6 New Uses of the Protozone

Introduction

There is an interesting book by David Loth entitled *How High Is Up* that explored the problem that has been an issue for national armed forces seeking to defend their countries for many centuries. The conclusion in Loth's book is that despite efforts to define things like national air space and sovereignty over land of a particular country, the practical answer has been the area that can be effectively defended. Today, national commercial air space is generally accepted to rise up to 20 kilometers (12.5 miles).

Military air space extends well above commercial air space and is assumed by many to rise all the way up to where outer space begins. Some have suggested that outer space starts at the Von Karman line, where planes can no longer fly, or 100 kilometers (62.5 miles). Some, such as Russia, have suggested that this is 110 kilometers, while others have suggested that it is 160 kilometers, which is the altitude where a satellite can remain in its orbit on a truly sustained basis. Yet other countries extend their claim out to the geosynchronous orbit and even beyond.

One of the reasons that defining what is national air space and what is outer space has not proved to be an issue of major practical importance is that there have not been many significant applications for the use of the area above commercial air space and below outer space where satellites can sustain their orbits. Jonathan McDowell at Harvard University has done an interesting study of various satellites that have maintained orbit for brief periods of time in the altitude ranges of about 100 to 160 kilometers, but this is largely an academic study, rather than being definitive in establishing exactly where outer space begins [1].

However, the rise of Space 2.0 and new thoughts about using the subspace, or the protozone (i.e., the zone above 20 and below 160 kilometers) for a number of practical purposes has increasingly given rise to concerns about who might use this near space area and under what regulatory or licensed control authority? In short the prime question has been as

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to what purposes might it be safely used and under whose authority or control? Is there ultimately going to be a mechanism for the legal, administrative, safety, and practical control of this region? If there is ever a systematic global approach to space traffic management, does it also apply to the protozone area? These questions are just some that Space 2.0 gives rise to and which no one has ready answers.

There are now perhaps a dozen possible uses of the protozone that have arisen. These uses include high altitude balloon and dirigible ascents for tourism and other purposes; telecommunications or IT services; surveillance or weather monitoring; high-altitude platforms that might also be used for telecommunications, IT, Earth observation or other purposes; high-altitude robotic air freighters to carry shipments at lower cost and higher efficiency; dark sky stations for research and to allow small payloads to be flown to low Earth orbit using electronic propulsion; high-altitude hypersonic flights for space tourism or transport: and various types of hypersonic vehicles or platforms that could be deployed for offensive or defensive military purposes. This might include such weapons as scram-jet missiles operating at speeds of Mach 6 to Mach 8.

In the last few years there has been increasing concern and interest in the issue of space traffic management and space situational awareness, in order to make operations in Earth orbit safer and more systematically controlled. This discussion has generally not addressed at what altitude space traffic management would begin and whether the protozone would be a part of this new international management and control system.

Space Situational Awareness

There are essentially two ways that might be used to monitor and thus keep track of orbit space debris, operational spacecraft in Earth orbit, and objects in the protozone. One means is via the U. S. S-band radar tracking system recently deployed in the Pacific Ocean region, and the other way would be to have GNSS units onboard spacecraft that are optimized for Earth orbit operations and are equipped to report on their exact location in near real time. This would, of course, work only for currently operational spacecraft and provide information for space debris that can only be tracked in a passive manner.

The new billion-dollar S-band Space Fence, that will be able to track some 22,000 space objects in low and median Earth orbit, is a facility that has been installed in the Pacific Ocean area on Kwajalein atoll by Lockheed Martin under a contract with the U. S. Air Force between 2015 and 2018. This facility has the sensitivity to track objects down to 10 centimeters in diameter in low Earth orbit (LEO). (See Fig. 6.1.)

A further S-band radar tracking facility has been discussed that would be located in Australia. This new facility would replace the earlier VHF-band radar system in Texas and Arizona known as "the Fence" and has a tracking sensitivity that is ten times greater than the earlier facility does [2].

Other key new radar systems include the DLR-funded GESTRA facility, which uses a new phased-array antenna design and is also known as the TIRA system. This facility will be able to track debris elements as small as 1 centimeter in size in low Earth orbit and would be

Fig. 6.1 The U. S. S-band Space Fence facility located on the Kwajalein atoll. (Illustration courtesy of Lockheed Martin.)

of great utility in tracking objects in the protozone [3].

Of the 22,000 objects currently being tracked in low or medium Earth orbit, some 20,000 are defunct space objects without active control systems. This represents a large problem in that space traffic management implies the ability to control space objects, but these space debris objects – in the form of spent rocket motors, defunct satellites, etc. – are without means to allow anyone to steer them or actively de-orbit them. Fortunately objects in subspace are often subject to some level of control and in some cases are capable of being steered or maneuvered except for the notable case of balloons. In short, effective space traffic management for the protozone is more likely to be implemented, especially at the national air traffic control level. Prime reasons for this are:

- Affected craft or objects are in lower altitude and thus easier to track and access.
- Many more objects are capable of being steered or maneuvered.
- Responsibility for the control of these objects is more likely to be carried out by experienced national aviation safety air traffic control – at least in most instances.

There are, of course, important exceptions to national air traffic control agencies being able to exercise exclusive traffic control for vehicles or objects in the protozone. Notable issues would include hypersonic vehicles that would be engaged in international transportation or the flight of scram-jet type hypersonic weapon systems.

There have been studies and particular proposals as to how better coordination of space situational awareness and space traffic managements might be carried out, and several of these ideas and suggestions would also likely apply to the protozone [4]. To date these have not been actively implemented, and there are currently no widely agreed processes whereby these could be formally implemented. Further progress in this area is complicated by recent U. S. space policy changes coming from the U. S. executive branch with regard to the possible creation of a U. S. Space Force [5]. Likewise there are potential complications that might come from the signing by the U. S. president of what is known as Space Directive 3. This document, signed by the president, charges the Department of Commerce, in coordination with the Department of Defense, to develop new capabilities with regard to space situational awareness and space traffic management capabilities – among other tasks [6].

New Technologies Under Development

Currently the world of NewSpace is creating not only a wide range of new technologies in terms of new systems and concepts for innovative spacecraft and launch systems, but it is also fueling many new and innovative ideas about how the region just below space might be used. The thought is that systems that do not have to go all the way into space might be more cost effective but still might offer new avenues to provide communications and IT relays, improved surveillance and observation, as well as new possibilities for near-space tourism, higher speed transportation systems or even new types of weapons or defense systems.

This has led to research in such diverse areas as: (i) dirigibles or specialized balloon systems for space adventures; (ii) high altitude transponder systems for communications or Internet connections, especially for improved coverage and interconnection for the many rural and remote regions of Earth that are currently not connected to the Internet; (iii) new types of systems for Earth observation, surveillance, fire detection, criminal activity monitoring, and other forms of remote detection or observation systems; (iv) new forms of hypersonic transportation plus weapons systems, coupled with research into sonic boom suppression; (v) robotic transport; and (vi) extremely high-altitude dark sky stations.

Reports on the status of these various research and development efforts goes well beyond the intended scope of this book, but the possible new applications in these various areas are outlined below. Further, since progress in these areas is currently so very rapid, any attempt to report on these technical areas and the current status of research and development would likely become outdated in a very short period of time. As an alternative, it is suggested that anyone interested in the current state of development in these various areas from a technical point of view might undertake a web search.

The Growing Number of New Applications for the Protozone

It is remarkable how the development of new technology and the passage of time can greatly redefine the value of things. The U. S. purchase of Alaska, and even the Louisiana Purchase, were originally considered highly questionable enterprises. For a great stretch of time near-space, the area below outer space, did not to seem to have any particular purpose or hold any particular value. Today however there are a burgeoning number of new applications, and many people are seeking frequency allocations and other authorization to use this once rather forlorn and almost forgotten area. The following actual or potential uses of the protozone are now in play.

High-Altitude Protozone Tourism

There are currently at least two new companies seeking to develop commercial offerings to clients who wish to experience the thrill and excitement of observing space from a platform that is sufficiently high to see the curvature of Earth and the dark sky, but without the extremely high cost of a suborbital flight and its associated risks. One venture that is the brainchild of former Biospherians Taber McCallum and Jane Poynter is called World View. This company has developed a parafoil that has been able to make ascensions up to 120,000 feet. This is equivalent to 32 kilometers (20 miles). Their business plan is to offer ascensions up to 30 kilometers in altitude with passengers contained in a capsule that is supported by a parachute in case there is a problem with deflation of the balloon system [7].

The other firm, which is based in Spain, is known as Zero 2 Infinity, and it has also had successful test flights of up to 25 kilometers. Eventually it plans to offer tourist flights that will go as high as 36 kilometers (22 miles). These flights will not require space suits but will require special equipment as well as clothing that will not give rise to electrostatic sparks [8] (Fig. 6.2).

Fig. 6.2 World View parafoil that is intended for tourist ascensions up to 30 kilometers in altitude. (Graphic courtesy of World View.)

UAVs or Balloons for Communications, IT and Earth Observation Services and High-Altitude Platforms (HAPS)

The idea is that balloons, unmanned aerial vehicles (UAVs) and high-altitude platform systems (HAPS) might be able to provide wide area coverage for communications, IT, surveillance, or other practical services. Such possible applications have gained great interest in the last two decades.

The small sat revolution has given rise to other ways to find new economies that depart from the old ways that involved expensive satellites and expensive launch vehicle services. Actually a number of ideas have surfaced in this regard. The Japanese first championed new frequency allocations to support communications from high-altitude platform systems (HAPS) and proposed a reverse allocation for the satellite Ku-band allocation. The proposal that was agreed was to have a Ku-band approved use that would be 12 GHz for the uplink and 14 GHz for the downlink, rather than the usual satellite allocation of a 14 GHz uplink and a 12 GHz downlink.

It was Google that came up with the idea that one might send up radio-accessible packages that could fly on balloons similar to meteorological balloons. These might be used to provide connectivity to the Internet in rural and remote areas of the world, where such access was either very limited or non-existent. These so-called "Loons" would carry equipment much akin to the equipment found in a cell tower. One of these tennis court sized Loons, with its radio system suspended below, is designed to allow wireless connection to the Internet in remote areas. Such balloon systems are designed to withstand the wind, cold and ultraviolet radiation conditions of the stratosphere at an altitude of 20 kilometers. They are intended to remain in service for up to 100 days and are then allowed to descend on a controlled basis. There are attempts to create a controlled drift of these balloons so that one balloon drifts off and another replaces it, but this is far from an exact science. They are sufficiently steerable or maneuverable to avoid collisions in the high-altitude stratospheric conditions. Currently the launch and ascension of balloons are controlled by national air traffic control agencies, which started with a release of balloons from New Zealand in 2013. These systems have been used to aid in emergencies such as during recent disasters in Puerto Rico and in Peru [9].

There is even more interest in the use of high-altitude platform systems/stations (HAPS) for telecommunications, broadcasting, surveillance and/or monitoring. Frequencies have been allocated by the International Telecommunication Union (ITU), and additional frequencies are being proposed for the upcoming 2019 ITU World Radio Conference. The current allocations for HAPS service are in the Ku-band (12 GHz uplink and 14 GHz downlink) and possible new allocations in 38 to 39.5 GHz bands globally; and in Region 2 possible additional allocations are in the 21.4 to 22 GHz and 24.25 to 27.5 GHz bands [10].

There have been a number of proposals as to how this type of service might be offered via solar cells and electric-powered dirigibles such as a Japanese system with 17 HAPS vehicles, balloon systems, or long endurance powered aircraft known as High-Altitude Long Operation/Endurance (HALO/HALE) platforms. These HALO or HALE platforms were most commonly seen as being either solar-powered with electric propeller systems or jet aircraft that would constantly cycle in and out of their fixed location. There have even been proposed futuristic concepts that would use beamed microwave power to stabilize these platforms in a steady or relative stable flight path. In short there have been over a dozen such systems proposed over the past decade. These various proposals were largely seen as the next generation of communication platform beyond the technology represented by earlier aerostats.

Most recently Facebook has decided to close down its support for the Aguilar High Altitude Platform System, which it had been backing for some time. Instead of the Aguilar project it is now going to seek partnerships to create HAPS or UAV projects [11]. In this evolving story, the latest chapter is that Facebook is building an in-house test satellite called Athena for launch in 2019. This satellite is also intended to provide Internet services to rural and remote areas, and if the test is successful, then presumably a larger satellite constellation would follow in due course [12].

At this time none of these earlier proposed HAPS projects are now operational, even though the Aguilar project might continue under alternative funding. The typical HAPS project would perhaps be deployed at an altitude of about 20 kilometers (see Fig. 6.3.)

One significant option in the HAPS development field is that Thales Alenia has now developed and tested a craft that they characterize as between a drone and a satellite. They have foreseen many different functions that a HAPS could provide, including telecommunications, broadcasting, Earth observation or monitoring services. (See Fig. 6.4.)

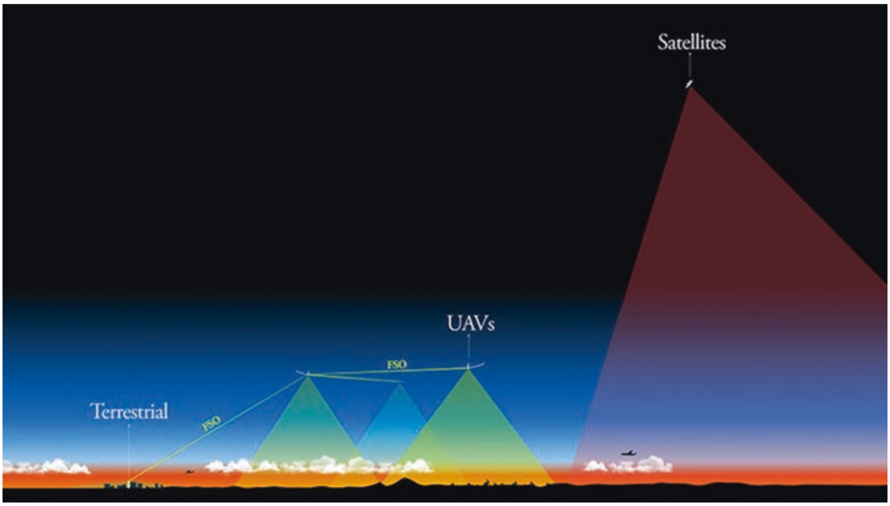

Fig. 6.3 Illustration of relative heights of terrestrial cellular, UAV or HAPS, and low Earth orbit satellites. (Graphic created by the author.)

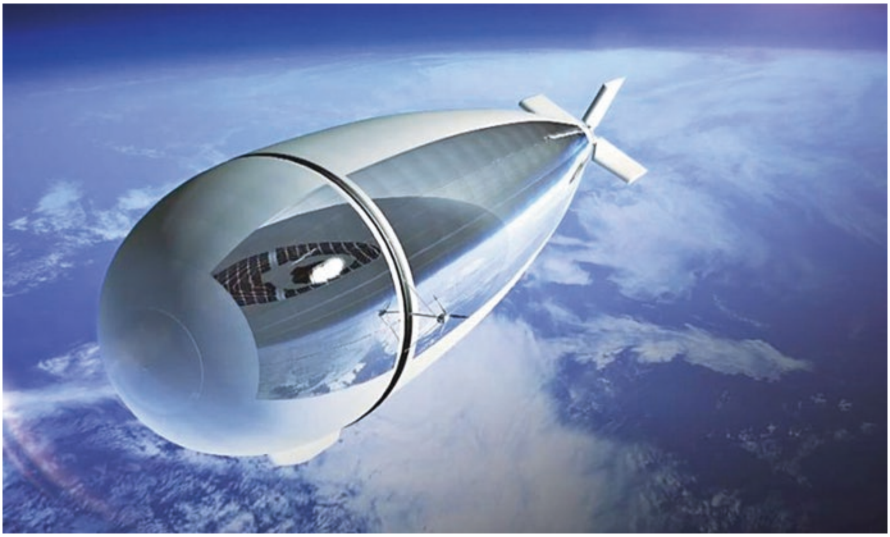

Fig. 6.4 The Stratobus[TM] HAPS as developed by Thales Alenia. (Graphic courtesy of Thales Alenia.)

The area of 17 to 22 kilometers is considered a suitable range of altitudes for HAPS operation, since wind speeds at these altitudes are typically at or below 100 kilometers per hour rates, and temperatures and UV radiation levels are generally acceptable for HAPS stations to be able to perform their functions for long periods of time.

Jean-Pierre Thessel, who heads the development of Stratobus for Thales-Alenia, is enthusiastic as to the possibilities. He has envisioned that this type of platform could be deployed to an altitude of 20 kilometers for many diverse applications that might become possible at a future date. The Stratobus[TM]

> *…could be used for surveillance missions, including land, maritime, oil platforms, piracy at sea, and…. environmental monitoring missions…. [It could] carry both radar and optical imaging payloads, for continuous surveillance capability, day or night and under all weather conditions. For military applications, it can be displaced as theaters of operation move. It would also be very useful in the telecommunications market, to provide 4G and 5G connectivity in the future. Its position in the stratosphere at an attitude of 20 kilometers is an optimal position for 5G, which demands very short latency of just a few milliseconds. Concerning navigation applications, it would strengthen the AIS* [Automatic Identification System] *network in heavy traffic zones, thus improving traffic control* [13].

This type of service via a HAPS station might prove particularly useful to provide cellular connectivity in recovery efforts where local mobile networks have had their power knocked out and for island countries the size of Jamaica, Dominican Republic, Haiti, Aruba, Singapore, Taiwan, etc., where one or a very few platforms could essentially cover the entire nation.

Dark Sky Stations

Another intriguing concept for deployment in the protozone is that of the dark sky station. This would involve the deployment of a lighter-than-air facility in the stratosphere with the purpose of carrying out a range of different missions. These missions might be to conduct scientific, meteorological or other practical experiments and demonstrations within the stratosphere.

These missions for the dark sky stations might include: (i) serving as a locale for short-term occupancy by human engineers and scientists for experimentation involving ozone layer or geomagnetosphere measurements, meteorological data, northern lights or climatological observation, and/or perhaps calibration of experimental gauges; (ii) serving as a launch point for electric ion propulsion-powered small satellites that could, at an altitude of perhaps 20 kilometers, be launched to spiral upward to achieve orbital speed and altitude; (iii) operating as a terminus and final checkout point for the launch of rockets that have been lifted by balloons to this altitude; (iv) providing a location for a new type of space tourism-type experience; and (v) serving as a multi-purpose location for commercial applications such as telecommunications, broadcasting, Earth observation, monitoring, etc.

JP Aerospace of California has undertaken the most concentrated study and experimentation into the possible feasibility. Below is a current prototype version of a dark sky station that JP Aerospace volunteer engineers have developed. But this is only for a proof-of-concept design. (See Fig. 6.5.)

Fig. 6.5 Prototype engineering concepts for a dark sky station. (Illustration courtesy of JP Aerospace.)

JP Aerospace has also developed quite ambitious futuristic concepts that have been developed on a theoretical implementation basis, including such ideas as a "Stratostation." This ambitious concept would have five different components essentially a half-mile in length (800 m) joined in a five-star configuration in order to create a giant dark sky station platform for space tourism and launch operations. It would be 1.6 kilometers in diameter [14].

There are many other possible applications that might come from a dark sky station that have yet to be fully explored. A location above a significant portion of Earth's atmosphere might provide an unclouded view of not only outer space, it also might provide a useful downward view of Earth in terms of observing patterns of pollution and to get a more synoptic view of certain climate change patterns.

Automated Robotic Air Freighters

There is today a very large volume of air freight across the oceans and across continents as well. Some of the largest providers of air freight services such as UPS, FedEx and others have begun to look at ways to provide their services more efficiently and at lower cost. One of the options being considered is the idea of a large air freighter that would essentially be robotically controlled and might fly at higher altitudes and somewhat slower speeds in order to conserve fuel. The idea would be for something like a converted Boeing 747 aircraft to fly at 50,000 feet (80,000 km) on such freight hauls. The aircraft would be mostly automated with only one emergency crew person aboard. This robotic freighter might cruise at, say, 500 kilometers per hour at higher efficiency and with much less wind resistance at the higher altitude. The result might be fuel consumption cut in half, and labor costs might be reduced by a factor of four.

In moving forward with such concepts one must look not only at the advantages, but also potential problems. There are many ideas for higher altitude flights at various speeds for different purposes. It is often not appreciated that the same amount of pollution released at sea level and in the stratosphere does not produce the same result. In a region where the atmosphere might be 10 times, 25 times or 50 times thinner, the impact of pollution is much more severe. In all of the ideas that include high altitude robotic air freight services, hypersonic transportation, suborbital flights for space tourism, hypersonic missile systems and launchers that use solid fuels and release particulates, there must be care given to the problem of air and stratospheric pollution and concern about mitigation processes that might be undertaken to diminish these harmful impacts [15].

There have been rumors for years that the U. N. World Meteorological Organization (WMO) and the U. N. Environmental Program (UNEP) would undertake a major review of air pollution coming from aircraft stratospheric flights, but none has proceeded. Various studies have been undertaken of the polluting effects of solid-fuel rockets in particular as well as other investigations of the effects of upper altitude aircraft and rockets on the stratosphere, but none of these efforts have triggered a global review of what this means to pollution of the upper atmosphere. This must be one of the issues that the U. N. COPOUS Working Group on the Longer Term Sustainability of Outer Space Activities (LTSOSA) should ultimately consider, perhaps in consultation with the WMO and the UNEP.

Hypersonic Transport Systems

If there is truly a massive new commercial opportunity in the new uses of the protozone, it is very likely to lie in the area of hypersonic transport. This would most likely involve the successful development of scramjet technology that uses air-breathing jet engines capable of enormous speeds or rocket engine systems for space planes developed to provide safe suborbital flights from point A to point B on our small planet. There has been speculative talk for decades of such hypersonic spaceplanes that could fly from London, England, to Sydney, Australia, or from New York to Tokyo in a matter of a few hours or so. Often the hype does not include the time for boarding and deplaning from the aircraft and consideration of the time that might be required to cool a spaceplane that has braked from a speed of Mach 6. Nevertheless the prospect of a mode of transport that could move passengers nearly half way around the world in a few hours is exciting if it could be done safely and without causing longer-term environmental harm. Certainly there are those that believe vacuum-sealed tunnels that use ultra-efficient maglev technology or so-called hyperloop systems may be the ultimate answer rather than hypersonic transport via the protozone.

Certainly there are a number of issues to be seriously addressed. These include:

- Development of reliable rocket propulsion or scramjet engines that can be used many times to make such flights reliable, cost-effective and safe.
- Careful study of environmental effects to confirm that it is possible to accomplish a number of such flights on an hourly basis without major polluting effects to the stratosphere.
- Economic and market studies to confirm that such offerings could be viable as a service that can commercially sustain itself.
- Development of new technology to create Quiet SSPs and Quiet HSPs that can avoid the creation of massive sonic booms near airports and cities as aircraft slow to land.

Currently there are a number of parallel technological development programs going on in the world that are essentially at odds with one another.

First, there are a number of quite advanced studies of electronic propulsion for air travel that would provide a service that is considered much more environmentally sound and that are likely to come first from European manufacturers (i.e., Airbus) and European carriers.

Secondly, there are a number of R & D projects underway in the United States, Europe, Japan and China to develop new jet airliners that are able to fly reliably, safely and cost effectively at speeds in the Mach 2 to Mach 4 range that are envisioned to provide air passenger service. Most of these fly with conventional liquid jet fuels or liquid hydrogen and liquid oxygen.

Thirdly, there are also efforts to create spaceplanes. These are designed to fly at speeds mostly in the Mach 6 to

Fig. 6.6 The A2 hypersonic jet proposed by Reaction Engines, Ltd. (Illustration courtesy of Reaction Engines Ltd.)

Mach 8 range, and many of these use hybrid solid-fuel systems that are capable of throttling. These are currently being designed either for suborbital flights associated with space tourism or as perhaps the first stage of a rocket launch system for small satellites. They include the Space Ship Company owned by Virgin Galactic, the now-defunct Swiss Space Ship (S-3) company or the Skylon single-stage-to-orbit vehicle powered by a "Sabre" scramjet engine and developed by Reaction Engines. Reaction Engines has also developed the plans for a spaceplane called the A-2 that would, in theory, provide service between the U. K. and Australia in under 5 hours. (see Fig. 6.6.)

Fourth and finally there are research agencies hard at work to take on the problem of sonic booms. The research is currently focused on telescope needle noses that could extend from the plane in such a way as to create a series of much smaller booms over time rather than one giant boom as the entire plane makes the transition from supersonic speeds to a velocity under Mach 1.

Anyone who feels that they have a complete and accurate idea as to the final outcomes and practice of commercial services actually to be provided say five to ten years from now would likely be mistaken. In fact there are many different and quite complex research programs being carried out in various countries, and even these are being conducted within different agencies and different commercial companies within those various countries. Even the top trend lines are hard to detect!

Key questions are: (i) Who will develop the best technology for suppression of sonic booms? (ii) Will electronic aircraft win out due to environmental considerations and hypersonic services consequently be delayed? (iii) Will hypersonic aircraft services be of the Mach 2 to Mach 4 type systems largely being developed by agencies such as NASA, JAXA and ESA; or will they be more like the spaceplanes with Mach 6+ speeds that commercial organizations such as Virgin Galactic (i.e., SpaceShip2), Reaction Engines (i.e., Sabre), or Sierra Nevada (i.e., Dreamchaser) are developing [16].

The main scenario as to how hypersonic spaceplanes would operate is fairly well established. This would be that most spaceplanes would take off from key authorized airports and would climb at subsonic speeds to a quite high altitude of perhaps 16 kilometers (53,000 feet) before transitioning to hypersonic speeds and climb on a parabolic path that would peak at around 80 kilometers and certainly below 100 kilometers. On their descent to a level of perhaps 16 kilometers they would slow to subsonic speeds. They would deploy a telescopic long needle-like extension that would serve to create a series of a mini sonic booms rather than one huge sonic boom as they go subsonic. Finally, they would land at designated airports and cool down and then deplane passengers. Sierra Nevada's Dreamchaser, which is being developed to fly into orbit, as well as Reaction Engine's Sabre are, however, currently aimed at launching into space and would thus follow a much different flightpath.

Hypersonic Weapons and Defense Systems

The development of new systems for hypersonic flight, spaceplanes and new more efficient rocket systems has implications that go beyond the civilian applications discussed above. The future of NewSpace applications for military and defense applications will be discussed in Chapter 9, with most of this discussion being focused on the development of systems that would involve ballistic missiles flying in outer space. It is useful to know that there will likely also be significant uses of the protozone for defense-related purposes and that the research and testing of weapons systems that would fly below outer space are in active development.

In April 2018 the U. S. Department of Defense awarded a $928 million contract to Lockheed Martin to develop and test a new system known as a Hypersonic Conventional Strike Weapon. This weapons system would be operated on a 'boost-glide' basis, but defense research is continuing on air breathing rocket systems or scramjet technology as well. The U. S. Defense Advanced Research Projects Agency (DARPA) is seeking in its 2019 budget an increase of $148 million in spending on hypersonic research [17].

All of this research and weapons systems development in hypersonic vehicles is apparently being driven by increased spending by both Russia and China in these areas. Reportedly China has carried out twenty times more test flights of systems in this area and that the Chinese DF-17 hypersonic missile, with a range of 1,800 to 2,500 miles (2,880 to 4,000 km) has already been successfully test flown.

Meanwhile Boeing is under contract to develop a hypersonic Experimental Space Plane (i.e., the XS-1), and the company has come up with the more evocative name of the Phantom Express, which will also fly at hypersonic speeds. (See Fig. 6.7.) [17]

The current situation is thus that both hypersonic rocket boost and glide systems as well as spaceplane technology are being developed as weapons systems, with more money and more emphasis currently being placed on hypersonic rocket systems rather than hypersonic spaceplanes.

The current accelerated development of these various types of weapons could be used in a wide range of conventional

Fig. 6.7 U. S. Air Force Phantom Express spaceplane that could be used as a launch system. (Graphic courtesy of the U. S. Air Force.)

war-fighting capacities and could also be used to carry tactical nuclear weapons. The more that these types of hypersonic weapons systems are developed along with ballistic weapons systems, along with discussions of creating 'space forces' that will be charged with fighting war in space, the more endangered the concept of outer space being a global commons jointly available for the peaceful uses of these areas for all of humankind will become.

Conclusions

For many years there have been two prime areas that have been referred to since the beginning of the Space Age back in the late 1950s. These areas were outer space and air space. The International Civil Aviation Organization (ICAO) that was established by the Chicago Convention of 1948 was responsible for international coordination of air traffic management around the world. The United Nations also moved to create the Committee on the Peaceful Uses of Outer Space (COPUOS) that was key to the negotiation of the Outer Space Treaty of 1967 and the four subsidiary international agreements that came in the 1970s.

Today there is increasing recognition that there is a new area of concern and usage that lies between air space and outer space. This subspace, near-space or protozone has a growing number of potential new applications. These include uses for research and civil and defense needs as some regulatory oversight and safety coordinative activities will likely become more and more necessary. It is a sad reality that governmental action is seldom proactive to take preventive action before a serious problem or even a disastrous event takes place.

This chapter outlines the many new technologies and especially the growing number of applications that are now developing in this region above commercial air space (i.e., 20 kilometers or 12.5 miles) and below outer space, that is sometimes defined as 100, 110 or even 160 kilometers. There is more and more focus on the need to address space traffic management and control to avoid the ever-rising problem of orbital space debris. As the number of active and defunct spacecraft increases, especially with the expected near-term deployment of large scale small satellite constellations, and the amount of space junk climbs, the need for space traffic management continues to grow. As progress is made toward agreeing on space traffic management and control processes, it is equally important to recognize that this system needs to apply to not only Earth orbit but also to the subspace area that is referred to in this book as the protozone.

The trouble with many of the issues that one encounters in the area referred to as outer space is that these issues are often compartmentalized. This is to say that there are efforts to address orbital space debris, while others are concerned with such subjects as potentially hazardous asteroids, space weather, coronal mass ejections and solar radiation, and/or changes to Earth's magnetosphere. Yet others, such as the U. N. Committee on Disarmament Affairs, are concerned with weapons in space. Then there are the World Meteorological Organization (WMO) and the U. N. Environmental Program (UNEP) that are concerned with weather satellites, meteorological research, Earth observation and environmental effects.

There are many other sectors where U. N. specialized agencies and space-related matters intersect, such as food and agriculture, health, maritime related issues, etc. One of the goals of a recent book, entitled *Global Space Governance: An International Study,* that this author co-edited with Dr. Ram Jakhu of the McGill University Air and Space Law Institute, was to show how interconnected space policy and regulation is and the need to a holistic and more proactive approach to emerging space policy issues and concerns [18].

The UNISPACE + 50 meeting held in Vienna, Austria, in June 2018 also tried to relate space tools and system capabilities together with the U. N. 17 Sustainability Development Goals. This represents yet another effort to show the many ways space systems and uses interconnect with every aspect of human life in today's world. In efforts that seek to address the vital interconnections that exist between Outer Space usage and most aspects of human life, it should also be recognized that there is also a close connection between outer space and the protozone.

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