV show." 3 Oct. 2013. NBC News 5 Mar. 2014. http://www.nbcnews.com/science/space/nbc-teams-virgin-galactic-space-race-reality-tv-show-f8C11329733.

[344] Wall, Mike. "Virgin Galactic Aims for 1st Rocket-Powered Flight This Year." 28 Feb. 2012. SPACE.com 3 May 2012. http://www.space.com/14706-virgin-galactic-spaceshiptwo-powered-flight.html.

[345] SpaceNews Staff. "Virgin Galactic Developing Small-satellite Launcher." 16 July 2012. Space News 5 Mar. 2014. http://www.spacenews.com/article/virgin-galactic-developing-small-satellite-launcher.

[346] Monteleone, James. "Spaceport Liability Waiver Unanimously Passes Senate." 30 Jan. 2013. Albuquerque Journal 5 Mar. 2014. http://www.abqjournal.com/164742/politics/spaceport-liability-waiver-unanimously-passes-senate.html.

[347] De Selding, Peter. "Export Regime Keeping Virgin Galactic in the U.S., for Now." 3 Dec. 2012. Space News 5 Mar, 2014. http://www.spacenews.com/article/civil-space/32636export-regime-keeping-virgin-galactic-in-the-us-for-now.

capital.[348] This decree, to be implemented within 2 years, with initial steps to be taken in early 2014, is intended to reduce costs in the industry by consolidating the country's numerous space hardware developers and manufacturers (including 43 currently separate companies, e.g. major prime contractors Khrunichev Space Center, RSC Energia, TsSKB Progress, and Lavochkin) into a single company. The move should allow the Russian space industry to eliminate excess manufacturing capacity, in addition to streamlining the purchasing of foreign electronic components with increased purchasing power to negotiate volume-based discounts.[349] However, some critics believe that the plan will eliminate competition and may bring more confusion to the industry. Russia's spending in space has more than doubled in the last 3 years to over $5 billion in 2013, yet the industry spends four times more than the global norm on satellites that are poor in quality and prone to accidents. Rather than rely on the poor electronics Russia developed in previous decades, up to 80 % of the equipment for new Russian spacecraft is imported from Europe or Canada. Continuity of experience is also in question. Two decades since the Soviet collapse, a brain drain has resulted in 90 % of the 240,000 people employed by the Russian space sector to be either older than 60 or younger than 30 years of age.[350]

The partially Russian- and Ukranian-owned Sea Launch AG consortium, back in operation after coming out of US Chapter 11 bankruptcy, in October 2010, experienced a launch failure on 31 January 2013, after five successful launches in the two previous years. Whereas in 2012 the company broke even, 2013 was more difficult due to the initial failure, and the success of SpaceX in its launch of the SES 8 satellite on 3 December 2013. While 2014 is also expected to be a slow year, with most of the missions for that year having been sold by others well ahead of time, the company hopes to have three missions in 2015, followed by an even greater launch capacity in the years that follow.[351] In February 2013, Boeing Co, the managing partner of Sea Launch sued its Russian and Ukranian partners for refusing to pay more than $350 million following Sea Launch's 2009 bankruptcy, leaving Boeing to cover loan guarantees of $449 million on its own. In its lawsuit, Boeing said that

[348] "Putin Signs Decree on Creation of United Rocket and Space Corporation." 2 Dec. 2013. ITAR TASS 30 Apr. 2014. http://en.itar-tass.com/russia/709849.

[349] "Putin Signs Legal Decree Consolidating Russian Industry." 9 Dec. 2013. SpaceNews 30 Apr. 2014. http://www.spacenews.com/article/civil-space/38551putin-signs-legal-decree-consolidating-russian-industry.

[350] "Russia Bets on Sweeping Reform to Revive Ailing Space Industry." 26 Dec. 2013. Reuters 30 Apr. 2014. http://www.reuters.com/article/2013/12/26/us-russia-space-idUSBRE9BP02S20131226.

[351] Henry, Caleb. "A Heavyweight Battle: How Sea Launch Plans to Stay Afloat With SpaceX in its Waters." 13 Dec. 2013. ViaSatellite 6 Mar. 2014. http://www.satellitetoday.com/launch/2013/12/13/a-heavyweight-battle-how-sea-launch-plans-to-stay-afloat-with-spacex-in-its-waters/.

Russia's RSC Energia owed at least $222.3 million and that Ukraine's Yuzhnoye companies owed at least $133.4 million.[352]

1.3.3.4 Industrial Developments in Japan

Mitsubishi Electric Co. (Melco) of Japan plans to double its annual satellite-related revenue to ¥152.4 billion ($1.9 billion) by 2021, partly by having completed a major expansion of its Kamakura satellite production facility to capture demand for telecom, navigation and Earth observation satellites. Having completed the expansion on 22 March 2013, with a ¥3 billion ($36 million) investment to enlarge total facilities (satellite production, integration and test floor space) to 7,700 square meters, Melco's production capacity is said to have doubled to eight large satellites per year.[353] Earlier in 2013, the company once again became eligible to bid on Japanese military contracts after having refunded the Ministry of Defence ¥60 billion for overcharges on services and hardware over the period of a decade.[354] With its DS2000 satellite frame proven in orbit on Japanese commercial and technology-demonstration missions, Mitsubishi will be more aggressive in the commercial market, positioning the platform as a relatively low-cost option that will also excel on being ITAR-free, which would normally keep these satellites from being exported to China for low-cost launch services. The DS2000 should also be compatible with the relatively low-cost Falcon 9 rocket of SpaceX.[355] Moreover, following Japan's launch of its first Quasi-Zenith Satellite System (QZSS) satellite in September 2010 to augment the US GPS system over the Pacific region, in April 2013, Melco was contracted to build three additional satellites, estimated to be worth ¥50.3 billion ($539.4 million). NEC Corp. was expected to win a ¥117.3 billion ($1.26 billion) contract to operate the QZSS system under a separate contract.[356]

At the start of 2012, NEC Corp. of Tokyo was contracted to design and build hardware for Japan's Hayabusa-2 asteroid sample-return mission, which JAXA

[352] Raymond, Nate. "Boeing sues Sea Launch partners for $350 million." 4 Feb. 2013. Reuters 30 May 2014. http://www.reuters.com/article/2013/02/04/boeing-sealaunch-idUSL1N0B31GP20130204.

[353] De Selding, Peter. "Melco Completes Expansion of Satellte Production Plant." 22 Mar, 2013. Space News 8 Mar. 2014. http://www.spacenews.com/melco-completes-expansion-of-satellite-production-plant.

[354] Berger, Brian. "Mitsubishi Electric Reinstated after Reimbursing Government." 13 Feb. 2013. Space News 8 Mar. 2014. http://www.spacenews.com/article/mitsubishi-electric-reinstated-after-reimbursing-government.

[355] De Selding, Peter. "Melco: Low Price Tag Will Sell DS-2000 Satellite," 12 Mar. 2012. Space News 8 Mar. 2014. http://www.spacenews.com/article/melco-low-price-tag-will-sell-ds-2000-satellite.

[356] De Selding, Peter. "Melco To Build Three QZSS Navigation Satellites." 3 Apr. 2013. Space News 8 Mar. 2014. http://www.spacenews.com/article/civil-space/34676melco-to-build-three-qzss-navigation-satellites.

plans to launch in 2014. The probe will be similar in design to the original Hayabusa spacecraft, weighing 600 kg when fully fuelled, and will be fitted on a larger satellite platform than its predecessor. The Hayabusa-2 will hold a more powerful sample collection system that will attempt to dig a crater in the asteroid to bring a bigger cache of samples back to Earth. Moreover, the Hayabusa-2 will be equipped with a Ka-band communications subsystem that will be faster than the original Hayabusa's X-band system, and it will carry a sophisticated camera to better capture the shape and the geography of the asteroid. The ¥16 billion ($204 million) spacecraft will be designed to visit 1999 JU3, a 920-m-diameter carbonaceous asteroid in a similar orbit to Itokawa. Carbonaceous asteroids are plentiful, rocky, and thought to contain water and organic materials, whereas asteroids such as Itokawa are stony, and are thought to lack organic materials.[357]

1.3.3.5 Industrial Developments in China

While the Chinese launcher, Long March 3B had been used to successfully place Eutelsat's W3C Commercial Telecom Satellite into geo-orbit on October 7, 2011, recent changes in US ITAR rules have restricted the EU from launching other 'so-called' ITAR–free spacecraft on Chinese launchers. That is to say that the US has restricted certain satellite components from export to China, directly or through third parties. While W3C had broken the 12-year gap in satellite launches from China, following the ITAR rule changes adding previously unrestricted satellite components to the controlled list in legislation passed late in 2012, the Thales Alenia-built Turkmen satellite is now barred from being launched on a Chinese launcher in 2014. Instead, it will be launched by an upgraded Falcon 9 rocket in late 2014 or 2015.[358] In fact, while the newly released US government "1248 report" recommends allowing the government to focus its ITAR controls on technologies and capabilities that are the most sensitive, it still recommends strengthening the US ban on shipping US satellite technology to China for launch on Chinese rockets.[359] Despite the export ban, Thales Alenia Space wanted access to the Chinese market, and has developed an "ITAR-free" product line.[360] However, it will need to make a long-term investment to replace all U.S.-built parts with parts made elsewhere to be able to have a to have a fully ITAR-free product.

[357] Kallender-Umezu, Paul. "NEC Tapped to Build Second Asteroid-bound Hayabusa Probe." Space News 30 Jan. 2012: 10.

[358] De Selding, Peter. "With Chinese Option Blocked, European-built Satellite To Fly Atop Falcon 9." 17 June 2013. SpaceNews 16 May 2014. http://www.spacenews.com/article/launch-report/35820with-chinese-option-blocked-european-built-satellite-to-fly-atop-falcon-9.

[359] Leone, Dan. "U.S. Report Supports Sweeping Reform of Satellite Export Rules." 18 Apr. 2012. Space News 23 May 2012. http://www.spacenews.com/policy/120418-report-backs-reform-sat-export.html.

[360] De Selding, Peter. "Chinese Rocket Launches Eutelsat's W3C Satellite." Space News 10 Oct. 2011: 4.

AsiaSat of Hong Kong reported an 12.7 % increase in revenue and a 20.1 % increase in operating profit for 2012, with total revenue reaching HK$1.78 billion ($229.6 million) from HK$1.58 billion ($203.4 million) in 2011, while operating profit was HK$1.22 billion ($157.4 million) from HK$1.05 billion ($135.2 million) in 2011.[361] In 2013, total revenue dropped by 15.8 % to HK$1.50 billion ($193.4 million) with operating profit similarly dropping by 26.1 % to HK$897.7 million ($115.8 million) for the year.[362] The reduction had been anticipated in 2012, when AsiaSat warned its investors that a major customer had insisted on renewing its transponder lease contract at a lower rate, in addition to ongoing competitive pressures of operating in a crowded Asian field.[363] AsiaSat also sold its subsidiary SpeedCast to TA Associates in late September 2012, with SpeedCast in parallel selling its 50 % stake in the money-losing Dish-HD Asia Satellite venture with EchoStar of Englewood, Colorado, USA, to an undisclosed third party. AsiaSat has four satellites in operation, with the latest being AsiaSat 7 which entered into service in February 2012. Work on two more satellites, AsiaSat 6 and AsiaSat 8, is already under way and they should be ready for launch in 2014.[364]

1.3.3.6 Industrial Developments in India

Very high regulatory barriers in India make access to its satellite telecommunications market an unusually difficult pursuit. Nevertheless, SES of Luxemburg is investing heavily there in the hope of capturing 40 % of the Indian satellite television market within the next few years. Capacity will increase as part of a major capital spending program, as SES's total in-orbit transponder supply will be increased by 23 %, i.e. 293 transponders on 12 satellites will be launched between 2011 and 2014; 85 % of that capacity will be directed toward emerging markets, mostly television markets. India is by far the biggest emerging market; its six pay-TV and one free-to-air DTH satellite television providers have a combined total of 32 million subscribers, with that number currently growing at a rate of nearly 1 million per month. With over 300 television channels awaiting regulatory approval, the sheer demand partly explains why India has been forced to allow SES and other non-Indian satellite providers into the market. It is likely that India will remain a growing market for non-Indian providers for the long term, as the

[361] AsiaSat Annual Report 2012. AsiaSat 16 May 2014: 54. http://www.asiasat.com/asiasat/EN/upload/doc/support_reports/ar2012_eng.pdf.

[362] AsiaSat Annual Report 2013. AsiaSat 16 May 2014: 55. http://www.asiasat.com/asiasat/EN/upload/doc/support_reports/ir_2013.pdf.

[363] De Selding, Peter. "AsiaSat's Appetite for Acquisitions Stimulated by a No-growth 2013." 21 Mar. 2014. SpaceNews 16 May 2013. http://www.spacenews.com/article/financial-report/39931asiasat%E2%80 %99 s-appetite-for-acquisitions-stimulated-by-a-no-growth-2013.

[364] De Selding, Peter. "AsiaSat's Appetite for Acquisitions Stimulated by a No-growth 2013." 21 Mar. 2014. SpaceNews 16 May 2013. http://www.spacenews.com/article/financial-report/39931asiasat%E2%80 %99 s-appetite-for-acquisitions-stimulated-by-a-no-growth-2013.

regulations will necessarily be relaxed since India will never launch enough bandwidth on its own to meet demand.[365]

Legislators in India have not come to the same conclusion, however. In April 2012 the Indian government proposed a new tax that would impose a 10 % royalty fee on foreign satellite communications services that would be retroactive covering the past 36 years. The government is looking for ways to reduce its deficit without regard to the crippling effect this tax will have on broadcast and communications. Such a move would put India in breach of its international tax treaties, as compliance with the royalty tax would amount to double taxation. The matter is now on appeal before the Supreme Court of India. However, if the tax is enforced and foreign satellite providers are unable to obtain a tax credit in their own tax homes, they will be forced to pass on the royalty to their customers in India. The 130-member Cable and Satellite Broadcasting Association of Asia (Casbaa), including many of the world's biggest commercial satellite fleet operators, is also attempting to persuade the Indian government that retroactivity violates basic international rules and principles of fair play.[366] The country is expected to release a new satcom policy in 2014, with satellite operators, equipment vendors and service providers all anticipating revised regulatory restrictions.[367]

1.3.3.7 World

The Canadian satellite component manufacturer Com Dev International reported increases in revenue for the years 2012 and 2013. Com Dev reported revenues of C$208.6 million ($208.5 million) in 2012, a 2.7 % increase from 2011; and C$215.5 million ($205.9 million) in 2013, another 3.3 % increase in revenue.[368] By the year ending 31 October 2013, Com Dev reported a 26 % increase in its backlog, stemming mainly from new orders for commercial satellite components, reaching C$164.7 million ($157.4 million) in 2013, from C$139 million ($138.9 million) in the previous fiscal year.[369]

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[365] De Selding, Peter B. "Despite Barriers, SES Invests Heavily in Indian Satellite Market." Space News 6 June 2011: 6.

[366] De Selding, Peter B. "Satellite Fleet Operators Protest Indian Tax Proposal." 5 Apr. 2012. Space News 9 May 2012. http://www.spacenews.com/policy/120405-sat-operators-protest-indian-tax.html.

[367] Krishnan, Deepu. "Challenges and Opportunities in the Indian Satcom Market." 17 Feb. 2014. SpaceNews 18 May 2014. http://www.spacenews.com/article/opinion/39541challenges-and-opportunities-in-the-indian-satcom-market.

[368] De Selding, Peter. "Com Dev Builds a Backlog Despite Slowdown in U.S. Defense Spending." 10 Jan. 2014. Space News 28 Mar. 2014. http://www.spacenews.com/article/financial-report/39028com-dev-builds-a-backlog-despite-slowdown-in-us-defense-spending.

[369] Ibid., De Selding, Peter. "Com Dev Balks at Fixed-price RCM Work." 11 Jan. 2013. Space News 27 Mar. 2014. http://www.spacenews.com/article/satellite-telecom/33122com-dev-balks-at-fixed-price-rcm-work.

Thaicom of Thailand generated a 20.5 % increase in its transponder lease revenue, along with an increase in revenue from its IPStar consumer broadband Ku-band satellite service in 2012, amounting to the company's first profit in 5 years.[370] Its revenue in 2012 reached 7.27 billion Thai Baht, a 9.7 % increase from 6.62 billion Thai Baht in 2011; its revenue in 2013 increased by a further 8.7 % to 7.90 billion Thai Baht.[371] Thaicom earned a net profit in 2012, amounting to 173.9 million Thai Baht; that net profit substantially increased by 548.43 % to 1.13 billion Thai Baht in 2013. Its satellite services revenue increased by 10.1 % to 6.32 billion Thai Baht in 2012 from 5.74 billion Thai Baht in 2011; and satellite services revenue increased by a further 10.4 % to 6.96 billion Thai Baht in 2013. Satellite services amounted to 88.2 % of the revenue generated in 2013, an increase from the 86.8 % share of revenue generated in the previous year. By 2013, Thaicom had presold 40 % of its capacity on its Thaicom 6 satellite, while also developing its Thaicom 7 (Asiasat 6) satellite under a partnership with AsiaSat.[372]

1.3.4 Industrial Overview

1.3.4.1 Launch Sector

Despite its crucial importance for the satellite industry, the launch sector is an enabler rather than a primary economic activity. The revenue it generates historically has been far less significant than that originating from the satellite manufacturing and satellite services businesses.

Whereas the year 2012 experienced decreased activity for the launch sector from 2011, with a total of 78 launches, 2013 saw increased activity with 81 launches conducted by launch providers from Russia, the United States, Europe, China, India, Japan, Iran, North Korea, South Korea, and the multinational Sea Launch AG (see Tables 1.1 and 1.2).

Important events marked both reporting years. For instance, in 2012, the four non-commercial launch failures were: an Unha 3 launch carrying the North Korean Kwangmyongsong 3 payload in April; a Safir 2 launch carrying the Iranian Fajr payload in May; another Safir 2 launch carrying the Fajr 2 payload in September; and a mission failure of the Orbcomm OG2-01 launched on SpaceX's Falcon 9 in

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[370] De Selding, Peter. "Top Fixed Satellite Service Operators | A Breakout Year: Thaicom." 8 Jul. 2013. Space News 27 Mar. 2014. http://www.spacenews.com/article/features/36180top-fixed-satellite-service-operators-a-breakout-year-thaicom.

[371] "Thaicom Public Company Limited Annual Report 2013." 13 Feb. 2014. MorningStar 27 Mar. 2014. http://quicktake.morningstar.com/stocknet/secdocuments.aspx?symbol=thcom&country=tha.

[372] De Selding, Peter. "Top Fixed Satellite Service Operators | A Breakout Year: Thaicom." 8 Jul. 2013. Space News 27 Mar. 2014. http://www.spacenews.com/article/features/36180top-fixed-satellite-service-operators-a-breakout-year-thaicom.

Table 1.1 Worldwide launches in 2012 per country, number of launched systems, and commercial status (Source: FAA)

Launchers	Number of launch systems active in 2012	Total number of launches	Commercial launches	Non-commercial launches
Russia	7	24	7	17
China	8	19	2	17
USA	10	13	2	11
Europe	4	10	6	4
Iran	1	3	0	3
Multinational	1	3	3	0
India	2	2	0	2
Japan	2	2	0	2
North Korea	1	2	0	2
South Korea	0	0	0	0
Total	**36**	**78**	**20**	**58**

Table 1.2 Worldwide launches in 2013 per country, number of launched systems, and commercial status (Source: FAA)

Launchers	Number of launch systems active in 2013	Total number of launches	Commercial launches	Non-commercial launches
Russia	10	32	12	20
USA	12	19	6	13
China	7	15	0	15
Europe	4	7	4	3
India	2	3	0	3
Japan	3	3	0	3
South Korea	1	1	0	1
Multinational	1	1	1	0
Iran	0	0	0	0
North Korea	0	0	0	0
Total	**40**	**81**	**23**	**58**

October. There was also one commercial launch failure, i.e. a Proton M launch carrying the Telkom 3 and Express MD2 payloads in August. In 2013, the launch sector experienced 2 non-commercial launch failures: the Proton M launch carrying the Glonass M46, Glonass M48, and Glonass M49 payloads in July; and a Long March 4B launch carrying the CBERS 3 payload in December. There was also one commercial launch failure, with a Sea Launch AG Zenit 3SL launcher carrying the Intelsat 27 payload in February.

When looking at specific countries, Russia remained the world leader in the number of launches for 2012 and 2013; of the total launches per year, Russia accounted for approximately 30.8 % in 2012, with an increased 39.5 % in 2013.

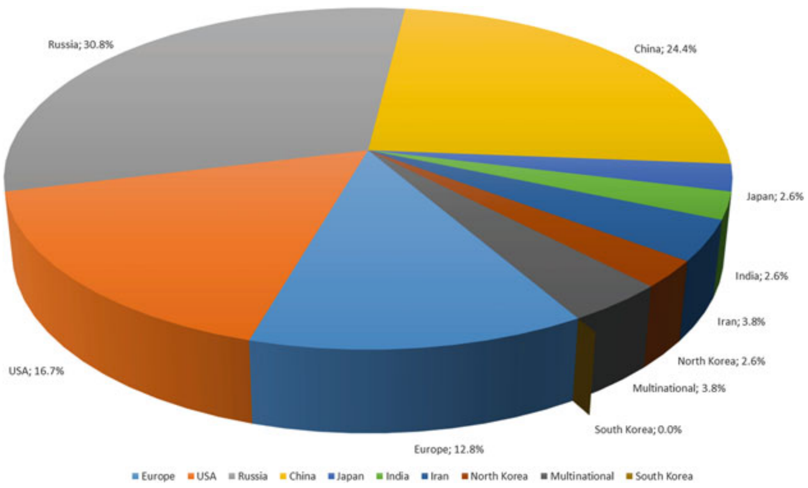

Fig. 1.16 Worldwide launches by country in 2012 (Source: FAA)

China had been in the second position in 2012, with a 24.4 % share, but lost its position to the United States in the next year in conducting 18.5 % of the year's launch activity. The United States in turn saw its share increase from 16.7 to 23.5 % by the end of 2013. Europe and the multinational Sea Launch saw their launch activities recede by several percentage places, further down the ranking Japan and India would exhibit increasing shares in global launch activity occurring in 2013 (see Figs. 1.16 and 1.17).[373]

In 2012, Russia launched 24 vehicles using seven different launch system configurations; it launched 32 vehicles using ten different launch configurations in 2013. The US used a set of ten different launch configurations for a total of 13 launches in 2012; in 2013, it used twelve different launch configurations for 19 launches. In 2012, China once again conducted 19 launches, this time using eight configurations; in 2013, China used seven different launch configurations for 15 launches. And India used two launcher configurations for both its two launches in 2012, and three launches in 2013. In 2012, Europe used its Ariane 5 ECA and ES-ATV launchers, its Soyuz 2 ST launcher, and its Vega launcher for its ten launches (6 Ariane 5 ECA, 1 Ariane 5 ES-ATV, 2 Soyuz 2 ST, and 1 Vega); in 2013, it used these four configurations for its seven launches. Japan had two launches using its two launchers in 2012, followed by three launches with three configurations in the following year; while Iran used its one launcher for its three launch attempts in 2012, with a gap in the following year; and the Multinational provider Sea Launch AG using one launch configuration for three launches in 2012, while attempting only one launch in 2013. North Korea was active in 2012 with two

[373] Commercial Space Transportation: 2012 Year in Review, 3, and Commercial Space Transportation: 2013 Year in Review, 3.

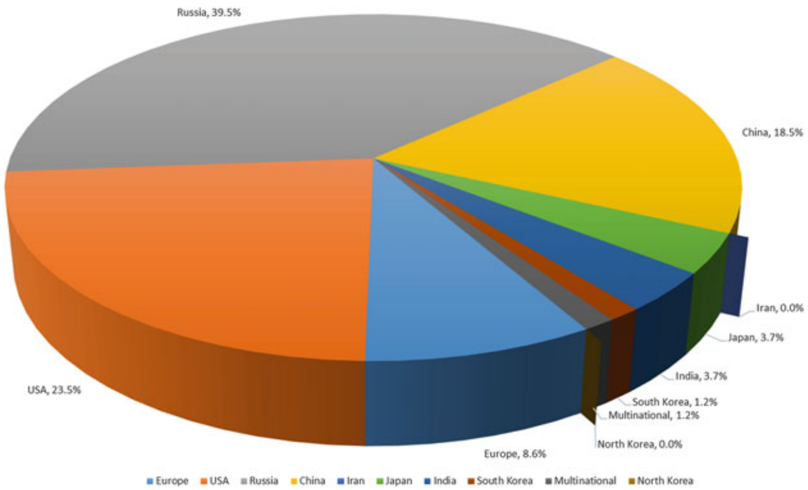

Fig. 1.17 Worldwide launches by country in 2013 (Source: FAA)

launches on one launch configuration, while South Korea was active in the following year with one launch on its single launcher. With many options available in terms of launch systems, the different launch system configurations used in 2012 were 36, although this increased by 4 to the 40 used in 2013.

With Ariane 5's dual payload capacity in mind, the activity of the two leaders of commercial launches (Europe and Russia) should be considered as nearly equivalent, with Europe leading in commercial revenue in 2012, but surpassed by Russia in the following period. When considering non-commercial launches, Russia's dominance is not quite apparent, as it now contends with China for first place. In 2012, the two countries shared the same first position, both with 17 non-commercial launches; in 2013, Russia beat China by five launches, and the US by seven launches. In the past 3 years, Russia has consistently held an average share at around 30 % of non-commercial launches; in 2012 it had a 29.3 % share, and in 2013 it grew to 34.5 %. China has taken second position in non-commercial launch activity, sharing the lead with Russia in 2012 with its 29.3 % share, though dipping to 25.9 % in 2013. In 2012, the US conducted 19.0 % of non-commercial launches, followed by 22.4 % in 2013.

The ratio of commercial to non-commercial payload launches appears unchanged from previous years, however the number of payloads launched increased significantly in 2012 and 2013. While the number of payloads in 2012 was slightly more than in 2011, it was nearly doubled in 2013 due mostly to what appeared to be the exponentially increasing number of cube satellites and microsats that were launched. The majority of non-commercial activity came from Russia, China, and the US. China, with its 17 non-commercial launches in 2012, and its 15 launches in 2013, is especially notable as a country that is rapidly developing its national programmes in remote sensing and navigation systems, as well as its own

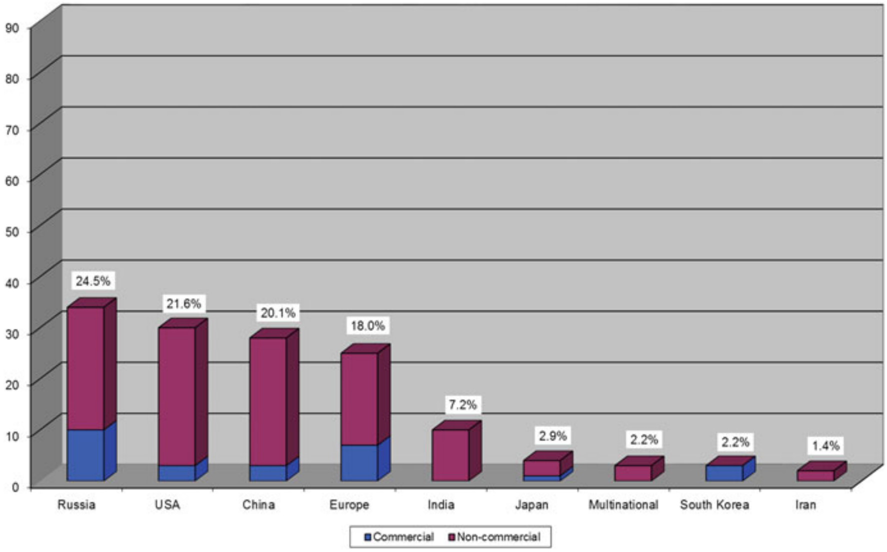

Fig. 1.18 Total payloads launched in 2012 by country, share and commercial status (Source: FAA)

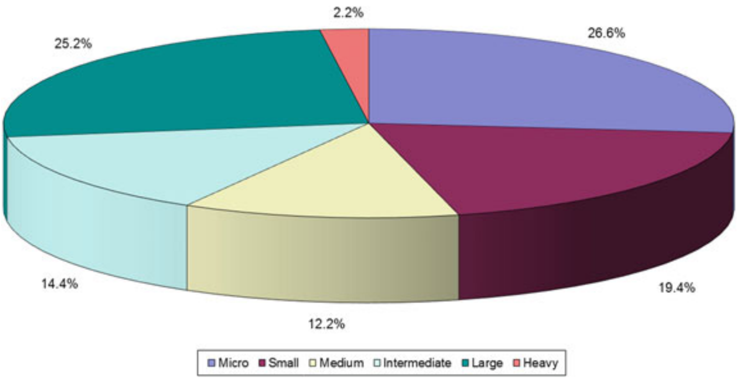

Fig. 1.19 Distribution of the payloads launched in 2012 by mass class (Source: FAA)

space station. A total of 27 non-commercial payloads from China were launched in 2012, followed by 21 payloads in 2013. Similarly, many of Russia's 87 payloads had non-commercial functions with 36 payloads involved in such programmes as ISS replenishment, the GLONASS system, etc. The US re-emerged in terms of launching commercial payloads in 2012 and 2013, following zero launches in 2011, although the its ratio in commercial to non-commercial payloads (not including microsatellites) was around 1–7 in 2012, and 1–4 in 2013.

Regarding the global share of payloads launched in 2012 and 2013 (see Figs. 1.18, 1.19, 1.20 and 1.21), Russia took first place in both years, albeit with a

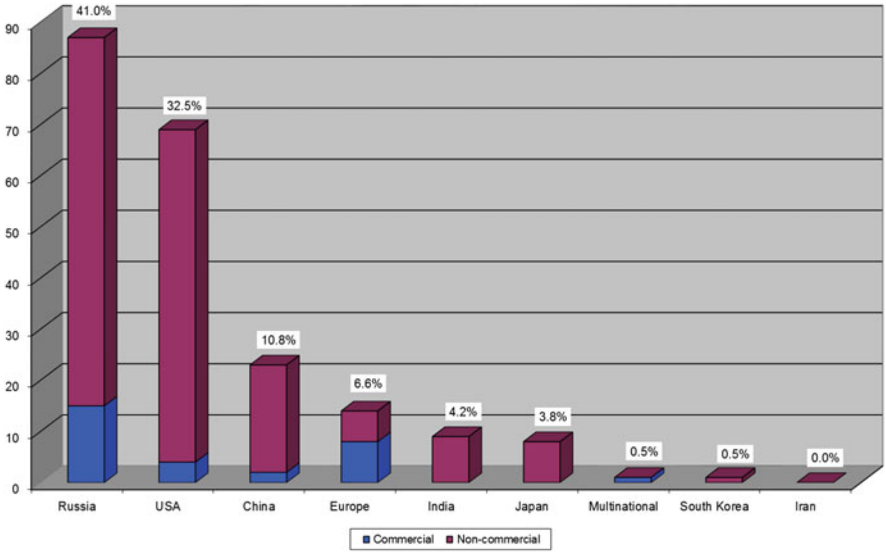

Fig. 1.20 Total payloads launched in 2013 by country, share and commercial status (Source: FAA)

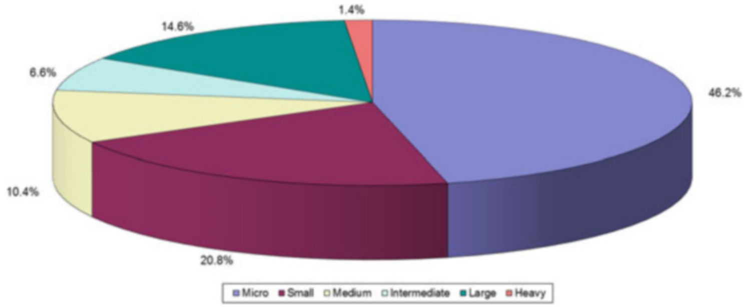

Fig. 1.21 Distribution of the payloads launched in 2013 by mass class (Source: FAA)

15.3 point decrease in its stake in 2012 where 34 payloads were launched, representing a 24.5 % share on the worldwide scale. In 2013, launching a total of 87 payloads, Russia held a 41 % share of payloads launched on the worldwide scale, marking a return to previous levels held in 2011 and 2010. Moreover, when excluding the 98 cubesat payloads from the assessment, Russia's share in payloads launched in 2013 reached 44.7 % of the remaining total. The US was surpassed by China for second place in 2012, launching 28 payloads, which amounted to a 20.1 % share; however, it regained its position in 2013, having launched a total of 69 payloads, resulting in a 32.5 % share of payloads launched on the worldwide scale. However, when not considering the cubesat payloads in the assessment, the US share dropped substantially, tying it with China at 17.5 %. On the other hand, China overtook the US in 2012, with its 30 payloads launched amounting to a 21.6 % share for that year; in 2013, 23 payloads were launched, amounting to 10.8 % on the worldwide scale—yet when discounting China's three cubesat payloads launched for that year, its share of payloads launched in 2013 tied with the US at 17.5 %, as mentioned. Europe launched 18 payloads with a share of 18.0 % in 2012, and 14 payloads with a share of 6.6 % in 2013 (11.4 % when excluding total cubesat payloads from the assessment). Japan overtook India in 2012 with ten payloads at a share of 7.2 %, while India had four payloads launched at a share of 2.9 %; in 2013 India regained its lead, launching nine payloads at a share of 4.2 %, to Japan's eight payloads launched at a share of 3.8 %.

Concerning the distribution of payload sizes, there were some significant changes over the 2012 and 2013 periods. In both periods, "Micro" was the mode with 37 payloads at 26.6 % of the total in 2012 (an increase of 13.1 points relative to 2011), and 98 payloads at 46.2 % of the total in 2013 (a further increase of 19.6 points from 2012). Large payloads were second place in 2012, with 35 launched at 25.2 % (up 1.1 points from 2011); yet they were outpaced by Small payloads in 2013, launching 31 payloads for that year, amounting to 14.6 % of the total (down 10.6 points). In 2012, Small payloads were in the third place, with 27 payloads at 19.4 % (down 6.1 points from 2011), 20 Intermediate at 14.4 % (up 3.9 points), 17 Medium at 12.2 % (down 9.6 points), and lastly, 3 Heavy payloads at 2.2 % (down 2.4 points). In 2013, Small payloads were in second place, with 44 payloads at 20.8 % (up 1.3 points from 2012), Large payloads were in third place, Medium payloads were in fourth place, with 17 payloads at 12.2 % (down 1.9 points), 14 Intermediate at 6.6 % (down 7.8 points), and lastly, 3 Heavy payloads at 2.2 % (down 2.4 points).[374]

In 2012, Arianespace held the top position, in terms of market share, with 31.6 %, followed by International Launch Services with 29.0 % (see Figs. 1.22 and 1.23). In 2013, while more launch systems were called upon, they were used for fewer GEO satellite launches. This time International Launch Services held the top position with 33.3 % market share, next ULA with 25.9 %, followed by Arianespace with 22.2 %.

[374] Micro payloads have a mass of 91 kg or less, and are mainly science satellites, technological demonstrators or small communications satellites. Small payloads weigh between 92 and 907 kg and are very often Earth Observation satellites, similar to the Jason or the RapidEye series. Medium payloads weigh between 908 and 2,268 kg, and feature the most diverse set of satellites, including small satcoms in geostationary orbit, Earth Observation satellites, and most of the Russian military satellites from the Kosmos series. Intermediate payloads, weighing between 2,269 and 4,536 kg, comprise medium satcoms and big scientific satellites. Large payloads, between 4537 and 9,072 kg, refer to big satcoms, as well as to the Soyuz and Progress spacecraft flying to the ISS. Finally, Heavy payloads, exceeding 9,072 kg, are linked to ISS activity, such as the cargo spacecraft, ATV, HTV, etc. *See* Commercial Space Transportation: 2011 Year in Review, 32.

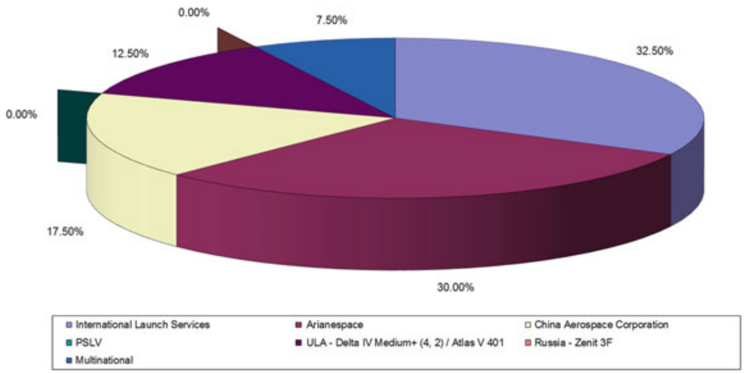

Fig. 1.22 Share of launch contracts for GEO satellites in 2012 by launch service provider

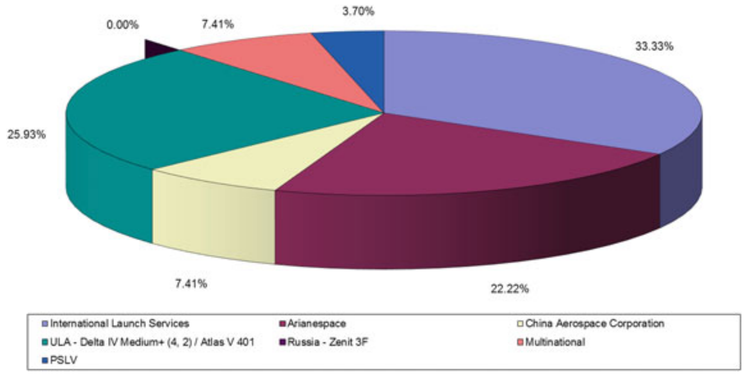

Fig. 1.23 Share of launch contracts for GEO satellites in 2013 by launch service provider

1.3.4.2 Satellite Manufacturing Sector

In 2012, 139 payloads were launched (including an estimated 14 crewed or cargo missions to the ISS or Chinese Tiangong 1 space station, one test launch of the US X-37B spacecraft). Russia manufactured 24.5 % of the launched payloads, while China made 21.6 %, and the US made 20.1 %. Europe accounted for 18.0 % of the payloads launched, while Japan accounted for 7.2 %, India produced 4.9 %, Iran and Multinational each provided 2.2 %, and North Korea accounted for 1.4 %.[375] In 2013, 212 payloads were launched (including an estimate of 98 cubesats, and 15 crewed or cargo missions to the ISS or Chinese Tiangong 1 space station). Russia manufactured 41.0 % of the launched payloads, while the US made 32.5 %, and China produced 10.8 %. Europe accounted for 6.6 % of the payloads launched,

[375] Commercial Space Transportation: 2012 Year in Review, 7. Payloads are assigned to the nation that commissioned them, not according to the nationality of the manufacturer.

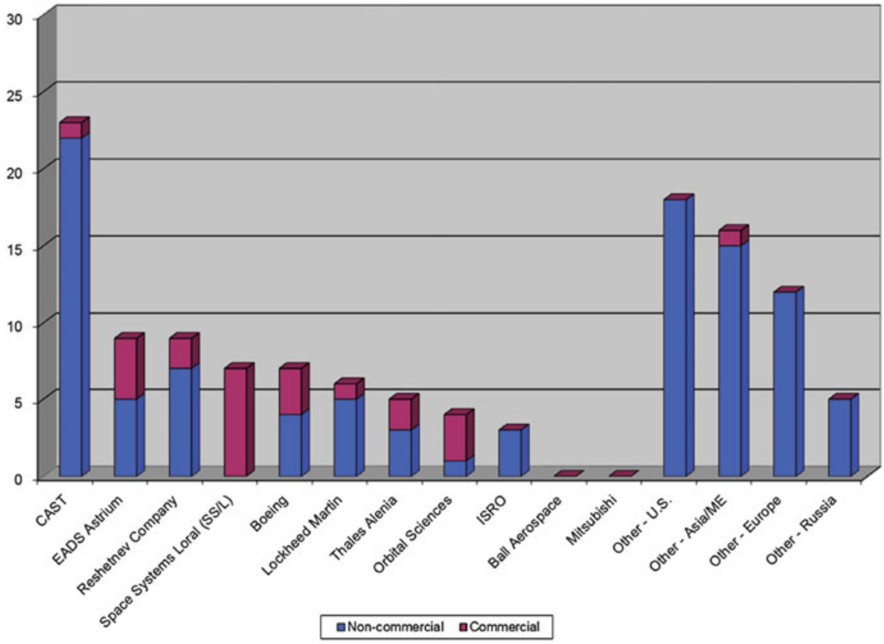

Fig. 1.24 Satellites launched in 2012 by manufacturer and commercial status (Source: Futron)

while India produced 4.2 %, and Japan accounted for 3.8 %. Multinational and South Korea each accounted for 0.5 % respectively (Fig. 1.24).[376]

Of the 124 satellites launched in 2012, 100 were non-commercial. China's CAST took the lead in manufacturing non-commercial satellites, with 22 satellites, followed by the Reshetnev Company which produced seven non-commercial satellites, showing increased presence in this market for both players; on the other hand Space Systems Loral (SS/L) and EADS Astrium (confirming their strong share in the commercial market), took the lead in commercial payloads manufacturing seven and four satellites respectively. Whereas SS/L's figures resulted from commercial orders, EADS Astrium also launched five non-commercial satellites. Finally, 2 of the 14 Russian satellites were designated for commercial activities, along with one commercial CAST satellite (Fig. 1.25). [377]

Of the 196 satellites launched in 2013 (not including the 15 crewed or cargo missions to the ISS or Chinese Tiangong 1 space station, or Chang'e 3 Moon lander and rover), 182 were non-commercial. Similar to the previous year, China's CAST took the lead in manufacturing non-commercial satellites, with 16 satellites, followed by the Reshetnev Company with 15, strengthening its previously

[376] Commercial Space Transportation: 2013 Year in Review, 14–17. Payloads are assigned to the nation that commissioned them, not according to the nationality of the manufacturer.

[377] Commercial Space Transportation: 2012 Year in Review, 29–32.

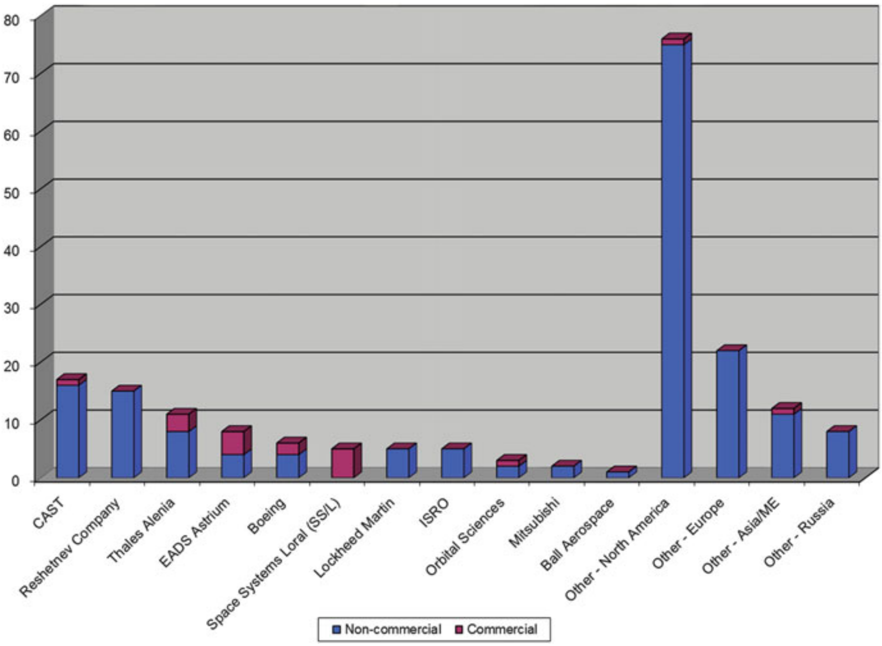

Fig. 1.25 Satellites launched in 2013 by manufacturer and commercial status (Source: Futron)

established presence; on the other hand Space Systems Loral (SS/L) and EADS Astrium took the lead in commercial payloads launching 5 and 4 satellites respectively. SS/L's figures resulted purely from commercial orders, whereas EADS Astrium also produced 4 non-commercial satellites. A majority of the satellites developed by Thales Alenia (8 of 11) were non-commercial in nature, as was the case with Lockheed Martin (5), Boeing (4 of 6), ISRO (5), Orbital Sciences (2 of 3), Mitsubishi (2), and Ball Aerospace (1). Of the 196 satellites launched in 2013, 98 were cubesats (49 of which had been developed in US institutions), and 44 small satellites developed globally (Figs. 1.26, 1.27, and 1.28).[378]

In 2012, the lion's share of orders for geostationary satellites went to US prime spacecraft manufacturers; Boeing took four commercial GEO satellite orders (i.e. ABS 3A, Intelsat 29e, Satmex 7, and SES 9), while SS/L also took four orders (i.e. Echostar 18, NBN 1A, NBN 1B, and Star One C4), and Orbital Sciences two orders (i.e. Amazonas 4A, and Amazonas 4B). This amounted to 66.7 % of commercial GEO communication satellite orders for 2012. On the other hand, European prime manufacturers stayed in the market with one order each, e.g. EADS Astrium (i.e. Express AM7) and Thales Alenia (i.e. Eutelsat 8 West B), accounting for 13.3 % of the activity. China's CGWIC took two orders (i.e. CongoSat 1, and SupremeSat 3), resulting in another 13.3 % share of the

[378] Commercial Space Transportation: 2013 Year in Review, 14–17.

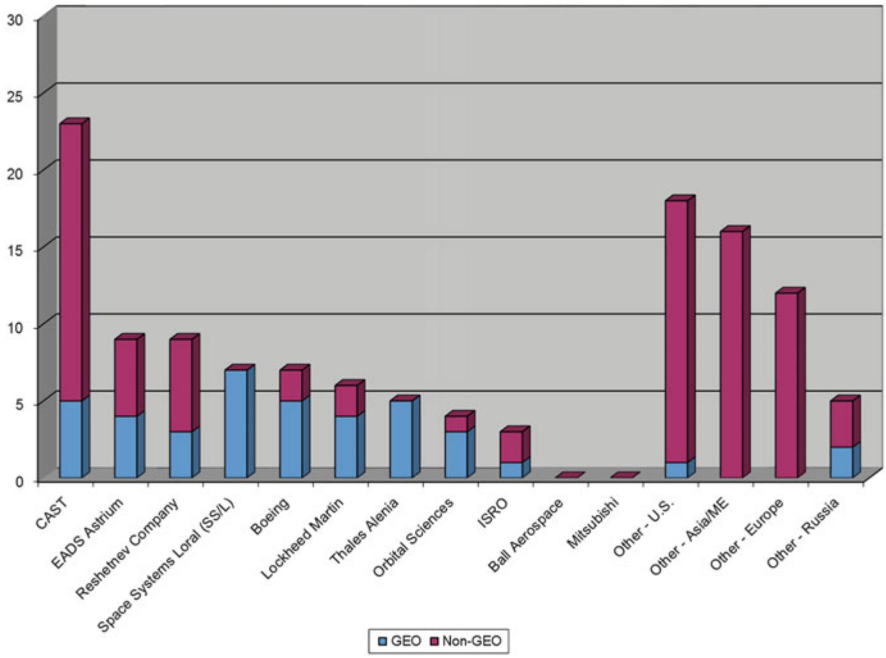

Fig. 1.26 Satellites launched in 2012 by manufacturer and orbit type (Source: Futron)

contracts awarded. And Israel Aerospace Industries was awarded a contract to develop the AMOS 6 communications satellite, resulting in a 6.7 % share.[379]

In 2013, European prime spacecraft manufacturers appeared to regain their competitive footing, catching up with US prime manufacturers for orders. While total commercial GEO communication satellite orders in the US accounted for 56.5 % of the contracts awarded, European contracts made up 21.7 % of the available awards. Boeing took seven orders (i.e. Inmarsat 5 F4, Intelsat 33e plus three future Intelsat Epic satellites, Satmex 9, and ViaSat 2), while SS/L had six orders (i.e. AsiaSat 9, Eutelsat 65 West A, Intelsat 34, JCSat 14, Jupiter 2/Echostar 19, and Star One D1). EADS Astrium had four orders (i.e. DirecTV Latin America Sat, Express AMU 1, Intelsat 32, and Telstar 12-Vantage), while Thales Alenia had 1 order (i.e. SGDC 1). Moreover, India's ISRO and China's CGWIC had two orders each, representing an 8.7 % share each of the contracts awarded; ISRO (i.e. GSAT 15, and GSAT 16), and CGWIC (i.e. APStar 9, and Nicasat 1). And lastly, Reshetnev had a 4.3 % share when tasked to develop the AOneSat 1 satellite.[380]

[379] "Satellite Orders Report—2012 Year-End Summary." Futron 23 Apr. 2014. http://www.futron.com/upload/wysiwyg/Resources/FoF/2012/FutronSM2012-EOY.pdf.

[380] "Satellite Orders Report—2013 Year-End Summary." Futron 23 Apr. 2014. http://www.futron.com/upload/wysiwyg/Resources/FoF/2013/FutronSM2013-EOY.pdf.

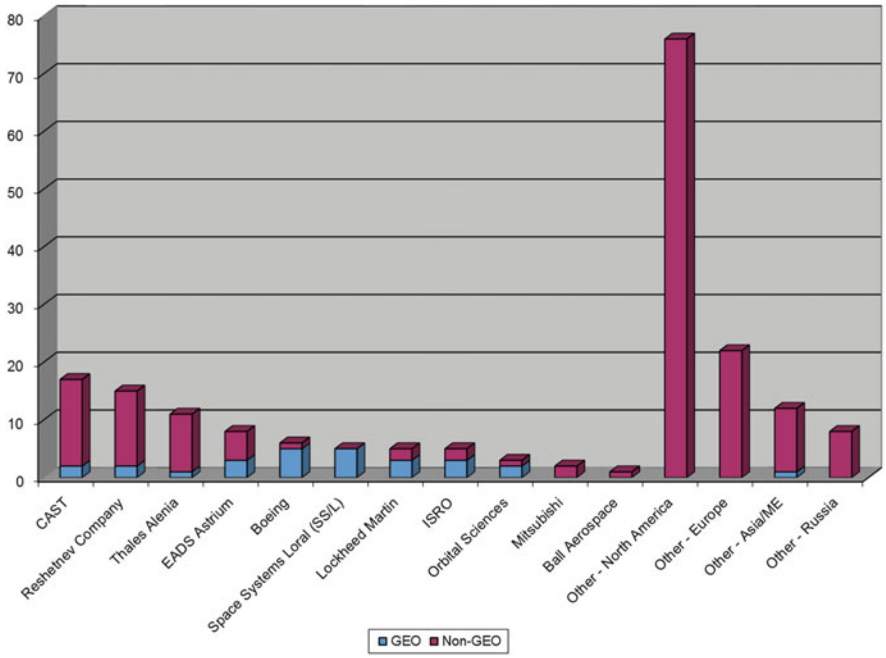

Fig. 1.27 Satellites launched in 2013 by manufacturer and orbit type (Source: Futron)

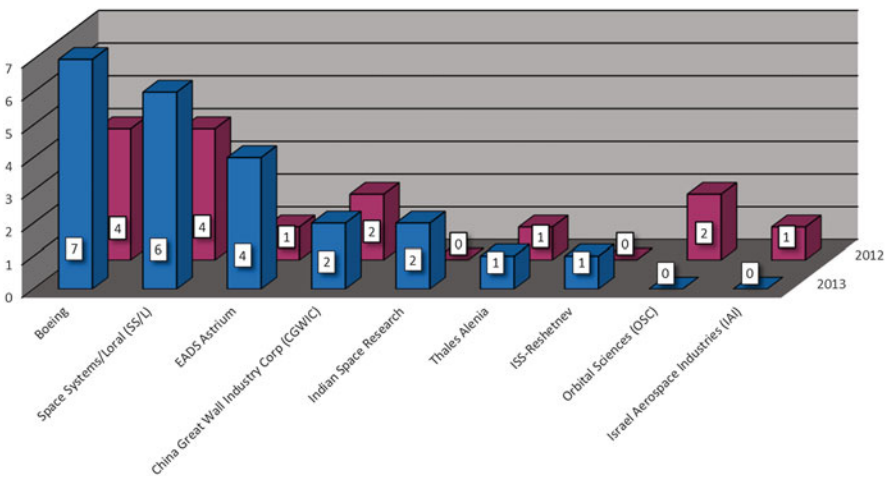

Fig. 1.28 GEO satellite orders in 2013 & 2012 by manufacturer

1.3.4.3 Satellite Operators Sector

Over 2012 and 2013, satellite operator business growth rates improved following the financial crisis although this growth is partly attributable to the industry's long investment cycles. Whereas global orders for commercial GEO telecommunications satellites fell by 30.4 %, from 23 in 2011 to 16 in 2012, marking the start of a decline of spending by the biggest satellite fleet operators, orders in 2013 bounced back to 23 satellites.[381] This reflected the cyclical spending patterns of the four largest satellite fleet operators: i.e. Intelsat (Luxemburg, Washington), SES (Luxemburg), Eutelsat (Paris) and Telesat (Canada), which held the same rank for both 2012 and 2013. In 2012 Intelsat, as the top FSS operator, had 54 satellites in orbit and five satellites on order; in 2013 it had 55 satellites in orbit and seven satellites on order. SES had 53 satellites in orbit and six satellites on order in 2012; and in 2013 it had 55 satellites in orbit and three satellites on order. Eutelsat had 31 satellites in orbit and six satellites on order in 2012; and in 2013 it had 37 satellites in orbit and six satellites on order. And Telesat had 14 satellites in orbit and without any satellites on order in 2012; while in 2013 it had ten satellites in orbit and one satellite on order.[382]

1.4 The Security Dimension

1.4.1 The Global Space Military Context

Space-related military spending saw an increase in most countries (not including the US), with total military spending estimated to have grown from $27.85 billion in 2011, to $36.2 billion in 2012, however, reduced spending by the US decreased overall amounts to $31.9 billion in 2013.[383] Euroconsult reported a similar outcome, estimating world government expenditures for defence space programs growing from $31.57 billion in 2011 to $31.69 billion in 2012; although that total decreased to $28.43 in 2013. Due to the nature of dual-use technology in space activity, there is a risk that certain military activity has been already included in larger budgets, which can result in double counting. Moreover, while missions, often listed as civil programmes, may also serve dual-purpose military objectives, their expenditure is not included in this section. The Space Report lists United

[381] Ibid.

[382] De Selding, Peter. "Top Fixed Satellite Service Operators | The List." 8 July 2013. Space News 30 May 2014. http://www.spacenews.com/article/satellite-telecom/36173top-fixed-satellite-service-operators-the-list>; De Selding, Peter. "The List | 2013 Top Fixed Satellite Service Operators." 7 July 2014 Space News 7 July 2014. http://www.spacenews.com/article/satellite-telecom/41157the-list-2013-top-fixed-satellite-service-operators.

[383] See: The Space Report 2013. Colorado Springs: The Space Foundation, 2013: 40, and The Space Report 2014. Colorado Springs: The Space Foundation, 2014: 40.

States military spending in 2012 to have been $27.47 billion, a slight increase from the previous year, with changes in military space spending to prioritize the development of new capabilities. As anticipated, space spending in the US decreased significantly in 2013, with military spending reaching only $21.72 billion.[384] This figure takes into account the space portion of the US Department of Defence budget (which includes the budgets of the National Reconnaissance Office (NRO), and the National Geospatial Intelligence Agency (NGA)). However, Euroconsult noted significant expenditure reductions in US defence space programmes for the whole period 2011–2013, from $24.13 billion in 2011 to $23.06 billion in 2012, and $18.93 billion in 2013.[385] While there is a significant discrepancy between the two authorities, it is likely due to the availability of information at their times of publication as well as the different programmes considered. It should be noted that these are conservative estimates that do not factor in US government programmes of a dual use nature, including military use of the National Oceanic and Atmospheric Administration (NOAA) weather satellite data. However, no matter how one looks at it there is clearly a trend towards decreasing military space spending in the US.

The Space Report 2014 estimated the US to account for about 68 % of global military space spending in 2013, less than the 75.9 % it estimated for 2012, and much less than the 95 % estimate of global military space spending in 2011. In contrast, non-US global military spending grew to 24.1 % in 2012, and 32 % in 2013.[386] However, the Euroconsult report is more conservative in this area, estimating US defence expenditure to be $23.06 billion, i.e. 72.8 % of the world total in 2012, and $18.93 billion, i.e. an even further diminished 66.6 % in 2013.[387] Russia, China, and Japan were next in line in military space spending, with 2012 defence spending estimates of $3.99 billion, $1.41 billion, and $1.15 billion respectively, while 2013 estimates increased to $4.58 billion, $1.67 billion, and $1.31 billion.[388] However, due to fluctuating exchange rates, variations in purchasing power, and different employment costs, a direct comparison of the budgets of these countries in fixed dollar values does not present a clear picture of their relative space defence efforts.

[384] The Space Report 2014. Colorado Springs: The Space Foundation, 2014: 40.

[385] Euroconsult 2014. Profiles of Government Space Programs: 12.

[386] The Space Report 2014. Colorado Springs: The Space Foundation, 2014: 40, The Space Report 2013. Colorado Springs: The Space Foundation, 2013: 40, and The Space Report 2012, 58.

[387] Euroconsult 2014. Profiles of Government Space Programs: 14.

[388] Ibid.

1.4.2 Europe

EU Member States continue to set the level of spending on military space programmes. Military space programmes are undertaken by all major European space faring nations, with an even larger number of European countries participating on the basis of bilateral or multilateral agreements and arrangements. While total European space defence spending dipped in 2012 to $1.04 billion from $1.21 billion in 2011, it returned to its 2011 level in 2013 with $1.21 billion in funding. This fluctuation came from a change in funding from the region's largest space defence players. Since 2011, France has sharply reduced its budget from $743 million to $558 million in 2012, followed by another reduction to $492 million in 2013; on the other hand, Germany's budget is estimated to have shifted from $69 million in 2011, to $63 million in 2012, and to $219 million in 2013. And while Italy's budget grew from $90 million in 2011, to $100 million in 2012, and $190 million in 2013, the UK's budget advanced from $235 million in 2011 to remain at $239 million in the next 2 years. The other military space budgets in Europe remained relatively unchanged from the previously recorded military space budgets.[389] This indicates that states may be increasing their cooperation to reduce redundant expenditure on military security. Outsourcing services and reducing public budget costs through PPPs has been established as an efficient alternative to individual government spending on Earth observation and dedicated military satcom services. Through cooperation and innovative funding schemes, European governments will be able to maintain current levels of security at less expense to tax payers.

In an effort to reduce expenditure, on 19 June 2013 the European Defence Agency (EDA) said it was in favour of replacing current separate British, French, German, Italian and Spanish military telecommunications satellites with a consolidated network owned by multiple nations. Britain, France, Italy, Spain and Germany have developed five individual military satellite communications networks, at a cost of between 6 billion Euros and 8 billion Euros ($7.77 and $10.36 billion), although these governments could significantly benefit from the shared use of a single next-generation military satellite communication system, enabling cost savings of more than 1 billion Euros ($1.3 billion) while still retaining much of their autonomy.[390] Sovereignty issues and national industrial policy interests are the initial hurdles to overcome in this endeavour. In April 2013, the EDA approved an effort called Secure Telecom by Satellite (SecTelSat), which requests EDA and other EU members to list their requirements for next-generation satellite systems. Under SecTelSat, a core group of nations would be contracted to develop the

[389] Ibid.

[390] De Selding, Peter. "Five European Nations Agree to Pool Resources for Satellite Bandwidth Buys." Space News 5 Dec. 2011: 5.

satellites and then lease portions of their capacity to other EU member states.[391] By the end of 2013, many EU members had stated their disapproval of the idea of pooling Europe's separate military satellite communications systems into a single constellation. Instead, on 19 and 25 November 2013, EU ministers adopted a set of recommendations from the EDA that left core command-and-control functions to individual governments buying their own hardened and encrypted satellite systems, while less-strategic satellite requirements would be merged into a pan-European system.[392]

On 2 July 2013, Germany's OHB AG announced its 816 million Euros ($1.1 billion) contract with the German defence procurement agency, BAAINBw, to develop the three-satellite SARah radar reconnaissance system; the system is expected to be operational in late 2019. SARah's ground segment will be operational in 2016, allowing the currently operating SAR-Lupe satellites to make use of the ground services prior to transitioning to SARah. OHB's SAR-Lupe satellites, operating since 2008, are under contract with the German military to run until November 2017.[393]

France also had plans to enhance its military capabilities, issuing its seven-year military program proposal on 2 August 2013, which emphasised a three-satellite 'Ceres' constellation, that would fly in formation conducting operational electronic intelligence as a top priority. The system, expected to be operational in 2020, would replace France's current French-Italian Syracuse military telecommunications satellite system. Even with the success of Syracuse, to France, military satellite telecommunications is preferably a "sovereign" undertaking, hence cooperation with Italy and Britain on a common milsatcom effort is expectedly a slow process. Even so, France had made some progress with Italy by mid-summer 2013.[394] The Defence Ministries of both France and Italy will have separate telecommunications payloads on the Sicral 2 satellite, being constructed by Thales Alenia Space, which is scheduled for launch in 2014. Both countries' military and civil space authorities also share the cost of the upcoming Athena-Fidus broadband satellite, which is

[391] De Selding, Peter. "Military Satellite Communications | Europe Faces Obstacles in Pooling Military Satellite Telecom Resources." 19 June 2013. SpaceNews 5 May 2014. http://spacenews.com/article/military-space/35877military-satellite-communications-europe-faces-obstacles-in-pooling.

[392] De Selding, Peter. "EU Backing Away from Combining Milcom Constellations." 26 Nov. 2013. SpaceNews 5 May 2014. http://spacenews.com/article/military-space/38368eu-backing-away-from-combining-milcom-constellations.

[393] De Selding, Peter. "OHB Signs Contract for Germany's Next-gen Radar Satellites." 2 July 2013. SpaceNews 6 May 2014. http://spacenews.com/article/military-space/36091ohb-signs-contract-for-germany%E2%80 %99 s-next-gen-radar-satellites.

[394] De Selding, Peter. "Ceres Satellites are a High Priority in French Defense Ministry's 7-year Plan." 2 Aug. 2013. SpaceNews 6 May 2014. http://spacenews.com/article/military-space/36597ceres-satellites-are-a-high-priority-in-french-defense-ministrys-7-year.

expected to carry an extremely high frequency/Ka-band payload for Italy and a Ka-band payload; also to be launched in 2014.[395]

1.4.3 The United States

While exceeding the combined military space budgets of the world by a large, yet receding margin, the US defence-related space budget dropped by 13.6 % in 2013 due to budgetary pressures on spending. Whereas the US spent an estimated $26.46 billion in 2011, its budget increased to $27.47 billion in 2012 but then dropped substantially in 2013 to $21.72 billion.[396] In this subsection the focus will be on US DoD programmes as listed by the Space Report 2014, allowing readers to distinguish purely DoD expenditures with greater clarity than can be gleaned from other space faring nations.

The US military space budget increased by $1.01 billion in 2012, followed by a steep reduction of $5.76 billion in 2013. While the US military space budget more than doubles any other country's budget, a difference of 20.9 % (not including adjustments for inflation) is likely to have a substantial effect on US military programmes. The US Air Force (USAF) terminated the Defense Weather Satellite System (DWSS) on 16 April 2012,[397] while plans for a second Space-Based Space Surveillance satellite, designed to detect debris, spacecraft or distant space objects without interference related to weather, atmosphere or the time of day were absent from budget requests.[398] The budget for the US Missile Defense Agency (MDA) was expected to decrease by 8 % between 2012 and 2013, from $8.42 billion to $7.75 billion.[399] Moreover, in April 2013 the MDA's Precision Tracking Space System (PTSS), a satellite constellation capable of tracking ballistic missiles during the midcourse portion of flight, was officially cancelled in the 2014 budget request.[400]

[395] De Selding, Peter. "Italian Military Buys $100 M Spy Satellite from Israel in Exchange Deal." 6 July 2012. SpaceNews 6 May 2014. http://spacenews.com/article/italian-military-buys-100 m-spy-satellite-israel-exchange-deal.

[396] Cf. The Space Report 2012. . .:44 & The Space Report 2011, 43.

[397] "Defense Weather Satellite System Termination." 26 Apr. 2012. SpaceRef 22 May 2014. http://www.spaceref.com/news/viewpr.html?pid=36846.

[398] Ledbetter III, Titus. "U.S. Military Space Spending To Decline 22 Percent in 2013." 13 Feb. 2012. Space News 12 May 2012. http://www.spacenews.com/military/120213-mil-space-spending-decline.html.

[399] Ledbetter III, Titus. "Missile Defense Agency Seeks Big Increase in Space Spending." 14 Feb. 2012. Space News 12 May 2012. http://www.spacenews.com/military/120214-mda-seeks-increase-spending.html.

[400] SpaceNews Staff. "PTSS Canceled Before Analysis Of Alternatives, Report Says." 29 July 2013. SpaceNews 7 May 2014. http://spacenews.com/article/military-space/36503ptss-canceled-before-analysis-of-alternatives-report-says.

The USAF has shown greater interest in placing military payloads aboard commercial satellites as a low-cost way of fielding new capabilities. However, it has held back in committing to their use until Congress starts to fully integrate hosted payloads into its future planning. Indeed, following 27 months in orbit, on 6 December 2013, the USAF announced it would decommission its experimental Commercially Hosted Infrared Payload (CHIRP) mission hosted by SES's SES-2 commercial satellite, due to reductions in US federal budget spending. Yet it should be noted that the mission had already been extended three times to include additional wide field-of-view staring demonstrations, and had originally been planned to complete its one-year mission in July 2012.[401] Moreover, the USAF has requested proposals for the Hosted Payload Solutions (HoPS) contracting vehicle which is designed to standardize the processes for placing dedicated military capabilities aboard commercial satellites. Experts on the topic highlight the potential in using hosted payload solutions for applications such as missile warning or weather monitoring.[402]

The USAF also plans to award a contract for its next-generation space-object tracking system in March 2014. This 'space fence' is a system of ground-based radars with enhanced ability to track greater numbers of smaller objects than the currently operating Air Force Space Surveillance System. The current system was slated to be shut down in September 2013, to save $14 million annually, while not compromising overall space surveillance capabilities; it being one component of the overall US Space Surveillance Network, which includes other ground and space based sensor assets. The new multibillion-dollar project had been delayed due to a Pentagon review of its major acquisition programs.[403]

Back in 2009, the Obama Administration cancelled plans to deploy a missile defence system in Europe in favour of a European Phased Adaptive Approach (EPAA) built around the Aegis Ballistic Missile Defence system. This system would be developed in stages, with the first phase having involved the deployment of Naval Aegis ships, carrying SM-3 Block 2A interceptors, in European waters in 2012. The second phase, having passed its critical design review in mid-October 2013, would place a land-based variant of the Aegis system and SM-3 Block 2A interceptors in Romania by 2015. By 2020, the third stage located in Poland would replace the current interceptor with the next-generation Aegis SM-3 Block 2B interceptor, and would be capable of targeting larger intercontinental ballistic

[401] "U.S. Air Force Decision To End CHIRP Mission Was Budget Driven." 12 Dec. 2013. SpaceNews 7 May 2014. http://spacenews.com/article/military-space/38628us-air-force-decision-to-end-chirp-mission-was-budget-driven.

[402] Gruss, Mike. "Industry Officials Call for Dedicated U.S. Air Force Funding for Hosted Payloads." 14 Oct. 2013. SpaceNews 7 May 2014. http://spacenews.com/article/military-space/37704industry-officials-call-for-dedicated-us-air-force-funding-for-hosted.

[403] Gruss, Mike. "U.S. Air Force Sets March 2014 Target for Space Fence Award." 21 Aug. 2013. SpaceNews 7 May 2014. http://spacenews.com/article/military-space/36887us-air-force-sets-march-2014-target-for-space-fence-award.

threats.[404] Raytheon Missile Systems is under contract to build 22 Block 2A interceptors for developmental testing.[405]

On 27 November 2012, the US DoD authorised the USAF to purchase up to 50 rocket cores during the next 5 years under its Evolved Expendable Launch Vehicle (EELV) programme. While 14 cores will be procured competitively, with the first of these competitive awards expected in 2015 for a mission launching in 2017, the other 36 will be procured from the DoD's traditional prime contractor United Launch Alliance (ULA) on a sole-source basis. The ULA is a joint venture between Boeing and Lockheed Martin, utilizing their respective Delta 4 and Atlas 5 rockets to launch both defence and scientific payloads for the US.[406] In 2012, the DoD had nine launches, four carrying classified National Reconnaissance Office payloads while the other five carried DoD or DoD-sponsored payloads including the launch of the X-37B[407]; in 2013, the DoD had eight launches, carrying two classified NRO payloads, in addition to six DoD-sponsored payloads.[408]

1.4.4 Russia

Russia has a long tradition of military space activity; however its current activity must be assessed in its current day context. Maintaining a reputation in the military space field may be in Russia's interest in a geopolitical sense, yet it should be borne in mind that Russia's reported military space budget makes up only a part of the total $8–10 billion spent by all countries in the world, excluding the US, while the US alone spent $21–27 billion. The Euroconsult Report 2014 is unclear as to the total amount Russia puts towards its military program, but reports that it should have been at least $3.99 billion in 2012, and $4.58 billion in 2013 (including dual-use programmes).[409] In 2012, Russia launched one optical reconnaissance satellite meant for intelligence, the Cosmos 2480, and launched its Cosmos Persona intelligence gathering satellite in 2013.

[404] Turner, Brinton. "MDA Budget Would Ramp Up Spending on European Missile Shield." 28 Feb. 2011. Space News 12 May 2012. http://www.spacenews.com/military/110228-mda-budget-spending-european-missile-shield.html.

[405] Gruss, Mike. "Military Quarterly | SM-3 Block 2A Passes Critical Design Review, Set for Flight Testing in 2015." 31 Oct. 2013. SpaceNews 7 May 2014. http://spacenews.com/article/military-space/37944military-quarterly-sm-3-block-2a-passes-critical-design-review-set-for.

[406] Leone, Dan. "Pentagon Approves EELV Block Buy, with Competitive Twist." 4 Dec. 2012. SpaceNews 15 May 2014 http://www.spacenews.com/article/military-space/32657pentagon-approves-eelv-block-buy-with-competitive-twist.

[407] Commercial Space Transportation: 2012 Year in Review, 11.

[408] Commercial Space Transportation: 2013 Year in Review, 7.

[409] Cf. Euroconsult Report 2014, 5.

On 30 March 2012, Russia launched its last Oko-series missile early warning satellite, labelled Cosmos 2479.[410] The satellite is designed to detect missile launches using an infrared telescope that senses infrared radiation emitted by the exhaust of rocket engines; it is part of an 8-satellite constellation—the first of the series was launched in 1991.[411] Russia reportedly operates between 60 and 70 military satellites, and plans to launch at least 100 additional military satellites in the next decade.[412] These satellites are meant to boost the country's reconnaissance and ballistic missile detection capabilities, the influx also benefitting the military's navigation and imaging capability.

In April 2013, Russia's military ordered five high-resolution optical-electronic surveillance satellites worth almost 70 billion roubles ($2.2 billion). Russia's Lavochkin aerospace company won the contract to design and build the satellites, but the electronic payload will be initially acquired either from Airbus Defence & Space, Thales Alenia Space, or Israel Aerospace Industries. The company intends to gradually increase the share of domestically produced electronic equipment in the payload, with the goal of eventually building several of the series on its own.[413]

Russia plans to launch additional military spacecraft in March 2014, following several years of delay due to technical reasons. In addition to the reform being conducted in Russia's launch and satellite sectors, it plans to qualitatively increase its space military forces to improve its strategic nuclear missiles and for capacity building for precision-guided conventional arms. In addition to improving its satellite technology, Russian will begin construction of terrestrial infrastructures to support these systems, with preliminary cost estimates reaching several trillion roubles up to 2020.[414]

Near the end of 2013, Russia's interest in placing Glonass navigation satellite ground stations in the US again came to light. The proposal was met with strong opposition from conservative lawmakers in the US, with some congressional Republicans proposing a legislative ban on any foreign satellite navigation facilities on US soil. Their concerns were based on the potential for the ground stations to be

[410] Clark, Stephan. "Russian early warning satellite orbited by Proton." 30 Mar. 2012. Spaceflight Now 12 May 2012. http://www.spaceflightnow.com/news/n1203/30proton/.

[411] Graham, William. "Russian Proton-K completes 45 years of service with US-KMO satellite launch." 29 Mar. 2012. NASA Spaceflight.com 12 May 2012. http://www.nasaspaceflight.com/2012/03/russian-proton-k-rocket-launch-us-kmo/.

[412] "Russian Military Orders Missile Early Warning Satellites." 25 Apr. 2012. Defence Talk 12 May 2012. http://www.defencetalk.com/russian-military-orders-missile-early-warning-satellites-41939/.

[413] "Russian Military Orders Five High-Res Spy Satellites—Media." 10 Apr. 2013. RIA NOVOSTI 14 May 2014 http://en.ria.ru/military_news/20130410/180548366/Russian-Military-Orders-Five-High-Res-Spy-Satellites--Media.html.

[414] Kislyakov, Andrei. "Russia's Military Looks to Outer Space." 6 Dec. 2013. Russia Beyond the Headlines 14 May 2014. http://rbth.com/science_and_tech/2013/12/06/russias_military_looks_to_outer_space_32341.html.

used for spying and improving the accuracy of Russian missiles.[415] On 26 December 2013, President Obama signed into law the US defense budget bill which contains a measure that effectively bars Russia from building about a half-dozen ground stations on US soil. With the new law, unless waived altogether on national security grounds, Congress would need certification from both the Secretary of Defense and the Director of National Intelligence that the ground stations would not be used to spy on the United States or improve the effectiveness of Russian weaponry; without that, Russian ground stations are barred.[416]

1.4.5 Japan

The Euroconsult report lists Japan's space defence budget at $1.15 billion in 2012 and $1.31 billion in 2013 (including dual-use systems), with 18 % of the 2013 budget directed toward satcom, about 47 % toward Earth observation, and about 30 % toward space security (i.e. mostly missile defence).[417] As a leading space faring country with broadly developed space capabilities, Japan has begun to refocus its efforts from its traditional multilateral "peaceful-use-only" position in space activities to the space security and defence areas. In the wake of several significant regional and international security events in recent years, Japan's space priorities have adapted to a more active role in the field of national security through the use of space technologies. A leader in multilateral diplomacy, it has increased even more its cooperation with multilateral organizations, as well as with its allies in building common space capabilities. Since 2011, Japan has become acutely sensitive to the challenges stemming from its region both in geopolitical terms and in terms of natural disasters. Hence, Japan has increased its focus on security; the results of which are new agreements, budget reshuffling and accelerated project completion times.

In 2008, Japan changed its basic law to allow active involvement in military space, whilst still respecting that this must be for peaceful purposes. Japan's 2009 Five year Basic Space Plan should also be mentioned in this context, as it calls for strengthening security through the utilisation of space. The plan recommended ¥2.5 trillion ($26 billion) in financing for civil and military space development activities between 2010 and 2014. In October 2011, Japan's Ministry of Defence requested an additional ¥260 billion in funding for military-purpose space programs in 2012. The

[415] Gruss, Mike. "Lawmakers Flag Proposal for U.S.-based Glonass Ground Stations." 25 Nov. 2013. SpaceNews 14 May 2014. http://spacenews.com/article/military-space/38340lawmakers-flag-proposal-for-us-based-glonass-ground-stations.

[416] Schmitt, Eric. "New Law All but Bars Russian GPS Sites in U.S." 28 Dec. 2013. The New York Times 14 May 2014. http://www.nytimes.com/2013/12/29/world/europe/new-law-all-but-bars-russian-gps-sites-in-us.html.

[417] Cf. Profiles of Government Space Programs. Paris: Euroconsult, 2014: 46-3.

2011 space budget of the Ministry of Defence was reduced by 32.2 % amounting to ¥41.3 billion, from ¥60.933 billion in 2010.[418]

In December 2010, Japan released a 10-year strategy document called the National Defence Program Guideline.[419] It calls for the strengthening of development efforts and the use of outer space in the field of information gathering, communications, disaster management and arms proliferation control. One of the main reasons why Japan decided to strengthen its position in space defence and security is constant security uncertainties from the Korean peninsula and East Asia military and space ambitions. On 12 December 2011, it successfully launched its next instalment of the much-delayed Information Gathering Satellite (IGS) system, consisting of two satellites with optical sensors and radar monitoring.[420] A long time in development (IGS was initiated following an August 1998 North Korean missile test that overflew Japan), with the launch of the IGS-Radar 4 spacecraft on 27 January 2013, Japan now has two functional radar satellites and an experimental optical satellite in orbit for disaster monitoring and national security purposes.[421] The IGS-Radar 4 carries a SAR that enables the satellite to peer through clouds and observe targets at night. Japan plans to replenish its surveillance constellation, with the launch of an optical satellite and a radar satellite in 2014, another optical satellite and a radar satellite in 2016 and a radar satellite in 2017.[422]

In October 2013, the governments of the US and Japan pledged to build on previous arrangements for the sharing of space situational awareness (SSA) information. In the following months, the countries had bilateral exchanges to discuss the topic, which resulted in the 3 October 2013 US-Japan SSA Sharing Agreement, calling on the two governments to deliver SSA data to one another expeditiously.[423]

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[418] Cf. The Space Report 2012, 55 & The Space Report 2011, 52.

[419] "National Defense Program Guidelines for FY 2011 and Beyond." Japan Ministry of Defense 11 May 2012. http://www.mod.go.jp/e/d_act/d_policy/pdf/guidelinesFY2011.pdf.

[420] Kallender-Umezu, Paul. "Japan Launches IGS Radar Reconnaissance Satellite". 13 Dec. 2011. Space News 8 May 2012. http://www.spacenews.com/launch/121311-japanlaunches-latest-radar-reconnaissance-satellite.html.

[421] "Japan Stays the Course on IGS under Latest Five-year Plan." 18 Feb. 2013. SpaceNews 30 Apr. 2014. http://www.spacenews.com/article/japan-stays-the-course-on-igs-under-latest-five-year-plan.

[422] Kallendar-Umezu, Paul. "With Launch, Japan Begins Rebuilding IGS Spy Satellite Network." 29 Jan. 2013. SpaceNews 8 May 2014. http://spacenews.com/article/military-space/33391with-launch-japan-begins-rebuilding-igs-spy-satellite-network.

[423] De Selding, Peter. "U.S., Japan Pledge Closer Cooperation on Space Surveillance." 4 Oct. 2013. SpaceNews 8 May 2014. http://spacenews.com/article/military-space/37551us-japan-pledge-closer-cooperation-on-space-surveillance.

1.4.6 China

China's space defence budget is estimated to have increased by 17.6 % from $1.20 billion in 2011 to $1.41 billion in 2012, followed by another increase of 18.6 % to $1.67 billion in 2013.[424]

The manner in which China develops its technical capabilities and the depth of its military interest in the space program merits analysis. It seems to be clear that Chinese space efforts are intimately connected to the Chinese army, principally because many space activities are under the direct control of the People's Liberation Army (PLA); moreover, all Chinese space operation facilities are entirely manned and operated by the PLA. In the case of manned space activities, all development and plans are directly under the control of the Chinese military and political bureau.

Analysis of China's space defence prospective is very difficult due to a dearth of unclassified sources. In May 2013, the US DoD presented its Annual Report to Congress on 'Military and Security Developments Involving the People's Republic of China 2013', confirming that China's growing space prowess shows no signs of slowing down. The report highlights China's interest in improving its capabilities "to limit or prevent the use of space-based assets by adversaries during times of crisis or conflict".[425] Having conducted a total of 19 space launches in 2012, and 15 in 2013, the country has expanded its space-based intelligence, surveillance, reconnaissance, navigation, meteorological, and communications satellite constellations. It should be noted that among other developments and trends mentioned, the report says some PLA writings emphasize the necessity of' using anti-satellite weapons to 'blind and deafen the enemy'.

However, the same report sparked protest from China's Defence Ministry, which had been strongly dissatisfied about the manner in which China's space programme had been cast. To respond to the report's statements over China's moves to assert its sovereignty in the neighbourhood and the questioning of the direction of China's defence policies, a spokesman for China's Defence Ministry said that "China's military build-up, meeting the country's needs of upholding sovereignty, security and territorial integrity, is part of the country's justified rights and does not target any specific country".[426] Also highlighted was the United States' heavy investment in developing state-of-the-art weapons and building up cyber-attack troops in recent years.

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[424] Profiles of Government Space Programs. Paris: Euroconsult, 2014: 14.

[425] David, Leonard. "China Space Program Ramping Up Capabilities, Pentagon Says." 21 May 2013. Space.com 13 May 2013. http://www.space.com/21251-china-space-capabilities-pentagon-report.html.

[426] "China Protests Against US Report on its Military." 8 May 2013. The Economic Times 13 May 2014. http://articles.economictimes.indiatimes.com/2013-05-08/news/39116773_1_pentagon-report-geng-yansheng-china.

Within weeks of China's protest of the US DoD's 'Report', some news outlets reported that China had conducted a land-based mid-course missile interception test on 27 January 2013. While unconfirmed by Chinese authorities, if substantiated, this would be the second time that China has conducted such a test; the country had successfully attempted a similar anti-missile test back in January 2007. These reports have led some US authorities to infer that Chinese policy makers are pursuing significant ballistic missile defence (BMD) capabilities. However, it should be noted that China's test was conducted just hours after the US had tested its own missile interceptor.[427] While Chinese authorities said that they had conducted a test of a sounding rocket, US authorities viewed it as a disguised ASAT missile test, pointing to similarities from the previous January 2007 ASAT test.[428]

According to China's 11th Five Year Plan, space activities are considered as one of China's major military advances. It suggests that development of certain technological areas, including space related capabilities, will play an important role in the army's modernisation efforts.[429]

Regarding space debris mitigation, following the 20 July 2013 launch of Chuangxin-3, Shiyan-7, and Shijian-15 on its Long March 4C launcher, the three spacecraft were observed conducting worrying manoeuvres, such as changing orbits and closing in on a separate satellite, the Shijian-7 (in orbit since 2005). While the mission was announced to be meant for "space debris observation", "mechanical arm operations" and the testing of "space maintenance technologies", its dual-use potential had the US alarmed that it could also be used for anti-satellite purposes.[430]

1.4.7 India

India is developing its own space military programme; however, the majority of the activities of the Indian Space Research Organization (ISRO) still focus on civil applications. Following China's ASAT test, defence scientists in India began

[427] Kazianis, Harry. "China Conducts Anti-Missile Test." 29 Jan. 2013. The Diplomat 13 May 2014. http://thediplomat.com/2013/01/china-conducts-anti-missile-test/.

[428] Gertz, Bill. "China Conducts Test of New Anti-Satellite Missile." 14 May 2013. The Washington Free Beacon 21 May 2014. http://freebeacon.com/national-security/china-conducts-test-of-new-anti-satellite-missile/.

[429] Cheng, Dean. "China's Space Program in the National Security Context." 18 Jan. 2012. The Heritage foundation 10 May 2012. http://www.heritage.org/research/reports/2012/01/us-needs-to-meet-chinas-space-challenge-of-the-next-5-years.

[430] David, Leonard. "Mysterious actions of satellites have experts guessing China's intentions." 10 Sept. 2013. NBCnews 21 May 2014. http://www.nbcnews.com/science/space/mysterious-actions-satellites-have-experts-guessing-chinas-intentions-f8C11122565.

focusing on “space security” to protect India’s $12 billion (Rs 60,000 crore) space infrastructure from electronic or physical destruction.

On 30 August 2013, India launched its first solely military communications satellite, GSAT-7 aboard the Ariane 5 launcher from the Kourou spaceport in French Guiana. The satellite is unique for India, due to its strategic character in providing a dedicated system for use by the Indian navy. In fact, the GSAT-7 had been ready for launch since 2010, but ISRO lacked a fully reliable GSLV platform to launch the spacecraft. To avoid further delay, India turned to Arianespace to carry the GSAT-7 along with Eutelsat’s ‘Eutelsat 25B’ commercial telecommunications satellite, to GEO orbit. The GSAT-7 will be used by India’s navy to monitor activities over both the Arabian Sea and the Bay of Bengal region, with an approximately 3,500- to 4,000-km footprint over the Indian Ocean region.[431]

By 30 November 2013, India’s Defence Research Development Organization (DRDO) began planning the first test of its newly developed interceptor missile from a defence base off the Odisha coast early in 2014. India’s Prithvi Defence Vehicle (PDV), part of India’s Ballistic Missile Defense (BMD) programme, has the potential to destroy incoming missiles with a strike range of around 2,500 km outside the earth’s atmosphere (at an altitude of over 150 km).[432] The BMD programme has also developed a long-range radar system that is able to detect incoming missiles and launch its own counter-projectile.[433]

India’s PDV can also be seen as a further step toward developing its own anti-satellite capabilities. In this pursuit, the DRDO is looking at the feasibility of developing such an anti-satellite vehicle by integrating its Angi-3 missile with its PDV. If it succeeds, the anti-satellite missile would have an effective range of about 1,400–1,500 km, and would advance India’s missile capabilities to be on a par with US and China.[434]

Currently, India’s DRDO is working on mini-satellites for battlefield use to protect India’s main satellites. This planned network of mini-satellites is expected to be capable of seeing a moving target on the ground or at sea anywhere in the

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[431] Lele, Ajey. “GSAT-7: India’s Strategic Satellite.” 9 Sept. 2013. SpaceNews 9 May 2014. http://www.spacenews.com/article/opinion/37142gsat-7-india%E2%80 %99 s-strategic-satellite.

[432] Rout, Hemant Kumar. “DRDO Planning to Test-fire High-altitude ‘Killer’ Missile in January.” 30 Nov. 2013. The New Indian Express 12 May 2014. http://www.newindianexpress.com/nation/DRDO-Planning-to-Test-fire-High-altitude-Killer-Missile-in-January/2013/11/29/article1917837.ece.

[433] “India Takes on China.” 01 May 2012. Military & Aerospace Electronics 09 May 2012. http://www.militaryaerospace.com/news/2012/05/01/india-takes-on-china.html.

[434] “India Contemplates Anti-Satellite Vehicle Integration with Agni-III Ballistic Missile.” 15 Oct. 2013. Missile Threat 12 May 2014. http://missilethreat.com/india-contemplates-anti-satellite-vehicle-integration-with-agni-iii-ballistic-missile/.

world, expanding India's military's intelligence, surveillance and reconnaissance capabilities.[435]

1.4.8 Iran

In 2009, Iran became the 11th country with space launch capabilities. Its inaugural launch put the Omid satellite (meaning "Hope") into orbit using the Iranian-developed launch vehicle, Safir-2.[436] Since that launch, the state has invested an estimated $100 million per year in its civil space budget; increasing that amount to $120 million from 2011 to 2013.[437] Iran has begun acting on its desires to be a Middle-East space power by 2020.[438] By February 2012, Iran had launched a small Earth-observing satellite into orbit, its third successful launch out of four attempts. This new Iranian satellite has a mass of 50 kg and was built by students at the Sharif University of Technology. Its applications can be used for meteorology, management of natural disasters and measuring the temperature and humidity of air.[439] Iran plans to launch three more indigenously designed and manufactured satellites into orbit by the end of the current Iranian calendar year (March 20, 2014).[440]Contrary to international suspicions, the Islamic Republic of Iran maintains that it has no military ambitions for its space program.

However, many Western countries, especially the United States and Israel remain concerned that Iran may be seeking to strengthen its military power.[441] Some experts expect Iran to use dual-use technology for military build-up purposes, while remaining under the guise of non-military purposes.[442] Iran states it wants to

[435] Raghuvanshi, Vivek. "India's Tech Roadmap Points to Small Sats, Space Weapons." 10 Sept. 2013. DefenseNews 12 May 2014. http://www.defensenews.com/article/20130910/DEFREG03/309100007/India-s-Tech-Roadmap-Points-Small-Sats-Space-Weapons.

[436] "Iran sends first home-built satellite into orbit." 03 Feb. 2009. AFP 10 May 2012. http://www.google.com/hostednews/afp/article/ALeqM5h6jwhaLtMvmnBIjBipoPXdLDlgpw.

[437] Cf. Euroconsult Report 2014, 8.

[438] Derakhshi, Reza. "Iran unveils missiles and satellites as warning to foes" 07 Feb. 2011. Reuters 10 May 2012. http://www.reuters.com/article/2011/02/07/us-iran-military-missiles-idUSTRE7162F520110207.

[439] "Satellite 'Promise of Science, Industry' put on orbit successfully: Defense Min." 03 Feb. 2012. IRNA10 May 2012. http://irna.ir/News/Politic/Satellite-%E2%80%98Promise-of-Science,-Industry%E2%80 %99-put-on-orbit-successfully,-Defense-Min/30795827.

[440] "Iran to Put 3 satellites into Orbit in 6 Months." 10 Oct. 2013. PressTV 8 May 2014. http://www.presstv.com/detail/2013/10/10/328683/iran-to-launch-3-satellites-into-space/.

[441] Brinton, Turner. "Iran's Satellite Launch a Signal of Missile Progress, Analysts Say." 12 Feb. 2012. SPACE.com 10 May 2012. http://www.space.com/5624-iran-satellite-launch-signal-missile-progress-analysts.html.

[442] Hsu, Jeremy. "Iran's Space Program: Lots of Talk, but a Chance to Shine." 09 Nov. 2011. SPACE.com 10 May 2012. http://www.space.com/9499-iran-space-program-lots-talk-chance-shine.html.

put its own satellites into orbit for civil protection purposes, monitoring natural disasters in the earthquake-prone nation, in addition to improving its telecommunication infrastructure. Iranian officials were quick to point out the United States use of satellites to monitor Afghanistan and Iraq, and said they needed similar capabilities for Iran's security.[443]

Unlike other Islamic countries that operate civilian-purpose satellites, the Iranian Defence Ministry plays a key role with potential contributions from the Islamic Revolution Guards Corps (IRGC). This military element also manages the Shahab ballistic missile program, which is capable of being modified into a space launch vehicle. The enhancement of the Shahab, with satellite-guided navigation, is a big concern for the US and Israel, because this would allow Iran to strike objects with increased precision.[444] Western countries are concerned that long-range ballistic technology used to propel Iranian satellites into orbit might 1 day be used to launch atomic warheads.

Analysts claim Iran's space goals are probably both scientific and military in purpose, with the added objective of increasing national pride—important to legitimize the current regime's policies and actions.[445]

1.4.9 North Korea

North Korea returned to the space scene in 2012, with two launches of its Unha-3 long-range rocket. Its first launch of the year, occurring on 12 April 2012, was unsuccessful, with the missile disintegrating prior to escaping Earth's atmosphere; both US and Japanese sources said it had fallen into the sea. Prior to the launch, North Korea's Foreign Ministry ignored the UN Security Council's condemnation of the launch of a long-range rocket and reasserted the nation's right to develop its own autonomous civilian space program. Paek Chang Ho, chief of the North Korean command centre, said the launch was for peaceful purposes.[446] He said the Kwangmyongsong-3 satellite on board the failed launcher, was designed to send

[443] "Iran Launches Rocket Capable of Carrying Satellite." 17 Aug. 2008. The Telegraph 10 May 2012. http://www.telegraph.co.uk/news/worldnews/middleeast/iran/2575063/Iran-launches-rocket-capable-of-carrying-satellite.html.

[444] Kahn, Gabe. "The Iranian Space Monkey Cometh." 17 June 2011. Israel National News 10 May 2012. http://www.israelnationalnews.com/News/News.aspx/144990#.T6o56egx_zA.

[445] Moskowitz, Clara. "Iran Says It Launched New Rocket and Capsule Into Orbit." 17 Mar. 2011. SPACE.com 10 May 2012. http://www.space.com/11153-iran-launches-rocket-space-capsule.html.

[446] "North Korea Threatens Retaliation for U.S. Aid Clawback." 17 Apr. 2012. CBCNEWS 10 May 2012. http://www.cbc.ca/news/world/story/2012/04/17/north-korea-rocket-reaction.html.

back images and data that will be used for meteorological and Earth observation purposes.[447] At the time, Western experts assessed that the launch's apparent failure "shows the weakness of the North Korea missile program" and suggested that the threat from North Korea had been "exaggerated." On the other hand, the UN and diplomats warned that Pyongyang would face further isolation if it went ahead. For example, the White House Press Secretary described the failed launch as a threat to regional security, a violation of international law and a breach of its own recent commitments.[448] Shortly after the launch, South Korea convened an emergency security meeting and said that Seoul would continue to closely monitor its neighbour's actions.[449]

At the end of 2012, North Korea had its first successful launch of its Unha rocket lifting North Korea's first payload the Kwangmyongsong-3 Unit-2 satellite into a 498 by 582-km Sun-Synchronous Orbit on 12 December 2012. The launch again drew condemnation from the US, South Korea and other nations, which viewed such launches to be thinly disguised missile tests. This time, the US White House called the launch a "highly provocative act that threatens regional security," while the UN Secretary-General declared it to be a "clear violation" of a UN resolution sanctioning North Korea.[450] Within hours of the launch, South Korea's navy retrieved of a portion of the Unha-3 rocket's first stage, which will allow South Korea to gain some insight into the North's rocket/missile technology.[451]

In response to the December 2012 launch, on 22 January 2013, the UN Security Council unanimously agreed to tighten sanctions against North Korea by issuing travel bans and asset freezes on Korean individuals and companies involved in the space launch work; making it difficult for North Korea's senior aerospace officials to leave the country, and specifically to attend professional conferences such as the 2013 International Astronautical Congress which took place in September 2013 in Beijing, China. The Security Council froze assets and issued a ban on travel for four individuals said to be key to North Korea's rocket launch program; moreover, six

[447] "Japan on Full Alert Ahead of North Korean Launch." 12 Apr. 2012. AdelaideNow 10 May 2012. http://www.adelaidenow.com.au/news/world/japan-on-full-alert-ahead-of-north-korean-launch/story-e6frea8l-1226324759731.

[448] Schwarz, Tim. "North Korea Rocket Breaks Up in Flight." 17 Apr. 2012. CNN 10 May 2012. http://edition.cnn.com/2012/04/12/world/asia/north-korea-launch/index.html.

[449] McCurry, Justin. "North Korea's Failed Rocket Launch Triggers Indifference in Seoul" 13 Apr. 2012. The Guardian 10 May 2012. http://www.guardian.co.uk/world/2012/apr/13/north-korea-failed-rocket-launch-reaction>; Young-jin, Kim. "DUP Head Urges NK Against Nuke Test." 05 July 2012. The Korea Times 10 May 2012. http://www.koreatimes.co.kr/www/news/nation/2012/05/116_110488.html.

[450] SpaceNews Staff. "Reports: North Korea Successfully Launches Satellite." 12 Dec. 2012. SpaceNews 7 May 2014. http://spacenews.com/article/reports-north-korea-successfully-launches-satellite.

[451] "South Korea Retrieves North Korean Unha-3 Rocket Debris." 15 Dec. 2012. Spaceflight 101 8 May 2014. http://www.spaceflight101.com/unha-3-launch-updates-kwangmyongsong-3-2.html.

organizations with alleged ties to the launcher/missile technology had their assets frozen.[452]

On 26 November 2013, US intelligence sources said Iranian missile technicians had secretly visited North Korea over the course of several months as part of joint development of a new rocket booster for long-range missiles or space launchers. US authorities believe the booster is intended for a new long-range missile or space launch vehicle that could be used to carry nuclear warheads, and could be exported to Iran in the future. Moreover, its recent assessments expect both North Korea and Iran to have missiles capable of hitting the United States with a nuclear warhead in the next 2 years, while presenting these activities as part of space launcher development to avoid international sanctions.[453] On the other hand, other sources say that North Korea is planning six more satellite launch vehicles in the near future, with the Unha 4 and 5 intended to launch Earth observation satellites, 6, 7, and 8 (supposedly to launch communications satellites), and the Unha 9 aiming to carry a lunar orbiter.[454] Be it for peaceful for belligerent purposes, the international community may have to accept that North Korea will soon have the technical capability to reach orbit and must consider the consequences of such a development.

[452] De Selding, Peter. "U.N Security Council Hits North Korea for Satellite Launch." 23 Jan. 2013. SpaceNews 7 May 2014. http://spacenews.com/article/un-security-council-hits-north-korea-for-satellite-launch.

[453] Gertz, Bill. "Iran, North Korea Secretly Developing New Long-Range Rocket Booster for ICBMs." 26 Nov. 2013. The Washington Free Beacon 15 May 2014. http://freebeacon.com/national-security/iran-north-korea-secretly-developing-new-long-range-rocket-booster-for-icbms/.

[454] Herman, Steve. "More N. Korean Long-Range Rocket Launches Expected 'Soon'." 31 July 2013. Voice of America 24 Apr. 2014. http://www.voanews.com/content/nkorea-claim-of-more-long-range-rocket-lauches-seen-as-credible/1713495.html.

Chapter 2
Developments in Space Policies, Programmes and Technologies Throughout the World and in Europe

Cenan Al-Ekabi

2.1 Space Policies and Programmes

All major space policy developments worldwide were presented in Chap. 1, above, to identify the principal space faring nations' strategies in 2012 and 2013. In the section below, there will be a brief discussion on developments in technology related areas, including policies and access to space technologies. The aim of this section is to clarify how these strategies interact with and influence specific space programmes, and related research and development projects.

2.2 Space Transportation

2.2.1 Europe

On the issue of future international cooperation, especially in the fields of space transportation and exploration, the retirement of the space shuttle in 2011 increased the potential for cooperation between Europe and the United States in terms of access to space vehicles. At the same time, it indirectly increased the value and relevance of ESA's Automated Transfer Vehicle (ATV). The combined use of the ATV and other similar spacecraft from the US (Dragon and Cygnus COTS missions), Japan (HTV) and Russia (Progress M) to serve ISS supply needs could create opportunities in the long term for the creation of common transportation policies among all participating space actors. Due to their technological proximity and operationally complementary nature, these spacecraft could also pave the way

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for future cooperation on a technology development level.[1] Indeed, on 16 January 2013, ESA had agreed to supply NASA with an ATV-derived service module to provide the Orion spacecraft with propulsion, power and thermal control, in addition to water and gas for the astronauts in the Orion module.[2] ESA's provision of ATV-technology for the Orion module is meant to pay for the space agency's 8.3 % share of the ISS's annual operating costs for the period 2018-to-2020; estimated at a total cost of 455 million Euros. The use of ESA's 5 ATV cargo supply vehicles has released ESA from paying further dues for the operation of the ISS until 2017.[3]

2.2.2 United States

On 21 November 2013, US President Obama signed the 2013 National Space Transportation Policy, intended to keep the US at the forefront of space activities by maintaining space transportation capabilities that are innovative, reliable, efficient, competitive, and affordable, and within US national interests. The new policy updated and replaced the 2004 US Space Transportation Policy, with the purpose of providing comprehensive guidance to all Federal Departments and Agencies on US priorities and on roles and responsibilities with respect to space transportation issues and programs.[4]

More specifically, the new Space Transport Policy seeks to: (1) promote and maintain a dynamic, healthy, and efficient domestic space transportation industrial base; (2) encourage and facilitate the US commercial space transportation industry to increase industry robustness and cost effectiveness, foster innovation-driven entrepreneurship and international competitiveness, and benefit the US economy; (3) conduct and promote technology research and development activities to improve the affordability, reliability, performance, safety, and responsiveness of US space transportation capabilities, while increasing collaboration and coordination among departments and agencies; (4) enable the capabilities to support human space transportation activities to and beyond low Earth orbit, including services to and from the International Space Station and the development of a deep-space-capable transportation system; and (5) foster the development of US commercial spaceflight capabilities serving the emerging nongovernmental human spaceflight

[1] Svitak, Amy. "U.S. And Europe Explore Common Space Transportation Needs." Aviation Week & Space Technology 27 June 2011: 41.

[2] "ESA Workhorse to Power NASA's Orion Spacecraft." 16 Jan. 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/Research/ESA_workhorse_to_power_NASA_s_Orion_spacecraft.

[3] "France is Reducing Its Space Station Contributions." 20 Feb. 2013. SpaceNews 28 Apr. 2014. http://spacenews.com/article/civil-space/33755france-is-reducing-its-space-station-contributions.

[4] "Fact Sheet: 2013 National Space Transportation Policy." 21 Nov. 2013. Whitehouse.gov 19 May 2014. http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_space_transportation_policy_fact_sheet_11212013.pdf.

market.[5] To implement this policy, a set of sector guidelines is laid out in the document, ranging from civil and national security space guidelines to commercial space guidelines. Moreover, cross-sector guidelines are listed in the fields of: space launch ranges; space transportation technology development, US space transportation industrial base; non-proliferation and excess intercontinental ballistic missile assets; and international collaboration.

Some of the differences from the previous 2004 US Space Transportation Policy relate to its emphasis on allowing new entrants to launch US government payloads, with the need to have available alternative US space transportation families. It also does not use the term ‘operationally responsive space’, and deemphasizes operationally responsive access to and use of space to support national security requirements, in favour of directing the Secretary of Defence to work with other agencies on “launch concepts, techniques, and technologies needed for augmentation or rapid restoration of national security space capabilities” without a specific goal or deadline. The policy clarifies the launch of US government hosted payloads on commercial spacecraft, and includes a provision to encourage increased technological innovation and entrepreneurship in the US commercial space transportation sector through the use of incentives such as non-traditional acquisition arrangements, competition, and prizes.[6]

2.2.3 Russia

Recently, Russian space policies have focused on improvement of the country’s self-sufficiency, on technological and operational levels, with a drive to increase Russia’s global market shares in the space sector. This was particularly true regarding the development of access to space systems, where over the course of 2012 and 2013, Russian authorities made a number of key government decisions on the development of the long-term space program. On 16 August 2012, the Russian government ordered the formation of the Directorate for the Vostochny Cosmodrome, currently under construction in the Russian Far East.[7]

Another characteristic of Russian space policies during the review period was its increased involvement in international cooperation, especially regarding the present and future of ISS operations. In April 2013, NASA signed a deal with Roscosmos to continue sending American astronauts to the ISS aboard Soyuz space capsules until June 2017. As in the previous contract, spanning flights for

[5] National Space Transportation Policy. 21 Nov. 2013. NASA 20 May 2014. http://www.nasa.gov/sites/default/files/files/national_space_transportation_policy_11212013.pdf

[6] Foust, Jeff. “New national space transportation policy makes modest, not major, changes.” 22 Nov. 2013. Space Politics 20 May 2014. http://www.spacepolitics.com/2013/11/22/new-national-space-transportation-policy-makes-modest-not-major-changes/.

[7] “Center to build of the Vostochny cosmodrome.” TsENKI 20 May 2014. http://www.tsenki.com/en/about/leading_enterprise/division/build_spaceport/.

American astronauts through 2015, this agreement continues Russia's ferrying services for the United States through 2016 and into 2017. However the cost has increased by 12.8 % for the six American seats on the Soyuz, from $62.7 million per seat to $70.7 million per seat on a $424 million contract. With the retirement of its space shuttle fleet in July 2011, NASA is dependent on the Soyuz for launching its astronauts until its CCP programme has matured fully; now expected to be sometime in 2017.[8]

2.2.4 Japan

Japan's Epsilon 3-stage launcher, meant to be a lower-cost replacement for its M-5 solid-propellant rocket, has been in development since 2011.[9] While the launcher costs around ¥20.5 billion to develop, launch costs are projected to be ¥3.8 billion ($44.5 million) per vehicle, resulting in a cost about half as much as the M-5 per launch.[10] The tradeoff for the lower price is one-third less capability than the previous M-5 rocket.[11] While the Epsilon 1 was scheduled to debut on 27 August 2013, poor synchronization between flight and ground-based computers caused an anomaly reading on a sensor aboard the launcher which forced JAXA to abort the launch 19 s prior to liftoff.[12] The launch was postponed until 14 September 2013, when the rocket successfully lifted the Hisaki (SPRINT-A) satellite into elliptical orbit from the Uchinoura Space Center in Japan.[13]

Japan also plans to develop a lower-cost, commercially viable successor to its H-2A rocket. On 17 May 2013, Japan's Space Transportation Systems Subcommittee of its Cabinet-level Office of National Space Policy (ONSP) presented a

[8] "NASA to Pay $70 Million a Seat to Fly Astronauts on Russian Spacecraft." 30 Apr. 2013. Space.com 30 Apr. 2014. http://www.space.com/20897-nasa-russia-astronaut-launches-2017.html.

[9] Kallendar-Umezu, Paul. "Japan To Take Incremental Approach for New Epsilon Launcher." 11 Apr. 2011. SpaceNews 30 May 2014. http://www.spacenews.com/article/japan-take-incremental-approach-new-epsilon-launcher.

[10] "JAXA to launch solid fuel rocket." 31 Oct. 2012. SpaceNews 30 May 2014. http://www.spacenews.com/article/jaxa-launch-solid-fuel-rocket.

[11] Ferster, Warren. "JAXA's Epsilon Rocket Scheduled for Aug. 22 Debut." 21 May 2013. SpaceNews 30 May 2014. http://www.spacenews.com/article/launch-report/35427jaxa%E2%80%99s-epsilon-rocket-scheduled-for-aug-22-debut.

[12] Onuki, Misuzu. "Out-of-synch Computers Cited in Epsilon Launch Abort." 30 Aug. 2013. SpaceNews 30 May 2014. http://www.spacenews.com/article/launch-report/37014out-of-synch-computers-cited-in-epsilon-launch-abort.

[13] Ferster, Warren. "JAXA's Epsilon Small-satellite Launcher Makes Successful Debut." 23 Sept. 2013. SpaceNews 30 May 2014. http://www.spacenews.com/article/launch-report/37363jaxa%E2%80%99s-epsilon-small-satellite-launcher-makes-successful-debut.

draft midterm report recommending an H-3 successor launcher.[14] By 24 December 2013, the Japanese government approved initial funding of $70 million for 2014 for the development of the launcher, estimated to need $1.9 billion for full development. The two-stage H-3 is tentatively scheduled to have its first launch in 2020, and is projected to lift up to 6.5 metric ton payloads to GTO at a cost ranging between $50 million and $70 million per launch.[15] Mitsubishi Heavy Industries Corp. is expected to be the prime contractor of the launcher.

2.2.5 *China*

The Chinese government's latest Five-year plan for 2011–2016, entitled "China's Space Activities in 2011', was released in December 2011.[16] This document updates and extends the country's strategic and operational objectives in space, recounts the progress made since 2006 and lays down China's short term plans, divided into four main activity areas, including the field of space transportation. Therein, China is focusing on the development of three new launcher configurations by 2016, using more efficient engines and an entirely new upper stage. They include Long March 5 (with a 14 tons to GEO lift capacity), Long March 6 (1 tons to LEO), and Long March 7 (5.5 tons to LEO). The realisation of this programme will provide China with comprehensive and flexible access to space capability, in line with the current and prospective space rocket development plans of all other major space faring nations. This underpins China's willingness to improve its space capabilities on a peer-to-peer basis. Of particular interest is Long March 6, which is described as a "high-speed response launch vehicle". This lightweight launcher will provide China with an operationally responsive launch capability for the first time, with obvious national security and commercial applications.

China's intensive launching campaign continued in 2012 and 2013. For example, once again, within two consecutive days (25–27 November 2012) from two separate launch sites, China launched two satellites—the Yaogan 16 remote sensing satellite to LEO, and Chinasat 12 (APSTAR 7B) communications satellite.[17] Between 2012 and 2013, there were 6 occasions where Chinese launches occurred within 4 days of one another.

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[14] Kallendar-Umezu, Paul. "Japanese Government Recommends Developing H-2A Successor." 27 May 2013. SpaceNews 30 May 2014. http://www.spacenews.com/article/launch-report/35499japanese-government-recommends-developing-h-2a-successor.

[15] Onuki, Misuzi. "Japan Approves $1.9B for H-3 Rocket." 13 Jan. 2014. SpaceNews 30 May 2014. http://www.spacenews.com/article/civil-space/39069japan-approves-19b-for-h-3-rocket.

[16] White Papers of the Government of China. "China's Space Activities in 2011. "Beijing 29 Dec. 2011. 6 Mar. 2012. http://www.china.org.cn/government/whitepaper/node_7145648.htm.

[17] Federal Aviation Administration. Commercial Space transportation: 2012 Year in Review. Washington, DC: FAA, Jan. 2013: 32.

2.2.6 India

India's space launch programme primarily relies on the use of its Polar Satellite Launch Vehicle (PSLV), capable of carrying 3,700 kg payloads to Low Earth Orbit and 800 kg to Geosynchronous Transfer Orbits (GTO).[18]

ISRO has also developed its Geosynchronous Satellite Launch Vehicle (GSLV)-Mark I & II over the past decade with mixed results. Capable of launching up to 2,500 kg into GTO, the launch vehicle uses two stage liquid fuel engines and a third stage with a solid fuel one. These launch vehicles are meant to orbit India's new and heavier communication satellites of the GSAT series. The GSLV has exhibited a trend of launch failures from 2006, and has not been used following launch failures in 2010.[19] In the meantime, ISRO has been developing its new GSLV Mk III rocket, meant to launch heavier communication satellites, reaching up to 5,000 kg in weight, into GTO. Rather than upgrading the current GSLV series, this new launcher will share a number of components. Its completion will enable full autonomy in launching heavier communications satellites of the INSAT-4 class. With its first flight test expected in January 2014, and commercial operations planned for 2016,[20] this launcher will be the first of its series to field a second stage equipped with a restartable liquid fuel engine that should greatly improve the system's operational flexibility and commercial attractiveness.[21]

2.3 Space Science and Exploration

In this section, space science is understood to mean using mainly remote observation to make discoveries on the origin, evolution and future of the Universe, its galaxies, our Solar System, and other celestial bodies, e.g. stars, exoplanets, comets, and asteroids. Space exploration, on the other hand, involves human and robotic spaceflight missions. While traditional governmental space agencies dominate in both these fields, expanded progress in the latter category can be seen with the further development of exploration involving commercial players, and with new space powers demonstrating the technology needed to carry out such missions.

[18] Federal Aviation Administration. Commercial Space transportation: 2011 Year in Review. Washington, DC: FAA, Jan. 2012: 15.

[19] "GSLV." ISRO 19 Apr. 2013. http://www.isro.org/launchvehicles/GSLV/gslv.aspx.

[20] "Heaviest rocket launch in 2014: ISRO." 10 Apr. 2013. The Hindu 30 May 2014. http://www.thehindu.com/sci-tech/technology/heaviest-rocket-launch-in-2014-isro/article4602878.ece.

[21] "GSLV MARK III." ISRO 19 Apr. 2013. http://www.isro.org/Launchvehicles/GSLVMARKIII/mark3.aspx.

2.3.1 Human Spaceflight Activities

Human spaceflight was focused in Low Earth Orbit (LEO), with the International Space Station (ISS) at centre stage, following its formal extension to at least 2020. Following the retirement of NASA's Space Shuttle, Roscosmos is the sole launch provider relied to transport crew regularly to the ISS and, using Progress and Soyuz, it provided ISS cargo resupply services with Europe's Automated Transfer Vehicle (ATV) and Japan's H-II Transfer Vehicle (HTV) providing auxiliary support.

ESA astronaut André Kuipers completed his 6-month mission on the ISS, returning to Earth on 1 July 2012.[22] With a background as a medical doctor, the astronaut of Dutch nationality began his PromISSe mission on 23 December 2011, conducting over 50 experiments in fields including biophysics, biology, and in improving computer models of fluids, in addition to carrying out maintenance and operational tasks, e.g. the rendezvous and docking of ESA's third ATV Edoardo Amaldi, and in berthing SpaceX's Dragon to the ISS.[23]

ESA's newest batch of astronauts, Samantha Cristoforetti, Alexander Gerst, Andreas Mogensen, Luca Parmitano, Timothy Peake, and Thomas Pesquet, graduated from the European Astronaut Centre (EAC) on 22 November 2010; with Luca Parmitano as the first one assigned to ISS Expeditions 36/37 in 28 May 2013.[24] Alexander Gerst will fly to the space station as a flight engineer for Expeditions 40/41 in May 2014.[25] Samantha Cristoforetti has been assigned as the eighth ESA astronaut to fly to the ISS for a long-duration mission. The 6–7 month mission is planned to begin in 2014.[26] Timothy Peake has been assigned to join the crew of Expeditions 46/47 for 6 months in 2015. Andreas Mogensen, the first astronaut of Danish nationality, is scheduled to launch to the ISS in September 2015, for a brief 10 day mission intended to study the short duration impact of spaceflight on astronauts, in which he will test a new 'skinsuit' made from elastic material that will mimic Earth's gravity and thus passively mitigate the deconditioning of an

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[22] "ESA Astronaut André Kuipers Returns to Earth." 1 July 2012. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/PromISSe/ESA_astronaut_Andre_Kuipers_returns_to_Earth.

[23] "André Kuipers." 3 Oct. 2013. ESA 13 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/Delta_Mission/Andre_Kuipers.

[24] "ESA—Human Spaceflight and Exploration—Astronauts—Graduation of Europe's new astronauts." European Space Agency 25 Aug. 2011. http://www.esa.int/esaHS/SEMRFLIRPGG_astronauts_0.html.

[25] "ESA Astronaut Alexander Gerst To Fly To Space Station in 2014." 18 Sept. 2011. ESA 18 Apr. 2013. http://www.esa.int/Our_Activities/Human_Spaceflight/ESA_astronaut_Alexander_Gerst_to_fly_to_Space_Station_in_2014.

[26] "ESA Astronaut Samantha Cristoforetti Set for Space Station in 2014." 3 July 2012. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/ESA_astronaut_Samantha_Cristoforetti_set_for_Space_Station_in_2014.

astronaut's body during spaceflight.[27] Thomas Pesquet will be assigned for flight before mid-2015 for launch by 2017.[28] In the meantime, these newly selected ESA astronauts are undergoing extensive training in various facilities in the US, Russia, Japan, Canada and Germany, in addition to survival training in places such as the isolated and complex cave systems in the Mediterranean.[29]

Luca Parmitano, the first of the new astronauts from 2009, began a 5-month mission on the ISS on 28 May 2013.[30] Under the mission heading Volare, Luca Parmitano was the first European flight engineer to co-pilot the Soyuz spacecraft on an approach to the station that was eight times faster than the typical procedure, and conducted only once previously; he and the crew arrived at the station within 6 h of launch from Kazakhstan. With training as a flight engineer, the astronaut of Italian nationality took part in docking ESA's fourth ATV, Albert Einstein, which launched on 5 June 2013; he was also closely involved in berthing other supply vessels during his mission: Japan's HTV, SpaceX's Dragon and Orbital Science Corporations's new Cygnus. Other aspects of Luca Parmitano's Volare mission included more than 30 experiments, two spacewalks to replace a camera mounted on Japan's Kibo laboratory and retrieve science payloads, and other operational and maintenance tasks. On his second spacewalk, a malfunction in the spacesuit caused water to accumulate inside the helmet, forcing him and NASA astronaut Chris Cassidy to cut short their spacewalk and return to the airlock as quickly as possible.[31]

While the life cycle of the ISS has been extended by another 5 years, ESA is stopping the production of Automated Transfer Vehicles (ATVs) after 2015. Following the completion of the five ATV missions, ESA will have paid its share of dues for the use of the ISS through 2017. Following the extension, ESA has directed Thales to look for ways to supply a service module for the Multi-Purpose Crew Vehicle (MPCV) that Lockheed Martin started building under the old Constellation program.[32] Prior to the launch of the ATV-4, the ATV-3 had been the

[27] "Andreas Mogensen Set for Soyuz Mission to Space Station in 2015." 28 Aug. 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/Astronauts/Andreas_Mogensen_set_for_Soyuz_mission_to_Space_Station_in_2015.

[28] "ESA Astronaut Timothy Peake Set for Space Station." 20 May 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/ESA_astronaut_Timothy_Peake_set_for_Space_Station.

[29] "Mission Accomplished: Cave Crew Returns to Earth." 19 Oct. 2011. ESA 18 Apr. 2013. http://www.esa.int/Our_Activities/Human_Spaceflight/Mission_accomplished_cave_crew_returns_to_Earth.

[30] "ESA Astronaut Luca Parmitano Arrives at Space Station." 29 May 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/Astronauts/ESA_astronaut_Luca_Parmitano_arrives_at_Space_Station.

[31] "ESA Astronaut Luca Parmitano Lands Safely Back on Earth." 11 Nov. 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/Volare/ESA_astronaut_Luca_Parmitano_lands_safely_back_on_Earth.

[32] Morring, Jr., Frank. "Spacefaring Nations Regroup For Push Beyond LEO." Aviation Week & Space Technology 10 Oct. 2011: 46.

heaviest payload the Ariane 5 rocket had ever launched into space with a launch-mass of over 20 tons.[33] The ATV-3 completed its 6-month servicing mission on 28 September 2012, supplying nearly 7 tons of propellant, oxygen, air and water, scientific equipment, spare parts, and other necessities to the station, and performing nine reboosts to counteract atmospheric drag on the ISS.[34] ATV-4 Albert Einstein, now the heaviest payload that the Ariane 5 rocket has launched into space, brought supplies to the ISS, in addition to performing six reboosts during its 5-month servicing mission. Undocking on 28 October 2013, the ATV-4 carrying ISS waste material, burned up harmlessly in the upper atmosphere several days later.[35] Before the end of 2013, the final ATV-5 Georges Lemaître had already reached Europe's spaceport in French Guiana, and is scheduled to launch in late June 2014.

ESA's Inter-Directorate Exploration Scenarios Working Group which awarded Exploration Scenario Studies contracts to various European companies in 2010 to contribute to the development of a Strategic Plan for Human Spaceflight and Exploration, was concluded by an ESA internal review that took place in September 2012. Options for roadmaps, identifying and defining potential building block elements and their integration into these optional roadmaps have been presented and will inform future decisions.[36]

In this context, national space agencies within Europe progressed in their exploration efforts in addition to participating in ESA activities. DLR participated in a number of exploration activities in the 2012–2013 period; notable highlights included the successful flight of the Sharp Edge Flight Experiment (SHEFEX II) in June 2012, testing innovative ceramic tiles able to withstand temperatures reaching 2,000 °C, for the improvement of future spacecraft. Moreover, further results from the MARS 500 mission in 2011 led to the longest study on sodium intake in humans, allowing university researchers to determine that sodium metabolism follows a biorhythm of several days, rather than a cycle of 24 h; a result that is crucial for long duration human space exploration.[37] Also, in May 2013 the DLR

[33] Botta, Oliver. "Factsheet—ATV-3 Edoardo Amaldi begins its journey to the ISS." 19 Mar. 2012. Swiss Space Office 6 May 2012. http://www.sbf.admin.ch/htm/dokumentation/publikationen/raumfahrt/FactSheet_ATV3-e.pdf.

[34] "Mission Accomplished for ATV Edoardo Amaldi." 3 Oct. 2012. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/ATV/Mission_accomplished_for_ATV_I_Edoardo_Amaldi_I.

[35] "A Fiery End to a Perfect Mission: ATV Albert Einstein." 2 Nov. 2013. ESA 8 Apr. 2014. http://www.esa.int/Our_Activities/Human_Spaceflight/ATV/A_fiery_end_to_a_perfect_mission_ATV_Albert_Einstein.

[36] "Annual Report 2012 of the International Space Exploration Coordination Group." 12 Nov. 2013. International Space Exploration Coordination Group (ISECG) 14 Apr. 2014. http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/11/ISECG-Annual-Report-2012.pdf.

[37] Ibid.

provided the Omegahab payload on the BION-M1 mission; Omegahab is a designed to function as a bioregenerative life support system in microgravity.[38]

In 2012 and 2013, CNES continued to implement the contract between the French government and CNES for the period 2011–2015, signed in October 2010, which tasks CNES to 'make proposals to promote an international exploration programme of the Solar System in renewed governance,' with the aim of an increased role for the European Union in exploration matters. In that pursuit, France had actively contributed to defining the contents of the EU's technological programme Horizon 2020, particularly with regard to its part in exploration. CNES was also active in the preparation of the second version of the ISECG Global Exploration Roadmap, and of the White Paper—"Benefits stemming from Space Exploration", both released in the summer of 2013. CNES was also involved in discussions preparing European participation in the second high-level international conference on exploration which was scheduled to take place in January 2014, in Washington, DC.[39]

With NASA's Space Shuttle Programme retired in mid-2011, it took over 2 years before the agency could announce the success of its Commercial Orbital Transportation Services (COTS) programme in November 2013. With this achievement, the US can deliver supplies and science experiments to the ISS with the option of two space transportation systems (i.e. the SpaceX Falcon rocket/Dragon spacecraft, or Orbital Science's Antares rocket/Cygnus spacecraft).[40] SpaceX completed two demonstration missions in 2012, followed by another commercial mission to the ISS on 1 March 2013, opening the way for at least 10 additional cargo supply and return flights to the ISS under SpaceX's contract with NASA.[41] Similarly, Orbital Sciences completed its two launches of the Antares rocket, including its first Cygnus cargo demonstration supply mission to the ISS mission on 23 October 2013, it being notable that the Cygnus is designed to burn-up upon re-entry into the atmosphere.[42] In an effort to restore US capability to domestically launch astronauts into space by 2017, NASA's Commercial Crew Program (CCP) requested proposals from US companies to complete the development of crew transportation systems that meet NASA's certification requirements, and can launch crewed missions to the ISS. This 'Commercial Crew Transport Capability' (CCtCap) stage of the programme requires at least one crewed flight to the ISS

[38] Annual Report 2013 of the International Space Exploration Coordination Group." 20 Dec. 2013. International Space Exploration Coordination Group (ISECG) 14 Apr. 2014. http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/Annual-Report_2013_FINAL.pdf.

[39] Ibid.

[40] "NASA Hails Success of Commercial Space Program." 13 Nov. 2013. NASA 8 Apr. 2014. https://www.youtube.com/watch?v=bj905HtsB-g.

[41] "Dragon Delivers." 3 Mar. 2013. SpaceX 8 Apr. 2014. http://www.spacex.com/news/2013/03/03/happy-berth-day.

[42] "Orbital Completes COTS Demonstration Mission to International Space Station." 23 Oct. 2013. Orbital Sciences 8 Apr. 2014. http://www.orbital.com/NewsInfo/release.asp?prid=1873.

before certification can be granted; NASA plans to have awarded CCtCap contracts by September 2014.[43]

In 2012 and 2013, Russia launched eight Soyuz spacecraft: TMA-04M on 15 May 2012 with the Expedition 31/32 crew of Joseph Michael Acaba, Gennady Padalka and Sergei Revin[44]; TMA-05M on 15 July 2012 with the Expedition 32/33 crew of Yuri Malenchenko, Sunita Williams, and Akihiko Hoshide[45]; TMA-06M on 23 October 2012 with the Expedition 33/34 crew of Oleg Novitskiy, Kevin Ford, and Evgeny Tarelkin;[46] TMA-07M on 19 December 2012 with the Expedition 34/35 crew of Roman Romanenko, Chris Hadfield, and Tom Marshburn[47]; TMA-08M on 28 March 2013 with the Expedition 35/36 crew of Chris Cassidy, Pavel Vinogradov, and Aleksandr Misurkin[48]; TMA-09M on 29 May 2013 with the Expedition 36/37 crew of Fyodor Yurchikhin, Karen Nyberg, and Luca Parmitano;[49] TMA-10M on 26 September 2013 with the Expedition 37/38 crew of Oleg Kotov, Michael Hopkins, and Sergei Ryazansky;[50] and TMA-11M on 7 November 2013 with the Expedition 38/39 crew of Mikhail Tyurin, Richard Mastracchio, and Koichi Wakata.[51] Russia also continued its regular resupply of the ISS with eight successful launches of the Progress cargo transfer vehicles: M-14M on 25 January 2012, M-15M on 20 April 2012, M-16M on 1 August 2012, M-17M on 31 October 2012, M-18M on 11 February 2013, M-19M on 24 April 2013, M-20M on 27 July 2013, and M-21M on 25 November 2013.[52]

In 2013, the US and Russia began exploring the concept of a 1-year mission aboard the ISS. Previously this was a Russian domain with four cosmonauts having spent more than a year in space between 1987 and 1995. Beginning in 2015, Russian cosmonaut Mikhail Kornienko and American astronaut Scott Kelly will

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[43] "NASA Advances Effort to Again Launch Astronauts from U.S. Soil to Space Station." 19 Nov. 2013. NASA 8 Apr. 2014. http://www.nasa.gov/content/nasa-advances-effort-to-again-launch-astronauts-from-us-soil-to-space-station/#.U0QSuPmSwj4.

[44] "Soyuz TMA-04M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma04m.html.

[45] "Soyuz TMA-05M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma05m.html.

[46] "Soyuz TMA-06M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma06m.html.

[47] "Soyuz TMA-07M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma07m.html.

[48] "Soyuz TMA-08M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma08m.html.

[49] "Soyuz TMA-09M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma09m.html.

[50] "Soyuz TMA-10M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma10m.html.

[51] "Soyuz TMA-11M." Russian Space Web 8 Apr. 2014. http://www.russianspaceweb.com/iss_soyuz_tma11m.html.

[52] "Spaceflight Now: Tracking Station: Launch Log." 14 Apr. 2014. http://spaceflightnow.com/tracking/launchlog.html.

participate in a year-long mission aboard the ISS—twice as long as a typical crew member—to gain knowledge on the medical, biomedical, and psychological challenges that explorers may face when they venture beyond cis-lunar distances, bound for deeper reaches such as a manned flight to an asteroid or Mars.

After launching only unmanned missions in 2011, successfully docking the Shenzhou 8 to the Tiangong 1 space laboratory,[53] China accomplished another historic milestone in 2012. After launching the first Chinese astronaut into space on 15 October 2003, aboard the Shenzhou 5,[54] and having another astronaut conduct China's first spacewalk on 27 September 2008, aboard the Shenzhou 7[55]; China accomplished two more milestones on 16 June 2012, when it successfully sent its first female astronaut, along with two male astronauts, aboard the Shenzhou 9 to dock with the Tiangong 1 on a 13-day mission—also making China the third nation to successfully dock a manned spacecraft to another in orbit.[56] China launched another three astronauts on a 15-day mission on 11 June 2013 aboard the Shenzhou 10 docking with Tiangong 1 on 13 June 2013.[57] China also plans to complete the construction and launch of its Tiangong 2 lab in 2015, followed by another experimental core module of the future space station around 2018.[58]

China's third Tianlian data-relay satellite, Tianlian I-03 was launched on 25 July 2012. It was preceded by the Tian-lian I-02 launched in July 2011, and the Tianlian I-01 launched in 2008. The Tianlian data-relay spacecraft support China's manned flights, in addition to being related to the development of China's Tiangong space station. China is now the third nation after the United States and Russia to build an operational data-relay service. This is viewed as being comparable to NASA's TDRS data relay satellites.[59]

While Japan has placed the development of human spaceflight capabilities at the forefront of its spending, attention is beginning to veer toward other areas including satellite navigation (with its QZSS constellation), and satellite reconnaissance systems. Under the government's updated Basic Plan on Space Policy, released

[53] Federal Aviation Administration. Commercial Space transportation: 2011 Year in Review. Washington, DC: FAA, Jan. 2012: 26.

[54] "China puts its first man in space." 15 Oct. 2003. BBC News 15 Apr. 2014. http://news.bbc.co.uk/2/hi/asia-pacific/3192330.stm.

[55] Moskowitz, Clara. "Chinese Astronauts Complete First Spacewalk." 27 Sept. 2008. Space.com 15 Apr. 2014. http://www.space.com/5902-chinese-astronauts-complete-spacewalk.html.

[56] "Touchdown! Chinese Space Capsule With 3 Astronauts Returns to Earth." 28 June 2012. Space.com 8 Apr. 2014. http://www.space.com/16357-china-space-capsule-lands-shenzhou-9.html.

[57] "Three Chinese Astronauts Land After Record-Breaking Spaceflight." 25 June 2013. Space.com 8 Apr. 2014. http://www.space.com/21720-china-astronauts-land-shenzhou-10.html.

[58] "China plans to launch Tiangong-2 space lab around 2015." 27 June 2013. Space Daily 8 Apr. 2014. http://www.spacedaily.com/reports/China_plans_to_launch_Tiangong_2_space_lab_around_2015_999.html.

[59] Todd, David. "Chinese data relay satellite TianLian-1C is launched successfully on a Long March 3C." 26 July 2012. Seradata 19 May 2014. http://seradata.com/SSI/2012/07/chinese-data-relay-satellite-t/.

on 25 January 2013, the two new priority targets are (1) to expand its utilization of space—to create new services and products to improve the quality of life, and to offer effective measures for disaster management and national security; and (2) to ensure autonomy in space related activities by maintaining the manufacture, launch and operation of satellites for navigation, remote sensing (including meteorological observation and information gathering) and communications/broadcasting, along with maintaining, strengthening and developing the domestic industrial base that supports those activities.[60] In the new space plan, the human space activity programme is listed beneath the space science and space exploration programme as a priority area, marking a change in Japan's interests since Japan's earthquake in March 2011.

Following the maiden voyage of Japan's H-2 Transfer Vehicle (HTV) to the ISS in September 2009, the Japanese cargo tug made four deliveries to the ISS by the end of 2013. The HTV-3 launched to the ISS on 21 July 2012, delivering 3,600 kg of supplies to the station before undocking on 12 September 2012 to burn up shortly after in Earth's atmosphere.[61] The HTV-4 launched to the ISS on 4 August 2013, bringing with its supplies, a talking humanoid robot Kirobo, and an advanced camera to photograph comets; the HTV also had an 'i-Ball' device attached to record and transmit images of the tug's fiery re-entry into the atmosphere.[62]

In 2012, the Canadian Space Agency (CSA) continued to operate its Mobile Servicing System (MSS), providing robotic maintenance and resupply operations on the ISS. The CSA's Canadarm2 captured and berthed three spacecraft resupply missions: SpaceX's Dragon COTS second demonstration flight launched on 22 May; JAXA's HTV-3 cargo resupply tug launched on 21 July; and SpaceX's non-demonstration Dragon ISS 1-D resupply spacecraft launched on 7 October.[63] In 2013, Canadarm2 was used to capture and berth three more spacecraft resupply missions: SpaceX's second Dragon ISS 2-D resupply spacecraft launched on 1 March; JAXA's HTV-4 cargo resupply tug launched on 3 August; and Orbital Science's Cygnus COTS Demonstration resupply mission launched on 18 September.[64]Canadarm2 and the CSA's Dextre also performed flawlessly during

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[60] Basic Plan on Space Policy. 25 Jan. 2013. Government of Japan 20 May 2014: 6. http://www8.cao.go.jp/space/plan/plan-eng.pdf.

[61] "Japanese Cargo Ship Re-enters over Pacific." 17 Sept. 2012. SpaceNews 8 Apr. 2014. http://www.spacenews.com/article/japanese-cargo-ship-re-enters-over-pacific.

[62] "Japanese Cargo Spacecraft Re-enters Atmosphere After Ending ISS Mission." 8 Sept. 2013. Astro Watch 8 Apr. 2014. http://www.astrowatch.net/2013/09/japanese-cargo-spacecraft-re-enters.html.

[63] "Annual Report 2012 of the International Space Exploration Coordination Group." 12 Nov. 2013. International Space Exploration Coordination Group (ISECG) 14 Apr. 2014. http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/11/ISECG-Annual-Report-2012.pdf.

[64] Annual Report 2013 of the International Space Exploration Coordination Group." 20 Dec. 2013. International Space Exploration Coordination Group (ISECG) 14 Apr. 2014. http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/Annual-Report_2013_FINAL.pdf.

the joint CSA-NASA Robotic Refuelling Mission (RRM), which resulted in the development of new flight products and procedures to support MSS operations, and expanded the boundaries of robotic operations on the ISS; the second phase is planned for some time in 2014. To maximise time for performing experiments, the MSS was also operated by ground control to relocate several On-orbit Replacement Units (ORUs) stowed on the ISS external storage platforms.

In addition to technological activities conducted on the station, the Canadian veteran astronaut Chris Hadfield began his third space mission and second trip to the ISS at the end of 2012. Launching to the station on 19 December 2012 for a 5-month period, Hadfield was on the ISS Expedition 34/35 mission where he worked as a flight engineer for 3 months during Expedition 34, and as a first for Canada, he assumed command of the ISS in March 2013. He returned from the ISS on 13 May 2013.[65] Also, Canada's two newly qualified astronauts, Major Jeremy Hansen and Dr. David Saint-Jacques, in addition to pursuing their pre-assignment training activities, were assigned to the Capcom/Training branch at NASA's Johnson Space Center. The two astronauts, both ready to be assigned to ISS missions and medically certified for ISS duties, were scheduled to complete their MSS robotics training at the CSA in early 2014.[66]

2.3.2 Lunar Science

The Moon stimulated a great deal of interest in this reporting period in regard to the science and exploration activities that were planned or already underway. Europe, China, Japan and India made steady progress toward a robotic and human lunar presence, however budget constraints had the potential to delay well-intentioned initiatives. The US and Russia also maintained their interest in exploring the Moon, and its potential benefit for future Mars exploration.

Looking to future interests in potential surface payloads on the Moon, ESA released a "Call for Declarations of Interest (CDI)" inviting members of the Science and Exploration community to register their interest in proposing a surface payload for a possible European Lunar Lander mission on 17 January 2012. This call was intended to support discussions with national agencies regarding potential contributions and to inform them of preparations for an Announcement of Opportunity (AO) in early 2013. The subsequent AO would lead to the formal selection of the

[65] "Chris Hadfield Safely Returns to Earth." 13 May 2013. CBCNews 8 Apr. 2014. http://www.cbc.ca/news/technology/chris-hadfield-safely-returns-to-earth-1.1403450.

[66] Annual Report 2013 of the International Space Exploration Coordination Group." 20 Dec. 2013. International Space Exploration Coordination Group (ISECG) 14 Apr. 2014. http://www.globalspaceexploration.org/wordpress/wp-content/uploads/2013/12/Annual-Report_2013_FINAL.pdf.

payload to be used as part of a Lunar Lander mission.[67] The mission would land autonomously near the previously unexplored South Pole of the Moon and was described as a precursor for future human exploration. The South Pole is a region of interest due to the near-continuous illumination of the surface and potential access to water.[68]

Unfortunately, despite experiencing steady development in the previous reporting period, with Germany backing the ESA Lunar Lander as a top priority, by the end of 2012 funding issues forced the programme to be shelved. The project was put on hold in favour of launcher development, EO, ISS operations, and the joint ExoMars mission with Russia.[69]

NASA's Lunar Reconnaissance Orbiter (LRO), launched in June 2009, is scouting the Moon in preparation for future lunar exploration, including finding landing sites, locating resources such as water, ice and hydrogen, and investigating the long-term effects of the lunar environment. The mission has created the most precise and complete topographic maps of the Moon yet, and has determined areas of the Moon that are in perpetual darkness or in near-continuous sunlight. Helium has been detected in the Moon's atmosphere, and the LRO's mini-RF radar instrument detected small patches of ice in the permanently shadowed craters with temperatures cold enough to permit ice to accumulate.[70] With extreme cold measurements from the Moon's poles, data from the LRO's Diviner instrument was paired with years of data collected by the Lunar Exploration Neutron Detector measuring the amount of hydrogen trapped in the Lunar soil, to locate hydrogen-rich areas in the poles. Such areas could be valuable to power hardware in support of a robotic or human mission. Moreover, high-resolution images from the LRO Camera revealed that the Moon is still retracting. Also, through measuring the Moon's radiation environment, the spacecraft's CRaTER instrument was able to show that lighter materials such as plastics can provide effective shielding against the radiation faced by astronauts in deep-space missions. The LRO is expected to continue transmitting data until October 2014, with the chance of continuing for an additional 2 years.[71]

NASA's Gravity Recovery And Interior Laboratory (GRAIL) mission was launched on 10 September 2011, with the primary goal of determining the total structure of the lunar interior and advancing understanding of the Moon's thermal

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[67] "European Lunar Lander—Call for Declarations of Interest." 17 Jan. 2012. ESA 20 Apr. 2013. http://www.esa.int/Our_Activities/Human_Spaceflight/Human_Spaceflight_Research/European_Lunar_Lander_-_Call_for_Declarations_of_Interest.

[68] "ESA Portal—Next step for ESA's first Moon lander." 16 Sep. 2010. European Space Agency 19 Aug. 2011. http://www.esa.int/esaCP/SEMUV2KOXDG_index_0.html.

[69] Clark, Stephen. "ESA lunar lander shelved ahead of budget conference." 20 Nov. 2012. Spaceflight Now 21 Apr. 2013. http://spaceflightnow.com/news/n1211/20moonlander/.

[70] "NASA—Lunar Reconnaissance Orbiter (LRO)." NASA 21 Apr. 2013. http://www.nasa.gov/mission_pages/LRO/main/index.html.

[71] "NASA's LRO: Four Years in Orbit." 18 June 2013. NASA 7 Apr. 2014. http://www.nasa.gov/mission_pages/LRO/news/4th-anniv.html.

evolution. A secondary objective was to extend the knowledge gained from the Moon to the other planets of the solar system.[72] By the end of 2012, the twin NASA probes were able to generate the highest resolution gravity field map of a celestial body, revealing tectonic structures, volcanic landforms, basin rings and other details that indicate the Moon's gravity field is unlike any terrestrial planet in the solar system. With GRAIL, the Moon's crust was determined to be between 34 and 43 km, i.e. 10–20 km thinner than had been previously thought. This finding supports models where the Moon is derived from Earth materials that had been ejected from a giant impact near the beginning of our solar system's history.[73] With the success of the GRAIL mission, NASA capitalised on the end of its life by intentionally crashing the twin spacecraft into a mountain near the Moon's North Pole on 17 December 2012, within view of the LRO at the time of impact. This allowed the LRO to take measurements of the cloud of dust and gas that was pushed up with each impact, enabling the LRO's Lyman Alpha Mapping Project (LAMP) to register mercury and enhancements of atomic hydrogen in the ejected plumes using its ultraviolet imaging spectrograph.[74]

NASA's newly launched Lunar Atmosphere and Dust Environment Explorer (LADEE) lifted into space on 6 September 2013. Completing its development phase in reaching the Moon before the end of 2013, it has now begun its 100-day mission to study the Moon's exospheric dust environment and determine the composition of the lunar atmosphere, including the processes that control its distribution and variability.[75] Further in the future, an International Lunar Network (ILN) is in its study phase and is expected to launch in March 2018; the mission, involving robotic landers, orbiters, instrumentation and other significant infrastructure contributions, will operate all upcoming lunar landing missions as nodes in a geophysical network.[76]

With respect to JAXA's lunar strategy and its "Lunar Exploration Strategy of Japan – World-Leading Robotic Lunar Exploration and Establishment of Technology Base towards Manned Space Activity" report from July 2010, more details on JAXA's proposed roadmap became available.[77] In an abstract presented at the 44th Lunar and Planetary Science Conference (2013), an update on the status of Japan's SELENE-2 and SELENE-X missions was provided. SELENE-2 is expected to be in

[72] "Missions—GRAIL—NASA Science NASA 26 Mar. 2013. http://science.nasa.gov/missions/grail/.

[73] "NASA's GRAIL Creates Most Accurate Moon Gravity Map." 5 Dec. 2012. NASA 7 Apr. 2014. http://www.nasa.gov/mission_pages/grail/news/grail20121205.html.

[74] "Lunar Reconnaissance Orbiter Sees GRAIL's Explosive Farewell." 19 Mar. 2013. NASA 7 Apr. 2014. http://www.nasa.gov/mission_pages/grail/news/grail20130319.html#.U0JlN_mSwj4.

[75] "Missions—LADEE—NASA Science." NASA 16 Apr. 2014. http://science.nasa.gov/missions/ladee/.

[76] "Missions—ILN—NASA Science" NASA 26 Mar. 2013. http://science.nasa.gov/missions/iln/.

[77] Sato, Naoki. "JAXA Status of Exploration and Human Space Program." 14 Nov. 2011. JAXA 21 Apr. 2013: 9. http://www.nasa.gov/pdf/605307main_JAXA-Status-(Final)-A-Sato.pdf.

its phase-B within fiscal year 2013, with the earliest launch of the SELENE-2 lander and rover on the Moon's surface in 2018; it will be followed by a SELENE-X advanced lander for South Pole missions.[78]

China's lunar exploration programme accomplished another major technological and scientific feat when it became the third country in the world to soft land a spacecraft on the Moon. Launched on 1 December 2013, and alighting on 14 December 2013, the Chang'e 3 will operate for a 1-year mission, carrying cameras and an ultraviolet telescope to observe Earth's plasmasphere in addition to conducting astronomical observations from the Moon's surface. Chang'e 3's six-wheeled 'Yutu' lunar rover will operate for a 3-month mission, conducting scientific explorations of the geography and geomorphology of the landing spot and nearby areas.[79] Continuing on with the second phase of the lunar exploration programme, China's Chang'e 4, originally a backup to the Chang'e 3, is being adapted to verify technologies for the sample return initiative in the third phase of China's lunar exploration programme. China plans to return a sample of lunar soil to Earth with its Chang'e 5 to be launched in 2017,[80] in addition to sketch plans for a manned lunar landing sometime between 2025 and 2030.[81]

India's second lunar mission, Chandrayaan 2 was envisioned as a joint venture between India and Russia, featuring an ISRO orbiter and rover, and delivery by a Russian-supplied lander, and is expected to launch before the end of 2015.[82] However, problems arising from delayed construction and financial constraints resulted in Russia being unable to provide the lander within the planned 2015 timeframe. As a result, following a high-level review by ISRO, it was determined that India could provide a lander module on its own; though the configuration of the Chandrayaan 2 mission would need adjustment to take into account the weight, volume, and power constraints of an ISRO lander.[83] The Chandrayaan 2 mission has five primary payloads on the orbiter, two of which will be improvements on instruments that were on board the previous Chandrayaan 1 mission; the rover too

[78] Tanaka, S., et. al. "Present Status of the Lunar Lander Project SELENE-2." 26 Mar. 2013. 44th Lunar and Planetary Science Conference (2013) 16 Apr. 2014. http://www.lpi.usra.edu/meetings/lpsc2013/pdf/1838.pdf.

[79] "Chinese Rover Hibernating to Survive Frigid Lunar Night." 27 Dec. 2013. Spaceflight Now 7 Apr. 2014. http://www.spaceflightnow.com/china/change3/131227hibernation/#.U0KlqvmSwj4.

[80] "China Targets Moon Sample-Return Mission in 2017." 26 Dec. 2013. Space.com 7 Apr. 2014. http://www.space.com/24055-china-moon-sample-return-mission.html.

[81] "China considering manned lunar landing in 2025-2030." 24 May 2009. China View 21 Apr. 2013. http://news.xinhuanet.com/english/2009-05/24/content_11425131.htm.

[82] "Chandrayaan-2 Expected to Launch within 2 Years." 15 Dec. 2013. CCTV 7 Apr. 2014. http://english.cntv.cn/program/newsupdate/20131215/104199.shtml.

[83] "India to go Alone with Chandrayaan 2." 14 Aug. 2013. The Hindu 7 Apr. 2014. http://www.thehindu.com/sci-tech/india-to-go-alone-with-chandrayaan-2/article5022717.ece.

will carry two additional instruments. Chandrayaan 2 will be launched on a GSLV using an indigenous cryogenic engine.[84]

Russia continued work on its Luna-Glob and Luna-Grunt series of missions, with the former now scheduled to launch its first Luna-Glob 1 lander mission (Luna-25) in 2016.[85] With this first mission postponed by a year, the launch schedule of the follow-up Luna-Resurs orbiter (Luna-26) has been pushed to 2018, while the Luna-Resurs lander (Luna-27) is now planned for 2019. These missions, involving a lunar orbiter and surface penetrators, will contribute to knowledge about the moon's formation. Following the Luna-Glob missions, the Luna-Grunt mission will comprise a lunar rover and the Earth return vehicle. The Luna-Glob probe will study the Moon's Polar Regions following NASA's LRO discovery of the presence of water ice in polar craters that are constantly in the sun's shadow. Four high speed penetrators, and a polar probe equipped with a radio beacon to facilitate future landings will be deployed on the Moon's surface.[86] While Roscosmos will not provide a lunar lander in time for the launch of India's Chandrayaan-2 mission, that mission had been intended to be part of Roskosmos' Luna-Glob moon exploration programme, and hence, collaboration with India will likely continue.[87] Moreover, European investigators have exhibited an interest in participating in the upcoming Luna-Glob missions.[88]

The Google Lunar X PRIZE is a competition for a total of $30 million in prizes for the first privately funded teams to safely land a rover on the Moon by the end of 2015. To win, the rover must travel at least 500 m on the Moon's surface and send high-definition video, images, and data back to the Earth. To provide additional incentive for accelerated development, the prize will reduce in value after a government-funded mission explores the lunar surface. Early in November 2013, in an effort to assist the competing teams by allowing them to access financing at a critical point in their mission timeline and raise public excitement and support for the teams, X PRIZE and Google announced a series of Milestone Prizes available to the competing teams. With amounts ranging from between $250,000 to $1 million available to several teams that demonstrate (via actual testing and analysis) robust hardware and software to combat key technical risks in the areas of imaging,

[84] Ramachanran, R. "Chandrayaan-2: India to go it alone." 22 Jan. 2013. The Hindu 21 Apr. 2013. http://www.thehindu.com/news/national/chandrayaan2-india-to-go-it-alone/article4329844.ece.

[85] "First Russian Moon Mission Delayed." 17 Oct. 2013. Exploring Space 7 Apr. 2014. http://spaceexp.tumblr.com/post/64287200145/first-russian-moon-mission-delayed.

[86] Pavlishev, Boris. "Lunar probe to search for water on Moon." 18 Oct. 2011. radio—The Voice of Russia 21 Apr. 2013. http://english.ruvr.ru/2011/10/18/58931510/.

[87] Ramachanran, R. "Chandrayaan-2: India to go it alone."

[88] "European-Russian Luna Mission Speed Dating." 3 Dec. 2013. Spaceports 7 Apr. 2014. http://spaceports.blogspot.co.at/2013/12/european-russian-luna-mission-speed.html.

mobility and lander systems, the awards can be won through the end of September 2014.[89] With 25 teams registered for the competition on 31 December 2010,[90] by the end of 2013, that number had reduced to 18 active teams, with several competitors leaving to pursue other business interests.[91] At the end of 2010, NASA announced that it would purchase data and contract with some of the teams to demonstrate technology in high technical risk areas associated with low-cost lunar missions.[92]

2.3.3 Mars Science

The focus for Mars science has for decades remained the investigation of the planet's habitability, in a search for the presence of water. The collected data continues to suggest that Mars was once partially covered by large oceans, and that life could have been possible in many locations on the planet's surface.

ESA's Mars Express orbiter, launched in June 2003, continued its mission imaging the entire surface of the planet at high resolution, including maps of the mineral composition and atmosphere, and determining the structure of the sub-surface to a depth of a few kilometres, the effect of the atmosphere on the surface, and the interaction of the atmosphere with the solar winds. In June 2013, on its tenth anniversary, new global maps of Mars enabled researchers to compare a series of global maps showing the distribution and weathering of minerals found in water and from volcanic activity, allowing researchers to trace the evolution of the planet through time.[93] In previous years data generated by the spacecraft's radar showed that there may be glaciers hidden beneath the surface of Mars' Phlegra Montes mountain range; and it also detected sediments that are reminiscent of an ocean floor within the previously identified boundaries of ancient shorelines.

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[89] "Recognizing Giant Leaps: Google Lunar XPRIZE Establishes Milestone Prizes (Op-Ed)." 7 Nov. 2013. Space.com 7 Apr. 2014. http://www.space.com/23503-google-lunar-xprize-milestone-prizes.html.

[90] "Google Lunar X PRIZE." Google Lunar XPRIZE 26 Mar. 2013. http://www.googlelunarxprize.org/.

[91] "As 2013 Comes To An End, Competition Intensifies In Private Race To The Moon." 19 Dec. 2013. Google Lunar X Prize 7 Apr. 2014. http://www.googlelunarxprize.org/blog/2013-comes-end-competition-intensifies-private-race-moon.

[92] Braukus, Michael, Lynnette Madison, and Josh Byerly. "NASA Awards Contracts For Innovative Lunar Demonstrations Data." 15 Oct. 2010. NASA Press Releases 26 Mar. 2013. http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-259_ILDD_Award.html; *see also* Harrington, J.D., and Josh Byerl. "NASA Selects Companies for Further Lunar Demonstrations Data." 20 Dec. 2010. NASA Press Releases 26 Mar. 2013. http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-344_ILDD_Selections.html.

[93] "Ten Years at Mars: New Global Views Plot the Red Planet's History." 3 June 2013. ESA 27 Mar. 2014. http://www.esa.int/Our_Activities/Space_Science/Mars_Express/Ten_years_at_Mars_new_global_views_plot_the_Red_Planet_s_history.

Moreover, a planetary alignment between Earth and Mars, both passing through a gust of the same solar wind, allowed researchers to compare the protective effects of Earth's magnetic field with Mars' lack of a magnetic field, showing that the existence of a magnetic field is vital for keeping an atmosphere in place. And gravity mapping data collected over a period of 5 years allowed researchers to determine that Martian volcanic lava grew denser over time and that the thickness of the planet's rigid outer layers varies in Mars' Tharsis volcanic region.[94] Near the end of 2013, the spacecraft was expected to make its closest flyby of Mars' largest moon Phobos reaching a nadir distance of 45 km from its surface, allowing it to yield the most accurate details of the moon's gravitational field and provide new details of its internal structure.[95]

The ESA ExoMars mission continued its development, undergoing a revision in spring 2011 following the uncertainties in funding that arose from NASA's constraints and eventual withdrawal.[96] On 13 February 2012, NASA announced that it would have to withdraw entirely for budgetary reasons, with Roscosmos replacing the NASA as a main partner in the mission at the end of the year.[97] Subsequently, in March 2013, ESA and Roscosmos signed a formal agreement to work in partnership on the ExoMars programme with launches of the two missions planned in January 2016 and May 2018.[98] ESA will provide the Trace Gas Orbiter (TGO) and the Entry, Descent and Landing Demonstrator Module (EDM) 'Schiaparelli' in 2016,[99] and the carrier and rover in 2018; while Roscosmos is responsible for the 2018 descent module and surface platform, and will provide launchers for both missions. Both partners will also supply scientific instruments and will cooperate closely in the scientific exploitation of the missions. The 2016 mission will search for evidence of methane and other atmospheric gases that could be signatures of active biological or geological processes, while the ExoMars rover, to be launched in 2018, will search the planet's surface for signs of life, past and present, and will be able to drill to a depth of 2 m.[100]

[94] "ESA—Mars Express." European Space Agency. 26 Mar. 2013. http://www.esa.int/esaMI/Mars_Express/index.html.

[95] "Mars Express Heading Towards Daring Flyby of Phobos." 23 Dec. 2013. ESA 27 Mar. 2014. http://www.esa.int/Our_Activities/Space_Science/Mars_Express/Mars_Express_heading_towards_daring_flyby_of_Phobos.

[96] "Annual Report 2011 of the International Space Exploration Coordination Group" International Space Exploration Coordination Group (ISECG) 26 Mar. 2013. http://www.globalspaceexploration.org/c/document_library/get_file?uuid=757abb46-0e23-4bfc-8c1c-dde1320faadc&groupId=10812.

[97] De Selding, Peter. "ExoMars Wins One-month Reprieve." SpaceNews 21 May 2012: 8.

[98] "ExoMars 2016 Set to Complete Construction." 17 June 2013. ESA 28 Mar. 2014. http://exploration.esa.int/mars/51931-exomars-2016-set-to-complete-construction/.

[99] "ExoMars Lander Module Named Schiaparelli." 8 Nov. 2013. ESA 28 Mar. 2014. http://exploration.esa.int/mars/53145-exomars-lander-module-named-schiaparelli/.

[100] "ExoMars: ESA and Roscosmos for Mars Missions." 14 Mar. 2013. ESA 28 Mar. 2014. http://exploration.esa.int/mars/51495-exomars-esa-and-roscosmos-set-for-mars-missions/.

NASA's Mars Odyssey mission, launched on 7 April 2001, is the longest-operating spacecraft to be sent to Mars. Orbiting the planet since 24 October 2001, some of its contributions include: confirming the mineral exposure that was selected as the landing site for NASA's Mars Exploration Rover Opportunity and helping to identify safe landing sites for NASA's Mars Phoenix lander; discovering carbon-dioxide gas jets at the south polar ice cap during the spring season; finding chloride salt deposits across the planet; and producing the best available global image map of Mars. The spacecraft also served as a communications relay for the two Mars Exploration Rovers.[101] The Mars Exploration Rover (MER) Opportunity reached the Endeavour crater, examining scientific targets in the surrounding area and finding mineral veins that were deposited by water. NASA's MER Spirit was deemed to have completed its mission on 25 March 2011, following failed attempts to communicate with the rover beyond the last transmission received on 22 March 2010.[102]

NASA's Mars Reconnaissance Orbiter (MRO) continued to provide valuable data for the purpose of determining whether or not life has existed on Mars, characterising the climate and geology, and preparing for future human exploration. In previous years, it returned data that suggested that water still flows in some places on Mars, depicted as dark, finger-like features that appear and extend down some Martian slopes that change during the seasons.[103] In September 2012, the spacecraft returned the clearest evidence yet of carbon-dioxide snowfalls (i.e. 'dry ice') occurring around Mars' South Pole in its winter season.[104] Moreover, researchers at the California Institute of Technology (Caltech) have discovered evidence of an ancient delta where a river might once have emptied into a vast ocean that could have covered as much as a third of Mars, mainly located in the planet's northern hemisphere.[105] In December 2013, more evidence of flowing water was returned—slender dark markings, most likely due to salty water that advances seasonally down slopes surprisingly close to the Martian equator.[106] And a previous study has suggested that if Mars ever incubated life, the longest lasting

[101] "Mars Odyssey." NASA Jet Propulsion Laboratory, California Institute of Technology" 26 Mar. 2013. http://mars.jpl.nasa.gov/odyssey/.

[102] "Mars Exploration Rover Mission: Home." NASA Jet Propulsion Laboratory, California Institute of Technology 26 Mar. 2013. http://marsrover.nasa.gov/home/index.html.

[103] "Mars Reconnaissance Orbiter." NASA Jet Propulsion Laboratory, California Institute of Technology 26 Mar. 2013. http://marsprogram.jpl.nasa.gov/mro/.

[104] "NASA Orbiter Observations Point to 'Dry Ice' Snowfall on Mars." 11 Sept. 2012. Jet Propulsion Laboratory 28 Mar. 2014. http://mars.jpl.nasa.gov/mro/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=1341.

[105] "Evidence for a Martian Ocean." 17 July 2013. Jet Propulsion Laboratory 28 Mar. 2014. http://mars.jpl.nasa.gov/mro/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=1493.

[106] "NASA Mars Spacecraft Reveals a More Dynamic Red Planet." 10 Dec. 2013. Jet Propulsion Laboratory 28 Mar. 2014. http://mars.jpl.nasa.gov/mro/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=1567.

habitats were most likely below the surface, in the clay minerals that formed in the shallow subsurface all over the planet.

The NASA Mars Science Laboratory (MSL) rover, nicknamed Curiosity, reached Mars on 5 August 2012, completing an 8-month journey to the planet.[107] As the largest rover to ever land on Mars, its mission will run for at least 687 Earth days (a full Martian year), and will study Mars's habitability. The rover has eight scientific objectives, i.e. determining the nature and inventory of organic carbon compounds; conducting an inventory of the chemical building blocks of life; identifying features that may represent the effects of biological processes; investigating the chemical, isotopic, and mineralogical composition of Martian geological materials; it will interpret the processes that have formed and modified rocks and soils; assess 4-billion-year timescale atmospheric evolution processes; determine the present state, distribution, and cycling of water and carbon dioxide; and characterize the broad spectrum of surface radiation, including galactic cosmic radiation, solar proton events, and secondary neutrons.[108] Since its arrival, Curiosity has transmitted results of initial experiments that show the mineralogy of Martian soil is similar to weathered basaltic soils of volcanic origin in Hawaii.[109] The rover was also the first to drill into a rock sample on Mars to collect a sample from its interior.[110] Analysis of similar samples has shown the presence of sulphur, nitrogen, hydrogen, oxygen, phosphorus, and carbon, all key elements that could have supported microbial life on ancient Mars.[111] Other samples collected from the planet's equator have shown a compound containing chlorine and oxygen, likely chlorate or perchlorate, a compound that had been previously found at Mars' North Pole, suggesting more global dispersion.[112] However, data from the rover surprised researchers when it revealed that the planet's environment lacks methane; contradicting positive detections that had been previously reported and reducing the probability of currently existing methane-producing microbes on Mars.[113]

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[107] "NASA Lands Car-Size Rover Beside Martian Mountain." 5 Aug. 2012. NASA 31 Mar. 2014. http://www.nasa.gov/mission_pages/msl/news/msl20120805c.html.

[108] Mars Science Laboratory (MSL). 14 May. 2012. NASA NSSDC 14 Jan. 2013. http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-070A.

[109] "NASA Rover's First Soil Studies Help Fingerprint Martian Minerals." 30 Oct. 2012. NASA 31 Mar. 2014. http://www.nasa.gov/mission_pages/msl/news/msl20121030.html.

[110] "NASA Curiosity Rover Collects First Martian Bedrock Sample." 9 Febr. 2013. NASA 31 Mar. 2014. http://www.nasa.gov/mission_pages/msl/news/msl20130209.html.

[111] "ASA Rover Finds Conditions Once Suited for Ancient Life on Mars." 12 Mar. 2013. NASA 31 Mar. 2014. http://www.nasa.gov/mission_pages/msl/news/msl20130312.html#.UzkhCPmSwj4.

[112] "Curiosity's SAM Instrument Finds Water and More in Surface Sample." 26 Sept. 2013. NASA 31 Mar. 2014. http://www.nasa.gov/content/goddard/curiositys-sam-instrument-finds-water-and-more-in-surface-sample/#.UzkiPfmSwj4.

[113] "NASA Curiosity Rover Detects No Methane on Mars." 19 Sept. 2013. NASA 31 Mar. 2014. http://www.nasa.gov/mission_pages/msl/news/msl20130919.html#.UzkiLfmSwj4.

NASA launched the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission on 18 November 2013. It is expected to reach Mars on 22 September 2014. MAVEN aims to explore the planet's upper atmosphere, ionosphere and interactions with the Sun and solar wind, which will be used to determine the role that the loss to space of volatile compounds from the Mars atmosphere has played in the history of Mars' habitability.[114] In other words, by studying the planet's upper atmosphere and measuring current rates of atmospheric loss, MAVEN scientists hope to understand how Mars transitioned from a warm, wet planet to its current dry desert state.[115]

ISRO's newly launched Mars Orbiter Mission (MOM) lifted into space on 5 November 2013. Its journey to Mars is expected to take 300 days, reaching the planet on 22 September 2014.[116] On reaching Mars, the spacecraft—carrying five indigenous scientific payloads consisting of a camera, two spectrometers, a radiometer, and a photometer—will observe Mars' surface, atmosphere and exosphere extending up to 80,000 km for a detailed understanding of the planet's evolution, especially its related geologic and possible biogenic processes.[117]

In 2011, the Russian Phobos-Grunt mission failed.[118] Russia now hopes to launch another probe Phobos-Grunt 2 to Mars's moon by 2022, to explore the theory that the moon might be a captured main-belt asteroid containing materials dating back to the formation of the solar system.[119]

2.3.4 Saturn Science

The Cassini-Huygens mission, a joint NASA, ESA and ASI mission, was launched in 1997. Reaching Saturn in 2004, Cassini went on to drop the Huygens probe onto Saturn's moon, Titan. The renamed Cassini Solstice Mission was supposed to end in June 2008, however, funding was provided to allow continued operation to provide new insights on Saturn and its moons; it is now slated to explore Saturn

[114] "MAVEN." University of Colorado at Boulder, Laboratory for Atmospheric and Space Physics 14 Jan. 2013. http://lasp.colorado.edu/home/maven/.

[115] "NASA Launches Mission to Study Upper Atmosphere of Mars." 18 Nov. 2013. NASA 31 Mar. 2014. http://www.nasa.gov/press/2013/November/nasa-launches-mission-to-study-upper-atmosphere-of-mars/#.Uzl3uvmSwj5.

[116] "Mars Orbiter Mission (MOM)—Manglayaan." Indian Space Projects 31 Mar. 2014. http://isp.justthe80.com/planetary-exploration/mars-obiter.

[117] "Indian Space Research Organisation | Mars Orbiter Mission." Indian Space Research Organisation 31 Mar. 2014. http://www.isro.org/mars/home.aspx.

[118] Amos, Jonathan. "Phobos-Grunt: Failed probe 'falls over Pacific'." 15 Jan. 2012. BBC News 14 Jan. 2013. http://www.bbc.co.uk/news/science-environment-16491457.

[119] "Phobos-Grunt-2: Russia to Probe Martian Moon by 2022." 18 Oct. 2013. Mars Daily 7 Apr. 2014. http://www.marsdaily.com/reports/Phobos_Grunt_2_Russia_to_probe_Martian_moon_by_2022_999.html.

until 2017.[120] In past years, the now 16-year old mission returned images of a storm that was 500 times larger than the storm Cassini witnessed between late 2009 and early 2010; the last storm covered approximately 4 billion square kilometres and was wrapped around the entire planet.[121] In June 2012, long-standing methane lakes, or puddles, in the "tropics" of Saturn's moon Titan were an unexpected finding because the models had assumed that these long-standing bodies of liquid would only exist at the poles.[122] Soon afterward, the spacecraft detected large tides on Titan, leading to the almost inescapable conclusion that there is a hidden ocean beneath the moon's ice crust.[123] The Cassini spacecraft was also able to observe small meteoroids breaking into streams of rubble and crashing into Saturn's rings. By studying the impact rate of meteoroids from outside the Saturnian system, scientists are better able to understand how the different planet systems in our solar system formed.[124]

On Enceladus, Cassini had previously observed plumes of 'dusty plasma' emanating from the icy geyser moon. In addition to recording the results that were previously only theoretical, Cassini's instruments showed that the 'heavy' and 'light' species of charged particles in normal plasma were actually reversed near the plume spraying from the moon's South Pole region.[125] The complexity of the plasma was increased by the presence of ionised water vapour that attached to dust particles, changing its properties and producing a new collective behaviour. Being a rare opportunity, as dusty plasma is thought to exist in comet tails and dust rings around the Sun, Cassini flew through the dusty plasma and directly measured its characteristics in situ.[126] Recent scientific results from a flythrough of the plumes also show strong evidence of the existence of large-scale saltwater reservoirs beneath Encelaus' crust.[127] Adding to this evidence of reservoirs beneath the moon's crust, data obtained by Cassini shows that the intensity of the jets of water ice and organic particles that shoot out from Enceladus depends on the moon's proximity to the ringed planet. Here, combining brightness data collected by Cassini's visual and infrared mapping spectrometer (VIMS) to previous models

[120] Mason, Betsy. "Cassini Gets Life Extension to Explore Saturn Until 2017." 3 Feb. 2010. WIRED 18 Dec. 2012. http://www.wired.com/wiredscience/2010/02/cassini-life-extension-2017/.

[121] SpaceNews Staff. "NASA's Cassini Spacecraft Witnesses Big Saturn Storm." 11 Jul. 2011. SpaceNews 18. Dec. 2012. http://www.spacenews.com/article/nasas-cassini-spacecraft-witnesses-big-saturn-storm.

[122] "Cassini Sees Tropical Lakes on Saturn Moon." 13 June 2012. NASA Cassini 26 Mar. 2014. http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20120613/.

[123] "Cassini Finds Likely Subsurface Ocean on Saturn Moon." 28 June 2012. NASA Cassini 26 Mar. 2014. http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20120628/.

[124] "Cassini Observes Meteors Colliding with Saturn's Rings." 25 Apr. 2013. NASA Cassini 26 Mar. 2014. http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20130425/.

[125] "Enceladus Plume is a new Kind of Plasma Laboratory." 31 May 2012. NASA Cassini 30 May 2014. http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20120531/.

[126] Ibid.

[127] Ibid.

of Saturn's gravity on Enceladus, scientists deduced that the stronger gravitational squeeze near the planet reduces the opening of the tiger stripes and the amount of material spraying out. In turn, they surmise that the relaxing of Saturn's gravity farther away from planet allows the tiger stripes to be more open and the spray to escape in larger quantities.[128]

2.3.5 Venus Science

ESA's Venus Express mission was launched in 1995 and reached Venus in 2006. It studies Venus's atmosphere, including its dynamics and chemistry, atmosphere-surface interactions, and interactions with solar wind, to address open questions such as the workings of the complex global dynamics of the planet, its cloud system, processes that govern the chemical state of the atmosphere, and the 'green-house effect' in its global climate. Previously, from the detected escape of ionic hydrogen and oxygen in the ratio of two to one from the planet, scientists inferred that solar ultraviolet radiation streams into the atmosphere and breaks up the water molecules into atoms. Venus Express has discovered an ozone layer high in Venus's atmosphere. Three oxygen atoms make up the ozone molecule, which in the Venus atmosphere is thought to be formed when sunlight breaks up carbon dioxide molecules, releasing oxygen atoms which are then swept to the dark side of the planet by atmospheric winds; they subsequently combine to form two-atom oxygen molecules, and occasionally, three-atom ozone molecules.[129] Recently, an extremely cold region in the planet's atmosphere was observed, with temperatures reaching around –175 °C at an altitude of 125 km above the Venus's surface, leading researchers to suspect that carbon dioxide ice might form there, pinned between two comparatively warmer layers.[130] Moreover, the spacecraft was able to shed more light on the solar wind's interaction with the planet, wherein during a period of very low density solar outflow, the ionosphere of Venus was observed to become elongated downstream moving outward to at least 15,000 km from Venus, similar to a long-tailed comet.[131]

Previously, Venus Express discovered that the planet rotated at a slower rate than first determined by NASA's Magellan orbiter in the early 1990s. Since last

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[128] "NASA's Cassini Spacecraft Reveals Forces Controlling Saturn Moon Jets." 31 July 2013. NASA Cassini 26 Mar. 2014. http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20130731/.

[129] Venus Express. "ESA finds that Venus has an ozone layer too." 6 Oct. 2011. ESA 9 Jan. 2012. http://www.esa.int/Our_Activities/Space_Science/Venus_Express/ESA_finds_that_Venus_has_an_ozone_layer_too.

[130] "A Curious Cold Layer in the Atmosphere of Venus." 1 Oct. 2012. ESA 27 Mar. 2014. http://sci.esa.int/venus-express/50884-a-curious-cold-layer-in-the-atmosphere-of-venus/.

[131] "The Tail of Venus and the Weak Solar Wind." 29 Jan. 2013. ESA 27 Mar. 2014. http://sci.esa.int/venus-express/51315-the-tail-of-venus-and-the-weak-solar-wind/.

being studied, surface features on Venus have been displaced by up to 20 km from where they were expected. Over a 4-year period, Magellan enabled scientists to determine the length of the day on Venus to be equal to 243.0185 Earth Days. Nearly two decades later, those surface features could only be lined up with those observed by Magellan if the length of the Venus day is on average 6.5 min longer than Magellan's measurements. These measurements help to determine whether Venus has a solid or liquid core; if it had a solid core, the planet's rotation would react less to external forces because its mass would be more concentrated towards the centre. Venus's dense atmosphere (i.e. more than 90 times the pressure of Earth's) and high-speed weather systems are the most important of those forces, and they are believed to change the planet's rotation rate by causing friction with the planet's surface. Earth experiences a similar but vastly diminished effect (largely caused by wind and tides), where the length of a day can change by roughly a millisecond, depending on wind patterns and temperatures occurring over the course of a year.[132] Operations of Venus Express have been extended until 2015, subject to a mid-term review and confirmation by ESA's Space Situational Awareness (SSA) programme in 2014.[133]

The Russian Federal Space Programme is planning to further build on its Venera programme—first initiated in the early 1960s. In the subsequent decades, the Venera programme launched a series of probes, landers, orbiters, and conducted repeated impact experiments and flybys up to 1985.[134] The Venera-D mission is currently being developed by the Russian Federal Space Programme, and it is now scheduled for launch in 2024. While previously projected to launch sometime in 2015–2016, the technical complexity of the project and the need to resume development of the lander technology resulted in the nearly 8-year schedule delay.[135] The mission will comprise of a lander, orbiter and a sub-satellite. The lander will study the formation and evolution of Venus, in particular the elemental and mineralogical composition of the surface, geology, iron-containing phases and the distribution of iron oxidation states. During its descent, the lander will make meteorological measurements, record the isotopic composition of the atmosphere, measure the structure, chemistry and microphysics of clouds, and monitor electromagnetic radiation. The orbiter will be in a daily polar orbit and will study the atmosphere from the surface to an altitude of 160 km, using spectrometers from the ultraviolet to millimetre ranges. The sub-satellite will allow the simultaneous

[132] Venus Express. "Could Venus be shifting gear?" 10 Feb. 2012. ESA 9 Jan. 2012. http://www.esa.int/Our_Activities/Space_Science/Venus_Express/Could_Venus_be_shifting_gear.

[133] "ESA Science Missions Continue in Overtime." 20 June 2013. ESA 27 Mar. 2014. http://sci.esa.int/director-desk/51944-esa-science-missions-continue-in-overtime/.

[134] Williams, David R. "Chronology of Venus Exploration." 29 Jun. 2011. NASA 10 Jan. 2013. http://nssdc.gsfc.nasa.gov/planetary/chronology_venus.html.

[135] "RAS: Start "Venus-D" will take Place no earlier than 2024." 9 Apr. 2012. Gazeta 27 Mar. 2014. http://www.gazeta.ru/science/news/2012/04/09/n_2284249.shtml.

measurements of plasma and magnetic fields. Europe and China have been invited to participate in the project.[136]

2.3.6 Mercury Science

Running as a partnership between ESA and JAXA, BepiColombo will be Europe's first mission to Mercury. The mission's targeted launch date has been moved to July 2016 with arrival at Mercury in January 2024 for a 1-year mission, with a possible 1-year extension. To be executed under ESA leadership, BepiColumbo is currently in the implementation stage, to be eventually launched on the Ariane 5 launch vehicle. The mission is made up of two spacecraft: the Mercury Planetary Orbiter (MPO), a three-axis stabilised spacecraft provided by ESA that will study the planet's geology, composition, inner structure, and exosphere, and the Mercury Magnetospheric Orbiter (MMO), a spin-stabilised spacecraft provided by JAXA that will study the planet's magnetic field, atmosphere, magnetosphere and inner interplanetary space. Enduring temperatures in excess of 350 °C, BepiColombo has been designed to provide the measurements necessary to study and understand the composition, geophysics, atmosphere, magnetosphere and history of Mercury.[137]

MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER), a NASA discovery-class mission, was launched in August 2004. On 18 March 2011, it became the first spacecraft to orbit Mercury, following three flybys. After completing its year-long task to perform the first complete reconnaissance of the geochemistry, geophysics, geological history, atmosphere, magnetosphere, and plasma environment of Mercury by 17 March 2012, MESSENGER began its extended mission to build on its discoveries.[138] The mission is designed to address six broad scientific questions: why Mercury is so dense, the planet's geological history, the nature of its magnetic field, the structure of its core, the nature of the unusual materials at the poles, and what volatiles are important on Mercury. MESSENGER was designed and built by the Johns Hopkins University Applied Physics Laboratory (APL).[139] By 29 November 2012, a long-held hypothesis that Mercury harbours abundant water ice and other frozen volatile materials in its permanently shadowed polar craters gained compelling support from three

[136] "VENERA-D: ВЕНЕРА: Изучение продолжается." 10 Mar. 2011. Roscosmos 25 Aug. 2011. http://venera-d.cosmos.ru/index.php?id=692&tx_ttnews[tt_news]=1288&cHash=f9bfd2c6e7616171412b316d206d73a4.

[137] "BepiColombo Fact Sheet." 3 Dec. 2013. ESA 27 Mar. 2014. http://sci.esa.int/bepicolombo/47346-fact-sheet/.

[138] MESSENGER Completes Primary Mission at Mercury, Settles in for Another Year. 19 Mar. 2012. MESSENGER 13 Jan. 2013. http://messenger.jhuapl.edu/news_room/details.php?id=197.

[139] "MESSENGER: Mercury Surface, Space Environment, Geochemistry, and Ranging: Mercury Orbit Insertion." Press kit. NASA 25 Aug. 2011. http://www.nasa.gov/pdf/525164main_MercuryMOI_PK.pdf.

independent lines of evidence: i.e. excess hydrogen at Mercury's north pole was measured with MESSENGER's Neutron Spectrometer; reflectance of Mercury's polar deposits at near-infrared wavelengths was measured with the Mercury Laser Altimeter (MLA); and the first detailed models of the surface and near-surface temperatures of Mercury's north polar regions that utilize the actual topography of Mercury's surface were measured by the MLA.[140] Dark patches with diminished reflectance were also recorded by the MLA, consistent with the theory that the ice in those areas is covered by a thermally insulating layer. By March 2013, in orbit for over 2 years, MESSENGER's +Mercury Dual Imaging System (MDIS) had imaged 100 % of the planet.[141] By that time, the spacecraft had completed its first year-long extended mission. In that time, the spacecraft completed 12 specialised measurement campaigns that led to new discoveries about surface volatiles on the planet, the duration of volcanism, the evolution of long-wavelength topography, the nature of localised regions of enhanced exospheric density, the effect of the solar cycle on Mercury's exosphere, and Mercury's energetic electrons.[142]

2.3.7 Jupiter Science

In May 2012, the proposed ESA Jupiter Icy moon Explorer (JUICE)[143] mission was selected by ESA's Space Programme Committee (SPC) as the first large (L-class) mission opportunity in ESA's Cosmic Vision 2015–2025 plan, with a foreseen launch date of 2022 and arrival in 2030. The proposed nearly 5 tons spacecraft will make a careful investigation of Jupiter's three biggest moons, i.e. it will use the gravity of Jupiter to initiate a series of close fly-bys around Callisto and Europa, and then finally to put itself in a settled orbit around Ganymede. As all three moons are suspected of having oceans of water beneath their icy crusts, scientists are trying to understand whether there is any possibility that these moons could host microbial life.[144] The final and formal adoption of JUICE is expected in 2014. At the time of JUICE's selection by the SPC, an agreement had already been established with

[140] "MESSENGER Finds New Evidence for Water Ice at Mercury's Poles." 29 Nov. 2012. NASA 27 Mar. 2014. http://www.nasa.gov/mission_pages/messenger/media/PressConf20121129.html#.UzQGLPldUj4.

[141] "MESSENGER Has Imaged 100 Percent of Mercury." 6 Mar. 2013. NASA 27 Mar. 2014. http://www.nasa.gov/mission_pages/messenger/media/Imaged100Percent.html#.UzQGLPldUj4.

[142] "MESSENGER Completes Its First Extended Mission at Mercury." 20 Mar. 2013. Space Daily 27 Mar. 2014. http://www.spacedaily.com/reports/MESSENGER_Completes_Its_First_Extended_Mission_at_Mercury_999.html.

[143] JUICE was renamed during its reformulation exercise from the designation Europa Jupiter System Mission (EJSM)–Laplace in 2011.

[144] "ESA Selects 1bn-Euro JUICE Probe to Jupiter." 2 May 2012. BBC News 27 Mar. 2014. http://www.bbc.com/news/science-environment-17917102.

NASA as a minor payload contributor, and negotiations on an agreement with Russia concerning payload provision for the JUICE spacecraft and the Russian Ganymede lander were in progress.[145]

Juno, NASA's new frontiers mission to Jupiter, was launched on an Atlas V55 on 15 August 2011. The $1.1 billion spacecraft carries an assortment of instruments, including a Gravity Science Experiment, a Magnetometer (MAG), a Microwave Radiometer (MWR), a Jupiter Energetic Particle Detector Instrument (JEDI), Jovian Auroral Distributions Experiment (JADE), Waves, a Jovian Infrared Auroral Mapper (JIRAM), Ultraviolet Imaging Spectrograph (UVS), and a JunoCam. The mission's objectives are to determine how much water is in Jupiter's atmosphere, measure the atmospheric composition, temperature, cloud motion and other properties, map the magnetic and gravitational fields, and explore the magnetosphere near the poles, especially the planet's auroras.[146] The spacecraft performed two 30-min Deep Space Manoeuvres (DSM-1, -2) on 30 August and 14 September 2012, respectively, to refine the spacecraft's trajectory, allowing for a gravity assist from a flyby of Earth on Oct 9, 2013, with arrival expected on 4 July 2016. Once on orbit, the spacecraft will circle Jupiter 33 times, from pole to pole, and use its collection of eight science instruments to probe beneath the gas giant's obscuring cloud cover to learn about the planet's origins, structure, atmosphere and magnetosphere, and seek a potential solid planetary core.[147]

2.3.8 Solar Observation

Continued observation of the Sun's external activity has the benefit of improving our understanding of its interior, its corona, the monitoring of solar wind and its consequences on Earth and its neighbouring planets. Coronal mass ejections (CMEs) from the Sun emit surges of charged particles in directions that may cross Earth's path and can damage satellites, impede space-based services and affect the terrestrial electrical infrastructure.

[145] "Forthcoming Announcement of Opportunity for Scientific Instrumentation Onboard the JUICE Spacecraft." 30 May 2012. ESA 27 Mar. 2014. http://sci.esa.int/juice/50400-forthcoming-announcement-of-opportunity-for-juice-scientific-instrumentation/.

[146] "NASA—Juno." NASA 4 Mar. 2013. http://www.nasa.gov/mission_pages/juno/main/index.html.

[147] "Juno's Two Deep Space Maneuvers are 'Back-To-Back Home Runs'." 17 Sept. 2012. NASA 27 Mar. 2014. http://www.nasa.gov/mission_pages/juno/news/juno20120917.html#.UzQtWPldUj4.

ESA's PRoject for OnBoard Autonomy (PROBA)-2 microsatellite continued its solar observation activity, having been given a programme extension in November 2012 by ESAs SPC, with the mission now extending until at least the end of 2014.[148] PROBA-2 tracks spikes in CMEs ejecting from the Sun that have previously been seen to just skim Earth, typically bringing with them a burst of radio energy.[149] By the end of 2011, the mission had gathered about 400,000 images of the Sun, and made nearly 20 million in situ ionospheric observations.[150] ESA is also developing the Proba-3, as a pair of satellites maintaining a fixed configuration to form a 150 m long solar chronograph to study the Sun's faint corona closer to the solar rim than previously achieved.[151] Expected to launch in 2017, the satellite pair—separated by 150 m—will be capable of flying in formation to within a tolerance of a millimetre and one second of arc of one another to provide heightened clarity of the rim.[152]

CNES' solar metrology mission 'PICARD', launched on 15 June 2010, aims to improve knowledge of how the Sun functions and the influence of solar activity on the Earth's climate. PICARD will accomplish this by measuring absolute total and spectral solar irradiance, solar diameter and shape, and by probing the interior of the Sun using the helioseismology method. In the last reporting period, among additional findings, the spacecraft observed a partial Sun eclipse and an unusual Sun-spot that extended eight times Earth's diameter.[153] On 6 June 2012, PICARD tracked the Venus transit of the Sun, and it also witnessed a solar eclipse on 13 November 2012. By January 2013, PICARD's SODISM instrument had acquired its millionth image; and on 3 November 2013, PICARD was able to photograph the second solar eclipse of 2013.[154]

The Solar Dynamics Observatory (SDO) is the first NASA mission to operate under its Living With a Star (LWS) programme. Launched on 11 February 2010, its objectives are to determine how the Sun's magnetic field is generated and structured, and how this stored magnetic energy is released in the form of the solar wind, energetic particles and variations in the solar irradiance. The spacecraft is comprised of three scientific experiments: the Atmospheric Imaging Assembly (AIA),

[148] "ESA Science Missions Continue in Overtime." 20 June 2013. ESA 1 Apr. 2014. http://sci.esa.int/director-desk/51944-esa-science-missions-continue-in-overtime/.

[149] "Small Sun-Watcher Proba-2 Offers Detailed View of Massive Solar Eruption." 9 June 2011. ESA 17 Apr. 2013. http://www.esa.int/Our_Activities/Technology/Small_Sun-watcher_Proba-2_offers_detailed_view_of_massive_solar_eruption.

[150] "ESA's Space Weather Station Proba-2 Tracks Stormy Sun." 2 Dec. 2011. ESA 17 Apr. 2013. http://www.esa.int/Our_Activities/Technology/ESA_s_space_weather_station_Proba-2_tracks_stormy_Sun.

[151] "About PROBA3." 19 Nov. 2012. ESA 1 Apr. 2014. http://www.esa.int/Our_Activities/Technology/Proba_Missions/About_Proba-3.

[152] "Proba-3 Mission will call on Satellites to Fly in Sub-Millimeter Precision." 17 Apr. 2013. Gizmag 1 Apr. 2014. http://www.gizmag.com/proba-3-satellite-mission/27124/.

[153] "PICARD NEWS." CNES 1 Apr. 2014. http://smsc.cnes.fr/PICARD/GP_actualites.htm.

[154] Ibid.

EUV Variability Experiment (EVE) and the Helioseismic and Magnetic Imager (HMI).[155] The SDO's global view of the Sun facilitates research that focuses on the previously unrecorded real fine structure of the star.[156] In August 2013, data from the HMI enabled scientists to show that, instead of a simple cycle of flow moving toward the poles near the sun's surface and then back to the equator, the writhing material inside the sun shows a double layer of circulation, with two such cycles on top of each, allowing for improved future predictions of the intensity of the next solar cycle.[157]

In June 2013, a NASA scientific balloon lifted the solar observatory mission SUNRISE from Kiruna, Sweden into Earth's atmosphere. Equipped with a one-metre mirror, SUNRISE is the largest solar telescope to fly above the atmosphere, drifting over the Atlantic Ocean for 5 days while gathering information about the Sun's chromosphere. SUNRISE provided the highest-resolution images to date in ultraviolet light of this thin corrugated layer, which lies between the sun's visible surface and the sun's outer atmosphere, the corona.[158] Initial findings show that the ultraviolet radiation from the chromosphere is highly suitable for visualizing detailed structures and processes.

The SOlar and Heliospheric Observatory (SOHO) continued to operate during this reporting period. As an international cooperation project between ESA and NASA, this EADS Astrium-*et al*—built spacecraft was launched on 2 December 1995. The spacecraft orbits around the Sun in step with the Earth, at a distance of 1.5 million kilometres from Earth, enabling an uninterrupted view of the star.[159] Its scientific objectives are to investigate the solar interior and explain the extreme heating of the solar corona and the mechanism by which the solar wind is produced and accelerated. Some of its key results include discovering new dynamic solar phenomena such as coronal waves and solar tornadoes, vastly improving our ability to forecast space weather by giving up to 3 days' notice of adverse space weather, and monitoring the total solar irradiance, which is important in understanding the impact of solar variability on the Earth's climate.[160] SOHO has helped to define

[155] "SDO | Solar Dynamics Observatory." NASA Goddard Space Flight Center 4 Mar. 2013. http://sdo.gsfc.nasa.gov/.

[156] SpaceNews Staff. "NASA Boasts Big Results from 5-minute Spaceflight." 28 Jan. 2013 SpaceNews 4 Mar. 2013. http://www.spacenews.com/article/nasa-boasts-big-results-from-5-minute-spaceflight.

[157] "NASA's SDO Mission Untangles Motion Inside the Sun." 28 Aug. 2013. NASA 1 Apr. 2014. http://www.nasa.gov/content/goddard/sdo-mission-untangles-motion-inside-sun/#.UzqOOvmSwj4.

[158] "SUNRISE Offers New Insight on Sun's Atmosphere." 27 Sept. 2013. NASA 1 Apr. 2014. http://www.nasa.gov/content/goddard/sunrise-offers-new-insight-on-suns-atmosphere/#.UzqORvmSwj4.

[159] About the SOHO Mission. "SOHO Fact Sheet." SOHO—Solar and Heliospheric Observatory 4 Mar. 2013. http://sohowww.nascom.nasa.gov/about/docs/SOHO_Fact_Sheet.pdf.

[160] "Solar and Heliospheric Observatory Homepage." NASA 25 Aug. 2011. http://sohowww.nascom.nasa.gov/.

what occurs during CMEs by providing simultaneous images of reactions on the sun and further out in the corona.[161] The SOHO mission has very significantly exceeded its expected lifetime of 2 years and on 19 June 2013, it was extended until 31 December 2016.[162]

In addition to SOHO, NASA's Solar TErrestrial RElations Observatory (STEREO) continued to operate. STEREO is made up of two space-based observatories, i.e. STEREO-A travelling in a smaller and faster orbit (ahead of Earth's orbit), and STEREO-B trailing behind with a larger and slower orbit; these spacecraft are now 180° apart relative to the Sun.[163] They provide new insights into CMEs, including detecting and processing data that enables the tracking of CMEs headed toward Earth. STEREO also benefits from crowd-sourced data analysis, using data analysed by the public to make predictions of solar storms that can reach Earth. It has captured the first-ever images of the entire surface of the Sun and has been used to discover more than 122 new eclipsing binary stars and hundreds more variable stars.[164]

NASA's Interface Region Imaging Spectrograph (IRIS) satellite was launched on 26 June 2013, with the purpose of observing how solar material moves, gathers energy and heats up as it travels through the Sun's lower atmosphere. In addition to being where most of the Sun's ultraviolet emission is generated, this region between the Sun's photosphere and corona, powers the Sun's million-degree atmosphere, and drives the solar wind. For its 2-year mission, IRIS will enter a sun-synchronous polar orbit, making continuous solar observations throughout this time.[165] By December 2013, the spacecraft had revealed that this interface region was more violent than previously had been understood, finding even more turbulence and complexity than expected, helping scientists to understand the way energy moves through the lower levels of the Sun's atmosphere to drive solar winds and heat the Sun's corona.[166]

The Deep Space Climate ObserVatoRy (DSCOVR), originally built to conduct observations of the Earth's climate will be re-purposed as a space weather and solar

[161] "Approaching 17 Years Of Observations For ESA/NASA's SOHO Spacecraft." 5 Dec. 2012. redOrbit 4 Mar. 2013. http://www.redorbit.com/news/space/1112742788/17-years-observations-esa-nasa-soho-spacecraft-120512/.

[162] "ESA Science Missions Continue in Overtime." 20 June 2013. ESA 27 Mar. 2014. http://sci.esa.int/director-desk/51944-esa-science-missions-continue-in-overtime/.

[163] "First Ever STEREO Images of the Entire Sun." 6 Feb. 2011. NASA 5 Mar. 2013. http://www.nasa.gov/mission_pages/stereo/news/entire-sun.html

[164] "NASA—STEREO." NASA 5 Mar. 2013. http://www.nasa.gov/mission_pages/stereo/main/index.html.

[165] "IRIS Solar Observatory Launches, Begins Mission." 28 June 2013. NASA 1 Apr. 2014. http://www.nasa.gov/content/iris-solar-observatory-launches-begins-mission/#.UzqYe_mSwj4.

[166] "IRIS Provides Unprecedented Images of Sun." 9 Dec. 2013. NASA 1 Apr. 2014. http://www.nasa.gov/content/iris-provides-unprecedented-images-of-sun/#.UzqYifmSwj4.

storm warning satellite,[167] to be launched early in 2015.[168] It is now designed to detect potentially Earth-threatening space weather that could harm electrical grids and communications systems, and disrupt air travel, satellites, and spaceflight. Its secondary mission has the spacecraft observe the Earth from the Sun-Earth Lagrange point 1 (where gravitational forces are in equilibrium), to measure ozone levels, cloud cover, vegetation changes, surface radiation, and atmospheric pollution.

The Hinode (Solar-B) probe, led by JAXA in collaboration with NASA, the Science and Technology Facilities Council (STFC, UK) and ESA, was launched in September 2006, with the mission of studying the solar magnetic field. The project explores the solar magnetic fields of the Sun to better understand the mechanisms that power the solar atmosphere and drive solar eruptions. The spacecraft's mission has been extended until 31 December 2016.[169] The Advanced Composition Explorer (ACE), a NASA mission launched in August 1997, with the primary science objective of measuring the composition of the solar corona, wind, interplanetary particles, the local interstellar medium and galactic matter, continued to collect data to improve forecasts and warnings of solar storms, and is expected to maintain its orbit until 2024.[170] The Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), a NASA SMall EXplorer (SMEX) mission with the objective of exploring the basic physics of particle acceleration and energy release in solar flares also continued to operate. By 22 Feb 2012, the spacecraft had undergone its third five-week anneal procedure to rejuvenate its detectors from the effects of radiation damage, and had resumed collecting solar X-ray and gamma-ray data.[171]

2.3.9 Outer Solar Science

Near-Earth Objects continue to be widely discussed as a target for human exploration, with renewed interest in the study of comets and asteroids. In addition to this

[167] Clark, Stephen. "Spaceflight Now | Breaking News | NOAA taps DSCOVR satellite for space weather mission." 2 Feb. 2011. Spaceflight Now 25 Aug. 2011. http://spaceflightnow.com/news/n1102/21dscovr/.

[168] "Long-Delayed Space Weather Satellite On Track for 2015 Launch." 13 Sept. 2013. Space.com 1 Apr. 2014. http://www.space.com/22740-mothballed-dscovr-satellite-2015-launch.html.

[169] "ESA Science Missions Continue in Overtime." 20 June 2013. ESA 27 Mar. 2014. http://sci.esa.int/director-desk/51944-esa-science-missions-continue-in-overtime/.

[170] "Advanced Composition Explorer (ACE) Mission Overview." California Institute of Technology 17 Apr. 2013. http://www.srl.caltech.edu/ACE/ace_mission.html.

[171] "RHESSI STATUS." 22 Feb. 2012. NASA 17 Apr. 2013. http://hesperia.gsfc.nasa.gov/rhessi2/home/news-ressources/status/.

topic, the following section covers some of the significant discoveries made about celestial bodies outside the Solar System.

Following Rosetta's successful flyby of the asteroid Lutetia on 10 July 2010, and its discovery that an object previously thought to be a comet is in fact a pair of colliding asteroids, the probe was put into hibernation while transiting in deep space on 8 June 2011. By August 2014, Rosetta will reach the comet 67P/Churyumov-Gerasimenko, and by November 2014, it will release a lander that will make the first landing on a comet's nucleus.[172]

The Herschel infrared telescope continued to make significant discoveries in this reporting period, making the first detection of water vapour in a molecular cloud on the verge of star formation, finding enough water vapour to fill Earth's oceans more than 2,000 times over in the L1544 system within the Taurus constellation.[173] Herschel has also allowed astronomers to accurately 'weigh' a star's disc in the constellation of Hydrae with ten-times higher accuracy than previous telescopes, providing more insight into the planet building process.[174] Herschel also detected a cool layer in the atmosphere of Alpha Centauri A, a finding not previously seen beyond our own Sun. The data will aid in understanding the Sun's activity, in addition to the discovery of proto-planetary systems around other stars.[175]

By November 2012, Herschel's counterpart the Planck microwave observatory, launched in May 2009 to study the Cosmic Microwave Background (CMB), made the first conclusive detection of a bridge of hot gas connecting a pair of galaxy clusters, Abell 399 and Abell 401, across 10 million light-years of intergalactic space. The early Universe is believed to have had filaments of gaseous matter that had formed as a giant cosmic web, wherein clusters eventually formed the web's densest nodes.[176] By March 2013, Planck had revealed the most detailed map ever created of the cosmic microwave background radiation of the Big Bang, showing tiny temperature fluctuations that correspond to regions of slightly different densities at very early times, eventually forming the stars and galaxies of today.[177] Planck data also set a new value for the rate at which the Universe is expanding,

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[172] "Wake Up, Rosetta!" 10 Dec. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Rosetta/Wake_up_Rosetta.

[173] "Large Water Reservoirs at the Dawn of Stellar Birth." 9 Oct. 2012. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Herschel/Large_water_reservoirs_at_the_dawn_of_stellar_birth.

[174] "Stars can be Late Parents." 30 Jan. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Stars_can_be_late_parents.

[175] "A Cool Discovery about the Sun's Next-Door Twin." 20 Feb. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/A_cool_discovery_about_the_Sun_s_next-door_twin.

[176] "Planck Spots Hot Gas Bridging Galaxy Cluster Pair." 20 Nov. 2012. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Planck/Planck_spots_hot_gas_bridging_galaxy_cluster_pair.

[177] "Planck Reveals an Almost Perfect Universe." 21 Mar. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Planck/Planck_reveals_an_almost_perfect_Universe.

measuring a significantly slower expansion, and implying that the age of the Universe is really 13.82 billion years, rather than the previous assessments of 13.772 billion years by NASA's Wilkinson Microwave Anisotrophy Probe (WMAP), and 11 billion years derived from globular clusters.[178] The mission ended on 23 October 2013 after 4.5 years of operation where it completed five full-sky surveys with both its Low Frequency Instrument (LFI) and High Frequency Instrument (HFI), with the spacecraft put into permanent hibernation. The HFI exhausted its liquid helium coolant in January 2012, whereas the LFI was able to operate until 3 October 2013 at higher temperatures, before being switched off shortly thereafter.[179]

The COnvection, ROtation and planetary Transits (COROT) space telescope operated by CNES probes the inner structure of stars using stellar seismology and is used to detect extrasolar planets. This astronomy mission, launched on 27 December 2006, announced the discovery of ten new planets at the beginning of this reporting period.[180] By December 2013, data from the satellite provided the first clear photometric signature of the granulation in stars beyond our Sun. After operating twice as long as originally planned, the COROT mission is scheduled to end in late spring 2014.[181] While in operation, the COROT mission was the first to discover a confirmed Earth-like exoplanet orbiting a star similar to the Sun, and has since revealed 32 planets, while 100 more await confirmation.[182]

On 4 November 2010, NASA's Extrasolar Planet Observations and characterisation/deep impact eXtended Investigation (EPOXI) flew past comet Hartley 2, returning images of the comet that provided new information on the role comets may have in planetary formation.[183] The spacecraft was supposed to observe comet ISON's visit in 2013, however due to a malfunction with the spacecraft, communication was lost on 8 August, with the mission being declared lost on 19 September 2013.[184]

Exoplanets are planets that orbit stars other than our solar system's Sun. NASA's Kepler space telescope mission was recently extended to 2016 with the continued aim of finding Earth-sized planets in the habitable zone of other solar-like

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[178] Redd, Nola Taylor. "How Old is the Universe?" 20 Dec. 2013. Space.com 26 Apr. 2014. http://www.space.com/24054-how-old-is-the-universe.html.

[179] "Last Command Sent to ESA's Planck Space Telescope." 23 Oct. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Planck/Last_command_sent_to_ESA_s_Planck_space_telescope.

[180] "CaRoT discovers 10 new extra-solar planets." 14 June 2011. CNES 17 Apr. 2013. http://smsc.cnes.fr/COROT/GP_actualite.htm.

[181] "Events." CNES 2 Apr. 2014. http://smsc.cnes.fr/COROT/GP_actualite.htm.

[182] "Mission Accomplished for CoRoT." 24 June 2013. CNES 2 Apr. 2014. http://smsc.cnes.fr/COROT/PDF/CP039-2013_mission_CoRoT_va.pdf.

[183] "SOHO Watches a Comet Fading Away." 28 Jul. 2011. NASA 17 Apr. 2013. http://www.nasa.gov/mission_pages/epoxi/index.html.

[184] "Mission Status Report." NASA 2 Apr. 2014. http://epoxi.umd.edu/1mission/status.shtml.

oscillating stars, where liquid water could exist on their surfaces.[185] In August 2012, Kepler-47b and 47c were discovered to be the first transiting circumbinary system, i.e. multiple planets orbiting two stars, with one of those planets existing in the binary system's habitable zone.[186] Data from Kepler was also used to identify a four-star planetary system, the first known solar system of its kind.[187] It has also discovered a new planetary system that is home to Kepler-37b, the smallest planet yet found around a star like our Sun, in the constellation Lyra.[188] And through the use of Kepler and Spitzer space telescope data, astronomers have created the first cloud map of a giant gaseous planet known as Kepler-7b.[189] Kepler-78b was determined to be the first Earth-sized planet with a Measured Earth mass.[190] After losing two of its four reaction wheels in May 2013, resulting in the spacecraft losing its ability to precisely point at the original field of view, plans are underway to recover stability in the spacecraft using the Sun to maintain stability, under the designation Kepler 2; in December 2013, the mission concept was invited to the 2014 Senior Review at NASA.[191]

NASA's Wide-field Infrared Survey Explorer (WISE) mission completed its survey early in 2011, scanning the whole sky twice in infrared light. Capturing millions of images in that time, some of the most recent findings in 2012 and 2013 revealed 2.5 million super-massive black hole candidates in the universe, and 1,000 of the brightest infrared light emitting galaxies ever found, normally obscured by dust that blocks their visible light. While normally hidden, black hole activity warms the dust, causing it to glow in infrared light.[192] Moreover, WISE discovered a binary system of brown dwarfs at a distance of 6.5 light-years—taking the title as

[185] "NASA Approves Kepler Mission Extension." 4 Apr. 2012. NASA 16 Apr. 2013. http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=199.

[186] "Kepler-47: Our First Binary Star 2-Planet System." 28 Aug. 2012. NASA 2 Apr. 2014. http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=228.

[187] "Planet Hunters Find Circumbinary Planet in 4-Star System." 16 Oct. 2012. NASA 2 Apr. 2014. http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=233.

[188] "Discovery: Kepler-37b, a Planet Only Slightly Larger than the Moon." 20 Feb. 2013. NASA 2 Apr. 2014. http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=256.

[189] "NASA Space Telescopes Find Patchy Clouds on Exotic World." 30 Sept. 2013. NASA 3 Apr. 2014. http://www.spitzer.caltech.edu/news/1564-ssc2013-08-NASA-Space-Telescopes-Find-Patchy-Clouds-on-Exotic-World.

[190] "Kepler-78b: First Earth-Size Planet with Measured Earth-Mass." 30 Oct. 2013. NASA 2 Apr. 2014. http://kepler.nasa.gov/news/nasakeplernews/index.cfm?FuseAction=ShowNews&NewsID=308.

[191] "NASA STATEMENT: Two-Wheel Kepler Mission Invited to 2014 Senior Review." 4 Dec. 2013. National Aeronautics and Aerospace Administration 2 Apr. 2014. http://www.nasa.gov/kepler/nasa-statement-two-wheel-kepler-mission-invited-to-2014-senior-review/.

[192] "NASA's WISE Survey Uncovers Millions of Black Holes." 29 Aug. 2012. NASA 3 Apr. 2014. http://www.nasa.gov/mission_pages/WISE/news/wise20120829.html.

the third closest star system to the Sun.[193] Although the spacecraft was placed into hibernation in February 2011, following the completion of its mission, it was reactivated in September 2013 for three more years of service with the goal of discovering and characterizing near-Earth objects (NEOs) with infrared light.[194] On 29 December 2013, this 'NEOWISE' mission detected the near-Earth asteroid '2013 YP139', found orbiting within 45 million km of Earth's path around the Sun.[195]

After running out of the coolant needed to chill its longer-wavelength instruments in 2009, NASA's Spitzer Space Telescope was repurposed to track exoplanets around other stars with the use of infrared light. As exoplanets cross in-front of their stars, they block out a fraction of the light, allowing the size of the planet to be revealed, in addition to giving clues about the planet's atmosphere by the infrared light that they also emit.[196] Spitzer has already observed infrared light emanating from a "super-Earth" planet in another solar system[197] and observed an unprecedented simultaneous elliptical galaxy with another thin disk existing in its interior.[198] And at the beginning of 2013, with the use of NASA's Spitzer and ESA's Herschel Space Observatory, a large asteroid belt was discovered around the star Vega.[199]

In July 2012, data from NASA's Hubble Space Telescope revealed the fifth known moon to orbit Pluto.[200] Hubble also discovered a new moon orbiting Neptune in July 2013, which is estimated to be less than 20 km in diameter.[201] It has also discovered the most distant galaxy to be found yet, with light that began

[193] "Closest Star System Found in a Century." 11 Mar. 2013. NASA 3 Apr. 2014. http://www.nasa.gov/mission_pages/WISE/news/wise20130311.html.

[194] "NASA Spacecraft Reactivated to Hunt for Asteroids." 21 Aug. 2013. NASA 2 Apr. 2014. http://www.jpl.nasa.gov/news/news.php?release=2013-257.

[195] "NEOWISE: The Wide-Field Infrared Survey Explorer (WISE)." NASA 2 Apr. 2014. http://neo.jpl.nasa.gov/programs/neowise.html.

[196] "How Engineers Revamped Spitzer to Probe Exoplanets." 24 Sept. 2013. NASA 3 Apr. 2014. http://www.spitzer.caltech.edu/news/1560-feature13-07-How-Engineers-Revamped-Spitzer-to-Probe-Exoplanets.

[197] "NASA's Spitzer Sees The Light of Alien 'Super Earth'." 8 May 2012 NASA 16 Apr. 2013. http://www.spitzer.caltech.edu/news/1419-ssc2012-07-NASA-s-Spitzer-Sees-The-Light-of-Alien-Super-Earth-.

[198] "NASA's Spitzer Finds Galaxy with Split Personality." 24 Apr. 2012. NASA 16 Apr. 2013. http://www.spitzer.caltech.edu/news/1412-ssc2012-06-NASA-S-Spitzer-Finds-Galaxy-with-Split-Personality.

[199] "NASA, ESA Telescopes Find Evidence For Asteroid Belt Around Vega." 8 Jan. 2013. NASA 3 Apr. 2014. http://www.spitzer.caltech.edu/news/1497-ssc2013-02-NASA-ESA-Telescopes-Find-Evidence-For-Asteroid-Belt-Around-Vega.

[200] "Hubble Discovers a Fifth Moon Orbiting Pluto." 11 July 2012. Hubble Site 3 Apr. 2014. http://hubblesite.org/newscenter/archive/releases/2012/2012/32/full/.

[201] "NASA Hubble Finds New Neptune Moon." 15 July 2013. NASA 3 Apr. 2014. http://www.nasa.gov/press/2013/July/nasa-hubble-finds-new-neptune-moon/.

700 million years after the Big Bang.[202] Hubble has also found faint signatures of water in the atmospheres of five distant planets,[203] in addition to observing water vapour above the south polar region of Jupiter's moon Europa, strongly suggesting that the vapour is generated by water plumes that erupted off Europa's surface.[204]

The James Webb Space Telescope (JWST), the successor to the Hubble Space Telescope (HST), survived the broad US budget cuts that threatened to derail the spacecraft from its planned 2018 Ariane 5 launch date. The spacecraft will investigate the formation of the first galaxies, planetary systems, and stars. Segments of the large primary mirror already underwent cryogenic testing throughout 2011.[205] And on 9 May 2012, NASA received the JWST's first completed instrument—the highly light-sensitive European-built Mid-Infrared Instrument (MIRI).[206] On 18 December 2013, the final three of 18 primary hexagonal mirror segments for the JWST arrived at NASA's Goddard Space Flight Center for integration prior to its launch. When in orbit, these hexagonal mirrors will fit together to form one unprecedented 6.5 m primary mirror, with the telescope stationed 1.5 million km from Earth, to be able to detect light from the first galaxies ever formed and observe planets in distant galaxies.[207]

2.4 Satellite Applications

2.4.1 Space-Based Communications

In 2012 and 2013, the satellite services industry continued to advance amid tepid global financial conditions. Yet while growth was positive, its rate diminished from 16 % in 2008 to 5 % in both 2012 and 2013. The growth can be credited to the industry's inherently global nature, allowing it to tap into the potential of emerging markets that had weathered the previous crisis with greater resilience. The industry continued to expand its technology development programmes with additional

[202] Texas Astronomer Discovers Most Distant Known Galaxy." 23 Oct. 2013. McDonald Observatory 3 Apr. 2014. http://mcdonaldobservatory.org/news/releases/2013/10/23.

[203] Hubble Traces Subtle Signals of Water on Hazy Worlds." 3 Dec. 2013. NASA 3 Apr. 2014. http://www.nasa.gov/press/2013/December/hubble-traces-subtle-signals-of-water-on-hazy-worlds/.

[204] "Hubble Space Telescope Sees Evidence of Water Vapor Venting off Jovian Moon." 12 Dec. 2013. NASA 3 Apr. 2014. http://www.nasa.gov/press/2013/December/hubble-space-telescope-sees-evidence-of-water-vapor-venting-off-jovian-moon/.

[205] "The James Webb Space Telescope." NASA 25 Aug. 2011. http://www.jwst.nasa.gov/.

[206] SpaceNews Staff. "First JWST Instrument Handed Over to NASA." 14 May 2012. SpaceNews 15 Apr. 2013. http://www.spacenews.com/article/first-jwst-instrument-handed-over-nasa.

[207] "Final James Webb Space Telescope Mirrors Arrive at NASA." 18 Dec. 2013. NASA 3 Apr. 2014. http://www.nasa.gov/content/goddard/final-james-webb-space-telescope-mirrors-arrive-at-nasa/.

investments in larger spacecraft with enhanced power and transponder capacity. Moreover, the industry exhibited the right mixture of investing in innovative technologies and new services while consolidating current operations, which boosted the industry's revenue for both reporting years.[208]

On radio frequency spectrum allocation, the ITU's World Radiocommunication Conference (WRC-15) is scheduled for 2015 and commercial satellite fleet operators have already begun preparing their defences, following their previous experience at WRC-07 when they struggled to prevent a raid on their C-band frequency allocations by terrestrial service providers. At the WRC-07, regulators agreed that the 3.4- to 4.2-GHz C-band frequencies should remain a priority allocation for satellite transmissions. Yet they also agreed that each nation could opt out of the agreement, and allocate these frequencies as it wished in its own territory (so long as resulting terrestrial wireless broadcasts did not interfere with satellite transmissions in a neighbouring country). Yet in practice, especially in the developing world, the decision by some nations to allow terrestrial wireless broadband services to operate more freely in C-band has produced multiple examples of satellite signals being wiped out. Now steps are being taken to coordinate with regional satellite broadcasting groups to try to develop a consensus position.[209]

2.4.2 *Space-Based Positioning, Navigation and Timing Systems*

The development of GNSS systems continued during this period, with the relevant actors increasing their efforts to complete their full satellite constellations.

Russia's Glonass GNSS constellation was still being restored at the end of 2013, following the successful launch of one GLONASS-M satellite on a Soyuz launcher, and the launch failure of a Proton-M carrying three GLONASS-M satellites. Next-generation model GLONASS-K satellites will succeed the GLONASS-M model of which 24 were operational as of 26 April 2013, with additional spacecraft in production.[210] The new spacecraft will most likely incorporate significant technical improvements, including a new more accurate timing device and a non-pressurised structure, bringing operational performance close to US and European standards.

[208] See generally State of the Satellite Industry Report—October 2013.

[209] De Selding, Peter. "Another C-band Challlenge Expected at Upcoming Global Spectrum Conference." 15 Mar. 2013. SpaceNews 18 May 2014. http://www.spacenews.com/article/satellite-telecom/34362another-c-band-challenge-expected-at-upcoming-global-spectrum.

[210] Clark, Stephen. "Third Soyuz launch in a week bolsters Glonass system." 26 Apr. 2013. Spaceflight Now 19 May 2014. http://www.spaceflightnow.com/news/n1304/26soyuz/.

The constellation requires 24 operational satellites to provide complete global navigation coverage, with 3 sets of 8 satellites operating on three orbital planes.[211]

In Europe, following the milestone launches of the first two Galileo GNSS in-orbit validation (IOV) satellites on 21 October 2011 aboard a Europeanised Soyuz rocket launched from the Kourou, French Guiana, and an additional pair launched the next year on 12 October 2012, the IOV phase was another milestone determining the first position fix of longitude, latitude and altitude conducted on 12 March 2013, with an accuracy of 10–15 m. The 30-satellite constellation (27 operational and 3 spare) is expected to be completed by 2019.[212]

On 20 September 2012, in a summit between the EU and China in Brussels, Belgium, the two sides agreed to take their dispute over satellite navigation frequencies to the International Telecommunication Union (ITU) in December 2012.[213] The EU and China had been debating the issue of navigation signal conflicts for over 2 years without success in resolving the issue. While the ITU regulates satellite orbital slots and frequencies, its mandate does not extend to resolving issues such as that between Europe's Galileo and China's Beidou system. While the ITU was willing to provide a forum for discussions, it can do little given that Galileo and Beidou do not interfere with each other's operations. However, both sides see their overlapping frequency issue to be a problem, since China's Beidou system is designed to use a portion of radio spectrum that overlaps the Galileo frequencies the EU wants for its encrypted Public Regulated Service (both reserved for government and military use). If either the EU or China wanted to disable the other's secure signals in a time of conflict, due to the shared frequencies, they would be at risk of knocking out their own service as well.[214]

In late December 2012, China began fielding its regional satellite navigation capability offering services including positioning, navigation, time and text messaging to users in the Asia-Pacific region;[215] it plans to complete the deployment of its entire 35 satellite Beidou GNSS constellation by 2020. In light of that expedited development, Japan also began its development of the Quasi-Zenith Satellite System (QZSS), the country's future regional satellite navigation constellation. Following the first QZSS satellite launched in September 2010, the program slowed

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[211] "Glonass System." Glonass.it 12 May 2012. http://www.glonass.it/eng/glonass-story.aspx.

[212] "Galileo: Satellite launches." 17 Jan. 2014. European Commission 18 May 2014. http://ec.europa.eu/enterprise/policies/satnav/galileo/satellite-launches/index_en.htm.

[213] De Selding, Peter. "China and Europe Taking Their Navigation Dispute to ITU." 8 Oct. 2012. SpaceNews 18 May 2014. http://www.spacenews.com/article/china-and-europe-taking-their-navigation-dispute-itu.

[214] De Selding, Peter. "EU, China Schedule Talks To Resolve Navigation Dispute." 15 Oct. 2012. SpaceNews 18 May 2014. http://www.spacenews.com/article/eu-china-schedule-talks-resolve-navigation-dispute.

[215] Associated Press. "China Satellite Navigation Starts Services to Asia." 27 Dec. 2012. SpaceNews 18 May 2014. http://www.spacenews.com/article/china-satellite-navigation-starts-services-to-asia.

due to unwillingness by the private sector to manage QZSS as a business without substantial government guarantees. In 29 March 2013, Mitsubishi Electric Co. was contracted to construct 3 additional QZSS satellites, i.e. one GEO satellite and two spacecraft following highly elliptical orbits, to complete the QZSS space architecture by 2017.[216] The QZSS system is designed to augment the regional accuracy of the GPS signal. The system scheme will provide Japanese authorities with a more accurate, secure and independent service. The future deployment of four spacecraft will allow for 24 h regional coverage, while deployment of the full seven satellite constellation will dramatically decrease Japan's dependence on GPS for regional coverage.[217]

On 2 July 2013, India also took a major stride in its regional navigation system launching its first dedicated navigation satellite, IRNSS-1A, into orbit. The first of 7 satellites, this autonomous regional system will consist of a ground segment, along with 3 IRNSS satellites in geostationary orbit and 4 satellites in inclined geosynchronous orbits. The system is expected to be completed be completed in 2015.[218]

2.5 Technology Developments

The new developments in space-related technologies merit discussion, as they indicate current trends in space technology and reveal the focus of relevant policy decisions. The following chapter provides an overview of recent activities, spanning all major space faring powers and institutions, both established and emerging ones.

2.5.1 Propulsion

Significant advancements have occurred within Europe and the US in the field of propulsion. Newly developed rockets and other methods of propulsion are being explored with favourable results.

In Europe, the Italian-led Vega small-satellite launcher made its successful inaugural launch on 13 February 2012. The Vega programme, approved by ESA

[216] De Selding, Peter. "Melco To Build Three QZSS Navigation Satellites." 3 Apr. 2013. SpaceNews 19 May 2014. http://www.spacenews.com/article/civil-space/34676melco-to-build-three-qzss-navigation-satellites.

[217] Kallender-Umezu, Paul. "Japan Commits To Deploying Satellite Navigation System by 2020." Space News 17 Oct. 2011: 14.

[218] "India's first ever dedicated navigation satellite launched." 2 July 2013. DNAindia.com 30 May 2014. http://www.dnaindia.com/scitech/report-indias-first-ever-dedicated-navigation-satellite-launched-1855830.

in 1998, spent 9 years developing the launcher at a cost of 710 million Euros.[219] Vega is a single body launcher with three solid propulsion stages and an additional liquid propulsion upper module used for attitude and orbit control, and satellite release. The launcher is capable of placing a 1,500 kg satellite in a 700 km low Earth orbit.[220]

ISRO's Geo-synchronous Satellite Launch Vehicle (GSLV-D5) is about to return to the launch platform, this time featuring an indigenous cryogenic engine in its third, final stage. It was planned to launch the GSLV-D5 on 19 August 2013, but this was aborted due to a leak in the rocket's second stage, which rained liquid fuel down the launcher, causing it to engulf in flames. The leak was due to the type of aluminium alloy used in the fuel tank, Afnor 7020, which was said to develop cracks over time. The GSLV-D5 has been refurbished since the incident, with a new second stage with its propellant tank made of aluminium alloy 2219.[221] If successful, this launcher will give India the capability to launch heavier satellites in the 2,000-plus kilogramme category into geosynchronous orbit, and launch interplanetary (or even lunar) spacecraft, while having been developed within ISRO's limited budget of around $1 billion per year.[222]

In the US, Pratt & Whitney Rocketdyne (PWR) began test-firing its J-2X upper-stage rocket engine in mid-July. The liquid propellant rocket engine maker is building nine J-2X engines: seven for development tests and two for certification tests.[223] The engine, previously envisioned as the upper stage engine for the Ares 5 rocket to be used in the cancelled constellation programme, is now the upper stage of the heavy-lift US Space Launch System. However, upon completion of development testing in 2014, the engine with be shelved for several years before it is needed to launch humans to Mars. For precursor missions to the Moon, the all-cryogenic J-2X is somewhat over-powered, with the ability to lift a 130 metric ton SLS to LEO, whereas missions to the Moon simply need to lift a 105 tons SLS. Until NASA tests for a Mars mission, it will likely rely on the use of three or four RL-10 engines that could produce the dialled-back amount of force needed for lunar precursor missions.[224]

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[219] De Selding, Peter. "Europe's Italian-led Vega Rocket Succeeds in Debut." SpaceNews 20 Feb. 2012: 10.

[220] Launch Vehicles—Vega. 30 Oct. 2012. ESA 8 Mar. 2013. http://www.esa.int/Our_Activities/Launchers/Launch_vehicles/Vega.

[221] "GSLV-D5 to Lift off on January 5." 22 Dec. 2013. The Hindu 9 Apr. 2013. http://www.thehindu.com/news/national/gslvd5-to-lift-off-on-January-5/article5487536.ece.

[222] "Cheaper Space Travel Technology." 11 Nov. 2013. Dawn.com 9 Apr. 2014. http://www.dawn.com/news/1055599/cheaper-space-travel-technology.

[223] SpaceNews Staff. "J-2X Engine Test Fired at NASA Stennis Space Center." SpaceNews 1 Aug. 2011: 9.

[224] "NASA's J-2X Engine To Be Mothballed After Testing." 4 Oct. 2013. Aviation Week 9 Apr. 2014. http://aviationweek.com/awin/nasa-s-j-2x-engine-be-mothballed-after-testing.

Space Exploration Technologies' (SpaceX) Falcon 9 launcher is the only currently operating launch vehicle that has engine out capability, able to lose 2 of its 9 Merlin engines in its first stage and still complete its mission.[225] In March 2013, SpaceX achieved flight qualification for its next generation Merlin-D engine, having accumulated a total test time of nearly 33 min, the equivalent of over 10 full mission durations.[226] The engine's 150 vacuum thrust-to-weight ratio, and enhanced design for improved manufacturability, makes it one of the most efficient booster engines ever built. Integrated on the upgraded Falcon 9 v1.1 launcher, the engines replaced the previous Merlin 1C engines and require a 60 % increase in the size of the rocket's propellant tanks; the Falcon 9 v1.1 had its debut launch on 29 September 2013.[227]

SpaceX developed a launch escape system engine to be used when eventually flying astronauts in its Dragon capsule to the International Space Station. The engine is an advanced version of the Draco engines that the Dragon uses to manoeuvre while in orbit and on re-entry. In the event of an emergency, at any stage in the launch, these "SuperDraco" engines can lift the astronauts' capsule out of danger with precise control, and can be restarted multiple times as needed.[228] The SuperDraco engines are built into the Dragon's side walls, and the 8 engines will produce up to 120,000 lb of axial thrust.[229] While the propellant used in its hypergolic engines spontaneously ignites when coming in contact with an oxidizer; hypergolic propellants tend to be corrosive and/or extremely toxic to handle.

By the end of 2013, XCOR Aerospace and ULA had advanced substantially in their liquid hydrogen (LH2) engine development programme. Building on their earlier success with liquid oxygen and kerosene pumps, the group overcame the technical challenges presented with the extreme low temperature and small molecule size of liquid hydrogen to develop and successfully operate the engine's liquid hydrogen pump at full design flow rate and pressure conditions—opening the way for integrated testing of the LH2 demonstrator engine.[230] On 19 November 2013, the programme conducted the first successful hot fire of the subscale 2,500 lbf thrust XR-5H25 engine in the XCOR and ULA liquid hydrogen (LH2) engine

[225] "Merlin Engines." 29 July 2013. SpaceX 10 Apr. 2014. http://www.spacex.com/news/2013/03/26/merlin-engines.

[226] "SpaceX's Merlin 1D Engine Achieves Flight Qualification." 20 Mar. 2013. SpaceX 10 Apr. 2014. http://www.spacex.com/press/2013/04/13/spacexs-merlin-1d-engine-achieves-flight-qualification.

[227] "Upgraded Falcon 9 Mission Overview." 14 October 2013. SpaceX 9 Apr. 2014. http://www.spacex.com/news/2013/10/14/upgraded-falcon-9-mission-overview.

[228] "Draco Thrusters." 13 Apr. 2013. SpaceX 15 Apr. 2014. http://www.spacex.com/news/2013/04/04/draco-thrusters.

[229] SpaceNews Staff. "SpaceX Test Fires SuperDraco Engine for Dragon Launch Escape System." SpaceNews 6 Feb. 2012: 9.

[230] "XCOR Aerospace and United Launch Alliance Announce Important Milestone in Liquid Hydrogen Engine Program." 23 Sept. 2013. XCOR Aerospace 14 Apr. 2014. http://www.xcor.com/press/2013/13-09-23_XCOR_ULA_announce_hydrogen_engine_milestone.html.

development programme.[231] The LH2 engine program is intended to produce a flight-ready cryogenic upper-stage engine in the 25,000 lbf thrust class with growth potential up to 50,000 lbf thrust or more, which should result in much lower cost and more capable commercial and government launch capabilities.

Reaction Engines is developing the Synergistic Air-Breathing Rocket Engine (Sabre) to power a planned single-stage-to-orbit (SSTO) spaceship, Skylon, as a part chemical rocket and part jet engine. Sabre will have the ability to use oxygen in airspace rather than from external liquid-oxygen tanks, and will eliminate the need for expendable boosters. When travelling at speeds of up to Mach 5.2, the super-heated air travelling through the engine is rapidly cooled to -150 °C, and then channelled through the engine's turbo-compressor, and into the thrust chambers, to be mixed with liquid hydrogen and ignited to produce thrust for the spacecraft.[232] ESA and the British government have invested a combined $92 million in the project, however completion of the engine will require an additional investment of $3.6 billion before it could be ready for flight tests. The Skylon itself would require a $14 billion investment.

NASA's Evolutionary Xenon Thruster (NEXT) Project has been operating for over 5.5 years, making it the longest space propulsion system demonstration project in history. The engine uses electricity generated by the spacecraft's solar panel to accelerate the xenon propellant to speeds reaching about 144,800 km/h. In an endurance test, the engine displayed a dramatic improvement in performance compared to conventional chemical rocket engines, consuming about 870 kg of xenon propellant to generate a total impulse that would require more than 10,000 kg of conventional rocket propellant for comparable applications.[233] The 7-kW class thruster could be used in a wide range of science missions, including missions in deep space.

Another strong potential propulsion system, in development for more than 25 years, is the Variable Specific Impulse Magnetoplasma Rocket (VASIMR). The VASIMR heats plasma to extreme temperatures using radio waves, which is then funnelled to the back of the engine with the use of strong magnetic fields, creating thrust. Plans are now underway to flight test a 200 kW variant of the

[231] "Hot Fire: XCOR Aerospace and United Launch Alliance Achieve Major Propulsion Milestone in Liquid Hydrogen Engine Program." 19 Nov. 2013. XCOR Aerospace 11 Apr. 2014. http://www.xcor.com/press/2013/13-11-19_XCOR_ULA_announce_hydrogen_milestone.html.

[232] "The Next Space Shuttle: Hybrid Engines Make Runway-To-Orbit Missions A Reality." 10 Sept. 2013. Popular Science 15 Apr. 2014. http://www.popsci.com/technology/article/2013-08/runway-orbit-and-back.

[233] "NASA Thruster Achieves World-Record 5+ Years of Operation." 24 June 2013. NASA 10 Apr. 2014. http://www.nasa.gov/home/hqnews/2013/jun/HQ_13-193_Ion_Thruster_Record.html.

VASIMR on the ISS as part of an electric-propulsion package on a commercial test bed that will operate as part of the station in the next few years. In addition to re-boosting space stations, the VASIMR could be used as a propulsion source in cleaning up space junk and powering superfast journeys that could reach Mars in less than 2 months.[234]

When selecting fuel for satellite propulsion, hydrazine with its highly energetic albeit equally toxic qualities has been the monopropellant of choice for over half a century. That may come to an end in the near future with the development of green propulsion fuel sources, and with the addition of hydrazine to the candidate list of "substances of very high concern" in the European Commission's Registration of Evaluation Authorization and Restriction of Chemicals (REACH) framework legislation in 2011. While some exemptions might be needed in the use of hydrazine for space, ESA is seeking industrial bids to study how propulsion system hardware might best be requalified to work with a less toxic 'green' propellant alternative as a replacement for hydrazine and other high toxicity propellants along with associated hardware. In ESA's pursuit, Sweden's ECAPS division of the Swedish Space Corporation Group (SSCG), with its High Performance Green Propulsion (HPGP) Ammonium DiNitramide (ADN)-based monopropellant designated 'LMP-103S', is considered to be most mature propellant option to serve as a hydrazine replacement.[235]

NASA is also evaluating alternative green propulsion technology, and has established a cooperative agreement with the Swedish National Space Board (SNSB) to test ECAPS' HPGP technology in the US. NASA will test and evaluate the 5-N and 22-N HPGP thrusters developed by ECAPS. LMP-103S is environmentally benign and significantly easier to transport and handle than hydrazine, while still being fully compatible with all of the traditional structural materials and commercial off-the-shelf (COTS) fluid control components that are typically implemented within hydrazine in-space propulsion system designs. In furtherance of the NASA-SNSB cooperative agreement, SNSB has contracted with ECAPS to mature both the 5 N and 22 N thrusters to Technology Readiness Level (TRL) 6, for demonstration purposes.[236]

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[234] "High-Tech VASIMR Rocket Engine Could Tackle Mars Trips, Space Junk and More." 19 Nov. 2013. Space.com 10 Apr. 2014. http://www.space.com/23613-advanced-space-propulsion-vasimr-engine.html.

[235] "Considering Hydrazine-Free Satellite Propulsion." 14 Nov. 2013. Product Design & Development 16 Apr. 2014. http://www.pddnet.com/news/2013/11/considering-hydrazine-free-satellite-propulsion.

[236] "NASA to Test and Evaluate ECAPS Green Propulsion Technology." 30 Oct. 2013. SCC Space 10 Apr. 2014. http://www.sscspace.com/nasa-to-test-and-evaluate-ecaps-green-propulsion-technology.

In the US, Ball Aerospace & Technologies and other members of the Green Propellant Infusion Mission (GPIM) project are developing a green propellant demonstrator for NASA's Technology Demonstration Mission (TDM). To be integrated as a subsystem on a Ball BCP-100 spacecraft bus designed for easy integration of "ride-share" payloads, this mission will be the first time the US will use a spacecraft to test green propellant technology.[237] The propellant is a hydroxyl ammonium nitrate fuel/oxidizer blend known as AF-M315E, which offers nearly 50 % better performance than traditional hydrazine fuel, in addition to reducing the environmental impact during propellant loading, potentially increasing payload capacity, enhancing spacecraft manoeuvrability, and extending mission durations. On 20 September 2013, the GPIM project team achieved milestone when it was granted a successful Preliminary Design Review by NASA.

Innovative Space Propulsion Systems (ISPS) is also developing rocket engines that run on an environmentally benign propellant, "NOFBX". SpaceX now expects to fly the thruster test bed, 'ISPS NOFBX Green Propellant Demonstration', to the ISS sometime after 2013 for an up to 1-year placement on the European Columbus module, where it will undergo a series of in-space performance validation tests.[238] Developed in partnership by Odyssey Space Research and Firestar Technologies, NOFBX is a high-performance nitrous oxide/fuel/emulsifier blended monopropellant that is non-toxic, low cost and easy to produce.[239] Capable of production from widely available chemicals, the fuel can be transported without excessive precautions.[240] In fact, NOFBX surpasses solid and bipropellants in many characteristics.[241] Also, due to its superior performance among competitors, NOFBX technology has been selected for development for low cost next generation tactical launch systems like DARPA's Airborne Launch Assist Space Access (ALASA) programme.[242]

And while many telecommunications satellites have relied on electric propulsion to maintain steady orbit in the last decade, a new trend involves the use of electric thrusters to carry the satellite from transfer orbit to final geostationary position. In

[237] "Green Propellant Team Propels Itself Through Preliminary Design Review." 20 Sept. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/mission_pages/tdm/green/green-propellant-preliminary-review.html.

[238] SpaceNews Staff. "ISS-bound Propellant Demo Passes NASA Safety Review." SpaceNews 28 May 2012: 9.

[239] "Current Projects: Nitrous Oxide Fuel Blend (NOFBX)." Paragon 1 May 2014. http://www.paragonsdc.com/index.php?action=viewPost&postID=50.

[240] Messier, Doug. "A Non-Toxic Fuel From the Mojave Desert." 9 Aug. 2011. Parabolic Arc 8 Mar. 2013. http://www.parabolicarc.com/2011/08/09/a-non-toxic-fuel-from-the-mojave-desert/.

[241] Mungas, Greg. "NOFBX® Monopropulsion Overview." 14th Annual FAA Commercial Space Transportation Conference 9 Feb. 2011. https://www.aiaa.org/uploadedFiles/About-AIAA/Press_Room/Key_Speeches-Reports-and-Presentations/Greg_Mungas.pdf.

[242] "Stu Witt's Prepared Remarks to Congress on Commercial Space." 21 Nov. 2013. Parabolic Arc 16 Apr. 2014. http://www.parabolicarc.com/2013/11/21/stu-witts-prepared-remarks-congress-commercial-space/.

order to obtain a significant reduction in weight at launch, Boeing's ABS and Satmex satellites will carry between 300 and 350 kg of xenon propellant for the electric thrusters, rather than use 2,000 kg of conventional fuel, as used with comparable satellites. Its 25 cm xenon-ion propulsion systems are installed on 18 larger satellites that are already in orbit, while subsequent systems will be upgraded with more fuel capacity. However, a downside in relying on electric thrusters stems from the extended time delay in getting a satellite into its final orbital position.[243] Nevertheless, the European Space Agency has also pursued electric propulsion in recent years, with missions including ESA's Smart satellite, and its Artemis technology demonstration satellite. And Astrium Satellites has electric thrusters on six commercial telecommunications satellites, purely for orbit maintenance.[244]

2.5.2 Information Technology

While the Ka-band radio-frequency allows higher bandwidth transfer in satellite communications, interest in the Ka-band spectrum has increased among terrestrial wireless broadband cellular network providers, wanting to expand their spectrum in the 30/20 GHz Ka-band range for their 5G terrestrial mobile systems. In this pursuit, the terrestrial wireless broadband industry, which competed with the satellite sector in 2007 over the use of C-band, is preparing to fight for new spectrum in the Ka-band at the World Radiocommunication Conference in 2015 (WRC-15), organised by the International Telecommunication Union (ITU). Should it be successful, Ka-band frequencies that now are reserved for satellite systems will be forced to share spectrum with terrestrial wireless operators. By the end of 2013, most of the 17 high-throughput satellites already in orbit used Ka-band, and another 30 satellites were scheduled for launch by 2022; while the revenue from these broadband satellites, which is expected to be less than $500 million in 2013, is expected to surpass $3 billion within 10 years. If spectrum is allowed to be shared, the satellite industry might find its services routinely violated in certain regions of the world, with broadband wireless networks causing interference with Ka-band satellite signals that in some nations are the main form of satellite communications.[245]

[243] De Selding, Peter. "ABS, Satmex Banding Together for Boeing Satellite Buy 13 Mar. 2012. SpaceNews 8 Mar. 2013. http://www.spacenews.com/article/abs-satmex-banding-together-boeing-satellite-buy.

[244] De Selding, Peter. "Europeans Vow To Check Boeing Advantage in All-electric Sats." SpaceNews 14 May 2012: 4.

[245] "News from the High-Throughput Satellites London Roundtable | Terrestrial Operators Eyeing Ka-band Satellite Spectrum." 5 Dec. 2013. SpaceNews 10 Apr. 2014. http://www.spacenews.com/article/satellite-telecom/38517news-from-the-high-throughput-satellites-london-roundtable.

Inmarsat's first Global Xpress system satellite, Inmarsat-5, was launched on 8 December 2013, marking the beginning of the world's first globally available high-speed mobile broadband service for government and commercial users. With four satellites planned to be built by Boeing, the Inmarsat-5 satellite series will provide global mobile broadband communications for vessels at sea, in-flight connectivity on commercial aircraft, among other services.[246] Boeing is also building the Intelsat EpicNG high-throughput satellite, Intelsat 29e, to provide three to five times more capacity per satellite than Intelsat's traditional fleet.[247] By May 2013, four more Epic high-throughput satellites had been ordered from Boeing, with the Intelsat 29e expected to launch in 2015, while the other four will be launched on a yearly basis starting in 2016.[248]

2.5.3 Spacecraft Operations and Design

In Europe, the European Space Agency's (ESA) Rosetta comet chasing spacecraft had to be put into hibernation for a period lasting 2.5 years on 8 June 2011. Now switched off and placed into an unprecedented 90 s rotation, the satellite's two 14-m-long solar arrays produce about 500 W of power to keep the thermal-control system and the on-board computer functioning as the spacecraft journeys to a point some 790 million km from the sun. The spacecraft was launched in March 2004 to rendezvous with the 67/P Churyumov-Gerasimenko comet in mid-2014. While en route, Rosetta developed attitude-control and propulsion system problems: two of its four reaction wheels started showing signs of degradation; and there was a leak in a helium-pressurization system that enables the propellant reservoir to direct fuel to Rosetta's on-board thruster engines. In response to the former issue, the Rosetta operations team will spend the hibernation period developing software to operate the satellite with three, and even two reaction wheels if necessary. Currently, the Rosetta spacecraft needs only three wheels to function, so when awakened in January 2014, one of the degraded wheels can be used as a spare. With the propulsion problem, ESA's first plan involved re-pressurizing Rosetta for future operations, allowing for maximum fuel efficiency; however that route had the potential to aggravate the current leak. The alternate approach adopted by ESA's European Space Operations Centre (ESOC) was to allow Rosetta to use more fuel than originally planned and fly a less-efficient route to the comet. Nevertheless,

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[246] "1st Boeing-built Inmarsat-5 Global Xpress® Satellite Sends Initial On-Orbit Signals." 9 Dec. 2013. Boeing 10 Apr. 2014. http://boeing.mediaroom.com/1st-Boeing-built-Inmarsat-5-Global-Xpress-Satellite-Sends-Initial-On-Orbit-Signals.

[247] "Intelsat Epic^{NG}." Intelsat 10 Apr. 2014. http://www.intelsat.com/infrastructure/intelsat-epicng/.

[248] "Intelsat Buying Four More Epic Satellites from Boeing." 9 May 2013. SpaceNews 10 Apr. 2014. http://www.spacenews.com/article/satellite-telecom/35242intelsat-buying-four-more-epic-satellites-from-boeing.

with this approach, Rosetta will still have enough fuel to complete its comet rendezvous by mid-2014.[249]

ESA's Herchel science mission ended on 29 April 2013, following the exhaustion of its helium coolant reserves, having conducted more than 3 years of observations of the cool Universe.[250] Data from the Herchel's mission has been combined with the South Pole Telescope's measurements, to make the first detection of gravitational waves during the Universe's rapid 'inflation' period.[251] This result had previously been anticipated by Herschel's counterpart Planck mission. The spacecraft's final command, following a complex series of flight control activities and thruster manoeuvres, put Herschel on a course toward a safe disposal orbit around the Sun and placed its systems into passive mode.[252]

NASA's Mars Odyssey orbiter was put into safe-mode on 8 June 2012, when one of the three primary reaction wheels used for attitude control stuck for a brief period. Anticipating the potential occurrence of such a problem prior to the spacecraft's launch in April 2001, engineers had installed a spare reaction wheel skewed at right angles to all three others so that it could be used as a substitute for any one of them, to provide control in all directions. The satellite's reaction wheels control the way it faces the Sun, Earth or Mars. Increasing the rotation rate of a reaction wheel causes the spacecraft itself to rotate in the opposite direction. Through having the spare replacement wheel available, the longest running Mars obiter was returned to full, nominal operation mode on 27 June 2012, returning observation data with its Thermal Emission Imaging System and its Gamma Ray Spectrometer, and relaying data back to Earth from NASA's Mars Exploration Rover Opportunity and Mars Science Laboratory mission on the Red Planet.[253]

NASA's Orion Multi-Purpose Crew Vehicle (MPCV) will conduct its first mission, Exploration Flight Test-1 (EFT-1), in 2014. For its first mission, the Orion crew module will fly nearly 5,800 km above the Earth, where it will conduct two orbits before entering Earth's atmosphere to test the spacecraft's heat shield then re-enter the atmosphere at speeds verging on those that would occur during a return from deep space. The key purpose of this launch will be to test whether

[249] De Selding, Peter. "ESA Controllers Buy Time To Fix Glitches on Comet Chaser." SpaceNews 20 Jun. 2011: 10.

[250] "Herschel Closes its Eyes on the Universe." 29 Apr. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Herschel/Herschel_closes_its_eyes_on_the_Universe.

[251] "Herschel Helps Find Elusive Signals from the Early Universe." 1 Oct. 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Space_Science/Herschel/Herschel_helps_find_elusive_signals_from_the_early_Universe.

[252] "Herschel End Operations as Orbiting Testbed." 17 June 2013. ESA 2 Apr. 2014. http://www.esa.int/Our_Activities/Operations/Herschel_ends_operations_as_orbiting_testbed.

[253] "Longest-Lived Mars Orbiter Is Back in Service." 27 June 2012. Jet Propulsion Laboratory 28 Mar. 2014. http://mars.jpl.nasa.gov/odyssey/news/whatsnew/index.cfm?FuseAction=ShowNews&NewsID=1242.

Orion's heat shield can withstand the forces of atmospheric re-entry at about 32,000 km/h, with temperatures reaching up to 2,200 °C.[254] While a total of 11 parachutes will be used to return the spacecraft to Earth, its 3 main parachutes, each weighing about 136 kg, will perform the major task of reducing Orion's speed to less than 32 km/h.[255]

In the private sector, following the permanent grounding of the NASA space shuttle fleet, NASA began the third phase of its Commercial Crew Development (CCDev) programme, called the Commercial Crew integrated Capability (CCiCap) initiative. In August 2012, following solicitations for proposals from US space industry participants to mature the design and development of an integrated crew transportation system (CTS) (which included spacecraft, launch vehicle, ground and mission systems), NASA awarded Boeing, SpaceX, and Sierra Nevada Corporation (SNC) funding to develop their vehicles to the next stage of providing domestic access to the ISS for US astronauts. Boeing was awarded $460 million, while SpaceX received $440 million, and SNC $212.5 million.[256] As at December 2013, the CCiCap award winners had the following milestone completion status: Boeing (14 of 20), SpaceX (11 of 17), and SNC (6 of 12).[257]

Boeing is developing its own Commercial Space Transportation-100 (CST-100) crew capsule, designed to send astronauts to the ISS as early as 2015. Boeing intends flight-testing CST-100 on three expendable Altas 5 rockets; four tests are planned, the first of which is a launch pad abort test planned for 2014. In 2015, three additional tests will be conducted involving an unmanned orbital flight of the CST-100, an in-flight test of the capsule's abort system, and the first manned flight of the CST-100 at the end of the year.[258] During September 2013, the spacecraft passed its ninth milestone, where it successfully tested its orbital manoeuvring and attitude control (OMAC) system of 24 thrusters, which gives it the ability to perform critical manoeuvres in space (e.g. refining the CST-100's orbit), and its braking manoeuvre near the end of a mission to slow the spacecraft down before re-entry into the atmosphere.[259] By late October 2013, the CST-100's launch-abort engines completed their development testing milestone, clearing the way for

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[254] Leone, Dan. "NASA Proposes Orion Test Flight in 2014." 8 Nov. 2011. SpaceNews 12 Mar. 2013. http://www.spacenews.com/article/nasa-proposes-orion-test-flight-2014.

[255] "Work on NASA's New Orion Spacecraft Progresses as Engineers Pivot to 2014." 23 Dec. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/content/work-on-nasa-s-new-orion-spacecraft-progresses-as-engineers-pivot-to-2014/.

[256] "NASA CCiCAP Funding for SpaceX, Boeing and SNC's Crew Vehicles." 3 Aug. 2012. NASA Spaceflight 15 Apr. 2014. http://www.nasaspaceflight.com/2012/08/nasa-ccicap-funding-spacex-boeing-sncs-crew-vehicles/.

[257] "NASA's Return on Investment Report." 20 Dec. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/sites/default/files/files/NASAROIReport_Dec2013_TAGGED.pdf.

[258] SpaceNews Staff. "Boeing Picks Atlas 5 for CST-100 Test Flights." SpaceNews 8 Aug. 2011: 3.

[259] "NASA Commercial Partner Boeing Tests CST-100 Spacecraft Thrusters." 20 Sept. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/press/2013/September/nasa-commercial-partner-boeing-tests-cst-100-spacecraft-thrusters/.

qualification tests of each engine requiring a firing duration of 11 s (double their design requirement). Similar to the SpaceX Dragon capsule, the CST-100 will have a pusher-style abort system, wherein four such engines would propel CST-100 and its crew to safety in the event of a launch problem.[260] Measuring 4.5 m across at its widest point, this seven-seat gumdrop-shaped capsule will be reusable for up to 10 flights.[261]

SpaceX is developing its Dragon 2.0 crew capsule, designed to send astronauts to the ISS, with two demonstration abort tests planned in 2014. SpaceX will flight-test its uncrewed 'DragonRider' to demonstrate the ability of the Dragon spacecraft abort system to lift the spacecraft clear of a simulated launch emergency. The second flight test involves simulating an in-flight emergency abort scenario during ascent at high altitude at maximum aerodynamic pressure at about 60 s into the launch. Both abort tests are essential for demonstrating that the spacecraft will activate its SuperDraco thrusters and separate in a split second from a potentially deadly exploding rocket fireball to save astronaut lives in the event of a real life emergency.[262] When crewed, the DragonRider will be able to lift up to seven astronauts to the ISS, and remain docked for at least half a year. SpaceX hopes to launch an initial crewed Dragon orbital test flight to the ISS as early as 2015.

The Sierra Nevada Corporation is developing the Dream Chaser, designed to send astronauts to the ISS on a winged, lifting-body spacecraft, with the capability of returning to Earth by landing on a conventional airstrip. The design of the reusable spacecraft is derived from NASA's HL-20 Personnel Launch System from the 1990s that had undergone years of development, analysis, and wind tunnel testing, along with related synergy with the retired US space shuttles. Capable of holding a crew of up to seven astronauts, the spacecraft would launch atop of an Atlas 5 rocket.[263] The first free flight of the Dream Chaser resulted in a milestone in successfully testing the spaceflyer's automated approach and landing system; although a malfunction in the Dream Chaser's left landing gear had it skidding off the runway at the end of the flight.[264] The landing gear door remained closed as the result of contamination in the hydraulic fluid that was used to power the system;

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[260] "CST-100 Launch-abort Engines Complete Testing Milestone." 17 Dec. 2013. SpaceNews 15 Apr. 2014. http://www.spacenews.com/article/launch-report/38731cst-100-launch-abort-engines-complete-testing-milestone.

[261] Chow, Denise. "Boeing's CST-100 Capsule Shooting for 2015 Debut." SpaceNews 30 Apr. 2012: 14.

[262] "What's Ahead for Human Rated SpaceX Dragon in 2014—Musk tells Universe Today." 30 Dec. 2013. Universe Today 15 Apr. 2014. http://www.universetoday.com/107505/whats-ahead-for-human-rated-spacex-dragon-in-2014-musk-tells-universe-today/.

[263] "NASA CCiCAP Funding for SpaceX, Boeing and SNC's Crew Vehicles." 3 Aug. 2012. NASA Spaceflight 15 Apr. 2014. http://www.nasaspaceflight.com/2012/08/nasa-ccicap-funding-spacex-boeing-sncs-crew-vehicles/.

[264] "Private Dream Chaser Space Plane Skids Off Runway After Milestone Test Flight (Video)." 29 Oct. 2013. Space.com 15 Apr. 2014. http://www.space.com/23370-private-dream-chaser-space-plane-skidded-off-runway-after-milestone-test-flight.html.

its parts had been donated from a fighter jet, as opposed to the custom gear provided for missions in the future.[265] The Dream Chaser has attracted interest from Germany's DLR and OHB System AG, wishing to finance a study to explore ways in which the spacecraft can be used to cover German and European requirements for the transportation of payloads and astronauts to the ISS and for deployment as a manned or unmanned space vehicle allowing German and European scientists to conduct research under weightless conditions over extended periods of time. Moreover, given its capability of reaching orbits at a substantially greater altitude than the ISS, the study will determine the extent to which it is able to supply satellites or remove decommissioned satellites from their orbits.[266]

Notwithstanding the CCiCap awards given to Boeing, SpaceX, and SNC, Blue Origin is also in the running to develop its orbital reusable launch vehicle program outside of the CCiCap programme. In March 2013, NASA and Blue Origin signed an agreement to extend their CCDev2 partnership in an unfunded capacity, wherein until mid-2014, Blue Origin will continue to advance the subsystems of its biconic-shaped spacecraft.[267] In December 2013, Blue Origin test fired its hydrogen- and oxygen-fuelled BE-3 engine at full power for 145 s in its boost phase, shutting down to simulate coast through apogee, and then restarted and throttled down to 25,000 pounds thrust to simulate controlled vertical landing.[268] The BE-3 is planned to be a Reusable Booster System, which would be refurbished for another mission. The successful test of Blue Origin's BE-3 engine completed its Engine Mission Duty Cycle test milestone.[269]

2.5.4 Suborbital Activities

Virgin Galactic and similar US firms (e.g. XCOR Aerospace, Armadillo Aerospace, and Blue Origin, etc.) have been given a regulatory grace period extension on developing suborbital spacecraft without Federal Aviation Administration (FAA)

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[265] "Dream Chaser Receives CCDev-2 Green Light from NASA." 16 Dec. 2013. NASA Spaceflight 15 Apr. 2014. http://www.nasaspaceflight.com/2013/12/dream-chaser-ccdev-2-green-light-nasa/.

[266] "Contract Signed with DLR for the Study Phase for the Utilization of U.S. Company Sierra Nevada Corporation's Dream Chaser® Spacecraft." 13 Nov. 2013. OHB System 16 Apr. 2014. https://www.ohb-system.de/press-releases-details/items/contract-signed-with-dlr-for-the-study-phase-for-the-utilization-of-us-company-sierra-nevada-corporations-dream-chaser-spacecraf.html.

[267] "Blue Origin Signs New NASA Space Act Agreement." 2 Mar. 2013. Innerspace 16 Apr. 2014. http://innerspace.net/cotscommercial-crew/blue-origin-signs-new-nasa-space-act-agreement/.

[268] "NASA Commercial Crew Partner Blue Origin Test-Fires New Rocket Engine." 3 Dec. 2013. NASA 16 Apr. 2014. http://www.nasa.gov/press/2013/December/nasa-commercial-crew-partner-blue-origin-test-fires-new-rocket-engine/.

[269] "NASA's Return on Investment Report." 20 Dec. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/sites/default/files/files/NASAROIReport_Dec2013_TAGGED.pdf.

imposed passenger and crew safety rules. The 2004 Commercial Space Launch Amendments Act barred the FAA from imposing those rules for a period of 8 years, unless an operator experienced a serious accident or an especially dangerous close call. In either circumstance, the FAA would be limited to restricting or prohibiting the craft's design features or operating practices resulting in those events. Whereas this grace period was due to finish by the end of 2012, with the expectation that commercial suborbital spaceflight has become established; the extension to September 2015 allows the fledgling commercial human spaceflight industry to develop without being weighed down with regulation, and allows operators to establish a base of safety-related best practices that the FAA could later on convert into regulations.[270]

On a related note, by late April 2013, Virgin Galactic completed the first rocket-powered flight of its suborbital space vehicle, SpaceShip Two.[271] This achievement officially marked the final phase of vehicle testing prior to commercial service from Spaceport America in New Mexico. The company cleared an important regulatory hurdle in 2012, when the US government granted Virgin Galactic a favourable EAR99 ruling, removing its suborbital operations from ITAR control. Without this ruling, the training and/or launching of non-US citizens on Virgin Galactic suborbital flights would have constituted an export activity requiring federal approval, and thus the need for export licenses that could take months for each case. However, as the spacecraft's flight hardware is still under ITAR's export control, any disclosure of controlled technical data to a foreign national, regardless of whether disclosed within the US, is treated as an 'export' of the technical data.[272] Virgin Galactic now expects to fly its first paying customers in 2014.[273]

Other groups have seen mixed results in their suborbital spacecraft development. Masten Space Systems, Armadillo Aerospace, and Blue Origin are developing spacecraft to rival Virgin Galactic's SpaceShip Two. Funded in-part with seed money from NASA's Commercial Reusable Suborbital Research program—a programme intended to mature experimental suborbital launch technology and help create a commercial suborbital launch industry—these groups are required to carry NASA payloads within near-space altitudes. Near-space is the grey-zone

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[270] Leone, Dan. "Private Spaceflight 'Learning Curve' Extension Approved." SpaceNews 13 Feb. 2012: 4.

[271] "Virgin Galactic Breaks Speed of Sound in First Rocket-Powered Flight of SpaceShipTwo." 29 Apr. 2013. Virgin Galactic 11 Apr. 2014. http://www.virgingalactic.com/news/item/virgin-galactic-breaks-speed-of-sound-in-first-rocket-powered-flight-of-spaceshiptwo/.

[272] Leone, Dan. "Virgin Galactic Granted License Exemption for Spaceflight Experience." SpaceNews 16 Apr. 2012: 22.

[273] "Branson Ready for Lift Off With 700 Space Tickets Sold." 18 Sept. 2013. The Telegraph 11 Apr. 2014. http://www.telegraph.co.uk/finance/newsbysector/transport/10319028/Branson-ready-for-lift-off-with-700-space-tickets-sold.html.

where the delimitation between airspace and outer space is uncertain, i.e. between around 40 and 107 km in altitude.

Masten is developing the Xaero; a vertical-takeoff, vertical-landing vehicle, that uses the firm's isopropyl alcohol- and liquid oxygen-burning Cyclops-AL-3 engine. While the first experimental suborbital launcher was destroyed on 11 September 2012 during the spacecraft's 110th test-flight, when a stuck engine valve triggered the rocket's flight termination system during its descent,[274] a second slightly larger Xaero-B continued the programme's development.[275] Armadillo Aerospace was developing the SuperMod suborbital rocket; another vertical-takeoff, vertical-landing rocket, derived from Armadillo's Module 1 (Mod) vehicle, but by mid-2013 it had paused development in search for new investors. The company's January 2013 launch of its STIG-B rocket from Spaceport America in New Mexico resulted in a failure after a parachute failed to deploy.[276] Blue Origin's New Shepard suborbital spacecraft will be launched atop a rocket-powered Propulsion Module. In December 2013, Blue Origin, created by Amazon founder Jeff Bezos, completed a full-duration burn of a liquid hydrogen-fuelled BE-3 engine developed for both the New Shepard suborbital spaceship and planned orbital vehicles.[277]

Additionally, XCOR's Lynx suborbital spacecraft is the company's entry into the commercial reusable launch vehicle (RLV) market. The Lynx is a horizontal takeoff and horizontal landing vehicle that uses its own fully reusable rocket propulsion system to take off and land on runway. This two-seat, piloted space transport vehicle will take humans and payloads on a half-hour suborbital flight to 100 km (330,000 feet) and then return to a landing at the takeoff runway. The piloted, two-seat spacecraft can be used to lift humans and payloads on a 30 min suborbital flight up to four times in a day. Lynx will be FAA AST-licensed, and has already passed the AST licensing process with an earlier vehicle concept.[278] In March 2013, a significant milestone was reached when the first firing of a full piston pump-powered rocket engine was performed.[279] With interest already created among commercial industry and research institutes, XCOR's Lynx Mark I will

[274] "Masten's Xaero Rocket Lost During Mojave Test Flight." 17 Sept. 2012. SpaceNews 14 Apr. 2014. http://www.spacenews.com/article/masten%E2%80 %99 s-xaero-rocket-lost-during-mojave-test-flight.

[275] "Masten Unveils Xaero-B Reusable Suborbital Rocket." 26 Mar. 2013. Flight Global 14 Apr. 2014. http://www.flightglobal.com/news/articles/masten-unveils-xaero-b-reusable-suborbital-rocket-383662/.

[276] "Armadillo Aerospace Suspends Vehicle Development Work." 2 Aug. 2013. SpaceNews 14 Apr. 2014. http://www.spacenews.com/article/launch-report/36590armadillo-aerospace-suspends-vehicle-development-work.

[277] "Blue Origin Rocket Engine Test-fired for Simulated Suborbital Run." 4 Dec. 2013. SpaceNews 14 Apr. 2014. http://www.spacenews.com/article/launch-report/38495blue-origin-rocket-engine-test-fired-for-simulated-suborbital-run.

[278] "About Lynx." XCOR Aerospace 11 Apr. 2014. http://www.xcor.com/lynx/.

[279] "XCOR Aerospace Announces Significant Propulsion Milestone on Lynx Suborbital Vehicle." 26 Mar. 2013. XCOR Aerospace 14 Apr. 2014. http://www.xcor.com/press/2013/13-03-26_XCOR-lynx-propulsion-milestone.html.

begin commercial flights in 2015 and will carry payloads smaller than 1 kg as a "ride share" or "secondary payload", and up to one 120 kg "primary" mission payload [integrated into the Lynx by the Czech Space Office (CSO)]. Payloads may be placed inside the Lynx pressurised cabin or exposed to the vacuum and radiation conditions of space.[280]

2.5.5 Other Technologies

Developments in technology and science continued to advance both in 2012 and 2013, with implications reaching beyond the space sector.

In January 2013, NASA's Robotic Refuelling Mission (RRM) was used to demonstrate that remotely controlled robots using current-day technology could refuel satellites that were not designed to be serviced. Following this success, a second-phase RRM mission is planned in 2014 to demonstrate how space robots can replenish coolant in the instruments of similar legacy satellites.[281] NASA's RRM was launched to the ISS on 8 July 2011, and is mounted outside of the station. With the aide of the Special Purpose Dexterous Manipulator (Dextre), a twin-armed Canadian-built robot that has been onboard the ISS since 2008, and with specially updated software, Dextre uses a set of satellite-servicing tools to perform simulated refuelling tasks on the RRM. Initial activities to demonstrate this in-orbit capability were completed in 2012 wherein with the aid of the original RRM tools and activity boards Dextre was used to cut away protective thermal blankets, unscrew fuel caps and transfer simulated fuel from one reservoir to another. It is hoped that the RRM might also spark a private satellite-servicing industry, which might also encourage satellite owners to put additional sensors, electronics and fuel-carrying capacity onto future spacecraft, as the potential to extend operational life would be seen as sufficiently worthwhile to make up for a higher up-front investment. However, the RRM is only meant to be a demonstrator, and it will be left to commercial companies to conduct commercial refuelling operations on satellites.[282]

With Robonaut 2 (R2) already active on the ISS, NASA engineers are developing climbing legs to provide added mobility for regular and repetitive tasks within and outside the station. No longer considered to be superfluous add-ons, once the legs are attached to the R2 torso, the robot will have a fully extended leg span of 2.7 m. Each leg has seven joints and an end effector with a camera, allowing it to

[280] "Czech Space Office and XCOR Aerospace Sign Payload Integrator Agreement for Suborbital Flights." 21 Nov. 2013. XCOR Aerospace 14 Apr. 2014. http://www.xcor.com/press/2013/13-11-21_czech_space_office_xcor_payload_integrator.html.

[281] "Japanese Vehicle Delivers New Hardware for NASA's Robotic Refueling Mission." 2 Aug. 2013. NASA 15 Apr. 2014. http://www.nasa.gov/content/goddard/japanese-vehicle-delivers-new-hardware-for-nasa-s-robotic-refueling-mission/.

[282] Leone, Dan. "Space Station-bound Refueling Demo Won't Start Before November." SpaceNews 5 Jul. 2011: 6.

grasp handrails and sockets in and on the station. R2 will receive its legs early in 2014.[283] NASA is also developing another robot, Valkyrie (R5), which competed in DARPA's Robotics Challenge. In the challenge, this $7.6 million robot used standard tools and equipment commonly available in human environments (i.e. hand tools, vehicles, etc.) to demonstrate capabilities to execute complex tasks in dangerous, degraded, human-engineered environments.[284]

NASA's robotic exoskeleton (X1), jointly developed with the Florida Institute for Human and Machine Cognition (IHMC), is another spinoff derived from NASA's Robonaut 2 project and the IHMC's Mina exoskeleton designed for paraplegic users on Earth. The X1 is a 26 kg device that can be worn over a person's body either to inhibit or assist movement in leg joints. The inhibit mode would supply resistance against leg movement, allowing the X1 to be used as an in-space exercise machine. Moreover, the same technology could also be used to assist individuals to walk for the first time; and as the technology matures, it could also provide a robotic power boost to astronauts as they work on the surface of distant planetary bodies. The X1 is currently in the research and development phase, with primary focus on the design, evaluation and improvement of the technology. When completed, the X1 may help astronauts remain healthy in space, while also assisting paraplegics in walking on Earth.[285]

DARPA's Membrane Optical Imager for Real-Time Exploitation (MOIRE) program, currently in its final phase, aims to create technologies that would enable future high-resolution orbital telescopes to provide real-time video and images of the Earth from GEO orbit. The MOIRE programme recently demonstrated a ground-based prototype that included a new lightweight polymer membrane optics to replace glass mirrors, balancing the loss of efficiency with the use of much larger lighter-weight lenses that more than make up the difference. In the past, size and cost constraints prevented large-scale imaging satellites from being placed within GEO. A new system incorporating MOIRE optics would be roughly one-seventh the weight of a comparable traditional system, and could be tightly packed into a configuration roughly 6 m in diameter, wherein upon reaching GEO, it would unfold to create the full-size multi-lens optics reaching 20 m in diameter. If successful, the satellite could have a 40 % field of view of the earth's surface,

[283] "NASA Developing Legs for Space Station's Robonaut 2." 9 Dec. 2013. NASA 14 Apr. 2014. http://www.nasa.gov/press/2013/December/nasa-developing-legs-for-space-stations-robonaut-2/.

[284] "NASA JSC Has Developed A Girl Robot in Secret (Revised With NASA Responses)." 12 Dec. 2013. NASA Watch 14 Apr. 2014. http://nasawatch.com/archives/2013/12/nasa-jsc-has-de.html.

[285] "NASA's Ironman-Like Exoskeleton Could Give Astronauts, Paraplegics Improved Mobility and Strength." 2 Aug. 2013. NASA 14 Apr. 2014. http://www.nasa.gov/offices/oct/home/feature_exoskeleton.html.

and would be able to focus on a 10 km-by-10 km area at 1-m resolution, providing real-time video at 1 frame per second.[286]

In an effort to improve astronaut mobility both within and outside the ISS and other spacecraft, the Draper Laboratory is developing a spacesuit called a Variable Vector Countermeasure suit (V2Suit), which incorporates control moment gyroscopes (CMGs) into astronaut spacesuits and extravehicular Activity (EVA) jetpacks. CMGs are positioned on various parts of the spacesuit to create a network, which would then be attached to corresponding parts of the wearer, providing torque in movement to imitate gravity, and allow the wearer to develop a sense of egocentric coordination. By moving against resistance, the suit is expected to help prevent astronauts' loss of bone mass and muscle strength during extended stays in space. The project began in September 2011, funded by NASA's Innovative Advanced Concepts (NIAC) program, and it should complete its phase 2 by the end of 2014. Draper expects the suit to be ready for space sometime in the next 5–10 years. Additional plans involve the use of CMGs on EVAs to help stabilize an astronaut when working around an asteroid or other larger object in space. As current EVAs use gas thrusters to counter astronauts' motion in space, CMGs may help reduce the need for thrusters by compensating for angular motion, letting the thrusters control linear motion, instead of using thrusters for both.[287]

On 20 November 2013, the US Secretary of Defence completed a Memorandum of Understanding with Australia's Defence Minister to have DARPA's Space Surveillance Telescope (SST) fully relocated to Australia by 2016. The SST will be moved from its current mountaintop location in White Sands, New Mexico, USA where the system underwent operational testing and evaluation, to Australia, where it will provide key space situational awareness from the largely unexplored southern portion of the geosynchronous belt. The relocation process will begin in 2014, and is expected to resume operations sometime in 2016. From its new location, the SST—with ten times more sensitivity than current state-of-the-art systems—will transmit its observations into the Space Surveillance Network (SSN). The SSN is a US Air Force system charged with cataloguing and observing space objects to identify potential near-term collisions with space assets, providing data to spacefaring countries around the world. In addition to detecting debris, the SST will also continue to provide NASA and the scientific community with

[286] "First Folding Space Telescope Aims to "Break the Glass Ceiling" of Traditional Designs." 5 Dec. 2013. DARPA 14 Apr. 2014. http://www.darpa.mil/NewsEvents/Releases/2013/12/05.aspx.

[287] "When You Think Gyroscopes, Go Ahead and Think the Future of Spacesuits and Jet Packs, too." 1 June 2013. Washington Post 15 Apr. 2014. http://www.washingtonpost.com/blogs/innovations/wp/2013/06/01/when-you-think-gyroscopes-go-ahead-and-think-the-future-of-spacesuits-and-jet-packs-too/.

surveillance data on transient events such as supernovae and potentially hazardous NEOs.[288]

By August 2014, the ISS will have its first 3D printer on board with the capability of building an estimated 30 % of the spare parts on the station, in addition to specialty tools and experiment upgrades. Developed by ‘Made in Space’, the selected printer was one of three prototypes demonstrated by the company in parabolic flights. The result of collaboration with NASA’s Marshall Space Flight Center, this 3D Printing in Zero G Experiment (3D Print) was meant to demonstrate that 3D printers can print in microgravity. As it is used on Earth, 3D printers use a technique called extrusion additive manufacturing to build objects layer by layer out of polymers, metals, composites and other materials. The main goal of the 3D Print experiment is to help jump-start an off-planet manufacturing capability, which could aid in deeper space exploration by making life in space easier and cheaper. In this pursuit, NASA has also recently funded the development of a prototype 3D printer designed to make space food products out of cheap raw materials that have a long shelf life; useful for long space journeys, such as the 500-day return trip to Mars.[289]

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[288] “DARPA Space Surveillance Telescope Ready for Delivery.” 9 Dec. 2013. SpaceRef 14 Apr. 2014. http://spaceref.com/nasa-hack-space/darpa-space-surveillance-telescope-ready-for-delivery.html.

[289] “3D Printer Passes Zero-Gravity Test for Space Station Trip.” 19 June 2013. Space.com 16 Apr. 2014. http://www.space.com/21630-3d-printer-space-station-tests.html.

Part II
Views and Insights

Chapter 3
Global Trends and Their Impact on Space

Nayef Al-Rodhan

This article addresses global trends and their impact on outer space issues from three main perspectives: (1) current and future challenges in outer Space, (2) developments in the international system over the past two decades, and (3) how these changes in the international system reflect on space issues, policies, challenges and opportunities.

3.1 What Challenges Exist in Outer Space?

Currently, there are three main issues and challenges that can be identified in outer space. First, the Outer Space environment belongs to everyone, which means that it is a modern day "Global Commons". Second, humanity is now at a juncture where it is increasingly and irreversibly dependent on Space. This has caused outer space to become more and more congested. Third, geopolitical competition and stakes in Space and on Earth are intertwined and interdependent, thus it has become contested.

3.2 What Has Changed in the International System Over the Past Two Decades?

The information/communications revolution over the past two decades has made the world increasingly globalised. The effects of this are manifold, yet two main consequences can be identified: instant connectivity and deepening interdependence. This has the potential to alter the global game for all of humanity,

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affecting actors and interactions at all levels. As suggested in a previous work, The Five Dimensions of Global Security: Proposal for a multi-Sum Security Principle, while the state remains the most pivotal unitary actor in the global system, global security is much more complex than the collection of the national securities of various states. Thinking of global security thus implies taking into account five dimensions: (1) National Security; (2) Transnational Security; (3) Human Security; (4) Environmental Security; and (5) Transcultural Security.[1]

Security issues and policies therefore need to be reconsidered in our globalised world, no longer fitting the simple classic scenario of a competition between weak and strong states. Therefore, rather than employing the paradigm of zero-sum security, and the so-called "Security Dilemma" which are no longer useful and may even be counter-productive, it is now more useful to advance the notion of what I have called the Multi-Sum Security Principle (MSSP), which states that:

> "In a globalized world, security can no longer be thought of as a zero-sum game involving states alone. Global security, instead, has five dimensions that include human, environmental, national, transnational and transcultural security and, therefore, global security and the security of any state or culture cannot be achieved without good governance at all levels that guarantees security through justice for all individuals, states and cultures."[2]

Therefore, global justice, irrespective of how we choose to define it, is a pre-requisite for the sustainable security of individual states as well as that of the global system.[3]

Geopolitical issues today, including in the outer space domain, need to be rethought and expanded to a definition that accounts for geopolitics in a more comprehensive way. A "Meta-Geopolitics Framework" is thus more appropriate, incorporating both traditional and new dimensions of geopolitics.[4] The Meta-Geopolitics framework includes seven state capacities which are: (1) Social and health issues, (2) Domestic politics, (3) Economy, (4) the environment, (5) Science and human potential, (6) Military and security issues and, (7) International diplomacy.

To better understand and explain our contemporary international system at large, as well as cooperation or antagonism over space issues in particular, realist interpretations of the international system prove inadequate. In a globally-anarchic world of instant connectivity and deepening interdependence, realism needs to be amended. A better way to make sense of this evolving global context is through what I called Symbiotic Realism, a theory of International Relations that explains

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[1] Al-Rodhan N (2007) The Five Dimensions of Global Security. Proposals for a Multi-sum Security Principle. LIT, Berlin, 35.

[2] Al-Rodhan N (2007) The Five Dimensions of Global Security. LIT, Berlin, 31.

[3] Al-Rodhan, Nayef "Sustainable Power is Just Power" 5 Dec. 2013 e-IR 18 Jan. 2014. http://www.e-ir.info/2013/12/05/sustainable-power-is-just-power/?utm_source=twitterfeed&utm_medium=twitter.

[4] Al-Rodhan N (2012) Meta-Geopolitics of Outer Space. An Analysis of Space Power, Security and Governance. Palgrave Macmillan, London, 19.

the international system and the multiple actors (state and non-state) which interact in it.[5] Symbiotic Realism aims to provide a comprehensive framework for understanding the character of relations generated by four interlocking facets of the global system: (1) the neurobiological substrates of human nature (as opposed to the interpretation of human nature underpinning classical realism); (2) global anarchy; (3) instant connectivity; and (4) deepening interdependence.

Symbiotic Realism expands the number of unitary actors in the international system to include the six following active actors:

- the individual
- the state
- large collective identities
- international organizations (multilateral institutions and NGO's)
- transnational corporations
- women

In addition to that there are three re-active actors:

- the environment
- natural resources
- information and communications technologies.

Symbiotic Realism also allows win-win solutions, absolute gains and non-conflictual competition. Additionally, it accounts for the emotionality of states including pride, prestige, collective historical and collective or national psychological baggage, and a skewed view of a state's own history as well as that of other states. This implies that Symbiotic Realism combats the realist notion of a monolithic state that always acts rationally and it suggests that states often do not act as rational actors.[6]

3.3 How These Recent Transformations in the Global System Affect Space Power, Security and Governance

Outer space has emerged as a key component of national power and is often considered an indicator of status and prestige in international affairs. While during the Cold War space issues had mostly pertained to the military field, space now has many more uses that are non-military and certainly not exclusively state-focused.

[5] Al-Rodhan, N (2007) Symbiotic Realism. A theory of International Relations in an Instant and an Interdependent World. LIT, Berlin, 67.

[6] Al-Rodhan, Nayef. "Emotionality of States and Symbiotic Realism" 7 May 2013 The Huffington Post 18 Jan. 2014. http://www.huffingtonpost.co.uk/nayef-alrodhan/emotionality-of-states-philosophy_b_3230027.html.

Numerous actors are now present in space and the range of space applications has expanded considerably.

Therefore, Space Power needs now to be defined more inclusively as it goes far beyond military capacity. As important as the latter remains, space is now relevant for all the seven state capacities mentioned above. Furthermore, space power is a 'two-way' concept, meaning that it also reflects back on power relations and dynamics on Earth. To incorporate these contemporary and emerging trends, I have previously defined space power as follows:

> the ability of a state to use space to sustain and enhance its seven state capacities as outlined in the meta-geopolitics framework, namely social and health, domestic politics, economy, environment, science and human potential, military and security, and international diplomacy.[7]

To further exemplify these linkages, space and space applications are now instrumental or pivotal to the seven state capacities:

1. In Social and Health issues—satellites are used, for instance, for remote delivery or communication of medical services, for disease monitoring (including surveillance of the spread of infectious diseases) or telemedicine, which is critical in situations where medical expertise is lacking.
2. In domestic politics, space projects also play a key role in enhancing prestige or national pride; satellites also monitor situations in unstable or war-shattered areas, as well as more generally border control and exchanges.
3. In economic terms—space and its applications have significant impacts through the effects they have on agriculture (for instance through crop monitoring), communications or mining as well as through the industry, market and science of space exploration itself, which requires a share of the national budget.
4. The environment and concerns over environmental issues are also of relevance to space not only through the monitoring techniques of environmental processes but also through the possibilities available in space for exploring new resources and materials.
5. In terms of science and human potential, space science plays a key role in a country's predominance in space as well as its power on Earth. Space research—both for civilian and military purposes—is now more and more pursued by countries that seek confirmation of their geopolitical status through space exploration (e.g. Pakistan, North Korea etc.).
6. Military and security issues are strongly dependent on space as all military operations now require satellite communication and navigation. Moreover, space itself has become a new milieu of weaponisation, reflecting or enhancing geopolitical competition on Earth and in the process, potentially triggering new conflicts.

[7] Al-Rodhan N (2012) Meta-Geopolitics of Outer Space. An Analysis of Space Power, Security and Governance. Palgrave Macmillan, London, 25.

7. In international diplomacy as mentioned above, space is used as a measurement of power and prestige, thus bearing on a country's leverage in international affairs. However, the uses of space also include less known and highly innovative aspects such as observation satellites to monitor implementation of arms controls treaties or inspections (the International Atomic Energy Agency, for instance, also relies on satellite images for its inspections), domestic or cross-border issues and conflicts or human displacement patterns. However, such uses of satellites have raised controversies and could be sources of frictions between states as they can monitor developments in countries and therefore infringe on national sovereignty.[8]

Given the complexity of space issues and possibilities, as well as the changes in the international system, space security has to be viewed as a multi-sum enterprise, where cooperative efforts are a pre-requisite to the future of space for all. Consequently, space cannot and should not be seen in terms of power enhancement but rather in terms of power sustainability in the twenty-first century. Therefore, space will either be safe for everyone or for no one.

From a theoretical viewpoint, the governance of space issues needs to subscribe to the tenets of the two theoretical frameworks mentioned above, Symbiotic Realism and Multi-sum security. In practical terms, it has to include: empowerment and enhancement of the UN Office for Outer Space, the Conference for disarmament, commitment on the peaceful use of outer space (COPUOUS), and international space law/treaties. In addition, the international community needs to find a way to ensure a commitment by all space-faring nations to the non-weaponisation of space, thus preventing a space arms race. This must also include prevention of irresponsible ASAT tests that produce additional space debris.

In addition, I have called for strict accountability and transparency of all non-state actors' use of space whether for commercial or tourist use. There also has to be a collective technological cooperative effort to de-clutter space from dysfunctional satellites and other harmful space debris. Pride and prestige of states, which are often central in space governance, must be balanced with the responsible use of space in order to ensure its safety and security for all. Simply put, space must be thought of as a global commons that belongs to all and remains safe for current and future humanity. This necessitates responsible and transparent use of space in terms of: arms control; code of conduct; extended communications between all parties; and confidence building measures.

In my Sustainable History theory I suggested an octagon for a sustainable global governance paradigm. This is applicable to outer space governance and includes the following measures: (1) effective multilateralism; (2) effective multilateral institutions; (3) representative multilateral decision making structures; (4) dialogue

[8] Hettling, J.K. (2003) The use of remote sensing satellites for verification in international law. Space Policy 19(1): 33.

between all stakeholders; (5) accountability; (6) transparency; (7) burden-sharing; and (8) stronger partnership between multilateral organizations and civil society.[9]

Space security and governance need to be thought of as a continuum with security on Earth and integrated in a wider context of global security where threats, challenges and opportunities are not seen as isolated national interests but as being of global concern. In this sense, space governance must rely on the principles of symbiotic realism. This means that while national interests will inevitably continue to prevail in global affairs in the future, states must realise that it is also in their interest to view space as a global commons. This approach must be viewed as a pragmatic necessity rather than an idealist aspiration.

On a cautionary note, it is of utmost importance for states and international agencies to accept that unless the global community collectively and seriously adopts the idea that outer space is a global commons which belongs to everyone, current and future humanity will pay the price of a cluttered and insecure outer space environment. The likelihood of weaponisation of outer space remains high and inevitable in the current international discourse. A set of perennial factors in global politics continues to reflect on the approach to space and space governance. Continuous global anarchy and slow progress in reaching legally binding space regulations, the pursuit of national interests or the use of space projects for pride and prestige, will only perpetuate and enhance existing fault lines and this will negatively impact security for states on Earth and beyond. This potential development, if not averted, will result in an insecure outer space, an insecure global system here on earth, and a vulnerable future for humanity.

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[9] Al-Rodhan, Nayef (2009) Sustainable History and the Dignity of Man. A Philosophy of History and Civilisational Triumph. LIT, Berlin.

Chapter 4
Space in a Changing World: The Future Regulation of Outer Space Technology, Warfare and International Law

Steven Freeland

4.1 Introduction: The Diverse Nature of Space Activities

There are undoubtedly myriad factors to consider when assessing the “future regulation of outer space”, which happened to my original brief when ESPI very kindly invited me to speak at its 2013 Annual Conference themed around “Space in a Changing World”. Indeed, having considered the breadth of the task assigned to me, I quickly formed the view that to even attempt to summarise in a short talk and a few pages a satisfactory “one size fits all” model of regulation for this ever-changing environment would be foolhardy in the extreme, and certainly well beyond my capabilities.

This is so for many reasons, not least that outer space is a dynamic area, with space-related technology, and the range of space activities to which it gives rise, continuing to move forward at breathtaking speed from the time of Sputnik I in 1957 onwards. As is the case in many areas of scientific development, the technology that drives outer space activities has progressed far more rapidly than the specific law that regulates it, which to the outsider appears to be lagging far behind. It is clear that many of these new activities could not even have been within the contemplation of the drafters of the United Nations space treaties. That does *not* mean that the fundamental principles of space law do not apply to those activities; we cannot simply say that there is “no law” that applies to such situations. Yet, even the fundamental space law principles that are set out in those treaties may not be enough, and we thus need to establish appropriate modes by which general international law and treaty principles can be utilised to fill these lacunae.

This is complicated further by the fact that outer space, once primarily the domain of states (and, even then, only a small number of them), is now “host” to a vast array of actors, each with differing goals, capacities, agendas and

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expectations. The growing numbers of space-capable states are still crucial players—and will probably remain the principal space participants for the foreseeable future—but they are now complemented by a range of other types of entities, including intergovernmental organisations, public and private corporations, universities and scientists, and even individual space entrepreneurs.

Moreover, given the sometimes fluid nature of global and regional geopolitics, a specific mode of regulation might be considered as appropriate for one period but may be totally unacceptable in another—witness, for example, the need for different approaches over time to address other areas of global concern such as international criminal justice and climate change. No doubt the future development of the regulation of outer space in a changing world will also be full of surprising twists and turns.

4.2 How International Law *Might* Regulate the Military Uses of Outer Space

As a consequence, rather than attempt the impossible, I decided to exercise some literary licence and to adapt my assigned topic somewhat, choosing to focus on one specific—albeit very important—regulatory area within the broad gamut of outer space activities; the regulation of armed conflict involving satellite technology. I have chosen this particular issue for a number of reasons:

1. It is topical—there is much current discussion about how best to regulate the increasingly ominous development of space-related weapons technology[1];
2. It is challenging—given the vested interests of the main space-faring states, and the emergence of a "space arms race" that seems to motivate military research and development even whilst it concerns the wider community,[2] it is by no means clear as to when, or indeed whether, a binding regulatory mechanism (treaty) directed towards "de-weaponising" outer space will be concluded among the major stakeholders anytime soon; and
3. It is crucial—indications suggest that, if we proceed down the current path, there is an increasing likelihood that outer space will not only be used to facilitate

[1] See, for example: Krepon, Michael. "Will Gravity Lift the Space Code of Conduct?" 11 Nov. 2013 Arms Control Wonk. http://krepon.armscontrolwonk.com/archive/3944/will-gravity-lift-the-space-code-of-conduct#more-4051.

[2] Refer to the numerous United Nations General Assembly Resolutions, beginning with Resolution 36/97C, 9 December 1981 and culminating most recently with Resolution 67/30, 3 December 2012, which have been directed towards the "Prevention of an arms race in outer space." The political dimensions of this issue in the early 1980s were indicated by a split, along ideological grounds, on the main thrust of these resolutions: see Jasentuliyana, Nandasiri. International Space Law and the United Nations. The Netherlands: Kluwer Law, 1999. 82. See also United Nations General Assembly Resolution 67/113, 18 December 2012, on "International Cooperation in the Peaceful Uses of Outer Space".

terrestrial armed conflict (as it already is), but may ultimately become a theatre of war in the future, with consequences almost too frightening to contemplate.

A starting point for this exercise is the acknowledgement of a number of truisms: first, that the international regulation of outer space—past, present and future—is "embedded" in international law. It is not an esoteric and separate paradigm. In a sense, this is an obvious point, but one that is still worthwhile emphasising. It is also a logical consequence of the provisions of Article III of the Outer Space Treaty,[3] which requires that activities in the exploration and use of outer space are to be carried on "in accordance with international law, including the Charter of the United Nations".

Secondly, international law is dynamic and evolving, as has been made clear by the International Court of Justice on a number of occasions.[4] It has tremendous breadth and tremendous depth, and extends to include non-traditional areas that are not "territorial" in nature, therefore encompassing outer space. Likewise, the application of public international law principles to the regulation of outer space is equally dynamic and evolving.

Thirdly, it is obvious that the future will see an even greater range of space activities evolve. This will give rise to considerable opportunities, but also considerable challenges. There is clearly a need for the regulation of such activities in an appropriate way, and there is no doubt that international law—supplemented by national space law—has an important role to play in this continuing evolution.

4.3 The Principles of the *Jus in Bello*

So far so good—the general concept is relatively simple to state—general principles of international law apply to activities in outer space. What is far more difficult and unclear is to determine precisely *how* this may work for specific situations, and precisely *which* principles are (or might be) directly applicable to particular space activities. In the absence of specific provisions in the *lex specialis* of international space law, can we simply "transpose" terrestrial international law regimes to outer space? This question seems directly pertinent at least in relation to two important international regulatory regimes in particular—international environmental law,[5]

[3] Treaty on Principles governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, London/Moscow/Washington, done 27 January 1967, entered into force 10 October 1967, 610 UNTS 205, 6 ILM 386 (1967) (Outer Space Treaty).

[4] See, for example, *Legality of the Threat or Use of Nuclear Weapons* (Advisory Opinion) [1996] ICJ Rep 226.

[5] For a discussion of the applicability (or otherwise) of the terrestrial international environmental law regime to the regulation of outer space see, for example, Bohlmann, Ulrike and Steven Freeland. "The Regulation of Space Activities and the Space Environment." Routledge Handbook of International Environmental Law. Eds. Alam, Shawkat, Md Jahid Hossain Bhuiyan, Tareq M.R. Chowdhury, and Erika J. Techera. UK: Routledge, 2013. 375–391.

and international humanitarian law (also known as the laws of war, or the *jus in bello*), to which I now turn.

The disastrous consequences of armed conflict upon civilians have led to an evolving international consensus, developed over many years, that international legal rules should be introduced and implemented in an effort to alleviate human suffering during times of hostilities. This has seen the emergence of a number of legal principles that limit the methods and means of warfare, and prescribe the rights and protections both of civilians and non-civilians in times of hostilities, a distinction that has been described as lying "at the very heart of the law of armed conflict".[6] These rules are regarded as the most essential of all of the law of nations, in view of the effects of warfare both on states and the broader international system.[7]

These laws and customs of war had their origins in the customary practices of armies on the battlefield. These have existed in various forms almost since antiquity.[8] In 1625, Hugo Grotius, regarded by many as the "father" of international law, published his seminal work,[9] in which he set out what he perceived to be the relevant rules relating to the proper conduct of armed conflict at the time. Since then, the rules have been significantly augmented and codified by a series of important treaty instruments, with the most important of these probably being the Hague Conventions of 1899 and 1907, the four Geneva Conventions of 1949, and Additional Protocols I and II to the Geneva Conventions of 1977.[10]

In (overly) simplistic terms given the space limitations of this chapter, the principal rules under the *jus in bello* can be described as follows[11]:

1. The principle of distinction—deliberate attacks against civilians and non-combatants are prohibited. In addition, those engaged in armed conflict must not use weapons that are incapable of distinguishing between combatants and non-combatants. These represent fundamental concepts in the conduct of military activities and illustrate the strong linkages between the scope of international humanitarian law and the development of formal legal principles for the human rights of the individual;

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[6] Reisman WM (2006) Editorial Comment: Holding the Center of the Law of Armed Conflict. American Journal of International Law 100: 852, 856.

[7] Falstrom DZ (2007) Can International Law Survive the 21st Century? Yes, with Patience, Persistence and a Peek at the Past. San Diego International Law Journal 8: 291, 326.

[8] For a discussion of the historical evolution of the regulation of armed conflict going back some 5,000 years, see Bassiouni MC (2000) A Manual on International Humanitarian Law and Arms Control Agreements. Transnational Publications, USA. 5–15.

[9] Grotius, Hugo. *De Jure Belli ac Pacis* (On the Law of War and Peace) (1625), as translated into English in 1814 by Campbell, A.C. 21 November 2013. http://www.constitution.org/gro/djbp.htm.

[10] For a comprehensive discussion of the various *jus in bello* treaty instruments, see: Roberts A and Richard G (2005) Documents on the Laws of War. Oxford University Press, Oxford.

[11] For further details, see: Freeland, Steven. "The Laws of War in Outer Space." Handbook of Space Security. Ed. Kai-Uwe Schrögl. Netherlands: Springer, forthcoming.

2. The principle of military advantage—attacks not directed at a legitimate military target are prohibited. The important issue is the need to distinguish between civilian persons or objects and military objectives—comprising the elements of 'effective contribution to military action' and 'definite military advantage'; and
3. The principle of proportionality—even when attacking a legitimate military objective, the extent of military force used, and any injury and damage to civilians and civilian property, should not be disproportionate to any expected military advantage. This demands an assessment of any potential "collateral damage" in the case of military action. However, it is often difficult to apply the proportionality principle in practice, given that different people ascribe differing relative "values" to military advantage *vis-à-vis* civilian injury and damage. One only need recall the Advisory Opinion in the *Legality of the Threat or Use of Nuclear Weapons*, where the International Court of Justice, could not say categorically that the threat or use of nuclear weapons would in every circumstance constitute a violation of international law.[12]

4.4 The *Jus in Bello* and the Changing Nature of Warfare

Historically, most commentators have argued that, with regard to these rules of international humanitarian law as applied to activities in outer space, the correct approach is to first try to apply the existing principles to armed conflict involving space technology, and only if it is concluded thereafter that these are not adequate or sufficient, should we elaborate on new additional principles for application to outer space.

This seems also to be the general viewpoint of, for example, the International Committee of the Red Cross (ICRC). At a conference in Bruges in 2010, at which the ICRC kindly asked me to speak, I questioned whether the existing *jus in bello* principles would be adequate and sufficient to regulate all aspects of a space conflict. I suggested that, instead, we should aim towards a complete prohibition of all types of weapons and weapons-related systems involving outer space as an additional *jus in bello specialis* for outer space.[13] However, the prevailing view at the time of many who attended that conference seemed to be that the existing principles *were* adequate and that "new" forms of armed conflict would somehow "fit into" the existing fundamental rules.

I am not entirely in agreement on this point for a number of reasons. Traditionally, the principles of international humanitarian law have often been regarded as being "one war too late". This reflects the typically "reactive" nature of international law where, rather than seeking to establish rules beforehand, it develops new

[12] On this issue, the Court was divided equally, with the casting vote of President Bedjaoui deciding the matter.

[13] Freeland S (2011) Legal Regulation of the Military Use of Outer Space. Collegium—the Journal of the College of Europe 41:87–97

rules (or adapts existing international law rules) to *respond* to certain, perhaps unforeseen, situations that arise. Whilst it is true that certain fundamental customary law principles codified in the United Nations space treaties—including those that aim at minimising the possibility of conflict and the risk of contamination—might be exceptions to this rule of thumb in that they were intended to *prevent* certain situations from arising, the reality is that much of the codification of international law, particularly, as noted above, in areas where technology moves forward very quickly, is (and can only be) responsive in approach. This certainly extends to areas where humans are engaged in conflict—as demonstrated in the area of international humanitarian law, as well as in international criminal law and international human rights law.

Indeed, with reference to space activities, the question arises as to whether, even if we wanted to, we are in a position to be proactive in relation to areas where we still do not fully understand the technology, and the risks and consequences associated with the utilisation of that technology or with certain actions, even where the activity may be "desirable" and, in theory, "permissible". One example of this is space "tourism"—are we really able to create international legal standards at this point, before the fact? Isn't there a risk that, if we attempt to do so, we may be setting standards that subsequent experience will show were not appropriate?[14]

With regard to regulating the conduct of armed conflict—which, by contrast, involves the specification of "undesirable" and "impermissible" actions—I would, however, suggest that a more proactive approach *is* warranted. Weapons-related technology, as well as the advent of different types of (non-state actor) participants in armed conflict has meant that the traditional modes of warfare no longer represent the absolute norm. More and more we will see the incorporation of sophisticated weapons-related systems, involving cyber technology, remote controlled weapons systems (drones), robotics and, of course, satellites to help to fight wars. These present very significant challenges to the application of existing legal frameworks without further adaptation and addition. One might argue that, to continue to rely solely on existing rules that were developed in a previous technological era—as important as they are—is akin to applying twentieth century rules to twenty-first century technology.

As Judge Lachs of the International Court of Justice has observed[15]:

> The great acceleration of social and economic change, combined with that of *science and technology*, have confronted law with a serious challenge: one it must meet, lest it lag even farther behind events than it has been wont to do.

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[14] For a discussion of the legal challenges posed by the anticipated advent of (large-scale) commercial space tourism see, for example: Freeland S (2010) Fly Me to the Moon: How Will International Law Cope with Commercial Space Tourism? Melbourne Journal of International Law 11(1):90–118.

[15] Dissenting Opinion of Judge Lachs in *North Sea Continental Shelf Cases* (*Federal Republic of Germany v. Denmark and Federal Republic of Germany v. The Netherlands*) [1969] ICJ Rep 3, 230 (emphasis added).

Indeed, the advent of this weapons-related technology offers both opportunities and challenges. One interesting opportunity that deserves further consideration is that, to the extent that it allows for greater target selectivity and accuracy, such technology might have the capacity to both minimise casualties during armed conflict and reduce the probability of collateral damage. Both of these consequences would, of course, be welcome and are in keeping with the fundamental *jus in bello* principles; so much so that one might be tempted to argue that they therefore oblige a combatant to *use* this technology during the conduct of armed conflict.

On the other hand, there are real dangers inherent in this continued resort to "zero casualty" style warfare. Apart from the increased likelihood of error during the course of any long distance engagement,[16] there is a real possibility that the physical detachment of the perpetrator from the injury/destruction he/she may render through the use of such technology may give rise to a greater moral, and even ethical, disengagement, and perhaps see a lowering in practice of the minimum threshold of adherence to standards of military conduct. Some commentators have spoken about a "play station mentality", given that the operation of many of these weapons-related systems is not dissimilar to using a computer keyboard. Whilst I am in no way qualified to comment on these suggestions in a meaningful way, history has repeatedly shown that the greater the sense of moral disengagement by combatants, the greater the likelihood that the *jus in bello* principles will be violated. This is clearly a cause for considerable concern and reflection.

4.5 Applying the *Jus in Bello* to Space Activities

As regards outer space, satellite technology now also plays an integral part in armed conflict. The first Gulf War in 1991 is often referred to as the first "space war", in that its conduct was significantly dependent upon satellite capabilities. This trend has ratcheted up considerably in the two decades since that time, in parallel with the increasing commercialisation of outer space. This has led to the growing reliance of states on continuous and reliable access to privately operated satellites, in order to protect their (real or perceived) national security interests.

Indeed, a combination of factors—the increasing dependence by military and strategic forces within (the major) powers on the use of satellite technology; the inability of governments to satisfy such demands for reasons associated either with costs or the lack of technological expertise (or both); and the advent of commercial satellite infrastructure and services that are responsive, technologically advanced,

[16] See, for example, an analysis of the various bombing errors giving rise to significant civilian casualties during the NATO bombing campaign in Serbia and Kosovo in 1999 ("Operation Allied Force") in Freeland S (2002) The Bombing of Kosovo and the Milosevic Trial: Reflections on Some Legal Issues. Australian International Law Journal 150: 150–175.

available and appropriate to meet these demands—has meant that military "customers" are now regularly utilising commercial satellites to undertake military activities.

Thus, we have become familiar with the concept of "dual-use" satellites. The concept of a dual-use facility or resource—typically a commercial facility or resource that is also utilised by the military for its own purposes—has become a common feature of contemporary technological society. It is also one that international law has had challenges with.

This presents particular difficulties for those engaging in armed conflict, since an asset that could *prima facie* be regarded as a legitimate military target on the basis of the *jus in bello* principles might also—even at the same time—be operating for civilian/commercial purposes. It is sometimes very difficult, or indeed impossible, to "quarantine" what is the civilian/commercial aspect of a facility from the military component. Given that such an increasingly important group of space assets used for military purposes comprise these dual-use satellites, one is also drawn to the question as to whether, and in what circumstances, such a satellite can (ever) be regarded as a legitimate target of war. Yet, it is possible that, taking into account at least the first two *jus in bello* principles described above (distinction and military advantage), one could quite cogently construct an argument that, in particular circumstances, a satellite *would* in fact constitute such a target.

This issue seemingly conflicts with the fundamental principles of Article IV of the Outer Space Treaty. Moreover, the resolution of the question I have posed involves not only a consideration of the *jus in bello*, but also the *jus ad bellum*. Also relevant will be the scope of the inherent right to self-defence as articulated under Article 51 of the United Nations Charter, and possibly as modified under customary international law (for example, is there now a right of pre-emptive self-defence under customary international law?).

Moreover, very significant—perhaps insurmountable—difficulties would arise in attempting to apply the principle of proportionality in assessing the legality of a strike against a satellite. Once again, we simply do not fully understand the consequences of such an action, which makes an objective (which, in reality, is a subjective) evaluation of that threshold requirement mere guesswork in most cases, particularly with respect to a dual-use satellite. As a consequence, if our only legal tool of regulation is resort to the fundamental principles of the *jus in bello*, then we might find it very difficult to reach a clear legal conclusion about such proposed action.

4.6 Concluding Remarks: A Willingness for Binding Regulation?

In these circumstances, therefore, my suggested proactive approach would ideally involve the conclusion of a binding treaty instrument that would comprehensively prohibit *all* weapons in outer space, as well as acts designed to permanently damage or destroy an operative satellite. Naturally, the devil would be in the detail, and great care would be required to craft the most appropriate wording for such an instrument. This is not to say that the important *jus in bello* principles would not also be relevant; rather, a specific treaty prohibition would add to and complement those principles to the extent that they apply to the regulation of outer space activities. I am not naïve enough to suggest that agreeing on the most appropriate regulatory framework would be an easy task but, given the uncertainties of relying solely upon the existing principles, I firmly believe that it is a necessary one.

Of course, when one moves to such considerations, one is dealing with areas that are heavily influenced with political considerations. This translates into a willingness—or not, as the case may be—on the part of states to conclude, let alone adhere to, binding international law agreements in relation to the legal regulation of outer space. Discussions among international lawyers are, at times, predicated on an assumption that states actually want such binding rules. But do they really, and in every circumstance?

In 2011, I was invited by UNIDIR to address a conference in Geneva on the issue of the legal regulation of military aspects of outer space, which was attended by delegates of the Member States of the Conference of Disarmament. I believe that I was the only (practicing) lawyer in a room full of diplomats and senior military officials. They listened politely as I spoke about the need for binding principles that, ideally, would prohibit any weaponisation, as well as any "active" armed conflict, in outer space.

Yet, almost as soon as I finished my presentation, the discussion quickly moved away from a path forward based on binding legal rules to one that was centred on that increasingly well-worn mode of "transparency and confidence building measures" (TCBMs). For many complicated and mainly political reasons, it seems clear that the main space powers do not yet feel that there is sufficient mutual trust such as would justify negotiations leading to a binding instrument addressing this issue. Indeed, given the difficulties that some see as far as verification is concerned, it is not likely that such a treaty will be concluded in the foreseeable future.

Of course, reference to TCBMs is quite common in United Nations General Assembly resolutions that deal with various aspects of the use and exploration of outer space, so those involved in areas relating to international law are not unfamiliar with the concept. Indeed, it does make sense for the protagonists to develop cooperative and friendly relations in matters relating to space security, so as to increase the possibility that we might eventually see binding rules.

However, the concern as I see it is that non-binding TCBMs are, in fact, for all practical purposes considered as the "end game" on this issue, so that the formalisation of binding obligations may *never* eventuate. This makes the application of general principles of international law more complicated with respect to this very important area and, in any event, is not satisfactory given the added flexibility that such non-binding regulatory measures may give to states, who may feel at some point that they no longer wish to abide by whatever voluntary guidelines have been specified, irrespective of the political cost.

This highlights again the increasing reliance in the regulation of outer space on so-called "soft law". Putting aside my objections to that descriptor, there is much debate about the legal status of such instruments. Certainly, it appears that some non-binding space instruments have a higher legal "value" than others. However, in (again overly) simplistic terms, at their core they are merely guidelines or recommendations that do not (necessarily) have the force of law, unless they are to be regarded as reflecting rules of customary international law. Given our increasing reliance on such measures in a whole range of space-related matters, do we run the risk that they will work only until they don't? Shouldn't they therefore be regarded only as interim measures, until traditional international law principles and binding instruments can be agreed upon and applied? And, indeed, is this non-binding approach feasible, given the plethora of risks associated with the continued development of space-related weapons technology, which is capable of very significant destruction on a multitude of levels?

These are difficult questions that require a lot of thought. They very much reflect the challenges of regulating outer space in a changing world. Law must play an integral role in addressing these issues. No doubt the terrestrial principles of the *jus in bello* are very important elements in a broader framework—but I believe that, whilst necessary, they are not necessarily sufficient binding norms to cover the challenges that lie ahead. Additional specific legal principles will be required. As we work towards that goal, it will be important to recognise the fundamental sentiment of "humanity" that underpins both space law and international humanitarian law. By doing this, we might get to where we must be for the sake of this and future generations.

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Chapter 5
New Space for Security?

Geopolitics and Sustainability in a Changing World

Columba Peoples

5.1 Introduction

'The first photograph of humanity's home, the earth floating in the void of space, alone and fragile, has changed forever how we think about our species' interaction with the natural world and how we manage our population, resources and environment. Curiously, this new way of looking at ourselves has yet to significantly affect thinking about security'.[1]

Published in 1983 the quotation above from the International Relations theorist Daniel Deudney—the opening statement of his *Whole Earth Security*: *A Geopolitics of Peace*—identified the apparently unfulfilled potential of space technologies for creating 'Whole Earth Security Consciousness'. Deudney's broader argument lamented the fact that the ability to envision Earth from space, as represented and popularised by photos of the Earth viewed from space taken by astronauts on the U.S. *Apollo* missions, had spurred a degree of environmental consciousness but not a corresponding degree of global security consciousness. If anything, the use of space technologies as the supporting reconnaissance, early warning and targeting support infrastructure of the Cold War's nuclear arsenals seemed to further embed divisive and potentially catastrophic geopolitical rivalries (Fig. 5.1).

Fast-forwarding three decades, this chapter revisits some of the thematic questions broached by Deudney's earlier reflections in the context of contemporary developments in global space policy: How have developments in space technologies affected our understanding of global security and insecurity? To what extent do recent developments in space technology and policy simply reproduce geopolitical

[1] Deudney Daniel (1983) Whole Earth Security: A Geopolitics of Peace. Washington D.C.: Worldwatch Institute: 5.

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Fig. 5.1 The 'Blue Marble from Apollo 17' (Source: http://earthobservatory.nasa.gov/IOTD/view.php?id=1133)

rivalries or, conversely, radically alter the nature of geopolitics? Can space technologies enhance global security consciousness?

To address these questions, the chapter uses the period covered by this Yearbook as a microcosm to assess the changing playing field of outer space in respect to security, geopolitics and sustainability. More specifically, the chapter argues that, historically, the development of space policy in relation to security has tended to give rise to two related but countervailing understandings of security: the first characterised here as an understating predicated on 'geopolitics'; and the second characterised as an understanding based on 'sustainability'. Reviewing policy and technological developments in the period specified, the chapter identifies the continuing presence of these two understandings, and a continuing tension between them. But it also points to ways in which these developments might yet provide resources for comprehending the nature of our changing world, and for conceiving global security in relation to it.

5.2 Historical Trends: The 'Securitisation' of Outer Space

The development of space technologies historically can be argued to have had an indelible link to state security and perceived military imperatives. A common assertion is that the Cold War rivalry between the U.S. and the Soviet Union provided not only the spur for developments in military space systems, but that, particularly in its early phases, even the ostensibly civilian space race between the two powers operated as a kind of proxy competition and propaganda war in the absence of direct military engagement.[2] In actuality, the Cold War period was marked by a more complex mix of competitive and cooperative dynamics in the military and civilian spheres respectively. Even as the superpowers continued research and development into military applications of space technologies, Sheehan,[3] for example, notes that the latter decades of the Cold War were characterised by 'an enormous amount of international cooperation'. Moltz[4] similarly traces contemporary concerns with 'space and environmental security' to a 'messy process of trial and error' in the development of both superpowers' scientific understanding of space as an environment, which he argues actually led towards a tendency of 'strategic restraint' in the military uses and application of space power.

In the post-Cold War era, this intermingling of civilian and military imperatives in states' space policies has if anything intensified even to the point of a consequent blurring of the civil-military space distinction. Of course, some would argue that the possibility for potential 'dual-use' of multiple space systems and technologies already creates, and has always created, an inherent ambiguity in this distinction.[5] But the waters have been muddied further in this regard by a trend towards the explicit identification of outer space as a security issue in policy terms, a process termed elsewhere as the 'securitisation of outer space': that is, a trend in which states increasingly identify both space technologies and access to outer space as security issues not just in narrow military terms but also in a much broader sense.[6]

In some instances, this entails simply identifying the centrality of space technologies to the world's most advanced military infrastructures. Thus, for example, the U.S. National Space Policy of 2010 maintains that the U.S. will 'Develop, acquire, and operate space systems and supporting information systems and networks to support U.S. national security and enable defense and intelligence operations during times of peace, crisis, and conflict', and 'Develop and apply advanced technologies and capabilities that respond to changes to the threat environment'.[7] But both states and international organizations now also increasingly assert the broader security functions of space technologies that can variously include crisis

[2] For example, see: Godwin, Matthew. "The Cold War and the Early Space Race." Spring 2006 Institute of Historical Research 21 Nov. 2013. http://www.history.ac.uk/ihr/Focus/cold/articles/godwin.html.

[3] Sheehan M (2007) The International Politics of Outer Space. Routledge, Oxon: 55.

[4] Moltz JC (2011) Asia's Space Race: National Motivations, Regional Rivalries, and International Risks. Columbia University Press, New York: 47, 50.

[5] Balogh, Werner. "Dual Use and Weaponization of Outer Space: Special Legal Issues of the Use of Outer Space Technologies." 13 Jan. 2010 University of Vienna 21 Nov. 2013. http://homepage.univie.ac.at/werner.balogh/pdf/Special%20Issues%20WS2009-2010/Dual%20Use%20and%20Weaponzation%20of%20Outer%20Space%20REV3_13012010.pdf.

[6] Peoples C (2011) The Securitization of Outer Space: Challenges for Arms Control. Contemporary Security Policy 32(1):76–98.

[7] "National Space Policy of the United States of America." 28 June 2010 Executive Office of the President of the United States 21 Nov. 2013. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

management, environmental and disaster monitoring—as in the case of, for example, the space policy discourse of the European Union[8]—and in support of 'human security'—as in the case of Japan.[9] More generally it is now also common to find direct reference to the need for 'sustainability' in both access to space and maintenance of the space environment itself as prerequisites for the security of terrestrial infrastructure, economics and political institutions, with even the more narrow defence provisions of the U.S. National Space Policy now positioned in relation to a broader principle of sustainability in this respect.[10]

In short, it can be argued that, historically, there has tended to be two interrelated but nonetheless relatively distinct understandings of security at play in space policy discourses: one based on a more narrow or traditional national security concept that emphasises the military applications and value of space assets and space as an environment as a key facet of contemporary geopolitics; the other based on a conception of security broadened to include non-traditional issues and even the use and sustainability of space as an environment as a security issue in its own right. To what extent, then, have developments in space policy and space technology in the period between July 2012 and June 2013 continued or bucked these trends?

5.3 Space for National Security: Developments in 2012–2013

Although, as noted above, a trend has emerged in which major space powers situate or frame their space policies in relation to broad understandings of security that encompass non-military issues and questions of environmental sustainability, key developments in the period of July 2012 to June 2013 still attest to the continued prevalence of a more narrow focus on the uses of space for national security purposes within states' policy discourses. It is not the case that there is a zero-sum relationship between such 'broad' and 'narrow' understandings, or that the former has simply displaced the latter. Rather, the advent of broader, sustainability-focused understandings in states' space policy discourses coexist—at times uneasily—with a continued focus on national security and geopolitics in a more traditional sense.

As hinted in the previous section, the space policy of the United States remains emblematic of this diptych. Under the first Obama Administration U.S. space policy

[8] Peoples C (2011) The Securitization of Outer Space: Challenges for Arms Control. Contemporary Security Policy 32(1):76–98.

[9] Peoples C (2013) A normal space power? Understanding 'security' in Japan's space policy discourse. Space Policy 29(2):135–143.

[10] "National Space Policy of the United States of America." 28 June 2010 Executive Office of the President of the United States 21 Nov. 2013. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

had initially been argued by some to have 'reversed' the previous stance of George W. Bush-era space policy.[11] In particular, in the National Space Policy 2010's allowance for consideration '[of] proposals and concepts for arms control measures if they are equitable, effectively verifiable, and enhance the national security of the United States and its allies', taken in tandem with the National Security Strategy 2010's identification of the 'space domain' as a part of the wider 'connective tissue around our globe upon which all nations' security and prosperity depend',[12] was seen by many as representing a discernable shift towards a more global and multilateralist outlook in U.S. space policy. Indeed some critics of the Obama Administration even went so far as to identify the National Space Policy of 2010 as 'reveal[ing] that national security is subordinated to policies for seeking cooperation, transparency, and most of all, arms control agreements regarding space systems and operations' with a consequent risk of 'the U.S. losing its military and intelligence advantages in space and increasing the effectiveness of "anti-access" strategies of U.S. adversaries'.[13]

In the period since those statements, though, the U.S. has remained generally cautious and reticent with regard to the development of any new binding regime on the uses of outer space, and particularly in relation to arms control. Most notably, the year in space policy saw no break in the 'deadlock' on PAROS (the proposal on Prevention of an Arms Race in Outer Space) even as it continued to remain an item for discussion at the Conference on Disarmament in March 2013.[14] It would of course be simplistic to lay entire responsibility for this continued deadlock on the U.S.—major proponents of PAROS, such as Russia and China, can doubtless as easily be accused of their own geopolitical machinations in relation to the proposal with a view to clipping the wings of the U.S. as a military space power. But in the absence of movement on PAROS or the emergence of a binding alternative to it acceptable to the U.S., the U.S. has continued to develop its emphasis on space for national security. The 2010 National Space Policy stipulated that '[The Secretary of Defence shall] Maintain the capabilities to execute space support, force enhancement, space control and force application missions', and subsequent policy and technological developments appear to have continued in the same vein.[15] In October 2012 a U.S. Department of Defence Space Policy Directive reasserted the commitment to

[11] Broad, William J. and Chang, Kenneth. "Obama Reverses Bush's Space Policy." New York Times 29 June 2010: A19.

[12] "National Security Strategy." May 2010 The White House 27 Nov. 2013. http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf.

[13] Spring, Baker. "Obama's National Space Policy: Subordinating National Security to Arms Control." 6 July 2010 The Heritage Foundation 27 Nov. 2013. http://thf_media.s3.amazonaws.com/2010/pdf/wm2950.pdf.

[14] "Space Security Index 2013" 2013 Spacesecurity.org. 27 Nov. 2013. http://www.spacesecurity.org/spacesecurityindexfactsheet.pdf.

[15] "National Space Policy of the United States of America." 28 June 2010 Executive Office of the President of the United States 21 Nov. 2013. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

Fig. 5.2 'U.S. Air Forces X-37B Space Plane' (Source: http://www.nbcnews.com/id/47965089/#.Uo3_LsS-3To)

'maintain and enhance the national security advantages afforded by the use of space' and 'the capabilities to respond at the time and place of our choosing'.[16] In the context of wider concerns over the scale of defence spending, commentators have noted that '[U.S.] Military space programmes appear to be in very good shape', with some estimates putting the portion of the overall Department of Defense spending request for 2014 for military space initiatives at 8 million U.S. dollars (Fig. 5.2).[17]

Tracking the funding of such initiatives, as well the development technologies is, of course, fraught with difficulties in access to reliable data and figures. However, the apparently successful testing of technologies such as the US military's X37-B (the so-called 'space plane'), which reportedly tested a second trip in to orbit in June 2012, does little to dispel the impression that the stated U.S. commitment to development of its capacity for space control and force application missions is anything other than serious.[18] Once again, though, it would be remiss to identify the U.S. as the only space power with an apparent interest in continued updating and innovation of military space technologies and capabilities. As noted by the Space Security Index, Russia continues to maintain the world's second largest fleet of military satellites, while in the past year China has continued to develop its Beidou satellite constellation which, for some U.S. observers at least, is frequently to be interpreted as presaging an independent Chinese capability for space-based military

[16] "Department of Defense Directive Number 3100.10: Space Policy" 18 Oct. 2012 U.S. Department of Defense 27 Nov. 2013. http://www.dtic.mil/whs/directives/corres/pdf/310010p.pdf.

[17] Werner, Debra. "U.S. Military Space Spending set at $8 billion for 2014." 17 April 2013 SPACE.com 27 Nov. 2013. http://www.space.com/20702-united-states-military-space-budget-2014.html.

[18] Wall, Mike. "China deeply suspicious of US Air Force's X-37B space plane." 26 July 2012 NBC News 27 Nov. 2013. http://www.nbcnews.com/id/47965089/#.Uo3_LsS-3To.

navigation.[19] At the very least, even more cautious observers of China's apparent 'rise' in space view the lack of a clear distinction between civil and military space developments in Chinese policy as perpetuating ambiguity over its potential military dimensions. [20] And in Asia more generally, North Korea's launch of an Earth observation satellite in December 2012 drew attention once again to the potential for a regional space security dilemma wherein national imperatives,[21] including also the development of Indian and Japanese space programmes, might lack sufficient regional coordination to allay fears that such developments have military applications.[22]

5.4 Space for Sustainability: Developments in 2012–2013

Whilst national space policy discourses tend to indicate continuing interest and investment in military space capabilities, thus indicating a more narrow concern with military security and traditional geopolitical concerns, international discussions of 'sustainability' in relation to outer space also continue to develop. Such discussions of sustainability in turn fall into two interrelated but distinct areas. The first is in relation to the sustainability of space as an environment for present and future human activity. As the Secure World Foundation—a key non-governmental organization advocating space for sustainability in this sense—defines it, space sustainability entails 'Ensuring that all humanity can continue to use outer space for peaceful purposes and socioeconomic benefit in the long term. This will require international cooperation, discussion and agreements designed to ensure that space is safe, secure and peaceful'.[23] Here a key focus continues to be the risks posed by effects of space debris, or, more accurately, the 'increasing density of debris in orbit', as well as the subsidiary challenges posed by the 'crowding' of satellites in key orbits and the continuing possibility that 'interference with satellites could spark or escalate tensions and conflict in space' (Fig. 5.3). And as the number and range of actors with a vested interest in access to space increases, so too does the imperative of space sustainability increase. 2012–2013 was no exception to this dynamic with the number of non-state actors interested in accessing outer space both increasing in quantitative terms and advancing, in some instances, in terms of technological capability (witness, most notably, the delivery of the 'Harmony'

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[19] "Space Security Index 2013" 2013 Spacesecurity.org. 27 Nov. 2013. http://www.spacesecurity.org/spacesecurityindexfactsheet.pdf.

[20] For further discussion consult: Zang; Hilborne.

[21] Hertzfeld HR and Li S (2013) Registration of the 12 December 2012 satellite launch by North Korea: Should UNOOSA have accepted it? Space Policy 29(2):93–94.

[22] For an extended discussion, consult: Moltz JC (2011) Asia's Space Race: National Motivations, Regional Rivalries, and International Risks. Columbia University Press, New York.

[23] "Space Sustainability: A Practical Guide." 2013 Secure World Foundation 27 Nov. 2013. http://swfound.org/media/121399/swf_space_sustainability_a_practical_guide_2013_edition.pdf.

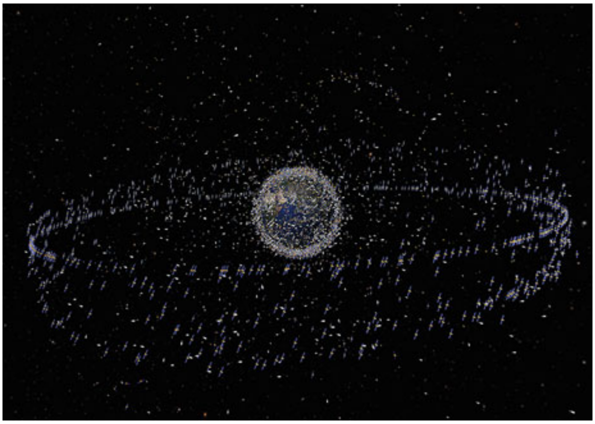

Fig. 5.3 'Space debris: An illustration of the problem' (Source: http://d1jqu7g1y74ds1.cloudfront.net/wp-content/uploads/2008/04/space-debris-1.jpg)

module to the International Space Station by the privately owned SpaceX in March 2013).

To some extent the year in space policy reflected a general acknowledgement by states of the need to develop an international regime to maintain sustainable uses of outer space. The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) met in February 2013 with an agenda of preserving 'Long-Term Sustainability of Outer Space Activities' (LTSOSA), which COPUOS had previously, in 2010, delegated to a specific scientific and technical committee of the same name.[24] In July 2013 the LTSOSA working group completed its draft report, which emphasised the need for greater transparency and confidence building measures between states as a prerequisite for the sustainable use of outer space. However, the LTSOSA framed these recommendations as voluntary 'best practices' for the use of outer space, as was specified by its initial remit.[25] While this should not be dismissed entirely—the activities of COPUOS and the LTSOSA indicate that member states of the UN at least acknowledge and are engaging with issues around space sustainability—the recommendations of the LTSOSA remain non-binding. And as Peter Martinez, the Chair of the LTSOSA working group remarked to the UNIDIR Space Security Conference in April 2013, significant issues remain even in defining 'best practice' in relation to space sustainability: the working group continued to encounter the challenge posed by the fact that states still have different views on what constitutes 'sustainability', that established space actors retained a concern that such initiatives should not 'limit their freedom of

[24] "Working Group on the Long-Term Sustainability of Outer Space Activities (LTSOSA)." 29 May 2013 United Nations Committee on the Peaceful Uses of Outer Space 27 Nov. 2013. http://www.asc-csa.gc.ca/pdf/eng/events/2013/20130529-uncopuos-ltsosa-eng.pdf.

[25] Chow, Tiffany. "UNCOPUOS Long-Term Sustainability of Space Activities Working Group Fact Sheet." June 2013 Secure World Foundation 27 Nov. 2013. http://swfound.org/media/109514/SWF_UNCOPUOS_LTSSA_Fact_Sheet_June_2013.pdf.

action in space', and that emerging space actors were concerned that any space sustainability initiatives should not limit their freedom to act in space'.[26]

One potential reading of this would be to suggest that even such discussions of space sustainability tend to ultimately transpose the earthly geopolitical concerns of nation states onto the space environment: states express a general interest in pursuing sustainability, but have reservations about how such initiatives might curtail and constrain their own interests. An alternative understanding of sustainability in relation to the uses of outer space, however, might instead be detected in the ongoing and increasing emphasis on satellite remote sensing and imaging technology as a means of gauging environmental and climatic change on Earth itself in a way that potentially transcends state interests and boundaries. This second understanding of sustainability has clear overlaps with the first—dependent as it is on the viability of space as an environment for the safe operation of satellites—but has a more explicit Earth-facing aspect.

In terms of international developments in the year in space policy, the European Union's Copernicus programme (the re-branded version of its previous Global Monitoring for Environment and Security—GMES—programme) remained emblematic in this respect. In July 2013, the European Parliament gave the 'green light' for a multiannual financial framework budget for the period 2014–2020 to include the provision of 3,786 million euros for the programme.[27] For its proponents, Copernicus is fundamentally distinguished by its potential to enhance global understanding of terrestrial sustainability. The European Space Agency in particular has heralded the programme as having the capacity to '[. . .] make a step change in the way we care for the planet by providing reliable, timely and accurate services to manage the environment, understand and mitigate the effects of climate change and help respond to crises'.[28]

Previous analysis of GMES (as the prior incarnation of Copernicus) raised questions as to the extent to which the programme was entirely detached from or independent of broader capacity-building in European defence[29] or from more traditional security concerns such as combating terrorism via overhead intelligence provision, and the management and monitoring of the EU's external borders.[30] The future development of Copernicus will consequently be of interest in terms of

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[26] Martinez, Peter. "UN Committee on the Peaceful Uses of Outer Space (UN COPOUS)." Presentation. UNIDIR Space Security Conference. Geneva, Switzerland. 2 Apr. 2013.

[27] "Green Light for GMES Copernicus." 4 July 2013 European Space Agency 27 November 2013. http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Green_light_for_GMES_CoperCoper.

[28] Ibid.

[29] Oikonomou I (2012) The European Defence Agency and EU military space policy: Whose space odyssey? Space Policy 28(2):102–109.

[30] Remuss, Nina-Louisa. "Space and security as an identity forming element – meeting Europe's external and internal security through space applications." European Identity though space: Space Activities and Programmes as a Tool to Reinvigorate the European Identity. Eds. Christophe Venet and Blandina Baranes. Vienna: SpringerWienNewYork, 2012. 132–144.

Fig. 5.4 'Satellite Image of deforestation in Mato Grosso, Brazil' (Source: http://www.mongabay.com/10deforestation_satellite.htm)

whether the 'step change' envisaged by the ESA is developed solely in terms of the ethic of planetary care suggested above. But looking beyond the formal governmental sphere, and particularly within the wider scientific community, substantial interest in the potential uses of outer space for deepening our collective understanding of terrestrial sustainability is detectable. June 2012, for example, witnessed the launch of the 'Future Earth' initiative, a 10-year research project that aims to 'develop the knowledge for responding effectively to the risks and opportunities of global environmental change and for supporting transformation towards global sustainability in the coming decades'.[31] Though not solely concerned or dependent on space technologies, the use of earth remote sensing from outer space is a crucial dimension of such initiatives, as is the capacity to visualise from space issues such as deforestation, coastal erosion, and the melting of icecaps over time (Fig. 5.4). Similarly, and largely independent of GMES/Copernicus, the ESA's 'Living Planet' initiative, with the most recent such symposium held in Edinburgh in September 2013, likewise embodies an attempt to incorporate satellite and earth remote sensing technologies to monitor changes in the global condition—particularly changes in the Earth's biosphere—from afar.[32]

[31] "Future Earth: Research for Sustainability." International Council for Science 27 Nov. 2013. http://www.icsu.org/future-earth.

[32] "Living Planet Symposium 2013" 9 Sept. 2013 Living Planet 27 Nov. 2013. http://www.livingplanet2013.org/.

5.5 Conclusion: New Space for Security?

So where, ultimately, does the future of 'space security' lie? In the continued transposition of states' geopolitical concerns onto the space environment? Or in the development of a broader and all-encompassing global vision of 'Whole Earth' sustainability and security? Developments in 2012–2013 would seem to attest to the continuing centrality of state-led initiatives on outer space. These initiatives may often point to or invoke broader understandings of space for sustainability, but even as they do so an often competing concern for national security, national self-interest and freedom of action remains a key factor. And in many instances it still seems that such concerns not only pose problems for, but also ultimately take precedence over, a broader understanding of space for sustainability. Yet, as also noted, nascent developments beyond the formal governmental sphere continue to point to the possibilities for a more comprehensive vision of 'Whole Earth Security'. As one of the foremost commentators on the subject puts it 'With the space age humanity has achieved unprecedented power, but has also come to experience, and to be fully aware of, unprecedented vulnerability. The ability to be simultaneously aware of both is the result of the unprecedented wealth of information and alternative ways of interpreting it, that space exploration and exploitation brought about through satellite technology and the computing revolution'.[33] Initiatives towards more consciously employing space systems and technologies towards advancing our understanding of the vulnerability of both space and earth environments, such as those indicated here, remain embryonic in nature; but they do also point to the continuing potential of space technologies for interpreting and envisioning 'global' security in a radically different way.

[33] Sheehan M (2007) The International Politics of Outer Space. Routledge, Oxon.

Chapter 6
Emerging Space Powers of Latin America: Argentina and Brazil

Robert C. Harding

6.1 Introduction

The Cold War space race between the United States (U.S.) and the Soviet Union was an integral part of the East-West struggle of that time period. Once the U.S. accomplished Kennedy's mandate to be the first on the Moon, the competition wound down like an unattended clock, even witnessing sporadic superpower cooperation such as the Apollo–Soyuz Test Project in 1975. After the fall of the Soviet Union, the U.S. decision to mothball its space shuttle fleet was a seeming dagger in the heart of the ambitious first 50 years of space activities.

However, into the resulting partial vacuum of space activities has entered an ever-expanding and diverse list of states. While there have been complementary space programmes in other developed regions, such as in Japan and the European Union (EU) for a long time, the novelty of this new, emerging era in space activities is that a growing number of states with active space policies are developing countries. The motivation of many of these countries, particularly the larger and wealthier ones, is not unlike that of the original space powers. These newest entrants into space activities have prioritised space-related programmes and investments as a means to achieve economic, and even military, security.

While Asian countries such as China, Japan, and India are leading the pack in this new space era, Latin America is nonetheless notable in that many of its states likewise have sought to pursue space capabilities and the resulting technological, economic, and strategic advancement it brings. Currently, four Latin American states have developed at least some rudimentary level of launch capability and still others are building their own satellites, purchasing others' space technology to further their national interests, or even contributing space-related technology to other countries' space programmes. At the forefront of Latin America's space

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ambitions are two of Latin America's largest and most technologically advanced countries, Argentina and Brazil. As will be demonstrated, their interest in space programs is a logical, and even predicable, development in this emerging twenty-first century space race.

6.2 The Changing Geography of Space Power

Since the earliest days of the space race, the growth of space programmes has often existed in a simultaneous, and even symbiotic, relationship with missile and nuclear weapons programmes, which I have termed the missile-nuclear-space (MNS) triad.[1] From Nazi Germany's V-2 programme in the 1930s to North Korea's contemporary satellite launcher programme, many countries' decision to pursue ballistic missile development has been rooted in perceived national security concerns and, consequently, to be a potential vehicle for desired nuclear armaments. These two aspirations frequently became the genesis for space programmes, partly as an offshoot of these technologies and partly as concealment for their development. As such, the oft-repeated rhetoric of space being used for the common good belies the historical fact that these space programmes have instead been traditionally an extension of military, and later, economic competition among the world's leading powers.

From the standpoint of the realist tradition in international relations, this makes perfect sense. Realism stresses that states will pursue those strategies meant to ensure the survival and prosperity of the state via a variety of power options. By extension, the launch of *Sputnik* in 1957 forever changed how states viewed the role of space programs as elements of this pursuit of power. The ability to launch payloads into space, and perhaps even control and/or deny space, became a matter of strategic advantage, national sovereignty, and national security. Later, as technology progressed, the economic necessity of space-based assets only added to the importance of space policy. As such, the development of a space programme is a representative example of power because it allows states to exercise both hard and soft power. The hard power of space programmes includes its direct military applications, such a spy satellites, and economic means to influence the behaviour or interests of other actors. Conversely, the soft power of space programme involves more subtle means that build prestige and influence others as well as one's own population.

A number of scholars over the past four decades have documented this power-oriented space struggle (e.g., McDougall 1985; Dolman 2001; Hardesty and Eisman 2007), and even a cursory examination of the Cold War space race reveals that both the U.S. and Soviet Union perceived their respective space programmes in the same

[1] Harding RC (2013) Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier. Routledge, London: 29.

light—political tools in a global political struggle. While not every state with an interest in space has pursued it with realist abandon, the history of space programmes to date strongly suggests that those states with adequate economic and political power have been inclined to at least try to achieve the MNS triad.

Besides the United States and the Soviet Union/Russia, other economic powers, such as France, Britain, and later, Japan, all developed indigenous rocket programmes, which evolved into national space programmes (or supranational, in the case of ESA). But space is no longer the sole domain of these traditional hegemons. While 23 of the top 25 countries measured by gross domestic product (GDP) have formal space programmes, the real additional growth of space programmes is found in the developing world.[2] From this total, in the coming decade at least one-third of these launches are projected to come from developing countries while only 26 % are anticipated to be from the United States. While private endeavours such as Space-X have been promoted in the United States as the key to furthering space activities, national government expenditures on space programmes will nonetheless remain the dominant factor in space activities. Some two-thirds of the over 1,100 satellites planned for launch in the coming decade will be government, not private-owned. From this number, new satellite systems emanating from some three dozen different emerging space countries will add previously undreamt diversity to the increasingly crowded orbital pathways.

6.3 Brazil's Political Space Ambitions

For much of its history, Brazil has existed as something of a dichotomy. Living in the world's fifth-largest country by area, Latin America's most populous state, and the seventh-largest economy in the world, Brazilians have long considered their country a natural regional and even potential world power. This concept of greatness (*grandeza*) provides a good basis for understanding the logic of Brazil's national development and defence priorities as they pertain to its space program. As early as World War II, Brazil was one of only two Latin American countries (along with Mexico) to commit troops to the Allied war effort, sending the 25,000 strong Brazilian Expeditionary Force (FEB) and two air force squadrons to Italy and committing its navy to patrolling the South Atlantic for German U-boats. Besides being a noteworthy historical footnote, Brazil's participation in the war marked the beginning of a concerted effort by Brazilian policymakers to elevate the country's standing and prestige in world affairs.

The post-war years saw Brazilian efforts in the development of ballistic missile and nuclear technologies follow the path blazed by the U.S. and Soviet Union. Brazilian nuclear research had already begun by the late 1930s and by 1947 the

[2] "Government & Industry to Combine for 1,150 Satellites Over Next Decade." 18 Dec. 2008 Euroconsult 4 Nov 2013. http://www.euroconsult-ec.com.

Brazilian navy became an enthusiastic advocate of developing nuclear energy and related technologies. The first U.S.-supplied research reactor came online in 1957 followed by two more West German-supported reactors during the next five years. The leaders of the 1964 military coup vowed to complete the nuclear fuel production cycle and develop an indigenous ballistic system for its delivery. In 1968, a then-secret government memo, the "National Strategic Concept," argued the importance of these two strategic areas as a means to elevate Brazil's prestige and world standing.[3]

Under a policy called *segurança e desenvolvimento* (security and development), Brazil likewise sought to bolster its sovereignty by reducing its reliance on outside weapons suppliers, particularly the United States, which Brazil viewed as an increasingly unreliable supplier during the Vietnam War.[4] There was also an assumption that the creation of a strong indigenous defence industry would boost Brazil's political and economic clout in the developing world, thus supporting its self-image of *primus inter pares*. Within a decade of the founding of the state-owned Embraer aircraft manufacturer in 1969, Brazil had nurtured the growth of a diversified and vibrant military-industrial complex that attracted both domestic and international investments in domestic missile launchers, tanks, and aerospace technology. Among the largest private entities that grew tremendously during this time was Avibras, a diversified company that makes artillery, rocket, and aircraft systems. The cancellation in 1977 by the United States of a military financing agreement out of fear of Brazil's nuclear programme only accelerated and deepened the growth of its domestic arms industry. This action led directly to Brazil becoming a leading exporter of weapons, particularly to the Middle East.[5]

The promotion of space as the third leg of the MNS triad was a logical step taken by the military governments of Brazil, which assertively predicted that Brazilian-made satellites would be launched atop Brazilian-made rockets. Symbiotically, the Brazilian leadership assumed that a space programme would further promote an even greater degree of technological independence in areas such as informatics, the arms industries, nuclear energy and weapons, and satellite technologies. By late 1965, foreign sounding rockets as well as the indigenous Brazilian *Sonda* rockets were being launched from the newly constructed Centro de Lançamento Barreira do Inferno (Barrier of Hell Launch Centre) in the state of Rio Grande do Norte. From this site, more than 2,000 launches would take place, many reaching altitudes of over 1,100 km.

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[3] "Reforma Da Carta Da OEA" 25 Jun. 1968 Government of Brazil 2 Oct. 2013. http://docvirt.com/docreader.net/docreader.aspx?bib=ACER_PNB_AD&pasta=PNB%20ad%201967.02.23.

[4] Kapstein EB (1990–1991) The Brazilian Defense Industry and the International System. Political Science Quarterly 105(4): 508.

[5] Marcella G (1982) Security Assistance Revisited: How to Win Friends and Not Lose Influence. Parameters 12(4): 43–52.

By 1969, Brazil's first space agency, the Institute of Space Activities (INPE), was founded but was soon absorbed into the military-supported Brazilian Commission of Space Activities (COBAE). The unstated mission of the COBAE was straightforward: to help achieve Brazilian self-sufficiency in missile technology, which would support the Brazilian military's goal of clandestinely developing a nuclear weapons programme.[6] In 1982, the Alcântara Launch Centre was constructed on Brazil's northern Atlantic coast, along with a tracking station in the western state of Mato Grosso and a mission control centre in São Paulo. At just two degrees south of the equator, Alcântara is still the world's best launch site in terms of launch efficiency, load capacity, and downrange safety.

Brazil was sufficiently successful in nurturing the country's technological capacity to be one of only two developing countries (along with Argentina) to sign the 1987 Missile Technology Control Regime (MTCR), an agreement that sought to control the proliferation of ballistic missiles. The downfall of the military regime also resulted in a parallel downturn in the Brazilian defence industry. Instead, Brazil sought space technology partnerships with other aspiring and growing space actors. In July 1988 Brazil and China signed a protocol for the development of two high-resolution remote-sensing satellites, CBERS-1 and CBERS-2. These satellites were designed to monitor the deforestation of the Amazon region, an area that comprises about one-third of Brazilian national territory and contains about two-thirds of all the tropical forests on Earth. The forest's preservation was declared by the Brazilian government to be a matter of national security.

By the early 1990s, Brazil was moving decisively away from previously military-oriented space policies, and had publicly abandoned its nuclear weapons and ballistic missile programs. The space programme itself was transferred to civilian control and the new Brazilian Space Agency (AEB) was founded in 1994 (though Alcântara remained a military-administered facility). The next year Brazil became a member of the Missile Technology Control Regime (MTCR), which required the country to pass legislation to tighten export control laws for dual-use items so that Brazil could retain its space programme. Then in 1997–1998 Brazil signed and ratified the Nuclear Non-Proliferation Treaty (NPT), thus officially removing the old national security raison d'être of the missile programme. Brazil's growing policy emphasis on the cultivation of its space programme is nonetheless part and parcel of its enlarged and redefined national security and socioeconomic development priorities.

In concert with the reorientation of its space policy, Brazil unambiguously sought to use its space programme to bolster its international standing as an economic and political rising power through international cooperation in space activities. In 1997, Brazil signed a memorandum of understanding that committed the country to a 100 million Euros investment of hardware to the International

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[6] Patti, Carlo. "Origins and Evolution of the Brazilian Nuclear Program (1947–2011)." Wilson Center. 22 Oct. 2013. http://www.wilsoncenter.org/publication/origins-and-evolution-the-brazilian-nuclear-program-1947-2011.

Space Station (which was subsequently pared down to just 8 million Euros). The Brazilian government has clearly stated that its space programme is "strategic for the sovereign development of Brazil" and possession of an autonomous space programme will allow it to have more diplomatic strength to achieve its long-term goals of a more powerful Brazil.[7] In 2005, Brazil paid 13 million Euros to Russia to train the first Brazilian astronaut, Lieutenant Colonel Marco Pontes, of the Brazilian air force. The next year, after a trip aboard a Russian rocket, Pontes spent a week aboard the International Space Station. While having no scientific value, the image and prestige value in promoting the Brazilian space effort was immeasurable.

Two tests of the indigenous Satellite Launch Vehicle (VLS) failed in flight in 1997 and 1999. In the early 2000s, Brazil offered NASA a cooperation agreement to use the Alcântara launch facility. After U.S.-proposed amendments to the agreement, which heavily favoured the U.S. in terms of technology transfers, were invalidated by the Brazilian congress, Brazil proceeded to negotiate with other space powers. Just eight months later, in August 2003, a catastrophic explosion of the VLS on the launch pad destroyed the site and killed 21 engineers and technicians. In 2008, Brazil concluded an agreement with the Russian Space Agency (RKA) to create the *Cruzeiro do Sul* (Southern Cross) Programme, which was to produce five different launch vehicles based on the Russian *Angara* launcher. Over 1 billion Euros were allocated for modification of the Alcântara facility. The expense was considered justifiable because Brazil's space policy is vital to the country's strategic policies.[8]

In 2013 however, Brazil decided to scale back its cooperation with Russia to focus on smaller launch vehicles that could be built using more domestically manufactured parts. Brazil and Germany are currently working on construction of a micro-satellite launcher able to put a 150 kg capacity into a 300 km orbit. To replace the larger Russian launcher, a cooperation agreement was signed between Ukraine and Brazil that same year, which called for the construction of a Ukrainian-designed *Cyclone-4* launch vehicle that would be specifically designed for use from Alcântara. The cooperation resulted in the creation of the Alcântara Cyclone Binational Space Company (ACS) with its headquarters located in Brasília. In 2010, Brazil broke ground on the new ACS launch site, which may cost upwards of 1 billion Euros. The first launch is scheduled for some time in 2015.[9]

[7] Brazilian Space Agency. "National Program of Space Activities: 2005–2014. Ministério da Ciencia e Tecnologia, Brasília" 14 Oct. 2013. http://www.aeb.gov.br/wp-content/uploads/2013/03/PNAE_INGLES.pdf.

[8] "Brazil To Propose $10 Million Space Station Contribution." 14 Oct. 2013. http://www.spacenews.com/article/brazil-propose-10-million-space-station-contribution.

[9] "Ukraine, Brazil Prepare for 2015 Cyclone 4 Launch." 24 Sept. 2013. Aviation Week 4 Oct. 2013. http://www.aviationweek.com/Blogs.aspx?plckPostId=Blog:04ce340e-4b63-4d23-9695-d49ab661f385Post:18609d33-7ed2-47b1-a7b2-19d6282a2cf2.

6.4 Argentina's Back-to-the-Future Space Plan

Like its northern neighbour and erstwhile rival, Argentina has had a long history of political ambitions that, for a time, encouraged the policy prioritisation of the MSN triad. This same trajectory led directly to the modern Argentine space programme. Similar to Brazil, Argentina's formal interest in developing rocketry blossomed after World War II. Latin America's first private space organisation, the Argentine Interplanetary Society, was founded by Teofilo Tabanera in Argentina in 1948 and the country became a founding member of the International Astronautical Federation in 1951.[10] Tabanera then went on to become the director of the predecessor to the country's space programme, the National Commission of Space Research (CNIE), in 1960. The CNIE worked in cooperation with the Argentine military's Institute of Aeronautical and Space Research (IIAE) to produce Latin America's first high-altitude sounding rockets and experimented with liquid fuelled missile technology.

Concurrently, Argentina aspired to achieve some measure of the prestige it held in the early twentieth century as one of the world's wealthiest countries—but this time through the tools of modern war. Immediately after the war, President Juan Domingo Perón contracted renowned German aeronautical engineer, Kurt Tank, to head the Instituto Aerotécnico in Córdoba. There, Tank designed and built for Argentina one of the world's first jet fighters, the *Pulqui II*. At the same time, one of Tank's former associates, Austrian scientist Ronald Richter, was also hired on the promise that he could generate energy from cheap nuclear fusion. The resulting attempt, called the Huemul Project, received an estimated 200 million Euros (in 2013 Euro) in funding, though after 3 years Richter's research was ultimately shown to be specious. Even so, Argentina's National Atomic Energy Commission (CNEA) was founded in 1950 to officially oversee three research reactors and to promote nuclear energy. In reality, the CNEA was a cover for the Argentine military's attempt to develop a nuclear weapons programme, which included the construction of a gaseous diffusion enrichment plant and reprocessing facilities. Not coincidently, Argentina refused to sign the Nuclear Non-Proliferation Treaty (NPT) or ratify the Treaty of Tlatelolco (which sought to make Latin America a nuclear-free zone).

The ballistic missile portion of the MNS triad was equally pursued. Though the Argentine military had experimented with liquid fuel rockets in the late 1940s and early 1950s, the programme accelerated in the 1960s with Argentina entering into a number of cooperative agreements with the United States, and receiving U.S. supplied technical data on sounding rockets and space launch vehicles.

[10] "History." International Astronautical Federation. 11 Nov. 2013. http://www.iafastro.org/index.php/about/history.

The result was an Argentine foundational sounding rocket programme using the indigenous, two-stage *Gamma Centauro*.[11] Contemporaneously, Argentina initiated its official space programme. In 1960, the first official state space agency was born, the National Commission of Space Research (CNIE). Further technical cooperation with West Germany yielded a two-stage solid-fuel rocket *Castor*, which provided a test platform for a more powerful future missile.[12]

Argentina missile ambitions truly took off following the 1976 military coup. The Argentine air force's General Management of Space Projects division, working with the West German company Messerschmitt-Bölkow-Blohm, promoted a single-stage ballistic missile called *Cóndor*, which was public advertised as a new sounding rocket. A number of other European countries—Austria, France, Italy, Spain, and Switzerland—contributed to the project.[13] A secret 150 million Euros missile research complex built in Falda del Carmen, near Córdoba, was supposed to produce a launcher capable of putting 200 kg into low Earth orbit. At the same time, the tactical, short-range battlefield ballistic missile *Alacrán* (Scorpion) was developed though never put into production for the Argentine military.[14]

Near-war with Chile in 1978 over the Beagle Channel and the country's defeat in the 1982 Falklands War, in part because of a shortage of French-made Exocet missiles, further emboldened the Argentine military to pursue a ballistic missile option. Even after the fall of the military government and the election of Raúl Alfonsín in 1983, the project continued as it attracted much needed foreign investment from twenty different European companies. By 1985, following a test launch of the *Cóndor*, the Argentine military acknowledged the missile's military utility and predicted the country's inclusion in the ballistic missile "club."[15,16] The follow-on project was the *Cóndor II*, which was expected to carry a 500 kg warhead over a 1,000 km range, thus giving Argentina a clear strategic regional advantage. The project was a joint effort between Argentina, Egypt, and Iraq (an almost-identical missile facility was built in Iraq during the development of the *Cóndor II*). Egypt contributed technical information, almost 3 billion Euros, and functioned as a middle-man with Washington, while Iraq lent foundational missile technology and about 75% of the funding. The collaboration was a classic case of *manus manum lavat*: Iraq and Egypt hoped to acquire advanced, longer-range missile technology to counter Israel and Iran, and Argentina aspired to establish a profitable

[11] Sánchez PM (2000) Scientific experiences using Argentinean sounding rockets in Antarctica. Acta Astronautica 47(2):302–303.

[12] Manfredi AF et al. (1986) Ballistic Missile Proliferation Potential in the Third World. Congressional Research Service, Washington, DC: 16.

[13] Nolan J (1991) Trappings of Power: Ballistic Missiles in the Third World. Brookings Institution Press, Washington, D.C., 53.

[14] Mistry D (2003) Containing Missile Proliferation: Strategic Technology, Security Regimes, and International Cooperation in Arms Control. University of Washington Press, Seattle, 75–76.

[15] Friedman A (1985) Flight of the Condor. International Defense Review August 1985: 1357.

[16] Barcelona E and Julio V (1992) Relaciones carnales: la verdadera historia de la construcción y destrucción del misil Cóndor II, Planeta, Buenos Aires: 22.

missile market in the Middle East to complement Argentina's already established nuclear energy sales market.

Through the late 1980s, the *Cóndor II* project was carried out like the plot from a John le Carré spy novel, with Argentines meeting their Egyptian contacts in France to pass on information and cash from Iraq. But by 1989, facing seemingly insurmountable technical challenges, domestic hyperinflation, Iraq's withdrawal of funding for the project, U.S. pressure to cut off credit and funding, and the requirements of the Missile Technology Control Regime, Argentina officially terminated the project. The official story was that the programme was discontinued to be in accordance with the MTCR. However, the accumulated *Cóndor* experience and infrastructure allowed Argentina to transmogrify a military missile project into the civil space programme.

Concurrently, in 1989, Argentina issued a joint communiqué with Brazil, the "Joint Declaration on Bilateral Cooperation on the Peaceful Uses of Outer Space," which signalled a decisive move away from defence-oriented rocket technology and a decoupling of rocketry and national prestige toward the self-promotion of an image as being a global participant (shortly thereafter Argentina would participate in the Gulf War, sending three warships to the Persian Gulf). The civilian National Commission of Space Activities (CONAE) was founded in 1991 and instead of rocket construction, it initially set its sights on developing remote-sensing and scientific satellites as well as technical cooperation projects with more advanced space powers.

Since this reorganisation, Argentina has had a series of small but steady successes. In 1996, Argentina's first home-built satellite, *MuSat-1*, was launched by Russia. Its purpose was to test low-cost communications and imaging technologies created by the Instituto Universitario Aeronaútico in Córdoba. Another small Argentine satellite, mini-satellite *SAC-A,* was put into orbit by the U.S. space shuttle *Endeavour* in 1998. Four more satellites in the series followed: *SAC-B* (gamma and X-ray research); *SAC-C* (environmental monitoring); *SAC-D/Aquarius* (measured the world oceans' salinity); SAOCOM (measured microwave radiation; joint project with the Italian Space Agency).[17] In 2004, the Argentine senate approved the creation of a state-supported satellite company called ARSAT, which would consolidate the rival Nahuelsat. The first task assigned to ARSAT was to create a telecommunications satellite to occupy the 81-degree orbital slot that had been previously assigned to Argentina by the International Telecommunications Union.

As is the case with Brazil, Argentina has declared its independent and unfettered access to space to be a matter of national security.[18] Also like Brazil, Argentina has

[17] "Satélites ARSAT". 18 Nov. 2013. http://www.invap.com.ar/es/proyectos/satelite-arsat.html.

[18] Classified cable from U.S. Embassy in Buenos Aires (#07BUENOSAIRES1793). 10 Sept. 2007. http://wikileaks.fi/cable/2007/09/07BUENOSAIRES1793.html.

been open to cooperation with non-Western space actors, particularly China, with whom an agreement was reached in 2004 to give Argentina access to Chinese commercial launch services, satellite components, and a communication satellite platform.

The final missing piece in Argentina's space ambitions has been autonomous launch capability. In 2007, President Néstor Kirchner signed a decree that mandated CONAE, state universities, the Argentine Aeronautical Institute, and the military's research division to work jointly toward the realisation of the goal of a light-payload launcher. By 2007, the 4-m-high, liquid-fuel prototype *Tronador* was unveiled and tested. The working version, the hydrazine-fuelled, two-stage, 33-m-tall, 64 metric ton *Tronador II*, was constructed at the Falda de Carmen facility. The test flight took place in February 2014, but suffered a launch failure. With 189 million Euros allocated to the project for 2014–2016, *Tronador* addresses one of the principal goals of Argentina's current "National Space Plan: Argentina in Space, 2004–2015," which declares that the space programme will be essential in the improvement of six areas: (1) Agriculture, fisheries, and forestry; (2) Climate, hydrology, and oceanography; (3) Disaster monitoring; (4) Environment and natural resource monitoring; (5) Cartography, geology, and mining; and (6) Health.

6.5 Conclusions

For two of Latin America's largest countries, the term "developing" has not been absolute for quite some time. This is especially true in their quest to join the growing ranks of space-faring states. But for both Argentina and Brazil, the road to the creation of their current space programmes was paved long before either embarked upon it. As aspirant regional powers, both have long sought to cultivate the modern capabilities that are attributed to powerful, influential states: modern rocketry, nuclear power and weapons, and high technology for security and economic growth.

Thus, in both cases, their proto-space development was solidly oriented, driven, and even managed by their respective military organisations. The development of their programmes emerged as political allies of the United States and Europe during the Cold War. The latter years of the Cold War saw both emerge as increasingly independent regional players in rocketry and nuclear programmes, and the fall of the Berlin Wall allowed and encouraged both countries to expand their circle of potential customers and friends. Moreover, both Argentina and Brazil have reached the point where space cooperation with others is only undertaken under circumstances where there is technological and political advantage to be had, and increasingly, the emphasis is on developing autonomous capabilities. Both countries are eagerly pursuing space policies that will allow them to utilise space technologies to the fullest extent possible to ensure state sovereignty and economic prosperity.

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Chapter 7
The Impact of China's Rise in Space

Mark P. Hilborne

7.1 Introduction

There is little doubt that the rise of China as a space faring nation will have a significant impact on other states operating in space. Any new or nascent space programme will create challenges. However, the rapid advance of its programme, and the questions that were raised more broadly as a result of its 2007 Anti-Satellite (ASAT) test regarding space debris and space security, highlight those potential challenges very particularly. China's rapidly accelerating space programme also challenges the status quo in space, and that will be felt most keenly by the most established space power, the United States (U.S.).

While it is not inevitable that such a scenario leads to tension, it of course frequently does. In this case, there are factors that make this likely. By a significant margin, the U.S. is the state that has most extensively invested in space, and is the most reliant upon it. Its space assets afford a vast array of services and capabilities and, in particular, provide its military with tremendous advantages. Simultaneously, however, these assets are virtually defenceless and create considerable vulnerabilities.

Against this background, the Chinese space programme, and its wider intention, are opaque. This lack of transparency creates the very real risk of a worst case hypothesis within U.S. policy circles, leading it, along with perhaps some of China's regional neighbours, to align its policy based on the premise that China intends to build an offensive capability in space.

Despite the rapid advances of China's space programme, however, parity with the U.S. in terms of space power is some way off. It is this current asymmetry, rather than China's expansion of its space activities, that creates perhaps the most dangerous dynamic. For in space, asymmetry creates unique challenges. Whereas in

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other environments possessing a preponderance of power does not create severe vulnerability, in space this is very much a danger. Defensive capabilities in space are either technologically extraordinarily difficult and thus commensurately expensive, or they create risks to the very assets that a state seeks to protect.

As a result, a state with few assets in space has less to fear from offensive actions in space compared to one with significant investment in and reliance on space capabilities. While there is danger in the tension that the opacity of China's programme creates, and its potential challenge to the status quo, in many ways this may in fact be reduced in a scenario where China reaches a peer competitor, or a near-peer competitor status.

While not necessarily in itself creating a harmonious balance in space, the increasing reliance that China will have on space, and the greater the extent of their space-based infrastructure, the more China's behaviour in space is likely to mirror that of the U.S. Therefore the risks inherent in deploying an offensive space capability would be similar for China as for the United States. Thus the impact of China's burgeoning space presence, particularly with respect to the U.S., will likely change over time and one destabilising aspect may be eliminated. That is not to suggest that the U.S. will embrace the surging programme of China, but it may be a long-term mitigating factor.

7.2 The U.S. Stake in Space

No state has explored space further, or invested in space as heavily as the United States. It has therefore developed the most significant reliance of any nation upon it. Given its value and dependence, the U.S. will be highly reactive to new space programmes that might impact on their own space capabilities or competitiveness. One indicator of the size of this investment is the number of operating satellites in orbit, which was recorded at 1,084 by the Union of Concerned Scientists Satellite Database in September 2013. Approximately half of the satellites orbiting the Earth, 461, are owned by the United States.[1] China has approximately a quarter of this number (107), or less than 10 % of the total, though that figure is rising quickly.

Space is also a buoyant and fast growing economic sector, of which the U.S. enjoys a significant share. The global space economy was valued at over $304 billion at the end of 2012, showing a growth of 6.7 % over the previous 12 months, and 37 % since 2007.[2] Within this, the U.S. is the largest participant—the U.S. government alone, including NASA, has been responsible for approximately a fifth of this overall sector.

[1] "UCS Satellite Database" 1 Sept. 2013 Union of Concerned Scientists 18 Dec. 2013 http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html.

[2] "Space Foundation's 2013 Report Reveals 6.7 % Growth in the Global Space Economy in 2012" 4 Feb. 2013 Space Foundation 18 Dec. 2013. http://www.spacefoundation.org/media/press-releases/space-foundations-2013-report-reveals-67-percent-growth-global-space-economy.

Clearly there is a significant amount at stake for the U.S., and it will undoubtedly view the increasing number of space programmes, China's in particular, with a certain amount of concern. This will be added to the existing list of challenges related to governance that are associated with the increased global use of space. Space debris, space traffic control, and the allocation of orbital slots and radio frequencies are all elements that become progressively more difficult with the proliferation of space programmes.

These in themselves are sufficiently problematic aspects. However, to these concerns must be added the direct implications for national security, and these will only serve to make Washington's apprehension more acute. They will remain the most sensitive and contentious elements of U.S. perceptions regarding space security, presenting new challenges alongside traditional security dilemmas. The issue's contentiousness will create difficult policy choices for Washington, and the costs and benefits of a multilateral and co-operative path towards achieving its security and commercial objectives will be weighed against the need for creating and maintaining a level of dominance in space. Current U.S. policy indicates an intention to follow a more accommodating course, though this is so far mostly rhetoric. However, while China's intentions and policies remain unclear, the debate as to whether China is following a path towards full-scale capabilities for conducting space warfare will continue, and it will remain to be seen whether the U.S. will continue on this trajectory.

7.3 China's Rise in Space

China's space programme has made remarkable progress in recent years in a number of areas, and has quite naturally attracted significant global attention. Its scope and ambitions are vast. A mere inventory of its accomplishments would provide an indication of the challenge China poses to the status quo, but that would not give a complete or comprehensible idea of China's strategic intent. Inherent within the programme across its range are incongruities and ambiguities that create great difficulties in deciphering its true direction, and create even greater unease.

The year 2013 can boast an impressive list of achievements. In June China launched its fifth manned mission into space with the Shenzhou 10 mission. This was launched in part to test the process for docking capabilities with Tiangong 1. Tiangong is in itself is an ambitious programme that will eventually culminate in China's own full-sized space station, in the 2020s.

In September, three more Yaogan Weixing remote sensing satellites were launched on the Yaogan 17 mission.[3] The claimed purpose of this series of platforms is "scientific experiments, land survey, crop yield assessment, and

[3] "Long March 4C launches three Yaogan Weixing-17 satellites" 1 Sept. 2013 NASASpacelight.com, September 1, 2013 http://www.nasaspaceflight.com/2013/09/long-march-4c-launches-yg17-mission/

disaster monitoring."[4] However, there is very likely military utility in these platforms. The designs incorporate synthetic-aperture radar (SAR) as well as electro-optical (EO) imaging technologies, both of which are of great value to military intelligence and targeting. The Yaogan satellite programme is a prime example of the difficulty of interpreting China's activities and intent in space.

China's most sensational achievement last year was the successful moon rover mission, the Chang'e 3. The landing, which occurred on December 14th, made China one of only three nations to carry out a soft-landing on the Moon's surface.[5] The 'Yutu' (Jade Rabbit) rover will continue to explore the lunar surface for another 3 months, while the lander will continue to function for the next year. Notable alongside the demonstrated soft-landing capability is the load capacity of the lander, which appears to be able to carry a far heavier load than the rover, suggesting it could be a highly flexible landing system in the future.[6]

These achievements run concurrent to the evolving satellite navigation system—the Beidou/Compass network. This is expected to be operational on a global scale by 2020. As with other aspects of their programme, there is obviously both civilian and military utility here.

Similarly, China has tested its ability to remotely rendezvous in space on two occasions, a capability that has obvious dual-use potential.

Such capabilities sit atop programmes that have a much clearer military function. The Shenlong spaceplane, similar in nature to the Boeing X-37, is thought to have been test flown in January 2011.[7] While not officially confirmed, it appears to have been announced via various Chinese media broadcasts.[8] In addition to this are of course the anti-ballistic missile and anti-satellite tests, which are well known.[9] However, as stated above, a mere list of achievements does not provide a clear idea of China's strategic direction, but there is not a great deal else upon which to make firm judgment. As a result, analysts are left to ascribe strategic significance to launches and tests. These may draw from or reflect their own understanding of their own programmes and institutions—therefore essentially mirroring their own

[4] "Jane's Space Systems and Industry: Yaogan series" 22 Jun. 2012 HIS Jane's 19 Dec. 2013. http://articles.janes.com/articles/Janes-Space-Systems-and-Industry/Yaogan-series-China.html.

[5] Buckley, Chris. "As Rover Lands, China Joins Moon Club" 19 Dec. 2013 The New York Times 14 Dec. 2013. http://www.nytimes.com/2013/12/15/world/asia/china-lands-probe-on-the-moon-report-says.html?_r = 0.

[6] Ibid.

[7] "Shenlong 'Divine Dragon' Takes Flight: Is China Developing its First Spaceplane?" 19 Dec. 2013 China SignPost 4 May 2012. http://www.chinasignpost.com/2012/05/shenlong-divine-dragon-takes-flight-is-china-developing-its-first-spaceplane/.

[8] Ibid.

[9] For China's first anti-ballistic missile test, see: Zhi, Lin. "China conducts test on ground-based midcourse missile interception" 18 Dec. 2013 Xinhua Net 11 Jan. 2010. http://news.xinhuanet.com/english/2010-01/11/content_12792329.htm. For a good overview of the 2007 anti-satellite test, see: Kan, Shirley. "China's Anti-Satellite Weapon Test" 23 Apr. 2007 CRS Report 20 Dec 2013. https://www.fas.org/sgp/crs/row/RS22652.pdf.

programmes. Alternatively, these assessments may assume the overarching grip of an authoritarian style of government with a command economy, therefore assuming unity but overlooking the many factions, internal pressures and rivalries that surely exist. Such factions and rivalries can belie the notion that China's space programme is one singular strategic vision, as they lead to decisions that seem to contradict strategic considerations.

For instance, China has often declared a peaceful stance in outer space. In 2002 China, along with Russia, presented the draft "Treaty on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects". The two states shared a concern that without such an agreement, U.S. missile defence plans could evolve into an ability to deploy space-based weapons. China's sentiment was summed up by its Ambassador to the United Nations (UN), who stated that there was an "outcry of the international community for the peaceful use of outer space and [for] nipping the danger of the weaponisation of outer space in the bud".[10] These initiatives garnered China a certain degree of moral high ground, particularly given the U.S. reluctance to sign up to any formal restrictions in space.

However, this moral high ground was dashed 5 years later with the 2007 ASAT test, underlining the difficulty in deciphering China's intent. The details of the test are fairly well established, and will not be examined here. While leaving a very large amount of debris in space in orbit for some time to come, it clearly placed into question China's commitment to the peaceful uses of outer space, and its future direction in space.

The event also raised the question of how such an event can be interpreted so to help understand the programme's intent more clearly. Was the test meant as a signal? Why were the official statements following the test so contradictory? How were China's interests served, given that the debris created was a danger to space platforms from many states, including China's?

It may be that the event cannot be explained as the product of a single mind-set displaying strategic singularity. In contrast to the notion that China's decision process is cohesive, it may rather have been an indication that the military, security, and foreign policy bureaucracy were not communicating or cooperating. These views are supported by a number of analysts.[11] Given the tensions that the ASAT test has created with so many other elements of China's space policy, this theory is quite persuasive. This of course is but one example that might provide some indication of China's strategic intention in space, though a highly consequential

[10] The Acronym Institute for Disarmament Diplomacy, "Russia and China Introduce Draft Treaty on Space Weapons" Disarmament Diplomacy 66 (2002).

[11] Bates G and Martin K (2007) China's Space Odyssey: What the Anti-satellite Test Reveals About Decision-Making in Beijing. Foreign Affairs 86.3:2–3 and, Brian W (2011) Conference paper: "The Dragon's New Eyes: China's Space-Based Surveillance Capabilities, Doctrine, Strategy, and Implications" Secure World Foundation, from audio transcript available at http://swfound.org/events/2011/the-dragon%E2%80%99s-new-eyes-china%E2%80 %99 s-space-based-surveillance-capabilities,-doctrine,-strategy,-and-implications.

one. It suggests there is a complete lack of strategic cohesion and structure and thus that it may not be as unified as some analysts believe.

As China's policy is opaque, it is very difficult to understand given the vagaries just described. ABM and ASAT tests have continued, whilst on the other hand in 2008 China tabled another draft on Prevention of an Arms Race in Outer Space (PAROS). The latter was never likely to relieve the apprehension within the U.S. and other policy-making circles.

The antidote is to increase transparency and communication, but given the sensitivity of many programmes this is difficult. Engagement between related institutions would aid accurate assessment while also reducing mistrust. This need not extend to cooperation, which is much more contentious, and thus represents a fairly simple and risk free step. China has traditionally resisted this kind of dialogue, even threatening to end all military dialogue over various disagreements on Taiwan. It rejected any formal agenda for strategic defence talks on Secretary Gates' visit in January 2011, agreeing only to 'study' his proposals.[12]

Admiral Mike Mullen Chairman of the U.S. Joint Chiefs of Staff expressed some of the problems resulting from the lack of dialogue: "One of the real problems of not having a relationship is I don't understand much about what they are doing... I don't understand the depth or the reasons for their military investment."[13] Without dialogue and a more profound understanding, Washington's policy responses will be based on an increasing body of worst-case conjecture.

7.4 Conclusions

While divining China's strategic direction in space is itself a subject that will continue to concern Washington, it is likely that the nature of China's challenge, and thus its impact in space, will change. It will not remain constant, even if its strategic intent might. For as the space programme expands and evolves, China will derive greater and greater value from space. As a result, it will feel it has a greater stake in space, and will be less likely to take risks in space. This long-term effect could remove a specific element of tension in an otherwise confrontational dynamic in space.

At the moment the vast array of American space assets present a soft target, creating a severe imbalance in terms of vulnerability. The defence of satellites is either extraordinarily difficult from a technological perspective and therefore a

[12] Barnes, E. Julian and Page, Jeremy. "China Snubs U.S. Defense Pitch" 18 Dec. 2013 Wall Street Journal 11 Jan. 2011. http://online.wsj.com/article/SB10001424052748703779704576073652543622180.html.

[13] Ford, Peter. "Gates's challenge in China: Why he's looking far beyond J-20 stealth fighters" 21 Dec. 2013 The Christian Science Monitor 7 Jan. 2011. http://www.csmonitor.com/World/Asia-Pacific/2011/0107/Gates-s-challenge-in-China-Why-he-s-looking-far-beyond-J-20-stealth-fighters.

financial perspective, or it creates risks to the very assets that a state seeks to protect—in particular from the debris resulting from a kinetic attack.

Given the disparity between the United States and its nearest competitors regarding space-based capabilities, and the resulting dependence on these capabilities, the disabling or destruction of satellites would represent a significant difficulty for the U.S. relative to other nations, and retaliating in kind would very likely not offer a commensurate gain. As one analyst eruditely notes, 'There's nothing for the U.S. to shoot at in space', while in turn, the "bad guys" have plenty of things to shoot at,[14] underlining the asymmetric environment.

It seems logical to conclude that as China becomes more reliant on satellites for communications and observation, military or otherwise, the greater stake it will feel it has in space, and the likelihood that it will take risks in space will reduce. Obstruction or meddling with U.S. satellites thus becomes less likely for fear of retaliation. The opposite should also hold true, potentially resulting in a greater equilibrium or stand-off between the two space faring powers.

This dynamic is in marked contrast to other environments of human competition and military activity in particular. A preponderance of power does not generate the same vulnerability in the land, maritime or air domains. Having an overwhelming number of air platforms, for instance, does not create the kind of exposure that it does in space.

Space is unique in this respect. Thus the U.S., despite the advantages it gains from its space assets, has a lot to lose given the current imbalance. Concepts of defence in space might have to evolve on quite different bases than defence in the traditional domains. That probably remains true even in a more equitable distribution of power in space as well.

Attacking or defending satellites can create dangers to one's own space assets regardless of the distribution of space power, quite unlike defending against an opponent's air assets for instance, which does not create the lasting threat of damage to a defending nation's own aircraft or their future employment.

So while the U.S. is the most powerful nation in space by a significant margin, it also faces the most significant vulnerabilities, and this will remain a highly relevant aspect in how it perceives the increase in China's space activities.

These inherent characteristics might mean there is less to fear from an established or significant space power than a rising one. Though such a conclusion may seem counterintuitive, the characteristics of space mean that defending space assets is nigh on impossible, at least based on the current state of technology. This would mitigate certain fears that might be harboured about the rise of ambitious space programmes such as China's in the long run.

[14] Pike, John of globalsecurity.org quoted in Book, Elizabeth G. "Will the "Bad Guys" Shoot Down U.S. Satellites?" 20 Dec. 2013 National Defense. 1 Oct. 2001. http://www.globalsecurity.org/org/news/2001/011001-asat.htm.

In the short term, it does not seem that the tensions created by China's rising space programme, for which 2013 was a significant showcase, are likely to fade. To the incumbent space power, China's lack of transparency seems fundamentally incompatible. However, if a period of transition can be overcome, a more balanced relationship might be forthcoming.

Chapter 8
Russia: Space Exploration and Development Prospects

Oleg Karasev, Natalia Velikanova, and Anastasia Edelkina

8.1 Introduction

This article presents data on the current state of the Russian space industry and describes its short- and medium-term development prospects. The analysis is based on statistical research and government policy documents to identify the key trends and development directions of space-related science and technology in Russia in the year 2012–2013. Significant attention is paid to analysing strategic and projected data and programmes approved by public authorities. This has enabled identification of the steps taken to regulate the space industry, major government policy tools, and goals and objectives set for the immediate future. Of particular interest are projects implemented during the period in question, and those planned for the near future. These projects cover all key areas of space exploration and space-based Earth observation. Development prospects for space-related services are analysed in the following segments: manned spacecraft launches, space navigation satellites, and remote sensing of the Earth. An important topic in this article is international cooperation and its prospects for the near future.

Activation of innovative economic development has been one of the priorities of state economic policy in Russia in recent years. The Decree of the Government of the Russian Federation of 8 December 2011, № 2227-R, adopted a Strategy for Innovative Development of the Russian Federation until the year 2020. The document states that "Russia has ambitious but realistic long-term development goals, aimed at ensuring a high level of welfare of the population and securing the country's geopolitical role as one of the leaders determining the world's political agenda. The only possible way to achieve these objectives is the transition of the economy to innovation and a socially oriented development model". In this regard,

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C. Al-Ekabi et al. (eds.), *Yearbook on Space Policy 2012/2013*, Yearbook on Space Policy, DOI 10.1007/978-3-7091-1827-6_8

Table 8.1 Expenditure on technological innovation, total sales of innovative goods and services: 2012

	Expenditures on technological innovation		Total sales of innovative goods and services	
	Million rouble	Million Euros	Million rouble	Million Euros
Mining and quarrying	87,775.3	2,199.3	522,890.9	13,101.8
Manufacturing	430,459.6	10,785.8	1,973,535.6	49,449.7
High tech	61,917.1	1,551.4	175,318.2	4,392.8
Manufacture of aircrafts, incl. spacecraft	25,953.1	650.3	72,310.5	1,811.8
Medium high tech	85,204.2	2,134.9	785,190.0	19,674.0
Medium low tech	219,170.9	5,491.6	756,622.1	18,958.2
Low tech	32,910.1	824.6	157,075.5	3,935.7
Electricity, gas and water supply	65,425.7	1,639.3	13,177.9	330.2
Total	583,660.6	14,624.4	2,509,604.4	62,881.7

Currencies were converted at the average annual exchange rate of 2012 (1 euro = 39.92 roubles)
Source: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/

special attention is paid to the high-tech sector, forming the core of an innovation system formed by aircraft and space technologies, the military-industrial complex and nuclear energy. The strategy is aimed at achieving a leading position for Russia in these sectors, which would lead to increasing the share of Russia in world markets for hi-tech goods and services by up to 5–10 % by 2020.

Table 8.1 shows that in 2012, aircraft manufacturing companies spent 650.3 million Euros on technological innovation. For high tech manufacturing companies the share of technological innovations expenditure borne by aircraft manufacturers is close to 40 %. According to the Federal State Statistics Service of Russia,[1] technological innovations are enterprises whose activities are related to the development and implementation of:

- technologically new products and processes, as well as significant technological improvements in products and processes;
- technologically new or significantly improved services;
- new or significantly improved methods of service production.

In 2012 the share of aircraft manufacturers' expenditure was 6 % of the total sales of goods and services—the highest figure for all types of economic activities. By comparison, the share of the high tech sector in total accounted for 5.1 % of the total sales of goods and services (see Fig. 8.1).

It should be noted that aircraft manufacturers in 2012 sold innovative goods and services for 1,811.8 million Euros—less than 4 % of the total sales of innovative

[1] "Statistics of Innovation in Russia" Federal State Statistics Service of Russia. http://www.gks.ru/free_doc/new_site/business/nauka/pril3.pdf/.

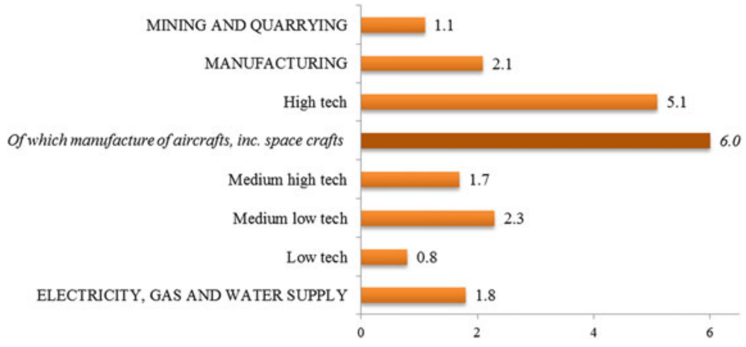

Fig. 8.1 Expenditure on technological innovation as a percentage of total sales of goods and services, by industry, 2012 (*Source*: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/)

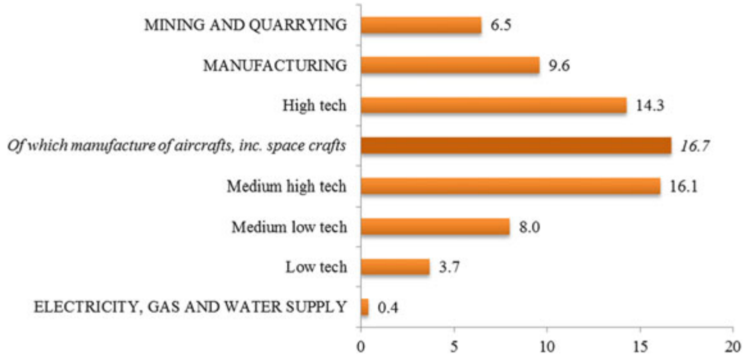

Fig. 8.2 Innovative goods and services as a percentage of sales of goods and services, by industry, 2012 (*Source*: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/)

products by manufacturing companies. However aircraft manufacturers lead in terms of the share of innovative products in total goods and services sales—16.7 %, as expressed in Fig. 8.2, which is higher than the share of the high tech sector—14.3 %. In official statistical reports the Federal State Statistics Service of Russia[2] defines innovative goods and services as new or improved goods and services during the last 3 years with a different level of technological change.

Both expenditure on technological innovation and sales of innovative goods and services by aircraft manufacturers are expected to grow in the long term. One of the key aims in the Russian Space-Based Activities' Development Strategy until 2030

[2] See footnote 1

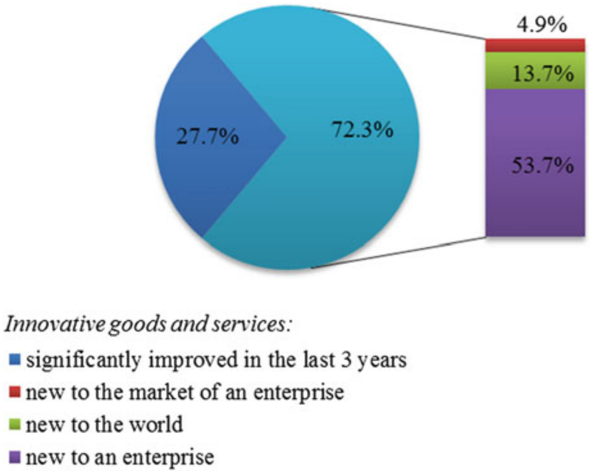

Fig. 8.3 Distribution of innovative goods and services in aerospace industry, by the innovation level, 2012 (*Source*: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/)

and Beyond[3] is the development of a sustainable, innovative, competitive, and diversified aerospace industry capable of meeting the strategic tasks of developing and promoting national space technologies in the global market. It is planned to achieve this objective through the development of space industry infrastructure ensuring the timely creation and use of technical, technological and organisational innovations, training and the effective use of highly qualified personnel as well as using a wide range of modern financial instruments to create a favorable environment for the dynamic development of the space industry business.

Figure 8.3 depicts the distribution of innovative goods and services in the aerospace industry in 2012 showing its huge innovating potential: 72 % of sold products were first introduced (or subjected to significant technological changes) during the last 3 years; 54 % of them were classified as new for the enterprise but not for the market; the share of market innovations amounted to 5 %. It is worth noting that the share of products and services new to the global market was about 14 %.

To promote innovation development in the industry it is planned to establish a Space Innovation Fund that provides financing for innovation with significant potential and its commercialisation. The Fund would have the right to commercialise innovations on national and foreign markets, meeting the constraints imposed by national security.[4]

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[3] "Russian Space-Based Activities' Development Strategy until 2030 and Beyond" 27 Apr. 2012 Aviation Explorer 17 Nov. 2013. http://www.aex.ru/docs/8/2012/4/27/1561/.

[4] See footnote 3

Table 8.2 Gross domestic research and development (R&D) expenditure by socio-economic objective, 2000, 2012

	Million roubles (at constant 2,000 prices)		Million euro[a] (at constant 2,000 prices)		Percentage of the total	
	2000	2012	2000	2012	2000	2012
Total	76,697.1	141,023.2	2,951.0	5,426.1	100.0	100.0
Economic development	28,635.9	59,624.0	1,101.8	2,294.1	37.3	42.3
Industry	20,944.7	40,392.4	805.9	1,554.2	27.3	28.6
Agriculture, forestry and fishing	1,947.6	3,254.5	74.9	125.2	2.5	2.3
Production, distribution and rational utilization of energy	2,974.6	6,205.8	114.5	238.8	3.9	4.4
Construction	568.4	1,713.6	21.9	65.9	0.7	1.2
Transport	1,454.8	4,833.2	56.0	186.0	1.9	3.4
Communications	574.8	2,850.7	22.1	109.7	0.7	2.0
Infrastructure and general planning of land use	107.9	183.9	4.2	7.1	0.1	0.1
Services sector	63.2	189.9	2.4	7.3	0.1	0.1
Social objectives	2,660.5	6,663.7	102.4	256.4	3.5	4.7
General advancement of research	23,066.0	23,751.4	887.5	913.9	30.1	16.8
Exploration and exploitation of the Earth and atmosphere	2,591.9	5,133.1	99.7	197.5	3.4	3.6
Civil space	*1,593.6*	*7,568.1*	*61.3*	*291.2*	*2.1*	*5.4*
Other	18,149.2	38,282.8	698.3	1,473.0	23.7	27.1

[a]Currencies were converted at the average annual exchange rate of 2,000 (1 euro = 25.99 roubles)
Source: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/

Breakthrough technologies will make a significant contribution to achievements in civil space exploration. Expenditure on civilian space development in 2012 amounted to more than 290 million Euros in constant 2000 prices, or more than 5 % of gross domestic research and development expenditure (Table 8.2).

It should be noted that expenditure on civilian space exploration has grown by a factor of 4.7 as compared to the year 2000. These high growth rates are comparable only to growth in the communications segment (Fig. 8.4). Russia regards space exploration as a multifaceted and interdisciplinary objective, achieving which would help to meet challenges of the near and remote future—based on Earth observation from orbit and observation of space from the ground-based and circumterrestrial orbital stations. In 2012–2013 various innovative government policy tools were applied to support the application of space activities' results for various purposes.

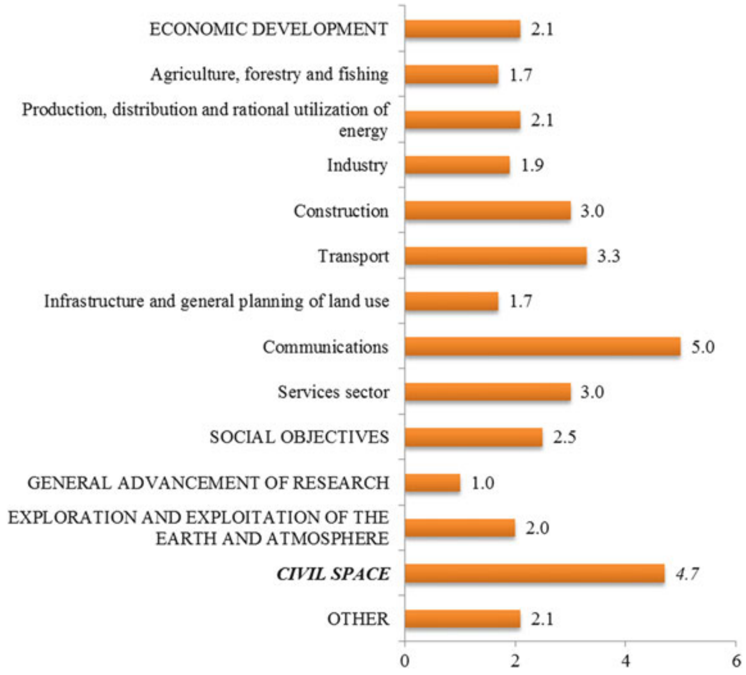

Fig. 8.4 Growth rate of gross domestic R&D expenditures by socio-economic objectives (2012 in Relation to 2000); (*Source*: Indicators of Innovation in the Russian Federation; Federal State Statistics Service in Russia, http://www.gks.ru/)

8.2 Innovative Space Policy Tools

During the period 2012–2013, Russian space policy moved to a new development stage. Currently the country's innovation policy is aimed at creating conditions to support exploration and the development and practical use of outer space for research and economic purposes.

8.2.1 Forecasts, Strategies, and Programmes

The aerospace industry is increasingly affecting the development of society, science, production and business, and is seen as a high-priority area in various-level Russian government programmes that include lists of priority areas, and in targeted federal programmes designed to support implementation of specific industrial projects. The latest document that summarises various forecasts, strategies and programmes related to space activities is the "Basic Russian Federation's National Space Policy Until 2030 and for the Subsequent Period", approved by the President of the Russian Federation (RF) on 19 April 2013. The Basic National Policy defines the principles, major goals, priorities and objectives of the RF national policy on the exploration, development and management of outer space, including international cooperation in the area of human spaceflight. According to the document, the main goal of developing space-related activities is "maintaining the world-class level of Russian cosmonautics, and securing Russia's leading role in the space activities field". Several objectives must be accomplished to achieve this goal, including:

- Meeting the country's growing needs in the socio-economic sphere, science, defence and security through application of Russian-made spacecraft;
- securing leading positions in the most important areas of basic space research (astrophysics, solar-terrestrial relations, etc.);
- securing leading positions in the most important areas of lunar research;
- participation in international projects, including missions to other Solar System planets;
- maintaining leading positions in the space launch industry;
- maintaining an independent spacecraft launch system;
- maintaining world-class operational and technological parameters of Russian-made spacecraft;
- developing an efficient high-tech aerospace industry;
- securing for Russia a rightful place in the global space-related services market.

The approved document integrated and adjusted existing space strategies and nine federal targeted programmes including "Development of Russian space launch facilities in 2006–2015" and "Support, development and application of GLONASS system in 2012–2020", as well as the national programme "Russia's space-related activities in 2013–2020" approved on 28 December, 2012. This is schematically depicted in Fig. 8.5.

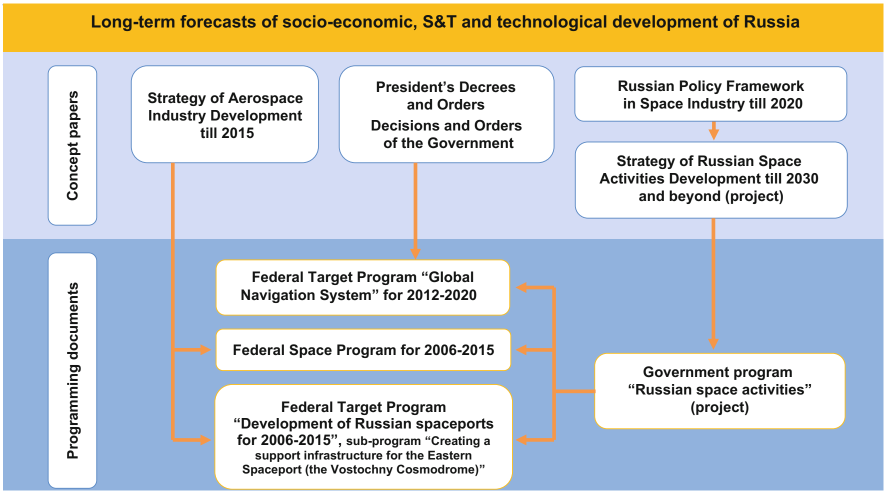

Fig. 8.5 Planning documents and programmes related to space activities (*Source*: Higher School of Economics)

Fig. 8.6 Programme and goal-oriented tools for strategic management of space industry (*Source*: Higher School of Economics)

The national programme "Russia's space-related activities in 2012–2015" has a particular place in the strategic planning system, which relationship is visualised in Fig. 8.6.

It sets specific objectives to be accomplished to achieve the major goals envisaged, in particular:

1. employment and maintenance of Russian spacecraft orbital groups sufficient for achieving the specified scientific and economic objectives, including the Russian segment of the ISS;
2. modernisation of Plesetsk and Baikonur spaceports and construction of the new Vostochny spaceport on Russian territory;
3. development of prospective, and upgrading existing spacecraft launching devices;
4. conducting forward-oriented research to develop prospective space-rocket hardware;
5. promoting international cooperation in civilian development and management of outer space;
6. extending the range of available services based on space exploration and development, to promote Russia's national- and regional-level development.

The programme sets three priorities for further development of the space industry. The first priority is to ensure: reliable access to outer space for Russia; development and application of space hardware, technologies and services for the socio-economic sphere; development of rocket and space-related manufacturing; and carrying out Russia's international obligations. The second priority is to provide space-related support to meet scientific requirements; and the third is human spaceflight. Until 2020, and possible even longer considering the U.S. has prolonged the lifetime of the ISS until at least 2024, spaceflights will be linked to the exploitation of the ISS, and preparing the ground for designing new manned spacecraft types. In line with the programme's priorities, government funding for space-based communications, remote sensing and basic space research has been doubled although the overall amount of government funding has remained stable. Significant funds will be provided for the implementation of this programme—2.12 trillion roubles, including non-government sources. The end result of the programme's implementation is intended to be more than a twofold increase of the industry's output, compared to 2011 figures. Productivity is expected to grow by a factor of 2.23 and the industry's technological level is expected to increase from 20 to 60 %. As a result, Russia's share of the global rocket and space hardware market may increase up to 16 %. In total, 650 billion roubles investment in the space industry is planned for the period 2012–2015. Implementation of the national programme is expected to produce quite specific results, including the following:

- completion of space rocket facility Angara-A5, and beginning of its operations;
- upgrading of Plesetsk and Baikonur spaceports; completion of the first (2015) and second (2018) stages of Vostochny spaceport;
- full deployment of the Russian segment of the ISS, to comprise six modules in 2015, and seven modules in 2018;
- obtaining by 2018 forward-oriented S&T results to develop advanced rocket and space hardware prototypes, including an advanced-drive transportation and power generation module ready for design testing;
- development of a prospective manned transportation system capable of delivering people to the Moon.

8.2.2 New Innovation Policy Tools

The years 2012–2013 were marked by active strategic planning of space-related activities for the period until 2030. Reform of the space industry is now being discussed, to reach with the following objectives:

- Separating procurement, application, and auditing functions for goods and services purchased by the Federal Space Agency (Roskosmos);
- Consolidation of the Agency's central office functions, focusing on strategy building, public policy and coordination;
- Increasing the autonomy of space sector organisations, including the right to redistribute resources and facilities;
- Separating technical, scientific and administrative functions in the management structure of the Federal Space Agency;
- Promoting harmonised horizontal and vertical integration of space sector enterprises;
- Designing a flexible project structure reflecting the goals and objectives of the space sector. Setting up temporary working groups comprising representatives of enterprises and research centres, to deal with specific problems;

- Setting up an agency (corporation) responsible for the commercialisation of technology;
- Setting up a sectoral Development Institute;
- Introduction of a results-based funding allocation system for all contracts, grants and subsidies;
- Revision of Human Resources (HR), compensation and benefits policies to attract qualified young professionals, and retain and develop the industry's human resources.

Reforming the industry includes setting up several larger integrated structures in the Russian rocket and space industry (5–7 holdings), and then establishing 3–4 conglomerates on that basis, plus an instrumentation corporation to make systems and aggregates for rocket and space hardware. The space industry's organisational structure needs to be streamlined to successfully deal with new challenges including development of the market economy and increased competition on the global markets—which demand consolidation of enterprises, integration of their programmes, skills and resource bases into a small number of associations comprising R&D, manufacturing, sales, and maintenance companies (divisions). At the same time, according to the strategic documents and programmes, the integration should be accompanied by promotion of a network of small and medium enterprises, including in the framework of territorial clusters being set up now, to develop and make components, equipment and other elements of rocket and space hardware. Emergence of this trend in Russia is evidence of the interest of private businesses in the space exploration and development field. A new mechanism to be promoted is public-private partnerships.

In 2012 the expert community actively discussed the legislation that needs to be adopted for successful cooperation between private and public organisations. In 2013 the first draft of the Federal law "On the basics of public-private partnership in the Russian Federation" was approved; in 2014 this law is expected to become the foundation for development of partnerships in the space industry and the more efficient commercialisation of relevant R&D results. Joint public-private participation is expected in the development and production of new materials and components for rocket and space complexes, the development of small spacecraft, making results of remote sensing of the Earth available to end users, and the application of navigation technologies and satellite communication. The following division of responsibilities is envisaged for public-private partnerships:

8.2.2.1 The Government

- Provides, supports and develops basic orbital and ground-based space infrastructure;
- Deals with national security-related aspects of space activities;
- Provides legal support for projects, approves technical procedures, requirements and terms of reference for equipment.

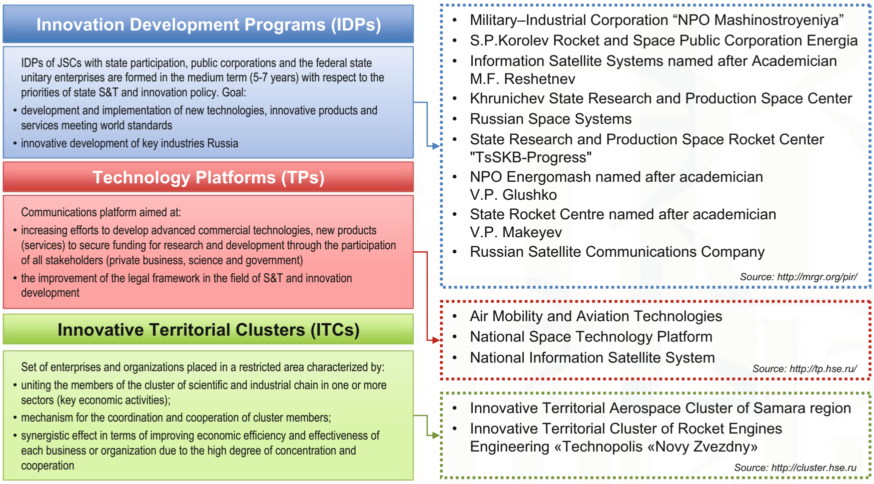

Fig. 8.7 Application of new innovation policy tools (*Source*: Innovation Development Programs http://mrgr.org/pir/; Technology Platforms http://tp.hse.ru/; Innovative Territorial Clusters http://cluster.hse.ru/)

8.2.2.2 Private Companies

- Finances development and maintenance of operating infrastructure required to provide services to customers;
- Develops and market new commercial projects;
- Designs and manufactures hardware for users;
- Provides services to end users, including government and municipal agencies.

New innovation policy tools for the Russian space industry include innovation development programmes supporting staged realisation of relevant tasks and accomplishment of identified objectives, technology platforms,[5] opportunities and potentials offered by the Space Technologies and Telecommunications cluster (Skolkovo Foundation) and, the Samara Region aerospace territorial cluster which comprises companies designing, manufacturing, testing and operating aircraft (Fig. 8.7).

8.2.3 International Cooperation

Roskosmos has signed intergovernmental agreements on space cooperation with more than 19 countries, including the USA, Japan, India, Brazil, Sweden, Argentina, and members of the European Space Agency (ESA). In the framework of the

[5] National Space Technology Platform and National Information Satellite System, approved by the Government's High Technology and Innovation Commission on 1 April, 2011.

International Space Station (ISS) programme, Roskosmos cooperates with Canada, the USA, Japan, and members of the European Space Agency. International legislation to support Russian-European space cooperation is now in place, comprising about 30 agreements at various levels, including the Agreement on conducting joint experiments in the ISS. Several projects are expected to be implemented in the framework of international cooperation. The BepiColombo project, for example, which will explore the surface of Mercury will be implemented by the ESA and JAXA (Japan) jointly with Russia. The Astrophysical observatory to study astronomical objects in X-gamma spectrum (0.08 keV–10.0 meV) is scheduled to start operations in 2014 in the framework of the joint Russian-German project Spektr-RG. In 2016 the Russian-Spanish project Spectre UV—World Space Observatory—Ultraviolet is planned to be implemented, to explore the Universe in the ultraviolet section of the electromagnetic spectrum inaccessible to Earth-based observations (100–320 nm). Germany, India, and other countries have expressed their interest in this project. Also, Russia participates in a joint project with the ESA "Soyuz at GSC"—launching Russian Soyuz spacecraft from the Guiana Space Centre facility.

Active cooperation is underway with China, India (exploration of the Moon, solar activity, satellite navigation, etc.), Kazakhstan (joint operation of Baikonur complex, development of Baiterek launch complex, and KazSat space-based communication system), and with other countries. Russia also participates in the work of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOUS), the International Committee on Space Research (COSPAR), the Inter-Agency Space Debris Coordination Committee (IADS), Space Agencies' Forum, the Committee on Earth Observation Satellites (CEOS), the International Astronautical Federation (IAF), and other organisations.

One of the most competitive areas of Russia's activities in the global space-related services market is commercial launches. Most such launches involving Russian carrier rockets are performed by joint ventures with American and European partners, such as IES (Russia-US), STARSEM and EUROCKOT (Russia-EU). According to strategic documents,[6] international cooperation is going to move on to the next development stage to comprise the following areas:

- Implementation, on government level, of political, legal, technical, and organisational measures to effectively ensure the Russian Federation's national interests in the field of international space activities, and to maintain and strengthen Russia's status as one of the leading space powers;
- Participation in the development of international space legislation, including a comprehensive United Nations (UN) Convention on Space Law;
- Collaboration with leading countries in the development and application of space equipment, including exchange of advanced technologies, joint

[6] "Basic Provisions of the Framework of the Russian Federation's National Space Policy until 2030 and the subsequent period, approved by the President of the RF on 19/04/2013 #PR-906" 13 Nov. 2013. http://www.roscosmos.ru/115/.

development of resource-intensive space projects, global initiatives on practical application of space technologies, implementation of best international practices;
- Cooperation with countries aspiring to take part in space activities, through development of business relations, licensing technology, making available use of space systems for communication, navigation and remote sensing of the Earth, spacecraft launches, and manufacturing space systems to order at Russian enterprises;
- Active promotion, in the UN and at other international forums, of the Russian Federation's policy on developing outer space exclusively for peaceful purposes, including "The Treaty on Prevention of Placement of Weapons in Outer Space";
- Participation in international decision-making concerning anthropogenic pollution of the near-Earth outer space;
- Informing the international community about the Russian Federation's achievements and capacities in the space exploration and development area.

8.3 Key Development Areas for Basic Space Research

In the basic space research field a number of projects are planned, aimed at closing the gap with the leading space countries and advancing Russian science to leading positions in major space-related disciplines, and in the long term becoming a world leader in exploring the Universe.

The key areas of basic space research currently include the following:

- Extra-terrestrial astrophysics—studying the origin and evolution of the Universe;
- Planetology—studying the planets and small bodies of the Solar system;
- Studying the Sun, cosmic plasma, and solar-terrestrial relation;
- Research in space biology, physiology, and material science.

The Russian Federal Space Exploration Programme for 2006–2015 envisages 25 projects on deployment of space-based facilities for basic space research, including specialised spacecraft equipped with relevant scientific instruments, and those designed for application for agricultural and industrial purposes. Thirteen of these projects are currently being implemented. Two more projects (Mars Surveyor and Coronas-K) are aimed at designing Russian research equipment to be installed on board foreign spacecraft (six instruments). In the planetary and Moon research areas, four projects are being implemented (Luna Globe, Luna Resource, Mars Surveyor). Five more projects are planned to start in subsequent years: Venus-D (exploration of Venus), Mars Net and Mars Soil (studying Mars), Mercury-P (studying the surface of Mercury), Sokol-Laplace (studying the surface of Jupiter), and further implementation of the Luna Resource project, in particular designing a spacecraft equipped with a lunar rover. These projects are scheduled to be completed by 2023. In the areas of astrophysics, solar research and solar-terrestrial relations, six more projects are planned to begin in 2014, scheduled to be completed by 2020.

A specific feature of these research projects is using standardised space platforms to the maximum possible extent—major spacecraft components designed for research, remote sensing of the Earth, supporting radio communications, etc. Modular technologies allow quick and low cost adaptation of space platforms' functionality for use with various types of spacecraft equipped with different hardware. Standardised platforms for small-size spacecraft will play a major role in supporting research in solar-terrestrial relation, observation of small Solar system bodies, and astrophysical experiments.[7] Several space observatories of the Spectre series are planned for orbital insertion, designed to operate in X-ray, millimetre, and ultraviolet spectrums. Exploration of the Sun and the Solar System planets will begin. The effort will be concentrated on lunar research, taking into account all the scientific data collected during the previous decade.

8.3.1 Manned Space Flights: New Areas

8.3.1.1 The International Space Station

According to the "Long-term programme for applied research and experiments to be conducted in the Russian segment of the ISS", space experiments conducted on board the ISS are grouped into ten subject areas. The programme describes the goals, objectives, and expected results of the research, and serves as the basis for specific work plans, designed in accordance with the available resources, hardware, and documentation. Each working day of the astronauts is full of scientific experiments and research in various fields, such as medicine, biology, geophysics, the Earth's natural resources, space biotechnology, humanities and education.[8] Certain experiments require 1 or more months to complete. For example, in November 2013 the astronauts: studied physical conditions in outer space—the *Matryoshka-R* project (studying dynamics of a radiation environment)—and monitored seismic effects (surges of high-energy particles in circumterrestrial space, the *Vsplesk* experiment); studied plasma wave processes of interaction between very large spacecraft and the ionosphere in the ISS subsurface (*Obstanovka* experiment); conducted experimental testing and adjustment of a ground-and-space based system for monitoring and forecasting natural and anthropogenic disasters (*Uragan* experiment); did biomedical research; studied mechanisms of outer space's effect on properties of materials designed for use in outer space (*Vynoslivost* experiment); identified perturbation sources when the microgravity situation at the ISS changes (*Identification* experiment); and did an integrated study of the ISS parameters as an anthropogenic environment for research purposes (*ISS Environment* experiment). In the field of

[7] "Fundamental Space Research" Roscosmos 14 Nov. 2013. http://www.federalspace.ru/116/.

[8] "Research on the Russian Segments of the ISS" RSC Energia 14 Nov. 2013. http://www.energia.ru/ru/iss/researches/iss-researches.html.

Table 8.3 Manned spaceflights in 2012–2013

Crew	Launch—landing dates	Spacecraft	Flight duration
Padalka G.I. (4)[a] Revin S.N. (1) Acaba J.M. (2)	15.05.2012—17.09.2012	Soyuz TMA-04M	124 days 23:51:30
Malenchenko Y.I. (5) Williams S.L. (2) Hoshide A. (2)	15.07.2012—19.11.2012	Soyuz TMA-05M	126 days 23:13:17
Novitsky O.V. (1) Tarelkin Y.I. (1) Ford K. A. (2)	23.10.2012—16.03.2013	Soyuz TMA-06M	143 days 16:14:49
Romanenko R.Y. (2) Hadfield C.A. (3) Marshburn T.H. (2)	19.12.2012—14.05.2013	Soyuz TMA-07M	145 days 14:18:15
Vinogradov P.V. (3) Misurkin A.A. (1) Cassidy C.J. (2)	28.03.2013—11.09.2013	Soyuz TMA-08M	166 days 06:15:10
Yurchikhin F.N. (4) Parmitano L.S. (1) Nyberg K.L. (2)	28.05.2013	Soyuz TMA-09M	Over 166 days
Kotov O.V. (3) Riazansky S.N. (1) Hopkins M.S. (1)	25.09.2013	Soyuz TMA-10M	Over 049 days
Tiurin M.V. (3) Mastracchio R.A. (4) Wakata K. (4)	07.11.2013	Soyuz TMA-11M	Over 008 days

[a]The figure means the number of flights
Source: Roscosmos http://www.federalspace.ru/116/; Space ASTROnote Encyclopedia http://www.astronaut.ru/

life sciences *Lactolen* and *Calcium* projects were conducted. Studying the Solar system (*BTN Neutron* project) included studies of fast and thermal neutron flows, while remote sensing of the Earth (*Econ-M* project) was concentrated on collecting data for environmental surveying of areas where various activities were undertaken from the Russian segment of the ISS, via observation and photography.

The volume of research conducted at the Russian ISS segment is steadily growing—which is due to the increased number of Russian cosmonauts on-board (currently three). In 2012, in accordance with the flight programme, four manned cargo ships (Soyuz TMA-M) were launched, delivering four international crews to the ISS, plus four cargo ships (Progress-M-M) that delivered research equipment and life support supplies for the astronauts. In 2013 there were also four launches of manned spacecraft, which is depicted in Table 8.3. All flights were manned by international crews, and were long-term. The crews comprised astronauts who had already repeatedly stayed onboard the ISS. On 7 November, 2013, six astronauts went to the ISS as members of the 38/39 (the last) long-term international ISS crew: commander Oleg Kotov (Roskosmos), flight engineers Sergei Riazansky (Roskosmos), Michael Hopkins (NASA), Mikhail Tiurin (Roskosmos), Rick Mastracchio (NASA) and, Koichi Wakata (JAXA).[9] Russian cosmonauts went into outer space with the Olympic torch, which subsequently was brought back to Earth by another crew.

[9] "Human Spaceflight" Space ASTROnote Encyclopedia 16 Nov. 2013. http://www.astronaut.ru/register/spaceflights.htm.

The national innovation policy also includes launches of manned space-rocket objects to implement major space projects on in-depth exploration of the Universe, the Solar system, and—primarily—the circumlunar space, the Moon and Mars. The plan for the Russian segment of the ISS is to deploy six modules in 2015, and seven in 2018. Accomplishing new objectives in the area of designing interplanetary unmanned and manned space complexes requires upgrading the existing ISS systems and development of new on-board hardware and equipment capable of providing efficient support to long-term manned flights and research. A multifunctional laboratory module *Nauka* is scheduled to be installed at the ISS in 2014—the 17th such module created at the Khrunichev State Research and Production Space Centre, commissioned by the Russian Federal Space Agency. The multifunctional module is going to be one of the largest at the ISS. Together with this, the European-made ERA manipulator will be brought to the station, to support outer-space operations of the ISS crew. In the future one more node modules and two research and power generating modules will be delivered to the Russian segment of the ISS.

8.3.1.2 Commercial Space Station

The companies Orbital Technologies and Rocket and Space Corporation Energia are developing a commercial orbital space station for space tourism and other commercial ventures. Its insertion into orbit by a Russian Soyuz carrier rocket is scheduled for the end of 2015 or the beginning of 2016. Initially the space hotel will have four cabins with total capacity to accommodate up to seven people. The project envisages docking facilities for Russian, European, American and even Chinese spacecraft. Compared to the ISS which is not designed to provide tourist comforts, the space hotel will offer sufficiently comfortable accommodation. Tourists will be brought there and back by Soyuz launchers and food and equipment will be delivered by Progress cargo craft. If necessary, the CSS will serve as a backup shelter for the ISS crew (in case of an accident). Between tourist visits, the hotel will be used for experiments. The orbit will be chosen to ensure close proximity to the ISS. The station's mock-ups were presented in 2011 at the MAKS exhibition.[10]

8.3.2 Technology Development Trends

Russia possesses innovative Science and Technology (S&T) solutions that enable it to make practical use of outer space—to address people's needs in satellite communications for remote sensing, navigational support for transport, tracking and monitoring mobile objects, emergencies management, and search and rescue

[10] May, Alex "The First Space Hotel can be put into orbit in 2016" 30 Sept. 2013 A Revolution in Space 16 Nov. 2013. http://revolution-in-space.blogspot.ru/2010/09/2016.html.

operations, etc. The following breakthrough areas of space-related S&T research were included in the "List of critical technologies for the Russian Federation" approved by the RF President[11]:

- Next-generation aerospace and transport engineering;
- Information technology, management, navigation systems;
- Electronic components and energy-efficient lighting devices;
- Nano-devices and microsystems engineering;
- Basic and critical military and industrial technologies for development of advanced weapons, military and special-purpose hardware;
- Structured and functional nano-materials.

In the future, development and application of a number of technological solutions is envisaged, in particular in the following areas[12]:

- Spacecraft based on available breakthrough technological solutions, to provide within the next 2–3 years better-quality services at lower prices to public- and private-sector customers from Russia and developing countries;
- Extending the functionality of individual spacecraft and their groups;
- Orbital maintenance of spacecraft with long service life;
- Creating an open, modular spacecraft design (LEGO principle);
- Integrated design and technological solutions for next-generation competitive standardised various-size space platforms;
- Remote sensing in optical and radio spectrums, monitoring and control of geophysical activities;
- Creating highly reliable on-board avionics components and systems, resistant to outer space's impact;
- High-power space-based nuclear power plants and their elements;
- Special-purpose equipment, sensors, on-board electronic equipment and power supply systems for various purposes spacecraft;
- Life support systems for long-term space missions;
- Large on-board antenna reflectors of sub-millimetre wavelength range, for next-generation spacecraft;
- Synchronisation and navigation software for deep-space flight control; space-time support for activities at the surface of and in close proximity to the Solar System planets;
- Heavy and extra heavy launch vehicles, including technologies for large-diameter tank structures and other elements based on advanced composite and other perspective materials; a line of rocket engine models including reusable high-thrust hydrogen-oxygen liquid fuel engines; technological solutions to ensure reusability of launch vehicles.

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[11] "List of Critical Technologies for the Russian Federation" 7 July 2011 President of Russia 16 Nov. 2013. http://президент.рф/ref_notes/988.

[12] See footnote 3

Russian space science and technology development prospects are based on the existing S&T potential and its strengths, specifically:

- Leading positions in the international markets for services such as payload delivery to orbit, design of liquid-fuel rocket engines, development of large-capacity launch vehicles, etc.;
- Unique groundwork for development and manufacturing of reusable space vehicles and engines;
- Participation in international projects;
- National satellite navigation system GLONASS;
- Technology transfer, e.g. application of new materials in spacecraft manufacturing and related industries.

8.4 Development Prospects for Russian Space-Related Services

The space-related services sector in Russia comprises many different activities ranging from research to entrepreneurship, including communication, navigation, remote sensing, special space-based systems, collecting meteorological data, and providing assistance during fires and natural disasters. Unique data collected by Russian space systems and transmitted to the ground is relevant, impartial, independent, accurate, and reliable, so it enjoys a growing demand by civilians, public authorities, companies and researchers. This promotes active development of space-related services that are applied for social, industrial, and scientific purposes at the regional, national and international levels. It should be noted that Russia considers itself a member of the post-industrial society, and sees prevention of space-originating threats to the human civilisation as its high-priority objective.

Currently Russian space systems constitute an integrated information field, which is turned to the Earth to monitor the safety of the planet's habitation (technosphere and ecosphere) and provide communication and navigation services. This information field includes various classes and types of spacecraft engaged in remote sensing of the Earth; navigation geodesic systems; communication satellites; navigation systems' spacecraft GLONASS, GPS, etc.; and search and rescue spacecraft COSPAS-SARSAT. As of 1 January, 2013, the Russian orbital spacecraft group amounted to more than 10 % of the world's total, or 1,140 spacecraft. Russia launched 24 carrier rockets, or more than 38 % of all carrier rocket launches in the world in 2012, and delivered 33 spacecraft to space. Out of that, in the framework of international cooperation with Kourou spaceport, two launches were made, and two spacecraft successfully inserted into orbit. Three launches were made from the Sea Launch facility, with four spacecraft inserted into orbit. All international obligations regarding transport support for the ISS were also carried out.

8.4.1 Space-Related Services Market

The global market of space-related services is divided into four segments: services based on data collected from space (over $90 billion a year); manufacturing and installation of ground-based equipment for use of space-related services ($50 billion a year); design and manufacturing of spacecraft ($13.5 billion); and payload delivery to orbit (up to $4.5 billion).[13] This market is steadily growing: in 5 years it grew from $170 to $250 billion. The space hardware manufacturing sector currently amounts to $72 billion; Russia's share of that segment is just over 10 %. Russia controls more than 40 % of the global launch services market; and with regards to spacecraft manufacturing, Russia's share is 7 %. The remaining market is services such as TV, Internet access, and telecommunications (over $115 billion); while ground-based equipment for receiving data transmitted from space generates just over $50 billion. According to various estimates, Russia controls between 1.0 and 1.7 % of this market. Currently this segment is seen as having high potential for active development. The plan for the next few years is to increase Russia's share of the international market from the current 0.3 to 10 %.[14] Figures 8.8, 8.9, and 8.10 show the main development trends and objectives for the Russian space-related services market, based on forecasts and programme documents.

8.4.2 Communication Satellites

The programme documents stipulate development of space-based communications, broadcasting, and retransmission services. Specifically, "extending the orbital group of fixed communication systems, mobile presidential communications, and TV and radio broadcasting based on next-generation spacecraft, up to 39 spacecraft—to provide the above communication services practically throughout the Russian Federation's territory, including the Arctic Region". Accomplishing these objectives requires deploying an orbital group comprising 95 spacecraft by 2015, and 113 spacecraft by 2020. The number of communication satellite transponders will grow 2.5 times by 2015, and threefold by 2020. Also, the plan is to develop the millimetre data transfer range by 2015 and, the optical range by 2020. Reshetnev Information Satellite Systems Company is currently developing a multifunctional space-based retransmission system *Luch*, comprising geostationary retransmission spacecraft Luch-5A, Luch-5B, and Luch-5C. The project is included in the Russian Federal Space Programme for 2006–2015, and has already been partially implemented.[15]

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[13] http://www.spacecorp.ru/press/branchnews/item3620.php

[14] See footnote 3

[15] "JSC 'Academian M.F. Reshetnev' Information Satellite Systems" Reshetnev Company 21 Nov. 2013. http://www.iss-reshetnev.ru/.

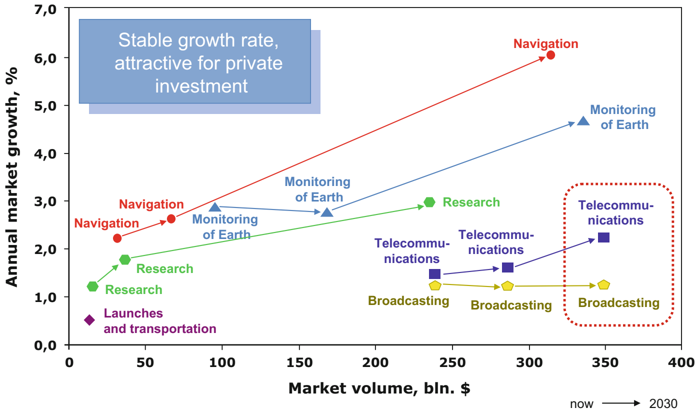

Fig. 8.8 Projected trends of space-related services' market segments (*Source*: Higher School of Economics)

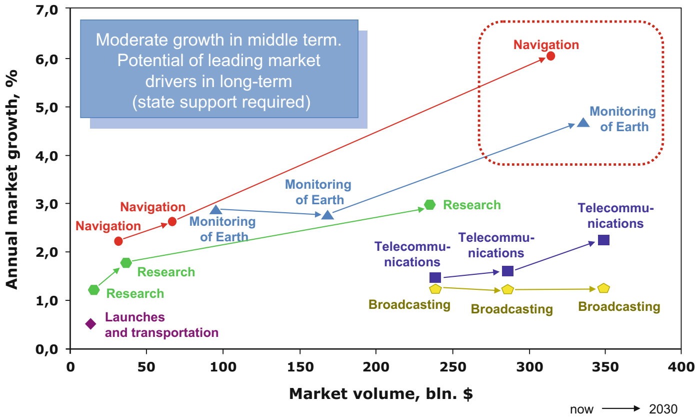

Fig. 8.9 Projected trends of space-related services' market segments (*Source*: Higher School of Economics)

Retransmission satellites are designed to work with low-flying spacecraft (up to 2,000 km above the Earth surface) including manned ones, particularly the Russian segment of the ISS. The retransmission satellites' objective is to receive data within the sections of the course outside the range visible from Russian territory, and retransmit it in real time to Russian data receiving stations. These satellites would make it possible to control spacecraft in orbits invisible form Russian territory. Luch-5A retransmission satellite paired with the telecommunication spacecraft AMOS-5 was successfully launched and inserted into orbit from Baikonur spaceport by a Proton-M carrier rocket with Breeze-M upper stage on 11 December 2011. Luch-5B was successfully inserted into orbit together with Yamal-300 K satellite

Fig. 8.10 Russia's position in future space-related services' markets (*Source*: Higher School of Economics)

on 3 November 2012. Luch-5C is scheduled for launch by the end of 2013 or early in 2014. Single-use orbit insertion rockets—Russian Proton and Soyuz—are going to remain the basic unmanned space transportation vehicles during the next two decades, since their service life can be quite long (more than 40 years for the Russian Soyuz and the American Delta-2). By that time they'll become very reliable and efficient. By 2020–2030 there may emerge a demand for new super-heavy single-use orbit insertion rockets of Saturn-5 or Energy class, to support manned expeditions to the Moon and then to Mars. But multiple-use carrier rockets will also be designed by 2020, to be used for special-purpose projects. Another satellite system is being developed in the framework of the Federal Space Programme for 2006–2015—the Russian multifunctional personal satellite communications system *Gonets*, based on low-orbit spacecraft.[16] Gonets-D1M, which is a group comprising seven low-orbit spacecraft [Gonets-D1 (1) and Gonets- M, is currently being designed (6)]. The system is being designed for monitoring the state and location of mobile transport vehicles and cargos; for environmental, industrial, and scientific monitoring; for providing communication services in remote regions with poorly developed infrastructure and in emergencies; and to create global departmental and corporate data transfer networks and paging systems. The first launch was successfully conducted on 12 September 2013 (three Gonets-M craft). By 2015 Gonets-D1M is scheduled to be deployed, comprising up to 16 spacecraft and seven regional stations. The automated circumterrestrial space emergency warning system ASPOS-OKP was put into trial operation. It is designed primarily

[16] Ibid.

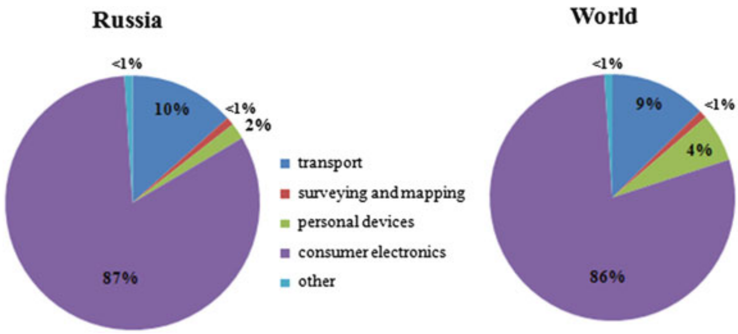

Fig. 8.11 Comparison of Russian and global market structures (Units sold, total numbers for 2012–2020); (*Source*: Authors' analysis; European Space Agency)

for ongoing monitoring of space objects' movements potentially threatening spacecraft flights, including collision with asteroids and meteorites; and detection, analysis and projection of dangerous situations in circumterrestrial space, based on processing measurements and other data from various sources.

8.4.3 Satellite Navigation System

8.4.3.1 Development of Navigation Services Market

The market for the Russian satellite positioning and navigation system includes goods and services for which receiving a global navigation satellite system's (GNSS) signal is an important consumer property. The total market is measured as total sales of GNSS devices (number of items sold) in 2012–2020 (Fig. 8.11).

The data for the global market structure is based on estimates by the European Space Agency,[17] and for the Russian market is calculated by summing up the forecasted GNSS market segment volumes for 2012–2020. Comparative analysis of this data supports the hypothesis that the Russian market of GNSS devices is following the global trend, and is a part of the global market. Satellite technologies' popularity is growing in the transport segment of the GNSS market the world over, in value terms.[18] And the Russian market is no exception.

Figure 8.12 shows a twofold growth of the GNSS devices market in value terms in 2013–2014, due to adoption of legislation mandating equipping vehicles with such devices, including the RF Government Regulation "On equipping transport

[17] "GSA GNSS Market Report—Issue 2" European GNSS Agency May 2012. http://www.gsa.europa.eu/sites/default/files/MarketReportMEP72012WEB.PDF.

[18] Bokov, M. et al. (2013) Development of Navigation Services and Devices—Evidence from a Case Study in Russia/Working papers by NRU Higher School of Economics. Science, Technology and Innovation 22:1–21.

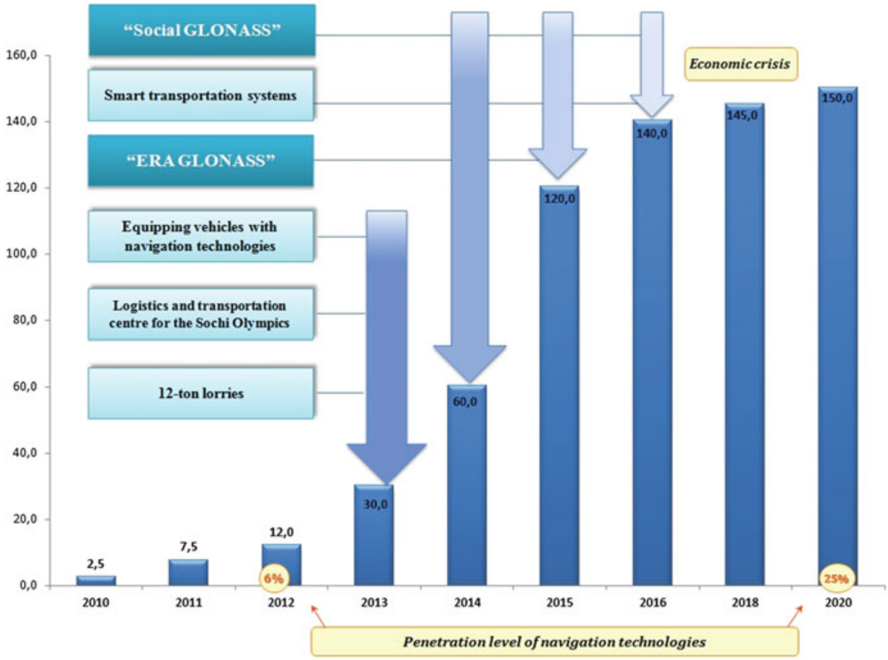

Fig. 8.12 Volume and growth of Russian GNSS devices market (billion USD); (*Source*: Authors' analysis; European Space Agency; ABI Research)

vehicles, machinery and systems with GLONASS or GLONASS/GPS satellite navigation devices".

The following transport vehicles, machinery and systems are supposed to be equipped with GLONASS or GLONASS/GPS satellite navigation devices:

- Spacecraft [carrier rockets, upper stages, spacecraft and space ships, landing modules (vehicles)];
- Government, civilian, and experimental aircraft;
- Marine, river, and mixed navigation (river-sea) vessels;
- Automobiles and railway vehicles used for transportation of passengers, special-purpose or hazardous cargos;
- Instruments and equipment for geodesic or cadastral surveys;
- Time synchronisation devices.

A number of legislative initiatives are being implemented in various countries, aimed at equipping vehicles with emergency response devices such as NG9-1-1 in the USA, eCall in the European Union, AND SIMRAV in Brazil, which must be installed in cars. ERA GLONASS, a major Russian government-sponsored project, is aimed at harmonising two systems—GLONASS and GPS—to create a unified pan-European transport safety area. The launch was scheduled for December, 2013.

Other major infrastructure development projects promoting development of the internal navigation services market include the following:

- Establishment of transportation and logistics centres in various Russian cities, to support the 2014 Winter Olympics and the 2018 FIFA World Cup;
- Development of a toll highways system, including the "12-Tonniki" (12 ton cars) and "Pay-as-You-Go Tax" projects;
- Equipping vehicles with digital tachometers;
- Development of a "smart transport" system for the City of Moscow;
- "Social GLONASS".

In the corporate sphere, the following projects should be noted:

- Equipping Russian Post vehicles with GNSS devices (the project has been underway since 2010; about 10 thousand vehicles are supposed to be covered);
- Equipping corporate (commercial) vehicles with such devices, to monitor their movements.

8.4.3.2 Development of the GLONASS Orbital Group

In default mode, the GLONASS orbital group comprises 24 spacecrafts (positioned in three planes, eight in each) rotating along circular orbits at an altitude of 19,100 km, with 64.8° inclination and 120° equatorial shift. This positioning of spacecraft, and their characteristics, allows coverage of the Earth's surface, atmosphere and circumterrestrial space up to 2,000 km altitude. By now all first-generation GLONASS spacecraft have been replaced with second-generation ones (GLONASS-M), with their service life extended from 4.5 to 7 years. Also, they can broadcast two signals to provide civilian services. GLONASS-K is the third generation of spacecrafts. These are fully Russian-made, and enable sending signals in CDMA standard (code demultiplexing used in GPS). Their active service life is 10 years. The first such satellite was launched in February 2011. Two versions of third-generation satellites will be inserted into orbit—GLONASS-K1 and GLONASS-K2. Full deployment of the orbital group won't take place before 2015.

In 2017, work on the third version of third-generation GLONASS spacecraft is scheduled to begin (GLONASS-KM), with the first satellite to be launched in 2025. These machines will be able to broadcast up to five open and two cyphered CDMA signals.[19] The expert study conducted by the National Research University Higher School of Economics confirmed the competitiveness of the GLONASS system, and a high potential for its further development in terms of the signal's accuracy and popularity of (demand for) receiving devices on the global navigation services market (see Fig. 8.13).

[19] "The Development of Glonass-KM Satellites will start in 2017" Dec. 2011 Position News. http://rcnmu.ru/news/20111216.

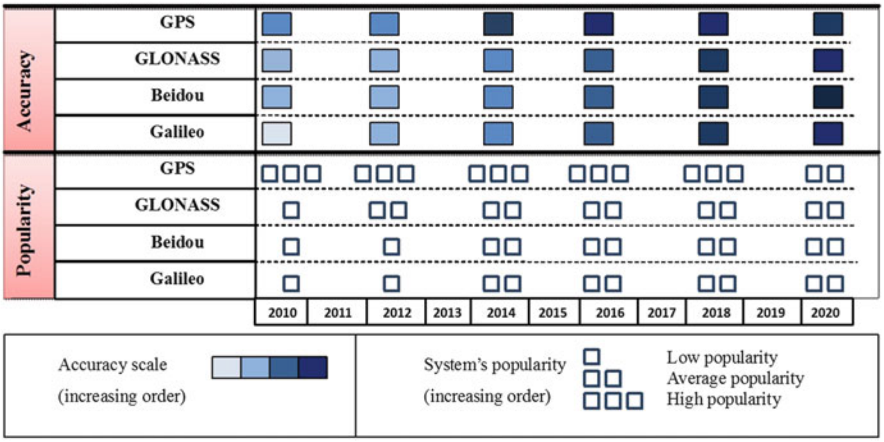

Fig. 8.13 Comparative analysis of major satellite navigation systems (*Source*: Authors' analysis)

On 3 March 2012 the Russian government approved the Federal Targeted Programme "Support, development and application of GLONASS in 2012–2020", with a total of 326.5 billion roubles of public funds to be provided for these purposes. The programme stipulates manufacturing of 35 spacecraft (13 GLONASS-M and 22 GLONASS-K).[20] Development of cartographic space-based system will begin in 2015. This includes launching two optical-electronic surveying spacecraft. It should be noted that Russia now has satellites whose service life is 12 years (see Table 8.4). They offer sufficiently accurate positioning of consumer signals (4.5 m), which is intended to be improved to 2.5 m. Meanwhile GPS provides civilian signal positioning accuracy of 100 m, Galileo—4–8 m, and BeiDou—10 m.

8.4.4 Remote Sensing of the Earth

The orbital group for remote sensing of the Earth currently comprises five active satellites, designed by Russian R&D organisations. Resurs-DK1 (Progress State Research and Production Rocket Space Centre) was launched from Baikonur spaceport in 2006. It's designed for panchromatic and multispectral photography of the Earth surface with a resolution of about 1 m.

Meteor-M1 (Space Monitoring Systems, Information & Control and Electromechanical Complexes corporation) was launched from Baikonur spaceport on 17 September 2009; it's the first of three spacecraft comprising space-based solar-stationary hydrometeorological complex and is scheduled to be fully

[20] Federal Space Programme "Support, Development and Application of GLONASS in 2012–2020".

Table 8.4 Technical characteristics of satellite navigation systems

Characteristics	GLONASS	GPS	Galileo	BeiDou
Country	Russia	USA	EU	China
Number of satellites	24 (basic)	24 (basic) extendable to 48	30 (basic)	35 (basic)
Number of orbital planes	3	6	3	3
Number of satellites in each plane	8	4	9	9
Orbital altitude (km)	19,100[a]	20,200	23,222	38,300 (IGSO), 31,500 (MEO)
Number of orbits per day	2	2	1.7	1
Batteries	Range: 7.2 m Power: 1,600 W	Range: 17.5 m Power: 1,600 W	Range: 18.7 m Power: 1,500 W	Range: 18.1 m Power: 1,600 W
Satellite warranty life (years)	3—GLONASS, 7—GLONASS-M, 10–12—GLONASS-KM	10	10	8
Signal coverage	Global (at the beginning of 2012—up to 90 % of the RF territory and 90 % of the world)	Global	Global	Global
Signals	Now: 2007: L1PT, L2PT Plan: L1PT, L2PT, L3PT, L1CR, L2CR, L5R	Now: 2009: L1 C/A, L2C Plan: L1 C/A, L1C, L2C, L5	E5 OS/SoL E6 CS/PRS E1 OS/SoL/PRS	B1 B2 B3 L5
Accuracy of signal consumer's positioning	4.5 m (now) 2.8 m (plan)	2.6 (now)	4–8 m	Up to 10 m (globally); 1 m (locally)
Accuracy of speed measurement (m/s)	0.05 v/s ÷ 0.1 m/s	10 (civilian signal), 0.1 (military signal)	0.2 m/s	0.2 m/s

[a]http://www.spacecorp.ru/directions/glonass/
Source: Russian Space Systems, http://www.spacecorp.ru/

deployed before 2015. Electro-L1 (Lavochkin Research and Production Association) is a geostationary craft designed to collect and retransmit meteorological data. It was launched in 2011.

Resurs-P1 (Progress State Research and Production Rocket Space Centre) was launched in the autumn of 2013. It's designed for high-resolution broadband hyper-spectral optical-electronic observation of the Earth surface. Canopus-B1 (Space Monitoring Systems, Information & Control and Electromechanical Complexes corporation) is a part of the space-based on-line complex for monitoring anthropogenic and natural emergencies Canopus-B, currently being designed by the A.G. Iosifian Research and Production Corporation "Space Monitoring Systems, Information & Control and Electromechanical Complexes". On 22 July 2012 the Soyuz-FG carrier rocket launched from Baikonur spaceport inserted five satellites into orbit. On 30 October 2012, flight tests were completed and the spacecraft was put into operation. Canopus-B1 is designed for monitoring anthropogenic and natural emergencies, including natural hydrometeorological phenomena; mapping; discovering forest fire seats and major discharges of pollutants into the environment; monitoring agricultural activities, water and coastal resources; land use; and for rapid-response observation of specified territories. The MKA-FKI 1 satellite (Russia) is designed for studying physical phenomena and processes taking place in the "land—atmosphere" system, to collect data for subsequent application in forecasting environmental and climate changes.

BKA is a Belorussian spacecraft designed for monitoring emergencies, natural and sustainable resources, land use and agricultural production, the state of the environment, and for updating topographic maps. BKA was made by the Space Monitoring Systems, Information & Control and Electromechanical Complexes Corporation (it's design and characteristics are similar to those of Canopus-B); the satellite's orbit is identical to Canopus-B's, shifted by 180°. There are plans for coordinated use of these satellites. TET-1 (Germany) is designed for testing and improving new equipment and technologies, and conducting various experiments in the framework of the programme "Orbital verification of new equipment and technologies". ADS-1B (Canada) is designed for identification and positioning of ships, as part of the group "Automated identification system" operated by marine and coastal services. The group of satellites used for remote sensing of the Earth is to be increased fourfold by 2015. Note that if currently the frequency of photography by Russian satellites is 5–6 days, by 2015 this is expected to be reduced to 1–2 days (depending on the region), and by 2020 it should not be more than 8 h.

8.4.5 Commercial Satellite Launch Services

A new niche in the space-related services market became available for Russia—satellite launches into specific target orbits. The Sea Launch and Land Launch projects, implemented by S.P. Korolev Rocket and Space Corporation Energia,[21] have the highest potential here. Sea Launch is the first international commercial project in the history of Russian cosmonautics that comprises establishment and

[21] "Science News" RSC "Energia" SP Queen 3 Dec. 2013. http://www.energia.ru/ru/archive/snews/snews.html.

operation of a sea-based mobile launching facility located in the equatorial area of the Pacific Ocean, near Christmas Island. In 2012 carrier rockets Zenith-3SL were launched from the *Odyssey* sea launch platform, inserting the spacecraft into the intended orbit. Land Launch plans on using Sea Launch's technological potential to the maximum possible extent. In the framework of Land Launch project, on 1 September 2013 carrier rocket Zenith-3SLB was launched from Baikonur spaceport, and successfully inserted Asmos-4 satellite into orbit. This craft is designed for high-definition TV broadcasting, and for receiving and transmitting data to provide two-way satellite Internet connections in Ka and Ku bands in Russia, the Middle East, and other regions.

8.5 Development of Space Infrastructure

The current Russian space policy includes the development of human capital and active improvement of existing space infrastructure, in particular launch and maintenance facilities at Baikonur and Plesetsk spaceports, and construction of the new Vostochny spaceport in the Amur Region in the Far East. The latter's total area will be 1,035 km^2. The first carrier rocket launch is scheduled for the end of 2015, the first manned spacecraft launch—for 2018. The spaceport will have a launch facility for medium-class increased-payload carrier rockets (up to 20 tons), comprising two launchers, an airfield, an oxygen-nitrogen plant, a hydrogen plant, a power supply system, 115 km of automobile roads and 125 km of railways, including the 30-km branch line from Ledianaya station. The Federal Space Programme allocates 92 billion roubles for development of space technologies. Until 2015 (inclusive), 173 billion roubles will be provided to finance construction of the Vostochny spaceport. In total, the spaceport's construction will cost about 300 billion roubles. A major element of the space infrastructure is the Russian Mission Control Centre (MCC). Theoretical and experimental research conducted at the centre enabled the development and implementation of a multipurpose technology for controlling spacecraft of various types and functionality. The existing MCC infrastructure includes specially designed equipment for receiving, processing, and disseminating data. Currently the MCC controls the Resurs-DK1 optical-electronic observation spacecraft designed for remote multispectral sensing of the Earth's surface with high spatial resolution, and Electro-L spacecraft designed to monitor the climate and the environment.[22]

[22] Homepage of the Russian Federal Space Agency Mission Control Centre 3 Dec. 2013. http://www.mcc.rsa.ru/prog.htm.

8.6 Conclusions

Analysis of completed, currently being implemented, and planned projects, and of programme documents, has revealed that during the period under consideration there was an increase of innovation activities in Russia in the area of the space industry's regulation and restructuring, strategic planning, launches of various-purpose satellites and manned spacecraft. There's every grounds for believing that the existing potential, coupled with active government support, will allow Russia by 2020 to develop new production technologies and technologies for satellite communication; remote sensing of the Earth; providing navigation support; conducting search and rescue missions, emergency monitoring, tracking and monitoring mobile objects using a space-based automated identification system and personal radio buoys. International cooperation in exploring the Solar system's planets and outer space are likely to grow and all international obligations regarding manned space flights will be carried out. Acceleration of innovation processes will allow Russia to reach new frontiers in space exploration and development, in the interests of the whole of humankind.

Chapter 9
India and Other Maturing Asian Space Enthusiasts

Ajey Lele

9.1 Introduction

By the end of 2013, hopes were higher than for many decades that the world was seriously heading towards developing an important constituent of international space regime in the form of an International Code of Conduct to address the challenges of space security. Over the past few years the debate around a code of conduct has provided impetus for states to begin to understand and appreciate each other's space programmes. It has also allowed developed states to realise the ambitions of smaller states in the space arena and provided them insight into how these states are overcoming the financial and technological challenges to realising their space dreams. To comprehend the interests of Asian states in space, this article analyses the space programme of one key player in the region, India, as well as the programmes of several other emerging space nations.

For many years the use of outer space was "the domain of an exclusive few". Today, having understood the importance of space technologies, many states are making investments in this field. Presently, there are three prominent states in Asia that have well-developed infrastructure in the space domain, namely, Japan, China and India. Of these, Japan and China became space-faring states in 1970 while India acquired this distinction in 1980. Table 9.1 presents a comprehensive overview of the status of the major Asian space nations.

This chapter examines the space programmes of India and several smaller Asian states. In the last few years in particular, smaller and developing states in Asia have realised that space technologies can be of great assistance in resources management, communication, navigation, education and disaster management support. Hence, their keenness to invest in this area has multiplied.

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Table 9.1 General overview of the major Asian space nations

Country	Acquired space-faring status	No. of satellites	Approximate budget USD
Japan	1970	167	2,460 million
China	1970	206	3,000 million estimated
India	1980	63	1,320 million

Data in this table and all other tables is based on multiple web sources and presented to put the investments into perspective. The budget estimates are broad approximations and could vary from source to source

9.2 Exploring India's Space Programme

In today's global economy, the ability of a country to develop, adopt and harness its potential for innovation has become critical for its long-term economic performance. Most developing and emerging economies have adopted a proactive approach and policy towards innovation. India is no exception to this trend as the evolution of the Indian space programme can be attributed to India's scientific community's quest for innovation.[1] The Indian space programme had its nascence in 1963 with experimentation on sounding rocket launches. The underlying idea was to learn more about the upper atmospheric and ionospheric phenomena above the geomagnetic equator. The first sounding rocket was launched on 21 November 1963.

The Indian journey in space could be summed up as a journey that had a slow but steady beginning in its initial few decades and subsequently followed an exponential growth curve. The first Indian satellite 'Aryabhatta' was launched with the help of the erstwhile Union of Soviet Socialist Republics (USSR) on 19 April 1975. India became a space-faring nation on 18 July 1980 when the 'Rohini 1' satellite was launched using an indigenously developed Satellite Launch Vehicle (SLV) from a site located at Sriharikota in the south of India. India has geographical advantages in launching satellites. The southern part of the Indian peninsula is close to the Equator and satellite-launching sites close to the Equator are always preferred since they require less energy to put a spacecraft in orbit.

During the first years of the Indian space programme there was constructive engagement with established space-faring states such as the United States (U.S.), the erstwhile USSR and France. India's very first sounding rocket launch was of an American-made Nike-Apache rocket along with other hardware and training aids. However, India's ties soured soon thereafter with the beginning of sanctions and the technology denial regime.[2] The denial regime was the result of India's nuclear

[1] Council of Scientific and Industrial Research—National Institute of Science, Technology And Development Studies (2013) India: Science and Technology. Cambridge University Press, New Delhi.

[2] Bagla, Pallava. "Indo-U.S. space ties ready for take-off: NASA chief" 29 Aug. 2013 The Hindu 14 Nov. 2013. http://www.thehindu.com/opinion/interview/indous-space-ties-ready-for-takeoff-nasa-chief/article5068749.ece.

policies and India conducting nuclear tests during 1974 and 1998. Interestingly, this embargo had both positive and negative implications for India's space programme. The negative consequence was that it hampered the rapid growth of India's space programme and even today India is still to achieve expertise in launching heavy satellites (weighing 4 tons and more). Conversely, the halt of technology transfers made India follow the path of indigenisation. Initially, limited technological expertise and an underdeveloped economy kept the growth of technology sluggish. Over time, however, the Indian Space Research Organization (ISRO) was successful in converting this limitation into an advantage and presently the Indian space programme is regarded as one of most cost effective programmes globally.

During the first years after its independence, India had limited technological infrastructure in place. Hence, initially, India's space programme started under the aegis of the Department of Atomic Energy[3] in 1962 with creation of the Indian National Committee for Space Research (INCOSPAR). The committee was responsible for the oversight of various aspects of space research in the country. In the same year work began on the establishment of the Thumba Equatorial Rocket Launching Station (TERLS)[4] with the first sounding rocket being launched in 1963.

Subsequently, TERLS[5] was dedicated to the United Nations on 2 February 1968 by then Prime Minister Ms. Indira Gandhi. This allowed the facility to be used by various developed states for conducting rocket-based experiments. On that occasion, INCOSPAR Chairman Dr. Vikram Sarabhai articulated India's aspirations in outer space, as he presented a vision for India in space. He stated that India's space programme would be civilian in nature, with a focus on the application of space technology as a tool for domestic socio-economic development. It was stated that the purpose of Indian investments was to use this programme to develop space technologies in the fields of communications, meteorology and natural resource management.[6] Appreciating the importance of space and its future, a dedicated organisation called the Indian Space Research Organization (ISRO) was formed under the Department of Atomic Energy in 1969. Subsequently, ISRO was brought under the Department of Space in 1972. That same year, a Space Commission was set up that reported direct to the Prime Minister. Presently, the Department of Space along with ISRO operate four independent projects: the Indian National Satellite Space Segment Project, the National Natural Resource Management System (NNRMS), the National Remote Sensing Agency (NRSA), and the Physical

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[3] At that time, the atomic energy department was possibly the only technologically sound organization in India. The government had very few independent departments (for example, in those days India's Meteorological Department was part of the Tourism sector!). Hence, it would be incorrect to link India's nuclear and space ambitions together.

[4] "Space History" BHARAT RAKSHAK: The Consortium of Indian Military Websites 1 Dec. 2008. http://www.bharat-rakshak.com/SPACE/space-history2.html.

[5] This station was subsequently renamed in honour of Dr. Vikram Sarabhai and is currently known as the Dr. Vikram Sarabhai Space Centre (VSSC).

[6] Sankar U (2007) The Economics of India's Space Programme. Oxford University Press, New Delhi.

Research Laboratory (PRL). The department also sponsors research in various academic and research institutions.[7]

Over the years ISRO has established a significant amount of infrastructure and now has approximately 16,000 people working on various projects. ISRO's various operating divisions deal with space systems, propulsion, communications, telemetry and tracking, research, launches, and other facets of the space programme. The major achievements of the Indian space programme have been in the area of the domestic design, production, and launching of remote sensing and communications satellites. ISRO has established a strong infrastructure for remote sensing and communications satellite systems with launcher autonomy. In 1992, ISRO established its commercial outlet, the Antrix Corporation (which is the word for space in Sanskrit). This company is responsible for the marketing of ISRO space and telecommunications products and services.[8]

There are few policy frameworks for the management of space technologies and related issues. A policy for satellite communication in India was formulated in 1997 and updated in 2000. It provides guidelines for the development of a healthy and thriving communications satellite and ground equipment industry as well as satellite communications service industry in India. The policy on Remote Sensing Data (RSDP) was reiterated in 2011 to provide modalities for approving and managing the acquisition and dissemination of remote sensing data in support of development activities.

During its initial years, ISRO kept its focus narrow and the emphasis was mainly on experimental, low capability projects. The idea was to gain experience in the construction and operation of satellites and launch vehicles. The challenge was to learn from the experiences of developed states and also to make progress with their assistance. Satellites developed in the early years of space evolution were systems like the Bhaskara earth observation satellites and a communication satellite (APPLE). ISRO conducted four flight tests on its SLV-3 satellite launch vehicle between 1979 and 1983.[9]

Subsequently, by the mid-1980s, a smooth transformation was made from the learning phase to a phase of professionalisation. During this period the focus was on more capable, mission specific systems. ISRO started designing and developing the Polar Orbiting Satellite Launch Vehicle (PSLV) and its successor the Geostationary Satellite Launch Vehicle (GSLV). These vehicles were required to launch the indigenously developed Indian Remote Sensing (IRS) satellite and a meteorology and telecommunications 'Indian National Satellite' (INSAT). PSLV commenced its operational launches in 1997 and since then has gained an enviable reputation as a most reliable workhorse with a track record of 25 successive successful flights up to November 2013. On 2 September 2007 India successfully launched its INSAT-4CR

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[7] "India Space programme Research- India Department of Space, Science Advancement" 1995 Indian Child 10 July 2008. http://www.indianchild.com/india_space_research.htm.

[8] Ibid.

[9] Mistry D (1998) India's Emerging Space Program. Pacific Affairs 71(2): 151–174.

geostationary satellite with the GSLV F04 vehicle. This launch proved India's capabilities in delivering payloads up to 2,500 kg to geostationary orbit. The first two stages of these GSLV vehicles were derived from the PSLV.

ISRO also has plans for the design and development of the Geosynchronous Satellite Launch Vehicle Mark III (GSLV Mk-III), which would be an entirely new launch vehicle rather than an upgrade of existing technology. In April 2002 the Indian government approved US$520 million funding for the development of the GSLV Mk-III capable of launching a 4,400 kg satellite to GTO with growth potential towards a 6,000 kg payload capability through minor improvements.[10] It may take a few more years to make this vehicle operational.

The basic limitation of the Indian space programme comes from the fact that the country is still devoid of cryogenic technology. For launching four ton plus satellites, ISRO has been developing a four-stage rocket. The third stage of this rocket is a cryogenic propulsion system and is still under development. In 1992, Russian President Boris Yeltsin was about to transfer this technology to India, but was pressured by the U.S. administration not do so, fearing that India could divert this technology for its missile programme. Instead Russia sold six cryogenic engines to India. Using these engines, India has undertaken a few launches but it is yet to mature this technology independently. The year 2010 witnessed two significant failures for ISRO in its attempts to launch heavy satellites. Unfortunately these failures resulted in reducing India's transponder capability. The recent attempt by ISRO in 2013 to undertake a GSLV launch by using an indigenously made cryogenic engine was also aborted a few hours before the actual launch because of a leak in the launcher system that was noticed on time.

Remote sensing is an area of excellence in India's satellite programme. In the area of satellite based remote sensing, two first generation satellites called Indian Remote Sensing (IRS) satellites respectively named as IRS-1A and 1B were designed, developed and launched successfully in 1988 and 1991 with multi-spectral cameras having spatial resolution of 72.5 m and 36 m, respectively. Second generation IRS-1C and 1D were launched from 1995 to 1997. These satellites had improved spatial resolutions of 70 m in multi-spectral and 5.8 m in panchromatic bands. These satellites have become main components in the National Natural Resource Management System and their data has been used for agriculture, forestry, and water resources management.

In 2003 a special remote sensing satellite called RESOURCESAT-1 was launched into polar orbit with sensors useful for land use and resource studies. The system provides five metre resolution of terrain features. India's cartographic series of satellites comprises satellites called CARTOSAT 1, 2, 2A and 2B. These satellites have the finest resolution in the world and offer stereoscopic imagery to simplify terrain mapping. CARTOSAT-1 was launched into polar orbit in May 2005, bearing two panchromatic imaging cameras each with a 2.5 m spatial

[10] "Space Launchers" BHARAT RAKSHAK: The Consortium of Indian Military Websites 21 Sept. 2008. http://www.bharat-rakshak.com/SPACE/space-launchers-gslv.html.

resolution. The stereoscopic imaging by the two cameras facilitates the construction of 3D terrain maps. These systems meet the demands of terrain visualisation, updating of topographic maps, generation of national topographic data base and other utilities planning.[11,12] The resolution of the satellites (2A and 2B launched during 2008 and 2010, respectively) matches the best in the world and offers sub-metric resolution (by way of comparison: the American satellite QuickBird is the world's highest-resolution commercial satellite and offers a spatial resolution of 60 cm).[13] Such satellites have strategic utilities too.

Satellite communication is another area in which India has made significant investments since the beginning of its space programme. The exact size of the investment is difficult to estimate because during the early years of its investments in space India followed the practice of developing an individual satellite with multiple capabilities. The basic reason behind this approach was saving money. INSAT series satellites were initially developed as multipurpose geostationary satellites with multiple payloads from communication to remote sensing to meteorology, all integrated in one single satellite.[14] More precisely, the INSAT-1 series, which consisted of four satellites, comprised mixed payloads for the purposes of communication and meteorology. The first two satellites of the INSAT-2 series were multipurpose satellites, while 2C and 2D had only communication payloads. The same was the case with the INSAT-3 series in which 3B and 3C were dedicated communication satellites.[15] The INSAT-4 series of satellites has also been initiated. It is proposed to have seven satellites in the series. INSAT-4A, 4B and 4CR satellites are already operational. These satellites cater for the communication requirements with C and Ku band transponders.[16,17] In 2004, India also launched the EDUSAT satellite into geostationary orbit for educational purposes. In 2002 for the first time an exclusive meteorological satellite called KALPANA-1 was launched. Another dedicated meteorological satellite INSAT 3A was launched on

[11] Krishnaswamy M and Kalyanaraman S "Indian Remote Sensing Satellite Cartosat-1: Technical features and data products" 24 Jan. 2008 EO Portal 17 Dec. 2013. http://www.gisdevelopment.net/technology/rs/techrs023.htm.

[12] Randall RC (2006) US-India Space Partnership: The Jewel in the Crown. Astropolitics 4 (2):166–167.

[13] Lele, Ajey "ISRO Delivers Ten Satellites at a Go" 30 Apr. 2008 Institute for Defence Studies and Analyses 20 Jan. 2014. http://www.idsa.in/publications/stratcomments/AjeyLele300408.htm.

[14] Srinivasan, Raman "No Free Launch: Designing the Indian National Satellite." Beyond The Ionosphere: Fifty Years of Satellite Communication, The NASA History Series. Ed. Andrew J. Butrica. Washington D.C., 1997.

[15] Sankar U (2007) The Economics of India's Space Programme: An Exploratory Analysis. Oxford University Press, Delhi.

[16] "Joint Statement by India and Brazil on the State Visit of Her Excellency Ms. Dilma Rousseff, President of the Federative Republic of Brazil to India" 30 Mar. 2012 Consulate General of India in Sao 20 Jan. 2014. http://www.indiaconsulate.org.br/comercial/p_nao_residentes/SatelliteProgram.htm.

[17] Various reports and statements by ISRO officials after 9 September 2007 regarding the launch of INSAT-IVCR.

9 April 2003. In October 2011 India opened a new chapter in its weather forecasting and atmospheric research capabilities by positioning the *Megha-Tropiques* satellite at an orbital altitude of 867 km. It is India's first major joint space project with France, and was launched to fill the void in atmospheric data in the equatorial region. This mission is also expected to provide a boost for aerospace research in Indian universities.

On 26 July 2013 a dedicated meteorological satellite INSAT-3D was launched, the payload of which is much more capable and accurate in comparison with other similar satellites launched almost a decade back. This is an advanced weather satellite configured with an improved imaging System and Atmospheric Sounder. The satellite also has a data relay transponder on board which collects weather observations from automatic weather stations located in some 1,800 inaccessible areas in desserts, mountains and water bodies. Another key payload of this system is the search and rescue unit that will pick up distress beacons from users on land, sea and in air during cases of emergency. India's neighbours and islands in the Indian Ocean region could also benefit from this system.[18]

In the twenty-first century smaller satellites have been the order of the day and many states are keen to invest in micro, nano and pico satellites. For developing states in particular, investing in such satellites is a cost-effective option and also satisfies their ambition to arrive on the 'space seen' for obvious reasons of nationalism and prestige. ISRO is concentrating on exploiting the emerging nano-satellites market and has already launched a few small satellites for other countries. In April 2008 ISRO launched two small satellites called IMS-1 (previously referred to as the TWSat-Third World Satellite, weighing around 83 kg) and IMS 1A also known as YouthSat.[19] ISRO is encouraging and helping domestic and foreign educational institutions to design and develop small satellites. Some future Indian investments are expected to revolve around development of small satellites and clusters of nano satellites with major contributions from Indian universities (ISRO has already launched several such satellites developed by university students). India is also keen on using satellite technology for scientific research and, plans to launch its first dedicated astronomy satellite, ASTROSAT, in the near future.

Indian thinking about the space arena could be said to have leapfrogged post-2005. One possible reason for this could have been the change in mindset of the Indian scientific community after the successful culmination of the Indo-U.S. nuclear agreement. This ended India's technological apartheid and it became obvious that India would be taken out of the international sanctions regime. In November 2006, 50 of India's topmost space scientists and technologists held a brainstorming session at Bangalore to explore the viability of undertaking

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[18] Lele, Ajey. "Weathering Heights: India Launches INSAT-3D Meteorological Satellite" 1 Aug. 2013 Society for the Study of Peace and Conflict 18 Sept. 2013. http://www.sspconline.org/opinion/IndiaINSAT3DMeteorologicalSatellite_01082013.

[19] "IMS-1" 28 Apr. 2008 Indian Space Research Organisation 24 Aug. 2013. http://isrohq.vssc.gov.in/isr0dem0v5/index.php/launchers/launchers-pslv/40-satellites-details/251-ims-1.

technologically challenging projects and making inroads into deep space to undertake missions such as a Moon mission.

In the 1970s, Prof. Vikram Sarabhai, the founder of India's space programme, articulated India's position as, 'a space programme with socio-economic application oriented space vision for the country'. He argued that India does not believe in the fantasy of competing with the economically advanced nations in the exploration of the Moon, or the planets, or manned spaceflight. For all these years India's investments mainly revolved around developing remote sensing and multi-purpose application satellites and related launcher technologies. Since 2006, India has probably redefined Prof. Sarabhi's vision of 'harnessing' outer space. Modern India appreciates that investing in deep space missions would also eventually offer various economic and social benefits. This is probably why India implemented a mid-course correction in its vision.

The year 2008 demonstrated India's reach into deep space as it successfully undertook its first Moon mission. On 22 October 2008, India successfully launched its first satellite probe towards the Moon, named Chandrayaan-1. India's lunar probe succeeded in finding the presence of water molecules on the surface of the Moon. Even though the mission was able to fulfil all its operational objectives it is important to note that this mission could stay on its course only approximately half of its designed lifetime (9 months of the envisaged 2 years). India is expected to launch its second moon mission in collaboration with Russia by 2014 when a rover is expected to land on the Moon. India also has plans for developing its own regional navigational system. It will consist of seven satellites and the first satellite in this constellation is already in space. It is expected that the system will become fully functional by 2015.

On 5 November 2013 India successfully launched the first phase of its mission to Mars. India's maiden mission to the red planet is called the Mars Obiter Mission (MOM) and will take about 300 days to reach its Martian orbit. If successful, India will become the first Asian nation to achieve such a milestone.

At present, any form of human spaceflight is costly and technologically challenging, and hence India has chosen to keep the scope of its space programme limited to robotic missions.[20] Notwithstanding this, a few years ago India started experimenting with the technologies required to undertake human missions. On 10 January 2007 India successfully launched a recoverable spacecraft into orbit (this mission was called the Space Recovery Experiment, SRE). India successfully tested the vehicle and re-entry technology through this mission by placing a capsule into orbit at an altitude of 625 km and successfully recovering it after 11 days. This capsule had an indigenously developed thermal protection system in the form of silica tiles, which proved their worth by withstanding extremely high temperatures during re-entry. This mission can be viewed as a first step towards fulfilling the

[20] Lele, Ajey. "India aborts a human Moon mission" 17 Sept. 2012 The Space Review 31 Oct. 2013. http://www.thespacereview.com/article/2157/1.

dream of a human space programme. However, no further validation of this technology has been attempted since.

Overall, one of the important reasons behind ISRO's success has been bipartisan political support. ISRO has been provided with reasonable budgetary support from the government for all these years. The value of ISRO's overall assets today is approximately US$25–30 billion.[21] Since India's independence, science and technology policies have more or less remained unchanged irrespective of the government in power. India's space programme is placed directly under the Prime Minister and hence has been relatively free of major bureaucratic delays and red tape restrictions.

The thrust India has given to its expanding space programme indicates that it has major expectations for its space agenda in future. From a geopolitical point of view, success in its space programme has boosted its 'soft power' status. In the near future developing nations interested in space activities will rely more heavily on India because of its reliable space infrastructure and economical commercial launching facilities. In the immediate future, India is expected to play an important role in the formulation of a global space regime that would involve not only the disarmament agenda but also formulation of a policy towards international technological collaboration in areas of mutual concern.

9.3 New Space-Faring States

Apart from Japan, China and India, one other country can be viewed as an important space state. Having made investments in space for almost two and half decades, Israel also possesses significant space capabilities. The country of 8 million people—which became a space-faring state in 1988—has an approximate $80 million space budget that caters for both civil and military needs. What Israel has accomplished over the years with small budgetary support is truly remarkable. Its space programme has a military bias but there are also signs that the civil and commercial programmes are set to grow.[22]

Other states in Asia that have made remarkable progress in their space activities are Iran, North Korea and South Korea. Iran became a space-faring state in 2009 while North Korea and South Korea achieved this feat during 2012 and 2013, respectively. All three programmes can be viewed as nascent programmes but are expected to have major growth prospects, particularity the programmes of Iran and

[21] Kasturirangan, Krishnaswamy "The Emerging World Space Order" Space Security and Global Cooperation. Eds. Ajey Lele and Gunjan Singh. New Delhi: Academic Foundation, 2009. 33.

[22] Boucher, Marc. "Military Space Drives Israel Space Program for Now" 5 Sept. 2013 SpaceRef Canada 10 Nov. 2013. http://spaceref.ca/space-quarterly/military-space-drives-israel-space-program-for-now.html.

South Korea. Obviously, not much is known about the North Korean space programme.

Amongst these three states the space policies of North Korea and Iran have always been suspect mainly because of the nuclear backdrop. Reaching outer space by launching satellites has direct military connotations because the launch technology in regard to satellites could be easily translated into ballistic missile technology. The U.S. and its allies are of the firm conviction that satellite launches by Iran and North Korea are actually instruments to establish expertise in long-range ballistic missile systems. In this respect, there has been a past history of technology transfer in the missile arena between North Korea and Iran. The Space programmes of North Korea and Iran are looked at with suspicion for their demonstrative missile designs. It is, however, important to note that both states entered the missile arena long before the conceptualisation of their space programmes. Hence, it would be incorrect to believe that space launches are the only option for them to display their missile prowess.

Particularly in the case of Iran, it has been observed that in spite of the strong scepticism of a few states about anything positive coming out of that country, Iran has shown slow but steady S&T progress. Clearly, Iran sees symbolic value in its space programme but it is also important to appreciate that according to the UK's Royal Society, Iran has recorded the world's fastest scientific growth over the past 15 years, with scientific output rising 18-fold between 1996 and 2008. Since 2009, Iran has launched some satellites successfully in space and has plans to launch three satellites called Tadbir, Nahid and Sharif Sat before March 2014. Iran has also launched a bio-capsule with a living monkey into space, which reached an altitude of more than 120 km and returned to Earth safely. It is expected that Iran will repeat this experiment shortly.[23]

South Korea has shown significant tenacity in developing its space programme. It started with various activities in the space domain in the late 1980s and its first indigenously produced satellite, KOMPSAT-1, was launched in 1999 aboard a Russian-produced rocket. Subsequently however, South Korea has taken a significant amount of time to achieve the status of a space-faring state. Its first two launch attempts failed and there was also a failure in putting the satellite into the correct orbit. Success came only in 2013. The country has big plans[24] for the future and is also keen to undertake deep space missions. Its progress, however, now depends on how quickly it is able to make technological headway and how much financial support it is willing and able to provide to its space agency. Table 9.2 presents the main features of Asia's upcoming smaller space nations.

[23] "Iran To Launch 3 Satellites in 6 Months—TV" 11 Oct. 2013 RIANOVOSTI 11 Nov. 2013. http://en.ria.ru/world/20131011/184063118/Iran-To-Launch-3-Satellites-in-6-Months--TV.html.

[24] United Press International "S. Korea outlines space program" 20 Nov. 2007 PHYS.ORG 12 Dec. 2011. http://www.physorg.com/news114789828.html.

Table 9.2 Summary of the chief features of Asia's promising space programmes

Name of the country	Space-faring status	Total number of satellites	LEO	MEO	GEO	Approximate budget USD
Israel	1988	15	6	–	5 (+4 other objects)	80 million
Iran	2009	4	4	–		500 million
DPRK	2012	2	2	–		Unavailable
ROK	2013	15	9	–	6	300 million

9.4 Smaller States with Space Cognizance

Various smaller Asian states that have limitations in terms of technological and financial capabilities are also showing increasing interest in acquiring capabilities in the space arena. A broad intra-regional distribution of these states can be divided into three sub-groupings: states from the Middle East, states from South Asia and states from Southeast Asia. Most of these states are aware that it could be difficult for them to acquire the status of space-faring nation and are trying to develop any launching technology. Consequently, their basic approach has been to accept outside assistance to put their own satellites into space. Some of them are very keen to join the rapidly growing space industry.

In the Middle East Region, the United Arab Emirates (UAE), a federation of seven states, is steadily building a portfolio of space resources and is fast emerging as a major aerospace hub. It has already put its first satellite in orbit and has plans for more. In July 2013 a 700 million euro order for two espionage satellites was given to a French company by UAE.[25] The UAE's capital Abu Dhabi is an advanced city in the region and is fast emerging as a major space hub. The private sector company Virgin Galactic is keen on building a spaceport in Abu Dhabi. Actually, Abu Dhabi's Aabar Investments has already acquired a 32 % stake in Virgin Galactic by paying $280 million.[26] Also, UAE's space agency is making investments in cities such as Dubai where multiple types of infrastructures are being developed including satellite testing facilities. Saudi Arabia is another country with potential for and interest in growth in the space field. Significant investments by Saudi Arabia have been made in the field of low orbit micro-communication satellites and the country has plans for various other space related investments.

In South Asia, Pakistan and Sri Lanka are developing their own space programmes. The space programme of Pakistan is more state-centric and the

[25] Seibt, Sébastian. "France beats US to Abu Dhabi spy satellite deal" 23 July 2013 FRANCE 24 20 Nov. 2013. http://www.france24.com/en/20130723-france-beats-us-abu-dhabi-spy-satellite-deal.

[26] England, Andrew. "Abu Dhabi company has stellar vision for Virgin Galactic stake" 29 July 2009 The Financial Times 24 July 2013. http://www.ft.com/intl/cms/s/0/50a781a2-7bd8-11de-9772-00144feabdc0.html#axzz2kVayA9at.

Table 9.3 Key Information regarding the operational satellites of Asian nations currently developing their space capabilities

Name of the country	Number of satellites	LEO	GEO
Saudi Arabia	12	12	–
UAE	6	1	5
Pakistan	4	2	2
Thailand	7	2	5
Malaysia	6	2	4
Indonesia	13	3	10
Vietnam	4	2	2

country has already put a few satellites into space, mainly with assistance from China. In the case of Sri Lanka, the only satellite launched so far actually belongs to a private company. Here too China is helping the agencies develop their space programmes. Private enterprises from Sri Lanka are engaging states like Afghanistan and Maldives to expand their commercial footprint and market share.

Being close to the Equator, the South East Asian region has a geographical advantage in launching satellites. However, as various littoral states in this region are both economically and technologically underdeveloped, they have not yet been able to exploit this advantage to its full extent. For the last couple of years various states from this region have been making investments in the space area appropriate to their needs and capabilities. States like Malaysia, Philippines, Singapore, Thailand, Indonesia and Vietnam have made important investments. Indonesia, the biggest economy in the region and a state with an amazing maze of islands, has been relying on space technology since the 1960s and its National Institute of Aeronautics and Space (LAPAN), a national space agency, was established in 1964. This was around the same time the Malaysian space programme was also established, but it did not make much progress at first. Most investments in the region are in the area of space based communication facilities.

In South East Asia, Malaysia is very interested in investing in multiple areas of space technologies and space sciences and has major ambitions for the future.[27] States such as Vietnam, Thailand, the Philippines and Laos are receiving taking assistance either from the U.S. or from China to develop their space programmes. As they are situated in a disaster-prone region these states are keen to make investments in space technologies that could offer them assistance in forecasting and managing disasters such as earthquakes and severe weather-related phenomena. Table 9.3 contains some key information regarding the operational satellites of those Asian states that are currently developing their space capabilities.

[27] Mohd. Alauddin Mohd. Ali. "Space Activities in Malaysia" 2011 Institute of Space Science—National University of Malaysia 6 Jan. 2013. http://www.unoosa.org/pdf/sap/hsti/Seminar2011/HSTI.Alauddin.pdf.

9.5 Asia and the Space Security Regime

In terms of the conduct of activities in outer space it is the responsibility of states to maintain the principles of cooperation and ensure the common interest of humanity. Asian states understand that outer space should only be used for peaceful purposes and are opposed to the weaponisation of the outer space environment. In general, there appears to be a broad conformity in space security related issues. North Korea is the only state in the region that has kept itself totally isolated from issues related to space disarmament and arms control.

The states in the region understand that threats to space assets are growing significantly with our ever-increasing use of outer space. Unfortunately, China has created ripples in regards to issues related to space weapons by undertaking an anti-satellite test (ASAT) during 2007. This test resulted in an increasing amount of debris, thus creating more threats to satellites. Appreciating the urgent necessity for the formulation of a global space regime, the states in the region have in principle approved the European Union's initiative for an international code of conduct for space activities. It is expected that the majority of Asian states will subscribe to a code of conduct as it takes a final shape. Table 9.4 gives an overview of the signature and ratification status of Asian space nations with regards to international legislation.

A check mark in Table 9.4 indicates that a state has both signed and ratified an agreement.

Table 9.4 Asian nations and their status regarding security related multilateral mechanisms

State	Outer Space Treaty (1967)	Rescue Agreement (1968)	Liability Convention (1972)	Registration Convention (1975)	Moon Agreement (1979)	COPUOS Member (1958)
Japan	✓	✓	✓	✓	No	✓
China	✓	✓	✓	✓	No	✓
India	✓	✓	✓	✓	Signed	✓
Israel	✓	✓	✓	No	No	No
Iran	Signed	✓	✓	Signed	No	✓
DPRK	✓	No	No	✓	No	No
ROK	✓	✓	✓	✓	No	✓

The information is collated based on the input available in various sources

9.6 Conclusions

Space programmes are valuable investments for Asian states in spurring their agenda of socioeconomic development and growth. States in the region are making significant efforts to improve the organisational performance of their space agencies and are keen to use their investments to feed into their economic and commercial planning.

India has made significant progress in the space arena over the last three to four decades. Since the beginning, India's interest in developing space sciences and technologies have been questioned by those who have challenged the relevance of space activities for a developing nation. The Indian state and scientific establishment, however, have always expressed a clear vision and rationale for the implementation of a space programme. It has become obvious that the Indian space programme has been focused on domestic needs. The Indian Space Research Organisation also invests in programmes in the areas of telecommunication, remote sensing and navigational programmes that have multiple utilities for the state and its citizens.

Having understood the emerging business potential of the global space market, India is making efforts to join other global powers in the commercial space arena. The exciting ISRO infrastructure, however, has been developed essentially to cater to India's social and scientific requirements. Hence, it is important for India to encourage and engage private industry and also for ISRO to transfer the technology to commercial players. For India there is a need to evolve a public-private partnership model at the earliest possibility so as to accelerate India's business interests.

The deep space arena is another field where ISRO is making successful inroads. In comparison with major space powers, India's achievements in this field are small. Nevertheless, India is in a position to technologically leapfrog and it needs to make sustained efforts and monetary investments to achieve greater success in this field.

For the coming decades India has established a significant roadmap and the nation is expected to make significant progress. But much of India's progress both in the commercial fields and otherwise will depend on how quickly ISRO develops its launch vehicle (GSLV) capable of sending heavy payloads (4 tons and more) in orbit.

Many smaller Asian states are confronted with challenges in terms of socioeconomic development, domestic politics, terrorism, natural disasters and others. These countries understand that satellite technologies have various utilities that could offer solutions to these problems and hence they are very keen to invest in satellite technologies. Moreover these nations also have commercial interests in the space area. Appreciating that space tourism is likely to become an important element of future space commerce, they are keen to establish a services industry. At the same time it is also important to note that all these states view space technologies as a tool to undertake symbolic activities and to raise the sense of nationalism amongst their population.

In general, Asian states are aware of the challenges in the space field too, particularly the challenges in respect of establishing a rule-bound space security regime. Many of them are hoping that a legally binding space regime will emerge in the near future. It is also felt that there is a need to amalgamate the non-state actors in the business of space smoothly and effectively and with correct security measures in place.

For many years developments in space have taken place in isolation and this is also true for Asia. Various states in this region are running their individual programmes and there is a need for various states in the region to learn from the European Space Agency model of regional pooling of resources and technology. Now the time has come for various Asian states to join hands and develop and execute joint projects, not only to increase performance but also to reduce cost. The technological expertise available in a few states could be pulled together and every state could contribute financially to undertake major projects useful for all contributing states. India could take a lead in this regard and an Asian space model could be developed.

Chapter 10
The Globalisation of Space Activities: The Implications for Europe and Possible Strategies to Pursue

Arne Lahcen

10.1 Introduction

The context in which space activities take place is gradually yet continuously evolving. Eventually economic, political, social and technological changes will give rise to a new space playing field. This field will be different from the twentieth century space environment in that it will have more heterogeneous actors, different market structures, more governance challenges and new innovation dynamics. The aim of this contribution is to answer some of the major questions that arise in this respect. This article is organised around three main parts, each with a different focus. Firstly, it describes the ways in which space is changing and how most of these changes can be understood in a coherent way. It is argued that many changes are in fact interconnected and self-reinforcing tendencies generated by an underlying process of globalisation of space activities. This helps to explain their occurrence and provides some clues about their anticipated implications. Secondly, the consequences of these changes for Europe are assessed in a Strengths-Weaknesses-Opportunity-Threats (SWOT) analysis. Applying this methodology to space reveals that while the challenges in terms of governance, sustainability and security are considerable, the opportunities include increasing overall demand, more dynamic and innovative markets and interesting cooperation opportunities. Finally, the article seeks to answer the question how exactly Europe can optimise its position to make best use of this changing environment. Four different strategies for decision-makers are described and substantiated based upon the findings of the SWOT analysis. For all four strategies some concrete proposals are formulated and the major potential benefits and issues of concern are highlighted.

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10.2 How Space Is Changing

The world we live in changes constantly. As we live through these changes on a day-to-day basis, however, it is quite hard to imagine how profoundly they eventually reshape society over time. This observation bias even plays out over the course of one or two decades. The commencement of the twenty-first century is not that far back and the memory of this event is still fresh for many. At the same time it is salutary to reflect that humanity then was clueless about events such as 9/11 and the global economic crisis, the occurrences of which have impacted society quite profoundly. Obviously these are just a few illustrations. The point is, however, that there have been many more events—minor and important, distant and afar—and that a society subject to a combination of sudden and consecutive changes in many parts of its segments will ultimately transform itself. As it does so, most activities conducted within this society will experience profound changes too. This article seeks to assess the changing context for space. As a first step it looks at the transformation of the environmental factors that exert influence on space activities.

10.2.1 Globalisation as a Theoretical Framework

Scholars in different academic disciplines spend a lot of time and effort studying the processes of change affecting our world, looking for theories that can explain why exactly they occur and how they give rise to the effects we perceive over time. To this effect, international relations specialists, economists, sociologists and political scientists have postulated and discussed a considerable number of different paradigms and theoretical frameworks. They do so because the usefulness of a theory lies in its ability to facilitate analytical processes, provide understanding of the root causes of change and of its potential to make valid predictions regarding future developments.[1] In this article the process of globalisation is understood as a supporting theoretical framework to make sense of the various changes currently affecting the space sector worldwide. Although an in-depth substantiation of the concept of globalisation falls outside the scope of this article, it is necessary to shed some light on the nature of its dynamic and highlight its relevance for understanding global changes in space activities.

[1] For a good overview, see for example: Jackson R and Sørensen G (2007) Introduction to International Relations: Theories and Approaches. New York: Oxford University Press.

10.2.1.1 Globalisation: A Complex and Multidirectional Concept

Significant volumes have been written about globalisation yet to date there is no scientific consensus regarding its definition, novelty or scope.[2] This is partially because the theory was matured in a number of heterogeneous scientific disciplines including geography, sociology, economics and political science. Therefore its definition tends to vary according to the background and scientific orientation of the scholar defining it. The lack of consensus is expressed in several ways. On the one hand scholars tend to disagree on the focus of the theory; whether it should be concerned with economics, culture or political power, for example. On the other hand scholars disagree on the nature and outcome of globalisation processes. While some argue that it reinforces homogenisation and socioeconomic convergence, others blame it for the rising social inequality in contemporary societies on a national and global level. These diverging views, however, do not necessarily refute each other. Globalisation is a highly complex process in that it simultaneously creates multiple outcomes that at first sight may seem to contradict each other. More overarching definitions of globalisation that focus on the driving forces that form the core of all globalisation processes avoid these seeming contradictions. In this respect the definition formulated by David Held, Anthony McGrew, David Goldblatt and Jonathan Perraton in their book "Global Transformations" is particularly illuminating. They define globalisation in its most general sense as "a process of widening, deepening and speeding up of global interconnectedness".[3] Under this definition globalisation can be conceived as a diffuse process that creates highly uneven geographical, socioeconomic and political outcomes depending on the context and the activities taken into consideration. It also implies that it is not solely concerned with the relationships between individual entities such as states, intergovernmental organisations and multinationals. On the contrary, its inherent generalist nature enables it to link together transformations in the spheres of economic relations, market structures, international trade, politics, security, society and, technology development in an intuitive and coherent way. Therefore, this definition will be used for the purpose of this contribution.

The choice of this theoretical framework and definition of globalisation to assess changes in space activities and policies worldwide is motivated by two reasons. Firstly, this theory of globalisation well fits the diverse nature of space activities and the outer space environment itself. Secondly, globalisation is a major driving force behind many of the more recent developments and changes in space activities and policies worldwide. Therefore, it helps a great deal in predicting some future

[2] For a more comprehensive overview of the different definitions and perspectives on globalisation, see: Beerkens, Eric "Globalisation: Definitions and Perspectives" 2006 Beerkens' Blog. http://www.beerkens.info/files/globalisation.pdf.

[3] Held, David, McGrew, Anthony, Goldblatt, David and Perraton, Jonathan. Global Transformations: Politics, Economics and Culture. Stanford: Stanford University Press, 1999: 2.

developments that can be expected in the space community and this in turn is necessary to formulate well-considered recommendations for decision-makers.

10.2.1.2 Space as a Driving Force Behind Globalisation (1957–Present)

From a historical perspective, space has been one of the pre-eminent driving forces behind the global integration the world has witnessed since the end of the Second World War. The ability to use space as an enabling environment has had far-reaching and profound impacts on society. In fact, it has done so in a variety of ways. Thanks to scientific progress and the courageous efforts of astronauts, humanity now has a much more global, all-embracing and rational perspective on the planet, the universe and the processes that have given them shape. In addition the emergence of spacefaring capabilities in the late 1950s gave rise to increased security threats, which in turn forced the international community to figure out a governance model based upon global consensus—a challenge that succeeded despite the dominance of a Cold War that profoundly divided the world along ideological lines. This is expressed in the regime for outer space governance as embodied by different international treaties and principles in the United Nations (UN) framework.[4] Moreover, space technologies have become an indispensable asset in the functioning of modern society which is characterised by time-space compression, complex interdependencies and the constant gathering and sharing of information on a global and instantaneous basis.[5] The various services provided today by remote sensing, telecommunication and satellite navigation satellites allow the global economy and society to function according to principles of immediate cause and effect. This is expressed by the global networks that spread news, information, culture and knowledge around the globe, acting as a nerve system of the human realm. Finally, space-dependent technologies anno 2013 have an enormous strategic and socioeconomic value, since they facilitate the worldwide mobility and protection of data, services, material goods, cultural goods, capital and people. In this sense space has to large extent spurred the processes that constitute the core elements of globalisation as defined in the literature by Held et al.[6]

[4] More precisely these are: the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, the 1972 Convention on International Liability for Damage Caused by Space Objects, the 1975 Convention on Registration of Objects Launched into Outer Space and the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies.

[5] Agnew, John. "The New Global Economy: Time-Space Compression, Geopolitics, and Global Uneven Development." Journal of World-Systems Research 7.2 (2001): 133–154.

[6] Faulconbridge James R., and Beaverstock Jonathan V. "Globalization: Interconnected Worlds" Key concepts in Geography. Eds. Sarah Holloway, Stephen P. Rice, Gill Valentine, and Nick Clifford. London: Sage, 2009. 331–343.

10.2.1.3 Globalisation as a Driver of Space Sector Changes (2001–Present)

Second, globalisation tendencies are a major driving force behind many of the more recent developments and changes in space activities and policies. Therefore, the paradigm of globalisation is very helpful in understanding a course of changing events that started in the late 1980s and has been accelerating, particularly recently. It is important to note that this tendency has not replaced the role of space as an enabling environment for worldwide globalisation processes. Rather, globalisation as a driving force of space sector changes is an additional dynamic that started to kick-in and reinforcing ever since the space sector reached a critical mass in terms of openness, strategic importance and profitability. For a long time the space sector was quite disconnected from the economic logic that dictated business in other sectors of the globalised economy. This was because, as opposed to the manufacturing of cars, furniture or mobile telephones, space technologies were considered an asset of national strategic importance with related security imperatives. Countries typically developed their space capacities under publicly funded programmes. The result was that the space sector, even where privatised, remained fairly subsidised in the sense that it was very dependent on continuous government spending. Recently, however, this logic has started to change; the percentage of space industry solely relying upon public resources is in relative decline as the demand of other customers has increased.[7] The space sector is becoming subject not only to privatisation tendencies but also to increasing commercialisation and thus subject to the economic laws that rule global markets. This globalisation of space activities means that concepts such as competitiveness and innovation are becoming much more relevant for both manufacturers and customers. As a consequence, many space actors and segments are now confronted with changes that propagate throughout the entire value chain. Although it is impossible to put an exact starting date on this process, it can be situated roughly around the turn of the millennium.

This chapter assesses how globalisation tendencies have impacted the four key elements that constitute and determine the global playing field of space activities: (1) the major governmental actors, (2) the institutionalisation of space activities, (3) the space industry and, (4) the link between space and society. Although the exact unfolding of changes is rather heterogeneous in each of these cases, the chapter shows how they can be seen as symptoms or consequences of globalisation tendencies or their secondary effects.

[7] Villain, Rachel. ed. Satellites to be Built & Launched by 2022: World Market Survey. Euroconsult, 2013. 127.

10.2.2 Major Governmental Actors

10.2.2.1 The United States

For the United States (U.S.), space has been a priority since the launch of the Sputnik in 1957; an event by which the USSR turned outer space into an environment of tremendous strategic military and geopolitical importance. During the Cold War the importance of space capabilities widened and diversified and, consequentially, the role of the space environment today is not only geopolitical but also technological, social, scientific and economic. Nevertheless space remains an environment where strategic advancement in capabilities still matter a great deal for purposes of power display and global leadership, especially among the major players and nations with conflicting ideological orientations. To date, the U.S. remains the largest space nation in terms of both overall capabilities and expenditures expressed in absolute dollar value and spending per capita,[8] in spite of flattening budgets for its National Aeronautics and Space Administration (NASA).[9] Globalisation is nevertheless putting pressure on U.S. leadership in a number of ways. Literature on the impact of globalisation on space activities states that this pressure is due to the global democratisation and diffusion of technology, information, economic power and international influence.[10] As the world becomes increasingly interconnected these elements create a levelling effect which decreases the relative lead of the U.S. in outer space affairs. Consequently the levelling effect will ultimately impact relationships with international partners, increase competition in space products and services, and challenge U.S. leadership abroad. In this sense the levelling effect is forcing the U.S. to rethink the aims and structure of its civil space programme in order to give it a new identity and relevance in a post-Cold War era.[11] This tendency is currently at work at different levels, as the U.S. is evaluating and reorienting its priorities, its industrial model and its reliance on international collaboration for its space activities.

In terms of overall priorities, the U.S. is shifting away from its NASA flagship programmes of the 1980s and 1990s towards a much more ambitious—yet realistic—human space exploration programme. The focus on LEO access that had endured for over three decades has now ended with the termination of the Shuttle programme. Instead NASA is now developing its new crew capsule Orion and the accompanying new heavyweight launcher Space Launch System (SLS). The launcher will give the agency the capability of sending humans beyond Earth

8 Bochinger, Steve. Government Space Markets World Prospect to 2022. Euroconsult, 2013. 4.

9 Rogers, Simon. "Nasa budgets: US spending on space travel since 1958 UPDATED" 1 Feb. 2010 The Guardian 10 Dec. 2013. http://www.theguardian.com/news/datablog/2010/feb/01/nasa-budgets-us-spending-space-travel.

10 Vedda, James A. "The Role of Space Development in Globalization." Societal Impact of Spaceflight. Eds. Steven J. Dick and Roger D. Launius. Washington DC: U.S. Governmental Printing Office, 2007. 193–205.

11 Ibid.

orbit for the first time since the termination of the Apollo programme in the early 1970s.[12] The advantage of this approach is that it serves as a countermeasure to the levelling effect in the sense that the U.S. is developing capabilities that are currently lacking on the global stage. Although other countries are pursuing similar goals in the mid-term, the country hopes to increase its strategic position and derived power in terms of leadership by being the first to achieve them. Although the opportunities arising from this approach are promising, the implementation and expected outcome have been subject to criticism. Concerns have been raised about the financial sustainably of the SLS programme.[13] In addition, there seems to be no political consensus in the American Congress on what the targets of Orion should be: catching a near Earth asteroid and putting it in orbit around the Moon to investigate it or land on the Moon.[14] This is remarkable, especially considering that space has traditionally been one of the few topics that could count on consensuses decision making and political support from both Republicans and Democrats. Whether these new approaches will eventually fulfil the expectations that were formulated at the outset still remains to be seen. It is nevertheless clear that, partially due to the levelling effect accelerated by globalisation, the U.S. is now more open towards reliance on international partners than in the past.[15] This tendency is not only expressed in the U.S. Space Policy and the U.S. Space Transport Policy of the Obama Administration.[16,17] It is also starting to translate into practice—even in the launching sector which is typically considered as a domestic asset of strategic importance. The service module of the Orion crew vehicle will be provided by the European Space Agency, which built the technology for its Automated Transfer Vehicle (ATV) developed to supply the International Space Station (ISS) with cargo. The latter is not unimportant, as including foreign partners on the critical path of certain programmes might be a first step to developing more integrated forms of collaboration in the long term. If things evolve at the pace they are doing right now, it is very likely that the slumbering goal of going to Mars will be too challenging for any one single agency to perform. This might eventually impose multilateral approaches to save agency resources, as happened with the deployment and exploitation of the ISS.

[12] "Exploration Systems Development: Extending human existence into deep space" NASA 11 Dec. 2013. http://www.nasa.gov/exploration/systems/#.Uvykkvl5P-k.

[13] Strickland, John. "Revisiting SLS/Orion launch costs" 15 July 2013 The Space Review 12 Dec. 2013. http://www.thespacereview.com/article/2330/1.

[14] Bochinger, Steve. Government Space Markets World Prospect to 2022. Euroconsult, 2013. 138.

[15] Sheenan, Michael. "The new 2010 U.S. space policy" Yearbook on Space Policy 2009/2010: Space for Society. Eds. Kai-Uwe Schrögl, Spyros Pagkratis, and Blandina Baranes. Vienna: SpringerWienNewYork, 230–241.

[16] "National Space Policy of the United States of America" 28 Jun. 2010 The White House 12 Dec. 2013. http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

[17] "National Space Transportation Policy" 21 Nov. 2013 The White House 12 Dec. 2013. http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_space_transportation_policy_11212013.pd.

In addition to changing priorities, globalisation is also affecting the United States' business model and industrial policy for space. This is evident in the reorganisation of production chains, industrial policy and the provision of access to Low Earth Orbit (LEO). NASA has recently started outsourcing some of its tasks to commercial companies. Space Exploration Technologies Corporation (SpaceX), for instance, uses its self-developed Falcon launchers and Dragon capsules to deliver cargo to the ISS and other LEO destinations. The underlying idea of this approach is that mature space agencies, such as NASA, should rather focus on the enabling technologies required for deep space exploration and leave to commercial providers the provision services and goods that are based on mature technologies. Doing so allows the governmental agency to work on long term innovation and capacity building. At the same time, the approach spurs the development of a domestic commercial space industry ready to face competition on the increasingly globalised markets for launches, satellite procurements and services.

10.2.2.2 Europe

Of course Europe is not a nation like the other major players in space, but rather a cooperating region. It is nevertheless appropriate to treat Europe as a somewhat unitary player because most of the major space capacities and policies are developed and performed within Europeanised structures; intergovernmental organisations resulting from a process of European integration. This is clearly illustrated by the allocation of overall funding for space activities. In 2012, the budgets of the European Space Agency (ESA) and the European Union (EU) accounted for 43.5 and 17.5 % of all European governmental expenditures in space, respectively. This means that pan-European institutions jointly account for 61 % of the total European space budget—even when civil and military are combined.[18] Within Europe, significant changes have taken place since the turn of the millennium. Those most noticeable have probably taken place in the sphere of governance, where a number of events are currently forcing Europe to find a new institutional approach that optimises its potential in space.

One of the major driving forces of change is the explicit competence over space matters that has been given to the EU. Since the entry into force of the Lisbon Treaty in 2009 space has become an instrument for the achievement of the EU's objectives as well as an EU policy in its own right. The occurrence of this event is neither an isolated nor independent development, it fits into a longstanding record of Europeanisation efforts that have to a large extent been driven by globalisation processes. Today a considerable number of policy domains and activities has—in one way or another—a policy dimension at EU level. Over time this process of European integration has been characterised by widening and deepening. Since its inception the EU has grown tremendously both in terms of geographical reach and

[18] Bochinger, Steve. Government Space Markets World Prospect to 2022. Euroconsult, 2013. 9.

in its scope of competences. From a high level perspective the process of Europeanisation has followed a rather systematic logic. Typically, policy domains were transferred to the EU because the European level offers economies of scale that benefit policy implementation. For some policy domains this has enabled the creation of wealth and benefits that would not have arisen otherwise. This has been the case, for example, in the fields of environmental protection, transport, energy and the internal market. In other instances policy areas were Europeanised because the EU is the only level at which external challenges can be addressed effectively, efficiently and with the required political weight—for example in security and international affairs and trade. As a result, the relationship between European integration and globalisation has evolved into one that has been described in the literature as "interrelated and mutually implicated" by which is meant that European integration is a reaction to and at the same time an expression of globalisation.[19,20] From this perspective the recent EU competence over outer space is rather self-evident. On the one hand it was a sensible thing to do because so many other policy domains that benefit from space technologies and capacities were already situated at EU level. On the other hand it was the only viable option to address the globalisation-induced challenges and opportunities that have arisen in Europe and the global context as illustrated throughout this chapter.

At the same time this dynamic is also impacting Europe's most prominent and established actor in space—the European Space Agency. The Agency is witnessing a new enlargement phase as demonstrated by the number of states that have recently joined and the fact that a number of initiatives are being taken to facilitate the integration of aspiring Eastern European countries in the near future.[21] Although ESA is well situated to cope with the accession of new European member states and a number of cooperative support mechanisms to this effect are in place, the scale of its recent enlargement has put some stress on its absorption capacity. Its industrial policy—and more specifically the geo-return principle around which it is structured—requires new member states to possess a national space industry that has a critical mass capable of procuring space hardware and infrastructure commensurate with national contributions. This is, however, not evident given the large number of ESA member states (twenty in 2013) and the speed at which the enlargement process has taken place (five states have acceded as full members since the year 2000). Notwithstanding these growing pains, ESA enlargement is a very positive evolution and it offers interesting perspectives for the future. In addition to this, ESA has taken some major strategic decisions with regard to future investments. In

[19] Rumford, Chris. "European Cohesion? Globalization, Autonomization, and the Dynamics of EU Integration" Innovation 13.2 (2000): 1983–197.

[20] Castells M (1998) End of Millenium: The Information Age: Economy, Society and Culture Volume III. Blackwell, Oxford: 352–361.

[21] For a comprehensive analysis of this development, see „Klock, Erich and Aliberti, Marco. "ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession—With a Special Focus on the CEE Region" Feb. 2014 European Space Policy Institute 18 Feb. 2014. http://www.espi.or.at/images/stories/dokumente/studies/ESPI_Report_47.pdf.

July 2009 the Agency signed a contract with EADS Astrium to develop advanced re-entry vehicle activities, based on further development of the successful Automated Transfer Vehicle, which, by 2013, it had used successfully four times to supply the ISS with cargo. Considering the termination of the American Shuttle programme, this decision—approved at the ESA Ministerial Council in 2008—will positively influence Europe's strategic position in human spaceflight operations. Further, it was decided that ESA would start the development of a European Space Situational Awareness (SSA) network. Around the same time, ESA also opened a new facility in the UK: the European Centre for Space Applications and Telecommunications (ECSAT) located at the Harwell Science, Innovation and Business Campus in Oxfordshire. The operations and research activities being deployed at ECSAT will spur the development of space-based services and applications, thus contributing to Europe's space innovation potential. Finally, subscriptions for the detailed definition studies of the new Ariane 6 launcher and the continuation of the development of the adapted Ariane 5 ME were agreed at the ESA Ministerial Council of 2012. Investing in future capacity building has been possible because to a large extent ESA budgets have been spared from severe austerity measures, in spite of the presence of a deep economic and financial crisis in Europe.

The fact that two major players are now determining Europe's path in space activities is currently reshaping the way the continent is dealing with space in several ways. In terms of programme development, EU involvement has enabled the deployment of operational services that will serve the needs of European citizens, enterprises and governments. The flagship programme Galileo will endow Europe with its own independent high-accuracy satellite navigation system. In 2013 the in-orbit validation phase of Galileo was successfully undertaken and completed. It is expected that initial Galileo services should be available by the end of 2014 or early 2015. Europe's other flagship initiative, the integrated Earth Observation programme Copernicus, is in its pre-operational phase with the launch of the first satellite of its space component Sentinel-1 scheduled for March 2014. As these are very large programmes they require the involvement of multiple actors in order to get all necessary expertise together. To this effect the EU acts as the leading authority under its seventh framework programme and Horizon 2020, while ESA is responsible for the development of the space components and the ground infrastructure.

The impact of globalisation on governance goes further, however, than the joint establishment of flagship programmes. Over the last decade the EU has been developing a space policy that validates its competence over space affairs in a manner that fits its scope and wide ambitions. To this effect a number of actions have been taken so far. A first official European Space Policy was formulated in 2007 together with ESA, and has led to a number of follow-up communications since. In these documents the European Commission outlined its ideas and a vision for a space strategy to the benefit of European citizens, an EU space industrial policy and proposals for establishing appropriate relationships between the EU and ESA as a follow-up to the Framework Agreement signed in 2003. Most recent developments reveal EU involvement in space sustainability initiatives, as expressed by the EU-led initiative on an International Code of Conduct for Outer Space Activities and programme support in the development of a European space surveillance and tracking service.

Unlike many other major players, however, many of the EU space policies and initiatives are still taking shape and many need to be translated into concrete programmes and actions. In this respect Europe is slightly behind in the actual reorientation process compared to other players. The major reason for this delay is the complexity of the European context: the very recent EU involvement in space and the duality in space governance between the EU and ESA.

10.2.2.3 Russia

The track record of Russia's space sector has witnessed some remarkable ups and downs over time. After the Cold War, the Russian space sector was subject to far-reaching reforms required to manage the programme execution and infrastructure in the complex and unconducive setting it inherited from Soviet times. In addition, the Russian space sector suffered from the cancellation of the Buran space shuttle programme and an economic crisis that struck the country in 1998. In the early 2000s, however, President Vladimir Putin breathed new life into the sector; freeing up resources and initiating a number of ambitious programmes, such as GLONASS. Nevertheless, to a large extent Russia's space sector remained inert and its industry too heavily dependent on older technologies.[22] The failure of a Proton M launch and a series of reliability problems in 2013 were catalysts for a major reform that is currently being implemented.[23] The institutional and policy changes currently pursued are not just intended to address some specific issues of concern, but rather to ensure that Russia remains one the world's leading space nations.

For the near-term, the objectives are outlined in various federal targeted programmes: one for the present and near future (Development of Russian space launch facilities in 2006–2015), one for the mid-term (Russia's Space-Related Activities in 2013–2020) and one specially for the implementation of Russia's own Global Navigation Satellite System (GNSS) GLONASS (Support, Development and Application of GLONASS system in 2012–2020). The federal targeted programmes are based on an approach of gradual reorientation structured around stage-by-stage milestones. By 2020, the country is aiming for a new generation of heavy, manned spacecraft and the establishment of research stations at Mars and missions to Venus, Jupiter and asteroids.[24] By that time it also wants to establish a leading position in the markets for space in developing countries.

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[22] Harvey B (2007) The Rebirth of the Russian Space Program: 50 Years After Sputnik, New Frontiers. Chichester: Praxis Publishing. 7–10.

[23] Emanuelli, Matteo. "Proton Failure Accelerates Reform of Russian Space Industry" 8 July 2013 Space Safety Review 14 Nov. 2013. http://www.spacesafetymagazine.com/2013/07/08/proton-failure-accellerate-reform-russian-space-industry/.

[24] Evans, Ben "Russia to Spend $70 Billion on Space Program in 2013–2020" 1 Jan. 2013 AmericaSpace 14 Nov. 2013. http://www.americaspace.com/?p=29114.

In April 2013, President Vladimir Putin approved the "Russian Space-Based Activities' Development Strategy until 2030 and Beyond". This new space policy defines the general principles, major goals, priorities and objectives for Russia's space activities for the following two decades.[25] The wording used to describe the objectives that must be met to maintain a world-class level of Russian capabilities reveals that the country is also getting ready to compete in the global markets. On the one hand it refers to the country's long-term needs in the socio-economic sphere, science, defence and security capabilities. On the other, the document puts emphasis on the development of an efficient high-tech aerospace industry to create a strong position for Russia on the global space-related service market. By 2030 Russia aims at the development of a number of breakthrough technologies and capabilities. These include the full operation of the Eastern Spaceport Vostochny Cosmodrome to decrease its dependency on Kazakhstan for the Baikonur Cosmodrome, a demonstration manned flight around the Moon and a competitive position in the global market for space technologies and services. The new approach also entails structural reform of the Russian space industry to make it more innovative, competitive and commercially self-sustainable. To this end a few principles are outlined. The Russian space agency Roscosmos will be reformed, receiving more managerial autonomy and financial flexibility. In addition an institute for technology commercialisation will be created and human resources policies will be reviewed so as to attract more qualified young professionals.[26] These decisions show that Russia is very consciously aware of the fact that reorientation will be required to deal with the challenges ahead: a more global and competitive market for space products and services, increased technological innovation demands worldwide and an ever more intensifying hunt for talent and skills in a labour market that is no longer restricted by national boundaries.

10.2.2.4 China

The globalisation of the world economy has given China the chance to generate the economic growth required to turn itself into the major geopolitical and economic power it is today. The Chinese government, which views space industry as an integral part of the state's comprehensive development and geopolitical power strategies, has been steadily developing an accompanying ambitious space programme. In this sense China is not really undergoing a huge transformation in terms of its space policies and programmes. Rather, the country continues to develop capabilities based upon a long term vision, in line with the development

[25] "Russian Space-Based Activities' Development Strategy until 2030 and Beyond" 27 Apr. 2012 Aviation Explorer 17 Nov. 2013. http://www.aex.ru/docs/8/2012/4/27/1561/.

[26] Hongxia, Liu and Serebryany, Igor. "Human resource management key to Russia's space industry reform" 8 July 2013 Space Daily 14 Nov. 2013. http://www.spacedaily.com/reports/Human_resource_management_key_to_Russias_space_industry_reform_999.html.

nature of its planned economy. Moreover China's ambitions in space are basically all-embracing and the translation of this ambitious programme into cutting-edge achievements and operational activities is scheduled to materialise rather fast. This was clearly demonstrated when China showed the world footage of its first Moon rover Chang'e, which landed on the 14th of December 2013—in spite of the technical difficulties that followed.

By 2020 the China National Space Administration (CNSA) aims to establish a long term EO system, an independent satellite telecommunication network, an independent satellite navigation and positioning system called Beidou, commercial launch services, remote sensing capabilities, a space science programme in the fields of microgravity, space materials, life sciences and astronomy, and, a Moon exploration programme.[27] In the long run, the goals include an inhabited space station in LEO, manned missions to the Moon, a crewed lunar base and robotic missions to Mars.[28] In terms of space programme development, China is currently the only nation in the world which has such clear goals and a development path to reach them. Major milestones in capacity building since the turn of the millennium include the first launch of a Chinese crewed mission aboard Shenzhou 5 in October 2003. This event made China the third country in the world with a successful independent human spaceflight programme. In mid-2011 the CNSA launched Tiangong 1, a target module that serves as a first step in testing the orbital rendezvous and docking technology required for its planned space station. Since then both unmanned and manned tests have been undertaken successfully. The second space lab, Tiangong 2 is scheduled for launch in 2015 and will be visited by future Shenzhou missions. China's space station should be finished in the 2020–2022 timeframe. Given the recent NASA announcement stating that the lifetime of the ISS will be prolonged until 2024 at least, two major space stations should thus be in orbit in the early 2020s.

These choices and priorities reveal some of the underlying reasoning of the Chinese state apparatus which sticks to the principles of independence, self-reliance and self-renovation, and adherence to long-term, stable and continuous development.[29] In the mid-term, these developments and the approach taken will further reinforce China's strong position, making it an ever more important player on the global stage. In the long term it is unlikely that China will diminish its ambitions until it has at least reached the level of capabilities of a global leader in space activities. Still, China's position with regard to its outer space ambitions and intentions remains rather opaque and sometimes even downright confusing. On the one hand the nation promotes space security and sustainability as illustrated, for

[27] Strickland, Eliza. "China: The Next Space Superpower: A lunar rover, a crewed space station, and new rockets top China's space agenda" 31 Dec. 2013 I.E. Spectrum 14 Jan. 2014. http://spectrum.ieee.org/aerospace/space-flight/china-the-next-space-superpower.

[28] Ibid.

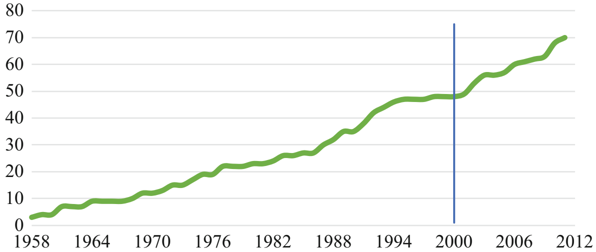
[29] Information Office of the State Council of the People's Republic of China "China's Space Activities (White Paper)" Nov. 2000 Xinhuanet 21 Dec. 2013. http://news.xinhuanet.com/employment/2002-11/18/content_633169.htm.

example, by its joint initiative with Russia in drafting a Treaty on the Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force against Outer Space Objects. On the other hand, the nation has undertaken a number of initiatives that have upset the international community such as the very recent ballistic missile intercept test and the 2007 anti-satellite missile test—actions that are diametrically opposed to its own policy intentions at the international level. This uncertainty creates tensions and makes it difficult for other nations to see China as a predictable and valuable international partner, which tends to marginalise the nation's strategic position. These tendencies make its future role in the international space community unclear.

10.2.3 The Institutionalisation of Space Activities

The changing world for space is not only expressed by the policy reorientations of the major players. It is also expressed by a growing institutionalisation of space activities. This section focusses on the space agencies that have been established since the year 2000, the total growth of which is depicted in Graph 10.1.

The trend line in the graph reveals that the number of agencies engaged in activities related to outer space and space exploration worldwide has witnessed a new growth phase since the early 2000s. The growth from about 50 to 70 space agencies and offices corresponds to a global increase of 40 %, which took place following a relatively stable phase that persisted throughout the second half of the 1990s. This steepening of the trend line indicates that the 'space club' is far from achieving a state of equilibrium in terms of membership and thus is still evolving. Although the numbers only reflect the institutionalisation of space activities and changes therein, it indicates that the overall involvement has increased, augmenting the number of stakeholders and the number of interests in the field of space. The latter is relevant for a number of reasons. First of all, as countries develop space capabilities and institutionalise a related space policy their voice within the global



Graph 10.1 The global number of governmental and intergovernmental agencies engaged in activities related to outer space and space exploration (Author's Visualisation) (The lists upon which this graph is based includes only space agencies. Other kinds of governmental or intergovernmental agencies concerned with space-based services such as meteorology, launchers, telecommunications and security and defence are not included)

space community will become more relevant. Second, an increase in quantity is also likely to lead to greater diversity in terms of interests and approaches. Studying these institutions in more detail reveals that there are two distinct processes at work. On the one hand a growing group of nations is establishing space capabilities for the first time. On the other hand, a number of countries have implemented institutional reforms to strengthen existing involvement in outer space activities.

10.2.3.1 Brand New Space Nations

Most of the agencies in this category are the result of nations establishing involvement in space affairs for the first time, or at least for the first time on a continuous operational basis with a dedicated focus. Interestingly, this new phase of space institutionalisation is taking place simultaneously in different parts of the world; new agencies have been established in Africa, Latin-America, Eastern Europe, Central Asia and South-East Asia.[30] Also, in line with the global geographical dispersion, the club of new space nations includes countries with different socio-economic backgrounds: low income countries, middle income countries that are steadily developing, and high income countries that have already gone through the process of industrialisation.

From an overall perspective, however, institutionalisation is mostly present in those nations that are in the middle of an economic transformation. In this category of growing economies the national motivations for the establishment of space agencies are not always homogeneous. Relatively small countries tend to focus on space capabilities that directly serve as a tool to spur their social and economic development, such as Earth observation and telecommunication. For Turkmenistan and Uzbekistan, for example, the new involvement in space will remain rather limited and with a narrow focus. Their agencies have purchased satellites from abroad and specialists are trained only to control the satellites in domestic ground control centres following the transfer of operations. Interestingly, China is slowly ramping up its geopolitical and economic influence in this region which was not so long ago dominated by Moscow.[31] It is doing so by providing launch opportunities

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[30] More precisely the list of new space agencies includes: Agence Spatialle Algérienne (Algeria—2002), South African National Space Agency (2011), Belarus Space Agency (2010), Hrvatska svermirska agencija (Croatia—2002), Ministerstvo dopravy České republiky (Czech Republic—2003), Institut for Rumforskning og –teknologi (Denmark—2008), Lithuanian Space Association (2007), Gabinete do Espaço da FCT (Portugal—2009), UK Space Agency (2010), Turkmenistan National Space Agency (2011), UzbekCosmos (Uzbekistan—2001), Japan Aerospace Exploration Agency (2003), Agensi Angkasa Negara (Malaysia—2002), Asia-Pacific Space Cooperation Organization (2005), Sri Lanka Space Agency (2010), Geo-Informatics and Space Technology Development Agency (Thailand—2002), Vietnam Space Commission (2008), Agencia Bolivariana para Actividades Espaciales (Bolivia—2005), Comisión Colombiana del Espacio (Colombia—2006) and, Agencia Especial Mexicana (Mexico—2010).

[31] Foust, Joshua. "Is China Really Moving Into Central-Asia" 11 Jan. 2012 The Atlantic 19 Dec. 2013. http://www.theatlantic.com/international/archive/2012/01/is-china-really-moving-into-central-asia/251191/.

and general bilateral economic cooperation and business opportunities.[32,33] In fact, the expansion of China's influence is a region-wide phenomenon and has been one of the underlying motives for the establishment of the China-led Asia-Pacific Space Cooperation Organization (APSCO) established in 2005 in reaction to the already existing Japan-led Asia-Pacific Regional Space Agency Forum (APRSAF). Other countries, such as the mid-sized Latin-American countries Bolivia and Colombia tend to focus on the expected outcomes of their space programmes in terms of national development and regional integration through technology-transfer projects.[34] To this end they are mainly concerned with Earth Observation satellites to gain geospatial information on their territories and natural resources and telecommunication satellites to increase the accessibility of remote areas and to deploy telemedicine networks. Larger emerging economies on the other hand, such as Mexico, South-Africa, Malaysia and Vietnam, have the critical mass required to set up space agencies to implement a wider array of space activities that include elements such as: technology transfer, space science, microsatellites and, long term programmes that entail domestic development of satellite components. The advantage of this approach is that it helps these countries in their pursuit of creating knowledge based economies because of spill-over effects and cross-fertilisation of technologies. In addition, in the long run these countries also will attain a certain independence in their capabilities.

In itself, the global interest in space activities is nothing new, but the continuation of this trend points to the increasing complexity and diversity of space activities in the future. This tendency is caused by a number of underlying factors. It was already noted in the beginning of this contribution that the relationship between space and society is intensifying and that space assets are becoming ever more indispensable as they are integrated into society. This implies that the benefits associated with certain space-based assets—especially in telecoms and Earth Observation—are typically higher than in the past. At the same time, the cost of establishing a particular space based service system has gone down because today instruments and payloads can be smaller, lighter and thus cheaper to build and launch. As a result, the overall trade-off point between investment costs and benefits is moving downwards. This implies that they become more efficient—making it more interesting for a large number of mid-size and small countries to develop space programmes and deploy activities in outer space. Considering the expected development paths of various world regions, this tendency is not likely to diminish any time soon. In the long run, this process will change the composition of the space club. Most industrialised and high income countries already have

[32] Hasanov, H. "China to Help Turkmenistan to Master Space" 10 Aug. 2013 Turkish Weekly 19 Dec. 2013. http://www.turkishweekly.net/news/140063/china-to-help-turkmenistan-to-master-space.html.

[33] Filous, Aaron. "China's Central Asia Overtures: Why Now?" 6 Nov. 2013 The Diplomat 18 Nov. 2013. http://thediplomat.com/2013/11/chinas-central-asia-overtures-why-now/.

[34] Ansdell M, Delgado L and Hendrickson D (2011) Analyzing the Development Paths of Emerging Space Nations: Opportunities or Challenge for Space Sustainability?

established space agencies, and thus over time their relative importance will decline as emerging countries join.

10.2.3.2 Governments Aiming at Institutional Optimisation

Some of the new actors, however, arose as a result of institutional reform aimed at centralising and strengthening existing space capabilities or programmes. This was the case for the United Kingdom (UK Space Agency), Denmark (Institut for Rumforskning og –teknologi) and Japan (Japan Aerospace Exploration Agency or JAXA). These industrialised countries have been involved in space activities for a longer time and the fact that they have gone through a process of institutional reform indicates a policy intended to bring about a more coherent and dedicated approach vis-à-vis their space activities. In some cases the reform is aimed at expanding the scope of space activities conducted. The UK, for instance, has recently ramped up its investment in space programmes, as well as its contribution to the European Space Agency.[35] In Japan additional administrative reforms have been implemented since the establishment of JAXA. The Basic Plan on Space Policy adopted in 2008 stipulated that the Japanese agency should also contribute to security, permitting the use of space for defense purposes.[36] The ability of JAXA to step outside its historic commitment to narrowly peaceful projects and become involved in the use of space for national security is, however, a controversial move as it is likely to provoke opposition to the military use of space. In Europe, the reorientation process is linked to the fact that many ESA Member-States link their involvement in intergovernmental organisations to an appropriate institutionalisation at the national level. Moreover, the enlargement process of the European Space Agency and the recent involvement of the European Commission in space activities are having regional repercussions, also for countries that are not (yet) members of ESA. This occurs as a consequence of regional alignment. When countries with similar regional objectives have the prospect of becoming members of intergovernmental organisations, they will tend to converge their institutional structures to anticipate the accession. Note that because of this many of the reforms eventually have a converging effect in terms of regional membership and orientation.

[35] Toor, Amar. "UK finds European space program profitable, ramps up investment" 9 Nov. 2012 The Verge 18 Nov. 2013. http://www.theverge.com/2012/11/9/3621770/uk-increases-space-program-spending-esa.

[36] Kallendar-Umezu, Paul. "Japan Moves To Relax Restrictions on Military Space Development" 30 Jan. 2013 Space News 17 Dec. 2013. http://www.spacenews.com/article/japan-moves-relax-restrictions-military-space-development.

10.2.4 Space Industry

10.2.4.1 A Mature Sector in the Making

As mentioned above, space industry has traditionally been subsidised because it was very strongly dependent upon institutional demand and at the same time it was considered an asset of national strategic importance. One of the first segments of space industry to detach itself from this governmental dependency was the telecommunications sector, mostly for practical reasons since it has a predisposition towards commercial viability. This process was initiated with the foundation of PanAmSat in 1984 and really took off once the de facto monopoly on international satellite communications, held by the Intelsat IGO since the 1960s, was broken following a U.S. Congress decision to liberalise the international telecom market in 2000.[37] Since then, the liberal market paradigm has been expanded in the U.S. and now also other industrial branches and certain operational services in space are being commercialised. As a consequence the upstream market segment of space industry, consisting of manufacturers of space hardware and launch providers, is rapidly growing and diversifying. Besides SpaceX other American companies such as Boeing, Sierra Nevada Corporation, Lockheed Martin, Bigelow Aerospace, Astrobotic Technology, Orbital Sciences Corporation, Blue Origin and many others are expanding their space activities as they see their business opportunities increase. The same trend is taking place in other parts of the world, albeit still on a smaller scale. In Europe EADS Astrium, Reaction Engines Ltd., Starchaser Industries and Copenhagen Suborbitals are pursuing tests and the development of various space hardware components, launchers or capsules—all with more or less the same underlying objective in mind.

Interestingly, this global array of commercial companies covers the entire spectrum of the upstream space segment. Research, development and testing is currently done for crew vehicles, cargo transport vehicles, propulsion systems, space station modules, launch vehicles of different payload capacity and reach, and landers, rovers and probes for planetary exploration. Even more remote concepts like space mining and planetary colonisation are being addressed by some emerging players. Although similar innovations have been attempted by governmental players and even some private companies in the past, the scale and the way in which it is currently being done is unprecedented. One the major benefits of the commercialisation process is its effect on innovation cultures and the number of innovative actors. Historically, governments developing space capabilities maintained a rather conservative approach with regard to innovation. They tended to focus on proven technologies in order to get their capabilities and services delivered with only the minimal—or rather known—risk of failures. Hence the space market was characterised by sustaining innovation, where the lion's share of

[37] The referenced bill is the "Open Market Reorganization for the Betterment of International Telecommunications (ORBIT) Act", Approved 17 March 2000 in Washington DC.

newer models and versions of launchers, satellites and modules were often improved and updated versions of existing technologies. Since the commercialisation of space manufacturing started gaining ground, however, the upstream market consisting of private companies is now less bound by this constraint. Increasingly, entrepreneurs rather than administrators decide in what kind of Research and Development (R&D) areas investments are made. As entrepreneurs have more freedom in their decision-making and private companies have different and more diverse innovation cultures than large governmental agencies, a new innovation dynamic is taking shape.

10.2.4.2 New Innovation Dynamics

The innovation dynamic currently displayed in commercial space industry brings new technologies, the revision of existing failed or poorly performing technologies, and research that seeks to determine the potential of new production and assembly processes.

In terms of launchers many private companies are currently optimising payload and cargo delivery to LEO. The advantage for the market here is not so much radical innovation, but rather the fact that many attempts—which increases supply options—will eventually demonstrate which approaches will lead to efficiency gains and lower cost—a sort of natural selection at work in the space sector. More disruptive is the revived interest in the concept of Single-Stage-To-Orbit (SSTO) spaceplanes. Reaction Engines Limited, for example, is working on its 'Skylon' project, a ground-controlled reusable spacecraft which is now in its development phase and aims at providing reliable, responsive and cost effective access to space. Engineering-wise the most challenging part of any SSTO vehicle is the engine, as it needs to provide propulsion both in the atmosphere and in the vacuum of space. Although the development phase of Skylon has been a lengthy process and the exact outcome is still unclear, progress is being made. Its engine has recently been earmarked as a high priority technology project by the UK government after it received favourable technical reports from ESA propulsion experts.[38] This shows that space agencies—in addition to their core activities—are also scanning the horizon for potential game-changing technologies that they can utilise in the long run. Interestingly, this kind of technology, if matured for the market in terms of cost and reliability, will drastically expand the number of spacefaring actors as potentially it could be purchased by companies and nations that want space access in a manner similar to current civil aircraft. They will find that purchasing such a vehicle will provide a much more cost effective option than trying to develop an independent launcher system.

[38] Emanuelli, Matteo. "ESA Examines Skylon Business Case" 9 Aug. 2013 Space Safety Magazine 17 Dec. 2013. http://www.spacesafetymagazine.com/2013/08/09/esa-examines-skylon-business-case/.

Elsewhere companies are pursuing innovation with an eye on fine-tuning. NASA's Space Shuttle, the first large-scale reusable Vertical Take-off Horizontal Landing (VTHL) spacecraft, eventually left unfulfilled its goals of cheap, frequent and reliable access to space, mainly because of interconnected issues in safety and complexity.[39] The VTHL concept itself, however, is not flawed by definition and industry is very aware of the added value the technology could bring once fine-tuned. To this effect new versions of VTHL technologies, such as the Boeing X-37, are being tested to demonstrate the real viability and potential of reusable space technologies.[40] SpaceX on the other hand is working on the viability of a reusable rocket launching system based upon the vertical take-off, vertical landing (VTVL) principle. Its first experimental technology-demonstrator, the Grasshopper, successfully passed its flight tests and the technology is now being further developed to assist development of reusable Falcon 9 and reusable Falcon Heavy rockets.[41] At the same time, many spaceflight companies are developing suborbital vehicles. This is being done for two purposes. On the one hand there is an interest in space tourism and a significant cost reduction is required here in order to expand this product to meet the global market's price readiness. On the other hand suborbital technologies are considered key for future point-to-point suborbital spaceflights as the follow-up to supersonic passenger travel. In both cases the long-term aim is to address future market potential and turn it into a profitable business. Perhaps even more remarkable than the revived interest in certain technologies are the new production methods that are being tested for space technologies. NASA, for instance, is currently testing the potential of 3D printing for the production of rocket engines as it will reduce the cost of flight hardware.[42] Bigelow, a U.S. space corporation, started producing inflatable modules that offer many advantages over traditional metal modules for habitability, launch mass and size.[43]

The downstream segment, focussing on products and services delivered through the use of space assets such as telecom, broadcasting, earth observation and satellite navigation, is experiencing a similar trend. This is mainly due to the fact that so many operational services for earth observation and satellite navigation are being

[39] "Space Transportation Costs: Trends in Price Per Pound to Orbit 1990–2000." 6 Sept. 2002 Futron Corporation 15 Dec. 2013. http://www.futron.com/upload/wysiwyg/Resources/Whitepapers/Space_Transportation_Costs_Trends_0902.pdf.

[40] "X-37B Orbital Test Vehicle: Overview" Boeing 11 Dec. 2013. http://www.boeing.com/boeing/defense-space/ic/sis/x37b_otv/x37b_otv.page.

[41] Klotz, Irene. "SpaceX Retires Grasshopper, New Test Rig To Fly in December" 17 Oct. 2013 Space News 25 Oct. 2013. http://www.spacenews.com/article/launch-report/37740spacex-retires-grasshopper-new-test-rig-to-fly-in-December.

[42] Kraft, Rachel, McMahan, Tracy and Henry, Kim. "NASA Tests Limits of 3-D Printing with Powerful Rocket Engine Check" 27 Aug. 2013 NASA 9 Dec. 2014. http://www.nasa.gov/press/2013/August/nasa-tests-limits-of-3-d-printing-with-powerful-rocket-engine-check/#.UukNRRCIW70.

[43] "Next Generation Commercial Space Stations" Bigelow Aerospace 9 Dec. 2013. http://www.bigelowaerospace.com/.

deployed, which will offer data sets and services on a continuous basis. Traditionally these services were used mainly for scientific research purposes. Thanks to the innovative dot-com industry with its flexible and custom-tailored online services, however, operational space based services are creating supply and demand for the mass market. Data and services in the fields of telecommunication, remote sensing and satellite navigation are creating business development opportunities in the form of applications and complementary technologies. This is being done by both established internet companies as well as by a growing number of start-ups. In fact, some dot-com companies are even involved in the development of upstream businesses, which indicates that space technology development has become a goal pursued by a much wider category of stakeholders than in the past. Google, for example, has launched the Google Lunar X Prize initiative that calls upon privately-funded spaceflight teams to compete to develop and successfully launch a robotic spacecraft that can land and travel on the surface of the Moon and send scientific data back to Earth.[44]

10.2.5 Space and Society

10.2.5.1 The Relationship of Space with Society

The significance of space for the current structure and proper functioning of human society at the beginning of the 21st century was briefly touched upon at the beginning of this contribution. How important space has been in spurring the integration of the global human society as we know it today, was also noted. While an in-depth analysis of all human activities relying on space based services and products would be beyond the scope of this contribution, it is possible to characterise the relationship between space technologies and our society and derive some general trends. When the 'space revolution' is examined in closer detail, it shows that this transformation possesses two characteristics.

First, the process of space interweaving itself with society follows a certain regularity in its unfolding—one that has been observed in other technological revolutions such as, for instance, the electrification and digitalisation of society. One of the first phases to occur is an experimental one in which the investments to be made are high and the benefits low to non-existent—this phase typically consists of proof-of-concept and technology demonstrator missions. Obviously, as the outcomes are not (yet) profitable, projects and programmes in this phase must be funded by public spending. Once prospects become more promising this phase is followed up by a growth phase in which a technology is maturing and fine-tuned, which leads to an increase in the derived benefits and system efficiency. Typically, it is in this second phase that a certain technology starts to become a facilitator;

[44] XPRIZE Foundation "Prize Details" Google Lunar X Prize 10 Dec. 2013. http://www.googlelunarxprize.org/prize-details.

offering an added value for its potential users and hence dramatically increasing the overall number of users. In the third phase, a technology and its applications become so wide-spread and internalised throughout various segments of society that their economic and strategic importance grows tremendously. Typically in this phase a technology and its uses in turn become an enabler of other technologies or capabilities—making them a necessary condition for certain other activities and economic sectors which in turn create added value.[45] By this process the strategic, social and economic importance of unfolding technology development increases over time and most of the time even in an exponential fashion.

Obviously, society in 2013 is much more reliant upon space than it was in the early 1960s. Yet, as space is an enabling environment suitable for various purposes, the process of propagation occurs in wave-like patterns, which is the second characteristic in the overall dynamic. More precisely this means that the abovementioned process of phased unfolding occurs at different times for various space-based technologies. On a macro-scale, time-wise this process has played out differentially for many of the services and data generated today: Earth observation and telecommunication systems were the first to be translated into an operational service, followed by satellite navigation once the American Department of Defence declassified its GPS constellation. Even for a specific field of technology, this process can be repeated as new generations of technology offer new kinds of use. In fact, this repetitive process occurs on a continuous basis. The first remote sensing satellites, for instance, were capable of offering a very general overview only and as a result their use was limited to meteorology. Currently, systems are being deployed in orbit that allow scientists, for instance, to run algorithms that count every individual tree in a certain ecosystem and whales in the oceans. The same process has occurred in navigation. The first uses of the GPS system were focussed on smart bombs and military applications whereas today, the service is used even by smartphones and industrial sectors such as logistics and construction.

As a consequence, the relationship between society and space today is one characterised by stratified complexity and is continuously evolving as space uses create benefits that propagate throughout the entire socioeconomic value chain. In the future, it can be expected that space will be much more critical than today for the supply of products, data and services. Moreover, many of the applications and services provided by space assets will be integrated and linked to other devices through what has been described as "the internet of things"—by which space assets will become indispensable for consumers without the latter realising it.[46] This

[45] The difference between the second and third phase lies in the concept of indispensability. As long as certain activities keep on functioning without a certain technology, in spite of certain efficiency losses, it remains a facilitator only. In case of non-functionality it has become an indispensable requirement—and the relationship between the activity and a technology has become one of a totally dependent nature. It is important to note that the concept of indispensability gives no information on the economic importance of space assets.

[46] Chui, Michael, Löffler, Markus and, Roberts, Roger. "The Internet of Things" Mar. 2010 McKinsey 15 Nov. 2013. http://www.mckinsey.com/insights/high_tech_telecoms_internet/the_internet_of_things.

process will be intensified in the mid-term, as new generations of operational systems for remote sensing and navigation are being deployed and eventually integrated in a society that is based upon instant production and sharing of information through the cloud. This process will result in a society where space is even more essential than today for the purposes of agriculture, transport, industrial production, construction, health, environmental monitoring, fundamental scientific research, education, economic growth and many more. At the same time the demanders of services will be even more heterogeneous, consisting of diverse governmental entities, international organisations, corporations, civil society, NGOs, the scientific community and citizens.

10.2.5.2 Society's Relationship with Space

In turn, this process of deepening dependency on space has also spurred society to change its position and approach with regard to space activities—evidence of the mutual relationship between both. Over the last decades, various university programmes with a dedicated focus on space related matters have been established. Although this process was already initiated during the 1980s, since then many universities have considerably expanded their programmes. As a result, space is now becoming settled among other disciplines as a full-fledged field of research and education. Thus the International Space University (ISU) located in Strasbourg started to offer a specialised space science master programme as of 1995. As the space sector is becoming more comprehensive in terms of quantity and complexity, the skills required for the execution of space programmes and understanding the sector increase as well. To address this change, additional curricula have been recently added by the ISU, putting their focus on the legal, managerial and policy expertise required to facilitate the work done by engineers and scientists. Obviously, the effect of those programmes on the labour market increases over time, as the number of alumni of those programmes finding their way into the space industry or related fields increases year by year. This approach of widening the focus of space to people with backgrounds in other disciplines has been picked up by other universities in Europe and beyond. This tendency is also reflected in the scientific journals published by research institutes and academia. Over the past two decades a considerable number of new journals has risen.[47] Many of the newly established journals are focused on one topic in particular such as space law, launchers or scientific research—providing their readers with the specialised information they seek. In line with the improved academic framework for space research, a number of think tanks are now conducting space related research. In some cases this is done by existing generalist think tanks such as the RAND Corporation in the U.S. In

[47] The list includes: Ad Astra, Aerospace Insider, Air and Space Law, Astropolitics, Espace Magazine, Inside GNSS, Launch Magazine, Planet Aerospace, Planète Mars, Raumfahrt Concret and, Space Research Today.

other cases new ones were established to focus specifically on space, like the European Space Policy Institute and the Secure World Foundation. Even in civil society a number of organisations have been set up to bring space to the attention of the general public and other stakeholders such as the Space Generation Advisory Council and Eurisy. Moreover, thanks to the internet, space related topics are also much more present on blogs, social media, forums, and networking platforms. As a result the space community has become globalised and much more networked and integrated than in the past. This is also evident in the labour market for space. Young professionals today are much more willing and able to work in different parts of the world.

All these changes indicate that space is no longer solely the playing field of a select group of specialists educated to work in one scientific or technical sub-discipline somewhere in a national space agency or company. Through the establishment of a more solid link between society and space it can be expected that in the long run, the space sector will benefit from more cross-fertilisation with other fields and industries, have more in and out-flows of knowledge, will benefit from more rapid innovation practices and will develop a more solid link with non-space fields of society and the economy. In addition, the increasing interconnectedness resulting from these processes will further spur the levelling effect on a global basis.

10.3 The Implications for Europe

The second chapter of this contribution described the four major changes that are currently affecting and reshaping the space sector worldwide and showed how they are in fact symptoms of an underlying globalisation process of space activities. Chapter 3 seeks to shed light on the possible implications of these changes for Europe. In order to capture and present this in a logical way, a SWOT analysis is deployed as a methodological tool.

10.3.1 SWOT Analysis as Methodology

A SWOT analysis is a structured planning method used to evaluate the Strengths, Weaknesses, Opportunities and Threats involved in a project or business venture, but it can also be applied to economic sectors as a whole. Essential to a SWOT analysis is that it groups pieces of key information together into two main categories. On the one hand there are the internal factors; the strengths and weaknesses internal to the entity in question—the space sector in Europe in this case. On the other hand it includes the opportunities and threats generated by the external environment—in this case the global context in which the European space sector is embedded. Table 10.1 below shows the major findings that resulted from the SWOT analysis. The actual explanation is elaborated in the following sections

Table 10.1 SWOT analysis for space from a European perspective (Author's visualisation)

	Helpful	Harmful
Internal context (European)	*Strengths*	*Weaknesses*
	• The European way: – Model of cooperation – Focus on peaceful purposes – Strong international partnerships • European strengths: – Certain critical technologies – Solid positions in launching industry, telecommunications and science – Deployment of operational capabilities in satellite navigation and earth observation – Long-term experience	• Critical mass issues: – Moderate spending per capita – Lack of military and dual use capabilities – No complete non-dependence (yet) • Governance issues: – Fragmented governance with asymmetrical memberships, diverging industrial policies and focus – Dual governance issue between the EU and ESA
External context (Global)	*Opportunities*	*Threats*
	• Expanding global demand: – >9 billion people by 2050 – Increasing reliance on space assets in different domains • Mature markets: – Dynamic markets – More innovation – More cross-fertilisation • Cooperation perspectives: – Increasing challenges require global responses – Parallel operational systems offer efficiency options	• Legal and policy challenges: – Increasing complexity will defy existing legal frameworks – Global markets require strong competitiveness and innovation • Sustainability risks: – Electromagnetic congestion – Space debris problem increases • Security threats: – Weaponisation and militarisation of outer space – Reflection of terrestrial conflicts in outer space

which focus on the European context, consisting of internal strengths and weaknesses, and the global context which is comprised of external opportunities and challenges. Globalisation, as far as its further impact can be predicted, is likely to further reinforce the tendencies of the past decades as described in the previous chapter. This implies that the benefits associated with certain promising tendencies are likely to increase, while at the same time the challenges related to some issues of concern are likely to become more pronounced.

10.3.2 Europe's Strengths

From an overall perspective, it is quite safe to say that the road Europe has taken in space is somewhat particular, at least when compared to other major space faring nations. So far this has yielded some specific areas of weakness and strength for Europe. The term Europe as used in this context refers to all actors, public and private, that deal with space in a way that is an essential part of their business activities. As such it includes the European Space Agency, the European

Commission, the different national space agencies in Europe, space industry and other Europeanised national and civil institutions that engage in space activities.

10.3.2.1 The European Way

By the time Europe figured out a solid institutional approach in the form of the establishment of the European Space Agency, most of the remarkable space achievements of the pioneering age had taken place. In this sense most European achievements are situated in the era of space consolidation and expansion of space utilisation rather than in the pioneering days. Nevertheless the continent has been the stage of some remarkable achievements. From a high-level perspective, it is possible to group Europe's strengths into two categories. The first strong elements relate to the way Europe has been able to achieve the status and benefits it enjoys today.

Generally speaking, the driving forces and impacts of space capacity development in Europe have been profoundly different from those in other parts of the world. Whereas space technology development actively spurred political competition and geopolitical tensions between the U.S. and the Soviet Union, it was embedded in a process of regional integration in Europe. The lion's share of European efforts in space—especially those on the pan-European level—has been performed in the context of partnership and cooperation—both of which have increased political and ideological alignment. This has been possible because to a large extent Europe's space programmes have been focussed on peaceful purposes, the creation of transnational socio-economic benefits and technology development and the creation of a European sense of identity. In addition, many European space institutions, both at national and intergovernmental level, pursue cooperation with non-European actors. The fact that Europe consists of so many different actors at various levels and that Europe is very open towards international cooperation has made it possible to develop a diverse set of cooperative relationships: bilateral ones between nation states (e.g. France-Russia), relations between major space agencies (e.g. ESA-NASA) and those between dedicated agencies (e.g. EUMETSAT-NOAA). This approach, in some cases even unintentionally, has brought a number of tangible and strategic benefits to the European continent. More precisely, it has enabled European agencies to: (1) benefit from exchange of views, skills and expertise, (2) develop satellites and instruments at lower costs, (3) obtain higher accuracy, robustness, timeliness and continuity of certain datasets and, (4) achieve certain goals that they would not have been able to achieve by themselves.[48]

[48] These benefits were illustrated in a report investigating the partnership between EUMETSAT and NOAA. It is, however, quite safe to say that many of the benefits described can be found in partnerships and international cooperation projects with comparable structures. For more info, see: Lahcen, Arne. "EUMETSAT-NOAA Collaboration in Meteorology from Space. Review of a Longstanding Trans-Atlantic Partnership." 18 Sept. 2013 European Space Policy Institute 10 Dec. 2013. http://www.espi.or.at/images/stories/dokumente/studies/ESPI_Report_46.pdf.

Finally, Europe has continuously emphasised and actively promoted many of its core values within the space community. These include sustainability, the creation of global governance, and the potential capabilities of space assets to serve purposes of development and global socioeconomic integration. In this sense Europe's approaches fit very well in the globalisation theory as explained at the beginning of this contribution.

These approaches have generated particular benefits. The often-repeated process of "Europeanisation" in a number of cases has enabled pan-European institutions to pick up existing proven approaches and technologies and fine-tune them further, both internally and vis-à-vis other parts of the world. Also, in some cases, successful scientific missions or technology demonstrations have begotten follow-up versions in a European context which then offered better accuracy and improved instrumentation. Both processes tend to increase the efficiency and effectiveness of European initiatives and programmes. For the creation and affordability of certain operational services such as Galileo and Copernicus, the European level is also the only one that offers the right scale and mass.

10.3.2.2 European Strengths

Europe has certain strengths in terms of critical technologies, capabilities, market position and experience which the continent has been able to acquire and strengthen over time—the more tangible assets. Although Europe has never produced icons as widely known as the American Apollo missions and the Space Shuttle programme, it has been able to achieve a reputable position in a number of fields.

In the launch market, Europe currently holds more than half of the global market share of non-institutional launches. At the same time the launch vehicle fleet has been expanded and diversified with the development of the Vega small payload launcher. Moreover the planning and development of Europe's next-generation launchers Ariane 5 ME and 6 are in progress. Similarly, the European large system integrators (Thales Alenia Space, Astrium and OHB) hold good competitive positions and are also in demand for the development of payloads and specific satellite instruments. The supply chain is supported, as well, by a great variety of small- and mid-size companies that act as subcontractors or suppliers of niche products and services. Despite the fact that Europe does not have an autonomous human spaceflight vehicle, ESA participates in the development of human spaceflight space infrastructure as it did by providing the Columbus module for the ISS. Moreover the Agency possesses critical in-orbit rendezvous technology for autonomous docking as demonstrated by the ATV and its follow-up in the form of a cargo return vehicle. Moreover, ATV technology will be used for the Orion service module. Significant research has also been performed in areas relevant for human spaceflight, such as sustainable life support systems and the effects of microgravity and radiation on humans and other living organisms.

One of Europe's major strengths in space compared to many other players, including fast emerging ones, is the continent's position in space science. This is true for both Earth sciences and for the study of the universe by means of astrophysics, planetary science and cosmology. In fact, science has been one of the driving forces behind Europe's space capacity development and, space science challenges have been a key element in fostering international cooperation. As a result, Europe currently plays a critical role in the endeavour to answer many of the scientific questions of our time. This is expressed in a large number of mid- and large size scientific missions such as Cassini-Huygens, WMAP, Planck, Herschel, Gaia, Euclid and Rosetta. These missions and the datasets they have generated (or will generate) have a high standing in the global space science community. As such, they serve as an indirect indicator of how Europe's cutting-edge scientific technologies have been indispensable for creating the current understanding of the evolution and functioning of the universe and our solar system.

In the field of satellite communication, Europe has continuously developed capacity and spurred innovation. The ESA driven Advanced Research in Telecommunications Systems (ARTES) project has played a major role in the process of maturing satcom products and services. On the commercial side, Europe has a strong asset in the international company Eutelsat, which enjoys a favourable market position and promising growth perspectives. In addition Europe is playing a significant role in Intelsat. Because of the fast privatisation of the satcom industry, however, this field is increasingly being managed by private equity firms and global financial consortia.

In terms of Earth Observation, capacity building has been a rather pan-European and decentralised effort. However, recently the overall tendency has been pointing towards centralisation of service provision and the commercial viability of the EO service industry. Traditionally, it was mainly the European Space Agency that developed proof-of-concept and experimental EO satellites, as well as satellites to serve scientific Earth monitoring missions, such as Envisat. Despite ESA still remaining responsible for the scientific mission satellites and technology demonstration missions, many of the services that are moving towards operational status are being provided and governed by other institutions. The clearest example of this tendency is of course the Copernicus 'flagship' programme, which will be procured by ESA as concerns the space segment, but managed by the European Commission which will provide Europe and the world, through GEOSS, with an integrated set of global and local environmental data. In the field of meteorology, EUMETSAT is responsible for the management and operation of the Meteosat and MetOp programmes, as well as the Jason programme which builds on technology previously developed by NASA and CNES to gain ocean altimetry data. This capability is the result of cooperative efforts with other partners in the global meteorological community and the WMO framework. On the national governmental level considerable experience was acquired by the French space agency CNES, much of which has now been translated into commercial EO capacity, such as the SPOT satellites (now owned by Astrium Services) and the dual use Pleiades constellation (owned by SPOT Image). Other assets in this respect are the German company BlackBridge AG, a geospatial information company using its SSTL-built satellite constellation to deliver rapid scanning services and, DMC International Imaging, a SSTL-owned company managing the Disaster Monitoring Constellation serving the International Charter for Space and Major Disasters.

Finally, Europe is about to increase its autonomy in another critical field of space-based assets: Global Navigation Satellite Systems (GNSS). For long, European citizens, governments and companies have relied on American Global Positioning System (GPS) signals for their satellite navigation services, but now the joint EU-ESA flagship programme Galileo is expected to become operational in a couple of years. This will provide Europe with its own autonomous and civilian GNSS. Although the procurement of the system has been problematic and characterised by delays, the technological perspectives of the Galileo system are promising and they will open up a new realm of opportunities compared to existing systems and those currently in development.

10.3.3 Europe's Weaknesses

10.3.3.1 Critical Mass Issues

When Europe's position is compared to other important players in the field of space, it seems that one of the internal weaknesses is an issue of critical mass. An important element in terms of critical mass is defined by the total investment in space. When Europe's overall public budget for space activities is considered it turns out to be rather humble compared to other major established players such as the U.S. and Russia.[49] This is true for the combined expenditures at different levels and countries as well as for the overall percentage of nominal European Gross Domestic Product (GDP) that is spent on space. At the same time the scope of Europe's space programmes and policies are rather wide and all-embracing in the sense that Europe is involved in a very wide variety of space related activities. Together, these elements have resulted in a situation where Europe is typically only able to provide modest contributions to large international infrastructure projects—at least those outside the realm of space science. In addition, Europe lacks certain critical technologies required for strategic non-dependence, in particular in the area of the manufacturing of satellites and launchers. In 2008, however, the European Commission, the European Space Agency and the European Defence Agency agreed to join forces in order to develop these critical space technologies in Europe. In spite of the recent process of catching up, the continent still lacks certain some demonstration of technological capabilities, skills and expertise, leverage of experience and the creation of regional cohesion and international prestige. This is all the more a pity considering that Europe is experienced in engaging in partnership projects and typically plays a role in every major international large infrastructure project.

[49] Bochinger, Steve. Government Space Markets World Prospect to 2022. Euroconsult, 2013. 6.

Secondly, Europe lacks critical mass in military and dual use space capabilities. Regardless of ethical considerations of whether one should pursue military capacities in outer space and the demonstrated benefits of Europe's peaceful orientation, the negative consequences of this play out in a number of ways. From a geopolitical perspective the lack of pan-European space assets with dual or military use weaken Europe's position on the international stage. Space is of course but one element in this equation but nevertheless an important one. In this regard it will be interesting to see how the deployment of the flagship programmes Galileo and Copernicus—both civil programmes with security dimensions—might change this dynamic. Obviously, merely deployment of these capabilities will not be sufficient to address this problem, it will have to be accompanied by general European reforms which are in turn complicated by a multitude of political, economic and social factors. At the same time, a stronger overall geopolitical voice supported by a space-based security capacity could serve as a stabilising factor in the future as other less stable regions and nations develop space assets. In addition to these elements, the lack of geopolitical critical mass has not only resulted in a number of security and international related concerns. As Europe's space programmes are by far more civilian orientated than in other important space nations, European space technology development does not benefit as much as other countries from spill-over effects from military into the civilian domain. This results in an inopportune passing up of potential in terms of social, economic, technological and strategic benefits.

10.3.3.2 Governance Issues

The consensus model upon which European space capacity development has been built was highlighted as one of the continent's strengths and achievements. There is, however, a downside to this approach: it has created a lot more complexity with the result that the European space sector is generally more inert than space sectors in other parts of the world. This is mainly evident at the European level of governance where two issues of particular concern can be identified. First, there is an historic issue of fragmentation in terms of institutions and policies—this increases over time as long as there is no tendency towards centralisation. Second, there is a precarious unresolved issue of dual governance at the highest level since the EU received the explicit mandate to develop space policies and programmes in 2009.

The aspect of fragmentation has two dimensions. One the one hand there is a degree of vertical fragmentation in Europe. Space activities are pursued by the various nations and their space agencies and the common approach towards space activities as executed in the framework of ESA. This is one of the main reasons why there is currently a lack of centralised geopolitical weight for space as described in the above section. On the other hand there is an increasing tendency to horizontal fragmentation—a dispersion caused by the fact that there are several organisations and institutions in Europe that deal with objectives in space, regardless of their hierarchical relationship. Of course, horizontal fragmentation also exists within nation states that have set up distinct agencies to deal with activities such as space science and exploration, meteorology and, environmental monitoring. In Europe, however, the fragmentation tendency is amplified by the fact that the institutional fragmentation coincides with other complicating factors such as diverging membership, different industrial policies, different procurement procedures and a deficiency of overall vision because of the lack of a top-down perspective.

Secondly, the pan-European level has been characterised by a duality in governance ever since the European Union became more actively involved in the execution of space programmes and the formulation of a space policy. The involvement of the EU in space activities is a promising perspective since it is the only actor with the scope and authority required to formulate space ambitions and administer space capabilities with geopolitical weight and critical mass. As long as the relationship between the EU and ESA remains unresolved, however, the status quo creates a number concerns, especially now that operational services are being deployed. The situation creates turf issues, slows down critical decision making processes, and prevents both players from settling into their most optimal position. Finally, it also creates uncertainty for the space industry because of the differences in industrial policy between the EU and ESA—one based on competitive dialogue and one based on geographical return, respectively. The problem regarding the industrial policies is that they are focused on Europe's internal context while the globalisation of markets will increase external pressure. In this sense, if the current lack of strong holistic governance remains unresolved, it could be very detrimental for Europe's innovation and competitiveness positions in the long run.

10.3.4 Global Opportunities

10.3.4.1 Expanding Global Demand

The market for space-related hardware and space based services is very likely to witness a significant increase in demand and this will probably be a global phenomenon. Over the past three decades space has increasingly become an environment for the provision of services. This started with telecommunications and later on satellite navigation and Earth observation services were added, but all with the same underlying logic that space is a tool beneficial for various aspects of our life on Earth. As a consequence, the degree of global GDP dependence in one way or another, on space assets has significantly increased in recent decades. In the future, this tendency will further increase and an important driving force in the growth of this demand will be demographic in nature.

According to United Nations' projections, the world population will number approximately 9.6 billion by 2050. Not only will this immense number of people on the face of the planet be unheard of in the history of human development, but also in relative terms it is one of the greatest increases since the dawn of mankind. Compared to the 6 billion people living on Earth in the year 2000 this is an increase of over 50 %. Since the growth is so huge—both in absolute and relative terms—it will require a great deal of management and planning to be sustainable, especially considering that the average environmental impact per person is increasing because of worldwide industrialisation and resource reclamation. Often industrialisation processes have been accompanied by advancements in information gathering and processing. The problem is, however, that most of the low hanging fruit in terms of optimising has already been picked on the exploitation and production side, while at the same time a lot more capacity will be required in the future to address global demand. Therefore, the further managing and optimisation of agriculture, fisheries, transport and, resource exploitation will create a stronger demand for space based services and other information related systems. At the same time, the impact of space on other fields will also increase further, strengthening the strategic importance of satellite data and services for 9 billion people in the fields of urban planning, environmental monitoring, crisis management, tourism and other sectors. In other words, the demand for satellite services will increase in terms of numbers, diversity and accuracy. Moreover a multitude of sectors and areas of human activity will drive this demand globally.

10.3.4.2 Mature Markets

Section 10.2.4 showed that globalisation has introduced a number of changes that are currently reinforcing the innovation dynamic of space technology in the commercial market. Obviously, many of today's innovative start-ups and established commercial companies will not be around in the future, as they might be faced with project failures or even bankruptcy. What is more, this will remain a given in the future because governmental financial support for the commercial innovation dynamic will eventually cool down. But from an overall innovation perspective, trial and error and the willingness to take risks are exactly what is needed to develop and market the innovative technologies that will eventually materialise and make space access more affordable, more reliable and less complex. As all three will contribute to lowering launching cost, it can be expected that payloads too will increasingly become the subject of innovation, as the risk of failure or poor performance will be associated with lower costs than is the case today.

As a result, both upstream and downstream segments of the space market will very likely benefit from the creation of more added value and increased business opportunities. In the upstream segment it will include—in addition to many of the established players—new private entities such as large system integrators, subcontractors and specialised companies that deal with specific technologies required for human spaceflight, deep space exploration and even planetary science. In the downstream market segment, business opportunities are increasing as a result of the increasing number of global operational services. The best known operational service so far is the U.S. satellite position and navigation system GPS. But as other players such as Europe, China and Russia are currently deploying their operational services in navigation and earth observation, operational services will become an even more global business and competition will be tougher, especially since the information needs of future society will be greater and will demand faster, more accurate and specialised data.

Finally, it is very likely that the space sector will be able to benefit by creating added value in terms of cross-fertilisation with other sectors in the future. As technology development and innovation practices advance, it has been seen that many key enabling technology applications are interdisciplinary in nature and relevant for different fields, such as advanced robotics, artificial intelligence, microelectronics, nanotechnology and smart materials. This will offer more business opportunities for spinning-off space technologies, and vice versa, by bringing non-space technology innovations into the realm of space.

The challenge related to these opportunities, however, is that space sector in a global market will become more subject to the unforgiving logic of markets and economics. This trend will put stress on existing industrial players as they will see increased competition. Avoiding industrial restructuring or introducing forms of protectionism might even worsen the problem because a considerable percentage of global transactions will be settled on the global market, especially considering that many nations and companies will just purchase space capabilities, rather than developing them domestically or internally.

10.3.4.3 Cooperation Perspectives

The final opportunity presented in the scope of this contribution relates to the future potential of space as an environment for international cooperation and global human achievement. In this respect it seems that there are two different processes at play. First, the need for multilateral approaches will further increase over time, simply because the challenges are getting bigger and thus less likely to be addressed by any one single agency. Historically, many of the major achievements in space exploration took place in a national framework but were partially also driven by geopolitical strategies with a wider logic, such as the pioneer flight by Gagarin and the first Moon landing. The deployment and exploitation of the International Space Station have already demonstrated that for expensive large-scale infrastructure projects, a multilateral approach with sharing of cost and responsibilities is the only viable option. In scientific projects the practice of international approaches is already more established. If our long term ambitions eventually point to human exploration of Mars, then international cooperation seems to be the only way forward.

Second, it is very likely that the existence of parallel space-based operational service systems will eventually lead to more international cooperation. In the field of meteorology, for example, Europe and the U.S. already cooperate in a number of fields and with varying intensity, ranging from exchange of data to sharing orbital responsibilities and jointly procuring certain ocean altimetry satellites. It is not illogical that, in due time, cooperation schemes will become relevant in other fields and with other partners as well. The formation of successful partnerships is, however, dependent upon various factors, such as technological capabilities, proven track record, sense of partnership, political will, ideological alignment, and the strategic importance of the joint activity pursued. Nevertheless, as multiple players deploy trusted space-based services, such as global satellite navigation, the dynamic for partnership building changes for the better. The various players build up experience, know-how and, not insignificantly, the comparative advantage of one partner having a specific strategic capability decreases, which in turn affects the security concern dynamic underlying systems that have dual use applications. In this sense, it can be expected that in the mid-term, certain systems will at least be coordinated to improve performance. In the long run, certain systems might even be integrated in one way or another, in order to save costs of what by then will be continuous global operational services.

In the long run these three opportunities have the potential of turning space into a global and intensely used fourth environment for humankind, transforming from a solely governmental club of a few members to a societal and globally shared common. This common will be shared by a variety of players and nations that seek to use it as a tool for economic growth, human and environmental protection, scientific knowledge, leisure, and transport. In this sense space in the twenty-first century has the potential to be a stage for tremendous human achievements, if, at least, we are able to deal with the barriers that lie ahead.

10.3.5 Global Threats

Whenever a combination of changes gives rise to opportunities, it is very likely that certain other issues become more difficult or precarious. This is also true for the changes that are affecting the context in which space is embedded. The issues that might merit more attention in the future can be grouped according to their degree of impact: (1) challenges in terms of governance and management, (2) sustainability risks and, (3) security threats.

10.3.5.1 Governance and Management Issues

Governance and management issues, which constitute the first category, are mainly situated in the political and business sphere and, as such, can be addressed if given due consideration and reorientation. A first element in this respect seems to be the global governance of space activities. The first part of this contribution showed that more nations are developing space activities and that their priorities are quite diverse as they are driven by divergent motivations. In addition, the commercia-lisation of space activities and the innovation dynamics that are spurred as a result, in the long run will increase the number of non-governmental actors in space. This will not only impact the number of players operating in orbit, but also the very concept of space utilisation. If space tourism and suborbital passenger travel find their way to the markets, the niche between the atmosphere and LEO will become more frequently used, which would raise the relevance of legal discussions on the delineation of outer space, and the concepts of launching states and liability as defined in the Outer Space Treaty and the Liability Convention, respectively. Moreover, the overall prospects of turf issues will rise simply because complexity tends to increase in a world that is characterised by entanglement and global implications of cause and effect. Tendencies towards increasing specialisation, the involvement of international commercial consortia and, a more unequal approach vis-à-vis space might give rise to forms of space utilisation that will defy the application of classical concepts and solutions that have been used so far as tools for regulation and dispute settlement. This tendency might be reinforced by the fact that the share of industrialised space nations will decrease as the overall club grows as a result of the soaring number of acceding emerging players.

For the commercial space industry, further globalisation of the space market will increase competition considerably. If a number of private or semi-private companies succeeds in offering launches at prices that are significantly more competitive than those offered by the established players, the latter will see their business opportunities decrease. In order to avoid failure this space industry will need to be able to restructure itself faster and more thoroughly than ever before. If some actors do not succeed in this challenge, it is likely that the relative subsidisation of the sector in some parts of the world will increase. In times of financial austerity and flattening budgets, political support for increasing subsidies will be practically zero and as a consequence the risk that some players will eventually push themselves out of market just because of inertia may increase.

10.3.5.2 Sustainability Risks

The major risks in the foreseeable future are related to the sustainability of the use of space as an enabling environment. Although risks share many of their underlying driving forces with challenges, they differ from challenges in that their structure entails a technical component. First, the problem of physical and electromagnetic congestion might become more precarious because of the intensification of space utilisation and the fact that many different nations aim to establish independent operational services. When satellites too close to one another transmit at the same frequency or when terrestrial communication systems operate on the same or similar frequency to a space system, the amount of unintended interference will increase. In a world where space will be utilised by more diverse actors this might raise issues of prioritisation. Who will get the short end of the stick if such a complex dispute were to arise—successful commercial consortium that has a small army of lobbyists at its disposal or the government of a developing country using satellites for its socio-economic development? The International Telecommunications Union (ITU) is in charge of the distribution of orbital slots and the allocation of radio frequencies and so far this approach has worked, but the ITU might see this task becoming more complex in a future where applications and competition increase.

The second risk is the persistent problem of space debris, which is of course also reinforced by increasing involvement in space activities worldwide. In this regard it is key that space-faring nations avoid the emergence of a debris level that would evoke the Kessler effect; an ablation cascade kicking in when a certain density threshold in debris is reached, which would exponentially increase the number of hazardous objects in LEO. Although this issue is receiving much consideration from the space community and some vehicles have been established to deal with it—such as the Inter-Agency Space Debris Coordination Committee—no enforcement mechanisms exist to date. Neither is there any mechanism to distribute cost in case (expensive) space debris mitigation technologies were to be developed in the future. The fight against climate change, however, has demonstrated that global issues of this order of magnitude typically require an attribution of cost based on individual responsibilities in order initiate the technical implementation of mitigation measures.

10.3.5.3 Security Threats

Security threats refers to problems that could be detrimental to the entire idea of space being a common heritage for humankind. Although, luckily, their chance of occurrence is rather limited, their impacts could be of an order of magnitude higher than those of challenges and risks. More precisely, this category includes the weaponisation and militarisation of space and the general reflection of terrestrial geopolitical tensions into the space environment. In this sense the root causes of those threats are political and not technical in nature. Historically, the possibility of military threats through space was one of the major concerns during the Cold War and at the time it gave rise to the establishment of the legal regime currently determining global space governance, that is, the five international treaties drafted in the COPUOS framework.

Although classical threats such as Inter Continental Ballistic Missiles (ICBM) are less imminent today compared to the Cold War era, other less harmful yet more likely threats have emerged. Particular issues of concern are threats of space terrorism in which a satellite becomes hijacked or jammed and anti-satellite tests (ASAT), such as that performed by China in January 2007. In a future where our reliance on space based technology and services will become far greater, the impact of these threats will increase correspondingly. The overall impact of globalisation on the possibility of threats is rather hard to predict as it causes effects with opposite tendencies. On the one hand globalisation spurs global interdependency and creates levelling effects. Those tendencies serve as balancing mechanisms rather than a source of conflict reinforcement because they imply that the implications of security threats would be shared—not solely felt by the rival parties. On the other hand globalisation has the tendency to increase inequality and reinforce competition for natural resources and territory. We currently see those effects at work in various parts of the world: the danger of military conflict over the Senkaku/Diaoyu Islands between Japan and China, increased political tensions between the EU and Russia over relationships with the Ukraine, and the situation with Iran and the whole Middle-East area, etc. It is clear that although space is not the central focus of most geopolitical tensions in the world, space assets, technologies and services might have an impact on or become impacted by their course and evolution.

10.4 Possible Strategies for Europe

Based upon the content of the SWOT matrix described in the previous chapter it is possible to construct four different types of strategies that would safeguard or further strengthen Europe's position with regard to space activities internally and worldwide on global markets and the international stage. These different strategies depend on the dimension in the SWOT matrix that is most easily controlled: the internal context. This means that possible strategies always emerge by first looking at Europe's own strengths or weaknesses in space. The next step then is to see whether the internal feature will be used to reap the benefit of a certain opportunity in the external field or reversely, to mitigate the potential risk of an external threat. Figure 10.1 below gives a schematic overview of how the elements of a SWOT analysis give rise to four different types of strategies: Strength-Opportunity (S-O) Strategies, Strength-Threat (S-T) Strategies, Weakness-Opportunity (W-O) Strategies and, Weakness-Threat (W-T) Strategies. This chapter proposes and describes some possible strategies and policies that could serve the interests of the European space sector.

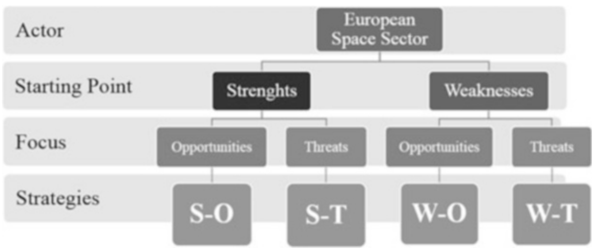

Fig. 10.1 Possible strategies resulting from a SWOT analysis (Author's visualisation)

10.4.1 Strength-Opportunity Strategies

Strength-Opportunity strategies make use of existing strengths to take advantage of opportunities that might arise in the future. As they start from internal strengths, they are typically an efficient way of creating added value or strategic benefits in the future.

10.4.1.1 Europe as the Quintessential Cooperative Continent

One way for Europe to leverage existing strengths into future opportunities would be to further reinforce its position as an international partner and collaborator. The future potential of this approach lies in the fact that space will become the stage of global cooperation opportunities: the challenges for space-based science are getting greater as the low-hanging fruit has been picked, and in operational services the development of parallel, independent systems of similar capability is very inefficient. Because of the globalisation of space and the world in general, both effects are likely to reinforce cooperation tendencies in the short and long run, respectively. To this effect, several approaches could be pursued, many of which even in parallel. The benefits Europe has been able to reap for itself and third parties through international collaborations raise the question as to how Europe can encourage partnerships and international cooperation for its own benefit and that of others in the future. A number of potential options could be considered in this respect. First of all, this diversity could be leveraged further by engaging in new cooperation projects with emerging space nations and intensifying partnerships with established players—both in number and in depth. Second, it should be considered whether Europe could export its expertise and experience in building partnerships with other parts of the world. European governance models are already used as a blueprint for regional integration elsewhere,[50] but would it be possible for certain European agencies to act as mentors by providing support and advice to partnerships of tender age? Or, one step further, could Europe help identify potential partnership opportunities to support, for example, regional forms of bi- and multilateral cooperation between Asian, African or Latin American agencies? The benefits of this approach would be that, in the long run, Europe will have more mature agencies to cooperate with and other space agencies will be more willing and able to take up commitments in the global scientific community. Considering that the number of space agencies is witnessing a new growth phase such opportunities are becoming more relevant than ever. These initiatives would allow Europe to transform some of its ad-hoc partnerships into strategic partnerships and help position itself as a bridge-builder in bi- and multilateral projects.

[50] The Convention of the Asia-Pacific Space Cooperation Organization (APSCO), for instance, has some resemblance to the Convention of the European Space Agency.

10.4.1.2 Maximising the Return of European Strengths

Another possible S-O strategy would be to further exploit the potential of the existing and foreseeable technological strengths and strategic capabilities. Considering that the global demand for space hardware and services will increase, Europe could develop strategies to increase the market potential of its (upcoming) operational services in the fields of Earth observation, telecommunication, satellite navigation, launch services and scientific expertise. This could be done in several ways. First, Europe could reap huge benefits from developing capabilities that serve its own specific needs such as an aging population, a further tertiarisation of its economy, the need to automate the agricultural sector, transnational integration, environmental protection and scarcity of natural resources. Other parts of the world are less—in some cases not at all—subject to these processes and as such it could be expected that helping address them with space capabilities might require Europe to develop innovative solutions by itself—others will not be inclined because they less need to do so. To this effect, Europe should bet more on smart programmes that link its technological capabilities to its social and economic needs. To date, there are several areas where this is not yet being pursued or planned to the most optimal extent imaginable. For example, will the EU stimulate the development of integrated transportation networks that connect space based services like Galileo and Copernicus to dynamic information systems on highways and driver-environment interfaces aboard cars? The potential of these kinds of capabilities are immense as they could, for instance, warn drivers upstream and divert larger masses of upcoming traffic depending on road conditions, observed congestion and accidents. A comparable degree of integration of space based services in the socioeconomic sphere could be the deployment of smart energy grids that benefit from information such as wind velocity, solar power input and local energy consumption.

Tackling the competitiveness issue on the global market is something that will mainly require some of Europe's weak points to be addressed. Part of the solution, however, will also be to further invest in fields in which Europe already has a comparative advantage and bring these strengths to the market so as to create growth and increase competitiveness. In a sector like space which is characterised by low volumes of high-tech complex products, a significant element in competitiveness is not so much price but innovation. This is perhaps less so in the launcher market in which price and trustworthiness are the determining factors. For payloads and services, however, customers are prepared to pay higher prices if it allows them to obtain higher quality in terms of, for example, accuracy, reliability, speed and usability. The SWOT analysis revealed that Europe has a set of comparative advantages over other players in a number of fields. One way to exploit the potential of European strengths is to turn technological and managerial expertise into an export product for countries that are currently developing space capabilities. This would enable European space agencies and industry to take up the role of consultant in capacity development and programme execution abroad. Considering the strategic value of certain technology areas and comparative advantages, this is something that should be reflected upon by both the European Space Agency, the European Commission, both their Member-States and the space industry.

Finally, Europe should make sure that the value-added services provided by its capabilities are accompanied by the creation of business-models that create profit by selling to consumers, governments and corporations worldwide. This will require a more global focus, taking into account: (1) needs and aspirations in different parts of the world, (2) the increasing relevance of space for many human activities and (3) the fact that potential customers will have divergent socioeconomic status levels and different priorities.

10.4.2 Strength-Threat Strategies

Strategies based upon the Strength-Threat principle are an efficient way of defensive action, as they build up existing strengths to overcome certain external and global threats.

10.4.2.1 Europe as an Engine of Improved Sustainability and Security

The SWOT analysis showed that increased use and diversity in outer space utilisation will introduce more and new governance challenges and threats in terms of sustainability and security. It was indicated that governance challenges will likely be characterised, among other things, by the need for a more accurate legal framework and clear mechanisms for prioritisation of use. At the same time, in the realm of space, but even more so in other fields, Europe has built up considerable experience in the establishment and functioning of regimes for international governance. In light of this, it would be a logical step for Europe to play an active role in ensuring that space will remain an environment characterised by proper governance and principles of equitable use. The EU-led multilateral initiative on an International Code of Conduct for Outer Space Activities is a very good step in this respect.[51] It does not, however, really address a number of practical concerns such as the delineation of outer space. Nor does it encompass any initiative to ensure equitable use in case of increased congestion or prioritisation principles to address divergent approaches with respect to space utilisation.

Europe is well-endowed in terms of technological capabilities and international relations to spur the development of potential solutions in the domain of sustainability. In this respect it would be sensible to address these challenges in a holistic fashion incorporating industry, governmental players and even, where relevant, crowdsourcing in the quest for solutions aiming at prevention and mitigation. On

[51] European Union External Action Service. Draft International Code of Conduct for Outer Space Activities. Sept. 2013. Brussels: European Union. http://eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_16_sept_2013_en.pdf.

the one hand this should result in the assessment of technical solutions and innovation for electromagnetic congestion and space debris. On the other hand, thorough solutions should entail mechanisms for prioritisation of use and attribution of individual responsibilities so as to enable space debris mitigation in later phases. Although the political implementation of these elements is very hard to achieve in the short term because of the inertia of the international community, it would be beneficial for Europe and the global community to initiate the process of reflection and research on these issues. Not only would this considerably shorten the decision-making process on these issues, but an early reflection process also has the potential of spurring global political alignment in the long run, which in turn facilitates global consensus on the way forward once the issue has gained a certain critical mass on the political agenda. The history of the Kyoto protocol in the fight against global climate change has shown that the impact of international commitment is seriously reduced if certain major players are not included in addressing a global problem. It would be foolish if the same mistake were to obstruct future generations in the utilisation of the outer space environment. To address the threat of geopolitical tensions and weaponisation of outer space, Europe should consider whether incentives could be offered in exchange for the ratification of and compliance with global security regimes. These incentives could consist of free data and services or technology transfer, depending on the context. The latter strategy would create a win-win situation: certain emerging nations would gain knowledge and/or strategic capabilities while Europe and the global community are ensured of a more inclusive and shared vision and approach vis-à-vis sustainability.

10.4.3 Weakness-Opportunity Strategies

Weakness-Opportunity based strategies are interesting because they simultaneously serve two purposes: overcoming an existing internal problem and gaining something from an external opportunity. In this sense they pay off twice—creating another win-win situation. They are, however, typically not the easiest category of strategies to pursue, especially not in this particular case. In the SWOT analysis it was assessed that the global demand for space capabilities and space-based services will increase significantly in the future. This increasing demand will increasingly come from outside the realm of space itself, as society will require increasingly complex and integrated information systems and services to manage the gap between global demand and supply. At the same time, the market for space is becoming increasingly dynamic, innovative and diversified. In order to fully reap the benefits these opportunities will create, it is key that Europe overcomes certain weaknesses that currently obstruct its long term growth perspectives. In essence, the main issues are global competitiveness and innovation. Both of them, however, are closely linked to the need for strong, centralised and swift political decision-making authorities.

10.4.3.1 Europe: Improving Its Long-Term Competitiveness

Political organs that seek to avoid profound changes in procurement chains and industrial policies to avoid painful decisions have rarely contributed to competitiveness. In fact, the world of today and the laws of its global markets have illustrated that other sectors suffering from this inertia typically fail. Even reforms that come late or are implemented over a longer time can be deadly in terms of market potential and position. This is because other more competitive and faster actors in the market have the strategic advantages of being first: establishing customer-supplier relationships in terms of trust, capabilities and a sense of partnership. Although the European Commission has shown its willingness to engage in a number of initiatives, it remains unclear whether the policy outcome will be far-reaching enough rather than too little, too late. European decision makers should not be afraid of looking into options that might be painful at first, but more sustainable for the overall European business model in the long haul. Examples in this respect include, for instance, outsourcing certain low value-added segments of less strategic industrial production chains, and, a revised optimisation of the trade-off between actual risks and costly risk-avoidance development processes and redundancy features. The latter would not be an illogical decision to consider since experience and time have led to a maturation of risk-perspectives and, the growing markets are making room for market segmentation in which various products and services can be purchased at a range of prices against different performance specifications.

10.4.3.2 Europe: Creating a Genuine Innovation Ecosystem

The stimulation of innovation will demand sufficient resources to be reserved for R&D and a will to think out-of-the-box. It requires, for instance, the application of unconventional mechanisms that would perhaps not be applied by established, mature players—regardless of whether they are commercial or institutional.[52] In terms of future market potential much of the wealth generated by space assets will be in the form of services and applications. So far, however, other parts of the world have been faster, more flexible and more inventive in the creation of commercial value-added services for the mass market. As services can be quickly deployed on a global level, it is important to tap into the market and become a relevant player before it has reached maturity—something that Europe has to a large extent failed to do so far. This is painfully illustrated by what has happened in the dot-com industry in the world of computing and IT services: Yahoo!, eBay, Google, Facebook, Twitter, Skype and other major dot-com companies are all American, not European. Obviously, this lack of swift innovation and proper marketing on the

[52] For a proposal of tools, please consult: Giannopapa C., Hulsroj P., Lahcen A. and Paradiso N. “Space and the Processes of Innovation” July 2012 European Space Policy Institute 15 Dec. 2013. http://www.espi.or.at/images/stories/dokumente/studies/ESPI_Report_43.pdf.

European side is not only an issue in space, but in fact this makes the reality even worse: it is an issue affecting most of Europe's economic sectors. Fortunately ESA has taken a good first step in this respect by means of its ARTES 20 initiative: the Integrated Applications Promotion (IAP) programme. IAP fosters the use of multiple space assets in order to create new solutions and as such is exactly aiming at the creation of space related services and applications. Yet, the amount of 'demand pull' for these services and applications remains rather modest on a pan-European level. The current absence of demand pull creates a lack of critical mass which results in a valley of death for a number of applications. This prevents European businesses from developing lucrative mass market products and services based upon space assets. Addressing this issue increases the need for proper governance even more, as it implies that space innovation will have to be part of an overall strategy to create an innovative environment in Europe. One could argue here that the EU is already actively involved in innovation schemes, with reference to the European Commission's communications on EU space industrial policy and its long term programme Europe 2020.[53,54] The problem is, however, is that the creation of a healthy and thriving innovative environment is much like the outcome of a multiplication equation; it requires all factors to be of a sensible value in order to produce results—including the financial context required to facilitate young entrepreneurs and the creation of start-ups and new SMEs. This will remain difficult as long as the EU does not facilitate access to finance and maintains its reluctance to import new talents and spur private spending in R&D.

10.4.3.3 Solutions with Double Impact?

One way that might partially address the two issues of concern at the same time would be to increase overall spending for space in Europe. Not only would this overcome the critical mass issue compared to certain other players; it might also have repercussions on the structure and functioning of the internal market for space. Higher institutional demand would—if properly managed—increase the overall number of actors in the space ecosystem and, the variety of technological activities conducted in it. Moreover, it would increase the capacity of the European Space Agency in absorbing new member states as they have more opportunities for developing a domestic space sector. From a natural selection point of view, these elements stimulate overall innovation practices and competitiveness because the struggle among companies to survive, grow and be involved in projects is intensified. The main issue in this respect is of course the availability of funding, which in

[53] Commission of the European Communities. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: EU Space Industrial Policy. Releasing the Potential for Economic Growth in the Space Sector. COM (2013) 108 final of Feb. 2013. Brussels: European Union.

[54] Commission of the European Communities. Communication From The Commission EUROPE 2020 A Strategy for Smart, Sustainable and Inclusive Growth. COM (2010) 2020 final of Mar. 2010. Brussels. European Union.

times of financial austerity remains very difficult. The use of non-conventional ways of gathering funding—such as crowd funding and boosting private R&D capital—could, however, be part of the solution. Finally, addressing the competitiveness and innovation issues requires a solution to the duality of governance in Europe. This is the only way to ensure that each institutional player acts—in coordination with others—to its best capabilities in the interest of the long-term sustainability of the European space sector. If Europe manages to solve the undefined governance and turf issues between the EU and ESA in a reasonable timeframe, it will be able to optimise the benefits of future opportunities. If not, Europe risks being marginalised in the harvesting of future wealth, as other players—such as the United States and certain Asian economies—will be better adapted to the future environment.

10.4.4 Weakness-Threats Strategies

Weakness-Threats based strategies are rather defensive in nature because their major aim is to prevent risk rather than reaping the economic benefits of opportunities. On the other hand, they are a strategic investment in the long run, as they reinforce the internal structure of Europe's space ecosystem, making it less vulnerable to unpredictable or uncontrollable external events.

10.4.4.1 Towards an Integrated Governance Model for Space?

In the section on Strength-Threat Strategies it was suggested that Europe has various strengths that can help addressing many of the major global issues of governance, sustainable use and security threats that might become more pronounced in the future. One of the conditions for Europe to use the full potential of its weight and position for the better, however, is the presence of a single pan-European entity endowed with the political mandate, scope and decision-making structures to do so. Many of Europe's governmental institutions dealing with space have reputable international positions and exert positive influence in their respective fields around the world. Nevertheless it is clear that only the European Union has the intrinsic ability to deploy Europe's geopolitical weight on the international stage to exert influence on the global political agenda. In spite of the institutional reforms initiated following the ratification and coming into force of the Lisbon Treaty, the question remains whether this capacity is sufficiently accompanied by an implementation strategy. It seems that the ability of the EU to valorise its potential relationship with space affairs remains to be consolidated. The European Union has formulated a space policy setting out a roadmap for the future development of space capabilities and to underpin their strategic importance for the objectives and policy fields with which it is concerned. In addition, the European External Action Service is currently trying to find international support for the multilateral initiative on an International Code of Conduct for Outer Space Activities, which outlines principles to guarantee future governance, sustainability and security. The battle against climate change, however, has shown that the strategy of leading by example-setting is no longer sufficient to involve other major players. Bringing about change requires pragmatic choices to be made, such as coalition forming, in order to prevent other major players to push their will on the global political agenda.

These elements indicate that space is increasingly finding its way to the governance level where its full potential can be reached, but that the final validation is still taking shape. In the globalised world of today, full leverage of space capabilities and services will remain incomplete as long as the EU is deprived of the geopolitical authority imagined under the principle of subsidiarity. It is important to note that this would not necessarily deprive other European institutions, and the European Space Agency in particular, from exerting political impact on the European space scene. On the contrary, it is feasible that a strong Meta-Governor for space activities in Europe in the form of the European Commission would create a pull effect in space capacity development from which other actors would also benefit, comparable to the approach of the United States. It remains very questionable, however, whether the creation of a Meta-Governance model for space is likely to happen in the foreseeable future. The process of Europeanisation requires political alignment and consensus decisions-making, both of which have been profoundly impacted by the financial and economic crises.

10.5 Conclusions

This contribution has focused on the changing context for space and its implications for Europe in particular. In the first instance it was assessed that the process of globalisation is key to understanding the various processes currently reshaping the global context in which space activities are embedded. On the one hand this is because the globalisation paradigm well fits the diverse and interdisciplinary nature of space. On the other hand it helps to explain and link many of the processes that impact space industry, governments and market structures. This was illustrated in a number of ways. First, most major space nations are currently changing their activities and policies. The United States is reorienting itself for two main reasons: it is seeking to maintain its strategic advantage at a time when globalisation is creating a levelling effect and, it seeks to spur the development of an innovative commercial domestic space industry. Europe has taken major decisions in terms of strategic investments as its space sector is widening geographically and deepening in terms of diversity and capabilities. At the same time the recent EU involvement in outer space affairs is shaping the formation of a new governance structure that is able to support Europe's position on a global level. In Russia reforms are aimed at increasing competitiveness, expanding space assets and modernising industry, while China is using space as an environment for and display of its intense socioeconomic and military development. At the same time the number of space nations is witnessing a new growth phase and space industry worldwide is being transformed into a truly innovative and competitive economic sector. All these developments are strongly reinforcing the link between society and space, increasing our dependence on space technologies, services and the sector itself—which in turn has made society more open and supportive towards space.

To assess the possible implications for Europe, a Weakness-Strengths-Opportunities-Threats (SWOT) analysis was conducted in the second part of the contribution. In order to shed light on Europe's internal context, its strengths and weaknesses in space were described in a concise manner. This revealed that Europe has benefitted from the approach it has taken in space capacity development and that this has enabled the continent to acquire a reputable position and tangible benefits in many of the most relevant space areas. At the same time, however, Europe has smaller institutional demand and is characterised by fragmented and dual governance structures. The future external global playing field was identified by extrapolating the effects of globalisation. This showed that opportunities will arise because the global demand for space capabilities and services will increase, markets will become more dynamic and flexible and the future will offer interesting cooperation prospects. On the down side current challenges in terms of governance, competitiveness, sustainability and security will become more precarious as things become more complicated with a growing number of diverse space actors and programmes.

Finally, the findings of the SWOT analysis were used to construct four different types of strategies for Europe to safeguard its current position and reap more benefits in the future. Possible Strength-Opportunity Strategies include Europe's positioning as a quintessential continent for global cooperation and a benefit maximisation of existing and to-be-developed technological and strategic strengths. Creating efficient defensive actions by means of Strength-Threat Strategies could be achieved by using Europe's experience to strengthen global governance so as to make it future-proof and by reinforcing Europe's role in the creation of global space sustainability and security. Implementing Weakness-Opportunity Strategies will require the continent's issues in terms of competitiveness and innovation to be overcome while constructing Weakness-Threats Strategies will require the internal governance issue to be settled soon and in a sensible fashion. For all four strategies some concrete proposals were formulated and the major issues of concern highlighted. In turns out, however, that many requirements for the proper implementation of the strategies go back to the core-issue of governance. As long as Europe struggles in defining a solid, centralised and holistic governance structure for space, it will find itself unable to reap the benefits of opportunities and incapable of tackling many of the threats that lie ahead.

Part III
Facts and Figures

Chapter 11
Chronology: June 2012–December 2013

Ewout Killemaes and Blandina Baranes

11.1 Access to Space[1]

All launch dates are calculated using Greenwich Mean Time (GMT), hence the date at the launch site may differ from the date listed here by 1 day.

Europe	Other countries
Launch log	
June 12	
	01 Zenit 3SL—Intelsat 19 (C)[a]
	13 Pegasus XL—NuSTAR (S)
	16 Long March 2F—Shenzhou 9 Descent Module (MF), and Shenzhou 9 Orbital Module (D)
	20 Atlas V 401—NRO L-38 (C)
	29 Delta IV Heavy—NRO L-15 (I)
July 12	
05 Ariane 5 ECA—Echostar XVII (C)[a], and MSG 3 (M)	09 Proton M—SES 5 (C)[a]
	15 Soyuz—Soyuz TMA-05M (ISS-31S) (ISS/MF)
	21 H IBB—HTV 3 (ISS), F-1 (R), We-Wish (D), FitSat-1 (D), TechEdSat (C), and RAIKO (D)
	22 Soyuz—Kanopus B1 (R), Zond PP (S), ExactView1 (R), TET-1 (D), and Belka 2 (R)
	25 Long March 3C—Tianlian-1C (C)

(continued)

[1] Federal Aviation Administration. Commercial Space transportation: 2012 Year in Review. Washington DC: FAA, Jan. 2013: 29+; Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2013. Washington DC: FAA, Feb. 2013: 192+.

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Europe	Other countries
	28 Rockot—Cosmos 2481 (C), Gonets M-03 (C), Gonets M-04 (C), and MIR (Yubileyniy 2) (C)
August 12	
02 Ariane 5 ECA—HYLAS 2 (C)[a], and Intelsat 20 (C)[a]	01 Soyuz—Progress M-16M (ISS 48P) (ISS), and SFERA-53 (D)
	06 Proton M (launch failure : failure due to third stage pressurization system)—Telkom 3 (C)[a], and Express MD2 (C)
	18 Zenit 3SL—Intelsat 21 (C)[a]
	30 Atlas V 401—Van Allen Probe A & B (S)
September 12	
28 Ariane 5 ECA—Astra 2F (C)[a], and GSAT 10 (C)	09 PSLV CA—SPOT 6 (R)[a], mRESINS (D), Proiteres (D)
	13 Atlas V 401—NRO L-36/NOSS 3-6A (I), NRO L-36/NOSS 3-6B (I), CXBN (S), AENEAS (D), CISSWE (S), CP 5 (D), CINEMA 1 (S), SMDC-ONE 2.1 (ABLE) (D), SMDC-ONE 2.2 (BAKER) (D), STARE A (D), AeroCube 4A (D), AeroCube 4B (D), AeroCube 4C (D), and OUTSAT (D)
	17 Soyuz 2 1A—MetOp B (M)
	18 Long March 3B—Beidou 2C-M5 (N), and Beidou 2C-M6 (N)
	22 Safir 2—Unknown (failure: failure to launch, Unkown)
	29 Long March 2D—VRSS 1 (R)
October 12	
12 Soyuz 2 1B—Galileo 3 (N), and Galileo 4 (N)	04 Delta IV Medium+ (4,2)—Navstar GPS 2F-03 (N)
	07 Falcon 9—Dragon ISS 1D (ISS)[a], and ORBCOMM OG2-01 (failure: Merlin engine could not reignite due to safety constraints near the ISS, C)[a]
	14 Proton M—Intelsat 23 (C)[a]
	14 Long March 2C—Shijian 9A (D), and Shijian 9B (D)
	23 Soyuz—Soyuz TMA-06M (ISS 32S) (ISS/MF)
	25 Long March 3C—Beidou 2-G6 (N)
	31 Soyuz—Progress M-17M (ISS 49P) (ISS)
November 12	
10 Ariane 5 ECA—Star One C3 (C)[a], and Eutelsat 21B (C)[a]	02 Proton M—Luch 5B (C), and Yamal 300K (C)[a]
	14 Soyuz 2 1A—Meridian 6 (C)
	19 Long March 2C—Huan Jing 1C (R), Fengniao 1A (D), Fengniao 1B (D), and Xinyan-1 (D)
	20 Proton M—Echostar XVI (C)[a]
	25 Long March 4C—Yaogan 16 Main (R), Yaogan 16 Subsat 1 (R), and Yaogan 16 Subsat 2 (R)
	27 Long March 3B—APSTAR 7B (Chinasat 12) (C)[a]

(continued)

Europe	Other countries
December 12	
01 Soyuz 2—Pleiades 1B (Pleiades HR 2) (R) 19 Ariane 5 ECA—MexSat 3 (C), and SkyNet 5D (C)	03 Zenit 3SL—Eutelsat 70B (C)[a]
	08 Proton M—Yamal 402 (partial failure: reduced lifetime due to partial launch failure, C)[a]
	11 Atlas V 501—X-37B/OTV 3 (D)
	12 Unha 3—Kwangmyongsong 3-2 (R)
	18 Long March 2D—Gökturk 2 (I)
	19 Soyuz—Soyuz TMA-07M (ISS 33S) (ISS/MF)
January 13	
	15 Rockot—Cosmos 2482 (C), Cosmos 2483 (C), and Cosmos 2484 (C)
	27 H-IIA 202—IGS-4D (RADAR) (I), and IGS-5 Optical Demonstration (I)
	30 Naro-1—STSAT-2C (S)
	30 Atlas V 401—CCAFS (C)
February 13	
07 Ariane 5 ECA—Amazonas 3 (C)[a], and Azersat 1 (C)	01 Zenit 3SL—Intelsat 27 (launch failure during first stage engine shutdown, C)[a]
	06 Soyuz 2.1a—Globalstar 2nd Gen 19, 20, 21, 22, 23 & 24 (C)[a]
	11 Soyuz U2/Progress—Progress M-18M (ISS 50P) (ISS)
	11 Atlas V 401—Landsat DCM (R)
	25 PSLV Standard—Saral (R), and six secondary payloads (including cubesats)
March 13	
	01 Falcon 9 v1.0 Dragon—Dragon ISS 2D (ISS)[a]
	19 Atlas V 401—SBIRS GEO 2 (EW)
	26 Proton M/Breeze-M—SatMex 8 (C)[a]
	28 Soyuz U2/Soyuz—Soyuz TMA-08M (ISS 34S) (ISS/MF)
April 13	
	15 Proton M/Breeze-M—Anik G1 (C)[a]
	19 Soyuz 2.1a—Bion M1 (S), and six secondary payloads (including cubesats)
	21 Antares 120—Cygnus Mass Simulator (D)[a], and four secondary payloads (including cubesats)
	24 Soyuz U2/Progress—Progress M-19M (ISS 51P) (ISS)
	26 Long March 2D—GAOFEN 1 (R), and three secondary payloads (including cubesats)
	26 Soyuz 2.1b—Glonass M47 (N)

(continued)

Europe	Other countries
May 13	
06 Vega—Proba V (R), VNREDSat 1A (R), and ESTCube 1 (D)	01 Long March 3B—Chinasat 11 (Sinosat 7) (C)[a]
	14 Proton M/Breeze-M—Eutelsat 3D (C)[a]
	15 Atlas V 401—Navstar GSP 2F-04 (N)
	24 Delta IV Medium + (5,4)—WGS 5 (C)
	28 Soyuz U2/Soyuz—Soyuz TMA-09M (ISS 35S) (ISS/MF)
June 13	
05 Ariane 5 ES—ATV 4 (ISS) 25 Soyuz 2.1b—O3b 01, 02, 03, and 04 (C)[a]	03 Proton M/Breeze-M—SES 6 (C)[a]
	07 Soyuz 2.1b—Cosmos Persona (I)
	11 Long March 2F—Shenzhou 10 Orbital Module (D), and Shenzhou 10 Descent Module (MF)
	25 Soyuz 2.1b—Resurs P1 (R)
	27 Strela—Kondor E (R)
	27 Pegasus XL—IRIS (USA) (S)
July 13	
25 Ariane 5 ECA—Alphasat I-XL (C)[a], and Insat 3D (M)[a]	01 PSLV XL—IRNSS 1A (N)
	02 Proton M/Block DM (failure: launch failure seconds after launch)—Glonass M46, M48, and M49 (N)
	15 Long March 2C—Shi Jian 11-05 (S)
	19 Long March 4C—Chuang Xin-3 (C), Shiyan Weixing-7 (S), and Shi Jian-15 (S)
	19 Atlas V 551—MUOS 2 (C)
	27 Soyuz U2/Progress—Progress M-20M (ISS 52P) (ISS)
August 13	
29 Ariane 5 ECA—Eutelsat 25B (C)[a], and GSAT-7 (Insat 4F) (C)	03 H-IIB—HTV-4 (ISS)
	07 Delta IV Medium+ (5,4)—WGS 6 (C)
	22 Dnepr—Kompsat 5 (R)
	28 Delta IV Heavy—NRO L-65 (I)
September 13	
	01 Zenit 3SLB—Amos 4 (C)[a]
	02 Long March 4C—Yaogon 17 Main (R), Yaogan 17 Subsat 1 (R), and Yaogan 17 Subsat 2 (R)
	06 Minotaur V—LADEE (S)
	12 Rockot—Gonets M-05, M-06, and M-07 (C)
	14 Epsilon Standard—SPRINT-A (S)
	18 Atlas V 531—Advanced EHF 3 (C)
	18 Antares 120—Cygnus COTS Demo (D)[a]
	23 Long March 4C—Feng Yun 3C (M)
	25 Kuaizhou—Kuaizhou 1 (R)
	25 Soyuz U2/Soyuz—Soyuz TMA-10M (ISS 36S) (ISS/MF)
	29 Falcon 9 v1.1—Cassiope (D), and six secondary payloads (including cubesats)
	30 Proton M/Breeze-M—Astra 2E (C)[a]

(continued)

Europe	Other countries
October 13	
	25 Long March 4B—Shi Jian-16 (D)
	25 Proton M/Breeze-M—Sirius FM-6 (C)[a]
	29 Long March 2C—Yaogan 18 (R)
November 13	
	05 PSLV Standard—Mangalyaan (Mars Orbiter India) (S)
	07 Soyuz U2/Soyuz—Soyuz TMA-11M (ISS 37S) (ISS/MF)
	11 Proton M/Breeze-M—Raduga-1M3 (C)
	18 Atlas V 401—MAVEN (S)
	19 Minotaur I—STPSAT-3 (D), and 28 secondary payloads (including cubesats)
	20 Long March 4C—Yaogan 19 (R)
	21 Dnepr—DubaiSat 2 (R), and 31 secondary payloads (including cubesats)
	22 Rockot—Swarm 1, 2, and 3 (S)
	25 Long March 2D—Shiyan Weixing-5 (R)
	25 Soyuz U2/Progress—Progress M-21M (ISS 53P) (ISS/MF)
December 13	
19 Soyuz 2.1b—GAIA (S)	01 Long March 3B—Chang'e 3 (Lander and Rover) (S)
	03 Falcon 9 v1.1—SES 8 (C)[a]
	05 Atlas V 501—NRO L-39 (I), and 12 secondary payloads (including cubesats)
	08 Proton M/Breeze-M—Inmarsat 5-F1 (C)[a]
	09 Long March 4B—CBERS 3/Ziyuan-1C (failure: launch failure involving third stage, satellite did not did achieve stable orbit, R)
	20 Long March 3B—Tupac Katari (C)[a]
	25 Rockot—Cosmos 2488, 2489, and 2490 (C)
	26 Proton M/Breeze-M—Express AM-5 (C)
	28 Soyuz 2.1v—AIST II (D), SKRL-756 1 (D), and SKRL-756 2 (D)

C Communications, *D* Development, *I* Intelligence, *ISS* International Space Station, *M* Meteorological, *MF* Manned Flight, *N* Navigation, *R* Remote Sensing, *S* Scientific, *EW* Early Warning System

[a]Commercial

11.2 Space Science and Exploration

Europe	Other countries
Earth sciences	
June 2012–December 2012	
24 October—ESA's quartet of satellites studying the Earth's magnetosphere, Cluster, discovers the magnetosphere behaves like a sieve[a]	*22 July*—Launch of Zond PP (Roscosmos, Russia) to study ocean circulation and climate dynamics[c]
16 November—ESA's GOCE gravity satellite delivers the most accurate gravity map of Earth[b]	*30 August*—Launch of Van Allen Probe A & B (NASA, U.S.) to understand the sun's influence on Earth and near-Earth space by studying the Earth's radiation belts[d]
2013	
6 May—Launch of Proba-V (ESA) which carries a vegetation imager to map global vegetation[e]	*25 February*—Launch of Saral (ISRO, India) to study the sea surface heights[j]
8 May—ESA selects the Biomass mission to become the next in the series of satellites developed to further our understanding of Earth, which aims to take measurements of forest biomass to assess terrestrial carbon stocks and fluxes[f]	*6 May*—Launch of VNREDSat 1A (Vietnam Academy of Science and Technology) to monitor and study the effects of climate change, while also improve predictions and actions to prevent natural disasters and optimize the country's management of its natural resources[k]
26 June—The biomass of the northern hemisphere's forests has been mapped with greater precision than ever before, using radar images taken by ESA's Envisat satellite[g]	
11 November—GOCE, to map Earth's gravity field, re-enters Earth's atmosphere and disintegrates in the high atmosphere as expected[h]	
22 November—Launch of Swarm 1, 2 and 3 (ESA) ESA's constellation to study Earth's magnetic field[i]	
Astronomy	
June 2012–December 2012	
20 June—ESA's mission Euclid, to explore the hidden side of the universe—dark energy and dark matter—received final approval to move into the full construction phase, leading to its launch in 2020[l]	*4 June 2012*—NASA pulls the plug on the Gravity and Extreme Magnetism Small Explorer (GEMS) X-ray telescope, an astrophysics mission that was to have launched in 2014 to observe the space adjacent to neutron stars and black holes[m]
	13 June—Launch of NuSTAR (NASA/JPL) to focus light in the high energy X-ray (6–79 keV) region of the electromagnetic spectrum. NUSTAR will survey the sky for collapsed stars and black holes, young supernova remnants, and relativistic jets of particles from

(continued)

Europe	Other countries
	the most extreme active galaxies hosting supermassive black holes[n]
	13 September—Launch of CXBN (Morehead State University, U.S.) devoted to observe improved measurements of the extragalactic diffuse X-Ray background, CISSWE (University of Colorado, U.S.) to observe solar particles, and CINEMA 1 (University of California, Berkeley, U.S.) to monitor space weather[o]
2013	
29 April—ESA's infrared observatory Herschel ends its science mission due to the exhaustion of its helium coolant[p]	*27 June 2013*—Launch of IRIS (USA) (NASA) Solar Dynamic Observatory which will examine how solar material moves, gathers energy, and heats up as it travels through a little-understood region in the sun's lower atmosphere, the chromosphere, to the corona[r]
19 December—Launch of GAIA (ESA) to chart a three-dimensional map of our Galaxy, the Milky Way, and in the process revealing the composition, formation and evolution of the Galaxy[q]	*21 August*—NASA announces that it will reactivate the Wide-field Infrared Survey Explorer, or WISE, to hunt for asteroids the next 3 years[s]
	14 September—Launch of SPRINT-A (JAXA, Japan) to target Venus, Mars, Jupiter and their satellites by a telescope in the extreme UV-region[t]
Exploration	
June 2012–December 2012	
	6 August—NASA's Curiosity rover lands safely at the Gale Crater on Mars[u]
2013	
	12 March—Curiosity's findings indicate that Ancient Mars was habitable and could have supported some form of life. The chemical analysis of material from deeper inside a slab of bedrock shows that the water had a neutral pH rather than being highly salty or acidic like the water in some other areas as documented by previous rovers[v]
	10 April—NASA administrator Charles Bolden unveiled the space agency's proposed budget for fiscal year 2014 to relocate an asteroid in near Earth orbit[w]
	19 April—Launch of Bion M1 (Roscosmos, Russia) the world's only returnable satellite, which will conduct numerous physiological,

(continued)

Europe	Other countries
	genetic, morphological and molecular-biological experiments during its 30-days flight[x]
	6 September—Launch of LADEE (NASA) a robotic mission that will orbit the moon to gather detailed information about the structure and composition of the thin lunar atmosphere, and determine whether dust is being lofted into the lunar sky[y]
	5 November—Launch of Mangalyaan (Mars Orbiter India) (ISRO, India) country's first Mars orbiter[z]
	18 November—Launch of the Mars Atmosphere and Volatile Evolution (MAVEN) (NASA) to study the Mars' upper atmosphere[aa]
	1 December—Launch of Chang'e 3 (Lander and Rover) (CAST, China) to make the first soft landing on the Moon since the Soviet Luna 24 probe in 1976[ab]
Manned spaceflight and cargo transfers	
June 2012–December 2012	
3 July—Samantha Cristoforetti (Italy) assigned to ISS Expeditions 40/41, to launch in 2014[ac]	*16 June*—Launch of Shenzhou 9 Descent Module (CAST, China) to deliver three Chinese astronauts to Tiangong 1 and bring them back to Earth[ad]
	15 July—Launch of Soyuz TMA-05M (Roscosmos, Russia) with three ISS Expedition 32 & 33 crew[ae]
	21 July—Launch of HTV 3 (JAXA, Japan) to deliver cargo to the ISS[af]
	1 August—Launch of Progress M-16M (Roscosmos, Russia) to deliver cargo to the ISS[ae]
	7 October—Launch of Dragon ISS 1D (SpaceX, U.S.) supplying the ISS with cargo and, because of its ability to return intact, bring back items to Earth[ag]
	23 October—Launch of Soyuz TMA-06M (Roscosmos, Russia) with three ISS Expedition 33 & 34 crew[ae]
	31 October—Launch of Progress M-17M[ae]
	19 December—Launch of Soyuz TMA-07M with three ISS Expedition 34 & 35 crew[ae]

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Europe	Other countries
2013	
29 May–11 November—Luca Parmitano (Italy) participated in ISS Expeditions 36/37 as a flight engineer for his Volare mission under a bilateral agreement with the Italian space agency and NASA[ah]	*11 February*—Launch of Progress M-18M[ae]
5 June—Launch of ATV 4, Albert Einstein (ESA), ISS resupply vehicle[ae]	*1 March*—Launch of Dragon ISS 2D (SpaceX)[ae]
20 May—Timothy Peake (U.K.) assigned to ISS Expeditions 46/47, to launch in 2015[ai]	*28 March*—Launch of Soyuz TMA-08M with three ISS Expedition 35 & 36 crew[ae]
28 August—Andreas Mogensen (Denmark) assigned a 10-day mission on-board the ISS, to launch in September 2015[aj]	*24 April*—Launch of Progress M-19M[ae]
2 November—ATV-4 completes a targeted destructive re-entry over the Pacific Ocean[ak]	*28 May*—Launch of Soyuz TMA-09M with three ISS Expedition 36 & 37 crew[ae]
	11 June—Launch of Shenzhou 10 Orbital Module and Descent Module (CASC, China) to deliver three Chinese astronauts to Tiangong 1 and bring them back to Earth[ae]
	27 July—Launch of Progress M-20M[ae]
	3 August—Launch of HTV-4 (JAXA, Japan)[ae]
	18 September—Launch of Cygnus COTS Demo (Orbital Sciences Corp.) Orbital Sciences' first Cygnus resupply spaceship to the ISS on the company's second Antares rocket to fly[al]
	25 September—Launch of Soyuz TMA-10M with three ISS Expedition 37 & 38 crew[ae]
	7 November—Launch of Soyuz TMA-11M with three ISS Expedition 38 & 39 crew[ae]
	25 November—Launch of Progress M-21M[ae]

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11.3 Applications

Europe	Other countries
Earth observation	
June 2012–December 2012	
5 July—Launch of MSG 3 (Eumetsat, Europe) third in a series of four second-generation weather satellites introduced in 2002[a]	*21 July*—Launch of F-1 (Fspace Laboratory, FTP Tech Research, Vietnam) first made-in-Vietnam satellite to help monitor maritime transport and prevent forest fires[e]
9 September—Launch of SPOT 6 (Spot Image, France) to form an Earth-observation constellation with SPOT 7 to be launched in 2014[b]	*22 July*—Launch of ExactView 1 (exactEarth, Canada) fifth satellite in exactEarth's advanced vessel monitoring satellite constellation, Kanopus B1 (Roscosmos, Russia) for real-time monitoring of natural and man-made disasters and other emergency situations, and Belka 2 (National Academy of Belarus) earth imaging satellite[f,g,h]

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Europe	Other countries
17 September—Launch of MetOp B (Eumetsat, Europe) replacing the ageing MetOp A weather satellite[c]	*29 September*—Launch of VRSS 1 (Venezuelan Ministry of Science and Technology) to monitor the country's territory, survey crops and natural resources, and aid Venezuela's security services[i]
1 December—Launch of Pleiades 1B (CNES, France) very-high-resolution Earth-imaging satellite for military as well as civil and commercial applications, together with Pleiades 1A[d]	*19 November*—Launch of Huan Jing 1C (China National Space Administration) third satellite in a series of three for land observation, and contributing to the Disaster Monitoring Constellation (DMC)[j]
	25 November—Launch of Yaogan 16 Main and Yaogan Subsat 1 & 2 (PLA, China) Yaogan satellite constellation is used for scientific experiments, land survey, crop yield assessment, and disaster monitoring, but it is believed they Yaogan series serve military purposes[k]
	12 December—Launch of Kwangmyongsong 3-2 (Democratic People's Republic of Korea, North Korea) that will be used for weather forecast purposes and agricultural monitoring; first successful placement of a satellite in orbit[l]
2013	
	11 February—Launch of Landsat DCM (NASA/U.S. Geological Survey) the eight satellite in the Landsat series[m]
	26 April—Launch of GAOFEN 1 (CASC, China) a new civilian high-resolution remote sensing satellite[n]
	25 June—Launch of Resurs P1 (Roscosmos)[o]
	27 June—Launch of Kondor E (NPO Machinostroyeniya) the Russian military's first radar satellite[p]
	25 July—Launch of INSAT 3D (ISRO, India) advanced meteorological satellite[q]
	22 August—Launch of Kompsat 5 (KARI, South-Korea) an Earth observation synthetic aperture radar satellite[r]
	2 September—Yaogan 17 Main and Yaogan Subsat 1 & 2 (PLA, China)[o]
	23 September—Launch of Feng Yun 3C (China State Meteorological Administration) meteorological satellite[o]

(continued)

Europe	Other countries
	25 September—Launch of Kuaizhou 1 (CASIC, China) to be used for emergency data monitoring and imaging[s]
	29 October—Launch of Yaogan 18 (PLA, China)[o]
	20 November—Launch of Yaogan 19 (PLA, China)[o]
	21 November—Launch of DubaiSat 2 (EIAST, United Arab Emirates) second Earth observation mini-satellite of the United Arab Emirates[t]
	25 November—Launch of Shiyan Weixing 5 (TBA, China) flew under a civilian designation, but its mission was likely to demonstrate stereo imaging techniques for military purposes[u]
	9 December—Launch of CBERS 3/Ziyuan-1C (INPE, Brazil) satellite did achieve stable orbit due to launch failure involving the third stage[v]
	Intelligence and early warning
June 2012–December 2012	
	29 June—Launch of NRO L-15 (NRO, U.S.) for intelligence-gathering purposes[o]
	13 September—Launch of NRO L-36/NOSS 3-6A and NRO-L36/NOSS 3-6B (NRO, U.S.)[o]
	18 December—Launch of Gökturk 2 (Turkish Military), military imaging reconnaissance satellite with various civil applications[w]
2013	
	27 January—Launch of IGS-4D (RADAR), and IGS-5 Optical Demonstration (Japan Defence Agency) part military spy satellite system[o]
	19 March—Launch of SBIRS GEO 2 (USAF, U.S.) second satellite in the Space-Based Infrared System (SBIRS) to detect ballistic missile launches and provide the U.S. with advance warning of potential nuclear attacks[x]
	7 June—Launch of Cosmos 2486 (Russian Space Forces) military imaging reconnaissance system[o]
	28 August—Launch of NRO L-65 (USAF, U.S.)[o]
	5 December—Launch of NRO L-39 (USAF, U.S.)[o]

(continued)

Europe	Other countries
Navigation	
June 2012—December 2012	
12 October—Launch of Galileo 3 and Galileo 4 (ESA) In-Orbit Validation (IOV) satellites[y]	*18 September*—Launch of Beidou 2C-M5 and 2C-M6 (PLA, China) China's full-scale global navigation system[o]
	4 October—Launch of Navstar GPS 2F-03 (USAF, U.S.) space-based radio positioning, navigation, and time distribution system
	25 October—Launch of Beidou 2-G6 (PLA, China)[o]
2013	
27 November—The first Full Operational Capability satellite in the future European navigation system Galileo has successfully completed thermal vacuum testing[z]	*26 April*—Launch of Glonass M47 (Russian Space Forces) Russia's full-scale global navigation system[o]
	15 May—Launch of Navstar GPS 2F-04 (USAF, U.S.)[o]
	1 July—Launch of IRNSS 1A (ISRO, India) first navigational satellite in the Indian Regional Navigational Satellite System (IRNSS) series of satellites[aa]
	2 July—Launch of Glonass M46, M48, and M49 (Russian Space Forces) launch failure seconds after launch[o]
Telecommunications/broadcasting	
June 2012—December 2012	
9 July—Launch of SES 5 (SES, Luxembourg)[o] *2 August*—Launch of HYLAS 2 (Avanti Screenmedia Group, U.K.) providing coverage across Europe, the Middle East and Africa[ab] *28 September*—Launch of Astra 2F (SES, Luxembourg)[o] *10 November*—Launch of Eutelsat 21B (Eutelsat, France) replacement of Eutelsat 21A satellite[ac] *3 December*—Launch of Eutelsat 70B (Eutelsat, France) replacement of Eutelsat 70A satellite[ad] *21 December*—Launch of SkyNet 5D (U.K. Ministry of Defence) last of four Skynet 5 satellites to be launched[ae]	*1 June*—Launch of Intelsat 19 (Intelsat, U.S.)[o]
	20 June—Launch of NRO L-38 (NRO, U.S.)[o]
	5 July—Launch of Echostar VXII (Hughes Network Systems)[o]
	21 July—Launch of TechEdSat (NASA Ames Research Center)[o]
	25 July—Launch of Tianlian-1C (CAST, China) data relay communications satellite[af]
	28 July—Launch of Cosmos 2481 (Russian Space Forces), Gonets M-03 and Gonets M-04 (Smolsat), and MIR (Yubileyniy 2) (Reshetnev Co.)[o]
	2 August—Launch of Intelsat 20 (Intelsat, U.S.)[o]
	6 August—Launch of Telkom 3 (Telkom Indonesia), and Express MD2 (Russian Satellite Communication Co.) launch failure due to third stage pressurization system[ag]
	18 August—Launch of Intelsat 21 (Intelsat, U.S.)[o]
	28 September—Launch of GSAT 10 (ISRO, India) communication satellite with navigation payload to augment GAGAN capacity[ah]

(continued)

Europe	Other countries
	7 October—Launch of ORBCOMM OG2-01 (Microsat Systems, U.S.) launch failure due to wrong orbit[ai]
	14 October—Launch of Intelsat 23 (Intelsat, U.S.)[o]
	2 November—Launch of Luch 5B (Roscosmos, Russia) data relay satellite, and Yamal 300K (Gazprom Space Systems, Russia) replacement of the cancelled Yamal 301 and Yamal 302 satellites[aj]
	10 November—Launch of Star One C3 (Star One, Brazil) replacement of Brasilsat B3 satellite[ak]
	14 November—Launch of Meridian 6 (Russian Space Forces)[o]
	20 November—Launch of Echostar XVI (Echostar Communications Corp., U.S.)[o]
	27 November—Launch of APSTAR 7B (Chinasat 12) (APT Satellite Co., Ltd., Hong Kong) part of the satellite's payload has been leased to Sri Lanka and is co-branded as SupremeSat 1, while the whole satellite was renamed ZX 15A[al]
	8 December—Launch of Yamal 402 (Gazprom Space Systems, Russia) reduced lifetime due to partial launch failure[am]
	19 December—Launch of MexSat 3 (Government of Mexico)[o]
2013	
7 February—Launch of Amazonas 3 (Hispasat, Spain)[o] *14 May*—Launch of Eutelsat 3D (Eutelsat, France)[o] *3 June*—Launch of SES 6 (SES, Luxembourg)[o] *25 June*—Launch of O3b 01, 02, 03, and 04 (O3b Networks, Jersey) constellation of satellites to deliver satellite internet services and mobile backhaul services[o] *25 July*—Launch of Alphasat I-XL (Inmarsat, U.K.) first satellite to be based on the Alphabus/Alphasat design[an] *29 August*—Launch of Eutelsat 25B (Eutelsat, France)[o] *30 September*—Launch of Astra 2E (SES, Luxembourg)[o] *3 December*—Launch of SES-8 (SES, Luxembourg) SpaceX' first geostationary transfer mission[ao]	*15 January*—Launch of Cosmos 2482, 2483 and 2484 (Russian Space Forces)[o] *30 January*—Launch of TDRS K (NASA) in support of NASA's Tracking and Data Relay Satellite System[o] *1 February—Launch of Intelsat 27 (Intelsat, U.S.) Sea Launch launch failure 40 s after lift-off* [ap] *6 February*—Launch of Global 2nd Gen 19, 20, 21, 22, 23, and 24 (Globalstar, Inc., U.S.) satellite constellation for satellite phone and low-speed data communications[o] *7 February*—Launch of Azersat 1 (Government of Azerbijan)[o] *26 March*—Launch of SatMex 8 (Satellites Mexicanos S.A. de C.V.)[o] *15 April*—Launch of Anik G1 (Telesat, Canada) to bring new capacity over South America[aq]

(continued)

Europe	Other countries
8 December—Launch of Inmarsat 5-F1 (Inmarsat, U.K.)[o]	*1 May*—Launch of Chinasat 11 (Sinosat 7) (China Direct Broadcast Satellite Co. Lt.)[o]
	24 May—Launch of WGS 5 (USAF, U.S.) global military communications system[ar]
	19 July—Launch of Chuang Xin-3 (TBA, China)[o]
	19 July—Launch of MUOS 2 (U.S. Navy) second of five satellites to replace UHF Follow-On (UFO) satellites currently used by the U.S. Navy[as]
	7 August—Launch of WGS 6 (USAF, U.S.)[o]
	29 August—Launch of GSAT-7 (INSAT 4F) (ISRO, India) India's first exclusive defence satellite for the country's maritime security[at]
	1 September—Launch of Amos 4 (SpaceCom Limited, Israel)[o]
	12 September—Launch of Gonets M-05, M-06, and M-07 (Smolsat, Russia) civilian versions of the Russian Strela-3 series of military store-forward satellites[au]
	18 September—Launch of AEHF 3 (DoD, U.S.) third satellite in a series of high-capacity communications satellites which will augment and eventually replace the Milstar spacecraft launched between 1994 and 2003[av]
	25 October—Launch of Sirius FM-6 (Sirius Satellite Radio Inc., U.S.)[o]
	11 November—Launch of Raduga-1M3 (Russian Space Forces) military communications satellite[o]
	20 December—Launch of Tupac Katari (Bolivian Space Agency) Bolivia's first communications satellite[aw]
	25 December—Launch of Cosmos 2488, 2489, and 2490 (Russian Space Forces)[o]
	26 December—Launch of Express AM-5 (Russian Satellite Communication Co.)[o]
Technology development	
June 2012—December 2012	
22 July—Launch of TET-1 (DLR, Germany) part of DLR's On-Orbit Verification programme[ax]	*16 June*—Launch of Shenzhou 9 Orbital Module (CAST, China) to be left at Tiangong 1 for automatic operation after the astronauts return to Earth[ay]
	21 July—Launch of We-Wish (Meisei Electric Co. Ltd., Japan) cubesat with infrared

(continued)

Europe	Other countries
	camera for environmental studies, FitSat-1 (Fukuoka Institute of Technology, Japan) cubesat for communication purposes, and RAIKO (Wakayama University, Japan) double technology demonstration cubesat[az]
	1 August—Launch of SFERA-53 (Roscosmos, Russia) to measure atmospheric density[ba]
	10 August—NASA's unmanned Morpheus lander, intended to deliver payloads to the moon and other solar bodies, crashes during its first free-flight test[bb]
	9 September—Launch of Proiteres (Osaka Institute of Technology, Japan) student-built nanosatellite to demonstrate electro-thermal pulsed plasma thruster device, and mRESINS (ISRO, India) miniaturised version of the RESINS inertial guidance system currently in use in the PSLV and GSLV launch vehicles[bc,bd] ,
	13 September—Launch of AENAES (USAF, U.S.), CP 5 (Cal Poly Aerospace Engineering, U.S.), SMDC-ONE 2.1 (ABLE) (USASMDC, U.S.), SMDC-One 2.2 (BAKER) (USASMDC, U.S.), STARE A (Lawrence Livermore National Laboratory, U.S.), AeroCube 4A, 4B, and 4C (Aerospace Corp., U.S.), and OUTSAT (NASA)[o]
	22 September—Launch of unknown payload (Iran) using Safir 2 launcher[o]
	28 September—Commercial spaceflight company SpaceX's Grasshopper makes 1st successful test flight[be]
	14 October—Launch of Shijian 9A and 9B (PLA, China) to demonstrate the functionality of a range of newly developed formation flying techniques and components and to validate the formation flight Guidance, Navigation and Control algorithms and strategies of the system configuration[bf]
	19 November—Launch of Fengniao 1A and 1B (China National Space Administration) new generic micro/minisatellite development of DFHSat, and Xinyan-1 (China National Space Administration) small satellite to test various components such as microwave switches, a lighter user communication terminal and more accurate thermostats to be used of future satellites[bg]
	11 December—Launch of X-37B/OTV 3 (USAF, U.S.) classified flight, no details about the vehicle's payloads, orbit and mission duration were disclosed[bh]

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Europe	Other countries
2013	
	28 January—Iranian space officials announce that they have successfully launched a live monkey into space, and returning it back alive after a suborbital flight[bi]
	30 January—Launch of STSAT-2C (KARI, South Korea)[o]
	21 April—Launch of the Antares rocket, built by Orbital Sciences Corp, to put a dummy payload into orbit during its inaugural flight[bj]
	29 April—The first rocket-powered flight of Virgin Galactic's SpaceShipTwo[bk]
	6 May—Launch of ESTCube 1 (Tartu University, Estonia) to test an electric solar wind sail; first Estonian satellite[bl]
	16 June—The U.S. Air Force's robotic X-37B space plane returns to Earth, after more than a year in orbit[bm]
	15 July—Launch of Shi Jian 11-05 (CAST, China) the semi-secret satellite series features different purposes including scientific experiments, technology demonstrations and other undisclosed purposes[bn]
	19 July—Launch of Shiyan Weixing-7 (TBA, China), and Shi Jian-15 (TBA, China) one of the most secretive Chinese missions in recent years; Shiyan Weixing satellites are usually used to test new technologies as well as the Shijian ('Practice') satellites used for technological demonstration. Shijian-15 probably will test a Chinese robotic arm, a mission that has been planned and announced for some time, while Shiyan Weixing-7 will scan for orbital debris[bo]
	29 September—Launch of Cassiope (CSA, Canada) to observe the ionosphere; new smallsat spacecraft bus and communications technology demonstration[bp]
	25 October—Launch of Shi Jian-16 (TBA, China)[o]
	26 October—Dream Chaser spaceship, built by Sierra Nevada Corp. under NASA's Commercial Crew Program, makes a crash landing[bq]
	19 November—Launch of STPSAT-3 (USAF, U.S.) technology demonstration to

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Europe	Other countries
	rapidly access space by using standard interfaces on a standard spacecraft bus[br]
	14 December—Iran claims it successfully launched a monkey into space for the second time and returned it safely to Earth after a 15-min rocket ride[bs]
	28 December—Launch of AIST II (RKK Energia, Russia), SKRL-756 1 & 2 (TBA, Russia)[o]
Business	
June 2012—December 2012	
12 October—Merger talks between defence industry giants BAE Systems and EADS collapse because of German opposition[bt]	*26 June*—Loral Space & Communications Inc. today announced its entry into a definitive agreement with MacDonald, Dettwiler and Associates Ltd. related to the sale of Loral's wholly-owned subsidiary, Space Systems/Loral (SS/L). The transaction provides for Loral to receive consideration from MDA of US$875 million and cash dividends and other payments from SS/L which are expected to be in excess of US$135 million[bu]
	24 July—Pratt & Whitney Rocketdyne is sold to GenCorp, which also owns Aerojet, for $550 million[bv]
	8 October—Virgin Galactic acquires full ownership of the Spaceship Company, the manufacturer of the WhiteKnightTwo carrier aircraft and SpaceShipTwo manned sub-orbital spacecraft[bw]
2013	
31 July—Eutelsat claims it will buy Mexican peer Satelites Mexicanos S.A. for a total enterprise value of $1.14 billion as the group aims to boost its presence in emerging markets[bx] *16 October*—SES partners with satellite builder OHB and ESA to develop a new generation of satellites propelled by solar electric thrusters[by]	*2 January*—Moog acquires Broad Reach Engineering Company, a leading designer and manufacturer of spaceflight electronics and software for aerospace, scientific, commercial and military missions, for a purchase price of $48 million[bz]
	9 January—The Canadian Space Agency and MDA Corp. sign a $692 million American dollar contract to move ahead with the construction of the Radarsat Constellation Mission, consisting of three satellites and slated for launch in 2018[ca]
	31 January—Imaging satellite operators DigitalGlobe and GeoEye complete their $900 million cash-and-stock merger[cb]
	6 June—Stratolaunch Inc., the company created by Microsoft co-founder Paul Allen seeking to develop a low-cost satellite launching system, gives Orbital Sciences Corp. a contract to build the world's largest air-launched space rocket[cc]

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11.4 Policy and International Cooperation

Europe	Other countries
General policy	
June 2012—December 2012	
13 September—Poland accedes to the ESA Convention to become the 20th ESA Member State[a]	*20 September*—Six members of the U.S. House of Representatives introduced the Space Leadership Preservation Act that calls for a radical restructuring NASA[c]
9 November—The British government commits itself to increase its investment in ESA by 25% starting in 2013 and extending through 2017[b]	
2013	
1 February—Copernicus, Europe's network of satellites and ground sensors for environmental monitoring, gets a budget reduction of 35 %[d]	*3 January*—U.S. President Barack Obama signs legislation allowing the White House to remove satellite technology from a list of export-controlled munitions and other military-grade components, clearing a competitive hurdle for U.S. satellite manufacturers in the global marketplace[e]
General cooperation	
June 2012—December 2012	
22 June—Roscosmos and the Irish National Space Center sign a memorandum of understanding on bilateral cooperation in space exploration[f]	
29 June—ESA and China enter the third phase of Dragon Programme, with the aim to promote the use of ESA, Third Party Missions and Chinese Earth observation satellite data within China for science and applications[g]	
2013	
17 June—ESA signs a contract with Thales Alenia Space to provide continuity to the work of the industrial team members of Thales Alenia Space, which is building the ExoMars Entry, Descent and Landing Demonstrator Module[h]	*30 April*—NASA signs a new deal that will keep American astronauts flying on Russian spacecraft through early 2017 at a cost of $70.7 million per seat[j]
27 June—ESA chooses Thales Alenia Space to build the new Euclid cosmology satellite in a contract worth of €322.5 million[i]	*16 May*—The U.S. Department of Defense (DoD) renews a controversial bandwidth leasing arrangement involving a Hong Kong company with substantial Chinese government ownership[k]
16 January—NASA and ESA announce the signature of an implementing agreement under which ESA will supply the service module for NASA's second Orion Multi-Purpose Crew Vehicle mission, now scheduled for 2017[l]	
14 March—ESA and Roscosmos sign a formal agreement regarding the ExoMars mission[m]	

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[k]"Pentagon Renews Controversial Satellite Lease Arrangement." 16 May 2013. SpaceNews 17 Feb. 2014. http://www.spacenews.com/article/military-space/35363pentagon-renews-controversial-satellite-lease-arrangement
[l]"Pact Puts ESA on 'Critical Path' for Second Orion Mission." 16 Jan. 2013. SpaceNews 17 Feb. 2014. http://www.spacenews.com/article/civil-space/33209pact-puts-esa-on-%E2%80%98critical-path%E2%80%99-for-second-orion-mission
[m]"ExoMars' Partners Sign Agreement Moving Mission Forward." 15 Mar. 2013. AmericaSpace 17 Feb. 2014. http://www.americaspace.com/?p=32761

11.5 Country Profiles

Austria	FFG
Population	8.45 million
GDP	313.20 billion Euro
Responsibility	The Austrian Space Program is financed by the Federal Ministry for Transport, Innovation and Technology (BMVIT) and managed by the Aeronautics and Space Agency (ALR), which is integrated into the Austrian Research Promotion Agency (FFG), the central organisation for fostering science and technology activities in Austria, and serves as a docking station to the international aero-space world for Austrian business and science

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Austria	
Activities	ALR of FFG implements national aerospace policy and represents Austria in numerous European and international aerospace institutions—from ESA and EUMETSAT through to EU committees and other international and national organisations responsible for aerospace policy. Austrian representation in the European Space Agency is of special strategic importance in this context. In addition to ESA programmes, the Austrian Space Applications Programme ASAP and the Space Programme under the 7th EU Framework Programme are of special relevance for space research projects
Budget	2013 ESA contribution of 50.1 million Euro; and 2013 National expenditure of 11.9 million Euro
Staff	ALR: 12
Direct Employment in Space Manufacturing Industry	337

"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013 <http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en>
"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013 <http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en>
"Space." FFG, October 2014 <https://www.ffg.at/en/space>
"ESA Budget 2013." European Space Agency 24 Jan. 2013 <http://www.esa.int/About_Us/Welcome_to_ESA/Budget_as_presented_during_DG_press_conference_24_January_2013>

Belgium	
Population[a]	11.16 million
GDP[b]	381.40 billion Euro
Responsibility[c]	The "Space Research and Applications" directorate of the Belgian Federal Science Policy Office (Belspo), is responsible for managing Belgium's participation in the programmes and activities of the European Space Agency (ESA) and of other national or international organisations

(continued)

Belgium	belspo
	which are responsible for research and scientific public service
Activities[d]	The Belgian space budget is dedicated for 90% to the programmes of ESA, in which Belgium is involved nearly all programmes but has developed a particular interest for small satellites in particular in the framework of the Small Missions Initiative decided at the 2012 Ministerial Conference The remaining 10% are related to Earth Observation through a bilateral cooperation with France (Pléiades and MUSIS) and on national level trough the remote sensing research programme Stereo
Budget[d,e]	In 2013: ESA contribution of 171 million Euro, bilateral cooperation 20 million Euro and national research programme: 3 million Euro
Staff[f]	Space research and applications directorate: 15
Direct Employment in Space Manufacturing Industry[g]	2,200

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Organisation | Belgian Federal Science Policy Office." 16 Sept. 2011. ERAWATCH 28 Feb. 2014. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/be/organisation/organisation_mig_0014
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space
[f]"Belspo—Space Research and Applications Divisions." 2013. Belgian Earth Observation Platform 28 Feb. 2014 http://eo.belspo.be/Directory/OrganisationDetail.aspx?orgID=198
[g]"MitarbeiterInnen-Verzeichnis." 2014. Agentur für Luft- und Raumfahrt 28 Feb .2014. http://www.ffg.at/team#Agentur für Luft- und Raumfahrt

Czech Republic	Ministry of Transport
Population[a]	10.52 million
GDP[b]	149.49 billion Euro
Responsibility[c]	The 'Space Technologies and Satellite Systems Department' of the Ministry of Transport is responsible for projects and commitments of the Czech Republic supporting the implementation of its space activities within the European Space Agency and European Union in the framework of the Czech Ministry of Transport
Activities[d]	Up until 2014, 45% of the Czech mandatory ESA contribution is being allocated to a special transitional ESA programme entitled Czech Industry Incentive Scheme to develop the competitiveness of Czech industry and academia in ESA programmes. In 2012, the European GNSS Agency (GSA) moved to its new headquarters in Prague
Budget[d,e]	2013 ESA contribution of 13.7 million Euro
Staff	

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Space Technologies and Satellite System Department." 2014. Czech Space Portal 28 Feb. 2014. http://www.czechspaceportal.cz/en/ministries/ministry-of-transport-of-the-czech-republic/space-technologies-and-satellite-systems-department/
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space

Denmark	DTU Space Institut for Rumforskning og -teknologi
Population[a]	5.60 million
GDP[b]	249.13 billion Euro
Responsibility[c,d]	Denmark's space activities are conducted under the supervision of the Ministry Higher Education. The National Space Institute (NSI) at the Technical University of Denmark (DTU) is the only organization in Denmark with the basic funding and mandate to carry out space research
Activities[c]	Within the ESA programmes, the Danish areas of strength encompass earth observation and climate monitoring, launchers, the international space station, telecommunications (ARTES) and technology development (GSTP) Besides ESA, the knowledge of the Earth's magnetic field is a main topic of interest in Denmark as Danish researchers are traditionally well-versed in this field

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Denmark	DTU Space Institut for Rumforskning og -teknologi
Budget[c,e]	2013 ESA contribution of 25.7 million Euro; and 2013 National expenditure of 5.0 million Euro
Staff[f]	DTU: 29
Direct Employment in Space Manufacturing Industry[g]	212

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[d]"About DTU Space." DTU Space | National Space Institute 28 Feb. 2014. http://www.space.dtu.dk/english/About_NSI
[e]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space
[f]"Organisation." 26 Aug. 2013. DTU Space 28 Feb. 2014. http://www.space.dtu.dk/english/About_NSI/Organisation
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Finland	Tekes
Population[a]	5.43 million
GDP[b]	193.44 billion Euro
Responsibility[c,d]	Administration of space activities in Finland takes place in a decentralised manner—the Finnish Space Committee acts as the coordinating body. In key roles are Tekes (the Finnish Funding Agency for Innovation), the Ministry of Employment and the Economy, the Academy of Finland, the Ministry of Education and the Ministry of Transport and Communications The Finnish Space Committee makes propositions and proposals and gives statements on matters related to space research, education and industrial development, exploitation of knowledge derived from space activities, and national and international cooperation
Activities[c]	The Finnish focus of space activities is on earth observation, telecommunications and navigation, technology and science. About 60% of Finnish public space activities financing goes to ESA's programmes. Finland has taken part in all ESA missions since SOHO. Bilateral projects

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Finland	Tekes
	have included e.g. Sweden (Odin), United States (Cassini) and The Netherlands (EOS-Aura)
Budget[c,e]	2013 National public expenditure for space activities approximately 50.0 million Euro about which ESA contribution 19.5 million Euro (20%)
Staff[f]	Tekes: Approximately 400 people in Finland and abroad [90 work in regional Centres for Economic Development, Transport and the Environment (ELY Centres)]
Direct Employment in Space Manufacturing Industry[g]	164

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[d]"Space Policy in Finland." Spaceinfo.fi 3 Mar. 2014. http://www.spaceinfo.fi/en/finland_and_space/space_policy/
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"Tekes Organisation." 12 Feb. 2014. http://www.tekes.fi/en/tekes/how-we-operate/
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

France	cnes
Population[a]	65.63 million
GDP[b]	2,059.85 billion Euro
Responsibility[c,d]	The Centre National d'Etudes Spatiales (CNES) is responsible for the French space activities. It is under the shared responsibility of the Ministry of Higher Education and Research and of the Ministry of Defence. The Office Nationale d'Etudes et de Recherches Aérospatiales (ONERA) is also responsible for space related research
Activities[e]	In addition to ESA programmes, civil, military and commercial programmes are undertaken by France (i.e. Sicral, Pleiades, SPOT, ELISA), as well as bilateral cooperation with the U.S. (CALIPSO, Jason) and India (Saral, Oceansat 3, Altika-Argos, Megha Tropiques)
Budget[e,f]	2013 ESA contribution of 747.5 million Euro; and 2013 National expenditure of 852.5 million Euro

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France	
Staff[g]	CNES: 2,392
Direct Employment in Space Manufacturing Industry[h]	13,205

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]Organisation | National Centre for Space Studies (CNES)." 11 Dec. 2012. erawatch 28 Feb. 2014. http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/fr/organisation/organisation_mig_0019
[d]ONERA | The French Aerospace Lab." ONERA 2 July 2013. http://www.onera.fr/en
[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[f]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space
[g]"Annual Report 2012." CNES 30 Apr. 2013. http://www.cnes.fr/web/CNES-en/10893-annual-report-2012.php
[h]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Germany	DLR
Population[a]	80.52 million
GDP[b]	2,737.60 billion Euro
Responsibility[c]	German space activities are coordinated by the Federal Cabinet Committee on Space, chaired by the Chancellor, which determines political principles and guidelines and settles the budget, and by a Steering Committee. The latter is chaired by the Secretary of State of the Ministry for Research and Technology (BMFT) The German Aerospace Center (DLR), under the authority of the Ministry of Research, is the national research centre for aviation and space flight of the Federal Republic of Germany and the German Space Agency
Activities[c]	Germany has a national civil programme, which includes bi- or tri-lateral co-operations, a participation in the ESA programmes, and a defence programme (e.g. SARLupe, MUSIS) The major areas of interest for Germany's domestic programmes are Earth observation, navigation, telecommunications, space transportation systems, space

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Germany	
	infrastructures, microgravity research, space science, space technologies and space exploration
Budget[c,d]	2013 ESA contribution of 772.7 million Euro; and 2013 National expenditure of 460.0 million Euro
Staff[e]	DLR: approximately 7,700
Direct Employment in Space Manufacturing Industry[f]	6,425

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en.
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en.
[c]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013.
[d]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space.
[e]"DLR at a Glance." Deutsches Zentrum für Luft- und Raumfahrt 28 Feb. 2014. http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10443/637_read-251#gallery/262.
[f]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013.

Greece	
Population[a]	11.06 million
GDP[b]	182.05 billion Euro
Responsibility[c]	The General Secretariat for Research and Technology (GSRT), under the responsibility of the Ministry of Education and Religious Affairs, is responsible for Greek space activities

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Greece	
Activities[d]	Space R&D is a priority area of the Greek Space Strategy, mostly pursued through ESA's technological activities' EOEP, GSTP, ARTES-1, ARTES-3-4 and ARTES-5, ELIPS, and GNSS Evolution Programme
Budget[e,f]	2013 ESA contribution of 15.1 million Euro
Staff[g]	GSRT: 34

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Οργανόγραμμα." 2013 General Secretary for Research and Technology. http://www.gsrt.gr/central.aspx?sId=119I428I1089I323I488743
[d]European Space Agency. European Space Technology Master Plan 2012. Paris: ESA, 2012: 105
[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[f]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[g]"GSRT Organogramma." 29 Jan. 2014. General Secretariat for Research and Technology 26 Mar. 2014. http://www.gsrt.gr/OrganizationChart/Files/ContentFiles410/organogramma29012014.pdf

Hungary	
Population[a]	9.91 million
GDP[b]	98.07 billion Euro
Responsibility[c, d]	The Hungarian Space Office (HSO), integrated into the body of the Ministry of National Development, manages, coordinates and represents Hungarian space activities Hungary's space activity is supervised by the Minister, who makes his decisions based on the advices of the Scientific Council on Space Research in scientific issues and the Hungarian Space Board in strategic questions

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Hungary	Magyar Űrkutatási Iroda
Activities[c]	Participation in microgravity, Earth observation, life and material sciences and GTSP programmes of ESA
Budget[c,e]	The Hungarian contribution for ESA ECS programme is 2.0 million euros per year
Staff[c]	About 300 personnel working in over 30 different research groups, belonging mostly to university departments, research institutes of the Hungarian Academy of Sciences and other national institutions and organisations

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en

[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en

[c]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013

[d]"The Structure of the Hungarian Space Activity." A magyar űrkutatási hirei 28 Feb. 2014. http://www.hso.hu/page.php?page=215

[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space

Ireland	ENTERPRISE IRELAND
Population[a]	4.59 million
GDP[b]	163.94 billion Euro
Responsibility[c]	Ireland's space activities are coordinated by the Department of Jobs, Enterprise and Innovation The Department has overall responsibility for Ireland's membership of ESA. The ESA programmatic, industrial and research strategies are coordinated by Enterprise Ireland
Activities[d]	The country's space activities are focused on participation in Horizon 2020 and ESA in developing innovative technologies for the European space programme and the global upstream and downstream space markets. There is no national space development programme

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Ireland	
Budget[d,e]	2013 ESA contribution of 17.3 million Euro
Staff[f]	Enterprise Ireland: 740
Direct Employment in Space Manufacturing Industry[g]	400+

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Home." Enterprise Ireland 3 July 2013. http://www.enterprise-ireland.com/en/
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"Report Says Enterprise Ireland Struggling due to Loss of Staff." 6 Oct. 2013. RTE 26 Mar. 2014 http://www.rte.ie/news/2013/1006/478688-enterprise-ireland-staffing/
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Italy	
Population[a]	59.69 million
GDP[b]	1,560.02 billion Euro
Responsibility[c]	Italian space activities are managed by the Italian Space Agency (ASI), under the Ministry of Education, University and Research
Activities[d]	Italian civil space activities comprise three branches: civilian (national and ESA), military and commercial. Italy is involved in all mandatory and non-mandatory ESA programmes. Other activities include scientific missions (LARES), dual-use Earth observation satellites (Cosmos-Skymed), military telecommunication (Sicral), and several small missions
Budget[d,e]	2013 ESA contribution of 400.0 million Euro; and 2013 National expenditure of 400.0 million Euro

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Italy	
Staff[f]	ASI: app. 200
Direct Employment in Space Manufacturing Industry[g]	4,711

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Agenzia Spaziale Italiana." ASI 3 July 2013. http://www.asi.it/en
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"Italian Space Agency Chief Enrico Saggese Quits in Wake of Investigation." 14 Feb. 2014. Physics World 3 Mar. 2013. http://physicsworld.com/cws/article/news/2014/feb/14/italian-space-agency-chief-enrico-saggese-quits-in-wake-of-investigation
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Luxembourg	
Population[a]	537.04 thousand
GDP[b]	45.48 billion Euro
Responsibility[c]	Space Affairs are led by the Ministry of Economy that defines the National Space Policy and manages relationships with ESA, EU and other Space agencies The Luxembourg Space Cluster (LSC), managed by Luxinnovation (the National Agency for Innovation and Research) brings together companies and public research organisations. LSC is a network that actively supports renowned and highly specialised actors in the space technologies field in Luxembourg by increasing their visibility on the international scene and promoting cooperation at this level
Activities[d]	The Luxembourg Space Cluster focuses on the following thematic areas: space telecommunications, global navigation satellite system and location based applications, Earth observation, maritime security and safety, and space related technologies
Budget[e,f]	2013 ESA contribution of 15.0 million Euro

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Luxembourg	Luxembourg Space Cluster
Staff[g]	Luxinnovation: 41 staff members are listed in the 2013 Annual Report, of which 2 are dedicated to the Space sector
Direct Employment in Space[h]	700

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Luxembourg Space Cluster." Luxinnovation | National Agency for Innovation and Research 3 Mar. 2014. http://en.luxinnovation.lu/Services/Luxembourg-Cluster-Initiative/Luxembourg-Space-Cluster
[d]"The Structure of the Hungarian Space Activity." A magyar űrkutatási hirei 28 Feb. 2014. http://www.hso.hu/page.php?page=215
[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[f]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[g]« Rapport Annuel 2013 » Luxinnovation. http://en.luxinnovation.lu/Publications/Luxinnovation/Rapport-Annuel-2013
[j]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Netherlands	SRON Netherlands Institute for Space Research; Netherlands Space Office
Population[a]	16.78 million
GDP[b]	602.66 billion Euro
Responsibility[c,d]	The Ministry of Economic Affairs, Ministry of Education, Culture and Science, Ministry of Transport, Public Works and Water Management and the Netherlands Organization for Scientific Research were involved in the establishment of the Netherlands Space Office (NSO). The NSO acts as the Dutch agency for space affairs, and is responsible for coordinating international space activities with ESA and other international space actors The Netherlands Institute for Space Research (SRON) is the Dutch expertise institute for the development and exploitation of satellite instruments in astrophysics and earth system science. It acts as the Dutch national agency for space research and as the national point of contact for ESA programs

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Netherlands	
Activities[e,f]	In the ESA context, the Netherlands participate in all major programmes with a special interest in Earth observation and environmental measurements and in robotics SRON develops and uses innovative technology for ground-breaking research in space, focusing on astrophysical research, Earth science and planetary research. In addition to this, SRON has a line of research into new and more sensitive sensors for X-rays and infrared radiation
Budget[e,g]	2013 ESA contribution of 79.5 million Euro; and 2013 National expenditure of 25.0 million Euro
Staff[h],[i]	NSO: 25, SRON: app. 200
Direct Employment in Space Manufacturing Industry[j]	835

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"The NSO." Netherlands Space Office 3 Mar. 2014. http://www.spaceoffice.nl/en/The-NSO/
[d]"Mission and Strategy." Netherlands Institute for Space Research 3 Mar. 2014. https://www.sron.nl/mission-and-strategy-about-sron-595
[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[f]"Agenzia Spaziale Italiana." ASI 3 July 2013. http://www.asi.it/en
[g]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[h]"Wie is Wie." 13 Feb. 2014. Netherlands Space Office http://www.spaceoffice.nl/nl/Het%20NSO/Wie%20is%20Wie/
[i]"Kerngegevens" SRON: Netherlands Institute for Space Research 13 Feb. 2014. http://www.sron.nl/kerngegevens-over-sron-1728
[j]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Norway	
Population[a]	5.05 million
GDP[b]	384.75 billion Euro
Responsibility[c]	The Norwegian Space Centre (NSC), under the Ministry of Trade, Industry, and Fisheries, is responsible for organizing Norwegian space activities, particularly with respect to ESA and the EU, and for coordinating national space activities
Activities[d]	In addition to ESA programmes (in particular Earth observation, telecommunications and launchers), Norway has

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Norway	
	national support programmes and commercial activities (Telenor). Moreover, Norway operates the Andøya rocket range and the Svalbard and Antarctica ground stations. Norway has also a bilateral agreement with Canada on the use of Radarsat 2 data
Budget[d,e]	2013 ESA contribution of 56.3 million Euro; and 2013 National expenditure of 155.0 million Euro
Staff[f]	NSC: 39
Direct Employment in Space Manufacturing Industry[g]	Approximately 1,000

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"More about the NCS." Norsk Romsenter | Norwegian Space Centre 3 Mar. 2014. http://web.spacecentre.no/eng/About/More-about-the-NCS
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"Luxembourg Space Cluster." Luxinnovation | National Agency for Innovation and Research 3 Mar. 2014. http://en.luxinnovation.lu/Services/Luxembourg-Cluster-Initiative/Luxembourg-Space-Cluster
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Poland	
Population[a]	38.53 million
GDP[b]	389.70 billion Euro
Responsibility[c]	The Space Research Centre of the Polish Academy of Sciences (PAS SRC) is the only institute in Poland whose activity is fully dedicated to the research into terrestrial space, the solar system and the Earth using space technology and satellite techniques
Activities[d,e]	The five main SCR's research areas are: physics of the Sun, study of planets and small solar system bodies, interplanetary space physics and astrophysics, plasma physics, and planetary geodesy and geodynamics

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Poland	
	The SRC is the body cooperating with ESA. Poland has participated or is participating in several scientific missions of ESA, such as: Ulysses, ISO, Soho, XMM, Cluster, DoubleStar, Huygens, Mars Express, Herschel, Planck, XEUS, Integral, Rosetta, ExoMars and BepiColombo
Budget[d,f]	2013 space expenditure of around 35 million Euro; 2013 ESA contribution of 28.9 million Euro
Staff[g]	Space Research Centre: 195

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"Activity." 30 Oct. 2012. Space Research Centre Polish Academy of Sciences 3 Mar. 2014. http://www.cbk.waw.pl/en/index.php?option=com_content&view=article&id=22&Itemid=16
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"The NSO." Netherlands Space Office 3 Mar. 2014. http://www.spaceoffice.nl/en/The-NSO/
[f]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[g]"Staff the Space Research Centre." CBK 13 Feb. 2014. http://www.cbk.waw.pl/en/index.php?option=com_contact&view=category&catid=49&Itemid=82

Portugal	
Population[a]	10.49 million
GDP[b]	165.67 billion Euro
Responsibility[c]	Portuguese space activities are coordinated by the Portuguese Space Office within the Portuguese Foundation for Science and Technology (FCT), which is accountable to the Ministry of Education and Science
Activities[d]	Mainly participation in ESA programs, with a special interest in navigation programmes. Portuguese companies have space activities in such fields as microgravity, specialised software, electronics and various scientific applications

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Portugal	
Budget[d,e]	2013 ESA contribution of 16.1 million Euro
Staff[f]	App. 5
Direct Employment in Space Manufacturing Industry[g]	126

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"FCT Space Office." Fundação para a Ciência e a Tecnologia 3 Mar. 2014 http://www.fct.pt/apoios/cooptrans/espaco/index.phtml.en
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"Kerngegevens" SRON: Netherlands Institute for Space Research 13 Feb. 2014. http://www.sron.nl/kerngegevens-over-sron-1728
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Romania	
Population[a]	20.02 million
GDP[b]	142.25 billion Euro
Responsibility[c]	The Romanian Space Agency (ROSA), under the responsibility of the Ministry of Education, Research Youth and Sport, coordinates the Romanian space activities
Activities[d]	On behalf of the Government, ROSA is the national representative in the cooperative agreements with international organizations, such as European Space Agency (ESA) and Committee on Space Research (COSPAR), as well as bilateral governmental agreements. Together with the Ministry of Foreign

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Romania	
	Affairs, ROSA is representing Romania in the sessions of the United Nations Committee on the Peaceful Use of Outer Space (COPUOS) and its Subcommittees
Budget[e,f]	2013 ESA contribution of 16.0 million Euro
Staff	

[a]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
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[d]"More about the NCS." Norsk Romsenter | Norwegian Space Centre 3 Mar. 2014. http://web.spacecentre.no/eng/About/More-about-the-NCS
[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[f]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space

Spain	
Population[a]	46.70 million
GDP[b]	1,022.99 billion Euro
Responsibility[c]	The Centre for the Development of Industrial Technology (CDTI), under the Ministry of Economy and Competitiveness, channels the funding and support applications for national and international R&D&i projects of Spanish companies, including the Spanish space activities in coordination with the Ministry of Industry, Energy and Tourism The National Institute of Aerospace Technology (INTA) is the other important Spanish actor in the space field. INTA is an independent body related to the Ministry of Defence. INTA is responsible for organising the Spanish participation in HELIOS and is responsible for approval and certification, research, technical assistance and services in several areas related to space

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Spain	
Activities[c]	In addition to ESA and EUMETSAT programmes, Spain has several national space programmes in the field of Earth observation (SEOSAT/INGENIO), communication satellites (Hispasat, Amazonas), defence space systems (SPAINSAT, XTAR-EUR, HELIOS, SECOMSAT, Pleiades and SEOSAR/PAZ), small satellites, space exploration (MSL-REMS) and ground control stations
Budget[c,d]	2013 ESA contribution of 149.6 million Euro; and 2013 National expenditure (including ESA) of approx. 200.0 million Euro
Staff[e]	CDTI: app. 300
Direct Employment in Space Manufacturing Industry[f]	App. 2,600

[a]Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[d]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[e]"Activity." 30 Oct. 2012. Space Research Centre Polish Academy of Sciences 3 Mar. 2014. http://www.cbk.waw.pl/en/index.php?option=com_content&view=article&id=22&Itemid=16
[f]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Sweden	RYMDSTYRELSEN Swedish National Space Board
Population[a]	9.56 million
GDP[b]	420.09 billion Euro
Responsibility[c]	The Swedish National Space Board (SNSB), a central governmental agency under the Ministry of Education and Research, is responsible for national and international activities relating to space and remote sensing, primarily research and development
Activities[d]	The Swedish space programme is mostly carried out through international cooperation. Sweden participates in almost all the optional ESA programmes, in addition to the mandatory basic and scientific programmes. Optional programmes of special interest are the remote sensing and launcher technology programmes Bilateral co-operation particularly concerns the

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Sweden	RYMDSTYRELSEN Swedish National Space Board
	co-operation with France on Spot, Vulcain MK2 and Proteus. Sweden also has a participation in the French Pleiades programme
Budget[d,e]	2013 ESA contribution of 75.0 million Euro; and 2013 National expenditure of 16.0 million Euro
Staff[f]	17
Direct Employment in Space Manufacturing Industry[g]	758

[a]Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
[b]"Eurostat—Tables, Graphs and Maps Interface (TGM) table: GDP." 22 Apr. 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tec00001&language=en
[c]"The Swedish National Space Board." RYMDSTYRELSEN 3 Mar. 2014. http://www.snsb.se/en/Home/Home/
[d]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013
[e]"Space." FFG 22 Apr. 2014. https://www.ffg.at/en/space
[f]"About SNSB." 3 Dec. 2013 RYMDSTYRELSEN 3 Mar. 2014. http://www.snsb.se/en/Home/About-SNSB
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

Switzerland	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
Population[a]	8.04 million
GDP[b]	489.98 billion Euro
Responsibility[c,d]	The Swiss Space Office, under the authority of the State Secretariat for Education, Research and Innovation (SERI) is the administrative body in charge of planning and implementing the Swiss space policy. The Space Office serves as the secretariat for the Federal Commission for Space Affairs (CFAS), which develops the Swiss space policy The Federal Council has given the Interdepartmental Coordination Committee for Space Affairs (IKAR) a mandate to prepare official Swiss position papers on space on the basis of CFAS recommendations. IKAR also coordinates the activities of various federal agencies involved in space affairs. IKAR is chaired by the SERI's Swiss Space Office, which also serves as the secretariat for IKAR

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Switzerland	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
Activities[e]	Most of the Swiss activities are undertaken within ESA programmes (space science, Earth observation, microgravity, human spaceflight, small satellites, telecommunications, navigation, and technology)
Budget[c,f]	2013 ESA contribution of 108.3 million Euro; and 2013 National expenditure of 2.0 million Euro
Staff	
Direct Employment in Space Manufacturing Industry[g]	821

[a]Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en
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[e]"About SNSB." 3 Dec. 2013 RYMDSTYRELSEN 3 Mar. 2014. http://www.snsb.se/en/Home/About-SNSB/
[f]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space
[g]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

United Kingdom	UK SPACE AGENCY
Population[a]	63.90 million
GDP[b]	1,908.54 billion Euro
Responsibility[c]	The UK Space Agency, an executive agency of the Department for Business, Innovation and Skills (BIS), and reporting to the Minister of State for Universities and Science, is responsible for the strategic decisions on all UK space activities. The UK Space Agency also interfaces with

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United Kingdom	UK SPACE AGENCY
	other departments on security and military programmes. Although it does not manage these programmes directly, the UK Space Agency is kept informed and involved in decisions relating to the programmes as necessary
Activities[d]	UK space activities include bilateral cooperation with JAXA, India and the U.S. and within ESA in Earth observation and space exploration (Cassini-Huygens, James Webb Space Telescope, Herschel, and Planck missions)
Budget[e,f]	2013 ESA contribution of 300.0 million Euro; and 2013 National expenditure of 60.0 million Euro
Staff[g]	UKSA: 31.3
Direct Employment in Space Manufacturing Industry[h]	3,777

[a]Eurostat—Tables, Graphs and Maps Interface (TGM) table: Population." 6 July 2013. http://epp.eurostat.ec.europa.eu/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tps00001&language=en

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[c]"Who We Are." UK Space Agency 3 Mar. 2014. http://www.bis.gov.uk/ukspaceagency/who-we-are

[d]"Home." UK Space Agency 4 July 2013. http://www.bis.gov.uk/ukspaceagency

[e]European Space Directory 2013. 28th Edition. Paris: ESD Partners, 2013

[f]"Space." FFG 22 Apr. 2014 https://www.ffg.at/en/space

[g]"UK Space Agency Annual Report and Accounts 2012-13." 2 July 2013. UK Space Agency 13 Feb. 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/246558/0460.pdf

[h]ASD-Eurospace. "Facts and Figures—The European Space Industry in 2012." 17th edition. June 2013

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