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Space Traffic Management: A Challenge of Cosmic Proportions

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Abstract
Space traffic management has often, for example in the IAA Cosmic Study of 2006, been rather broadly defined as "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from space to Earth free of physical or radio-frequency interference." Oftentimes, especially in space law literature, references or even comparisons have been made to traffic management as it has developed in aviation and (to a lesser extent) in maritime transport.

However, it should be realized that space traffic management, especially under the definition quoted, comprises a considerably larger range of activities than air traffic management. If space traffic management is ever to become feasible, therefore, rather than just referring to air and/or maritime traffic management, first a high-level overview should be performed of what space traffic management effectively will comprise, what has already been taken care of and to what extent, and where perhaps guidance from the aviation realm may be useful after all.

The present paper will provide such a first high-level inventory, duly taking into account the various special features of space activities which may provide major obstacles for any truly comprehensive space traffic management regime, much more so than in the airspaces of this world.

1. Introduction

Space traffic management has often, for example in the IAA Cosmic Study of 2006, been rather broadly defined as "the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from space to Earth free of physical or radio-frequency interference."[1] Oftentimes, moreover, especially in space law literature, references or even comparisons have been made to traffic management as it has developed in aviation and (to a lesser extent) in maritime transport.

However, if space traffic management is ever to become feasible, such comparisons should be scrutinized with great care. "Space traffic management" would not only encompass the orderly management of (1) "piloted vessels," which is what air traffic management is at the heart all about, but in addition would have to deal with (2) "vessels" which are piloted remotely (read "unmanned spacecraft"), some of which moreover intend to operate in earth orbits for many years whereas others by contrast are supposed to move beyond earth orbit altogether, (3) "vessels"—and their component and fragmented parts—which are no longer "piloted" in any meaningful sense (read both "small unguided satellites" and "space debris"), and, following the Cosmic Study definition, as an even more different "item," (4) the use of radio frequencies. Moreover, several specific aspects of space activities, such as the military and dual-use ones, the physical operational environment and the needs for communication, as well as the speed of movement pose additional problems for any truly comprehensive space traffic management regime, much more so than in the airspaces of this world.

Thus, the present paper represents a first high-level framework analysis of the major structural aspects of that challenge—on the assumption that it would still need to be addressed in the not too distant future.

2. The point of departure: "traffic management" in air law

The term "traffic management," in particular in an international context, has mainly become an issue of importance in aviation and, to a considerably lesser extent (due to the velocity of the vessels concerned being a dimension or two smaller), in maritime transport.

In international aviation, "air traffic management" (ATM) has evolved out of the more concise and limited notion of "air traffic control" (ATC). Whereas the latter was very much focused on specific (legal as well as resulting factual) control of aircraft movements to avoid collisions and near-collisions of aircraft for safety reasons (as well as subsidiary, security purposes of controlling entry into sovereign airspace),[2] the former came to incorporate also broader aspects such as efficient and environmentally friendly use of airspace.[3]

In all cases, however, the baseline category of targeted vehicles was fairly straightforward and, at a certain level of abstraction, uniform in nature: "aircraft," meaning "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface"[4] capable of considerable maneuvering even at short notice since being piloted by humans on board. Compared to the four categories which the Cosmic Study asserts should be addressed by space traffic management, this represents the aviation version of only the first category, that of piloted vessels.

In addition, from a legal perspective, the authorities responsible for ATM were clearly demarcated by "geographical," "spatially" defined borderlines. Every state was sovereign in its own national airspace, which was clearly bounded by the borders of its territory and territorial waters,[5] and could within such sovereign airspace guarantee the implementation of a coherent and comprehensive ATM system. That the vertical boundary of airspace sovereignty was not in any way formally determined constituted no problem, at least from the perspective of air law: nobody would dispute that all aircraft addressed by ATM systems were flying in airspace as opposed to any other kind of "space," read: outer space.

As for the airspace above international waters, under the auspices of the International Civil Aviation Organization (ICAO) specific states were "appointed" to provide for such an ATM system on behalf of the international community and such a role was formally accepted by all other ICAO member states.[6] While "geographically" speaking such international airspaces covered the greater part of the globe, in terms of actual aircraft operations they were much less relevant than the totality of sometimes heavily used national airspaces. International air law, including on ATM as developed under ICAO auspices, was thus allowed to develop almost organically from the handling of most aviation needs at a national level.

In sum, for respective national airspaces each time one single national authority was made responsible for the management of all relevant traffic and given the competences and instruments to do so, whereas for the international airspaces one single intergovernmental organization operating under a single international conventional regime ensured proper arrangements of such responsibilities, competences and instruments.

Though formally military aircraft did not fall under the rules of the Chicago Convention,[7] individual states would of course in their national ATM systems take care of any potential interference of military aircraft with civil aviation wherever this could—occasionally—be at issue, for example by the creation of special "no-fly zones" reserved for air force maneuvers.

These ATM systems also generically allowed for special flights of aircraft not engaged in civil aviation as principally addressed by the Chicago Convention and ICAO, whether this concerned commercial aviation (the small business jets), amateur aviation, aviation sporting events, hot air balloons or even rocket launches (where the launch area would become a temporary no-fly zone for the duration of the launch window). This simply worked, principally because there was little question—or at least an underlying assumption—that ATM could focus on civil aviation and handle other uses of the same three-dimensional spaces as exceptions to the standard approaches and procedures.

The core of the system finally consisted of two main elements: (1) awareness with a central entity of the positions and intended trajectories of all aircraft and occasional other craft—all, however, so far comprising "piloted vessels"—in a certain three-dimensional airspace, and (2) the competence of such an entity, following *a priori* rules, regulations, procedures, and standards, to direct specific aircraft to change position or trajectory in such a manner as to avoid threats to safety or security or allow for efficient use of airspace.

While undoubtedly the example of ATM would thus be very interesting and useful in a number of respects when it comes to creating a space traffic management system, when transferring this comprehensive but straightforward and relatively monolithic system-of-systems to outer space the above evaluation has to be borne in mind. At least three major issues would consequently arise here.

3. The awareness issue: the reality of spaceflight

First, the maneuverable manned vessels which formed the core of the global ATM system comprise, certainly so far, a minority of all vessels moving in outer space. A system mainly based on communicating with pilots would consequently fall woefully short of a comprehensive and safe system of "awareness." Self-reporting by automated devices would need to be comprehensively effectuated to establish that.

In addition, for unmanned spacecraft any traffic management system should substitute such communication for awareness purposes with pilots and automated onboard systems with communication to the ground control systems. That should not be an insurmountable problem, yet it has to be taken into account—for instance, because a particular space object may be monitored by various ground stations spread across the globe depending upon the particular location at issue at any given point in time.

For unguided small satellites and space debris, however, mostly even that approach of taking on board ground stations would not work—both would normally not have any automated self-reporting capability on board (anymore). Whereas for the unguided small satellites—hopefully—proper registration with the Registration Convention[8] combined with the usually short duration of their presence in a limited area at the lower margins of outer space would be sufficient to create positional awareness of maneuverable spacecraft as part of a space traffic management system, it does indeed require an across-the-board application of the registration obligations. Currently, however, the picture in this regard is not very comforting; many small satellites as of yet go unregistered because of confusion on the applicability of the Registration Convention to "a space object [not] launched into Earth orbit beyond."[9]

As for space debris, however, it has already become abundantly clear that no amount of fully-fledged application of the Registration Convention would be able to take care of the extent to which a space traffic management would require relevant position and trajectory information.[10] While there are some "unilateral" efforts to provide the international community with data on identified space debris, such as the US Space Surveillance Network (SSN), also these are currently far removed from the level of comprehensiveness necessary for a viable and effective space traffic management system.[11]

Finally, the use of radio frequencies for communication purposes has of course also been present in aviation almost since its inception, and through the ITU system does allow for at least a general level of "awareness."

A summary investigation of current law and key players in the realm of awareness thus shows the complexity of (and the loopholes within) the existing landscape. An ITU-regime takes care of assignment of frequencies used by satellites as well as the attendant orbital slots or orbits at the international level, with some national regimes implementing that regime for national operators—but also for exclusively national usage of frequencies and orbital slots/orbits. Frequencies used by space vehicles, whether sub-orbital or orbital, and space stations such as the ISS, also somehow fit within that system.

The Outer Space Treaty at the same time "rules" the general behavior of states with respect to satellites and other space objects, notably including the notification and consultation obligations under Article IX. Further to Articles VIII and IX of the Outer Space

Treaty, the Registration Convention provides for its own—though rather summary—system of "awareness," read registration of main parameters, including national registration as appropriate. As said, there is furthermore considerable doubt regarding its application to sub-orbital launches, whether manned or unmanned.

As for "space debris," that system is rather unsatisfactory, and awareness exclusively relies on a few national, unilateral surveillance systems, as indicated.

4. The competence issue: the "*faits accomplish*" of space (law)

Second, in outer space there is no system for allocating ATM-like authority along the lines of the Chicago Convention, individual sovereign states and the ICAO system. Unlike air space, outer space of course as a whole falls outside of individual states' sovereign jurisdiction[12] and thus basically equates with the (airspace above the) high seas in terms of its international legal status. And whereas the Chicago Convention has provided the baseline formula for handling ATM above the high seas under ICAO guidance further to individual states operating domestic ATM systems in national airspace, there is no comparable provision in the Outer Space Treaty or comparable authority resting with COPUOS to assume the central coordinating role of ICAO in its framework—including in the context of ITU-related frequency management.[13]

Yet, simply providing ICAO with an extension of its authority to address aircraft so as to encompass also spacecraft not only would require considerable expertise with space flight (generally available much more in specialized space agencies than at ICAO) and profound adaptation of the system of the Chicago Convention (such as overhauling the current definition of "aircraft" quoted above), but also would ignore a few fundamental aspects of current space activities and space law which would make the exercise of such authority by ICAO a rather different paradigm as compared to its longstanding role in international aviation.

To start with, the ICAO system of "competence" hinges on communication with pilots to initiate flight maneuvers following the directions of an ATM authority—but piloted vessels only comprise one category out of four needed to be regulated by a space traffic management system.

For the other categories, it would be required to establish a system addressing the remote control mechanisms instead. For the second category this might still work, although one needs to be aware again that a number of ground stations may come into play, as opposed to the piloted vessels which operate under the single authority of the aircraft commander.

Then again, the third category could still not be properly addressed, as this consists of space objects which are, by definition, nonguidable. This category, in other words, is essentially beyond any "compliance."

As for the fourth category: it was never envisaged as an element to be regulated by traffic management, as the Cosmic Study would have it, but instead as an element to allow traffic management to become possible in the first place! The role of ICAO and its member states in ensuring that such radio frequency use was duly protected in the context of the

ITU thus also was a key element of air traffic management itself, where no comparable international construct exists for space traffic management.

Furthermore, as indicated, contrary to ATM technology which is widely available across the world, only a handful of states currently possess the actual possibility—read technology—to generate and properly use the information needed to order spacecraft around for safety purposes as part of a space traffic management system. In view of the major military and dual-use aspects of space activities, those few states would already have a fundamental problem with freely sharing such information—whereas on the other end, space activities by definition having a global impact, all other states may not feel comfortable with becoming lopsidedly dependent on such information—let alone with directive management of their space activities and spacecraft.[14]

Furthermore, in terms of the law, ICAO would not step into a vacuum. COPUOS has by way of the space treaties and more recently for example the COPUOS Guidelines on Space Debris Mitigation provided for a legal framework for space activities that, although far from sufficient to provide for or even deal with space traffic management, does provide for some important legal framework rules and principles.[15] Even more pertinently, as indicated, with regard to the last major element to be incorporated into any viable space traffic management system, the use of radio frequencies has since a number of years been (by and large satisfactorily so) arranged through the mechanisms available with the ITU—which as a matter of fact also addressed the orbital slots respectively orbits the spacecraft using those frequencies were to occupy.[16] No future space traffic management could feasibly be envisaged without recognition, likely even proper integration, of these existing legal regimes.

Also in the realm of competence a summary investigation of current law and key players thus shows the complexity of (and the loopholes within) the existing landscape.

The ITU does not so much "possess a competence" to determine relevant elements of space traffic management in the context of frequencies and orbital positions, but rather represents a "gentlemen's system of exchange of information and coordination of behavior for the common good"—largely dependent furthermore on national implementation by those with real authority to direct operators to move a space object. Would that be really sufficient for an all-encompassing space traffic management system, in an environment where more and more commercial interests interfere with the more traditional military and political interests?

To begin with, this addresses essentially at best only two out of the four Cosmic Study categories in any comprehensive manner: radio frequencies and unpiloted vessels—the latter actually only to the extent completing orbits around the earth (including for this purpose the geostationary orbit).

Whereas space traffic management competence in the context of space debris boils down to the right to move it out of harm's way, this essentially accrues not to any international organization, platform or system-of-systems but to the state accountable for it in the first place, witness also the discussion on space debris remediation as potentially requiring states to allow their defunct space objects to be taken out of harm's way by other states willing to do so, along the lines of the concepts of "abandonment" and "ship wrecks" in the law of the sea.[17]

Finally as to piloted vessels, while they also use radio frequencies, the ITU has no authority whatsoever to determine where these vessels should fly, or even what messages the radio frequencies to be used are to transmit in that regard. That remains exclusively the competence of the states operating (or, in the future with private manned spaceflight, controlling) such vehicles.

Even in the United States, however, the state furthest advanced in (addressing) manned spaceflight management, the discussion on how to exercise US jurisdiction in space *inter alia* for traffic management purposes is only just gearing up.[18]

Here, it should be noted moreover that developments seem to go against any more or less straightforward extension of air law at least for the purposes of traffic management to outer space. Noting of course that we have not seen any actual such flights yet, the United States has chosen not to address key issues for traffic management purposes such as permission to operate and use a certain trajectory as a special kind of aviation, but as a (space) launch activity.

Thus, it was the 1984/1988 Commercial Space Launch Act which was amended in 2004 to address seemingly impending private commercial sub-orbital flights.[19] In the launch license due attention is given to the permitted launch trajectory, if only for the purposes of calculating the Maximum Probable Loss (MPL) which forms the basis of any third-party liability of the operator and the insurance he is obliged to take out to cover such liability.[20] US air law and ATM regulations would only come into the picture to the extent of the habitual temporary clearance of US airspace around the launch site. The most recent step here is effectively just a first step: a requirement imposed by Congress upon NASA in conjunction with other relevant US government bodies "to *study* alternate frameworks for the management of space traffic and orbital activities."[21]

While in Europe for some time an effort (meanwhile aborted or at least put on hold) was made to address the future operations of at least those sub-orbital vehicles that fitted the definition of "aircraft,"[22] this focused on the certification of such craft as per EASA,[23] not on ATC and ATM as per Eurocontrol.[24]

5. The issues of "delimitation" and "innocent passage"

Third, whereas for air law purposes the need to determine where, vertically speaking, (sovereign) airspace gives way to outer space did not really exist, for purposes of a future space traffic management system it seems that this would have to change. This directly relates to the question of "innocent passage" through foreign airspace on the way to or back from outer space, as this has often been posited analogously to the law of the sea.[25] Is a spacecraft flying at altitudes of 60, 80, 100 respectively 120 km over the territory of a state different from where it took off already in outer space, meaning that the underlying state cannot claim any sovereign territorial control over that spacecraft, including subjecting it to its national (air) traffic management system? Or would such spacecraft still be considered as crossing a foreign state's sovereign airspace, in which case the latter's jurisdiction allows it to condition such flight on compliance with certain traffic management regulations or even completely prohibit it—unless the aforementioned "innocent passage" applies, in which case the underlying state presumably would still be allowed to impose traffic management–related obligations, as long as not thereby effectively denying passage as such.[26]

As sufficiently discussed elsewhere,[27] the best that could be said is that as of today a convergence could be noted on agreement to take the 100-km altitude line as presenting the legal boundary between airspace and outer space, which would be ready to morph into customary international law if it would not be for the official resistance of the United States, the leading spacefaring nation of today certainly when it comes to private manned spaceflight, to accepting such a boundary line—or indeed, any legal boundary.

6. Toward a solution?

In any event, in contrast to aviation, the vast majority of space operations to be subjected to a future space traffic management system takes place in a global commons as opposed to sovereign territories. This fact alone makes the role of some kind of intergovernmental organization on space traffic management more crucial and indispensable still than ICAO for international aviation, which after all was established after several decades of international commercial aviation had already passed by.

Much more than in aviation, the management of traffic in outer space for the purpose of safe flights of manned and unmanned vehicles alike, would require a near-comprehensive space situational awareness system taking into consideration not only the many objects unmanned and difficult to maneuver but also the many objects impossible to maneuver—yet capable of causing devastating damage to other spacecraft by impact. After all, as compared to aviation, the speed of movement has become a dimension or two larger still, making it even less likely for visual or other last-minute course corrections to remain the ultimate solution for avoiding accidents or serious threats thereof. Also the communication with those space objects that are capable thereof would largely differ from the classical modes of communication with aircraft, in view of most of the aforementioned ones being unmanned.

Perhaps the most helpful approach is to start by recognizing that at the end of the day an intergovernmental authority, whether existing or newly to be established, should approach the issue of space traffic management along the lines of ATM over the high seas: get all states to agree within the bounds of an international regime for specific states to provide the services necessary in a particular part of outer space for everyone concerned to operate safely and efficiently—and without violating existing international law or otherwise threatening the international peaceful status quo regarding outer space.

Where this would, likely, for the foreseeable future not be a politically feasible option, a start could be made on the level of awareness—as is currently, to some extent, done by way of various space situational awareness initiatives. From such an "awareness system" a "competence system" should evolve along gradual lines, not necessarily immediately giving rise to a comprehensive globally accepted legally binding construct.

In a first step, this could give rise to an optional adherence to such a system by a few leading—and farsighted—states willing to take a bow to an international regime, perhaps even entity, for the sake of an ultimately better and safer space environment.

In a second phase, such an adherence could then gradually translate into a major factor mitigating liabilities in particular in the context of fault liability for damage caused by one space object to another. Ultimately, thus the ground could be prepared for the third and final step: a properly binding system of space traffic management with an effective international dispute settlement mechanism.

Depending on whether there would be such a massive increase in spaceflight (manned or unmanned) as to urgently require an international, comprehensive, and coherent space traffic management system, we might perhaps still have the time to overcome the political and other impediments in the way of the above suggested role of an intergovernmental entity, first in the realm of awareness, then in that of competence, first under an optional approach, then in legally binding fashion across the globe (read universe). Best, therefore, to start the discussion in earnest now—after all, it is even by comparison to aviation truly a challenge of cosmic proportions to develop a coherent, comprehensive, efficient, and acceptable system of space traffic management in the sense of the Cosmic Study's definition.

Notes

1. Cosmic Study on Space Traffic Management, International Academy of Astronautics, 2006, 10.
2. *E.g.*, already in 1944 Art. 37(c), Chicago Convention (Convention on International Civil Aviation, Chicago, done 7 December 1944, entered into force 4 April 1947; 15 UNTS 295; TIAS 1591; 61 Stat. 1180; Cmd. 6614; UKTS 1953 No. 8; ATS 1957 No. 5; ICAO Doc. 7300), calls for the development of Standards and Recommended Practices (SARPs) on "air traffic control practices."
3. *Cf.* the efforts from the 1990s onward of the International Civil Aviation Organization to develop a CNS/ATM (Communications, Navigation, Surveillance/Air Traffic Management) system based on the use of GNSS, as per *e.g.* the Global Air Navigation Plan for CNS/ATM Systems, ICAO Doc. 9750 AN/963, 2nd ed., 2002.
4. *E.g.* Annex 7 to the Chicago Convention, Aircraft nationality and registration marks, 5th edition, July 2003, Definitions; Annex 8, Airworthiness of aircraft, 10th edition, April 2005, Definitions.
5. *Cf.* Arts. 1, 2, 11, 12, 28, Chicago Convention.
6. As further elaborated in the SARPs; *cf.* Arts. 12 ("Over the high seas, the rules in force shall be those established under this Convention."), 37(c), Chicago Convention. Annex 2 to the Chicago Convention embodies those particular SARPs.
7. See Art. 3(a), (b), Chicago Convention.
8. Convention on Registration of Objects Launched into Outer Space (hereafter Registration Convention), New York, done 14 January 1975, entered into force 15 September 1976; 1023 UNTS 15; TIAS 8480; 28 UST 695; UKTS 1978 No. 70; Cmnd. 6256; ATS 1986 No. 5; 14 ILM 43 (1975).
9. Art. II(1), Registration Convention; *cf.* the Dutch Space Law (Law Incorporating Rules Concerning Space Activities and the Establishment of a Registry of Space Objects, 24 January 2007; 80 *Staatsblad* (2007), at 1; *Nationales Weltraumrecht/National Space Law* (2008), at 201), which originally did not apply its licensing system to unguided satellites (largely because of the resulting assumption of liability under the Convention on International Liability for Damage Caused by Space Objects (hereafter Liability Convention), London/Moscow/Washington, done 29 March 1972, entered into force 1 September 1972; 961 UNTS 187; TIAS 7762; 24 UST 2389; UKTS 1974 No. 16; Cmnd. 5068; ATS 1975 No. 5; 10 ILM 965 (1971)), requiring a recent *de facto* amendment to make it so apply by way of an administrative measure entering into force 1 July 2015. Even

with large satellites and spacecraft, however, there is a considerable lack of across-the-board registration; *cf.* Y. Lee, Registration of Space Objects: ESA Member States' Practice, 22 *Space Policy* (2006), 42–51; F. G. von der Dunk, International space law, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), 98; F. G. von der Dunk, Legal aspects of private manned spaceflight, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), 682.

10. See *e.g.* Lotta Viikari, Environmental aspects of space activities, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), 737–38, 768.
11. See *e.g.* Viikari, 720.
12. See Arts. I, II, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereafter Outer Space Treaty), London/Moscow/Washington, done 27 January 1967, entered into force 10 October 1967; 610 UNTS 205; TIAS 6347; 18 UST 2410; UKTS 1968 No. 10; Cmnd. 3198; ATS 1967 No. 24; 6 ILM 386 (1967).
13. The closest the Outer Space Treaty comes to addressing such an issue as management of traffic in the global commons of outer space concerns the provisions of Articles VI through IX, providing for responsibility and liability (as elaborated by the Liability Convention) for space activities, the retention of jurisdiction on the basis of registration as a rudimentary mechanism for providing position and trajectory data on particular spacecraft (as elaborated by the Registration Convention), and a general obligation to consult in case one's own space activities may pose a serious threat to other states' space activities.
14. *Cf.* also the discussions in ICAO on the hesitation of its member states to adapt GPS (and GLONASS) as safety-critical navigation systems without clear-cut acceptance of international liability for erroneous navigation signals on the part of the United States (respectively the Russian Federation); see *e.g.* L. J. Smith, Legal aspects of satellite navigation, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), 602–7.
15. This concerns notably of course the Outer Space Treaty, Liability Convention and Registration Convention as discussed above; whereas the COPUOS Guidelines (International cooperation in the peaceful uses of outer space, UNGA Res. 62/217, of 22 December 2007; UN Doc. A/RES/62/217) may be well on their way to becoming customary international law; see *e.g.* Viikari, 742 ff.
16. See *e.g.* Art. 44, Constitution of the International Telecommunication Union (hereafter ITU Constitution), Geneva, done 22 December 1992, entered into force 1 July 1994; 1825 UNTS 1; UKTS 1996 No. 24; Cm. 2539; ATS 1994 No. 28; Final Acts of the Additional Plenipotentiary Conference, Geneva, 1992 (1993), at 1, as amended; also F. G. von der Dunk, Legal aspects of satellite communications, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), esp. 464 ff.
17. *Cf. e.g.* Viikari, 757–58; M. P. Schaefer, Analogues between Space Law and Law of the Sea/International Maritime Law: Can Space Law Usefully Borrow or Adapt Rules from These Other Areas of Public International Law?, in *2012 Proceedings of the International Institute of Space Law* (2013), 316–30.
18. See *e.g.* F. G. von der Dunk, From Space Tourists to Unruly Passengers? The US Struggle with "On-Orbit Jurisdiction," in *Proceedings of the International Institute of Space Law 2014* (2015), 391–405.
19. See now, further to the Commercial Space Launch Amendments Act (23 December 2004, Public Law 108-492, 108th Congress, H.R. 3752, 49 U.S.C.; 118 Stat. 3974), Commercial Space Launch Activities; 51 U.S.C. 509.
20. See Sec. 50914, 51 U.S.C.; further *e.g.* F. G. von der Dunk, Legal aspects of private manned spaceflight, in *Handbook of Space Law* (Eds. F. G. von der Dunk & F. Tronchetti)(2015), 684.

21. Sec. 109(b), U.S. Commercial Space Launch Competitiveness Act; 114th Congress, H.R. 2262, of 6 January 2015; emphasis added.
22. See *e.g.* J. B. Marciacq *et al.*, Towards Regulating Suborbital Flights: An Updated EASA Approach, Paper IAC-10-D2.9.5, 61st International Astronautical Congress, Prague, 2010, 2, not published in the *Proceedings of the International Institute of Space Law 2010* (2011); J. B. Marciacq *et al.*, Accommodating Sub-Orbital Flights into the EASA Regulatory System, in *Space Safety Regulations and Standards* (Eds. J. N. Pelton & R. S. Jakhu) (2010), 187–212.
23. The European Aviation Safety Agency (EASA) was established by Regulation of the European Parliament and of the Council on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, No. 1592/2002/EC, of 15 July 2002; OJ L 240/1 (2002); later superseded by Regulation of the European Parliament and of the Council on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC, No. 216/2008/EC, of 20 February 2008; OJ L 79/1 (2008).
24. Eurocontrol was established by the Convention Relating to Co-operation for the Safety of Air Navigation (hereafter Eurocontrol Convention), Brussels, done 13 December 1960, entered into force 1 March 1963; 523 UNTS 117; UKTS 1963 No. 39; Cmnd. 2114; later amended *inter alia* by the Protocol Amending the Eurocontrol International Convention Relating to Co-operation for the Safety of Air Navigation of 13 December 1960, Brussels, done 12 February 1981, entered into force 1 January 1986; 430 UNTS 279; Cmnd. 8662; and the Protocol consolidating the Eurocontrol International Convention Relating to Co-operation for the Safety of Air Navigation of 13 December 1960, as variously amended, Brussels, done 27 June 1997, not yet entered into force; Eurocontrol Revised Convention, Sept. 1997 edition at Eurocontrol.
25. Here, it constitutes the only fundamental exception to the territorial sovereignty of the coastal state over its territorial waters; *cf.* Arts. 17-26, United Nations Convention on the Law of the Sea, Montego Bay, done 10 December 1982, entered into force 16 November 1994; 1833 UNTS 3 & 1835 UNTS 261; UKTS 1999 No. 81; Cmnd. 8941; ATS 1994 No. 31; 21 ILM 1261 (1982); S. Treaty Doc. No. 103-39.
26. See further Von der Dunk, International space law, 72–78.
27. See *e.g.* Von der Dunk, International space law, 60–72, and literature referenced there.