SDA Bocconi SCHOOL OF MANAGEMENT

SEE LAB
SPACE ECONOMY EVOLUTION

Space Commercialization, new Technologies and Defense: tackling the future Policy Challenges

Simonetta Di Pippo

SDA Bocconi Professor of Practice of Space Economy

Director, Space Economy Evolution Lab – SEE Lab

Agenda

1 | The Space Economy Evolution Lab – SDA Bocconi School of Management

2 | Commercial markets as a push for policy development

1. *Overview on the Space Economy*

3 | Present and Future Policy Challenges

1. *Space Data Commercialization in Europe*
2. *Space Debris and Orbital Sustainability*
3. *International Relations for the Peaceful Uses of Space*

4 | Defense and Security in and from Space

5 | New Technologies and Security Challenges: The Need for new Skills

6 | Perspectives and Direction for the Future

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1. The Space Economy Evolution Lab – SDA Bocconi School of Management

The SEE Lab: from 2018 to 2023 (Q1)

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The SEE Lab was founded in 2018 at SDA Bocconi by Professor Andrea Sommariva, under the shared vision of Professor Nanni Bignami.

At the time, the SEE Lab was the first research center, at global level, dedicated to the analysis of the economy of space, a sector that is facing an historical transition.

Since the intersection of different disciplines of the space sector, the SEE Lab has embraced a multidisciplinary approach for conducting its activities.

The SEE Lab was created to provide its multiple stakeholders with the in-depth understanding and strategic insights to leverage the opportunities presented by the evolution of the space economy.

FACT SHEETS

- **4** ANNUAL INTERNATIONAL CONFERENCES
- **5** INTERNATIONAL WORKSHOPS
- **7** APPLIED RESEARCH PROJECTS
- **9** INTERNATIONAL CONFERENCES ATTENDED AS SPEAKERS
- **1** START-UP COMPETITION
- **8** MEMBERS
- **20** NATIONAL AND INTERNATIONAL STRATEGIC PARTNERS

The SEE Lab's new Director

Simonetta Di Pippo

- Director of the SEE Lab
- Professor of Practice of Space Economy at SDA Bocconi

1980'	• Master Degree In Astrophysics And Space Physics – Università Of Rome 'La Sapienza • National Space Plan – National Research Council (CNR), Adv. Studies
1990'	• ASI Management Roles– Italian Space Agency
2000'	• Chair, ESA Board Of Potential Participants - Aurora Program • ASI Secretary General – Italian Space Agency • Chair, ESA Program Board Of Human spaceflight, Microgravity And Exploration (HME) • Director, Observation Of The Universe – Italian Space Agency • Director, Human Spaceflight – European Space Agency • Co-founder, Women In Aerospace Europe – WIA Europe (Current)
2010'	• Member, EC Space Advisory Group On H2020 • Head, European Space Policy Observatory – Italian Space Agency • Director, United Nations Office For Outer Space Affairs – United Nations (March 2014 – March 2022)
2020'	• WEF Global Future Council On Space – World Economic Forum (current) • Director of the SEE Lab, SDA Bocconi School of Management (current)

The SEE Lab's activities

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- The SEE Lab believes that the combination of cutting-edge knowledge and pragmatic outcomes and insights drives the impact of education programs and the value of dissemination events.
- At the same time, they bolster new ideas and perspectives in the context of the space economy. Thus, applied research projects represent the primary focus of the Lab activities through which feed strategic thinkings for private corporates and public institutions.

IDEAS GENERATION

TITAN BRAIN TRUST

High-level roundtable with external subject experts to discuss political, market, and technology topics.

GENERAL ASSEMBLY

General assembly during which the SEE Lab activities, achievements and future perspective are presented to its stakeholders.

APPLIED RESEARCH

OUTPUTS AND STRATEGIC INSIGHTS

Elaboration of data and strategic insights offered by the SEE Lab on specific topics.

ANNUAL REPORT

Highlights on global space economy trends and focus on conjoint activities with members.

DISSEMINATION

EVENTS

Conferences, workshops, and seminars organized by the SEE Lab involving relevant stakeholders belonging to the space industry and various business fields to stimulate the debate for innovative ideas and boost the pragmatism of the events.

EDUCATION

TRAINING OF TALENTS

Design and implementation of personalized courses, combining the organization's strategic objectives with individual professional and personal development.

SEEData

Dataset representing SEE Lab main core asset and the basis for all its activities. It includes key economic and financial data on global space industry*.

NOTE: The release of the database is progressive and based on building-blocks.

9 The SEE Lab's Strategic Partners

The SEE Lab's Partners with international **public institutions**, **research centers**, **universities**, and **foundations** to deepen its understanding in technology, science, space law and regulation, and international policy fields.

➞ PUBLIC INSTITUTIONS

esa

UNITED NATIONS Office for Outer Space Affairs

EU-Japan Centre for Industrial Cooperation 日欧産業協力センター

STATO MAGGIORE DIFESA

UNIDROIT International Institute for the Unification of Private Law Institut international pour l'unification du droit privé

➞ NGOs

AIPAS

ASAS

MOON VILLAGE ASSOCIATION

polispace

➞ RESEARCH CENTERS

INAF Istituto Nazionale di Astrofisica National Institute for Astrophysics

iit ISTITUTO ITALIANO DI TECNOLOGIA

➞ UNIVERSITIES

Colorado School of Mines

Space Policy Institute THE GEORGE WASHINGTON UNIVERSITY

SAPIENZA UNIVERSITÀ DI ROMA

NYU ABU DHABI

NOVA SCHOOL OF BUSINESS & ECONOMICS

Politecnico di Torino

UNIVERSITÉ FRANCHE-COMTÉ Membre de UBFC Université Bourgogne Franche-Comté

➞ FOUNDATIONS

SECURE WORLD FOUNDATION

FONDAZIONE LEONARDO Civiltà delle Macchine

FONDAZIONE NORD EST forum economico del nordest

10.2 The SEE Lab's Members

SILVER | GOLD | PLATINUM | DIAMOND

SITAEL

AVIO
ADVANCED VISION INTO ORBIT

ThalesAlenia Space
a Thales / Leonardo company

INTESA SANPAOLO

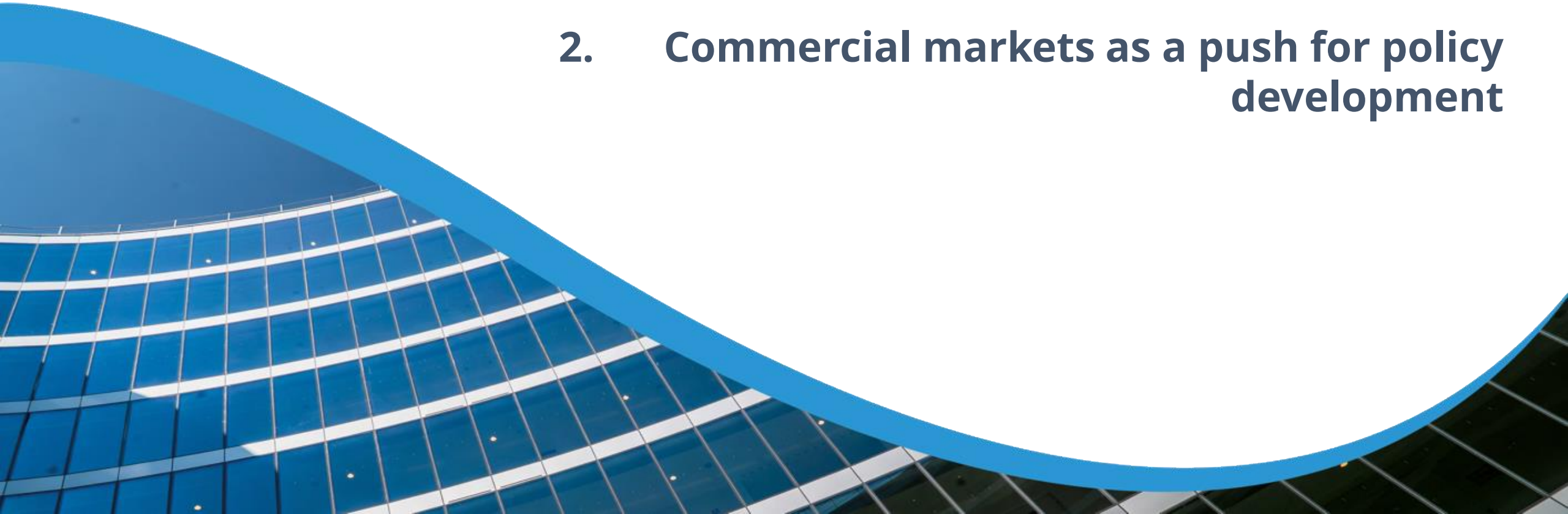
D-ORBIT

Capgemini

TELESPAZIO
a LEONARDO and THALES company

Tyvak
A Terran Orbital Corporation

AIRBUS



2. Commercial markets as a push for policy development

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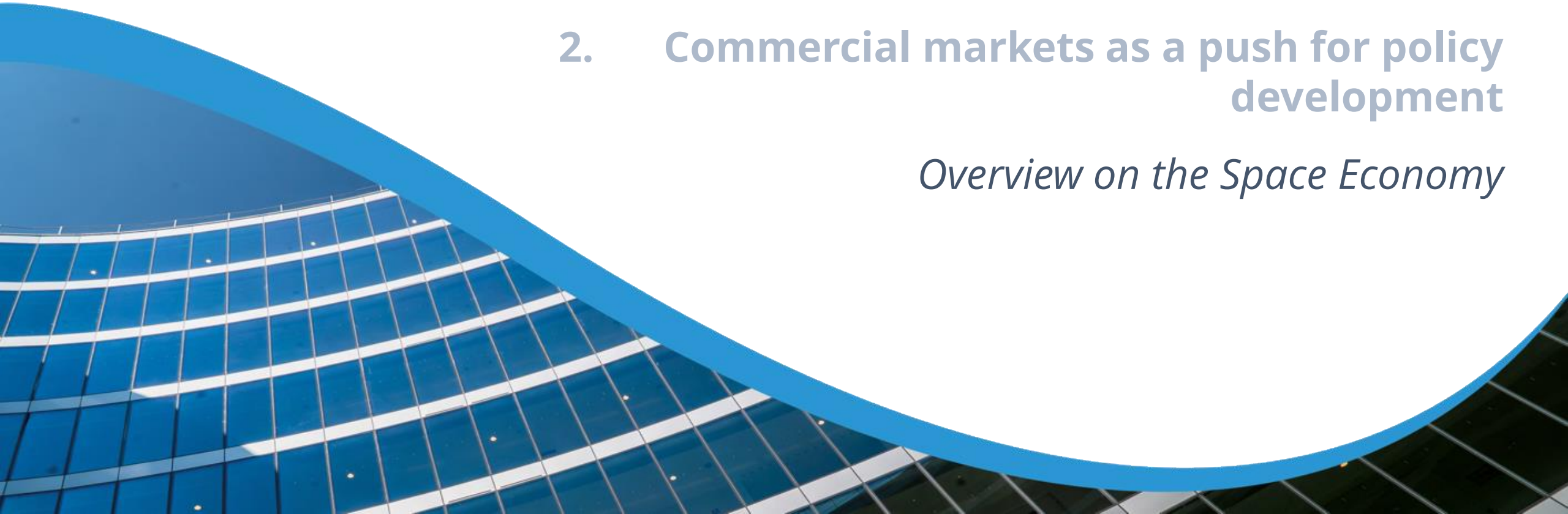

2. Commercial markets as a push for policy development

Overview on the Space Economy

The space economy is more than space…

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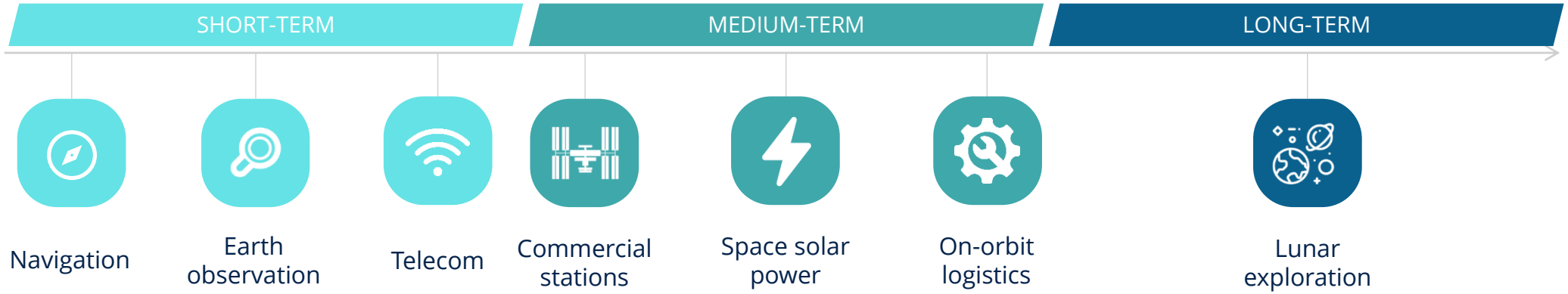
- Space Economy is defined by OECD as the full range of activities and the use of resources that create value and benefits to human beings while exploring, researching, understanding, managing, and utilizing space.
- The Space Economy is growing and evolving, together with the development and profound transformation of the space sector and the further integration of space into society and economy. The space sector is not only a growing sector itself but is a vital enabler of growth in other sectors.



DOMAIN	On earth			In Earth orbits			Beyond Earth orbits		
CUSTOMERS	Government	Business	Consumer	Government	Business	Consumer	Government	Business	Consumer
FUNDS	Private-based capital market			Public-Private-based capital market			Public-based capital market		
TECHNOLOGY	Commercialization			Validation			Demonstration		

- Service: **civil (and military) connectivity in LEO**
- Ex. Society: Starlink - Starshield.

CHANGE OF PARADIGM

- Program: OSAM-1
- Service: **logistic-in orbit servicing (LEO)**
- Ex. Society: Maxar, MADA

- Program: Space Based Solar Power
- Service: **Solar Energy for Earth**
- Ex. Society: Northrop Grumman

- Program: Orbital reef
- Service: **commercial station**
- Ex. Society: Blue Origin, SierraSpace

- Program: Star Lab
- Service**: commercial station**
- Ex. Society: Nanoracks, Voyager Space, Airbus ,Hilton

- Program: Axiom Space Station
- Service**: commercial station**
- Ex. Society: Axiom

- Program: Northrop Gruman Space Station
- Service**: commercial station**
- Ex. Society: Northrop Gruman

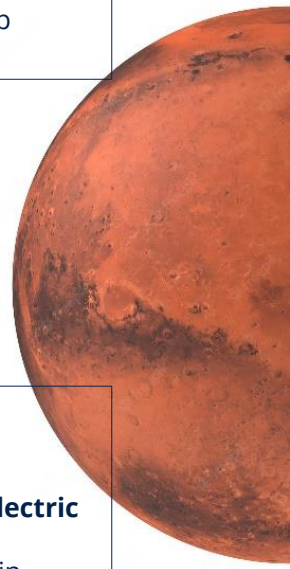
- Program: LunaNet
- Service: **Lunar Navigation and Telecommunication**

- Program: NextSTEP
- Service: **logistic-from the Moonr Gateway to low-Moonr orbit**
- Ex. Society: Blue Origin, Boeing, Lockheed Martin, Northrop Grumman, Sierra Nevada

- Program: Common Exploration Systems Development
- Service: **Exploration ground systems, Orion Program, Space Launch System**
- Ex. Society: Lockheed Martin for Orion

- Program: Artemis Campaign Development
- Service: **Gateway, CisMoonr and surface capabilitis, human landing systems, surface mobility program**
- Ex. Society: Boeing, Lockheed Martin, Northrop Grumman

- Program: OSAM-2
- Service: **logistic- In orbit servicing (Moon-Mars)**
- Ex. Society: Redwire, Northrop Grumman



- Program: Mars Campaign Development
- Service: **in-situ utilization, habitation systems, solar electric propulsion**
- Ex. Society: SpaceX, Blue Origin, Boeing, Lockheed Martin, Northrop Grumman

Note:
American programs only. Non-exhaustive examples.

Source:
NASA

...but the only value that we have is on the space sector.

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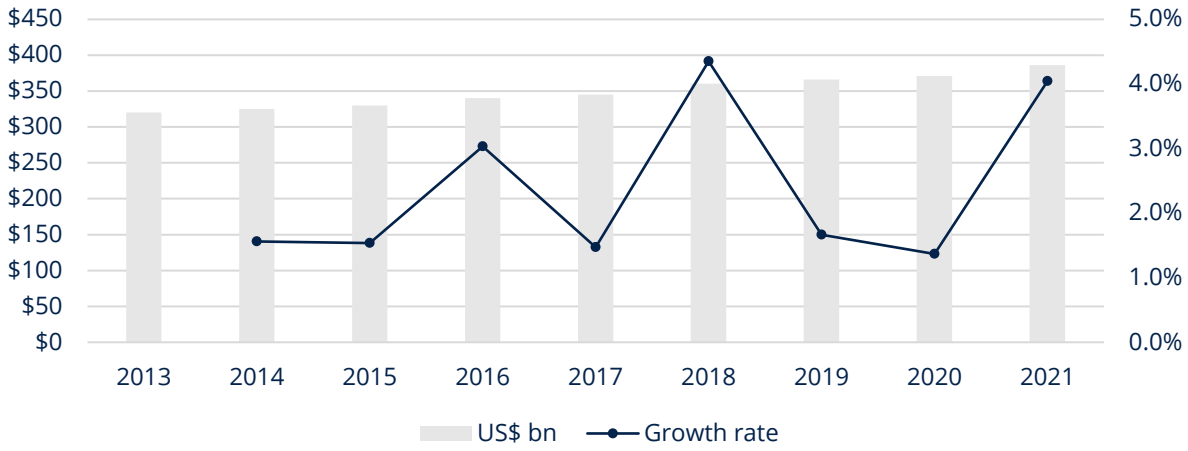
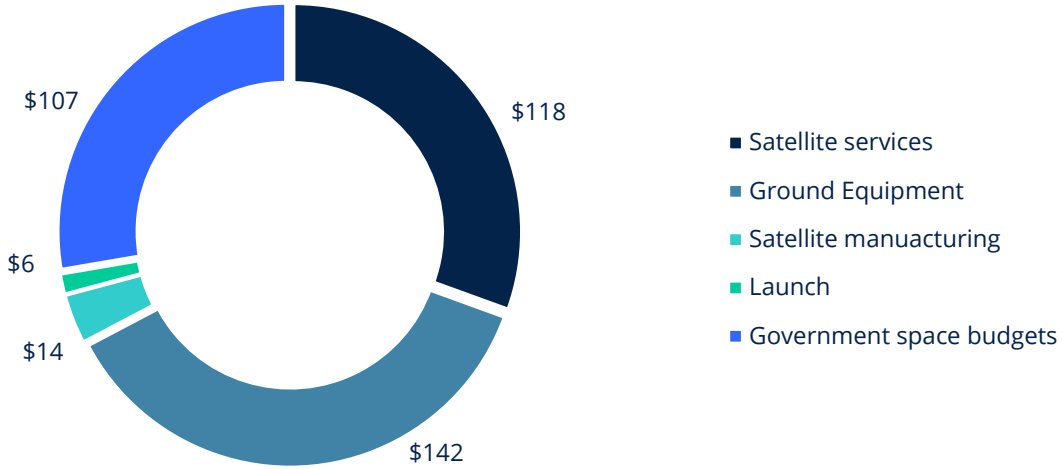
Space sector value (US$ bn) and YoY growth rate (%), 2013-2021



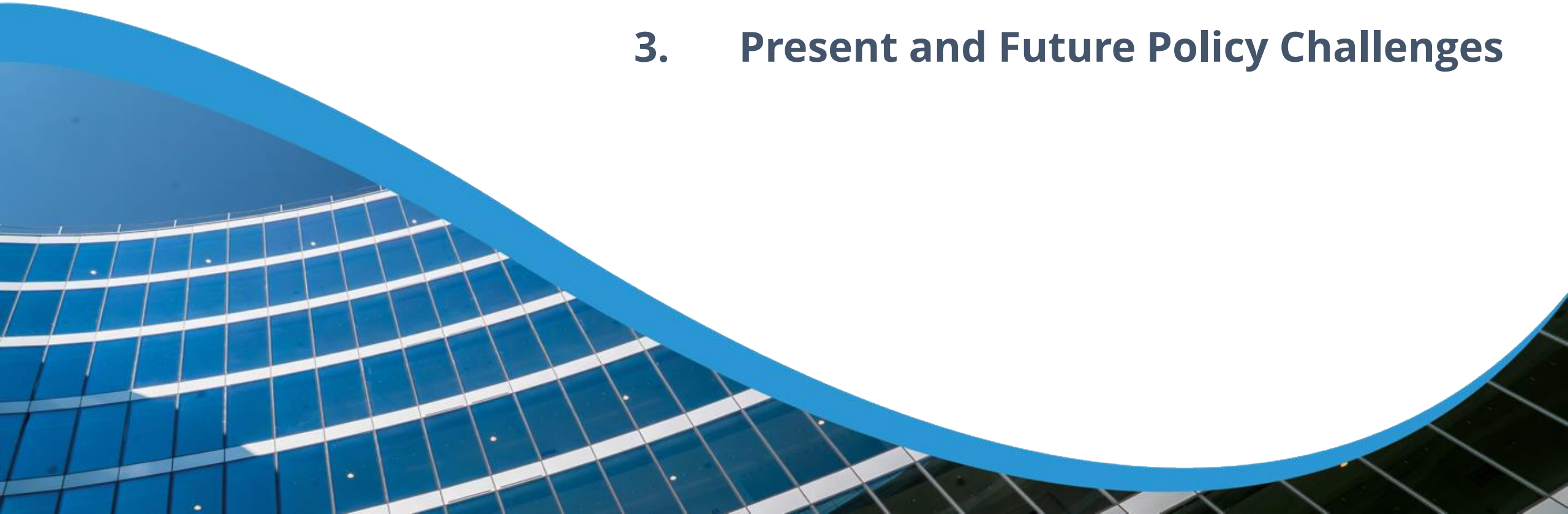
Break-down of the space sector value (US$ bn), 2021



In 2021, the estimated value of the space sector is in the order of US$ 386 billion. The estimation evaluated the:

- Government space budget: government spending (public space programs);
- Commercial satellites and launches: satellite manufactures and launch service providers outside public markets;
- Ground stations and equipment: ground stations, teleports, networks and user equipment
- Space products and services: economic activity of companies selling space-enabled products and services.

Source: SIA/ Bryce



3. Present and Future Policy Challenges

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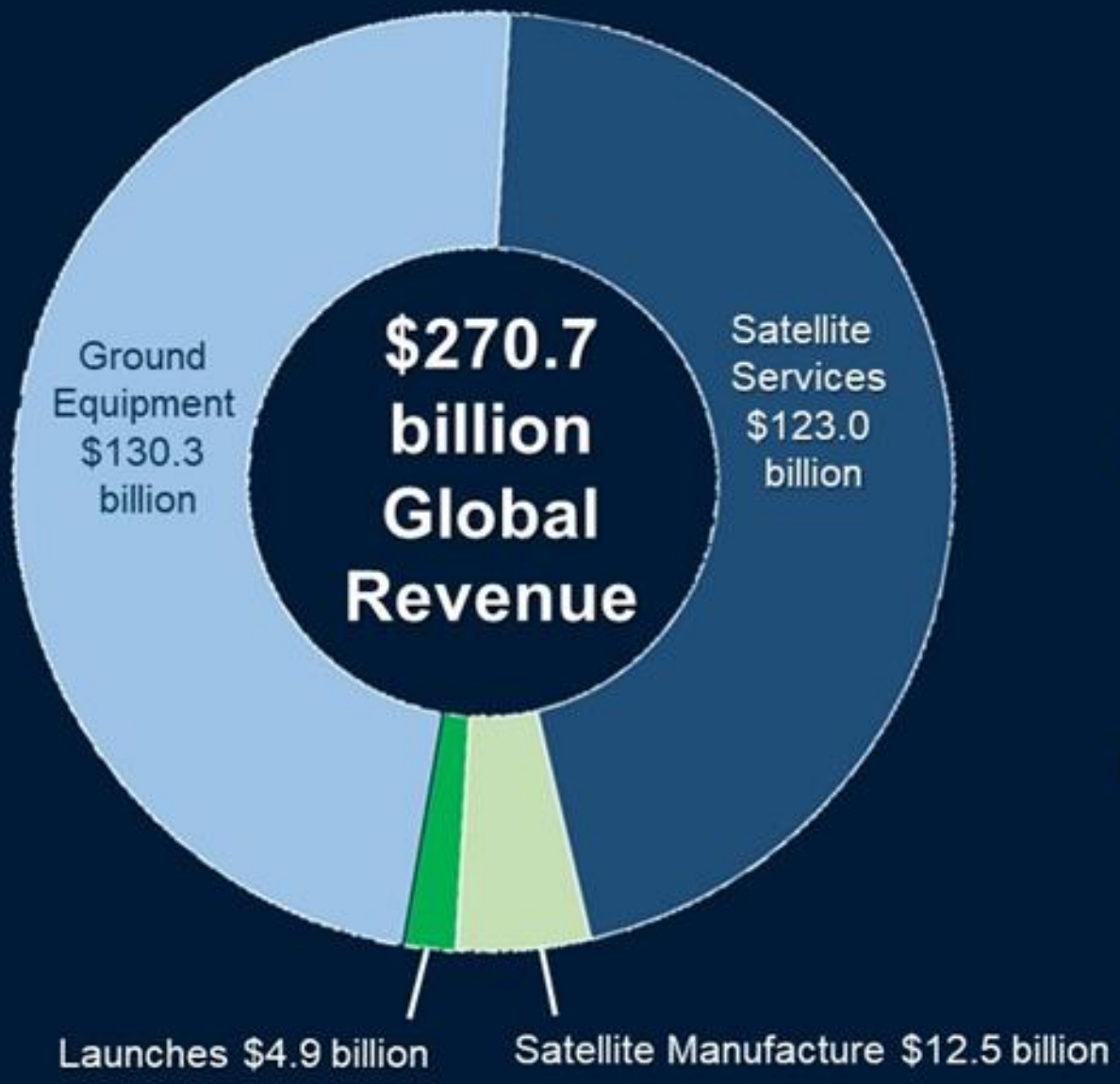
3. Present and Future Policy Challenges

Space Data Commercialization in Europe



The global commercial revenue linked to space is more than 15 times that of the revenue of launchers and satellite manufacturing

"The global space industry could generate revenue of US ***$1 trillion or more*** *in 2040"*

Morgan Stanley, 2020

Space Data Commercialization in Europe

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- In several areas of the space industry, particularly those where **technology is advanced** and **markets are willing to pay for services or information**, companies have shifted their approach and are actively participating in the co-development and co-funding of space projects.

- One domain with significant economic potential is **Earth observation**, although accessing the data can be challenging due to certain barriers. However, advancements in high-performance computing technologies can be leveraged to maximize the benefits of the data collected by the Copernicus Sentinel satellite fleet.

- The Copernicus Program itself aims to boost the proportion of European commercial VHR data, both on-demand and systematic CCM data supply, to **80% by 2027**. The program seeks to achieve this goal by promoting the emergence of **diverse supply sources** and exploring various types of commercial satellite data. This strategy aims to encourage the growth of European New Space players, including **SMEs** and **start-ups.**

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"The commercialization of European space activities will only succeed with the help of ESA.

*Until 2021, **SpaceX** (always referred to as "the" commercial success in space) has received, a total of **USD 28 billion** in revenues: **56% from public funding** (NASA, DoD, FCC), **24% private equity**, **20% commercial contracts**.*

NASA has provided 12.3 of that 28 billion dollars, roughly 44%, in addition to a huge engineering skill base.

In other words, SpaceX would not exist without NASA".

Josef Aschbacher, Director General, ESA

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3. Present and Future Policy Challenges

Space Debris and Orbital Sustainability

Sustainability in space: the space debris issue

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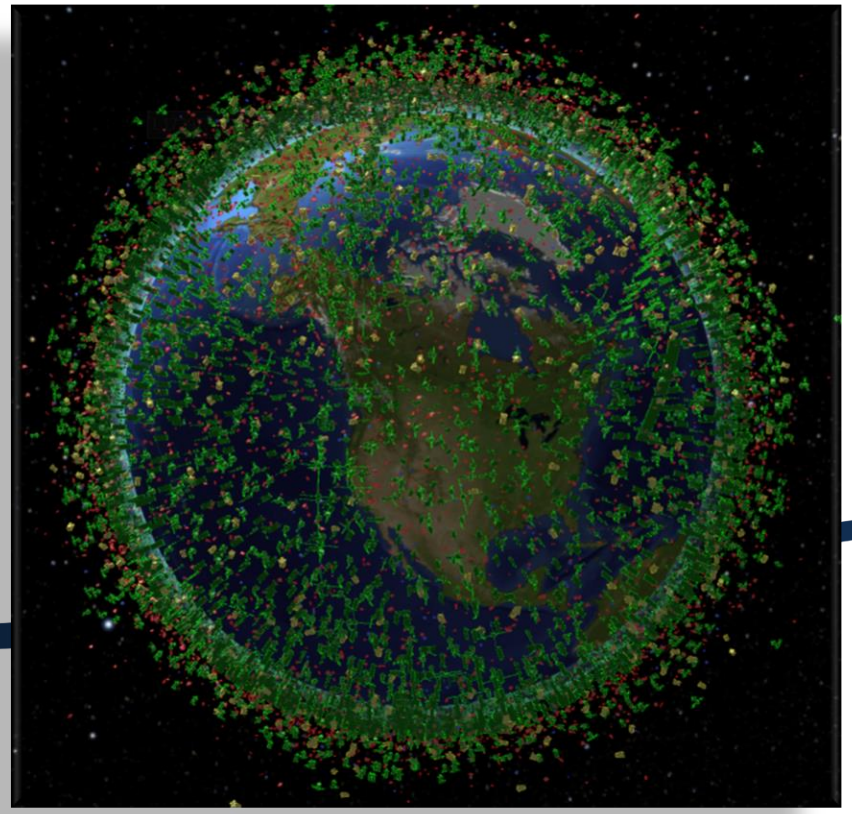
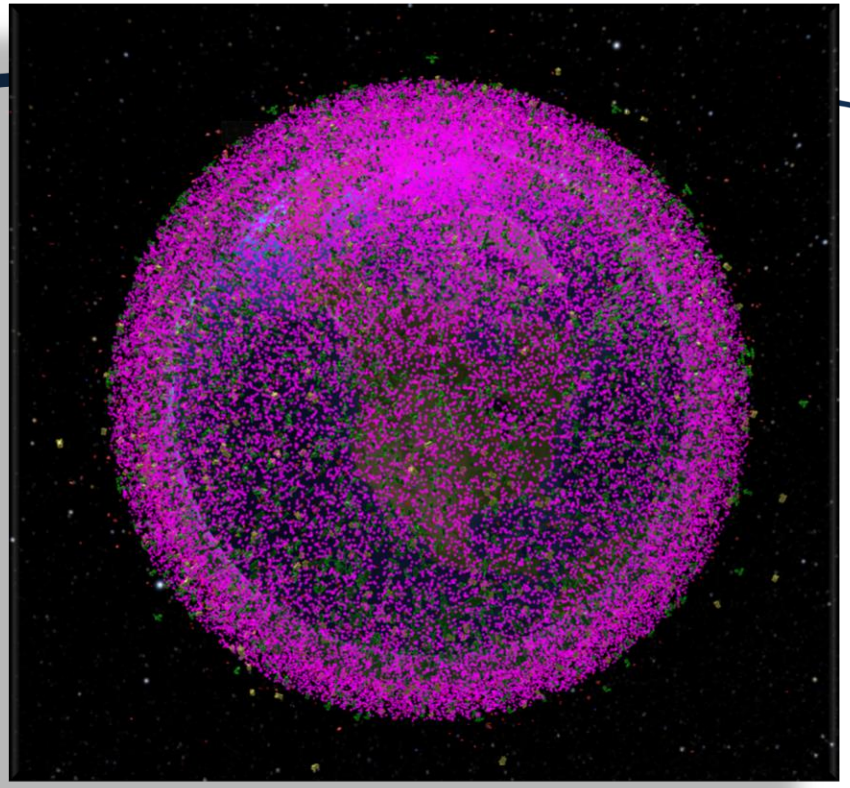


Space debris in Earth's orbits

The most recent estimates show that Earth's orbits are crowded by ca. **130m** debris between 1mm and 1 cm of dimension, ca. **1m** debris between 1cm and 10cm, and **36.500** debris bigger than 10cm. [2]



Active satellites and spacecrafts orbiting Earth

Currently, there are more or less **9.300** satellites orbiting Earth. More than 90% of them are concentrated in Low Earth Orbit (LEO). [1]

Kessler's Syndrome

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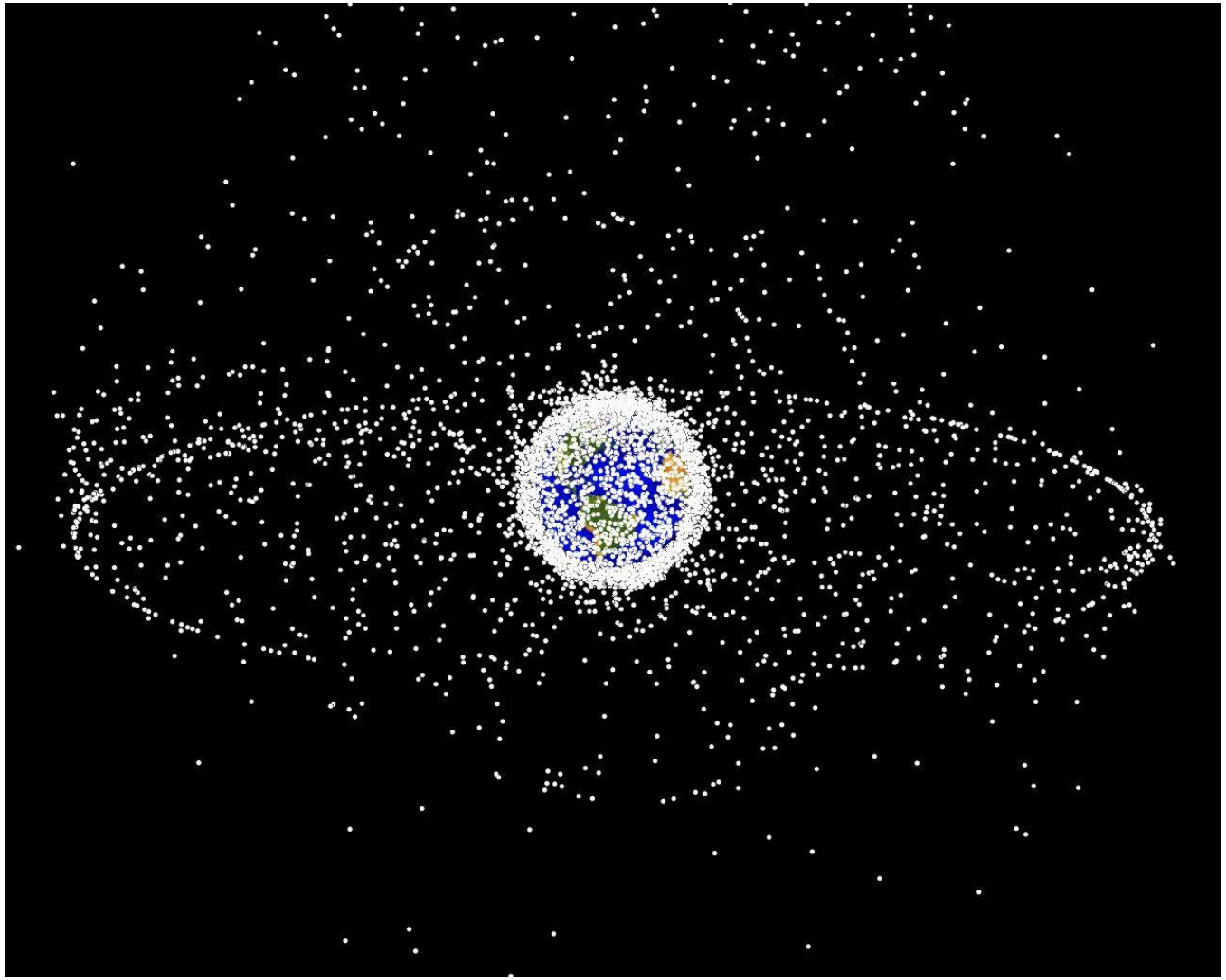
- At typical collision speed of 10 km/s in low orbits, impacts by millimeter-sized objects could cause local damage or disable a subsystem of an operating satellite.

- Collisions with debris larger than 1 cm could disable an operational satellite or could cause a breakup of a satellite or rocket body.

- Impacts by debris larger than about 10 cm can lead to a catastrophic break up: the complete destruction of a spacecraft and generation of a **debris cloud**.

- The fragments created by a collision can drive a cascading process, the so-called '**Kessler syndrome**', in which each collision between object generates more space debris, which increases the likelihood of further collisions.



Potential solutions for the space debris problem

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Mitigation guidelines

Resolution A/RES/62/17, United Nations, December 2007

Mitigation guidelines refers to a list of recommendations to be followed in the whole mission construction, development, management and operations.

Space Traffic Management (STM)

STM is referred to as the practice to let a satellite operate its specific purpose without being disturbed by other spacecrafts or debris on a collision course.

Long-term sustainability guidelines

Report of the Committee on the Peaceful Uses of Outer Space, sixty-second session, United Nations, June 2019.

21 guidelines divided in 4 sections:

- Section A: **Policy and regulatory framework for space activities**
- Section B: **Safety of space operations**
- Section C: **International cooperation, capacity-building and awareness**
- Section D: **Scientific and technical research and development**

Active Debris Removal (ADR)

ADR technologies enable a given spacecraft to physically capture space debris, in order to de-orbit or destroy them. ADR is currently in a testing phase, with several technologies under investigation:

- **Robotic arms**
- **Magnetic traps**
- **Nets**
- **Hook, harpoons**

The Guidelines of the United Nations

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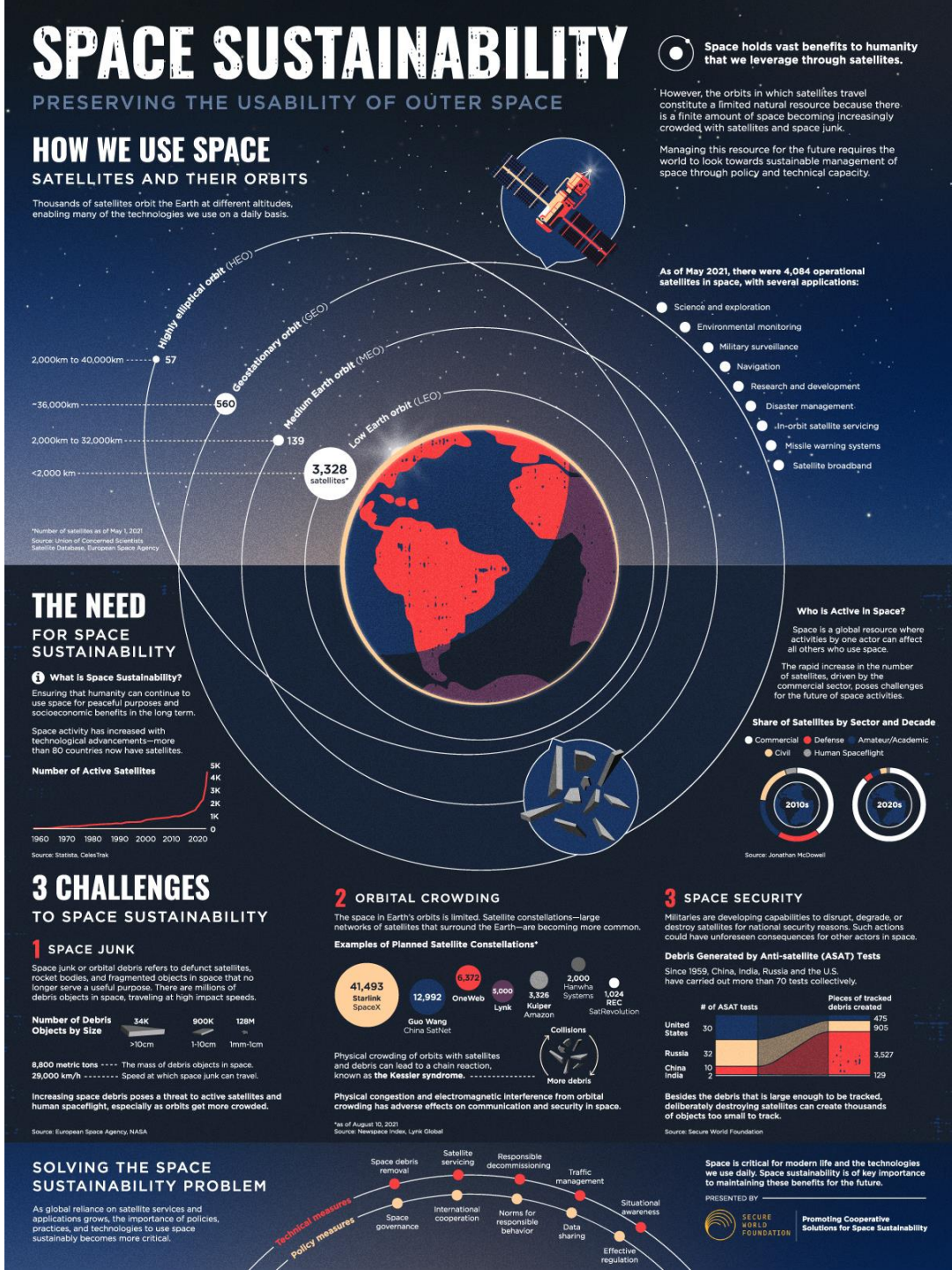
- The United Nations Committee on the Peaceful Uses of Outer Space has paid particular attention to the issue of preventing and minimizing the creation of space debris. Every year, States and organizations exchange information on their space debris research at the Committee's Scientific and Technical Subcommittee. One important result of those discussions has been a set of **Space Debris Mitigation Guidelines**, which were endorsed by the General Assembly in 2007.

- The Guidelines are the following:

1. to limit debris released during nominal operations,
2. to minimize the potential for break-ups during operational phases,
3. to limit the probability of accidental collision in orbit,
4. to avoid intentional destruction and other harmful activities,
5. to minimize the potential for post-mission break-ups resulting from stored energy, and
6. to limit the long-term presence of spacecraft and launch vehicle orbital stages in the low- Earth orbit (LEO) region / geosynchronous Earth orbit (GEO) region after the end of their mission.

The Guidelines of the United Nations

- In 2010, a Working Group on the Long-term Sustainability of Outer Space Activities was established, the objectives of which included identifying areas of concern for the long-term sustainability of outer space activities, proposing measures that could enhance sustainability, and producing voluntary guidelines to reduce risks to long-term sustainability.
- In June 2019, the **Guidelines for the Long-term Sustainability of Outer Space Activities** of the Committee on the Peaceful Uses of Outer Space were adopted. The Guidelines provide guidance on the policy and regulatory framework for space activities; safety of space operations; international cooperation, capacity-building and awareness; and scientific and technical research and development.



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3. Present and Future Policy Challenges

International Relations for the Peaceful Uses of Space

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967)

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- The 1967 Outer Space Treaty consists of 17 articles that created what can be considered the foundation of international space law.
- The Treaty bans the stationing of weapons of mass destruction (WMD) in outer space, prohibits military activities on celestial bodies, and details legally binding rules governing the peaceful exploration and use of space.
- Space is no longer the exclusive domain of the Russians and Americans. And with the rise of companies like SpaceX and Blue Origin, a private space race is on, with plans for tourism, asteroid mining, and even off-Earth settlements.
- States are now recognizing an uncomfortable fact: the Outer Space Treaty starts to be outdated, and several other, more specific norms are now needed to guarantee the peaceful, yet prosperous development of space activities.

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)

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- The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) is a United Nations body whose principal duty is to examine and develop international cooperation in the peaceful uses of outer space, as well as to consider legal concerns emerging from space exploration.
- The Committee was instrumental in the creation of the five treaties and five principles of outer space; moreover, International cooperation in space exploration and the use of space technology applications to meet global development goals are discussed in the Committee every year.

Virtuous example of collaboration

Mission Soyuz MS-23

Launched in February 2023 – Re-entry is scheduled for September 2023

- Moscow has launched a rescue vessel to the International Space Station to bring home three crew members who were in effect stuck in orbit after their original capsule was hit by a meteoroid.
- The docked Soyuz MS-22 sprang a major leak, spraying radiator coolant into space and prompting a pair of cosmonauts to abort a planned spacewalk.
- Due to its incapability to execute a crew return, Soyuz MS-22 made an unmanned return. On 24th February 2023, MS-23 was launched without a crew and will serve as a substitute, facilitating the return of the MS-22 crew in September 2023, By that time, the crew will have spent nearly a year in space.
- Space has remained a rare area of cooperation between Moscow and Washington since the conflict in Ukraine started.

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4. Defense and Security in and from Space

EU Space Priorities and Agenda

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At this year's 15th **European Space Conference's** opening session, High-Representative / Vice-President Josep Borrell and Commissioner for Internal Market, Thierry Breton discussed the priorities and challenges for the **2023 European Space agenda.**

The main areas of emphasis include the **competitiveness, resilience, sovereignty, and security** of the European Union in space.

The officials emphasized the **significance of space in the geopolitical context**, which has become even more apparent after Russia's military aggression against Ukraine.

Strategic Compass

EU Space Strategy for Security and Defense

The Strategic Compass

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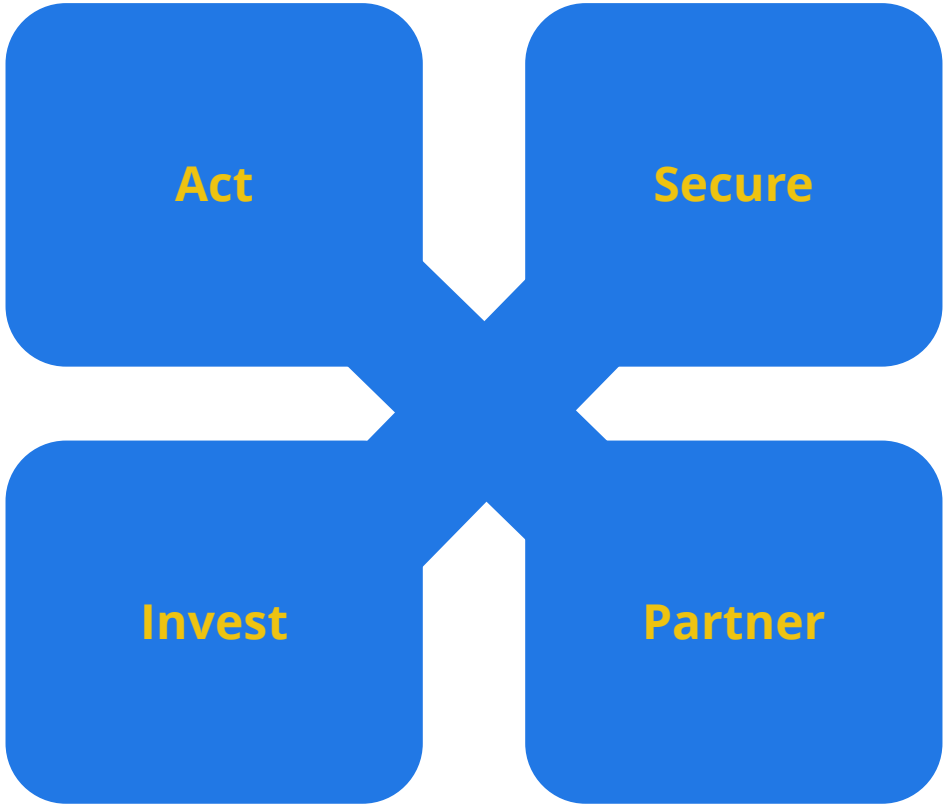

The Strategic Compass is a comprehensive **plan of action** that aims to strengthen the **European Union's security and defense policy by 2030**. Its goal is to enhance the EU's capacity as a provider of security, making it more robust and capable. This would have a positive impact on global and transatlantic security, and complement **NATO**, which is the foundation of collective defense for its members. Moreover, it will reinforce the support for the global rules-based order, with the **United Nations** at its core.

The Strategic Compass provides a shared assessment of the EU's strategic environment and the challenges and threats it faces. It proposes concrete and practical measures with specific timelines to improve the EU's ability to respond effectively to crises and safeguard the security of its citizens.

The EU Space Strategy for Security and Defense

- The Strategy highlights the threats to space systems and their ground infrastructure and outlines the counterspace capabilities required to mitigate these risks, utilizing a common definition of the space domain. The European Commission aims to achieve several objectives, including proposing a comprehensive EU Space Law to establish a consistent and EU-wide approach to security, safety, and sustainability in space.

- The Commission will also establish an Information Sharing and Analysis Centre (ISAC) to facilitate the exchange of best practices among commercial and public entities, raising awareness about resilience measures for space capabilities. Additionally, it will undertake preparatory work to ensure long-term autonomous access to space, specifically addressing security and defense needs.

- Furthermore, the Commission will strive to enhance the EU's technological sovereignty by minimizing strategic dependencies and ensuring the security of supply for space and defense, in close collaboration with the European Defense Agency and the European Space Agency.

Non-EU Perspectives:
The privates take up the challenge

- In December of last year, SpaceX unveiled **Starshield**, a program that will deliver **tailored spacecraft, sensors, and secure communication systems** to US defense and intelligence entities.

- Starshield promises to provide a greater degree of security than Starlink, with **enhanced cryptographic capabilities** to facilitate the hosting of classified payloads and secure data processing, in compliance with the most rigorous government standards.

- Furthermore, Starshield's spacecraft will be **compatible** with other satellites that utilize the laser-communication terminal technology used by Starlink vehicles.

Change of paradigm: the private sector, in the development of its own business strategies, becomes a Governments' supplier.

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5. New Technologies and Security Challenges: The Need for new Skills

New technologies and threats to security

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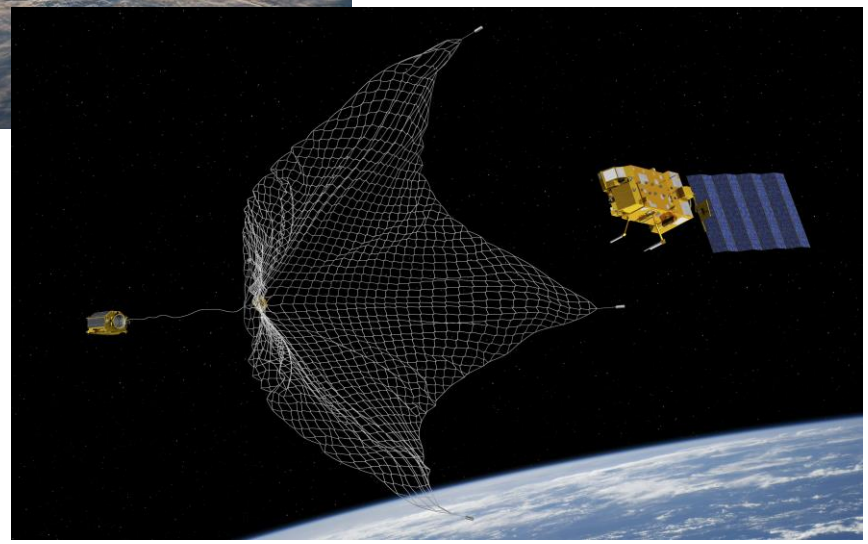
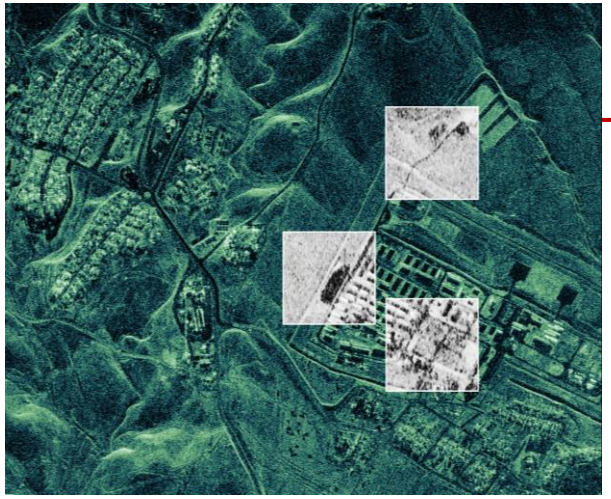
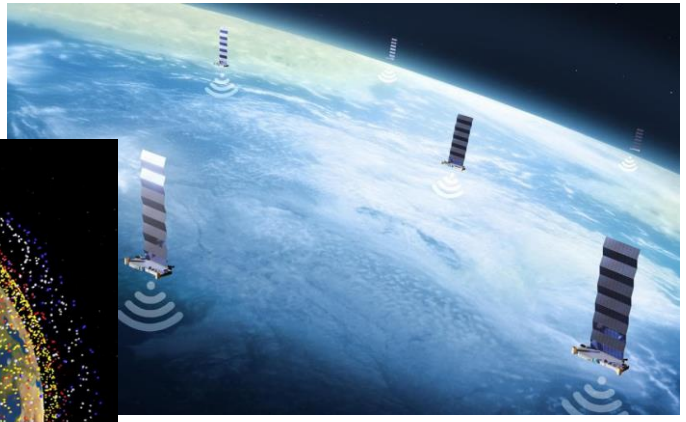
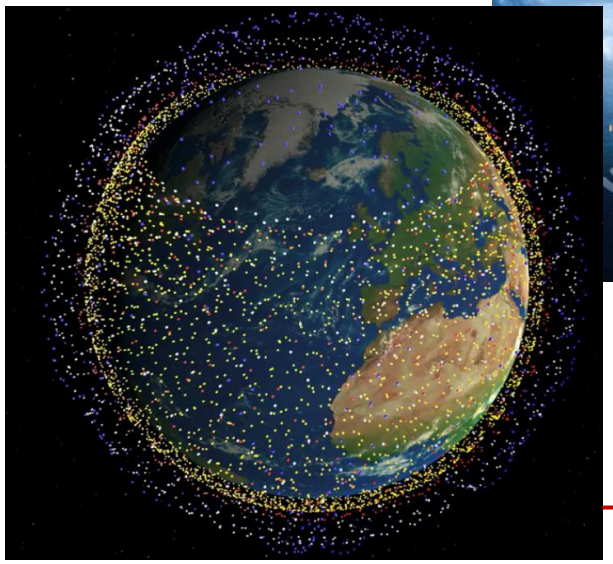
Harmful uses of ADR technologies





Military uses of EO data





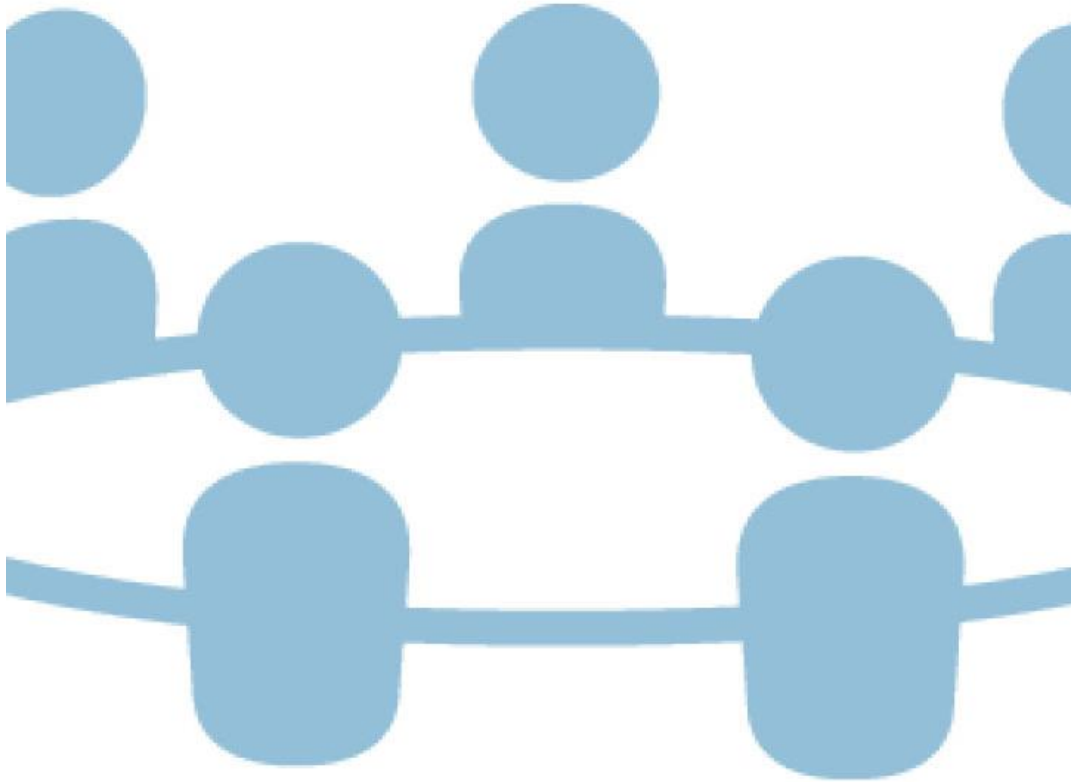
Cybersecurity of satellite internet connectivity

The need for new, multidisciplinary skills

The space sector is becoming increasingly complex. **New forms of international collaboration** are emerging, but so are various **defense and security implications**. The conflict in Ukraine has highlighted issues about dual-use technologies, new space weapons, and the use of satellite data for military purposes.

Moreover, **technology** is becoming more and more complex, as the lunar infrastructure's and the space station's ventures provide several examples.

This wholly new context requires novel, cross-thematic skills that not only focus on technical competences, but spread across geopolitics, diplomacy, economics, and social science.



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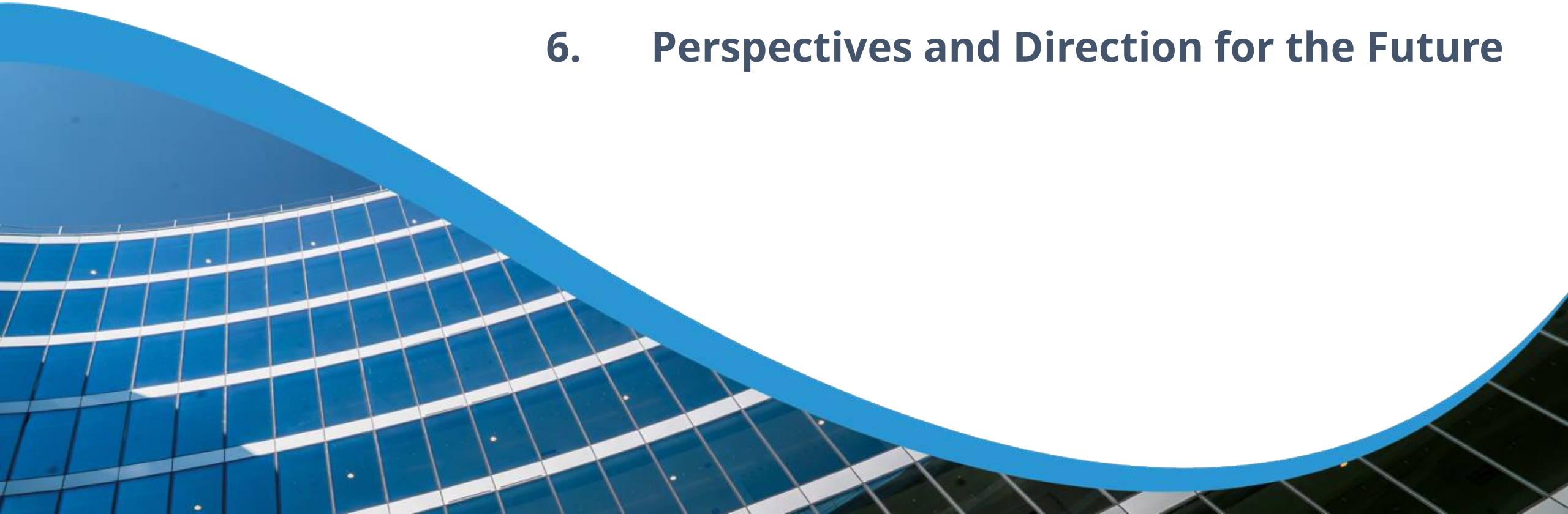

6. Perspectives and Direction for the Future

Towards the commercialization of space: the US case

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Innovative approaches

- **Objectives**: cost efficiency and sharing of development and operational risks between the public and private sectors.
- **Procurement scheme**: promoting competitiveness and innovation of the product/service.
- **Contracts**: hiring private companies through fixed-price contracts. Unlike cost-plus contracts, the milestones of fixed-price contracts guarantee payments only upon achieving predetermined objectives.
- **Collaborations**: public-private partnerships (PPPs) based on cost and risk sharing, promoting commercialization. The private sector is incentivized to adhere to the program's development stages to avoid incurring additional costs, attracting private capital.

Use cases

1. The public sector as a facilitator and partner

- **Innovative Public-Private Partnership for ISS Cargo:** COTS Program, to develop technologies for crew and cargo transportation to the International Space Station by private companies. Examples: Falcon 9 and Cargo Dragon (SpaceX).
- **Next Space Technologies for Exploration Partnerships (NextSTEP) - public-private partnership model:** As part of the Next Space Technologies for Exploration Partnerships (NextSTEP) initiative, NASA has awarded Axiom a $140 million contract to provide at least one habitable spacecraft to the ISS.

2. The public sector from entrepreneur to client

- **Maxar:** Contracts received from NASA to develop, for example, SMS-1. Later, in 1993, Maxar received the first license for commercialization of Earth Observation data. Today, among its objectives, Maxar aims to expand the sales of its commercial solutions also to the defense market.
- **SpaceX:** With Starshield, it aims to sell the commercial telecommunications service based on Starlink to the defense market as well.

Notes:
* Commercial Orbital Trasportation Services (COTS)
** US Department of Commerce guarantees to WorldView Imaging the first private licence to perform Earth observation activities.

Sources:
Academic Literature;
NASA

Benefits of the public governance transition: the US case

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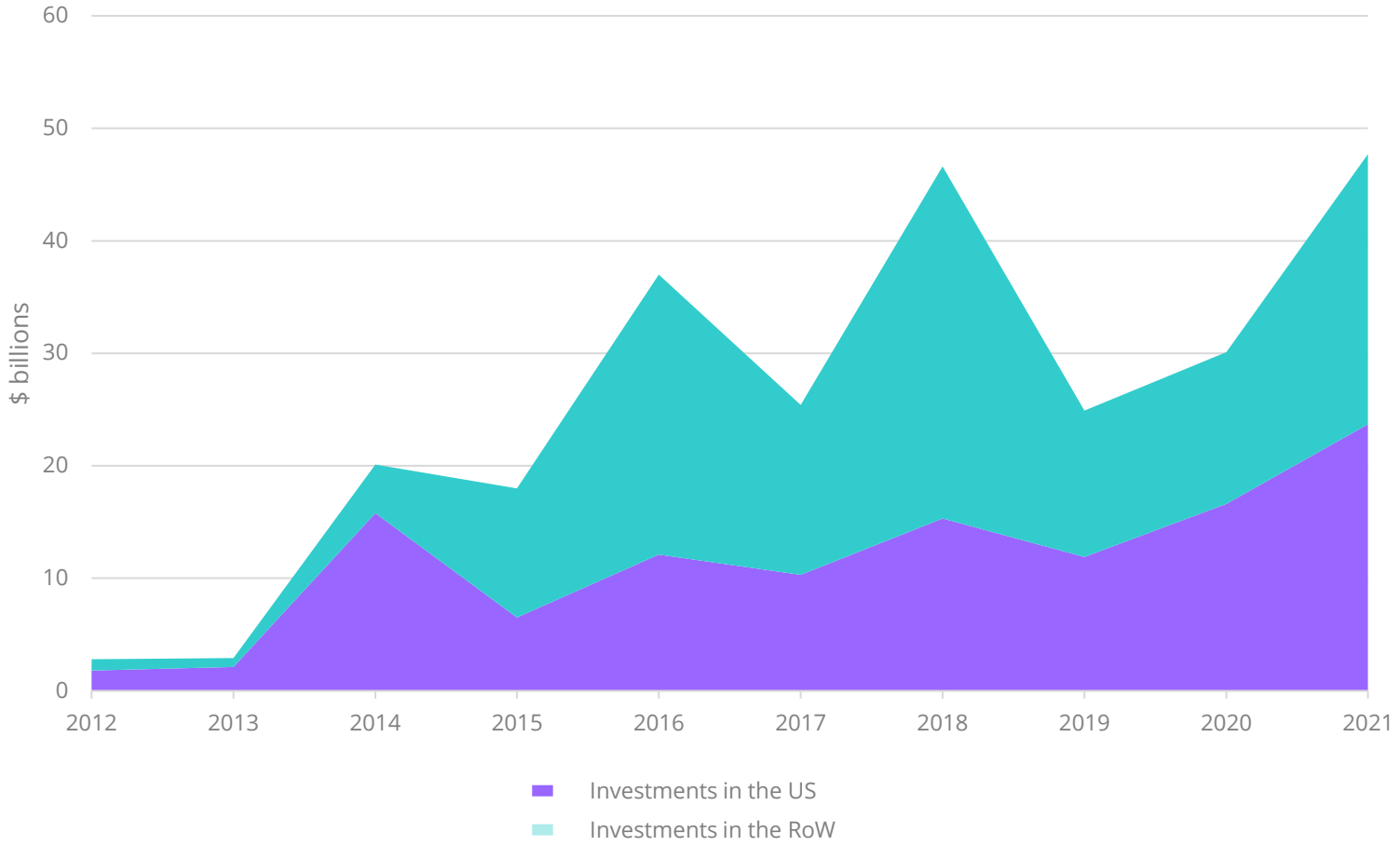
Amount of private venture capital investment in US and RoW*, $ billion, 2012-2021



- Cumulative value of private capital investment (2012-2021):
  - USA: **$ 116 billions**
  - RoW: **$ 139 billions**
- Compounded annual growth rate:
  - USA: **29,4%**
  - RoW: **37,4%**

Benefits of the public governance transition: the US case

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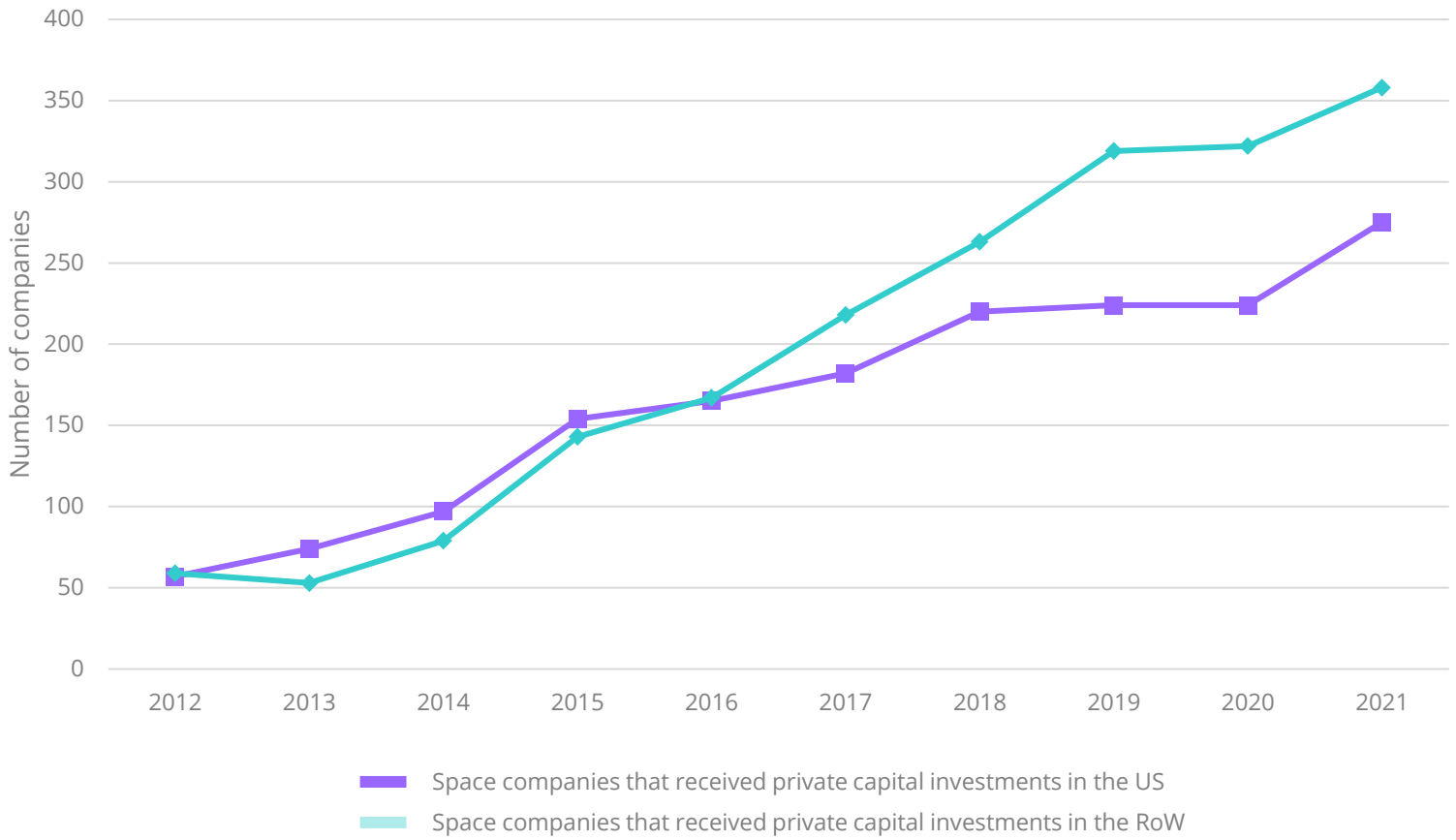
Number of space companies receiving venture capital investments in the US and RoW, 2012-2021



- In 2021, of the total number of companies receiving investment:
  - **45%** in US;
  - **55%** in the RoW.
- Compounded annual growth rate:
  - US: **17%**
  - RoW: **19,7%**

So what?
Conclusions and a look ahead

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Challenges

Space data commercialization
Sustainability
International relations & Geopolitics
Defense and Security
Advancements in dual-use technologies

Institutional perspective

Common European strategy
Need for institutional concentration
Need for new models for public procurement and PPPs

Private sector perspective

Private capital attraction
New and innovative business models

Policy skills renovation

&

Multidisciplinarity

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Thank you!

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