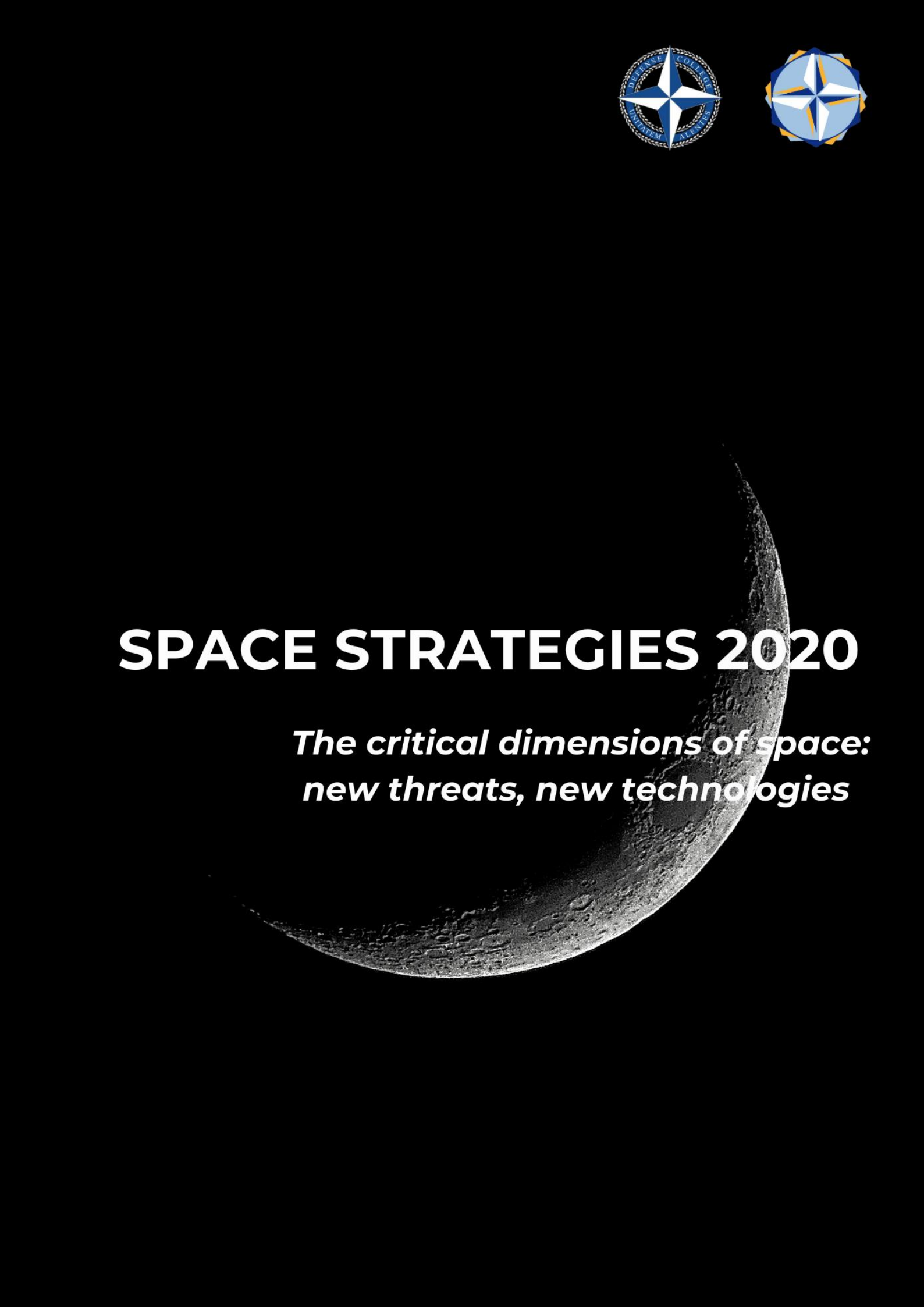

SPACE STRATEGIES 2020

The critical dimensions of space: new threats, new technologies

The NDCF is a unique think-tank: international by design and based in Rome, due to its association with the NATO Defense College. Its added value lies in the objectives stated by its charter and in its international network.

The charter specifies that the NDCF works with the Member States of the Atlantic Alliance, its partners and the countries that have some form of co-operation with NATO. Through the Foundation the involvement of USA and Canada is more fluid than in other settings.

The Foundation was born nine years ago and is rapidly expanding its highly specific and customer-tailored activities, achieving an increasingly higher pro le, also through activities dedicated to decision makers and their staffs. Currently the Foundation is active in three areas: high-level events, strategic trends research and specialised decision makers' training and education. Since it is a body with considerable freedom of action, transnational reach and cultural openness, the Foundation is developing a wider scientific and events programme.

SPACE STRATEGIES 2020

The critical dimension of space: new threats, new technologies

HIGH-LEVEL WEBINAR

ORGANISED BY

THE **NATO DEFENSE COLLEGE**

AND THE **NATO DEFENSE COLLEGE FOUNDATION**

ROME, 5TH OF JUNE 2020

PLATFORM: BIG BLUE BUTTON

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WELCOME REMARKS

Ambassador Alessandro Minuto Rizzo - *President, NATO Defense College Foundation*

Welcome, ladies and gentlemen, to this event planned and organized by the Foundation and by the College together.

The project on space is an ambitious one and we had foreseen a big public event to take place at ESRIN, the branch of Earth Observation of the European Space Agency. Unfortunately, the pandemic lockdown has blocked everything, including that plan and we decided to change and to use the virtual modality of today.

Ladies and gentleman, we know that space affairs are relevant and probably even more so in the future. It is therefore important that the College has decided to include the topic in the curriculum of the Senior Course; it is important to keep in touch with these developing realities in security affairs, since space is not the only emerging challenge.

I am personally fond indeed of space affairs and I have been involved for years in discussions about shaping those activities at European and national level. It is also very clear that no area more than outer space is open to international cooperation as well as competition.

Why? Because space means science, knowledge, Earth observation, communications, high technology, operations in an uncommon environment, and many other things. It is also associated by nature to our tendency to reach out to things that we do not yet know.

There is ample room for a variety of projects and each of them can potentially change in some way the course of our future, because it gives place to new thinking and understanding. Think about the International Space Station (ISS) and how it has been useful to develop new human activities.

We have some actors being historically at the forefront: NASA first, the European Space Agency in partnership with Canada, Russia, more recently Japan, China, India and perhaps others. Many NATO countries have a national space agency. In Europe I will limit myself to mentioning France, Germany and Italy.

Things are changing fast and a new security and military dimension is emerging space affairs. There are various strategic issues that have new visibility as well as new powerful technologies, to the point that

NATO mentioned space for the first time, as an area of direct interest to the Alliance, in its last NATO Leaders Meeting in December 2019 in London.

Our primary objective is peaceful coexistence, agreed rules, open doors to cooperation. But all sorts of The Senior Course is the core business of the College since many decades. It is a unique place in forging friendship, competence and understanding. Its success is proven by facts, including the number of Anciens who meet here every year from a large number of countries. I wish to recognize on this occasion the leadership of the College, the Commandant General Whitecross, the Dean, the Faculty and the advisors. The College continues to lead the way in training, education, civilian-military relationship.

The Foundation for its part was established nine years ago, in 2011, and wishes to contribute with its flexibility and passion.

Flexibility to adapt, to add value and also to do a parallel work towards the host country, Italy. It has already a proven record acquired in nine years of hard work. Passion because we wish to make a difference in analysis, understanding and outreach.

I believe that a good reading of facts and the capacity to put together different inputs from various sources is today more relevant than ever in such a fast-changing environment; so relevant for all of us. And we, the Foundation, wish to be on the forefront of those efforts.

In a certain way the Cold War was easy to understand and to explain. Today, the international environment is changing before our eyes in unforeseen directions and to be on the right track is not easy: this is why we are trying hard.

In conclusion, I welcome everybody again; I wish to thank the speakers and all those who contributed to the realization of this interesting event. I am sure that we are going to have a very important discussion. Thank you very much for your attention.

WELCOME REMARKS

Stephen J. Mariano – *Dean, NATO Defense College*

Thank you for joining us and thanks for the support of the NATO Defense College Foundation. I will not add too much, Ambassador, to your remarks but just to say that indeed we are here today due to a couple of reasons of which perhaps the most important being the NATO decision at the Leader's You course members, you talked a little about our NATO quotient and working on that, so part of the objective today is to understand: what is this for NATO? Why is NATO declaring space as an operational domain? What does that mean?

Alongside that, as Ambassador Alessandro Minuto Rizzo mentioned, several nations are exploring the outer space capability and in fact two nations at least have embarked on creating space forces (maybe we will see in the new show on Netflix about these space forces).

How we are going to cover this idea of space? Well that brings us to this relationship with the NATO Defense College Foundation and of course the long-standing relationship that the College has with the ESRIN, an ESA agency and research institute here in Frascati. And we thought it to be a great way to collaborate with our Foundation and with our partners here and bring this topic to you in this unique way in collaboration with the Foundation.

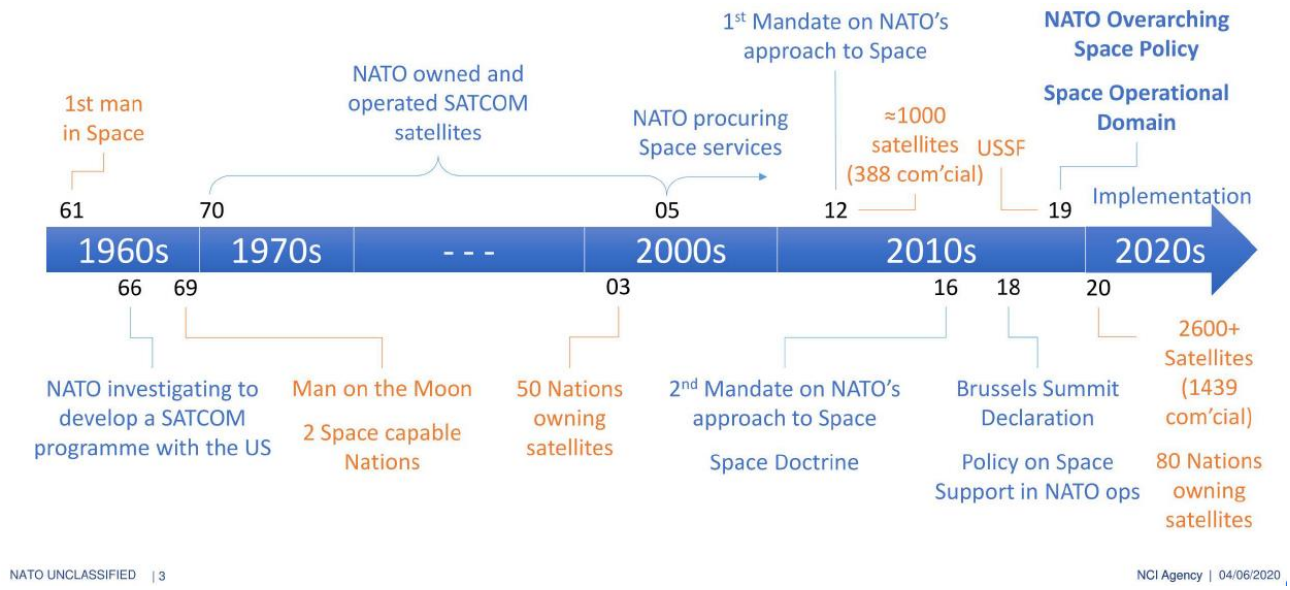
We also reminded upon the importance of this by watching the news in this last week when we see commercial activities in space with Space X collaborating with NASA for this historic launch of a commercial site putting man into space and back in the space station.

So, what are the things to talk about today? I do want to leave it at this point by saying thank you once again to everyone for embarking on this other unique way of delivering the curriculum here at the College and welcome to all of the guests from the Foundation and the participants. We hope we will have a great session this afternoon, I am sure we will. Thanks everybody.

NATO AND SPACE AS OPERATIONAL DOMAIN

Flavio Giudice – *Space Support in Operations, NATO Communications and Information Agency*

Good Afternoon. Thank you for the introduction, and for having invited me to this webinar. Today I am going to provide to you a deep non-classified overview on how NATO is following the evolution of space. In the first part of my presentation, I will describe the rationale that let NATO to declare space as an operational domain; while in the second I will mention some implications this decision. To start my brief I have chosen the evolution of the space within NATO. This timeline highlights that NATO has been actively in space since the 1960s, using satellites for communication, weather forecast and geolocalisation.



Source: speaker's material.

NATO owned and operated its own communication satellites until 2005, when it switched to a leasing agreement with nations and commercial companies that does not include ownership but access to the services. This changed due to the fact that in half a century the number of space capable nations passed from two to 40 and space became accessible even for commercial purposes. This trend accelerated in the last decade and it became clear that NATO's strategic advantage is largely related to space capabilities.

The increased effectiveness of operations, the leasing of resources needed to achieve the desired end state and the need to have qualified personnel are the reasons why the work of space in NATO rounded up in the last five years, culminating in the approvals of the NATO overarching space policy and the declaration of space as an operational domain in 2019.

2019 was an important year for space also at national level with the funding of the US Space Forces and the activation and definition of the two Space Commands. However, some essential capabilities were already existent before the US Space Forces was created: for example US counted more than 50.000 military personnel working on space within the different armed forces. Likewise, France has now its own military structure dedicated to space, with an important background of means and experience. Other nations, like Germany and Italy, are stepping up their own space structures by putting together the existent capacity under the same umbrella.

Why are all these nations doing this? Because they are reliant on space for growing civilian and military needs (as in slide 5 below), in fact NATO nations have approximately 60% of world satellites.

Source: idem. Explanation of abbreviations FFT/N (Friendly Forces Tracking/Navigation). JPR (Joint Personnel Recovery). PGM (Precision Guided Munitions). Intel (Intelligence). BDE/A (Battle Damage Equipment/Assessment). C2 (Command and Control). RPA ops (Remotely Piloted Aircraft operations). BLOS coms (Beyond Line Of Sight communications). SEW (Shared Early Warning).

With ISR (Intelligence Surveillance Reconnaissance) space assets the Alliance is able to gather wide and deep intelligence over every territory and therefore carrying out targeting activities while providing, in general, situational awareness. Space assets also enable meteorological, oceanographic and space weather forecasts, critical for all planning operations. Space Situational Awareness (SSA) provides

advance information to blue forces by predicting the overflight of adversary satellites. In brief, as shown by the above slide, space enables 21st century military operations.

From the civilian perspective, today national critical infrastructures rely highly on space systems and the introduction of new technologies like 5G and Internet of Things (IoT) increased significantly this dependency. Even without these ones, the pandemic showed that digital technologies and their space support helped in mitigating the effects of the quarantine through the relaying of multimedia content and efficient communications; political, economic and psychological impacts would have been much worse without space. Just imagine today flying or urban navigation without GPS (Global Positioning System) and weather forecasts.

This slide (slide 7) provides a personal assessment of space capabilities of NATO countries, Russia, China and the commercial sector in seven sectors: PNT (Positioning, Navigation and Timing), ISR, METOC (Meteorological and Oceanographic), SSA (Supply Support Activity), MD (Missile Defence), launching capabilities.

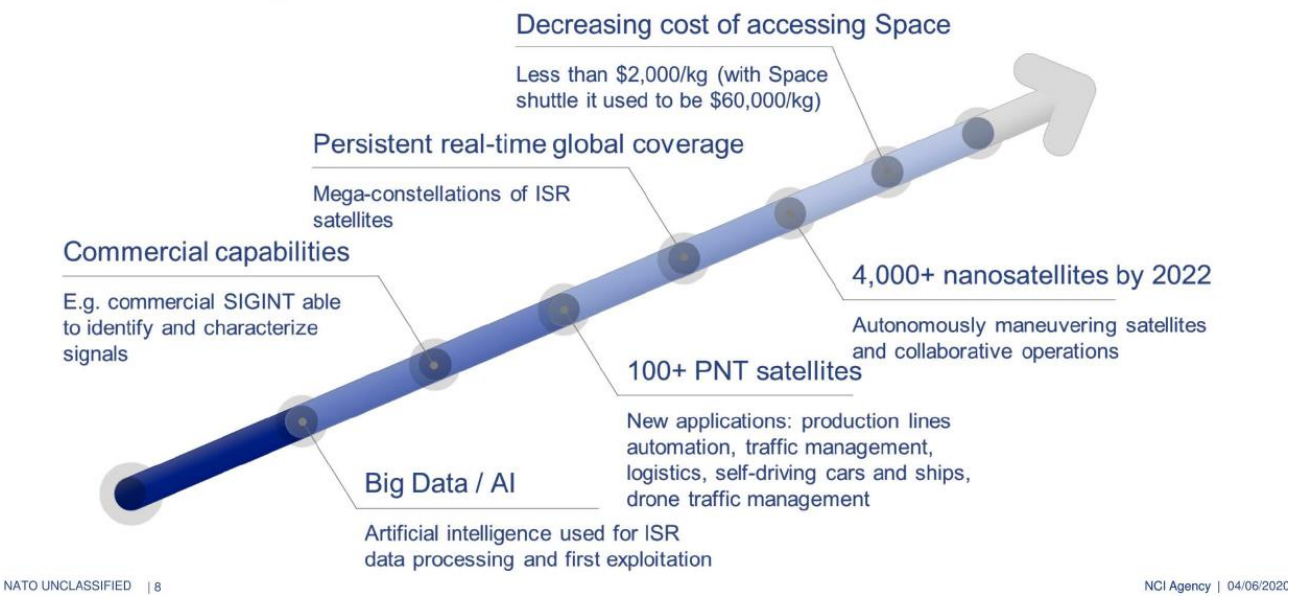
Source: idem.

As you may see, the Alliance has a very strong position because it can access national and commercial satellites covering the full spectrum of functional areas. Other major countries have a mix of capabilities, not always at the top, but in general rapidly improving, like China, a power has less traditions and huge current investments

Commercial companies are getting reliable in almost all functional areas, including launch capabilities, as we see this week the first launch of astronauts with SpaceX. The ability of integrating commercial capabilities into the military architecture faster than the adversaries represents an example of how to maintain a strategic edge.

An idea about commercial capabilities is given by this slide, where one can see that falling costs allow buying commercial services without costly investments by nations totally deprived of space capabilities.

Let us consider for example the commercial signal intelligence capability. This capability was an exclusive of two nations until 2018, while now can it be potentially purchased by anyone



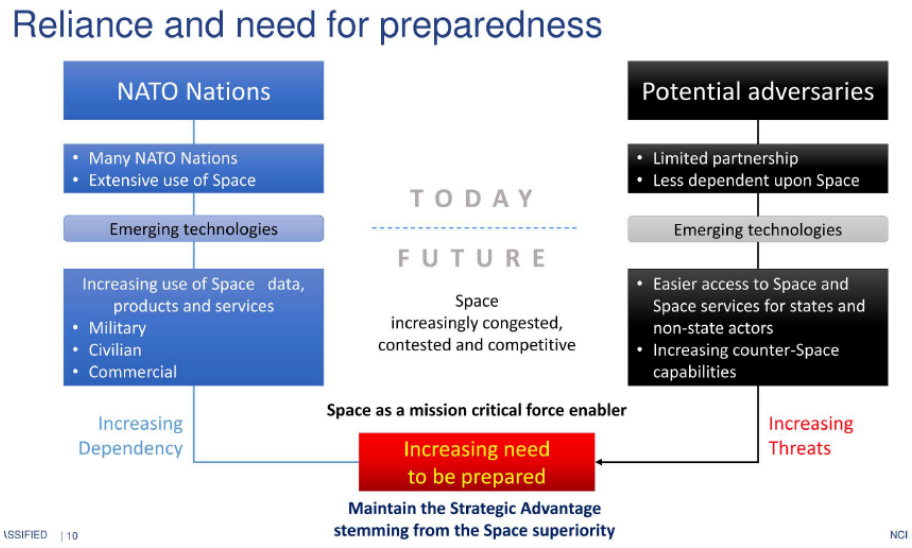
Source: idem.

Falling costs and miniaturisation will mean the possibility to put in service very numerous constellations, entailing in turn an ISR persistent real time global coverage, for instance.

On the other hand, the same technologies may facilitate the development of means that can make space a much more hostile environment as we can see here.

Source: idem. SAR (Synthetic Aperture Radar).

Potential adversaries are developing sophisticated counterspace technologies that could threaten Allies' access to operate freely in space. Let us take as an example on-orbit threats; rendezvous and proximity operations (RPO) appear early in space age, but today new, automated activities include satellite formation flying, on orbit satellite servicing and refuelling and some of the proposed methods for actively removing space debris from orbit. How can we distinguish an active removal of debris from a direct physical attack against a satellite? Other technologies, such as GPS jammers are less sophisticated but easily accessible and can cause significant disruptions. Further threats derive from the inherently limited control over the supply chain in the commercial world, thus exposing satellites to cyber-attacks.



This scheme provides a summary of what we have seen so far. On the left we have NATO nations with their improved performance of space services, followed by a massive integration between commercial, civilian and military systems, thus increasing the reliance on space capabilities. On the right we have NATO potential adversaries, who do not rely as much as NATO nations on space and consider space systems as high value target. Their growing counterspace capabilities represent an increasing risk. Therefore, there is an increasing need for the Alliance, to be prepared, to maintain and protect the strategic advantage stemming from the space superiority. NATO is adapting to this scenario and therefore declared space as an operational domain.

Declaring space as an operational domain recognises officially the importance of space for the nations and strengthens NATO's deterrence posture. It will drive a NATO's commitment in the areas of DOTMLPFI (Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities, Interoperability) to support a new domain, including new requirements, resilience, and effective services' provisions across the spectrum. It will also have significant implications in three domains (Political, Organisational and Operational), as shown below.

Source: idem.

Cooperation means also increased collaboration with the EU and ESA, while underlining the need for respecting international law has also effects on NATO's strategic communication, because it must be very clear (notwithstanding hostile propaganda) that the Alliance is not aiming at weaponising space.

With this respect we already see how space is considered in official plans: AFSC (Allied Future Surveillance Capability), which aims at replacing the Boeing E-3 Sentry AWACS (Airborne Warning and Control System) aircraft, already includes space as a complementary capability.

NATO since the Cold War was in space, now its stakes will be greater opening new opportunities to guarantee the three core tasks.

THE EU AS SPACE ACTOR

Ambassador Sorin Ducaru – *Director, European Union Satellite Centre*

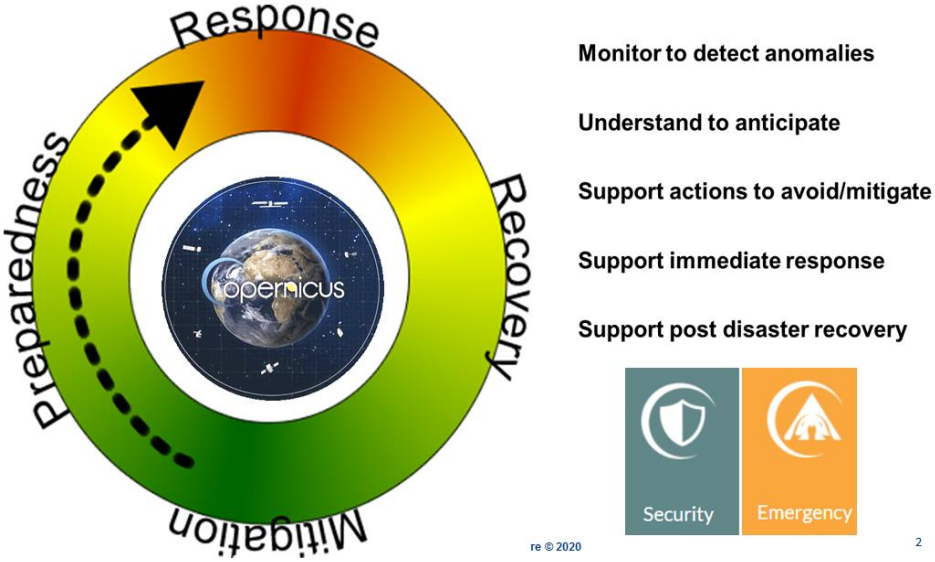
As proposed by the moderator, I will start by covering the new space military and security dimensions affected by the creation of specialised space commands, particularly the effects in the management of crises and deterrence.

Then, I will afterwards briefly address the technological and industrial ramifications of the increased use of advanced computing in scenario where civil satellites may influence military operations and possibly the militarisation of space.

Q1 The new space military and security dimensions will be affected by the creation of specialised space commands. What are their effects in the management of crises and deterrence?

It is important to consider separately the crisis management and deterrence issues.

Indeed, space already plays an important role in crisis management. For example, the European Union Copernicus programme today supports all the dimensions of crisis management, particularly thanks to the Emergency Response and the Security services where SatCen is involved.



Source: Speaker's material.

SPACE STRATEGIES 2020. *The critical dimension of space: new threats, new technologies*

For the defence dimension of crisis management, we have to recall that space has the prime objective to provide information superiority in supporting a large spectrum of services. So far, this support is based on several national stakeholders and assets owned by several branches: Telecommunications, Earth Observation, Positioning & Timing… The creation of several space commands is a game changer since it constitutes a powerful way to rationalise the processes of monitoring military crises. A "centralisation" will de facto enlarge the use of the services delivered by space but also allow the optimisation of spending with an overall and synergetic view.

Concerning deterrence, the initial objective was to avoid the use of nuclear weapons. Among the involved assets, space is already playing an important role. However, deterrence against aggressive actions on space assets is so far limited, but is gaining priority. Indeed, two aspects hugely modified the landscape:

- the increasing value of space provided services in economy, security and defence,
- the demonstration of operational means for voluntary outage or destruction of space systems, recently done by China and India.

Within this frame, it was clear for some space faring nations that the security and continuity of the space delivered services and thus of space assets became a priority.

The first step of such space deterrence is to have the means to detect problems and understand situations: this is the goal of "Space Situational Awareness" (SSA). The EU Space Surveillance & Tracking programme is the first European Union step where SatCen is involved as front desk. It will evolve indeed towards a more SSA global approach.

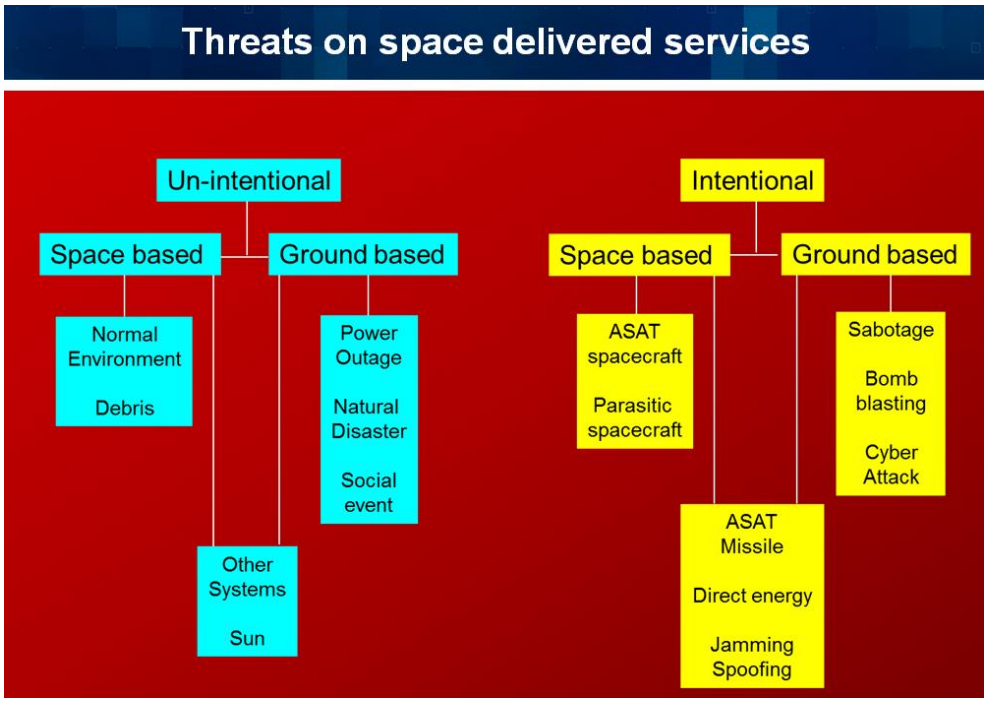
The EU Space Surveillance & Tracking programme

European consortium, supported by the EU, providing 3 services:

- collision avoidance (45 users and 131 satellites)
- re-entry analysis (70 users)
- fragmentation analysis (60 users)

[5] *Source: idem.*

However, it shall be noted that, excepted for anti-satellite missiles, determining the cause of anomalies/outages/break-out of space devices is very difficult. They may be caused by several events, accidental, natural or intentional ones as shown below.



Source: idem.

This is why deterrence for space systems implies another important step to clearly identify the reason and the origin of the detected problem, vital for deciding later on the appropriate reaction to perform. This implies huge means, on the ground as well as in orbit, and efficient organisations: this is indeed a fundamental raison d'être for the newly created space commands.

Q2 Many space technologies are inherently dual. What are the technological and industrial ramifications of the increased use of advanced computing in scenario where civil satellites may influence military operations and possibly the militarisation of space?

Concerning the technological side, we can see a "gold rush" in two linked spaces: outer space and cyberspace. Indeed, the advanced Information Technologies such as Artificial Intelligence, Big Data management, quantum computing are dual use by nature, are/will be powerful enablers for increasing the added value of the space delivered data and thus the associated services, particularly for crisis management and space deterrence.

Excepted for human flights, all space missions are dealing with information and data: relaying communications (telecommunications), collecting data (Earth Observation) or providing data (Positioning, Navigation and Time).

It is thus clear that the technological advances in the general field of Information Technologies (computing, but also new approaches such as big data and artificial intelligence and tomorrow quantum computing) have/ will have huge impacts on space activities and organisations.

The first impact is the extensive use of IT tools to analyse and exploit the data delivered from space. A first example is Earth Observation, where the collected data volume will require new approaches in terms of tools (soft and hardware), approach (a non-deterministic one with Artificial Intelligence) and organisation (particularly to optimise the complementarity human/machine).

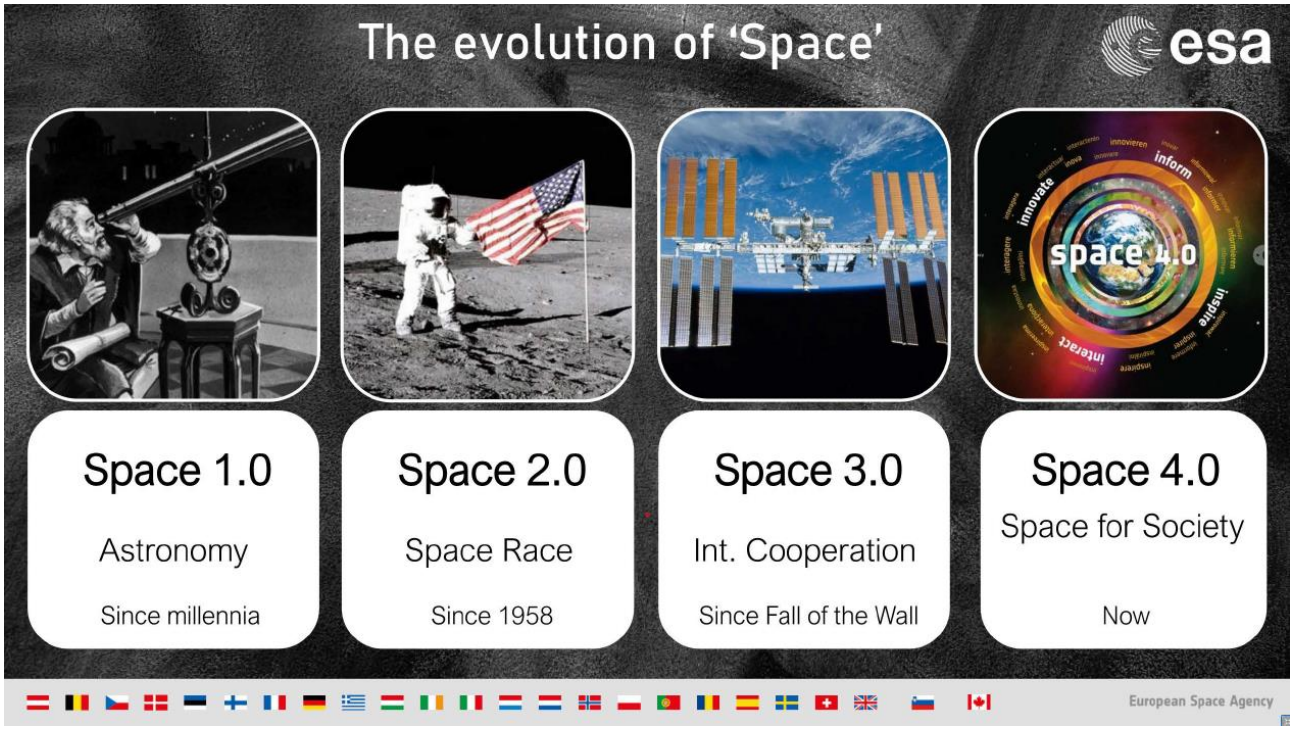
But another example comes back too on the point mentioned before: space situational awareness and deterrence will imply huge a IT effort; one has to recall here that, today, we have about 20.000 objects in an orbit larger than 10 cm (among them 2.700 operational satellites), while the Starlink (Space X) constellation alone is planning to operate up to 42.000 satellites, tripling the number of space objects! Within this situation you can imagine that the procedures for avoiding collisions on operational satellites, currently based on emails and phone calls, will have to be automatized.

The second impact, that is a consequence of the previous one, is the importance taken by IT technology providers over the "classical" space systems providers and operators. We can already see this trend, for example in Telecommunications (internet Tycoons entering in the field) or space situational awareness where private companies already provide operational services. This trend is going to expand since the needs of our digital society are pushing hard towards new developments providing fast Return Of Investment. Space cannot compete but can follow, in reusing these developments. In summary, the involvement of IT companies will be increasing in the field of exploitation of data delivered from space, considered as a new attractive "niche". For defence and military applications, it opens issues on sovereignty and security.

THE AGE OF SPACE 4.0

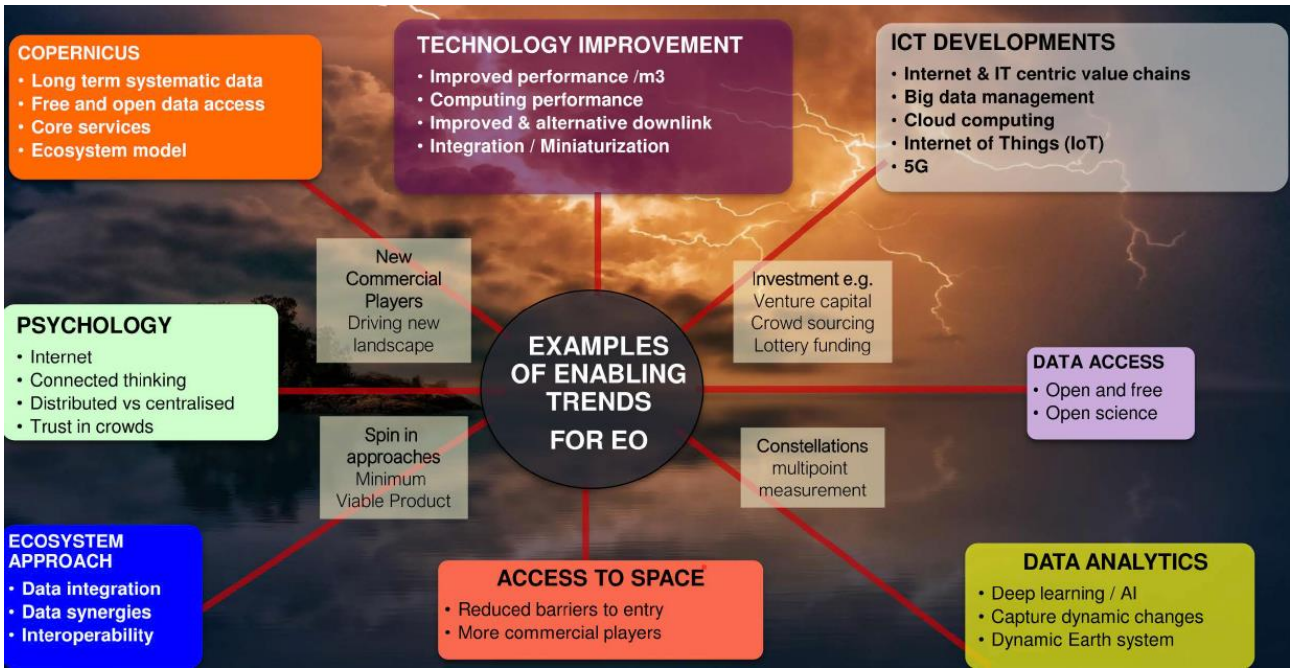
Amanda REGAN – *Head of Invest Office, Phi-Lab, Earth Observation ESA-ESRIN*

We are actually in the middle of an evolution in space at the moment. We have had Space 1.0, 2.0, and 3.0 and now we are very much in what we call at the age of Space 4.0 that is really bringing space out of space pervading society with space data and space information for its advancement.



Source: Speaker's material.

This slide (slide 2) is really something that I have put together some of last ten years also from about 2012 we have seen a real explosion in the over role of the Earth observation landscape. We are in the middle of a perfect storm with many many different facts twisting and turning and crushing into the Earth observation that may have never really happened before.



Source: idem.

I am just trying to catch some of the main points that I see from my experience. For example, we have the Copernicus system which is providing long term systematic data, free and open data access, six core services as well as it is in an ecosystem model. And we also have technologies advances, so in terms of satellites we have a performance per cubic meter that is exponentially increasing and it is really since 2012 that we have seen this jump. This is coupled with computer performance improvements, in methodologies and also integrations and miniaturisation; all this is really exploding in terms of what we are able to do in space, particularly the smallest satellites. As well as that, we have the ICT development so we have the internet, big data management, cloud computing, all of these distributed systems which have been developed for other sectors, that they are all crashing untoward Earth Observation at the moment.

Together with other aspects like data access and access to space, all of these are becoming much cheaper, and with advanced computing comes the ability for huge data analytics within Earth observation. More and more satellites, more and more data. We are having aspects like deep learning and artificial intelligence that can capture very dynamic changes: before we would be able to gather data maybe in sixteen days between a single satellite pass, now we have a daily intake with a much improved re-visit. We are also able to capture activities on human activities' scale which is also it quite interesting and is attracting a lot more people.

Also, even the psychologies of people are changing, we have a generation now that:

- has no life without the internet;

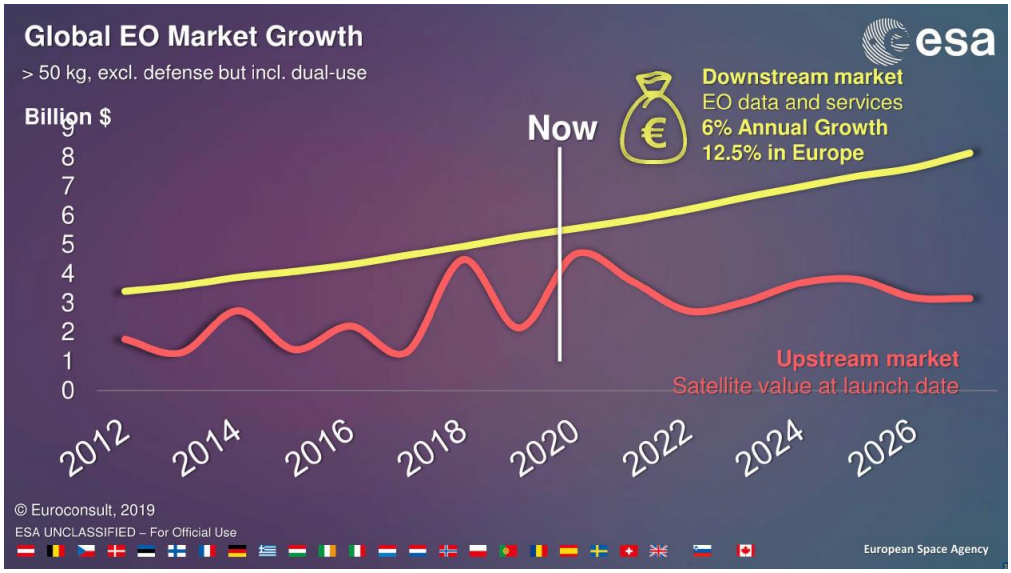
- implying that there is certain trust in distributed systems over centralized systems;
- has a sort of connected thinking;
- has a trust in the crowd, like for crowd funding and sourcing, which we didn't have 20 years ago.

So, this is really bringing in new commercial players that are driving this new landscape. We are also getting in space a lot more money: we are getting venture capitalists, crowd sourcing and even lottery funding. All of these actually gets to economies of scale, so we are having constellations meaning that the temporal resolution (revisit) is becoming extremely interesting particularly for commercial applications.

We are now seeing practices spinning approaches from, for example, minimum viable products, something that software industries have been using for many years. This is something that is now moving into satellites' development, and all of this is really enabling not just data and images but we are looking now at **intelligent decision making and also the commoditization of business intelligence** and this is what we are seeing within Earth Observation right now.

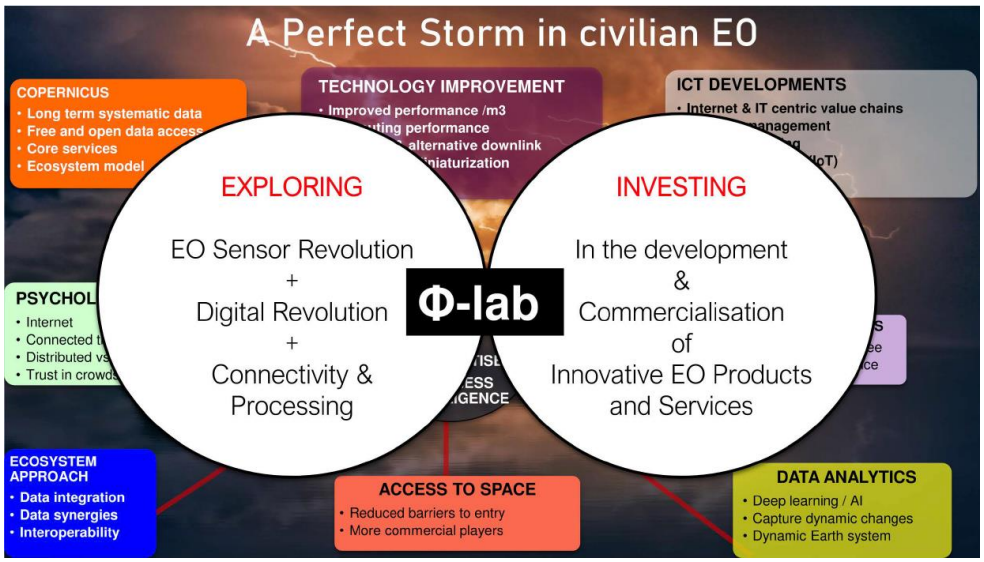
The idea that the new landscape is called **new space**, with a nice definition from the European Investment Bank (a **global trend** encompassing an **emerging investment** philosophy and a series of **technological advancements** leading to a private space industry largely driven by commercial motivations) that highlights very clearly where Earth Observation is really changing.

This report it is a couple of years old shows the downstream of products and services from Earth Observation is starting to increase. You can see hereafter the global Earth observation market growth all the satellites are the red line underneath and the downstream activities is represented by the yellow line at +6% annual growth which is really quite something.



And while the value increases, the objects multiply: from 2007 to 2017 there were just 2.000 satellites launched, and from 2018 up to 2025 there is almost 3 times of that. So, you can really see the exponential growth of these economies of scale to be able to have all the satellites in space which have implications of course. What we are seeing here, is basically that, rather than individual satellites which are often particularly beautiful cathedrals of science that are launched by ESA and other agencies, we are now seeing instead satellites which are becoming an element of an overall network towards a kind of internet of things arrangement.

What we see here (Slide: A Perfect storm in civilian EO), the idea is that we have actually a lab at ESA-ESRIN that is called Phi-lab and there are two elements of this particular lab: an exploring element focussing on sensor revolution, digital revolution and finally put those together in terms of networking, connectivity and processing; and there is an investing element looking at the commercialization of Earth observation products and services.



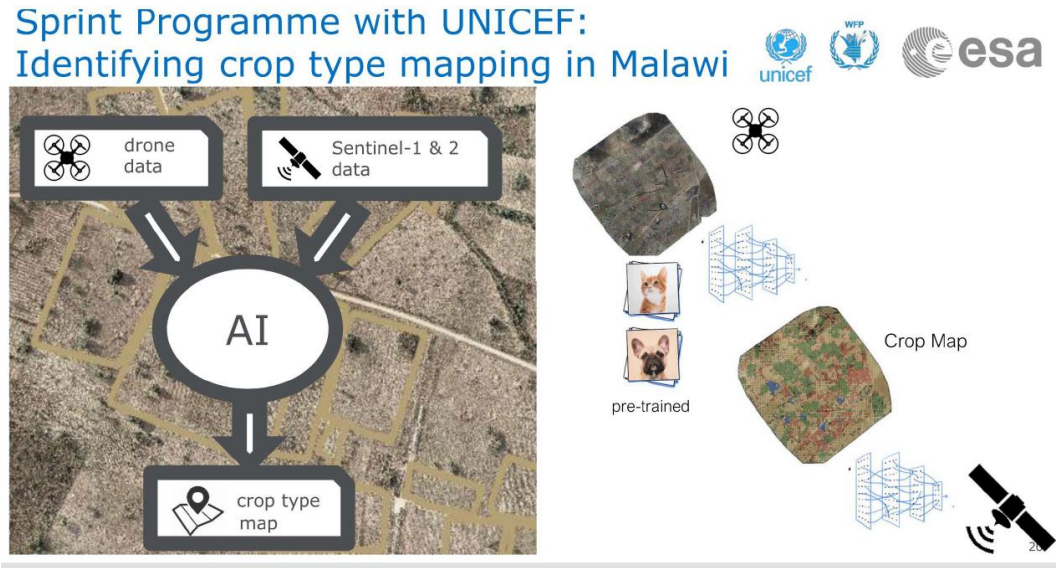
Source: idem.

So, we have the Phi-lab and we have two offices. One is the Explore Office that is more concentrated on the research part of developing the sensor capabilities, looking at artificial intelligence, machine learning and internet of things and etc. The second is the Invest Office, which is what I am looking after, trying to commercialise these particular products and services and we have a particular programme for this, which I will talk about.

I will talk about the explore office just for a second, just to show the kind of work we are doing. In the Explore Office of the Phi-lab we are looking to connect what the new technologies in sensing offer with the digital revolution and we are trying to connect them together in a way that makes sense using machine learning topologies, computer vision etc. They are looking at three main things. They have *Use cases* or prototypes, *ecosystem building* and also *capacity building*. What we are seeing is that new artificial intelligence is really the new commodity, the new electricity: the idea is that you just plug your system in and you get this capability (we are not there, of course).

The problem is that if you consider Earth observation data, these are very big data, coming from all kind of satellites, measuring different things, diverse types of data measuring, things using different physics, diverse sampling and producing diverse errors, etc. How do we actually put this together? So, this needs automation, scalability, agility and also speed. Therefore, in the lab we are looking particularly at data surveillance process automation, different kinds of applications, as well as on board autonomy and edge computing.

Two couple of use cases, just to give you a flavour; we are using artificial intelligence and machine learning for the analytics newsfeeds and looking at classification as a service regarding European land cover . This is a short piece of work we did for UNICEF looking at crop type map of Africa using AI.



Source: idem.

This is an interesting one, done between ESA and SATCEN, looking at infrastructure monitoring in desert regions, using radar data. There is an obvious difference between an optical and a SAR image, because with the latter you can actually see infrastructure that is usually covered by the terrain.

We do a lot of collaborations, particularly around Artificial Intelligence. We have got some work that we do with the Frontier Development Lab (FDL, a NASA-ESA public-private joint venture) both in England, in Oxford, and also in the USA. We are making collaboration with a Dublin-based organization called CeADAR (Ireland's national centre for Applied Data Analytics & AI) and also with Claire (Confederation of Laboratories for Artificial Research Intelligence in Europe).

Concerning the Invest Office, on the one hand we to try hard to commercialise EO services and products and on the other we have a programme called Investing in Industrial Innovation (i.e. InCubed); as you understand, commercial space is much faster, it is profit driven and it is very competitive, and InCubed has to operate in this environment.

InCubed works in this way. It is co-funded which is interesting because it means that companies have to put skin in the game as well as fundamentally changes their attitude rather than just having 100% funding.

InCubed/InCubed+ supports European Commercial EO

Investing in **In**dustrial **In**novation is an ESA/Industry co-funding programme aimed at supporting and scaling the European commercial Earth Observation sector.

- **Proposals written by industry**
- Aimed at commercially sustainable and innovative EO related products/services
- Scope: **End to end** (satellites, systems to data platforms and data analytics
- TRL typically starts 4/5 → end 7-8 with a robust commercial roadmap
- Two possible cycles depending on the TRL (de-risking and product development)
- End point is at least **minimal viable product + roadmap to commercialisation**
- Deliverable: **Customer/Investor information pack**
- Co-funding depends on individual member states
- Typically funding is 50% / 50%
- Higher co-funding ceilings are possible for SMEs (member state dependent)

NATIONAL DELEGATIONS
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INDUSTRY

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Source: idem, TRL – Technology Readiness Level.

Here some examples of the activities deriving from this approach. I would like to highlight this Earth observation platform, set up by an Austrian company (top left) who was using Earth observation data to maximise the yield of potatoes for the agro-food industry (a consortium of two Dutch potato growing companies)

What is interesting about this is that they have an ideal end-to-end value chain (from the data directly to the customer) fully representative of the interaction and a quite different situation for Earth observation.

Another example was the funding of a little hyperspectral imager the size of a milk carton which has been launched initially in 2018 (Hyperscout-1) and is now operational since two years, also in the agricultural sector. This new sensor (Hyperscout-2) has been rescheduled for launch with a Vega vector by the 17th of August 2020. It is a very important event as I will explain by the end of my presentation.

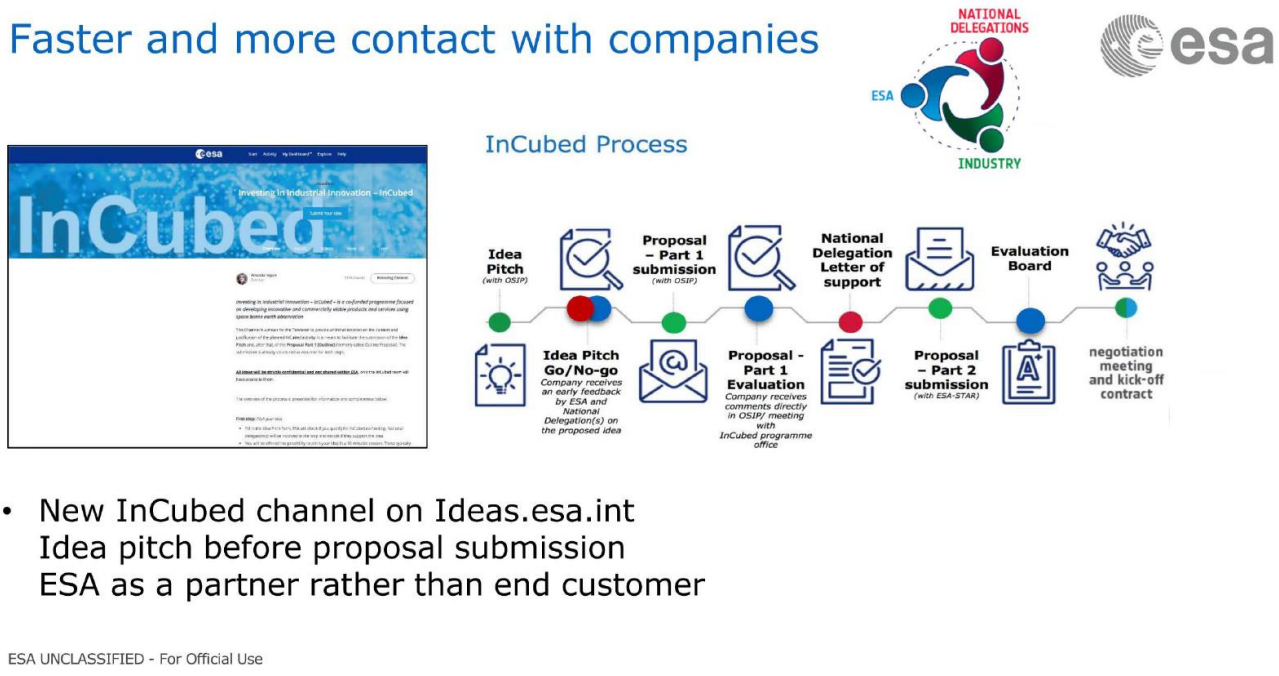
In other applications, we are looking for commercial products and services for embankment monitoring, cargo monitoring, port analysis, and also water availability particularly if for agricultural uses; actually it is one of the leading sectors in the commercial Earth Observation at the moment.

I want also to draw your attention on what are called "Dedicated end to end satellites" to service industrial verticals, i.e. specific technology niches that can support several different major markets and that attract investments. The MANTIS (Mission and Agile Nanosatellite for terrestrial Imagery Services) will be part of a constellation, but InCubed is funding the first minimum viable product, so the demonstrator.

Source: idem.

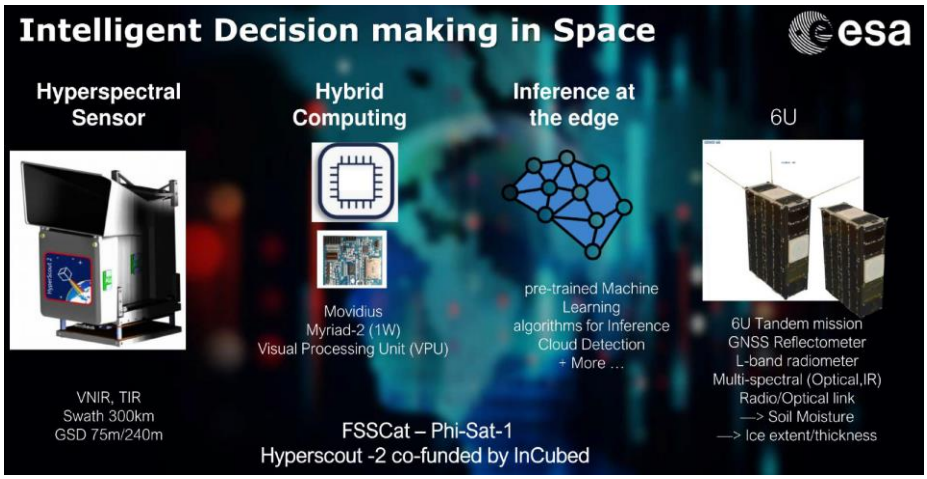
Serving the energy sector means requirements to monitor oil and gas infrastructures with the possibility to tune the satellites' orbit so as to revisit certain strategic locations.

The way we work in InCubed is highly interactive between companies, national delegations, ESA and its fast-paced, thanks to our platform Ideas.esa.int



Source: idem.

I anticipated that the Hyperscout-2 was an important endeavour, because it means to launch for the first time an Artificial Intelligence chip on board of the mentioned hyperspectral sensor, which entails that response times for the customer will considerably shorter and that weather applications will particularly benefit regarding cloud, ice thickness, soil moisture detection and measurement.



Source: idem.

SPACE STRATEGIES 2020. *The critical dimension of space: new threats, new technologies*

We are in a very different era from those of the founding fathers of space, much similar to the transition from colossal centralised mainframes to decentralised networks of smaller faster computers, and in this change our mission is precisely to support Space 4.0.

DUAL-USE AND MILITARY SPACE

Maj. Gen. (Ret) Pascal LEGAI – *Senior Adviser to the EOP Director, ESA/ESRIN*

Thank you very much to NATO Defense College and NATO Defense College Foundation for this invitation. It was a pleasure to listen my very good friend Amb. Sorin Ducaru and my colleague Amanda Regan gave a comprehensive picture of this storm in this civilian Earth Observation, also describing technological innovation and industry situation.

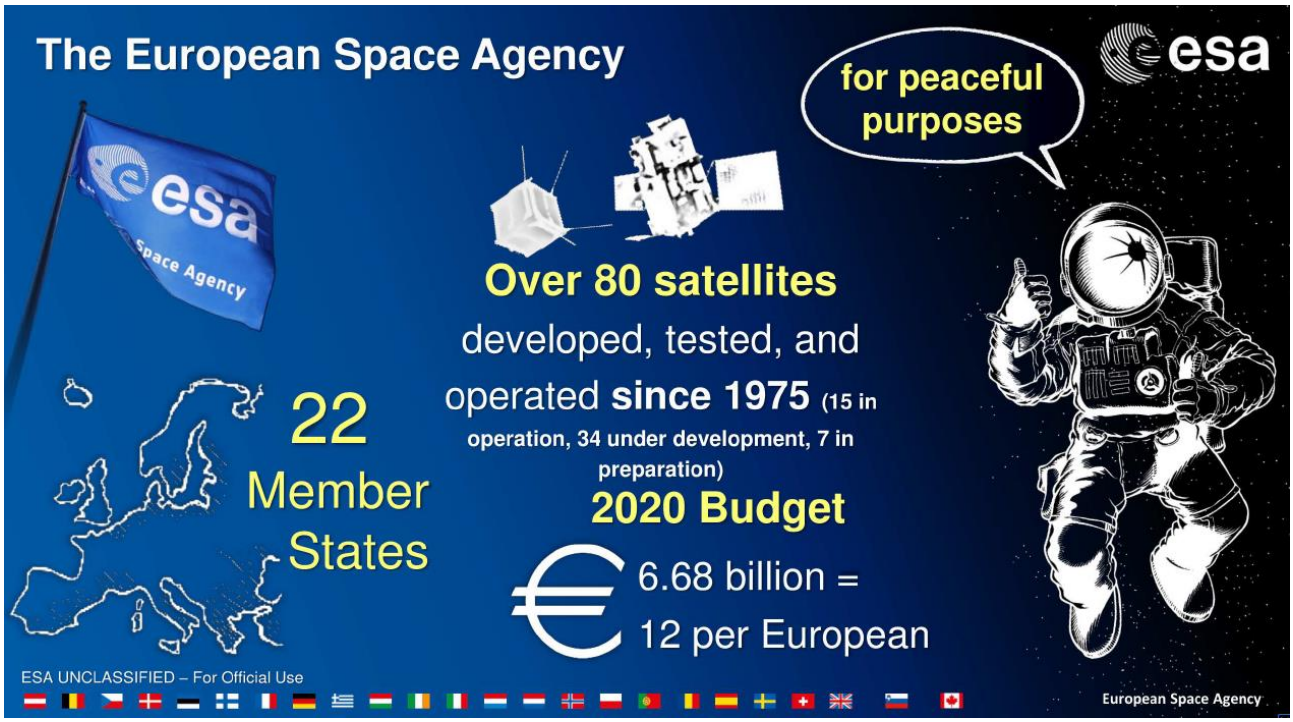
The first thing I would like to focus on this notion of dual-use, before turning to the issue of the militarization of space.

To carry out military operations, the issue of the means available turns out essential, in particular space capacities. In this regard, the very notion of **dual-use** deserves to be examined. Many space technologies are inherently dual. For instance, a satellite by nature is not civilian or military but is a technical object orbiting the Earth meeting various needs depending on the sensor specifications. Usually, a space system is labelled civil or military if it is respectively paid by a civil or a defence budget, or if it is uniquely used for civil or military purposes.

As an example, the EU Space Programme is composed of four main components: Galileo (Positioning/Navigation/Timing), Copernicus (Earth Observation), GovSatcom (Governmental Satellite Communications), SSA/SST (Space Situational Awareness/Space Surveillance and Tracking). The EU Space Programme is officially civilian under civilian governance.

However, each of its components is of dual nature: Galileo has a Public Regulated Service (PRS), protected, reliable and more accurate. Copernicus has a security service for border/maritime surveillance and to support the EU external action. GovSatcom can also satisfy civil or military needs. SSA/SST is of strategic importance to ensure safety in space. Henceforth, the dual use of the programme does not depend on technical limitations but clearly on a political decision to do so. Moreover, we can use the same data for targeting purposes or precision agriculture, protected communications for bank transfer or military needs. The dual-use issue can be also translated into the following question: why should civil technological progress be limited because there is a possible risk of dual-use?

As regards the **European Space Agency** (ESA), an intergovernmental civilian R&D organisation, its role and mission are exclusively for peaceful purposes according to the ESA Convention.

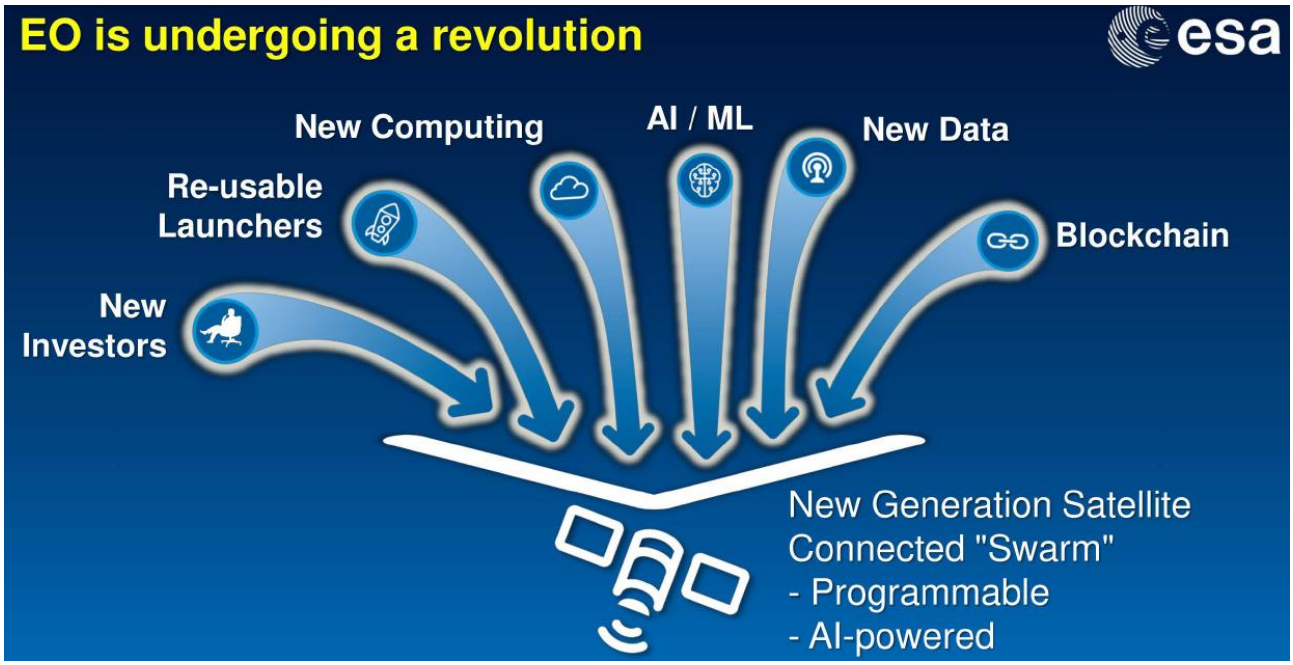


Source: Speaker's material.

ESA strongly cooperates with the European Commission to design and develop the space and ground segment of the EU Space Programme, mainly Galileo and Copernicus. Among its various activities, science field plays an important role covering CO_2 monitoring, climate change, sea surface temperature, agriculture, water resources, food security, vegetation and ground motion and polar ice topography, for example. The results are often interesting and of strategic nature: the study of the evolution of the Arctic region, strategic area, shows that by 2050 sea ice will be completely gone.

Furthermore, ESA also focuses on the use of small satellites combined with HAPS (High Altitude Pseudo Satellites) or drones with in-orbit processing. HAPS are unmanned airships, planes or balloons watching over Earth from the stratosphere and creating the missing link between satellites and low-flying drones.

ESA works also on downstream applications resorting to Artificial Intelligence/Machine Learning, Block Chain, Internet of Things, computing capacities, testing the full range of hyperspectral, thermal infrared, LIDAR (Laser Imaging Detection and Ranging)) or full motion video sensors giving added-value to raw data.



Source: idem.

In addition, the "New Space" brings a strong impetus for innovative solutions thanks to an active network of companies and start-ups. Civil R&D is beneficial for military developments that the military budgets cannot pay alone. Advances in civil space strongly contribute to the exponential growth of a wide variety of applications of dual-use nature.

Another concept is also of interest: the **militarization of space**. First of all, it is important to make a distinction between weaponization of space, that is the deployment of weapons in space, and militarization of space which means force enhancement including communications, navigation, intelligence gathering.

Following the NATO summit in London in early December 2019, it has been decided to declare space an operational domain like air, land, sea and cyberspace. Jens Stoltenberg, NATO Secretary General, considers space in a purely defensive approach, whereas Gen. John Raymond, Chief of the US Space Command sees space as a war domain where to apply the deterrence principle.

From a legal point of view, the UN Space Treaty of 1967 explicitly prohibits nuclear and mass destruction weapons in space, but it is not very clear on other issues related to the potential militarization of space. We witness as well a "democratization" of the space sector boosted by the ever-accelerating development of space and non-space technologies: cube-satellites are much easier to build and to launch, access to space is facilitated thanks to a cost-competitive launcher market (SpaceX, Boeing, Blue Origin), miniaturization, acquisition off the shelf, commercial actors offering almost all

services and cutting-edge technology. Finally, all the ingredients are there for a new arms race in space, even if we hope that political wisdom will prevail.