Traffic Management for Responsive Space: The Mega-trend for Space Activities in the Decades to Come

One “frequently asked question” addressed to a space policy think tank is: “What will space look like in 30 years?” Far from venturing into speculation about technology developments, a policy think tank might respond by identifying trends that relate to the issues of how space is used, for which purposes and how the utilisation is organised and governed. Attaching labels to these two fields, the respective trends could be denominated as “Responsive Space” and “Space Traffic Management”. Both are concepts in the making. At some point in the future they will merge. This might be in the visionary timeline of thirty years. They will then have become “Traffic Management for Responsive Space”, which is now the mega-trend, and, in 2040, an era of “Space 3.0” might begin.

1. “Space 3.0”

It has become fashionable to proclaim new eras for the use of space. And while there is an abundance of such models, it is still useful to give names to the results of analyses and attempts to understand the dynamic setting that is the use of space. There is no doubt that today’s use of space considerably differs from the early space age. A major difference is the proliferation of space technology to now around fifty states that use space with their own assets. Even more significant is the expansion of commercialisation and – above all – the emergence of space activities conducted by private entities in orbit and sub-orbit. This “Space 2.0” setting requires new ways of regulation (like national space legislation) and finding answers to the question of how to make space utilisation sustainable in the future by more thoroughly dealing with issues like space debris mitigation and other harmful interferences.

But how will “Space 3.0” look and when will it come – or has it already arrived? In order to proclaim a third space age, fundamental changes have to occur. Adding a few more users or some new technology applications may constitute “Space 2.3” or Space “2.5” but would not be enough for “Space 3.0”. So, what would constitute a “revolution” given the explosion of space use and privatisation? It can be summed up in two trends: the first is that space utilisation will become more “responsive”, which means that it will be more flexible: new developments will be introduced in a more timely manner, the costs will be lower and launches will be conducted more rapidly. Technology development will therefore focus on new generations of missions and new ways of reaching space. While large scale missions and satellites will continue, the share of “responsive” elements will grow considerably allowing these to be spoken of as a dominating characteristic of the whole system.

Space 3.0 will be constituted by merging the concepts of “Responsive Space” and “Space Traffic Management”.

The second trend involves a new concept for the organisation and governance of space activities. It Rather than being the current state-centric system building around the status of outer space as it is laid down in current international space law, the new concept will regard the use of space as a traffic system, thus setting up completely new rules for the use of outer space and interaction among the users.
Both trends have already received their names: “responsive space” and “space traffic management”. Both have already been studied and perspectives for each of them have been developed by academic as well as policy oriented analysis. So far however, they have not been linked and merged into a comprehensive outlook on the future use of space. Together, they could constitute “Space 3.0”, setting a thoroughly new order for outer space.

2. "Responsive Space"

Promoting “Responsive Space” (RS) implies first of all the assessment that space activities have so far not been sufficiently responsive to user needs. The multi-year design and manufacturing cycle of satellites, their long lead time for launching and finally their fixed and predetermined performance in orbit are actually far from the idea of being able to manage, direct and command satellite services in the twinkling of an eye. While the time of the “mammoths’ in space might have ended with Envisat, the current generations of smaller satellites are still far from meeting the need for the rapid launch of space assets assembled on demand, which might even be reconfigured in orbit for tasks that were not foreseen at the time of their launch, as with traditional satellite projects.

The first and still dominant driver for RS is the U.S. military. The Rumsfeld Commission in 20011 pointed to the vulnerability of U.S. military space assets and stirred a debate on how to guarantee the imminent replacement of space assets in the event of their loss. Together with the growing need for more flexible space services on the battlefield, this constituted the baseline for the request by the U.S. Congress, addressed to the Department of Defense, to formulate a “Plan for Operationally Responsive Space”. This plan was presented in 2007.2 It described how ORS would aim at achieving the timely and assured provision (including rapid replacement) of space services for commanders on the ground. Since then, the U.S. has been working on the implementation of this concept.

The concept has become a topic of broad debate in military as well as civilian circles. While the impulse came from the military, the idea of faster access to space, shorter manufacturing times for space assets and, consequently, easier replacement of space assets (be it due to loss through meteorites, debris or hostile acts) is also attractive to civilian users of space. Europe, together with other major space actors like Russia, China or India, will have to assess whether the various initiatives might be brought together in a comprehensive concept.3

RS could build on the following elements: the identification of the emergence of new technology requirements; the need for operational capabilities, in particular the question of how to address the transition from the demonstration to the operational phase; the need to exploit synergies between military and civilian applications, including services by private providers; the need to further involve users in the research and development process; the need for the standardisation and protection of data; and the need for a more comprehensive approach in terms of integrating not only space assets, but also applications (e.g. SatCom, navigation and Earth observation), ground segments and terrestrial means.

Implementing “Responsive Space” in the foreseeable future is compromised by the present “slow” access to space.

Based on these elements, the main features of “responsiveness” would be its operational flexibility (the timely development and ability to adapt to changing operational requirements), its low development and operational costs, and its rapid launch capability. The key is the schedule structure of the design, manufacturing and testing processes. The concept’s crucial levers include the design and architecture of systems (for example the use of off-the-self, standardised, modular and plug-and-play subsystems), the type and range of launch vehicles, and regulatory issues such as acquisition and authorisation. An almost off-the-shelf satellite, launched with a matching rocket kept in storage and ready to deliver immediate services to its customer(s) would be the fulfillment of RS. Small satellites, flying alone or in swarms, reconfigured and replaced as the

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users and customers wish, would constitute the future population of outer space orbits. They would not replace the large infrastructure in the GSO in particular, but they would complement it and open completely new fields of applications.

This scenario comprises one probable and one less probable component. While miniaturisation is progressing to the point of placing microchips in orbit, the question of how to access space in a timelier (and cheaper) manner remains unresolved. Further extending the "launcher families" is currently leading to smaller size but not yet to real responsiveness. The next thirty years might however bring breakthroughs, quite possibly initiated by the private sector.

3. "Space Traffic Management"

Early ideas about "traffic in outer space" were put forth as early as the 1980s. It was only in 2006, however, that the first comprehensive analysis on "Space Traffic Management" (STM) was published. This study, by the International Academy of Astronautics (IAA), was followed by other research projects, most notably by the International Space University (ISU) and the International Association for the Advancement of Space Safety (IAASS). They are all based on the assumption that activities in outer space now require a new format of organisation that can rest on the basic principle of "free use of outer space" as laid down in the Outer Space Treaty of 1967, but which has to be complemented by rules of the road in order to guarantee the safe use of space in the future.

Less than 1000 active satellites, some 30,000 pieces of catalogued objects larger than 10 cm, and a statistical distribution of $10^{-7}$ of such objects per km$^3$ do not seem to characterize a dramatic setting. However, four (certain) collisions of larger objects with operational satellites have already taken place. Numerous impacts of smaller man-made objects are constantly raising the attention and concern of space operators and government decision-makers alike. Indications of this are, inter alia: agreeing on space debris mitigation guidelines, regarding space situational awareness as an international issue, giving consideration to the sustainable use of outer space and discussing ideas and proposals for rules of the road and codes of conduct. One forum for this is the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), where space debris and sustainability are regularly discussed. Furthermore, the use of the Geostationary Satellite Orbit (GSO) is being organised in the framework of the International Telecommunication Union (ITU). Large private satellite operators are coordinating themselves in a data exchange mechanism and the European Union has proposed a Code of Conduct for Outer Space Activities that is currently under international negotiation. These are all indicators of a new look at organising space activities, which nevertheless can only be regarded as the partial elements of a future truly comprehensive conceptual approach.

"Space Traffic Management" replaces the model of a state-centric use of space with the concept of space as a traffic system.

This comprehensive conceptual approach is STM. It does not limit itself to selecting specific issues for regulation or single areas in outer space. It transcends what is possible today under the current political situation and with the current diplomatic tolls. It does not apply a "piecemeal engineering" of small incremental steps but sets out a comprehensive concept: how to regulate access to outer space, operations in orbit and the return of objects to Earth. The answer is to shape space activities as a traffic system with precise rules governing operations and the respective provision of information available to all users of the system. The goal is to achieve safety for all operations in outer space and to avoid collisions or misperceptions threatening their security.

Some reasons why STM as a comprehensive concept has not yet been negotiated at the inter-governmental level are: the pressure for action is not yet high enough (space debris mitigation had to go through one and a half decades of discussions in UNCOPUOS before non-binding guidelines were adopted); there are no efficient forums for negotiating such a fundamental change (UNCOPUOS is not ready for this: a comparable case could be the United Nations Conference on the Law of the Sea, which
elaborated a new law of the sea emerging from diverse legal instruments); States would not be ready today to accept sanction mechanisms that would be part of STM and a consensus on which organisation should be tasked with the operations of STM must be developed very carefully (proposals have already been made that this could be ITU, or – even more likely – the International Civil Aviation Organization (ICAO, which owns and successfully employs mechanisms for air transport).

This is not discouraging. Establishing STM is a long-term process. Taking into account that the term received broader recognition only with the 2006 IAA study, its proliferation and use (even by institutions like the U.S. Air Force) seems to be astonishing. Less astonishing, however, is that growing concern regarding the deterioration of safety in outer space operations is driving this process. Even if the actors now using the term STM are not ready to go all the way to establish a comprehensive concept, they seem to be ready to work in a stepwise manner. In parallel, RS will raise the pressure to establish STM through the creation of novel ways of reaching and operating in outer space. Other new technology developments and applications over the next decades (from utopian space elevators to already tested tether, or more traffic in between air space and outer space with suborbital flights and stratospheric platforms) will further support the need for STM.


Merging these two trends leads to “Space 3.0” or, in more technical terms, “Traffic Management for Responsive Space” (TMRS). This scenario includes new ways and means of reaching outer space, apart from the use of large rockets. In outer space, miniaturisation and specialisation will lead to an explosion in the number of space objects in orbit. By 2040 return from outer space to Earth will also occur more frequently, most certainly in the field of human spaceflight. An international space situation awareness system would provide operators with information that, would also be fed by operator notifications of their manoeuvres. Rules of the road (priorities, keep out zones etc.) would be established and sanctions could be agreed upon for misbehaviour (for example the revocation of orbit positions or frequencies). An international organisation would manage and supervise the system and also make sure that member states implement binding technical standards. An international treaty would govern the system by stating principles (which could not be easily changed), comprised of binding rules (which could be more easily changed) and technical standards (which would not have the status of international law). Private actors are an integral element of this system as they would become part of the decision-making process (as for example in the ITU).

5. Europe’s Role

In the few decades ahead that will lead to the implementation of “Traffic Management for Responsive Space”, Europe should realise that it could play a major role on an international level. It is evident that the international actors that would become the driving force behind the conceptual formulation and the diplomatic developments regarding TMRS, would also benefit the most from its emergence. European institutions, governments and private entities all have vested interests in using space assets. Therefore, Europe has and will continue to have a need for reliable, guaranteed and unhindered access to space and the use of space assets, safe from interference from third parties. It will consequently have a growing interest in possessing information and space situational awareness, as well as ensuring that any international regulations do not unduly restrict its activities, allowing for other international actors to position themselves as the rulers or policemen of space activities. Europe would also have a special interest in applying the rule of open and fair international competition in the commercial use of space, not distorted by non-harmonized regulations allowing for “flags of convenience”.

Europe meets all the conditions to lead diplomatic efforts to implement “Traffic Management for Responsive Space”.

With the Draft Code of Conduct (recently presented in its second version), Europe has established itself as the diplomatic driver behind new approaches to the regulation of outer space activities.\(^8\) Decision-makers should now consider taking both strands (“Responsive Space” and “Space Traffic Management”/Code of Conduct) into account, understanding their conceptual linkage and developing a diplomatic approach that Europe would consequently lead and promote. Europe has been regarded since

the 1970s as a special actor in international politics, being more a “civilian power” than an actor striving for hegemony. ⁹ This notion has found its realisation in space diplomacy throughout the past decades, with respect to both the civilian and military uses of space and the issues of governance related to them.¹⁰ Europe can also be a trusted leader, which would ensure that the use and the governance of space will be built on fairness and responsibility.¹¹ “Space 3.0” from 2040 onwards can be driven by Europe – today.

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