14 The Way Forward

The Blossoming of Space 2.0 Enterprises

The world of NewSpace or Space 2.0 enterprises has blossomed in just a few short years. Commercial space activities now dwarf governmental space programs. The scope of these activities just keeps on expanding. Innovative new space businesses keep increasing in original and sometimes even unsuspected ways. When the cyber-industries found their way into the world of aerospace it encountered a fertile ground in which to plant new ideas, grow new enterprises and reform and revitalize institutional and regulatory processes.

The chart in Fig. 14.1 shows just how sophisticated and diverse commercial space-related activities are today. Currently private space businesses outstrip public space activities – both civil government and defense – and by a large margin. This ratio of governmental to commercial ratio for 2016 is shown in the chart. For 2016, governmental space activities, including defense space activities, totaled $83 billion (U. S.) versus $261.5 billion (U. S.) if commercial products and services are considered as a whole. This adds to a global total of $344 billion (U.S.) [1].

The rapid advent of new launch and new satellite applications, and other Space 2.0 activities causes the ratio to tilt even more to the commercial world. The merging of space-linked activities with cyber and Internet-based activities will fuel the growth of both of these industries. Internet of Thing-type services that are linked to satellite connectivity is but one of the ways in which this phenomena is true.

This significant shift to commercial space activities is driven by many factors. These include new technological innovation and new ways of approaching the management of these space systems. The biggest change is the reshaping of entrepreneurial thinking about commercial space opportunities and the regulatory and business reform that has followed.

The latest comprehensive information for 2017 now available indeed shows this continuing shift in favor of commercial space activities with reduced governmental space expenditures. Thus the global space economy

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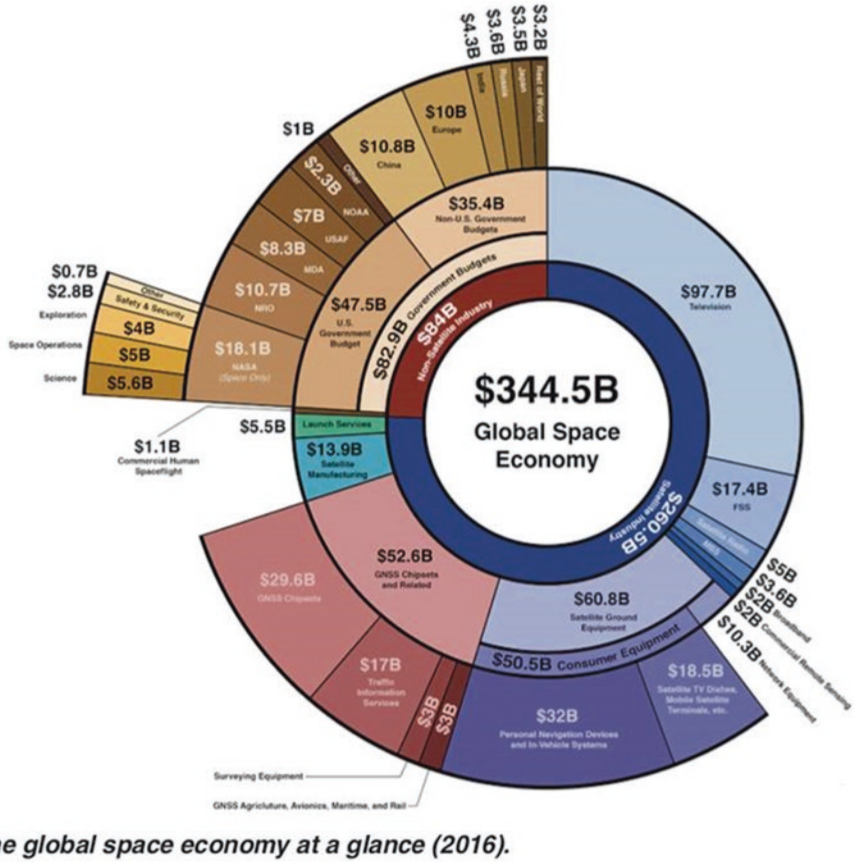

Fig. 14.1 This chart shows the shift from governmental involvement in space to commercial involvement in space. (Graphic courtesy of the Satellite Information Association.)

for 2017 totaled $348 billion. Of this amount $79.3 billion (U. S.) related to governmental and military expenditures while the remainder related to all combined commercial activities at $268.7 billion (U. S.) Thus total governmental expenditures were down about $4 billion (U. S.) and total commercial space activities went up by about $8 billion [2].

These changes in part are fomented by entry into commercial space business of new players. New regulatory regimes, standards, services and even technologies have served to lower the barriers to engaging in space business enterprise. The more that Space 2.0 began to be like the world of computer services and the social media enterprises, the more the door was opened to new types of space services. These changes also lowered the amount of capital financing and shrunk the size of the companies and their expert staffing needed to compete in this new world. Satellite communications services, for instance, are today at least ten times more efficient than they were a decade ago. The bulk of these gains have not come from better hardware. No, the largest improvements in throughput of bits per Hertz have come from better software, improved coding techniques and better forward error correction systems.

The explosion of activities that now populate Space 2.0-type ventures is almost mind boggling. Let us explore the new dimension of commercial space activities.

The Ever Widening Range of Space 2.0 Enterprises

NewSpace activities are now envisioned in three different areas. These include the so-called protozone region (20 to 160 kilometers in altitude), near-Earth space and some of the most ambitious new space enterprises, which envision deriving benefits from the far reaches of outer space. The range of activities includes at least the following:

- large-scale small satellite constellations in non-geostationary orbit.
- high throughput satellites for telecommunications, broadcasting and IT services.
- hyper-spectral cube sats and other types of small sats for remote sensing.
- hypersonic transport that would employ spaceplanes to fly through the protozone.
- The space tourism and space adventures business.
- new low cost and reusable commercial launcher systems. (This includes systems such as Stratolauncher by Vulcan Industries, carrier planes by Virgin Galactic, reusable launch systems and small satellite launcher systems, including those that add a launcher stage to spaceplanes.)
- other advanced space transportation systems such as those using large-scale space tethers, solar sails, nuclear propulsion, advanced electrical ion systems and other new approaches.
- high altitude platform systems (for communications, broadcasting, remote sensing, law enforcement, fire and crime detection, etc.).
- on-orbit space servicing and retrofit of satellites, including active space debris removal, redeployment of satellites that did not achieve proper orbit, etc.
- dark sky systems for research, deployment of small satellites to orbit using electric ion propulsion, etc.
- robotic freighters operating in the protozone for global air freight activities.
- space processing and manufacturing and reclaiming of resources from outer space (i.e., space mining).
- large-scale constructions in space including the building of planetary defense systems against cosmic hazards (solar-shields in L-1 against coronal mass ejections, space systems to combat asteroids and comets, etc.).
- private space habitats and private orbiting research facilities.
- solar power satellites that can beam back clean energy from space 24 hours a day.

These are only some of the systems where commercial ventures or serious research and development are underway. Arthur C. Clarke, in discussing forecasts of the future, had noted that most things we can conceive of we may one day be able to accomplish. His three laws of prediction, described following, are useful reminders that we should not be too quick to discount what might be accomplished by new technology in the future [3].

- *First Law:* "When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong."
- *Second Law:* "The only way of discovering the limits of the possible is to venture a little way past them into the impossible."
- *Third Law:* "Any sufficiently advanced technology is indistinguishable from magic."

If one considers where we have come in the past hundred years it is truly amazing. We have seen the development of airplanes, computers, rocket launchers, nuclear fission and fusion, antibiotics, stem cell research, and even the invention of spandex. It seems that we have just begun to exploit a tiny fraction of human potential if we do not end up making Earth uninhabitable or annihilating our species. Space 2.0 seems to be a giant part of that human potential.

In many ways the future of Space 2.0 seems likely to be shaped by just a few things. These are, in essence: technology, regulatory policy and governance, and economic, social and cultural potential.

The Potential of Technology

For years space applications have made advances in such areas as satellite communications and broadcasting, remote sensing, space navigation, weather satellites and more. Progress has been made on all fronts. Launch vehicles have become more capable of launching larger payloads to space. Antennas have become larger, achieved higher gain and been pointed more accurately to achieve higher throughput. Sensors have become smaller while also achieving higher spatial resolution. Ground systems have also become more capable and cost efficient.

In the area of satellite communications important gains have been achieved in all three of the vital areas available for performance advancement. Thus these satellites today have much greater power, access to much wider bands of spectrum through use of new bandwidth provided by higher radio frequencies and digital processing complexity that allows much greater throughput of bits per Hertz.

Comparable advances have been made in remote sensing and meteorological satellites through the use of more and more capable sensors that have shrunk in size while improving the resolution of space-based imaging. Precise navigational and timing satellites have also advanced through the use of more accurate atomic clocks. In all areas of satellite operations, in space and on the ground, improved software and digital processing has advanced performance, accuracy and cost-efficiency.

There is nothing to suggest that the improvements in satellite hardware and software have run their course. In short, the ability to design and create better hardware, exploit higher bandwidth and create improved software, achieve higher performance and allow improved cost-efficiency all seem very much likely to continue for some time to come.

This is not to suggest that there are no limits to growth. Today, perhaps the greatest barriers to future growth and improved service come from two sources. These are the limits that come from orbital space debris and access to frequency spectrum. This is, of course, to put aside the political and military dimension in that warfare and hostilities in space could set back progress in space in almost unimaginable ways.

Significant Increase in Space Debris

The current situation is that the number of operational satellites in orbit might rise from 1,500 spacecraft to over 15,000. The amount of debris over 10 centimeters in diameter currently being tracked is over 22,000, and projections of new significant orbital collisions are that these will occur perhaps as frequently as once every five years, with this likely to give rise to over 2,000 new debris elements. This future profile of space debris has led to recommendations that there be new active space debris programs to remove the largest debris elements, such as Envirsat, from low Earth orbit as quickly as possible with at least 10 such removals a year. There is serious concern that the so-called Kessler syndrome can unfold in coming days and endanger all forms of space deployments in the future. There is grave danger that inaction to reduce space debris would ultimately lead to runaway buildup of debris and a lethal avalanche of space junk unless action is taken. Currently harmful space junk thus seems to pose the greatest risk to low Earth orbit operations.

Satellite RF Spectrum Concerns

The other major significant technical concerns for the future relate to allocation of RF spectrum to meet future satellite application needs. Currently there is enormous demand for spectrum to satisfy the needs for terrestrial broadband and the streaming needs that will come with 5G and 6G broadband systems that are likely to claim frequencies that have been reserved for satellite services. There are many ways to make satellites' use of frequencies more efficient and achieving even more bits of throughput per Hertz, but the loss of key spectrum allocation could hamper the development of satellite services in the future. Further the demands for spectrum to support high altitude platforms systems and UAV-based services could also make inroads into satellite spectrum needs.

The Reinvention of Space Processes

Space 2.0 initiatives have grown out of technological innovation and new ways to design, deploy and use space systems. Economic efficiencies, miniaturization of design and new ways of delivering space-based services have, in many ways, come from the cyber-industries. "Silicon Valley meets and transforms the aerospace industry" is the big story of the last few years of the global space industry.

The story can in part be told in the names of the space billionaires who are intent on reinventing an industry to be more nimble and innovative, an industry that was for decades dominated by the supply of spacecraft and launchers to governments, military forces and large and well-established aerospace organizations. Today the key names in this industry are different. They are now people like Elon Musk of SpaceX, Jeff Bezos of Blue Origin, Robert Bigelow of Bigelow Aerospace, Sir Richard Branson of Virgin Galactic, Bill Gates involvement in Kymeta, and Paul Allen's Vulcan Industries and Stratolaunch.

Yet the realization of these innovations via NewSpace infrastructure and new kinds of startup companies requires more than just new ways of thinking and new leadership. In many cases there also had to be other innovations to make these ventures possible. Thus there had to be changes to regulatory frameworks, new types of licensing processes and new ways for startups to get their financing such as "Kickstarter" and other ways to turn an idea into an actual business.

Despite the many new ways of designing and building satellites, new kinds of exciting Earth station technologies, new launch vehicle designs and new markets to be served in the omnipresent world of the Internet, much more is still to be done to make digital access via satellite even more pervasive.

There still remain many tariff and non-tariff barriers to entry into domestic markets around the world and especially in rural and remote areas. This is not only a matter of overcoming tariff barriers, incompatible technical standards, landing-license constraints or other regulatory barriers and obstacles. In many areas of the world there are still fundamental barriers to getting what seem to most as a fundamental right to service. There are still billions of people who cannot obtain remote telecommunications, broadcasting, networking, weather services, navigational, remote sensing, access to education and health services and basic governmental services. This is because even more basic needs cannot be met. In these areas of the world, there remains a lack of access to electrical energy or even more fundamental problems such as a lack of food, potable water and protection against virulent disease.

The Economic, Social and Cultural Potential of Humankind

The world still faces many challenges at the fundamental level. These include climate change and the ability of nations to provide their citizens with basic physical needs that include water, food, education and health care. Space services by themselves cannot be a panacea. The lack of electricity, lighting, food and water, education and health care, and a source of jobs and livelihood, must be seen as a holistic problem of which vital satellite services are only a part. The U. N.s seventeen Sustainable Development Goals for 2030 have actually attempted to create a global framework for meeting overall needs, but the road to success remains long and difficult to travel.

Satellite services can provide help in meeting many of the U. N. Sustainable Development Goals. The full and effective use of space services to meet these goals requires some recognition that satellite services are more than an add-on frill, but in many ways are vital to human survival in the 21st century. The central role that space services can play in meeting these goals is provided in the Chart 14.1.

Regulatory Reform by Governments to Encourage NewSpace Enterprises

The reinvention of the space industry has many dimensions. The most important dimensions include the development and application of NewSpace technologies, new launch systems and new ground systems and user facilities, new operating techniques and effective use of artificial intelligence and smart algorithms that allow for more effective and safer deployment of new technology, new spectrum bands, better systems to cope with space debris, new and innovative ways to finance NewSpace initiatives and better regulatory systems and space governance systems to allow for the allocation and use of radio frequency spectrum at the national, regional and global level.

As NewSpace industries are created and new types of spacecraft and launch systems are developed it will be crucial for regulatory systems to adjust to these new requirements and to find efficient and effective ways to license these services. In this way, they can be safe, well-coordinated so as to not create interference between the systems, and avoid collisions that would lead to increases in space debris that would be harmful to all types of space operations.

Concerns About Future Hostilities in Space

As noted in Chapter Nine all the progress that has come from Space 2.0 initiatives could be disrupted by hostilities in space or the launching of weapons of mass destruction into Earth orbit. Since the beginning of the Trump administration in the United States there have been many changes, such as the recreation of a National Space Council. There has been the issuance of at least three National Space Policy Directives as provided in the appendices to this book. Finally and perhaps most ominously there has been proposals and discussion about the creation of a U. S. Space Force.

Many space policy and law people around the world are concerned that these policy shifts as well as new military and strategic efforts in space on the part of China, Russia and the United States could disrupt the peaceful uses of outer space. If we actually see the rise of hostilities in space it would retard or perhaps even abruptly end all the exciting private space initiatives that are described in this book. One must always look to the future with optimism and recognize the sky is no longer the limit. Indeed the many riches of outer space now beckon.

Conclusions

The field of space research, applications and exploration is over sixty years old. There has been steady and consistent development in the areas of space technology, launch systems and practical applications of space systems over the past six decades. There have been many successful efforts to coordinate the uses of space during this time. There have been efforts to minimize interference, to make spacecraft networks safer, and to use spectrum efficiently, especially through the good offices of the International Telecommunication Union (ITU). There has also be useful coordination of efforts and improved forms of space governance achieved through the U. N. General Assembly, the U. N. Committee on the Peaceful Uses of Outer Space (COPUOS) and its Committees and Working Groups, plus the U. N. Office of Outer Space Affairs (OOSA). Specialized agencies of the United Nations that have contributed to this work have included not only the ITU but also the International Civil Aviation Organization (ICAO) (with regard to space traffic management) and the World Meteorological Organization (with regard to coordination of meteorological and remote-sensing/Earth observation satellites). Assistance has also been provided by U. N. Office of Disarmament Affairs (UNODA).

The original U. N. Outer Space Treaty and its four additional international agreements that were negotiated and agreed to in the 1960s and 1970s, set the basic ground rules for the peaceful uses of outer space. But since that time no major space agreements or treaties have been agreed to and ratified. This has led to a new era of agreement and cooperation that is sometimes referred to as 'soft law,' or the development of best practices, transparency and confidence-building measures (TCBM), and various efforts to create rules of the road in space or codes of conduct.

One of the true challenges that come from the Space 2.0 framework that is emerging is the lack of a legal framework for commercial space activities. Currently the activities of private enterprises in space keep expanding, and this commercial space activity is now on the order of three times the size of governmental and defense-related space activities. Despite this growth and despite the importance of commercial space activities all such effort remains explicitly under the licensing processes and responsibilities of nation states and in particular the registering launching state.

The space industry, as explained in the various chapters of this book, has been changed and, indeed, reinvented, especially in the last few years, but the legal framework and governance structure has not changed to reflect this new reality. The final step in this reinvention process seems clear. This changed state seems to cry out for some new governance systems and new approaches to regulating the future of space. On top of these new conditions and the expanding growth of commercial systems, there is the further complication that comes from the strategic and security requirements to limit the military uses of space systems that could also compromise the peaceful uses of outer space.

This issue also calls out for new ground rules and better means to restrict the possible deployment of space weapons in an iron-clad way so that no nation is tempted to violate the principles so well defined in the original Outer Space Treaty.

See Appendix C at the end of this book for a list of the U. N. Sustainable Development Goals and Space-Related Services.

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