

AN INTERNATIONAL CIVIL AVIATION ORGANIZATION FOR OUTER SPACE?

Tommaso Sgobba*

The international space community has identified the rapid international commercialization of outer space, in particular in the fields of telecommunication, navigation and launch services, as an important and positive step toward the continual global and national economic growth. Recent interest and actions from the private sector in the field of commercial human spaceflight illustrates the widening range of financial commitments and business risks the private sector is willing to make in outer space. In addition, several government and business communities around the world are cooperating to help fund the building of commercial spaceports. Corporations, like Virgin Galactic and the European Aeronautic Defence and Space Company, have made firm commitments in pursuing a new suborbital space tourist market and shown interest for a possible extension to point-to-point international hypersonic travel. At the same time the Russian and US governments are promoting early steps toward commercial orbital human spaceflight. The Russians flew to the International Space Station the first paying orbital space tourist customer back in 2001 and have continued regularly to do so since then. In the meanwhile, the US National Aeronautics and Space Administration (NASA) launched an important initiative to procure commercial transportation services to the space station.

However, the Space Shuttle Columbia accident in 2003, a sequence of accidents on the ground, recently at a commercial spaceflight company in July 2007, and various spectacular launch failures demonstrated that the business of outer space is still fraught with risks not only for the crew on board and ground personnel, but also for the public on the ground, at sea or travelling by air. Furthermore the space and ground environments are at risk. Currently there are thousands of objects tracked in orbit, which are

* The opinions expressed here are those of the author and the International Association for the Advancement of Space Safety, and not necessarily those of the European Space Agency.

a potential direct threat to manned and unmanned orbiting space assets, and indirectly threaten the terrestrial safety of critical services. There are also important atmospheric effects from chemical rocket propulsion, and environmental impacts on the ground in case of launch failure. In September 2007 the explosion briefly after launch from Baikonur of a Russian Proton M rocket, which was carrying 200 metric tons of toxic fuel, has been reported to have caused contamination of a vast swath of land.

Though there is great promise about the further commercial potentials of outer space for the world economy, and the safety risks are very real and growing, there is no international cooperative effort to balance the multiple commercial interests in outer space with internationally agreed and nationally enforceable safety-risk mitigation standards. Because of this, the International Association for the Advancement of Space Safety (IAASS) Legal and Regulatory Committee established a working group called "An ICAO for Space?" , ICAO being the International Civil Aviation Organization, the existing UN organization for international civil aviation safety. The working group was composed of outstanding international experts in space safety and related fields. They were requested to answer two basic questions: a) if the international civil aviation cooperation represented by the ICAO is a valid model for a future civil/commercial international organization for outer space, and b) if there were a valid rationale for extending the scope of the current ICAO to include outer space, as at national level the United States did by creating their space transportation office within the Federal Aviation Administration. The working group has produced a white book for public distribution about the stakes involved and the merits of an international civil space regulatory framework. The white book discusses the various legal and regulatory treaties, organizations and standards that currently impact commercial space safety. It notes that the International Standards Organization (ISO) is the only international body that has attempted so far to develop space safety standards for global use. They are in any case unstructured, sparse, generic and not endorsed by national space regulatory bodies. Because the ISO mission is to develop industrial standards to facilitate international commerce and not safety regulations, all its past and present efforts in the field of safety are doomed to be neglected (as currently the case for the ISO standards for toy safety). Furthermore ISO standards are meant for voluntary use thus defeating the key purpose of achieving an even level of risk worldwide while preventing unfair competition due to the use of national substandard safety practices. However, some national and multinational space bodies have developed

their own space safety standards, which are the natural reference for any international harmonization effort. In addition few countries actually formally regulate commercial space activities. The US Federal Aviation Administration Office of Commercial Space Transportation is one example, and also the most advanced.

Examining international regulatory organizations from analogous industries can give us important insight into how such an international space safety regulatory framework might look. For example, the International Telecommunications Union regulates radio broadcasts. The telecommunication industry found that an international body that can control and manage the broadcast spectrum was necessary to help the industry grow in a sustainable way. Important search and rescue frequencies are reserved to ensure that they are not negatively impacted by telecommunications spectrum use and growth. The International Maritime Organization is another example. Again, to support an orderly growth of international maritime people, goods and services, it was paramount to determine international safety regulations. The United Nation's definition of national and international waters and boundaries was critical to solving very difficult "state's rights" issues. Probably the best analogy is the ICAO, which was created toward the end of the Second World War. States quickly realized that a commercial civil aviation industry could not achieve and maintain sustainable growth without an international regulatory framework to ensure that civil aircraft could take off, fly and land safely anywhere in the world. Common international safety standards have made civil aviation one of the most successful and safe transportation modes. For this reason, and also because there is a wide commonality of interests, first of all the sharing of crowded airspace, the IAASS white book focuses particular attention on ICAO as a model for a future international commercial space safety regulatory body.

Review of the variety and interrelationship of safety risks that space organizations are facing is important to fully comprehend the scope of the challenge of creating an international space safety regulatory framework. Launch and ground-processing hazards are real and impact those communities contiguous to the launch range. Orbital and suborbital flights face safety risks such as avoiding orbital debris, spacecraft traffic management and accidents in outer space that impact other spacecraft. There are additional risks from spacecraft re-entering the atmosphere and landing.

SPACE LAW: MANY PRINCIPLES, NO RULES

UNITED NATIONS SPACE TREATIES

The following four United Nations international treaties and agreements apply to space activities:

- the Treaty on Principles Governing the Activities of States in the exploration and Use of Outer Space, including the Moon and other celestial Bodies (the Outer Space Treaty, 1967);
- the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the Astronaut Treaty, 1968);
- the Convention on International Liability for Damage Caused by Space Objects (the Liability Convention, 1972); and
- the Convention on Registration of Objects Launched into Outer Space (the Registration Convention, 1976).

The space treaties provide generic principles but no implementing rules. They were produced at a time in which the United States and the Soviet Union, locked in the Cold War atmosphere, had a monopoly on space activities with little presence of the private and commercial sector. The space treaties were therefore conceived for the purpose of defining the overall limits applicable to each state's space activities and not to facilitate and promote commercial and civil international cooperation. During the negotiation of the Outer Space Treaty, the Soviet Union even proposed a text which would have prohibited private activities in outer space. The negotiation on this point eventually led to a compromise which represents a fundamental difference in space law with reference to both maritime and air law, and which makes states both "responsible" and "liable" for the space activities of their nationals (persons, companies and so forth), while for commercial ships and planes states exercise a supervisory role (responsibility) but do not bear financial risk (liability).

It should be noted that Article IX of the Outer Space Treaty does require safety cooperation in the form of consultation in case of international risk of space activities, but such consultation consists basically in participating to few specialized committees of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), which issues only generic guidelines, if any. After two decades of debate COPUOS has been even

unable to agree where to lay the legal border between airspace and outer space.

COPUOS

COPUOS was established in 1959 by the UN General Assembly with the wide mandate of reviewing the scope of international cooperation in the peaceful uses of outer space. COPUOS and its subcommittees work on the basis of consensus and make recommendations to the General Assembly for endorsing resolutions.

With reference to space safety issues, in 1980 COPUOS established a Working Group on the Use of Nuclear Power Sources in Outer Space which took more than a decade to produce a set of guiding principles, which were endorsed by the General Assembly in December 1992. Although the Working Group is still in place, nothing more than the original principles has been produced to date.

Another safety-related area in which COPUOS operates is that of space debris mitigation. After publishing its Technical Report on Space Debris in 1999, COPUOS mandated in 2001 the Inter-Agency Space Debris Coordination Committee (IADC) to develop guidelines regarding space debris mitigation techniques. Subsequently, the Scientific and Technical Subcommittee established the Working Group on Space Debris with the mission to develop a set of recommended principles based on the technical content of the IADC space debris mitigation guidelines. A revised draft of these guidelines was submitted by the Scientific and Technical Subcommittee of COPUOS during its forty-third session in 2006 and was endorsed in 2007 by the General Assembly. The guidelines are not legally binding under international law and it is also recognized that exceptions to the implementation of individual guidelines or elements may be justified. The relative value of UN guidelines was spectacularly underlined by the destruction of one satellite in 2007 and one in 2008, events which created a massive and hazardous amount of new orbital debris.

THE NEW SPACE AGE

The emerging trend for the twenty-first century is that of a global space industry involving, along with the traditional space powers, a multiplicity

of government and corporate stakeholders worldwide. A mixture of factors ushered in this new space age. The worldwide spread of (dual-use) space technologies and services, global economic trends, but also the dramatic socio-economic and political changes that followed the end of the Cold War, the collapse of the Soviet Union and the abandonment of the communist economic orthodoxy by China. Finally the Space Shuttle Columbia accident in 2003 precipitated an overhaul of US space policy, first as a redirection of NASA toward exploration missions, and later in October 2006 with the enunciation of a new overall US civil, commercial and (in particular) military space policy. This policy made overnight the previous concept of “outer space” obsolete or at least pushed it somehow beyond the geostationary orbits, while a sort of “near space” has taken shape which a nation has the right to exploit for its own interest and no more as an ambassador of mankind for the benefit of all. The new US space policy is not revolutionary but it is just a factual picture of what outer space has become. Commercial and military space-based systems are nowadays synergetic with systems on Earth and indeed essential to human activities. Military and civil/commercial space operations need therefore to be clearly separated and their coexistence (in time of peace) adequately managed. In other words outer space has become as sea and air—another realm where it is in the interest of the global community to operate in accordance with clear international rules instead of vague principles. Not only orbital usage and telecommunication frequencies allocations, but also space traffic control, safety risk and a number of support services such as space weather forecasting and orbital debris monitoring need to be coordinated transparently and effectively at the national and international levels. The fallacy and limits of the current approach based on voluntarism and good intentions is becoming apparent, as clearly demonstrated by the vain attempts to limit the proliferation of space debris, a major threat to spacecraft and the primary source of risk for human spaceflight.

WIDENING ACCESS TO OUTER SPACE AND ITS ECONOMIC SIGNIFICANCE

By the end of the 1990s the extent and importance of the commercial space revolution and the merging of several technologies was already very clear as outlined in the following excerpts from testimony in March 1999 from Keith Calhoun-Senghor, then Director of the Office of Space Commercialisation, US Department of Commerce, before the House Subcommittee on Space and Aeronautics:

This revolution is increasingly blurring the traditional distinction between things military and commercial, between things private and governmental, and things domestic and international. We are dealing with a new set of historical conditions, many of them unprecedented. Therefore, we must resist the temptation to apply models or adopt solutions that were more appropriate to the past, or to entirely different historical or economic circumstances without first understanding the implications for the future. ... This New Space Age or era of "New Space" differs dramatically from the era we have just left in significant ways. First, it is increasingly privately funded and commercial in nature. Second, it will be predominantly international, blurring the once clear lines between what is "ours" and what is "theirs".

Already in 2000 the commercial worldwide satellite industry was generating revenues several times in excess of global military space expenditures. In 2003 China became the third world power, after Russia and the United States, with the capability of sending humans into outer space. India has announced plans to initiate a human spaceflight programme leading to a first mission in 2014 and landing on the Moon in 2020.

Also the number of actors with unmanned orbital launch capability continues to grow and now includes 10 states plus international operators such as Sea Launch and International Launch Services. A further 18 states have acquired suborbital flight capabilities (from Argentina to Syria). In February 2007 Iran launched its first suborbital flight. Iran and North Korea maintain long-range military missile programmes that could enable them to develop an orbital launch capability. As of 2007 about 50 states had accessed outer space, either with their own launchers or those of other states, and have assets in orbit. This number is expected to continue to grow rapidly. Finally in the first years of the twenty-first century commercial space has started taking the first (but epochal) steps in the ultimate frontier of personal spaceflight.

SAFETY RISK OF SPACE MISSIONS

The space industry is expanding rapidly worldwide and with it the safety risk is increasing even faster because of poor attention, lack of widespread knowledge in the field of risk control techniques, cumulative effects and weak or non-existent international rules. Eventually the prospect for industry

growth will be badly hurt if the necessary course of corrective actions is not undertaken in the short term. In other words the technical progress in acquiring space access and use capabilities does not necessarily go hand-in-hand with safety awareness and management.

ACCIDENTS

Safety risk in space missions refers to the general public safety (on the ground, in air and at sea), the safety of launch range personnel and the safety of humans on-board. Space safety is also generally defined in a wider sense as encompassing the safeguard of valuable facilities on the ground (for example launch pads), of strategic and costly systems in orbit (such as space stations and global utilities) as well as the safeguard of the space and Earth environments.

Up to now, all space accidents in space programmes with human casualties happened either on the ground or during re-entry, with the one exception being the Shuttle Challenger in 1986, which exploded in the early ascent phase. As of today there have been nearly 200 people killed by rocket explosions during ground processing, testing, launch preparations and launch. The figure is only approximate due to discrepancies between some official accounts and media sources. In the last 10 years there have been also at least six launches that have been terminated by explosion commanded by the launch-range safety officer to prevent risk to the public. There were also several more cases of launchers that did not make orbit and crashed back to Earth. It should be noted that the ground safety record is not uniform worldwide. Europe has a spotless record, and also the United States except for the accident in July 2007 at Scaled Composites, a leading private spaceflight industry, with three killed and three seriously injured, and the spectacular explosion of a rocket fuel plant in May 1988 at Henderson, Nevada. The explosion claimed two lives, injured 372 people and caused damage estimated at over US\$ 100 million over a large portion of the Las Vegas metropolitan area. Seismographs in California measured the event at 3.5 on the Richter scale. Of the 200 killed on the ground since the beginning of the space age, 35 casualties were counted just at the beginning of this century. First the blast in August 2001 at the Russian Space Agency fuel production plant in Omsk, which killed four, then the explosion in October 2002 of a Russian Soyuz which killed a young soldier and just by luck did not involve members of a large international support team that was on site. Then there was the explosion in August 2003 of the Brazilian VLS-1

rocket at Alcántara Launch Range which claimed 21 lives, and the accident at the Indian solid-rocket processing facility in Sriharikota in February 2004 with six people killed. Finally, there was the terrible accident mentioned above at Scaled Composites.

A total of 22 astronauts have lost their lives since the beginning of human spaceflight. The first was the Soviet cosmonaut trainee V. Bondarenko in March 1961 who died in a pressure chamber fire during training. Three US astronauts were also killed by a fire during training in January 1967 inside an Apollo capsule. The re-entry accidents are three in total: Soyuz 1 in April 1967, Soyuz 11 in June 1971, and the Columbia in February 2003. In the latter case, in addition to the loss of the crew, the public on the ground and passengers travelling by air, within the continental-wide curtain of falling debris, were subjected to an unprecedented level of safety risk.

INTERNATIONAL SAFETY RISK

In a different category are the environmental accidents such as failures leading to the dispersal of radioactive material. As of today there have been 10 such cases, including the plutonium on board the Apollo 13 lunar module jettisoned at re-entry, which ended up in the Pacific Ocean close to the coast of New Zealand, or the 68lbs of uranium-235 from the Russian Cosmos 954 which were spread over Canada's north-west territories in 1978. The most recent accident of this kind was in 1996, when the Russian MARS96 disintegrated over Chile releasing its plutonium, which has never been found.

Finally there is the risk represented by orbital debris, including those 200 "dead" spacecraft abandoned in valuable geostationary orbits, and the risk of uncontrolled spacecraft re-entry. Of the 12,500 identified objects larger than 10cm, 40% are satellites no longer in operation and spent rocket upper stages, and the rest are fragments and other objects. There are then at least 300,000 objects between 1cm and 10cm, and possibly several million below 1cm. Some of this material will remain in Earth orbit for hundreds or thousands of years and constitutes a potential catastrophic hazard for operational spacecraft because of the high relative velocities at impact. Currently the debris hazard is partially controlled by manoeuvres for debris large enough to be above the detection threshold. Shielding is also used on manned spacecraft to (partially) protect those in the habitable modules. Debris impacts on the Space Shuttle are counted on every mission

and samples of residual materials are routinely recovered from the thermal protection for examination. The second largest hit ever experienced by the Space Shuttle was the perforation of a thermal radiator which happened during the STS-115 mission in September 2006. It did not cause any major problem to the orbiter, but could have killed instantly an astronaut performing an extra-vehicular activity during that mission.

To reduce the space debris risk, satellites should be disposed of at the end of their operational life by either de-orbiting (those in low orbits) or moving to “graveyard” orbits (those in geostationary orbits). De-orbiting space hardware means also the possibility of debris surviving re-entry and causing casualties on ground. Here it is not so much a matter of trading one hazard for another because natural de-orbiting in any case would take place in due time because of the physics of the residual atmosphere in low Earth orbit. Currently there are no means to remove the re-entry risk but only guidelines to move it in the timeframe (the well-known 25-year rule). Instead the use of “graveyard” orbits is quite a dilemma for commercial operators. In fact they support the common good at the loss of substantial profits (by using the remaining fuel for spacecraft disposal and not for commercial operations), while there is no national or international legal obligation to do so. Even accounting for the self-interest of commercial companies in protecting their operational orbital environment, there is a substantial percentage of satellites that cannot be moved to graveyard orbits with their own means because of failures or malfunctions. Although nowadays the technological capability exists to develop “space tug” systems (for example the HERMES project of GEO Ring) to come to the aid of spacecraft in distress, the lack of legal obligations for the operator to remove an inactive spacecraft does not allow such services to become established and economically viable.

The limits and failure of the “voluntarism” approach, instead of binding regulations, was spectacularly demonstrated by the January 2007 destruction of an orbiting Chinese satellite by a medium-range missile, resulting in the creation of a debris cloud. This was the second-ranking fragmentation event in space history, and probably the most severe one concerning the damage potential of the fragments. The debris has caused an increase of collision risk for many satellites. For example, the collision risk for the International Space Station (ISS) increased by nearly 60% for fragment sizes bigger than 1cm, which is above the shielding capability of the ISS and below the threshold for detection in order to initiate anti-collision manoeuvres.

Finally, launch and re-entry operations are very much international in nature. Typically, launch support personnel are confined to an area about the launch point within the territorial domain of the launching state. As launch vehicles proceed downrange, they typically leave the territorial domain of the launching nation and begin to overfly international waters and the territory of other nations. As a matter of fact the risk to the overflowed population is managed by the launch state based on their national space safety standards, which may well differ from those of the foreign populations at risk. Furthermore it should be noted that current practice is for each range to manage risks on a mission-by-mission basis. Minimal attention is addressed to annual risks generated by the range's launch operations. There is no agency—national or international—that monitors and controls risk imparted to overflowed populations. An area may be placed at risk by launches from multiple launch sites without the launching states performing any coordinated calculations to assure the levels are tolerable and indeed accepted by the states at risk. With reference to re-entry risk, most rocket upper stages, and all satellites operating in low Earth orbit, except the cargo spacecraft servicing the ISS, are destined sooner or later to re-enter uncontrolled into the atmosphere thus creating a risk anywhere for the general public. In February 2008, US President Bush ordered the destruction of a malfunctioning national intelligence satellite. The reported reason was to prevent the potential danger to populations on the ground from the spacecraft's half ton of hydrazine, a highly toxic propellant.

PROPOSED PRINCIPLES FOR NEW REGULATIONS

The ever increasing number of international actors involved in civil and commercial launch and re-entry activities, the envisaged expansion of human access to outer space for tourism and point-to-point hypersonic travel, the increase in the use of nuclear power systems in support of civil exploration programmes and the placement in orbit of global utilities raise the central question of how to ensure the public and space passengers and crew safety as well as the integrity of other valuable unmanned assets in orbit. It comes as logical consequence the necessity to develop a harmonized framework of international rules, which would include in particular uniform safety certification practices for ground and flight systems, personnel, activities, as well as the establishment of the means to control space traffic to prevent interferences with air traffic and orbital operations. We should also further consider that currently there is little (commercial) interest for the region of

outer space beyond the geostationary orbits, while there are substantial strategic interests (civil/commercial and military) for the region up to and including the geostationary orbits, the so-called “near space” region. It is therefore proposed that a new civil/commercial international regulatory framework be established for that region for the purpose of achieving the following ultimate goals:

- ensure that citizens of all nations are equally protected from the risks posed by launching, overflying, and re-entering/returning of space systems;
- ensure that all space systems are designed, developed, built and operated in accordance with common minimum ground and flight safety rules, procedures and standards based on the status of knowledge and the accumulated experience of all spacefaring nations;
- establish international traffic control rules and management for launch, on-orbit and re-entry operations to prevent collisions or interference with other space systems and with air traffic and air navigation systems;
- ensure the protection of the ground, air and on-orbit environments from chemical, radioactive and debris contamination related to space operations;
- ban intentional destruction of any on-orbit space system or other harmful activities that pose safety and environmental risks; and
- ensure that mutual aid provisions for emergencies involving space safety are progressively agreed, developed, implemented and made accessible without discrimination or restriction anywhere on the Earth and in outer space.

The establishment of an international civil/commercial space regulatory framework is sometimes perceived as a potential threat to national sovereignty. As a matter of fact it would instead have far reaching beneficial consequences in removing obstacles to the international space trade, as well as meeting the growing demand of military commands for the transparent and accountable use of outer space by civil and commercial operators. An international regulatory framework is not only needed to ensure that citizens of all nations are equally protected from “unacceptable levels” of risk from space missions, but also to ease the barriers that different national safety regulations may create to international space commerce, to prevent distortion of the commercial competition due to substandard safety

practices, and to allow for mutual assistance and rescue in case of need. Some examples of such benefits are as follows.

COMMERCIAL PAYLOADS SAFETY REQUIREMENTS

Commercial launch sites tend nowadays to be quite international by hosting large foreign teams during (foreign) spacecraft preparation for launch. As a first step, the harmonization of launch range safety requirement for payloads would:

- develop and propagate a common safety culture in the specific field;
- allow spacecraft developers to design their systems according to a single set of safety requirements, no matter which launch vehicle and site is later used; and
- exclude safety programme costs from the commercial competition equation.

In perspective, uniform safety technical requirements would allow a regime of mutual recognition of safety certificates which may be granted by a national safety authority for international use, as is already the case in many comparable fields (aviation, for example). Such an approach would allow a further enhancement of overall system safety by not limiting the safety certification to the safety design aspects as is currently the case, but including all elements of independent quality assurance surveillance of the actual manufacturing and testing by the national space authority.

SPACE TOURISM

In the field of space tourism there are currently about 26 different concepts and vehicles under development, mainly in the United States, but also in Canada, Russia and Europe. Spaceports dedicated to suborbital flights are being established in Malaysia, Scotland, Singapore, Sweden and the United Arab Emirates. Several civil aviation authorities have initiated their own studies on possible regulatory frameworks. The SpaceShipTwo vehicles being built by the US company Scaled Composites will be owned and operated by the UK company Virgin Galactic. This is similar to the Canadian Arrow, to be operated by the US Company PlanetSpace.

Because of such cross border relationships, complicated legal and regulatory issues arise. For example, as SpaceShipTwo is classified as rocket,

Virgin Galactic had to obtain technical assistance agreements under US armament technology transfer rules to work and exchange data with Scaled Composites. Because of the Outer Space Treaty clauses, the vehicle has to be certified by UK space authorities and by those of each state, legally “launch state” (therefore also responsible and liable), in which the vehicle would be operated. A coordination and indeed harmonization of the national spaceflight certification regulations becomes therefore unavoidable to make space tourism a worldwide industry.

ICAO AS A MODEL

WHAT IS THE ICAO?

In 1910, just a few years after the first uncertain “jump” into the air of the Wright brothers, the first important conference on an international air law code was convened in Paris. The treatment of aviation matters was a subject at the Paris Peace Conference of 1919 and it was entrusted to a special Aeronautical Commission. Later, an International Air Convention was established which brought about the creation of an International Commission for Air Navigation in 1922. A small permanent secretariat was located in Paris to assist the commission in its tasks of monitoring the developments in civil aviation and to propose measures to states to keep abreast of developments.

In consideration of the great advancements being made in the technical and operational possibilities of air transport during the Second World War, the United States initiated in 1943 studies of post-war civil aviation. The studies confirmed, once more, the belief that civil aviation had to be organized on an international scale or it would not be possible to use it as one of the key elements for driving the economic development of the post-war world. The US government therefore extended an invitation to 55 states to attend in November 1944 an International Civil Aviation Conference in Chicago, which culminated with the signature on 7 December 1944 of the Convention on International Civil Aviation.

The 96 articles of the convention established the privileges and restrictions of all contracting states and provided for the adoption of international standards and recommended practices to secure the highest possible degree of uniformity in regulations and standards, procedures and organization regarding civil aviation matters. The convention set up the permanent

International Civil Aviation Organization. In October of 1947 ICAO became a specialized agency of the United Nations.

INTERNATIONAL AIRSPACE AND SPACE OPERATIONS

Uninhabited areas such as oceans and seas are very important for the safety of space launch and re-entry operations. Major spaceports and launch sites are usually located close to the ocean coastline for the obvious safety reason of launches quickly clearing inhabited areas. In some cases launches even take place directly from modified, self-propelled, ocean platforms to provide for the most direct route to orbit and maximum lift capacity. Spacecraft re-entry trajectories are selected as much as possible with similar criteria, and all controlled destructive re-entries are directed toward oceans.

Because the nationality of airspace is determined by a state's landmass and waters, the large majority of space-bound traffic takes place through international airspace under ICAO jurisdiction. More precisely, states are sovereign in their "territorial sea" which extends a mere 12 nautical miles from the coast. There are then the so-called "contiguous zones", which states have the right to control to prevent infringements of their customs, fiscal, immigration and sanitary laws, which are set at 24 nautical miles. Finally the "exclusive economic zones" are defined as extending up to 200 nautical miles, where a state controls natural resources of the water and seabed. Beyond that line the "high seas" begin. States are sovereign in their airspace which is defined as the atmospheric zone directly above their landmass and territorial sea, all the remaining worldwide airspace is international. The civil aviation convention of 1944 placed such international airspace under the authority of ICAO.

Responsibility for the provisions of air traffic control services in this airspace is delegated by ICAO to various states, based generally upon geographic proximity and the availability of the required resources. Currently the oceanic air traffic control system is procedurally based, relying heavily on filed flight plan data. There is no radar coverage over the ocean. Pilots must report their positions verbally or have them automatically sent through a relay station. The infrequency of position reports, coupled with limitations in navigational accuracy and communications, have resulted in the large separation standards between aircraft. As aviation and space traffic continue to grow, ICAO has an increasing primary responsibility and duty for promoting innovative strategies to ensure the safety of the "integrated"

air and space traffic in the international airspace, which is where those traffics mostly interact.

AIR AND SPACE TRAFFIC CONTROL INTEGRATION

Today's air traffic management system for civil aviation is still not much different from that of the 1960s. It is still fundamentally based on radar tracking, reliance on analogue voice radio and the guidance of air traffic controllers. In the future civil aviation will make use of space-based systems for traffic management, approach and landing. Such systems are currently under development and make use of a Global Navigation Satellite System (GNSS) such as the US Global Positioning System, plus various precision augmentation systems and position broadcasting capabilities. The improved navigation accuracy in the cockpit will allow further applications such as the Automatic Dependent Surveillance system. This system will truly be revolutionary for air traffic control by allowing aircraft to automatically broadcast their position to various receivers on other aircraft and on the ground.

Also in the case of rocket launches there is a forthcoming transition from ground-based radar to GNSS applications. One of the most important safety responsibilities of a launch-range safety officer is to monitor the track of launch vehicles during flight and, in case of malfunction and risk to the public, to terminate the flight. The method used for flight termination depends on the vehicle, the stage of flight and other circumstances of the failure. Propulsion is terminated and, in addition, the vehicle may be destroyed by on-board explosive charges to disperse propellants before surface impact, or it may be kept intact to minimize the dispersion of solid debris. Flight termination can also be initiated automatically by a break-wire or lanyard pull on the vehicle if there is premature stage separation. It can be expected that for hybrid manned vehicles (aero-spacecraft) there will be a preference not to include a flight termination system by explosive charges, but to rely on flight control redundancies as in traditional aircraft. In such cases the vehicles will make use, for navigation and traffic control purposes, of the same GNSS systems in use for aviation. Furthermore in the near future a number of critical aviation systems, from traffic control to high-resolution weather forecasts and digital aviation communications, will be based in near space, which extends up to and including geostationary orbits. This means that aviation safety will very

much depend on the integrity and reliability of space-based systems and services.

In summary, air-traffic management and space-bound traffic management are highly interdependent, and both will be very much dependent in the future on space-based systems. Because orbital traffic management (to avoid collisions and interferences) is essential to ensure the integrity of space-based systems, integrated air and space traffic management is essential for ensuring aviation safety and public safety. Assigning the international coordination and control of near-space traffic management to ICAO, instead of a separate international space organization, would bring about obvious advantages in terms of synergy and efficiency.

INTEGRATION OF AVIATION AND SPACE INFRASTRUCTURES AND SERVICES

Similarly to traffic management integration, the trend to operate aerospacecraft for space tourism from dual-use ground infrastructure (airport/spaceport), requires a well-integrated international regulatory framework both for flightworthiness certification and ground operations, which a single organization (the ICAO) could better achieve than separate international space and aviation organizations. Such integration would become unavoidable as soon as the space tourism industry starts offering point-to-point international flights (via outer space).

There are then further areas of integration and common interest. While it is well known that terrestrial weather forecasts are essential also for space system safety during launch and re-entry operations, only recently has the aviation community become interested and indeed concerned about dissemination of space weather forecasts, and planning of related operational responses.

Space weather is a collective term for radiation from a number of varying conditions on the Sun plus cosmic rays, which have potential serious effects on electronic systems and on human beings.

As airline cross-polar traffic (above 78° N) increases, the aviation industry is becoming concerned about a number of safety-related issues such as disruption in high-frequency communications, navigation system errors, the risk of failure of avionics and radiation hazards for crews. The same concern exists for high-altitude flights above 50° N (for example space tourism). The

aviation and space weather communities are already soliciting ICAO to take the lead in coordinating international rules on space weather forecast dissemination and uniform risk mitigation responses.

CONCLUSIONS

A global civil/commercial space industry is emerging involving the traditional space powers with a multiplicity of government and corporate stakeholders worldwide. Today space activities are still too driven by national mission objectives while international interdependence and the global interest of safety tend to be overlooked. It is commonly believed in the private spaceflight industry that safety regulations are potentially detrimental to its development because of related costs. Such a misconception is quite singular. In fact there is no commercial industry in which safety risk is treated as secondary to commercial goals, costs or profits. Civil aviation, nuclear and pharmaceutical industry—even the toy industry—are examples of a deeply rooted safety culture being prerequisite for success and expansion. The idea that the pollution of the space environment by orbital debris can be controlled on a voluntary basis, and that the current safety risk of space projects cannot be substantially improved otherwise there would no space industry, is obsolete, faulty and may end up negating access to outer space for future generations. Furthermore because the safety risk of space operations is predominantly international in nature it should be no longer treated according to “local” policies.

As critical services for aviation safety move to outer space, space traffic through the international airspace increases, hybrid aero-spacecraft are developed, and aviation and space ground infrastructures and services are merged, the case for an integrated international civil aviation and space regulatory framework becomes clear. In this respect an international civil space regulatory branch within ICAO would fulfil at the international level the same role currently performed within the US Federal Aviation Administration by its space branch.

Near space, the region of outer space that extends up to and includes geostationary orbits, is nowadays a strategic asset of international interest comparable to the high seas and international airspace. The current international space treaties are insufficient to address near-space global safety and traffic management issues. It is time for a new air and space international convention.