

# **The joint Call of the Science Academies on the G7 Governments to Manage Large Satellite Constellations**

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**Académie des Sciences**

**Second Space Capacity Allocation  
For The Sustainability Of Space Activities Workshop**

**June 5, 2026, Milano**



ACADÉMIE  
DES SCIENCES  
INSTITUT DE FRANCE

# LARGE SATELLITE CONSTELLATIONS

- **The S7 Statement**
- **Context and Benefits**
- **Impact on Astronomy, Upper Atmosphere and Near Space**
- **Observations and Recommendations**

## G7 – SCIENCE 7

- **The G7 countries: Canada, France, Germany, Italy, Japan, the United Kingdom and the United States**
- **The S7: scientific component of G7, organized by the science academies of the G7 countries**
- **S7 meetings: Designed to inform international policy decisions with available scientific knowledge**

## SCIENCE 7 2026: PARIS, MAY 18–19

**Three Statements were jointly**

- **discussed and prepared** by members of the science academies
- **endorsed and signed** by the heads of the science academies
- **presented to and discussed with President Macron**



**Aim of this talk: summarize the Statement entitled  
Large Satellite Constellations: Perspectives and Challenges**

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## CONTEXT: NEW SPACE ERA

- **End of state monopolies**
- **New offered services**
- **Newcomers: giants like Starlink, large number of SMEs (12 000)**
- **New orbits: GEO → LEO/MEO**
- **New platforms: cubes sats, nanosats**
- **Cost reduction for satellite manufacturing and launching**
- **Injection of private funds for commercial services**

## CURRENT FUNCTIONALITIES & BENEFITS

### – **Communications**

few constellations, each with a large number of satellites

### – **Earth observation**

many constellations, each with fewer satellites

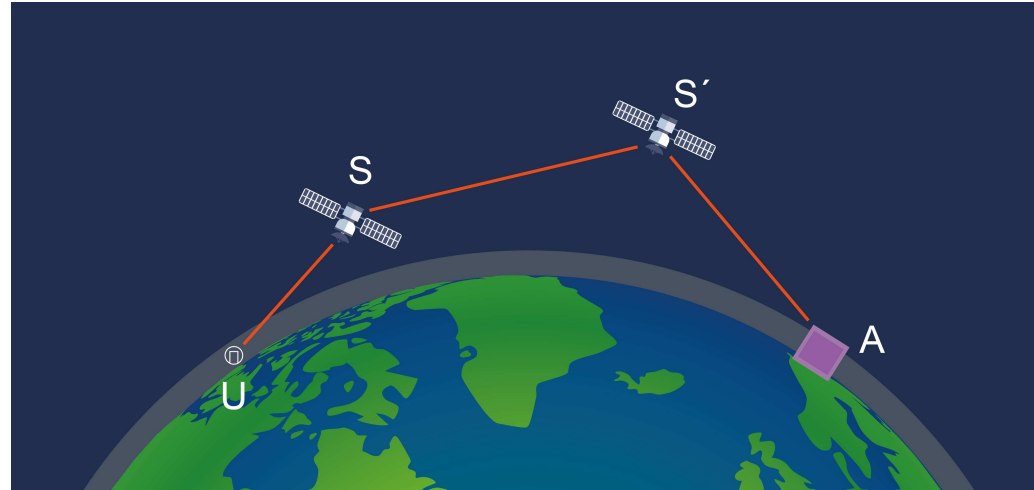
### – **Geolocalisation**

few constellations, each with few satellites

### **Communications and Internet access**

- **universal** (latitude constraints for some configurations)
- **without interruptions** (if sufficiently many orbits and satellites)
- **broadband** (constraints on number of users per satellite)
- **low latency** (thanks to low orbits)
- **resilient** (distributed system)

## ORGANIZATION OF COMMUNICATIONS



**U:** *UE*, **S:** *satellite*, **A:** *gateway station*

**Examples of S-U and S-A links:**

*Ku (10,7-14,5 GHz), Ka (17,3-30 GHz), V (37-50,4 GHz) & 5G Bands*

**Inter satellite links:** *Laser*

**No need for gateways in the countries to be covered**  
**Long distance communications faster than through terrestrial networks**

## OLD, NEW & FUTURE CONSTELLATIONS

### Communications and Internet Access

**Iridium** (USA), \*, N < 100

**Globalstar** (USA), \*, N=48

**Oneweb** (UK, F), \*, N=624

**O3B** (USA), equatorial, N ~30

**Starlink** (US), mix, N=10K → 42K

**Amazon Leo** (USA), mix, N=11K

**IRIS<sup>2</sup>** (UE), mix, N ~300

**Guowang** (China), N=13K

**Qiafan** (China), N=12K

**Honghu-3** (China), N=10K

**Prospects: 80 000 satellites over the next decade**

## FUTURE FUNCTIONALITIES & BENEFITS

- **New paradigm for communication networks in terms of**
  - **Internet access for the 3 billion persons not covered**
  - **Improved resilience**
  - **Faster communications**
  - **Critical Real Time**
- **New and remarkable **Space-Based Internet** foreseen:**
  - **Joint communication and sensing**
  - **Embedded edge computing**
  - **Space-based data centers and AI**

**1 million satellite constellation announced  
for the space-based data center AI Starlink project alone**

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## IMPACT ON OPTICAL ASTRONOMY

- In the optical domain, the reflection of sunlight by satellites produces **streaks that contaminate telescopic images of the night sky**
- This has a **significant impact on sky surveys with large-field-of-view instruments**, in particular those searching for transient phenomena



A long-exposure image of the Orion Nebula showing satellite trails in 2019 (IAU)

## IMPACT ON RADIO ASTRONOMY

- **Radioastronomy is already very much disturbed, 24 hours a day, through interference from**

1. **downlink transmissions**
2. **on-board electronics at low frequencies**

**This threatens highly sensitive observations of radio sources and fundamental cosmological surveys**

- **Local radio sanctuaries accepted by some operators mitigate 1.**
- **Even in this case, 2. disturbs extremely sensitive radio astronomical observations (e.g. the Square Kilometer Array Observatory)**

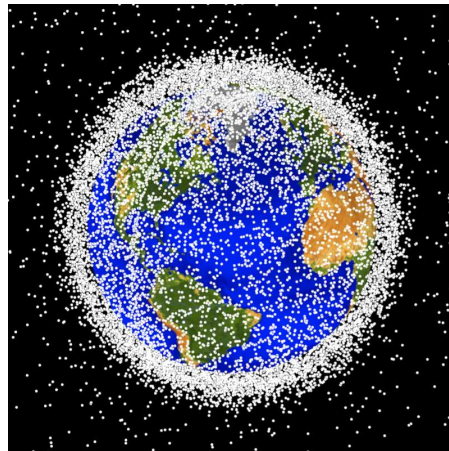
**The multiplication of these constellations will dramatically degrade observations if nothing systematic is done to mitigate their disturbances, even more if million scale constellations are deployed**

## IMPACT ON UPPER ATMOSPHERE CHEMISTRY

- The increase of launches leads to greater depositions of chemicals in the atmosphere:
  - during launch: **Black Carbon and other combustion products**
  - during satellite reentries: **Lithium, Aluminum, Titanium**
- **These chemicals accumulate in the mesosphere and stratosphere**  
Their residence times there is very long
- Their **impact on the upper atmospheric chemistry** and more specifically on the ozone layer are not well understood
- The impact of these launches and constellations on the **Earth's global radiative balance** should also be assessed

## IMPACT ON NEAR SPACE

### The current space debris situation



**Orbiting debris  
larger than 10 cm  
NASA, 2022**

**More than 28,000 objects larger than 10 cm are currently tracked**

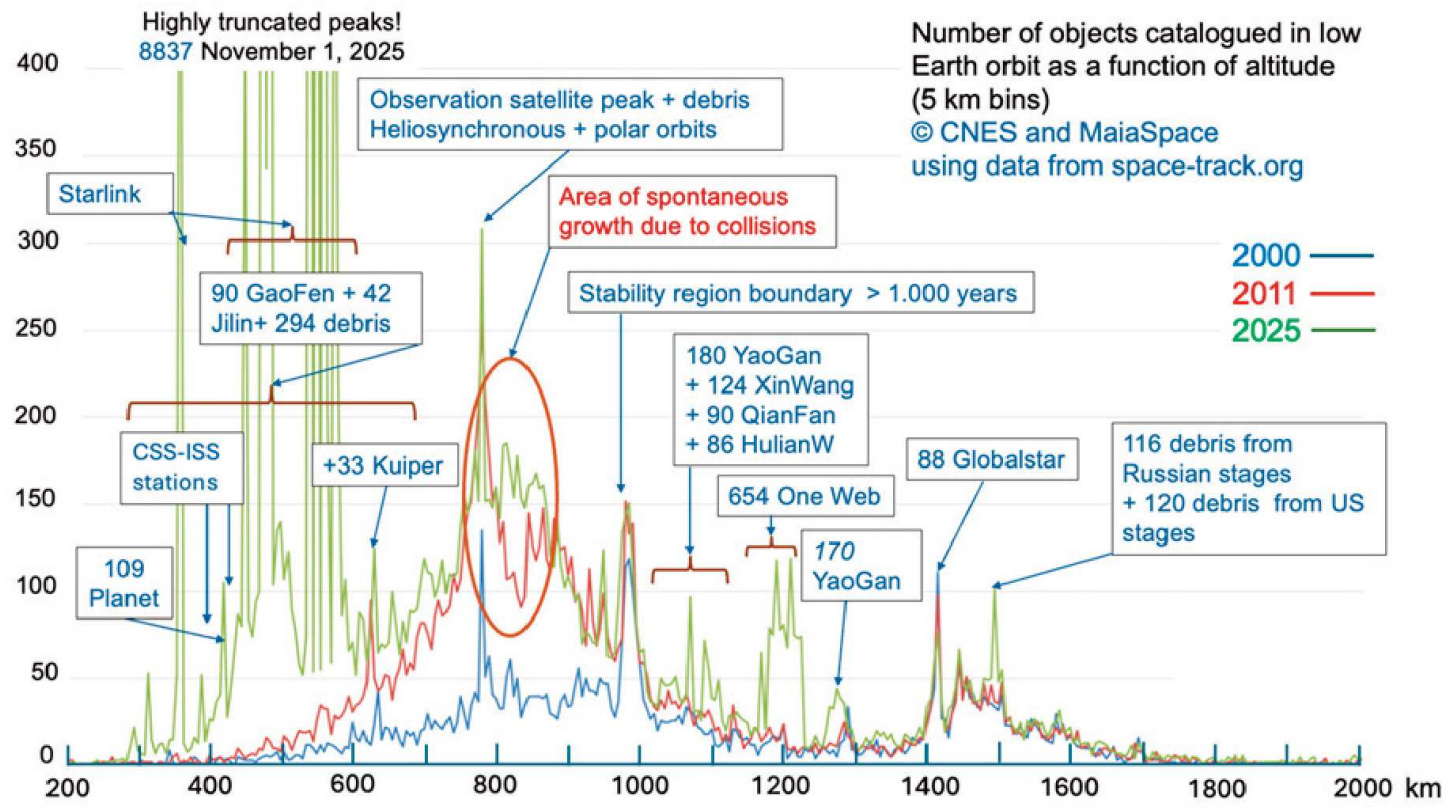
**Further orbiting debris:**

- $\frac{1}{2}$  million of order 1 cm
- 100 million of order 1 mm

**Causes (beyond lack of care):**

- **Satellite collisions**
- **Use of anti-satellite weapons**

# LEO ORBITAL POPULATION TODAY



## SPACE TRAFFIC MANAGEMENT

- In 2009, a collision between an active US satellite and a dead Russian satellite generated over 1000 trackable debris staying in orbit
- The **number of maneuvers required for avoiding collisions** is already quite high: more than 100 000 in a single year of Starlink operation
- **Kessler Syndrome**: between 300 et 1100 km altitude, an uncontrolled augmentation of the number of satellites and debris could lead to
  - a multiplication of collisions
  - a **chain reaction** with exponential increase of the number of debris

## MORE ON SPACE TRAFFIC MANAGEMENT

- **With the growing number of satellites and debris in LEO and MEO, STM becomes a highly complex and costly task** due to difficulties with
  - tracking and collision predictions
  - collision avoidance procedures
  - on-board energy expenditure of maneuvers
- **Need for further surveillance and tracking systems to**
  - maintain and update orbital data of a fast growing population of satellites and debris
  - estimate collision probabilities
  - provide timely information to implement avoidance measures
- **Need to assess the maximal operational load for which STM remains feasible by determining the carrying capacity of LEO and MEO orbits**

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## OBSERVATIONS

- The current attribution of orbital resources does not take into account**
- the negative impacts of these constellations on astronomy and upper atmosphere chemistry**
  - thresholds beyond which an orbital region can no longer reliably support safe, economically viable, and unimpeded operations**
  - the risks induced on near space by growing divergence between independent tracking catalogs and forecasts and the absence of an effective space traffic management system**

**The remarkable advances brought by these LEO/MEO satellite constellations will only be sustainable if these risks and impacts are thoroughly assessed and taken into account**

## RECOMMENDATIONS

- (1) Strengthen research, development and uncertainty quantification to take full advantage of the benefits of satellite constellations**
- (2) Improve space traffic management by enforcing de-orbiting and debris-mitigation standards and advance orbital carrying capacity assessment methods as a basis for licensing**
- (3) Protect astronomical observations from disruptive consequences through design innovation and regulation, and assure that Earth observation satellites will be able to pursue their mission with minimal interference**

## RECOMMENDATIONS

- (4) Assess and minimize impact on atmospheric environment**
- (5) Implement new, more informed and fair allocation schemes for finite orbital and frequency resource management**
- (6) Extend to the future space-based Internet the principles of universality, transparency and equitable participation of the current terrestrial Internet**

## RECOMMENDATIONS

### (7) Implementation:

- (i) **Promote all actions already under way for addressing these issues, and establish an intergovernmental panel providing policy makers with regular assessments of space sustainability**
- (ii) **Create an intergovernmental panel like the International Telecommunication Union, but with broader responsibilities covering not only frequency and orbit allocations, but also taking into account traffic management, orbital carrying capacity, environmental and astronomical impact**
- (iii) **Based on (i) and (ii) let an international treaty emerge on these questions as a common framework for consolidating the advances brought and addressing the issues raised by these constellations**

## CONTRIBUTORS TO THE S7 STATEMENT

### Large Satellite Constellations: Perspectives and Challenges

- **Académie des Sciences:** François Baccelli (chair), Sébastien Candel, Guy Perrin, Christophe Salomon
- **Accademia Nazionale dei Lincei:** Paolo De Bernardis, Francesca Matteucci, Marco Tavani
- **National Academy of Sciences:** Moriba Jah
- **Nationale Akademie der Wissenschaften Leopoldina:** Karl-Heinz Glaßmeier
- **Science Council of Japan:** Kumi Nitta
- **The Royal Society:** Martin Sweeting
- **The Royal Society of Canada:** Peter Brown

## S7 STATEMENT AND SUPPORT DOCUMENTS

<https://www.academie-sciences.fr/>

[s7-les-academies-des-sciences-des-pays-du-g7-reunies-paris-pour-porter-la-voix-de-la-science](https://www.academie-sciences.fr/s7-les-academies-des-sciences-des-pays-du-g7-reunies-paris-pour-porter-la-voix-de-la-science)