Looking into the Future

The Case for an Integrated Aerospace Traffic Management

*Michael Chatzipanagiotis**

Abstract

Space Traffic Management (STM) is being developed to deal mainly with the problems of satellite operations and space debris. Therefore, currently is being examined separately from air traffic management (ATM). However, the advent of reusable space vehicles (RLVs) and the increase of private spaceflight operations calls for a joined examination of the STM with ATM. Among others, airspace will be shared by both aircraft and RLVs, while outer space traffic in Low Earth Orbit (LEO) will increase and begin resembling air traffic. At the same time, modernization of ATM worldwide focuses also on satellite-based navigation. Therefore, developing a comprehensive AeroSpace Traffic Management (ASTM), to include both aviation and LEO space flights, could be useful.
In this regard, some core concepts and technologies already developed or under development for ATM could set a useful example. The *Automatic Depended Surveillance – Broadcast* (ADS-B) technology uses satellite navigation to locate the position of a given aircraft and the aircraft flying nearby, and transmit it to other aircraft and the Air Traffic Control (ATC). The *4d-trajectory* management is based on the integration of time into the 3D aircraft trajectory, to ensure flight on a practically unrestricted, optimum trajectory for as long as possible, provided that the aircraft meets accurately an arrival time over a designated point. The *System Wide Information Management* (SWIM) concept envisages prompt and efficient data sharing among airspace users and Air Navigation Services Providers (ANSPs) through a wide-array network or a centralized flight data processing system. Such concepts and technologies could prove useful to regulate spaceflight traffic to and from LEO as well as coordinate such traffic effectively with air traffic.
Moreover, developing an efficient ASTM system requires designating competent authorities, which will supervise the service providers. The nature of outer space as *res nullius* is similar to international airspace, which falls under the jurisdiction of no State. Air traffic in such airspace is controlled through air navigation regional agreements, which designate a specific national or transnational authority as responsible to control the airspace and ensure flight safety, without affecting the international status of the airspace. Similarly, LEO could be divided into zones, for each of which a competent authority can be designated through special international agreements. Such authorities could be linked to a SWIM, which would include both air traffic and space traffic data available to all affected authorities, service providers and aerospace users.

* Attorney-at-law, Athens Greece, m.chatzipanagiotis@gmail.com.

I. Air Traffic Management and Space Traffic Management

Operations in both airspace and outer space are evolving. In airspace, a significant increase of air traffic is expected in the following decades. In outer space, the increasing involvement of private actors offering a variety of services is about to change the traditional operational concepts. Technological development is expected to decrease the cost of access to outer space regarding the transfer of both payloads and humans, which will increase significantly the number of space operations. Reusable Launch Vehicles (RLVs) operations, space tourism,[1] Point-to-Point Earth transportation through outer space,[2] private space stations[3] and massive deployment of microsatellites (cube sats)[4] are only but few of the new developments expected in the future. At the same time, some traditional satellite applications, like wide-band telecommunications, are going to occur through high altitude platforms in the atmosphere,[5] to decrease operational cost and enhance accuracy of service.

Such developments blend the boundaries between airspace and outer space operations, and create the need of developing unified tools for traffic management. We will examine how and to what extent some key concepts of future Air Traffic Management (ATM) could be used in Space Traffic Management (STM), to create an integrated Aerospace Traffic Management (ASTM). To this end, we need to examine first the notion and the objectives of both STM and ATM.

I.1. Space Traffic Management

Space Traffic Management (STM) has been defined as the set of technical and regulatory provisions for promoting safe access into outer space, operations into outer space and return from outer space to Earth free from physical or radio frequency interference.[6] Thus, STM aims at ensuring the unimpeded use of outer space.

---

1 See e.g. www.virgingalactic.com/human-spaceflight/your-flight-to-space/ (last visited on 30 Nov. 2015).

2 E.g. US Department of Transport, *Report on PTP commercial space transportation in the NAS* (10 March 2010), available at: www.faa.gov/about/office_org/headquarters_offices/ast/media/point_to_point.pdf (last visited on 30 Nov. 2015).

3 Messier, Douglas, *Private space stations could become a reality by 2025*, posted on 25 Aug. 2015 at www.space.com/30359-private-space-stations-reality-2025.html (last visited on 30 Nov. 2015).

4 E.g. www.zmescience.com/space/elon-musk-spacex-satellite-fleet-0560421/ (last visited on 30 Nov. 2015).

5 See e.g. Project Loon by Google www.google.com/loon/ (last visited on 30 Nov. 2015).

6 International academy of Astronautics, *Cosmic Study on Space Traffic Management*, Paris 2006, p. 10.

I.2. Air Traffic Management

The International Civil Aviation Organization (ICAO) defines Air Traffic Management (ATM) as the dynamic, integrated management of air traffic and airspace, including Air Traffic Services (ATS), airspace management (ASM) and air traffic flow management (ATFM) through the provision of facilities and seamless services in collaboration with all parties, and involving airborne and ground-based functions.[7]

The objectives of ATS is are to (a) prevent collisions between aircraft; (b) prevent collisions between aircraft on the maneuvering area and obstructions on that area; (c) expedite and maintain an orderly flow of air traffic; (d) provide advice and information useful for the safe and efficient conduct of flights; (e) notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required.[8] The ATFM aims at contributing to a safe, orderly and expeditious flow of air traffic by ensuring that Air Traffic Control capacity is optimally utilized.[9]

II. Key Concepts and Technologies in Future ATM Systems

In recent years, a transformation of the traditional ATM concepts has been taking place, to meet future challenges concerning airspace capacity, environmental protection and economic efficiency of air travel.

ICAO has laid down a new global ATM concept, the key features of which include that:

a) all airspace will be the concern of ATM and will be a usable resource;
b) airspace management will be dynamic and flexible;
c) restriction on the use of airspace will be considered transitory; and
d) all airspace will be managed flexibly, in the sense that airspace boundaries will be adjusted to particular traffic flows and should not be constrained by national or facility boundaries.[10]

The ICAO concept has begun being implemented. The most ambitious programs in this regard are the US *Next Generation Air Transportation System* program (NextGen), and the European *Single European Sky ATM Research* program (SESAR).

7 See the section *Definitions* in ICAO Procedures for Air Navigation Services, Air Traffic Management, ICAO Doc 4444, 15th ed. 2007.
8 ICAO Annex 11 to the Chicago Convention, Air Traffic Services, 13th ed. 2001, para. 2.2.
9 See ICAO Doc 4444, *supra* note 7, *Definitions*.
10 ICAO Global Air Traffic Management Operational Concept, Doc 9854, AN/458, 2005, para. 2.1.2.

II.1. Dynamic and Flexible Airspace Use and Management

According to the ICAO Global ATM Concept, all available airspace should be managed flexibly. Any restriction on the use of any particular volume of airspace will be considered transitory. The airspace will be organized and managed in a manner that will accommodate all current and potential new uses of airspace, including unmanned aerial vehicles and transiting space-vehicles.[11] Transition between areas will be transparent to users at all times.[12]

Airspace use will be coordinated and monitored, to accommodate the conflicting legitimate requirements of all users and to minimize any constraints on operations. When conditions require that different types of traffic be segregated by airspace organization (e.g. civil traffic, military traffic, transiting space traffic), then the size, shape and time regulation of that airspace will be set to minimize the impact on operations.[13]

There will always be airspace that is primarily used or organized for a specific purpose (e.g. trajectory-oriented airspace, high-density airspace, special-use airspace). However, this does not mean that aircraft neither operating in that particular mode nor equipped accordingly for such airspace will be excluded – they will be accommodated by the system where deemed safe and appropriate.[14]

In this regard, the concept of *flexible use of airspace* (FUA) stipulates that airspace should not be designated as purely civil or military, but rather as a continuum in which all user requirements are satisfied to the greatest extent possible.[15] Airspace reservations should be applied only for limited periods of time and based on actual use of airspace.[16] The FUA concept requires effective communication, cooperation and coordination between civil and military entities, which is necessary to ensure a safe, efficient and predictable use of airspace.[17] Moreover, the FUA concept should, whenever possible, be applied across national borders and/or the boundaries of flight information regions (FIRs).[18] In general, while acknowledging sovereignty, ICAO promotes the global organization of airspace: homogeneous ATM areas and/or routing areas will be kept to a minimum, and consideration will be given to consolidating adjacent areas.[19]

The most prominent example of FUA are the European *Functional Airspace Blocks* (FABs), which are unified airspace sections that comprise the airspace

---

11 *Ibid.,* para. 2.2.1.
12 *Ibid.,* para. 2.2.3.
13 *Ibid.,* para. 2.2.11.
14 *Ibid.,* para. 2.2.8.
15 ICAO Cir 330, AN/189, Civil Military Cooperation on Air Traffic Management, 2011, para. 3.2.1.
16 *Ibid.,* para. 3.3.1 (c).
17 *Ibid.,* para. 3.2.2.
18 *Ibid.,* para. 3.3.1 (d). FIRs are airspace areas, where a particular State is responsible for providing ATS. FIRs may include both national and international airspace.
19 Para. 2.2.2.

of more than one State, to focus on traffic flows, rather than national boundaries, without affecting national sovereignty. FABs are managed by a single Air Navigation Services Provider (ANSP), which, however, can also use the services of other providers.[20] This means that airspace users will be dealing with a single entity as to air navigation services, yet this entity may combine and receive information from other entities. The service providers are overseen by National Supervisory Authorities (NSAs) of the States concerned.

II.2. 4D Trajectories and TBOs

The 4d trajectory concept is based on the integration of time into the 3D aircraft trajectory. We can consider a 4d trajectory as an enhanced flight plan with the addition of time details during the flight: at the moment T, the aircraft will be at X longitude, Y latitude and Z altitude.

This concept aims to ensure flight on a practically unrestricted, optimum trajectory for as long as possible, provided that the aircraft meets very accurately an arrival time over a designated point.[21] Such *Trajectory Based Operations* (TBOs) and the related Trajectory Management concept entail the systematic sharing of aircraft trajectories among various participants in the ATM process, to ensure that all partners have a common view of a flight and access to the most up-to-date data available to perform their tasks.[22] Thus, dynamic 4d trajectories will be a key element in future air traffic synchronization.[23]

II.2.1. Establishment and Implementation of 4D Trajectories

Non-detailed 4d trajectories are initially communicated to the "demand and capacity balancing service" of ATM, to facilitate strategic airspace organization and management. Such communication occurs several months before flight and provides information on intended operations, with accuracy appropriate to the planning stage.[24]

When the availability of forecasts allows for meteorological flight planning, the airspace user will negotiate the "user-preferred" 4d trajectory with the demand-and-capacity-balancing service of the ATM provider. The "user-preferred" 4d trajectory includes route, altitudes, speeds and, where feasible with respect to the planning horizon, runway and arrival times, taking into account weather, airspace constraints, aircraft performance capability and

---

20 See Arts 8-10 of Regulation (EC) No 550/2004 (Official Journal L 096, 31.03.2004 pp. 10-19).

21 www.skybrary.aero/index.php/4D_Trajectory_Concept#Further_Reading (last visited on 30 Nov. 2015).

22 SESAR Concept of Operations, Step 1 para. 3.1.1, available at www.sesarju.eu/sites/default/files/documents/highlight/SESAR_ConOps_Document_Step_1.pdf (last visited on 30 Nov. 2015).

23 ICAO, Global ATM concept, *supra* note 10, para. 2.1.5.

24 *Ibid.,* paras. 6.11, 7.2.

user constraints such as schedules.[25] If users are aware of restrictions that will prevent the preferred trajectory, they may also propose a preferred alternative trajectory.[26] Hence, the user-preferred trajectory is a flight route most closely matching user expectations.

The ATM provider will communicate the available trajectory, complete with departure time, weather data and waypoints with estimated time/altitude/speed to the flight deck (aircraft) for acceptance.[27] This "system-delivered" trajectory should be as near to the requested 4d trajectory as possible.[28] The airspace user can negotiate the system-delivered trajectory as part of the collaborative decision-making process.[29]

Once an agreement has been reached, the "negotiated" trajectory will be produced, which will be stored for access by all potential ATM service providers. The agreed 4d trajectory will be approved with tolerances, which will constitute a "4d trajectory contract" between the airspace user and the service provider. The intent of these tolerances is to provide the airspace user with some freedom for changes within the trajectory, without further reference to the service provider. The tolerances are intended to provide as much flexibility as the ATM system can allow, while balancing the requirements of other airspace users.[30]

II.2.2. Implementation of 4D Trajectories

After the 4d trajectory has been agreed upon, there may be changes either in ATM resources or in the situation of the airspace user. Then, a new trajectory will be negotiated.

The initially agreed 4d trajectory may be amended by the provider of aerodrome operations services regarding mainly the departure phase of the flight, in which interaction with other departing or arriving aircraft may occur. Further amendments are possible en-route due to unforeseen factors, e.g. adverse weather, equipment malfunction, destination arrival delays, the need for conflict management and resolution with other flights, changes in airspace capacity, changes to aircraft performance, etc. Eventual arrival delays should be absorbed during the amended en-route 4d trajectory.[31] Any deviation from the negotiated trajectory will be negotiated anew directly between the flight deck (aircraft) and the ATM service delivery management.[32] Collaborative decision making will consider alternative trajectories. If time permits, several

25 *Ibid.,* para. 7.3.
26 *Ibid.,* para. 6.12.
27 *Ibid.,* para. 7.4.
28 *Ibid.,* para. 7.6.
29 *Ibid.,* paras. 6.13-6.14.
30 *Ibid.,* para. 6.15.
31 *Ibid.,* para. 7.9.
32 *Ibid.,* para. 7.7.

options may be considered; however, if time is limited, this process may be replaced by pre-agreed procedures and preferences.[33] Any amended trajectory will be dynamically provided to the ATM system, to become available for other ATM processes and airspace users that may be affected.[34]

II.3. System Wide Information Management

System Wide Information Management (SWIM) is a technology enabler that provides the Information Technology (IT) standards, infrastructure and governance necessary for ATM systems to share information, improve interoperability, and reuse information and services.[35] It is a net-centric system of sharing information in real-time among all ATM stakeholders (ANSPs, aircraft operators, airport operators, military authorities etc.), so that each user has the information it needs at the time it needs it.

ICAO defines SWIM as "an advanced technology program designed to facilitate greater sharing of ATM system information, such as airport operational status, weather information, flight data or status of special use airspace". SWIM will replace the current system of sharing information, in which information is provided point-to-point between two specific users that have to be connected using the same protocol and the same data interface.[36] Under SWIM, all airspace users and service providers will be able to communicate with each other through a centralized platform, using interoperable systems. They will have access to the same information on the current and forecast status of the ATM system.

As a result, the SWIM will improve collaborative decision making and situational awareness.[37] It will contribute significantly to the safety of the flights, because shared data reduce the chances of misinterpretation, improve awareness of weather hazards (e.g. thunderstorm activity) and mitigate the risk of traffic overloads.[38]

In order to achieve the objective of providing each ATM stakeholder timely with pertinent and accurate information, information provision will be separated from information consumption: information will not be provided through bilateral point-to-point connections between stakeholders, but through net-centric operations.[39] In the ATM network, almost every participant is a producer as well as a consumer of information. Decoupling producers of information from potential consumers avoids the need of deciding in

33 Para. 6.16.
34 Paras. 6.18, 7.7.
35 https://www.faa.gov/nextgen/programs/swim/overview/ (last visited on 30 Nov. 2015).
36 Ibid.
37 ICAO Global ATM Concept, *supra* note 10, para. 6.18.
38 SESAR ConOps, *supra* note 22, para. 3.7.1.
39 SESAR SWIM Factsheet, pp. 2-3, available at www.sesarju.eu/sites/default/files /documents/reports/factsheet-swim.pdf (last visited on 30 Nov. 2015).

advance who will need what information, obtained from whom and when. As a result, the number and nature of the consumers can evolve through time.[40]

II.4. ADS-B

Automatic Dependent Surveillance – Broadcast (ADS-B) is a surveillance technique that transmits the identity of the aircraft and data derived from Global Navigation Satellite Systems (GNSS),[41] especially position and velocity, to Air Traffic Control (ADS-B Out) and to other aircraft (ADS-B In).[42] ADS-B In can be used for multiple applications, including Cockpit Display of Traffic Information, which provides a graphical depiction of air traffic, and Guidance Display, which provides relative guidance, predominantly based on speed control, to maintain a given spacing from a selected target.[43] ADS-B is *automatic*, because no external stimulus is required, and *dependent*, because it relies on on-board systems to *broadcast* surveillance information to other parties.[44] As a result, ADS-B is a key technology to future ATM and is going to replace current surveillance radars, providing more accurate data on airborne traffic situational awareness and facilitating spacing, separation and self-separation.

II.5. Data Communications

Data communications are going to replace current voice communications between air traffic controllers (ATCO) and cockpit. Pilots and ATCO will communicate using electronic data, which can convey information of much larger volume and complexity, as well as of higher quality. Such information can be processed by ground and on-board information management systems.[45]
Data communications are one of the crucial technology enablers of the planned integrated and collaborative ATM. They enable real-time negotiation of 4d trajectories between ANSP and pilots, and real-time sharing of information for all aircraft on aircraft position, navigation and identification, information on weather and security, on the operational status of the aircraft and the ATM.[46]

---

40 SESAR ConOps, *supra* note 22, para. 3.7.1.
41 E.g. GPS, GALILEO, GLONASS etc.
42 See www.skybrary.aero/index.php/Automatic_Dependent_Surveillance_Broadcast_%28ADS-B%29 (last visited on 30 Nov. 2015).
43 FAA/AST *Point-to-Point Commercial Space Transportation in National Aviation System, Final Report,* March 10, 2010, available at www.faa.gov/about/office_org/headquarters_offices/ast/media/point_to_point.pdf (last visited on 30 Nov. 2015), p. 12.
44 Ibid.
45 See https://www.faa.gov/nextgen/update/progress_and_plans/data_comm/ (last visited on 30 Nov. 2015).
46 See details in Concept of Operations for the Next Generation Air Transportation System, Version 3.2, Washington 2005, pp. 4-6 et seq., available at http://docplayer.net/927153-Concept-of-operations.html (last visited on 30 Nov.

III. Future ATM and STM

The above concepts and technologies could be useful in STM. Space objects transiting airspace should be accommodated in the new ATM system. At the same time, future ATM concepts and technologies could be adjusted for use at least in Low Earth Orbit operations.

III.1. Accommodation of Space Traffic in Future ATM

The implementation of future ATM technologies and concepts to space vehicles transiting airspace is being studied extensively, especially in the United States (US).

The US envisages using in the its National Airspace System (NAS) *Space Transition Corridors* (STCs) and *Flexible Spaceways* for frequent space operations.[47] STCs will be defined according to the needs of the specific operations and will be dynamically issued and withdrawn, as necessary, to maximize safety while minimizing the impact to air traffic.[48]

Such corridors currently represent mainly segregated airspace, i.e. airspace closed to air traffic, either permanently in the form of Special Use Airspace, or temporarily in the form of Temporary Flight Restrictions.[49] However, the current practice will not be sustainable in the future, when a significant increase in both air traffic and space traffic is expected. Therefore, the principles of Functional Use of Airspace are expected to apply, according to which airspace segregation in both spatial and temporal terms will be minimized.

Flight through space transition corridors could be conducted using 4d trajectories, which is also being studied by the FAA. However, the implementation of Trajectory Based Operations (TBO) in transiting space traffic may have certain limitations, related mainly to the flight profile and maneuverability of certain types of vehicles, such as ballistic launching and re-entry, as well as unpowered flight after re-entry (gliding in the atmosphere). Thus, TBO for space vehicles will need to be organized taking these limitations into account and upon thorough technical research.[50]

2015). As to Europe, See also Art. 3a of Regulation (EC) No 551/2004 (OJ L 096, 31.3.2004, p. 20), as amended by Regulation (EC) No 1070/2009, which foresees the provision of electronic aeronautical information to airspace users.

47 FAA, *Concept of Operations for Commercial Space Traffic in the National Airspace System*, v. 2.0, May 11, 2001, p. 4, available at https://www.faa.gov/about/office_org/headquarters_offices/ast/media/CST_CONOPS_v2.pdf (last visited on 30 Nov. 2015).

48 Murray, Daniel P./ van Suetendael, Richard, *A Tool for Integrating Commercial Space Operations into the National Airspace System*, paper presented at the AIAA Atmospheric Flight Mechanics Conference and Exhibit, 21-24 August 2006, Keystone, Colorado, p. 3, available at https://www.faa.gov/about/office_org/headquarters_offices/ast/reports_studies/media/aiaa-2006-6378-450.pdf (last visited on 30 Nov. 2015).

49 Murray/ van Suetendael (*supra* note 48), p. 2.

50 FAA/AST PTP Study (*supra* note 43), p. 16.

At the same time, the need of space vehicles, especially manned ones, to have ADS-B equipment on board has been recognized.[51] This way, pilots of aircraft and space vehicles, as well as the Air Traffic Controllers will have increased situational awareness.[52] In the same vein, data communication equipment and connection to SWIM is also deemed necessary.[53] Concerning space traffic transiting the airspace of more than one State, the US envisages managing air and space traffic by dividing Earth into six regional operational segments.[54]

III.2. Expansion of Future ATM Concepts to LEO

A further step would be to expand and adjust the above future ATM concepts for operations in Low Earth Orbit (LEO), concerning mainly manned space operations.

Operations in LEO are operations in outer space environment and are quite different from operations in airspace: there is zero gravity; space objects, the vast majority of which are unmanned, orbit the Earth; Radio-Frequency communications may be affected during re-entry[55] in the atmosphere or because of interference with the ionosphere of the Earth.[56] Therefore, not all future ATM concepts are applicable to LEO, while adjustments to the operational environment of outer space are necessary.

Since space objects move in stable orbits, transferring the concept of dynamic and flexible use of airspace to outer space operations does not appear very feasible.

The same goes for 4d trajectories and TBOs, in principle. Earth orbits are natural 4d trajectories. Nonetheless, 4d trajectories make sense for re-entry operations, in which entry to a specific Space Transition Corridor has to occur at a specific time and place to ensure safety.

---

51 FAA/AST Study (*supra* note 43), p. 12. Orndorff, Gregory/ Boone, Bradley/ Kplan, Marshall, *Space Traffic Control: Technology thoughts to catalyze a future architecture*, Paper presented at AIAA SPACE 2009 Conference & Exposition, 14-17 September 2009, Pasadena, California, available at http://enu.kz/repository/2009/AIAA-2009-6485.pdf (last visited on 30 Nov. 2015), pp. 6-7.

52 FAA/AST Study (*supra* note 43), pp. 12, 15-16.

53 FAA/AST Study (*supra* note 43), p. 12.

54 FAA, *Space Transportation Concept of Operations, Annex for NextGen*, available at https://www.faa.gov/about/office_org/headquarters_offices/ast/reports_studies/library/media/Space_Transportation_Concept_of_Operations_Annex_for_NextGen.pdf (last visited on 30 Nov. 2015), p. 34.

55 See Hartunian R.A. et al. *Causes and mitigation of Radio Frequency (RF) Blackout during Reentry of Reusable Launch Vehicles*, Aerospace Corporation Report No ATR-2006(5309)-1, 26 January 2007, available at www.researchgate.net/publication/254895057_Causes_and_Mitigation_of_Radio_Frequency_%28RF%29_Blackout_During_Reentry_of_Reusable_Launch_Vehicles (last visited on 30 Nov. 2015).

56 See e.g. www.ips.gov.au/Educational/1/3/2 (last visited on 30 Nov. 2015).

On the other hand, a System Wide Information Management (SWIM), in which all orbital data of both functional and non-functional space objects are entered, would be an extremely useful tool. A SWIM would boost situational awareness in LEO for all users, like operators of satellites, Reusable Launching Vehicles, space stations etc.
The same applies to ADS-B, which would promote significantly human spaceflight safety. Especially ADS-B Out technology could provide spacecraft pilots and operators of space stations with valuable information from both manned and unmanned space objects.
Data communications between spacecraft and STM authorities will also be of primary importance in information sharing.

III.3. Regulatory Requirements

In order to implement the above concepts and technologies, regulatory changes would be necessary.

III.3.1. Delimitation of Outer Space

Delimitation of outer space is necessary, in view of the fundamental differences between aviation and space law as to national sovereignty.
The State retains national sovereignty in the airspace above its territory (Art. 1 CC). Thus, ATM remains a primarily sovereign function, even when it is exercised through international cooperation. On the contrary, outer space cannot be appropriated by any State and it remains free to use and explore (Art. I OST). Thus, effective STM can only be based on international agreements. An integrated AeroSpace Traffic Management (ASTM) requires the delimitation of outer space, in order to set the limits to the right of unilateral action of States.

III.3.2. Transit Rights

Under current international law, space objects have no right to transit foreign airspace ("right of innocent passage"), because of the established principle of absolute State sovereignty in the airspace above national territory, recognized by Art. 1 CC.[57] However, establishing such right is supported by various

57 E.g. Wassenbergh, Henry A., *Principles of Outer Space Law in Hindsight*, Dordrecht 1992, p. 37; Schwenk, Walter, *Der Durchflug von Weltraumgegenständen durch den nationalen Luftraum*, Zeitschrift für Luft- und Weltraumrecht 1982, pp. 1 et seq.; Cheng, Bin, *Studies in international space law*, Oxford 1997, p. 649; Benkö, Marietta / de Graaf, Willem, *Questions relating to the definition/delimitation of outer space and outer space activities and the character and utilization of the geostastionary orbit* in: Benkö Marietta et al. (eds), *Space Law in the United Nations*, p. 121 (135). Compare, however, *Cosmic Study on STM*, *supra* note 6, pp. 88-89, which doubts the applicability of the 1944 Chicago Convention to spacecraft.

scholars and the Russian Federation has already granted such right concerning its own airspace.[58]

Transit rights of foreign space objects through national airspace should be established, because they would facilitate relations between States. Nevertheless, each State is internationally responsible for assuring the safety of air traffic in its national airspace.[59] At the same time, States bear a notification duty towards other States for eventual risks their operations pose (Art. XI OST). Therefore, the expected dense traffic in the upper airspace would necessitate prior clearance from aerospace traffic control center for safety reasons. As a result, spacecraft operators will have to issue at least a form of previous notification to the territorial State, regardless the issue of transit rights, to receive clearance and enable coordination with air traffic and maritime traffic.[60]

III.3.3. Development of STM Principles and Technical Rules

Integration of space traffic into ATM and establishment of a STM system require comprehensive planning at both strategic and tactical level. Hence, adjustment of ATM concepts to the needs of space vehicles and possibly development of new concepts are necessary.

These concepts should be combined with technical requirements on equipment and procedures for their implementation. Therefore, technical standards and recommended practices should be developed also for space vehicles and space traffic, in order to have a functioning traffic management system.[61]

III.3.4. International Coordination

The above standards and recommended practices could function most effectively, if they are based on international cooperation and coordination.

Ideally a global STM master plan, which will explain the concept of operations, should be laid down. This could be the work of a global international organization, based on existing structures (ICAO, UNCOPUOS) or even on a new structure like the International Space Flight Organization, envisaged by the FAA in the past.[62]

---

58 Art. 19 of the Russian Law on Space Activity.

59 See Arts 12 and 28 of the Chicago Convention and Annex 11 thereto, *supra* note 8, para. 2.1.1.

60 Compare *Cosmic Study on STM*, *supra* note 6, p. 89, which recommends notification of and coordination with local maritime traffic and air traffic authorities.

61 *Cosmic Study on STM*, *supra* note 6, p. 89.

62 FAA, Concept of Operations for Commercial Space Traffic in the National Airspace System, *supra* note 47, p. 8.

This global STM master plan ought to be combined with regional aerospace navigation plans and agreements.[63] Guidance could be drawn from the existing regional air navigation agreements.[64] It might be helpful if such plans and agreements were the extension and modification of the already existing regional navigation agreements, since transiting space traffic would necessarily be part of the air traffic in the lower airspace.

Such regional agreements could be combined with *Integrated Functional Aerospace Blocks* (IFABs) at the example of the European FABs. These IFABs could ensure international cooperation of the underlying States on a functional level without affecting national sovereignty.

IV. Conclusion

Both STM and ATM share the objective of ensuring the safety of flights and operations from collisions with other vehicles. The advent of new technologies and the increasing use of both airspace and outer space by a growing number of actors render necessary not only the accommodation of space traffic into ATM concepts, but also the elaboration of an Integrated Aerospace Traffic Management. In this respect, some of the main concepts and key technologies of future ATM could be adjusted for application to space objects, especially manned ones. Flexible Use of Airspace and Trajectory Based Operations would be very useful during access and return from outer space. System Wide Information Management, Data Communications and Automatic Dependent Surveillance – Broadcast could increase significantly situational awareness as to operations in both airspace and Low Earth Orbit.

The successful implementation of these concepts and technologies requires the development of appropriate legal and technical rules through extensive international cooperation. From a legal view, delimitation of outer space and establishment of transiting rights through national airspace upon appropriate notification would be very useful. From a technical view, the development of uniform technical standards and recommended practices, as well as of a global ASTM Master Plan, implemented through regional international agreements, would be necessary.

---

63 In this regard compare FAA, *Space Transportation Concept of Operations, Annex for NextGen*, *supra* note 54, p. 34, which proposes six global STM regions of responsibility.

64 A regional air navigation agreement is an agreement approved by the Council of ICAO usually based on the outcome of the findings of Regional Air Navigation Meetings. Regional air navigation agreements determine the portions of international airspace where ATS will be provided as well as the State or interstate agency responsible for the provision of such services – See Annex 11, *Air Traffic Services*, *supra* note 8, paras. 2.1.2-2.1.3.