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Opinion of AAE on

Security of space activities

Towards a proactive European action

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EXECUTIVE SUMMARY

‘*2021 will be a defining year for our space strategy and the position of Europe on the global space stage. We have enormous challenges to face, with a serious risk of losing ground. We need to be able to find the resources to reinvent ourselves, to break taboos and the established cooperation*’. **Commissioner Thierry Breton at the 13th European Space Conference, 12 January 2021.**

Ensuring the security of European assets in space is a significant issue today and requires technical capability and know-how in the fields of: **SST** (Space surveillance and tracking), in order to obtain accurate data on space objects and create a catalogue; **SSA** (Space situation awareness), to manage this catalogue so as to establish a recognized situation; and **Intelligence** to be able to identify space objects and attribute actions in space. To achieve an acceptable level of autonomy, Europe must drastically improve and enhance existing national assets.

Full capability (All orbit surveillance, Tracking, Intelligence, Analysis and Command & Control) should be a goal for Europe in the long term. However, short-term decisions should be taken urgently.

RECOMMENDATIONS

1. **In the face of proliferating space debris and the risk of irresponsible or aggressive in-orbit behaviour, the European Union must protect its satellite systems – today Galileo and Copernicus – and ensure, together with its Member States, that the European weather and climate monitoring satellites operated by EUMETSAT and the suite of commercial satellites under the control of Europe-based companies, as well as other satellites operated by the European Space Agency and by the national institutions of several European nations, benefit from the same protection.**

   In view of the increasing threats to ground-based facilities (terrorist attacks, cyberattacks, interference, jamming and spoofing), the protection and security of the terrestrial components of European space systems will have to be strengthened.

2. **In building and operating its own autonomous surveillance system, the European Union must drastically improve its capacity to analyse the situation in space independently. Europe, through the European Union, needs to set up a full, high-performance space awareness capability going far beyond the present capability provided by the combination of various national space surveillance systems.**

3. **Ideally, Europe should operate a surveillance system allowing it to independently detect, track and identify every satellite launched into orbit, as well as proliferating debris, and monitor their behaviour. A fully operative system may be built according to progressive implementation steps:**

- in the short term, by using existing infrastructure to the full to reach a basic level of space situation awareness;
- in the medium term, by reinforcing its tracking capabilities for regular catalogue updating;
- in the long term, by achieving autonomous surveillance of traffic in outer space.

The improvement of tracking capabilities should apply to all Earth orbits.

4. Concerning the budgetary aspect, the European Union should seek synergies from relevant funding sources available under the Multiannual Financial Framework 2021-2027, i.e. the EU Space Programme, the European Defence Fund and the Horizon Europe Programme. This should pave the way to implementing the necessary high-performance SST/SSA infrastructure, capabilities and services, to conducting dedicated R&D and to planning for future developments.

5. On that basis, the European Commission should be able to provide the increase in EU funding required for proceeding further under the next MFF and identify/ propose relevant sources and programs.

6. Considering the trend observed, in the United States and in various international fora, to plan for a future Space Traffic Management (STM) framework, either through a dedicated international convention or through a series of internationally agreed guidelines, preferably backed by a Resolution of the United Nations General Assembly, the European Union should contribute proactively to high-level international (multilateral and bilateral) policy and governance discussions, to guarantee its freedom of access to space and action in space and to preserve European economic interests.

7. In parallel, Europe should support or contribute pragmatic proposals to the ISO Space Operations working group also involving commercial operators for expanding the range/scope of ISO standards to cover STM operational aspects in areas where international consensus can be rapidly achieved and promote the ISO standards as a reference for all national space laws.

8. **Finally, to achieve a full, autonomous situation assessment capacity in space in support of its diplomatic or defence and security actions, the European Union must be able, in a fully sovereign manner, to attribute any action in space that threatens, or could potentially threaten, safety and security in space.**

1- AN INCREASINGLY CONGESTED EARTH ENVIRONMENT

Since the first orbital flights in 1957, space applications have developed well beyond exploration and science. Satellite systems have become critical infrastructure, delivering services to society and the economy and contributing to the security and strategic autonomy of spacefaring nations.

As of May 2021, more than 5,900 successful launches had brought substantial benefits to a growing number of nations with direct or indirect access to space. However, an estimated population of over 34,000 objects larger than 10 cm has also been left in space, of which only ca. 23,000 (67 %) are catalogued by state-of-the-art Space Surveillance and Tracking systems. Another 900,000 smaller objects larger than 1 cm, also uncatalogued, could still severely damage active satellites. Overall, the total mass in orbit is roughly 8,800 tons.

The 23,000 catalogued objects include 4,000 “active” satellites, of which around 1,000 are believed to have no manoeuvring capacity, including a large subset of the already launched 1,700 nanosatellites (0.3 to 30 kg).

The remaining 19,000 (83 %) catalogued objects represents the population of uncontrolled “non-functional artificial orbital objects” referred to as space debris. It is composed of 3,431 dead satellites (18 %), 2,231 launcher bodies (12 %) and smaller objects (70 %) released during nominal operations and fragments resulting from in-orbit breakups, explosions and collisions.

The space debris mitigation guidelines established since 1995 at agency (NASA, JAXA, CNES), international (IADC, UNCOPUOS, ISO 24113) and European (ECSS) levels to promote more responsible use of orbits, have failed to contain the increase in the number and mass of debris to within reasonable limits. Very few spacefaring nations have enforced these guidelines in full through national legislation (e.g., the French Space Operations Act). Furthermore, the cascading impact of breakups, collisions and explosions of pre-existing large debris has compounded the problem.

1.1. The sustainability and safety of space operations are already at risk

The risk of any casualty on the ground due to uncontrolled atmospheric re-entry of large debris is statistically not very significant. However, the case-by-case risk remains unpredictable due to limited knowledge of key features of some re-entering objects and large uncertainties on atmospheric properties.

More significant are risks to the *sustainability* and safety of space operations.

The main threats to sustainability, defined as the possibility offered to all nations and operators of conducting space operations in high-value orbital bands, are:

- an ongoing lack of enforcement of internationally agreed debris mitigation guidelines and standards by some spacefaring nations;
- the likelihood of future break ups and collisions of existing large debris or other non-manoeuvring objects triggering a "Kessler syndrome[1]" cascade, i.e. an exponential growth in the number of smaller pieces of debris large enough to destroy active spacecraft.

While stronger political commitments can address the first threat, the second calls for new technical solutions and in-orbit services contributing to a Large Debris Traffic Management (LDTM) system, e.g., Active Debris Removal or trajectory shift techniques for just-in-time collision avoidance (JCA) between large debris like the two Zenit upper stages (9 m, 9 tons) coming closer than 100 m once a month.

Assuming long-term sustainability can be preserved, day-to-day space operations will remain exposed to the *safety* risk of collisions between operational satellites and other objects.

The most likely risk for a manoeuvrable satellite in low Earth orbit (LEO) is a conjunction with a piece of debris or a

1 *Kessler syndrome occurs when the regeneration of debris by collision is greater than atmospheric cleaning.*

non-manoeuvrable satellite. Indeed, the probability that an actual conjunction is of that type can be estimated at 23 % for catalogued debris, compared to less than 2 % for a conjunction between two manoeuvrable satellites and 75 % for a conjunction involving two catalogued debris items.

This risk is in principle manageable by a Space Traffic Management system. A satellite operator can perform a collision avoidance manoeuvre if a Space Situational Awareness (SSA) service detects a conjunction risk with an object catalogued by the supporting SST system and delivers accurate, actionable information well in advance.

However, current SST/SSA systems fall short of efficiency expectations and do not catalogue all high impact objects.

The very high rate of false alarms is the primary efficiency shortcoming, illustrated by the three million “Conjunction Messages” processed by CNES in 2019 for 27 satellites in LEO, leading to only 18 collision avoidance manoeuvres.

More critically, 98 % of the deadly collisions involve debris that cannot be catalogued by current SST systems, leaving space operators blind, in particular to an estimated 33 % of the debris larger than 10 cm. Some ten deadly collisions are suspected every year. The probability of losing a satellite in sun-synchronous orbit due to collision with debris is in the order of 8 % over its lifetime. The probability of a collision with uncatalogued debris of 1 mm in size that can still cause damage is even once per month.

1.2. The challenge of the New Space era

The risks will rise further in the New Space era, with the rapid, unprecedented increase in the number of small satellites deployed in low Earth orbits by commercial operators, predicted to exceed 30,000 by 2030, and the unavoidable associated further growth of the population of failed and non-manoeuvrable spacecraft.

Mega-constellations under deployment already involve thousands (with plans for tens of thousands) of relatively short-lived satellites, which will have to be frequently replaced in orbit to achieve targeted service availability and performance improvements.

While some operate at altitudes below 650 km, where uncontrolled atmospheric re-entry occurs within 25 years as required by current guidelines, others operate from higher altitudes, e.g., 1,200 km, where uncontrolled re-entry takes 2,000 years. This raises concern about the sustainability of such orbital bands if failed satellites are left in orbit and collide with other large debris.

On the other hand, mega-constellations operating at lower altitudes will co-exist with a proliferating population of short-lived nanosatellites, currently launched at a rate of roughly 400 per year. These nanosatellites often have no manoeuvring capacity, and the smallest (0.25 U)[2] are barely trackable by current SST systems. And even if these nanosatellites re-enter the atmosphere in less than 25 years, their slow uncontrolled drift may adversely affect the safety and efficiency of day-to-day operations of critical satellite systems, causing higher collision risks and triggering more frequent manoeuvres. It is worth noting that member companies of the Space Safety[3] Coalition (SSC) advocate for more stringent requirements for space operations above 400 km, including the obligation to dispose of manoeuvring capacity.

1.3. An urgent need for drastic improvement to the international regulatory framework

Closely related risks to long-term sustainability and day-to-day safety of space operations need to be mitigated within an improved international framework, supported by higher performance SST systems and SSA services and innovative debris management systems and on-orbit services.

Spacefaring nations, groups of nations and commercial space operators need to meet this challenge if they are to take part in and share the growing benefits of New Space infrastructure and services embedded in integrated value chains and preserve their autonomy of decision in space operations.

This requires continued multilateral and bilateral discussions to enhance agreed space debris mitigation guidelines and standards and to provide a framework for Space Traffic Management. A proper regulatory framework should be enforced worldwide through international conventions and consistent national space legislation.

2 *CubeSats 1 Unit (1U): Size: 10 cm; Weight: 1 kg; Volume: 1 Litre.*

3 *Space Safety coalition : The Space Safety Coalition (SSC, SpaceSafety.org) is an ad hoc coalition of companies, organizations, and other government and industry stakeholders that actively promotes responsible space safety through the adoption of relevant international standards, guidelines and practices, and the development of more effective space safety guidelines and best practices. Space safety includes physical safety, communications safety and space weather awareness.*

An agreed Space Traffic Management framework will need to impose more stringent operations and coordination requirements on operators to keep day-to-day operations safe in traffic that will see an increase in LEO satellites of at least one order of magnitude. These may include obligations to notify non-manoeuvrable satellites before launch and after an incident in orbit and to access and use a standardized conjunction evaluation tool for reducing the likelihood of collisions with non-manoeuvrable satellites and debris and thus the proliferation of dead satellites and debris threatening the sustainability of operations in the longer term.

2- SPACE SECURITY CONCERNS

Space and objects therein have served military purposes from the beginning of spaceflight. Satellites for military reconnaissance, electronic intelligence, early warning, meteorology, communications, and navigation were launched, initially by the USA and the Soviet Union, in compliance with the 1967 Outer Space Treaty (Treaty on principles governing the activities of states in the use of outer space).

Today, many more states have invested in military and dual-use space infrastructure, including European states, as military satellite systems have become a core component of **intelligence, surveillance, target acquisition, and reconnaissance operational functions used by the armed forces' chain of command**. Satellite systems are now "force multipliers" and thus an essential driver of military superiority, particularly in remote theatres of operation. Space Commands/Forces have therefore been set up in the United States, in Russia, in India, in Japan and in Europe. In China, all space operations are under direct military control.

As a consequence, systems for interfering with military satellites have also been developed since the 60s. The Soviet Union and the United States have carried out Anti-Satellite (ASAT) weapons tests since 1963, involving co-orbital and direct ascent technology. While ASAT testing practically ceased with the end of the Cold War, the last 15 years have seen a resurgence of tests by Russia, China, the United States and, since 2019, India. Given the relationship between midcourse missile defence and some ASAT technology, other states that master the former may also master the latter, at least for low Earth orbit (LEO).

Objects in orbit move with speeds of around 7 km/s (in LEO). Any collision at a relative velocity of even a fraction of this speed is lethal for a targeted satellite, making any manoeuvrable object a potential space weapon. During the Cold War, co-orbital ASATs sought to destroy their targets by direct impact or explosion. Destructive ASAT tests have produced an immediate large increase in the debris population, as was the case of the Chinese ASAT test of 2007, exacerbating the risks to safety and sustainability of space operations described in section 1.

Moreover, for several years now, tests have been carried out as rendezvous and proximity operations where target satellites were pursued by presumptive ASATs that could interact with their targets in different non-destructive ways. These tests have demonstrated the capability of approaching adversary space assets for interference.

Several tests of rendezvous and proximity operations between Chinese satellites occurred in recent years, both in LEO and in GEO, while inspection activities are conducted in GEO by pairs of spacecraft of the US Geosynchronous Space Situational Awareness Program (GSSAP). Another example is the Russian Olymp/Luch spacecraft in GEO that drifted for more than 100 degrees longitude back and forth, passing by many telecommunications satellites from many states in a probable signals intelligence mission.

As long as these activities are carried out in agreement with the satellites' legal owners, there is no reason for concern. But an unexplained approach by another state's satellite can be seen as a provocation, a threat or even an indication of hostile intent.

In addition to kinetic attacks, spacecraft are increasingly exposed to attacks from directed energy systems, electronic warfare and cyberattacks carried out from the ground or in orbit.

Indirect cyberattacks, consisting of hacking and taking control of one of the hundreds of nanosats launched in recent years and operated with no security management – of their command-and-control system in particular –, then using it for attacking a military asset, are increasingly of concern, raising tricky attribution issues. Consequently, the most significant future threat in space could be the asymmetric threat from transnational terror organizations that shadow operate their own satellite or hack the command & control link of someone else's satellite.

More generally, the development and testing of ASAT technology is increasingly a cause for concern with the emergence of hostile "hybrid strategies" combining military and non-military, direct and indirect, but always ambiguous courses of action designed to remain below the estimated threshold of open conflict and targeting military as well as civilian space infrastructure. Nevertheless, given the reliance of states and societies on space-based infrastructure for their welfare and security, any interference can have grave economic and political consequences, and if satellites fail due to an actual or presumed attack, political tensions or even conflicts may arise. If the origins cannot be clearly explained or attributed, misperceptions and misinterpretations with serious outcomes may result.

Attempts by the international community to apply the classic instruments of legally binding arms control to space operations have failed. Given the nature of space technology, it is clear that the definition of a "weapon" in space, whose development, testing or deployment could be legally curtailed, is impossible. The technical principles of ASATs are the same as those used for normal, non-weapon-related space operations, a tendency which will only increase in the future, as interactions between space objects are further developed, for satellite inspection, servicing, repair or retrieval from orbit, and the use of space tugs for orbit corrections or debris removal.

Space is becoming a domain of warfare. Europe, including the European Union and ESA along with their Member States, has to face this reality. Whether military or non-military, many European satellites form part of critical and essential infrastructure, such as GNSS, telecommunications or reconnaissance satellites. They may be subject to harmful interference in a conflict, either as targets of direct attacks or as collateral damage in an exchange between third states. The level of this interference may range from temporary and reversible electronic or optical perturbation up to kinetic destruction.

Europe is insufficiently prepared for all this, whether at the national or the EU level. Excluding avoidance manoeuvres or diplomatic approaches, Europe has no capability to respond to an attack on its space assets. There is barely any debate on the need to prepare for contingencies in space. The "EU Space Strategy for Europe" (COM (2016) 705 final) disregards military threats, and no "EU Space Security Strategy" exists. Some Member States, such as France and Germany, have created space command elements within their military forces, but these are mainly dedicated to the command and control of national military space assets and the surveillance of their orbital environment. The establishment of a combat capability in space at the European level is not envisaged politically for the time being.

High-performance space situational awareness to obtain a recognized space picture is a key element in support of deterrence against aggression due to the high probability of attribution and recognition of intent. Even in the absence of means to respond in kind, retaliation might occur in other domains such as land, sea, air or cyber, or just by diplomatic/economic sanctions, whatever seems appropriate and proportional under the circumstances.

The only possible way of addressing security risks is to combine a dedicated political response, focusing on the behaviour of spacefaring states, with a dramatic improvement of space situational awareness technology and capabilities. Rules for responsible behaviour in outer space need to be agreed upon and a system of transparency and confidence-building measures (TCBMs) established. An agreement could be sought on a "code of conduct", similar to the Hague Code of Conduct for the transparency of missile launches. Access to more reliable and timely space situational awareness data would achieve the prerequisite confidence-building transparency, avoid uncertainty and thus promote security.

3- NEED TO PROTECT EUROPEAN SPACE ASSETS

The European Union has fully funded and deployed a critical space infrastructure in the form of the Galileo constellation and thus secured independent provision of global real-time positioning and time tagging (GNSS) services. In addition, the EU, in cooperation with the European Space Agency and EUMETSAT, has already deployed under its Copernicus programme four series of Earth observation satellites called Sentinels to establish an autonomous, comprehensive capacity for monitoring the environment and climate, and plans to deploy more in the current decade. The EU owns the Galileo and Copernicus space assets and has direct responsibility for protecting them.

Another essential European space infrastructure has been deployed by EUMETSAT, again in cooperation with ESA, to provide permanent observation of the atmosphere and oceans required by Europe for weather forecasting and climate monitoring, in synergy with Copernicus Sentinels. This EUMETSAT-owned infrastructure consists of Geostationary (Meteosat) and low Earth orbit (Metop) satellite systems, both entering their next generation in the current decade.

Beyond these collective European infrastructures, European States have deployed several national satellites for security and defence purposes. These include dedicated communications satellites, optical and radar reconnaissance satellites, electronic intelligence satellites and possible future early-warning satellites.

Most of these satellites, whether national or European, have been launched by European launchers from the European Space Port in French Guiana. They together form a European space infrastructure that is already integrated into value-adding chains delivering critical digital services serving the sovereignty, security and other policies of the EU and European states (in particular the digital transformation and the Green Deal), the economic competitiveness of Europe and the day-to-day life and safety of its citizens. For the same purposes, the European Commission is contemplating the deployment of a broadband connectivity constellation to expand the collective European infrastructure.

In addition, many commercial satellite operators based in European countries, such as Eutelsat, SES, Inmarsat, Hispasat, Airbus Defence and Space, own and operate large fleets of commercial satellites both in the Geostationary orbit and, increasingly, in low Earth orbit. These commercial space infrastructures contribute to the European economy and, at the same time, provide essential services to governments and European citizens. A significant capacity deterioration would not only cause commercial losses but would expose governments themselves to severe risks.

In all, the suite of European satellites today comprises over 200 operational spacecraft in orbit. They contribute directly to European sovereignty, to its independent ability to assess situations and to its economic competitiveness in the digital era. They must therefore be protected from physical threats, interference and cyberattacks, from a safety and security perspective, on the same footing as their control and data reception networks, which form an integral part of the space infrastructure. While the latter are generally well protected from physical and cyberattacks, constant attention is required to avoid new types of dependencies, such as the moving of essential digital databases to “digital clouds” outside European control.

Protecting our European in-orbit infrastructure entails, first and foremost, monitoring the orbital environment to minimize the risk of collisions with orbital debris. It also involves being able to detect and track potentially threatening spacecraft operated by other nations and to attribute any threatening action without ambiguity.

Relying primarily on the space surveillance capabilities of the United States, as is the case today, is not a long-term option. Europe has to establish a high-performance space surveillance capacity of its own to maintain its decision autonomy and create a necessary condition for balanced cooperation with the United States in the provision of SSA services, including those leading to a future Space Domain Awareness (SDA) capacity.

In parallel, Europe needs to take a leading role in bilateral and multilateral space governance discussions to avoid the proliferation of debris beyond limits that would render space unusable and to establish a Space Traffic Management framework preserving its freedom of action in space and the level playing field for commercial space operators.

4- PRESENT CAPABILITIES OF EUROPEAN COUNTRIES,

their limitations, and our dependency on US-provided information

Today, several EU nations have developed and are operating assets in every single domain of space surveillance and tracking[4]. Most of them are federated among the EU Space Surveillance and Tracking (EUSST) programme, initially established in 2014 by Decision No. 541/2014/EU. The EU SST programme already delivers a first set of SST services. However, significant gaps remain regarding existing sensors and the catalogue. Coverage (all Earth orbits), information detail (objects size) and information quality (accuracy) are not yet adequate.

Current SSA services are based mainly on US data that cannot be verified by European means. Some substantial gaps in intelligence make European countries and the EU reliant on US data and related information for object identification and attribution.

An efficient European SSA capacity requires the following different components:

- sensors, in sufficient quality and quantity, to get data on space objects; these can be sorted by mission (surveillance, tracking, intelligence[5]),

4 *For details, see Annex 2.*

5 *Surveillance consists of detecting space objects in a wide space area and obtaining sufficiently accurate orbital parameters to store them as individual objects in a national reference catalogue.*
Tracking consists of following one single object in space to get more accurate orbital parameters to improve catalogue data quality or to perform a specific operation (conjunction analysis, manoeuvre). Some sensors, like phased-array radars, can perform surveillance and tracking simultaneously.
Intelligence consists of getting very accurate data about a space object (optical image, radar image, EM frequencies, pattern of life, open publications, etc.) to assess very accurately its nationality, mission and behaviour.

type (Radar, optical, laser), location (ground or space), range (LEO, MEO, GEO, Mix) or coverage (depending on geolocation);

- a shared, updated database of known space objects catalogued according to their orbital parameters and relevant associated data;
- SSA services, including conjunction warnings for collision avoidance, atmospheric re-entry monitoring, fragmentation in space warning and analysis. For strategic purposes, other services can be provided, such as unusual behaviour detection and warning, jamming activity or cyber-attack assessment.

5- EUROPEAN AMBITIONS IN TERMS OF SPACE SECURITY

The build-up of a European SSA capability should necessarily be progressive and based on a mix of national and EU assets.

It should:

- take into account the financial means of the EU and its Member States, it being understood that availability of funds is essentially a question of prioritization;
- be geographically inclusive: as many Member States as possible should benefit from SSA to allow a sort of "Space security alliance" for the next Multiannual Financial Framework (MFF). The benefit comes from the availability of the service and the contribution to the service;
- take advantage of all European industrial players, including new space actors located in both smaller and larger Member States;
- take into account the military nature of the available assets and the military constraints;
- be developed in a coordinated approach with allied countries and, more particularly, with the USA;
- progressively provide the EU and Member States with an autonomous capability, including standard European SSA services to space operators, ensuring the protection of their assets and services and free access to space.

We consider that developing a full capacity (Surveillance, Tracking, Intelligence, Analysis and C2 - Command & Control) will require a vast R&D effort and huge investment. It could be a long-term goal with components developed in an incremental way so as to bring more freedom and more autonomy to the EU step by step while enabling better complementarity, interoperability, and resiliency with allied countries.

To that end, technical performances in surveillance, tracking, intelligence and SSA services need to be drastically improved, most urgently:

- the current cataloguing threshold should be lowered from 10 cm to 5 or even 3 cm in size, as foreseen by the newly commissioned US Space Fence system.
- the orbital object parameters accuracy must be improved by at least a factor of 10 over the current standard of +/- 1 km along the velocity axis and +/- 100-200 m perpendicularly.

Command and control of sensors and space operations (C2 capacity) will be required in the future. We consider that studies about active defence should also be performed to prepare a real space deterrence capacity in the long term.

We recommend adopting a multi-year progressive approach to better balance financial efforts and integrate technical assets and capabilities.

6- EUROPEAN INVOLVEMENT IN BUILDING UP AN INTERNATIONAL FRAMEWORK FOR SPACE TRAFFIC COORDINATION

Given the rapid growth in the number of active satellites and the proliferation of space debris, many space actors are taking measures to mitigate the risk of collisions or near misses that jeopardise their assets. For example, launch windows are narrowed down to avoid any risk of collision with an orbiting object crossing the trajectory of a launcher's upper stage. This forms the initial step of what is generically called "Space Traffic Management", a concept that is still rather fuzzy.

Indeed, the notion of Space Traffic Management (STM), although widely discussed in multiple fora, has no widely accepted definition as yet – particularly what exactly the word "Management" is supposed to mean. For example, some argue that discussing space traffic "coordination" might be more productive. According to the International Academy of Astronautics (IAA), which published two studies on the subject, Space Traffic Management can be defined as "*the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.*" This definition introduces a relatively wide scope and suggests that STM encompasses a rather broad range of activities addressing an even broader spectrum of concerns in all phases of spaceflight (development, launch, operations, end-of-life, atmospheric re-entry). The IAA states that the purpose of STM "*is to provide appropriate means for conducting space activities without harmful interference* *[in support of] the universal freedom to use outer space as laid down in the Outer Space Treaty of 1967.*" and stresses that "*for the purpose of achieving a common good, actors have to follow specific rules, which are also in their self-interest.*"

Another definition of STM is the one provided in the preamble of the United States National Space Traffic Management Policy, published in 2018: "*Space Traffic Management shall mean the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment*." The US policy definition enlarges the purpose of STM to enhance safety, stability, and sustainability of operations in space but narrows down its scope to more operational aspects of space activities. With this definition, the US policy also underlines the importance of better coordination among actors operating in space. By focusing on shared operational issues, this definition also enables the concerns of military/civil and public/private actors to be reconciled.

The objectives of Space Traffic Coordination (or Management) are therefore quite straightforward: enhancing the safety of on-orbit operations by reducing the risk of collisions and interferences and thus contributing to the long-term sustainability of space activities by mitigating negative effects on the space environment.

To reach this objective, Space Traffic Coordination addresses operational risks both of a physical (e.g., collisions, breakups) and of a radiofrequency nature (interferences, coordination). Today, international discussions on STM primarily focus on the physical risks since spectrum management issues are addressed in the International Telecommunication Union (ITU) framework. It should be kept in mind that STM applies to the various phases of the space system lifecycle, from design to production, launch and deployment, in-orbit operations, and end-of-life disposal. However, current STM discussions tend to focus on the in-orbit operational phase. The STM study published in 2020 by the European Space Policy Institute (ESPI), "Towards a European Approach to Space Traffic Management" spells out the three functions that an STM framework must fulfil:

1. Space Traffic Monitoring: Detection, identification, tracking and cataloguing of active and inactive objects constituting space traffic to provide necessary data and services to ensure the safety of space operations, from launch to re-entry;

2. Space Traffic Regulation: Definition, enforcement and verification of technical and regulatory provisions encouraging or compelling actors to conduct their activities in ways that are not detrimental to the safety and sustainability of the space operating environment;
3. Space Traffic Coordination: Means and measures to support, promote or constrain actors to conduct their space activities in a coordinated manner with others by sharing information, synchronising their operations, or defining and following common procedures.

It is thus clear that an internationally agreed regime for Space Traffic Management or Coordination will have to be built on three pillars:

- a policy and framework pillar, spelling out its objectives and principles;
- a regulatory regime, including a set of rules, norms, and guidelines, possibly inspired by the UN COPUOS model for developing the 21 guidelines for the long-term sustainability of outer space activities;
- a set of capabilities necessary to implement STM, including the infrastructure, for SSA and data exchange mechanisms, modelling and expertise, possibly following the organisational model demonstrated successfully by the IADC.

The UN COPUOS is probably the appropriate forum to discuss and propose an international regime for STC/STM, particularly as its Debris Mitigation Guidelines and the LTS guidelines that it agreed upon in 2007 and 2019 contain elements that are foundational for any future STC/STM regime.

COPUOS is a UN forum of state representatives, and it is the states that continue to bear international responsibility for activities in outer space. It must be ensured that these states exercise this responsibility by authorising and continuously supervising the space activities of their increasingly active commercial space community, as required by the Outer Space Treaty.

In this way, the implementation of emerging norms for responsible behaviour or of standards such as agreed under the auspices of the International Standards Organisation (ISO) ought to be ensured in both governmental and non-governmental space activities. (Otherwise, there would be the risk of emerging “space havens”, in other words, states that attract space business by exercising lower standards of supervision.)

Excellent work is also being carried out under the auspices of the International Standards Organisation (ISO), where the commercial sector is very active, showing how this can be achieved.

The UN COPUOS agrees by consensus. Whether a consensus on an STM/C system would be achievable with the participation of all major spacefaring states is open to question. Therefore, a decision on a limited STM framework may have to be taken among like-minded states which nonetheless remains open to later accession by those who prefer not to cooperate from the outset.

Europe, i.e. the European Union and its Member States, must establish itself as an actor in the field of space law and diplomacy. As such, it should be prepared to take the initiative in support of norms for responsible behaviour in outer space to promote safety, security and sustainability and with the eventual goal of a widely supported Space Traffic Management/Control system. For this initiative, Europe should join ranks with like-minded partners outside Europe, particularly those with whom cooperation on SSA already exists.

The EU and its Member States should recognise space as a priority area for both CFSP and industrial policy. They should agree on a common strategy towards this objective and pursue a coordinated approach in international organisations such as the UN and in their bilateral dialogues with third states.

The publication in 2018 of the US STM Policy directive mentioned above highlighted the potential for a US-led regime. However, little has emerged so far following this publication, beyond the signature of coordination agreements by US governmental agencies and major commercial operators, e.g., SpaceX/Starlink.

The Council of the EU has recently[6] expressed an interest in helping to develop common views of the EU Member States on this issue.

It should be encouraged to do so alongside a necessary, accelerated reinforcement of Europe's autonomous SSA capabilities.

6 *Council Conclusions on New Space for People, 28 May 2021.*

7- CONCLUSION AND RECOMMENDATIONS

Assessment of space activities today represents a great challenge for the world's spacefaring nations. Europe must play a central role in guaranteeing its freedom of access to space, freedom of use of orbits and the security of its space assets, in support of the European economy, society and citizens.

To that goal, we recommend that:

1. In the face of proliferating space debris and the risk of irresponsible or aggressive in-orbit behaviour, the European Union must protect its satellite systems – today Galileo and Copernicus – and ensure, together with its Member States, that the European weather and climate monitoring satellites operated by EUMETSAT and the suite of commercial satellites under the control of Europe-based companies, as well as other satellites operated by the European Space Agency and by the national institutions of several European nations, benefit from the same protection.

   In view of the increasing threats to ground-based facilities (terrorist attacks, cyberattacks, interference, jamming and spoofing), the protection and security of the terrestrial components of European space systems will have to be strengthened.

2. In building and operating its own autonomous surveillance system, the European Union must drastically improve its capacity to analyse the situation in space independently. Europe, through the European Union, needs to set up a full, high-performance space awareness capability going far beyond the present capability provided by the combination of various national space surveillance systems.

3. Ideally, Europe should operate a surveillance system allowing it to independently detect, track and identify every satellite launched into orbit, as well as proliferating debris, and monitor their behaviour. A fully operative system may be built according to progressive implementation steps:
   - in the short term, by using existing infrastructure to the full to reach a basic level of space situation awareness;
   - in the medium term, by reinforcing its tracking capabilities for regular catalogue updating;
   - in the long term, by achieving autonomous surveillance of traffic in outer space.

   The improvement of tracking capabilities should apply to all Earth orbits.
4. Concerning the budgetary aspect, the European Union should seek synergies from relevant funding sources available under the Multiannual Financial Framework 2021-2027, i.e., the EU Space Programme, the European Defence Fund and the Horizon Europe Programme. This should pave the way to implementing the necessary high-performance SST/SSA infrastructure, capabilities and services, to conducting dedicated R&D and to planning for future developments.
5. On that basis, the European Commission should be able to provide the increase in EU funding required for proceeding further under the next MFF and identify/propose relevant sources and programs.
6. Considering the trend observed, in the United States and in various international fora, to plan for a future Space Traffic Management (STM) framework, either through a dedicated international convention or through a series of internationally agreed guidelines, preferably backed by a Resolution of the United Nations General Assembly, the European Union should contribute proactively to high-level international (multilateral and bilateral) policy and governance discussions, to guarantee its freedom of access to space and action In space and to preserve European economic interests.
7. In parallel, Europe should support or contribute pragmatic proposals to the ISO Space Operations working group also involving commercial operators for expanding the range/scope of ISO standards to cover STM operational aspects in areas where international consensus can be rapidly achieved

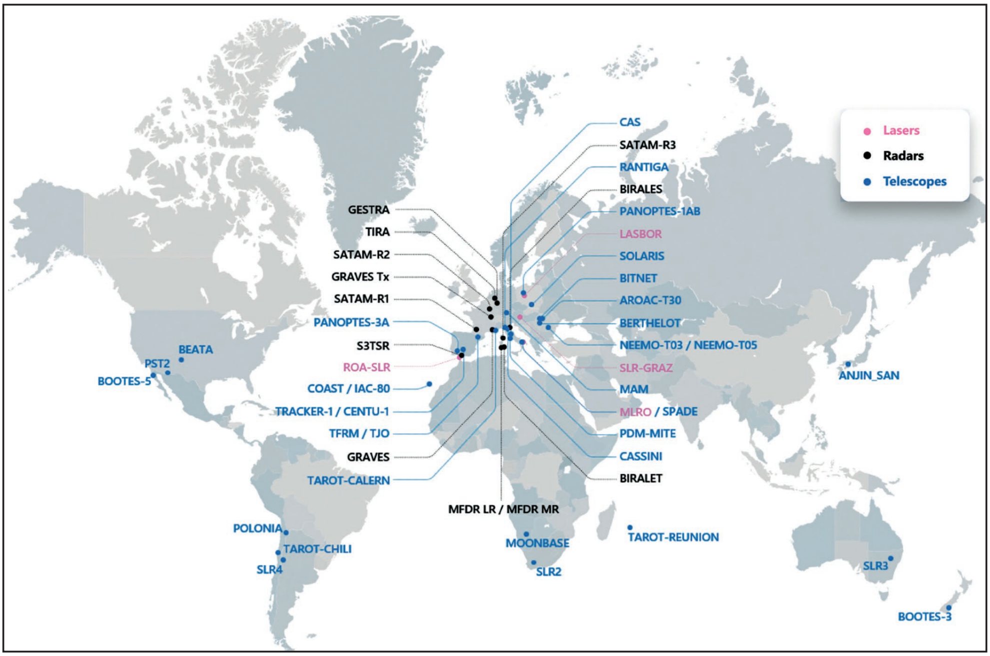
and promote the ISO standards as a reference for all national space laws.

8. Finally, to achieve a full, autonomous situation assessment capacity in space in support of its diplomatic or defence and security actions, the European Union must be able, in a fully sovereign manner, to attribute any action in space that threatens, or could potentially threaten, safety and security in space.

ANNEX 1: ACRONYMS

ADR	Active Debris Removal
ASAT	Anti-satellite
CNES	*Centre national d'études spatiales* – French space agency
ECSS	European Cooperation for Space Standardization
EM	Electro-magnétique
ESA	European Space Agency
ESPI	European Space Policy Institute
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GEO	Geostationary orbit
GNSS	Global Navigation Satellite System
GSSAP	Geosynchronous Space Situational Awareness Program
IAA	International Academy of Astronautics
IADC	Inter-Agency Space Debris Coordination Committee
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JCA	Just in-time Collision Avoidance
LDTM	Large Debris Traffic Management
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
MFF	Multiannual Financial Framework
MS	Member States
NASA	National Aeronautics and Space Administration
RSP	Recognized Space Picture
SDA	Space Domain Awareness
SSA	Space Situation Awareness
SSC	Space Safety Coalition
SST	Space Surveillance and Tracking
STM	Space Traffic Management
TCBM	Transparency and Confidence-Building Measures
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space

ANNEX 2: GEOGRAPHIC DISTRIBUTION OF EU SST ASSETS



The Space surveillance and tracking systems contributing to the EUSST project are numerous and well diversified. Their geographical distribution is satisfactory, but the main challenge lies in their operational implementation. Since not all are primarily dedicated to space surveillance, their availability for this purpose is reduced. Optimising their use requires effective planning and therefore an efficient coordination and quality control system which has yet to be developed. Additional resources are also needed to satisfy the whole set of requirements.

Previous Opinions

Opinion No. 1 on “Aviation accidents, technical and legal responsibility”, 2007

Opinion No. 2 on “The proposed European regulation on investigation and prevention of accidents and incidents in civil aviation”, 2010

Opinion No. 3 on “The European Regulation on aviation safety”, 2011

Opinion No. 4 on “The eruption of Eyjafjöll volcano in April 2010”, 2011

Opinion No. 5 on “Combat Aviation”, 2013

Opinion No. 6 on “The European Defence Agency”, 2015

Opinion No. 7 on “A robust management system for on joint European defence programmes”, 2016

Opinion No. 8 on “The European Strategy for Aviation proposed by the European Commission”, 2016

Opinion No. 9 on “The Future of European launchers”, 2019

Opinion No. 10 on “Human Spaceflight: what strategy for Europe?”, 2019

Opinion No. 11 on “Preparing for green aviation while preserving commercial transport aircraft development know-how in Europe”, 2020

Opinion No. 12 on “European secure connectivity”, 2021

Opinion No. 13 on “Air transport in crisis and the climate challenge: towards new paradigms”, 2021