ASD-EUROSPACE

EARSC

Industry consultation on future ESA Earth Observation programmes presented at CM22

Key Trends and Summary of Discussions

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Contents

Background and introduction

On April 12-13 ESA hosted an Industry consultation seminar event (online) covering the future of the EO programmes in ESA with a particular focus on the proposal prepared for the ESA Council at Ministerial level for 2022.

The seminar was organised by Eurospace with the support of EARSC.

The seminar featured more than 50 speakers through various keynotes and panel sessions.

This document provides a synthesis of the key trends and issues raised throughout the event in a first section, and a summary and highlights of each panel discussion in chronological order in the second section.

The complete workshop minutes and presentations set is available on request from ESA or Eurospace (pending approval for release by ESA).

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Key trends arising from the Seminar

From data to application: the user centric model of EO

Verticalisation: user driven EO applications

The history of EO programmes is rooted in technology, building on generations of systems **relying on a horizontal approach to data** (one data set per system and per generation, with multiple sensors available from different sources and vendors). It has favoured the emergence of technology market leaders. This situation has **led to the seemingly never-ending cycle of technology push towards technology adoption**, relying on evangelisation efforts and expectations for market take-up.

But EO data provides solutions across industries and **multi-purpose EO is superseding market-focused EO**. Companies tend to converge towards similar verticals and combine their business needs creating a **general trend for data fusion intersecting the user needs**. This would enable effective B2B solutions making use of space-based information and the embedding of EO data into customer processes supported by a strong, flexible supply chain.

To emerge as a real user driven commercial market, the **EO sector needs mature technologies and a projection towards a market dimension** that will allow entering a user driven era of EO services.

ESA has historically focused on being a systems and technology enabler directly supporting the supply chain, **its role in the context of the verticalisation trend must be reassessed**, with a reflection on users and apps, and their relationship with sensors, systems and ultimately, with technology.

Data to verticals: EO in the background

The value creation for the data generation segment is very complex, since sensors develop into a variety of bands and resolutions and build upon generations of observations sometimes lacking continuity. There is a **widening gap between data complexity/diversity and user requirements for actionable information**.

Analytics will bridge the gap, enabling the growing integration of data and data acquisition into services and information. Eventually the space between Earth Observation and Information Technology sectors is really narrowing. A lot of **technologies, concepts and approaches developed and used in IT applications and services are now moving to the EO environment**, while the EO data is feeding the IT segment.

The **expanded testing of new concepts and prototyping integration of new (and often non-EO) datasets** in modern IT systems, with the effective exploitation of leading-edge AI, on board/edge processing, cloud computing, cloud data access, is promoting the **emergence of applications and services where EO data sits in the background and is not taking centre stage anymore**.

This creates the **dilemma of EO technology advancement vs EO technology adoption**. Is there a trade-off between technology advancement and adoption waiting time? Is the technology adoption the key point and the sole driver of EO development? Shouldn't rather the user service, the application development and the information data stream and distribution to the end user be in the driver seat? **State of the art technology is progressively losing its ground** and may not be any more the ultimate and critical system differentiator or the foundation of value creation.

From data to service, enabled by anchor

From Capex to Opex[1]: infrastructure as a service

EO programmes offer the widest range of technology domains for satellite applications. They are also moving fast towards the applicability of new sensors, and the range of observable phenomena is

[1] *Capex: Capital Expenditures; Opex: Operating Expenses. Opex are the operating expenses that relate to a product, a system, or above all, to a business. The use of the term allows for a better understanding and visualization of the cost structure of a business. In concrete terms, Opex are the day-to-day costs with the most direct link to profitability. They are expenses necessary for the smooth functioning of the business to achieve*

growing fast. And while EO programmes thus provide a unique array of opportunities for technology development and evolution, the **only caveat is the growing criticism of 'technology push'** where systems evolve faster than the ability of users to take in and absorb the new technology into operational products and services.

Today's EO model relies on institutions owning the infrastructure. It is a 'patrimonial' model that has proven to be successful in the past (e.g., Meteosat and Copernicus). **European and national programmes are thus considered to be essential and a stepping stone** for the future development of the EO market.

The economic perspectives for EO are positive and **a new paradigm and a new era of services is emerging**, supported by the user centric and the verticalisation models of commercial EO. **Business models are developing in the "as a service" dimension** (DaaS, PaaS, SaaS...) more project-based, and with partnerships to address the full value chain, from data creation to value added, processing, packaging into a service (or 'app') and the delivery to the end user.

This potential paradigm change for commercial EO invites to a **reflection on the evolution towards a service driven model for the institutional programmes**. The idea of **hybrid or full delegation of services model is very much welcomed by the private sector**, provided that it is a **sustainable and gradual**. The switch from Capex to Opex, (or from systems procurement to data/service acquisition from the user/customer perspective) must be transitioned through a sufficiently long period (e.g. a decade or more) to avoid revenue disruptions and to enable the leverage on sufficient capital for investment. The relatively long technology adoption cycles of EO must also be considered.

The paradigm change shall also be supported by a **simplified access to space infrastructure**: the move from Capex to Opex is only possible if satellites become increasingly easy to develop, build and launch. There is thus a strong interplay between technology, procurement, system designs and architectures and the realisation of the new paradigm.

Technology disruption and state of the art programmes **may not be suitable candidates for the Opex model**, unless there is full re-elaboration of the budget/risk/reward scheme for scientific & demonstration missions.

The private initiative will be driven by **easier access, enabling technologies** (platforms) to seamlessly support user centric business models (e.g. as-a-service type approaches, universal interoperability etc.) and the **connection with commercial clouds and IT infrastructures**.

Dissemination will be coupled with infrastructure: moving towards the provision of data platform and digital data market places.

From Opex to anchor: the role of public demand

To emerge as a real private market and answer with more accuracy these priorities, the **EO sector needs mature technologies but also a clear projection towards a vertical market dimension with the support of public institutions**. Public demand will play a critical role towards the development and adoption of as a service models. A transition is progressively also coming from the top, with new policies driving expanded demand among institutional customers and with the changing nature of the demand (outsourcing, data focus, ...).

The **promotion of anchor tenancy contracts and the evolution of the contractual relationship between the infrastructure industry and the institutional customer**, are necessary transformational steps towards the implementation of the infrastructure as a service that will allow a market driven era, fully adapted to the customer driven/centric approach, of EO services. Anchor tenancy is both the **enabler and the justification of the transition** from technology driven EO to customer driven EO.

Public entities would support the market uptake with **appropriately sized and stable contracts** in specific domains, providing medium term visibility on revenues to support return on investment and the justification of investment cases for the new business models. Anchor tenancy approaches can be

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steady growth. Unlike Opex, Capital Expenditures (Capex) relate to investment costs geared more toward the business's long-term growth. Capital expenditures take their toll on the working capital requirements balance. They constitute a significant financial commitment with a Return on Investment (ROI), which is only seen gradually after several months or years. Capex is particularly relevant to space business models considering that the deployment of space infrastructure is a large upfront investment. Furthermore the relatively short span of space infrastructure, particularly in LEO, scaled **at regional and national levels**, but also aggregated with a **bottom up approach** to create critical mass and achieve the sufficient volumes to enable the service infrastructure to be deployed. Key and high-volume anchor customers should drive the aggregation of demand, such as new procurement processes where **ESA is one of a number of institutional anchor tenants to stimulate new developments** that can then be more widely exploited. This could be complemented by different pricing models for systems, data and services according to users.

Public policies and public institutions in the new paradigms of EO

ESA role, and EO programme evolution

There are today ESA programmes that are trying to enable both scientific findings, state of the art systems and technologies and to promote commercialisation.

However, **for RD&I to be fully effective it must be user-driven**, ensure that the supply chain is **mature enough** to ensure technology adoption and that the **innovation remains cost driven**. Furthermore, R&D and operational projects would remain distinct and conducted in full transparency.

Since the cooperation between Science and Industry is crucial to achieve technology excellence, **ESA will have to play a role in EO both as an anchor customer** for state of the art and science driven programmes embracing the full spectrum of EO missions and technologies, thus de-risking innovation (and promoting the dependence reduction on critical non-European technologies), **and as an enabler of commercial services** in new innovative application domains brought (e.g.) by climate change or meteorology.

- The European strategic autonomy must be appreciated **from the bottom up technology level to the data provision and service layers** and the ability to pursue operations in full independence.
- The **early involvement of users in the programmes** are potentially game changing. The establishment of a three ended dialogue on programme (and service) requirements between users, ESA and industry would make a clearer pull-through pathway to operational services.

ESA should embrace the possibility to accept more risks and to be ready to support Industry in case of need, to avoid micro-management in projects and to **transfer more responsibilities to industry (including possibly for shared risk)**, in order to accelerate projects.

- Proposing **more frequent opportunities** for agile small-scale missions would allow to test and introduce new ideas, more innovation and more risk taking
- **Simplifying the tendering process**, and avoiding over complexity and over-deterministic context would also accelerate innovation and allow the participation of a more diverse supply chain (e.g. Design-to cost vs re-use, Geo-return, SME-clauses, Core size limitations...).
- In Copernicus, to increase efficiency and significantly reduce development time, risks and non-recurrent costs, **ESA could promote adequate level of flexibility to allow synergies** between HPCM and Sentinels NG in terms of industrial team composition and common platform implementation.

Industry has also highlighted the issue of funding and budget planning in the early stages of Earth Explorers missions.

- The funding of the early definition phases (mainly in Phases 0&A) is still not adequate in view of the requested scope of work and the huge number of deliverables. **ESA should be able to anticipate the definition of the industrial procurement rules** as early as the Phase A system study (tentatively for the PCR). This is key to set up Phase B1 in order to effectively prepare the B2/C/D/E1 bid phase and ensure higher chances of success.
- There is still a gap between selection of future candidate missions and the budgetary constraints given to industry for their implementation, leading to non-feasible candidates after industry study and extreme financial pressure for remaining candidates. In Earth Explorers **ESA should not impose a binding cap for the mission cost** already in the call for ideas/missions phase, and should base the mission selection process on a balanced compromise among science attractiveness, technological maturity and financial and programmatic aspects.

The ESA EO programmes are at risk of becoming victims of their success: they are the only optional programmes where all member states actually subscribe at least one component, and are open to the widest variety of implementation schemes, including the programme delegations and the joint programmes elaborated with Eumetsat and the European Union.

- Clarify the programme – overcome the suspicion that there is fat or "hobby activities"
- Perhaps be responsive to MS and industry who cannot address the whole envelope

The **issue of industry typologies** (LSIs, MicDaps, SMEs) and relevant programme workshares has been raised, with repeated requests to find the right solution for sharing the work between typologies. The diverse contractual schemes implemented in the EO programmes managed by ESA make them **particularly relevant for a variety of pilot schemes and experimentations**, making the EO programmes excellent candidates for pilot schemes and testing a diversity of new approaches tending to these expectations.

Special focus: Embracing the security dimension in Earth Observation programmes and applications

EO is not only useful to respond to civil policy needs, it could be a tool to generate regulations in multiple applications areas, should the EO sector manage to face challenges such as a fragmented institutional market and a shift of the political momentum it may be able to address security and defence applications within a European framework.

The implementation of EO security applications is potentially of a great benefit for EU citizens and a concrete opportunity for the European space industry*, it also opens a new field for the EO programmes.*

The Galileo PRS, could be a ***template for a pilot approach to the security component of European institutional EO infrastructures****. The current interest of the European Commission towards* ***very high resolution and high revisit*** *could support such a pilot approach, and overcome the reluctance of some Member States.*

The multi-domain activities (Civil Security from Space and the accelerator 2 Rapid and Resilient Crisis Response initiative) in the CM22 proposal invite to propose a suitable implementation roadmap.

Technology trends

Drivers: leveraging expectations from a diverse set of user communities

The seamless link between scientific research and industrial research is the pathway to technology excellence. This is where **ESA is playing the role of facilitator and customer** by regularly promoting and de-risking the innovation trajectory. There is however the long-standing hurdle of technology adoption, which is seen today as a **showstopper** for past initiatives and seems to limit the development of services and commercialisation. If technology and state of the art is the differentiator, it must also be the facilitator of future service uptake by focusing on innovation for value.

There are many challenges in leveraging value from EO data, and the **need to reconcile the interests and drivers** of the three key stakeholder groups.

- Policy makers focus on **policy/law enforcement and societal challenges**: they are concerned with strategical autonomy (and potential control over the infrastructure, beyond ownership, and including its design, development, production and even launch), with sustainability, consistency with public policy and procurement regulations, compliance with standards, support to competitivity, and interest in widespread adoption through usage promotion.
- Users focus on **data centric issues**, valuing information at the highest: data availability is a core need, enabled by several platforms, clouds and data sources with a diversity of access methods; full data consistency (temporal and spatial) is a must, and the proper calibration, indexing, cataloguing are centrepieces of the commercialisation toolbox; data integrity for both download, implementation in APIs, and for cloud and edge processing in real-time are key concerns (the first of which is probably the processing requirement); the availability of tools and APIs, the open access (to avoid vendor lock-in) and simple licencing tools.
- Data providers are concerned with: **the generation and management of growing data volumes and the growing number and variety of datasets**, the **bottlenecks in downlink** bandwidth or insufficient global coverage of gateways, the difficult access to customers and

users, while **keeping costs reasonable** and in control for both institutional and commercial customers.

Technology is bridging the gap of diverging interests of the stakeholder communities with encouraging trends:

- There is an expanding potential for "mid-level" EO satellites (i.e. between Copernicus/Explorer high performance systems and basic cube-sat low expectations), a potential sweet-spot between technology sophistication and prototyping and overly basic designs. The **technological trade-off between fit for all and unique design must be found** for the transition to constellations.
- The developments outside of space sector are opening up **possibilities for expanded markets and new space capabilities** (on-board processing, artificial intelligence, machine learning, distributed networks, cloud computing, edge computing etc.), putting the focus on information rather than data and leaving EO in the background. The interconnection of space EO infrastructure with data lakes and terrestrial clouds is a key step. Eventually data fusion must be complete, where EO data is leveraged by in-situ data and other data sources to create the value-added services and apps of the future.
- There is more effective complementarity between different investments to be found, effectively **aligning R&D investment and industrial policy to capture commercial opportunities for Europe**. The current trend for venture-capital (VC) funded ventures in space, and the relatively high interest of private equity for EO projects must be leveraged to the advantage of public institutions, embracing new production methods, new designs new architectures as they are enabled by new funding opportunities.

Enablers: key technology trends in the new paradigms of EO

Europe should be able to **seize the transformational opportunities offered by the paradigm shifts in EO markets and applications**:

- Achieve **dependence reduction at components and equipment level**, and the issue of component sourcing: This market has been disrupted in recent years, in particular by China whereas US based solutions are more difficult to source and more expensive. From a European perspective we still depend from the US on EEE components, in the future we will have to reassess the situation and make this issue of strategically high importance.
- **Enable and implement edge computing** and its utilisation in upcoming missions to enable Saas. Europe could act fast enough to become a leader in this new segment.
- **Strengthen Machine learning and underlying technologies**: this is another area where Europe shall carefully address its shortcomings on this technology area to develop capabilities and AI engines that are European.

In this context, **ESA should consider a holistic technology development roadmap** to make available:

- **Enablers for innovative and higher performance sensors**: European competitiveness requires staying at the leading edge of technical EO capabilities in terms of advancing sensors with the highest spatial, spectral and radiometric resolution, complemented with miniaturisation and mechanisms to achieve larger field of regard in order to optimise system revisit and its affordability.
- **Enablers for high frequency revisit**, mostly thanks to constellations: focusing on cost reduction manufacturing technologies, series approaches, standardisation and modularity, low cost components and supply chain efficiency and global competitiveness.
- **Enablers for smart and autonomous systems**: agility solutions, smart tasking, autonomous data selection and processing, on board processing are key to increasing the productivity of EO systems and infrastructure, giving more value for the same investment and generating economies of scale in data production.
- **Enablers for data rate growth**: large data amounts are often a showstopper so that big data management solutions, cloud solutions, smart storage, edge computing, data sorting and selection, semantic layers enabling data discovery, high data rate space-to-ground transfers, data relay solutions, and data compression become essential building blocks for future system efficiency, and the management of high frequency observation with good levels of details.

- **Enablers for big data processing**, at system level, are the key to enabling the big data revolution, with distributed systems, high speed processors, embedded AI, software, machine learning, and inter-satellite links.
- **Enablers for customer access**: data centres, interfacing with commercial clouds, on-demand and satellite tasking, real-time data access, edge computing, resource planning and network orchestration for real-time tasking and data on demand and platform as a service operations.
- Of course, the system is only as performing as its weakest part, so that the full data acquisition, processing, handling and transmission functional chain must be **supported by core technologies** at the component, equipment, subsystems, and software levels. The areas of EEE components (e.g. sensors, microprocessors and optical components), active RF and microwave technologies, high precision optics, and solutions for high stability (mechanical and thermal) shall be regarded with great attention, considering the trade-off between state-of-the-art solutions and industrialisation and standardisation for affordable constellation concepts.

Seminar Summary

Panel A - EO as part of the Digital economy: how are the roles of the private and public actors evolving?

Summary

This panel aimed at providing some reflections on the roles of the private and public actors in the new digital economy paradigm in which the EO sector is evolving. The EO sector, beyond being fully immersed in the shift towards new digital technologies to execute tasks better, faster and differently than before answering to user needs, is first and foremost answering major economic, social and policy priorities.

To emerge as a real private market and answer with more accuracy these priorities, the EO sector needs mature technologies but also a projection towards a vertical market dimension supported by public institutions (i.e., promotion of anchor tenancy contracts, infrastructure as a service) that will allow entering a market driven era, fully adapted to the customer approach, of EO services.

As such, the public and private sector need to collaborate, each of them providing their know-how, innovation and agility, in an enlarged innovative ecosystem to improve the competitiveness and strategic autonomy (via the promotion of European patents and protection of intellectual property) of the European EO sector and achieve the economic, social and policy challenges of tomorrow.

Panel highlights

EO sector moves towards higher levels of abstraction in the variety of segments associated to the downstream industry.

The current trend for information layers is to leverage various sensors, various sources and merge/fuse data sets to create more value in the information.

The value creation for the data generation segment is very complex, since sensors develop into a variety of bands and resolutions and build upon generations of observations sometimes lacking continuity.

Going from the “Technology development phase” to the “Pilot service delivery by public sector” phase can be enabled by the capability to analyse big data, an appropriate funding, and a clear data policy.

Each EO industry segment is moving along specific poser lines:

- Acquisition: trends towards **space as a service**, because satellites are increasingly easy to launch and get access to.
- Dissemination coupled with infrastructure: move towards the provision of **data platform and market places**
- Analytics: growing integration with data and data acquisition: **Advances in data fusion supported by on-board computing**. Companies tend to converge towards similar verticals and combine their business. This is a more general trend for data fusion.

And some trends are affecting the sector holistically

- Evolving **national EO strategies**, providing support to national champions
- **Business models developing in the "as a service" dimension** (DaaS, PaaS, InsaaS, SaaS) more project-based, and partnerships to address the full value chain.
- **Verticalization**: EO data has solutions across industries, solutions can be specific to markets, **multi-purpose EO is superseding Market-focused EO**.

Food for thought, items to ponder

- **EO technology advancement vs EO technology adoption:** What is the trade between technology advancement and adoption waiting time? Is the adoption the key point? Is technology advancement and state of the art a critical differentiator? Is it the best solution to create value?

- **EO technology market leaders vs EO vertical market leaders:** There are going to be market leaders for technology solutions, but how do you match that with vertical market leaders?
- **Horizontal EO business strategy vs vertical EO business strategy:** this is where the business positioning will have to make the difference
- **Evangelising EO vs selling EO:** Do we evangelise or do we sell? EO as a market or as a concept? This a major dividing frontier between a business model and a mission concept. There must be a sweet spot to be found between promoting adoption and selling.
- **EO in the background vs EO in the foreground:** Where do we want EO data to be? Is EO in the background or the foreground? What is the right level? For example, when you use a weather app, you may expect a weather alert but do you need/want to know what is the role of EO data in that?

The three stages of EO development

- These were first the “Technology development phase”; followed by the “Pilot service delivery by public sector”; and finally, the “Market uptake by private sector”.

Important subjects

- Anchor tenancy to transition from technology driven to user driven phase
- Strong need to verticalise to develop and intercept the user needs.
- To emerge as a real private market, the EO sector therefore needs mature technologies but also a projection towards a market dimension that will allow entering a market driven era of EO services
- From infrastructure to service: switch from Capex to Opex.
- The space between EO and IT is really narrowing, because EO is about the data and IT is about information. A lot of technologies and approaches used in IT are now moving to the EO environment.
- ESA cannot go vertical because it goes against the ESA Convention. We would need in ESA to find equal partners in this domain in Europe.

Panel B - From Climate change mitigation to External action: what policies are driving the EO sector?

Summary

This panel aimed at explaining the relation between environmental policies and EO programmes. Indeed, both on an international and a European level, EO has been playing a key role in assessing and monitoring the effectiveness of environmental policies turned towards sustainability and digitalisation. This has allowed ESA to pursue cross-sectoral activities extending to the requirements of the policies.

However, EO is not only useful to respond policy needs, but could be a tool to generate regulations in multiple applications areas, should the EO sector manage to face challenges such as a fragmented institutional market and a shift of the political momentum towards security and defence.

Recommendations from the panellists included a better definition of the strong R&D&I package from ESA to the EO programme, thus enhancing competitiveness and synergies on space through collaborative approaches. To widen the EO sector’s impact and allow for it to push for new regulations, key technologies remain to be acquired the use of available data is to be developed.

Panel highlights

Primary driving policies:

- **Climate** (UN Paris Agreement and EU Green Deal Fit for 55): from Earth Science and Climate modelling, to GHG National Reporting, Climate Mitigation and Adaptation applications.
- **UN SDGs and Ecosystems sustainability** related to various Green Deal policies (such as the newCAP, Forestry and Biodiversity): for monitoring, reporting and verification of policies. It was stressed that policies are cross-domain/sectorial and it was highlighted that that EO

Industry can actually anticipate and help shaping new policies and regulatory frameworks (e.g., towards the valuation of the natural-capital).

- **Security**: from civil security to intelligence, in a context where the European Commission is willing to acquire VHR/high revisit capabilities at EU level but where several Member States are reluctant to entrust the EU with such a capability .

Recommendation on the role of public entities:

- **Public entities should support the strategic autonomy of Europe** for technologies, data provision and operational services capacity.
- **Strengthen synergies and collaboration across the Public and Private entities** to mutually benefit from each other. This is not only about establishing PPPs, but to define clear synergy of roles.
- **Public entities should keep on investing on R&D to de-risk future advancements:** from sensors and on-board technology, to science and applications with cutting-edge information and digital technology and the integration of non-EO data.
- **Public entities can support the market update with large stable contracts in specific domains.** E.g., for security, the GALILEO Public Regulated Service (PRS) was also mentioned as a possible approach.

Panel C - From CM22 to 2030-2040, the long term vision

Summary

The EO market, for which the demand growth on data and Value-Added Services is expected to increase significantly. It is driven by several dimensions: the market itself, but also the technological push and the policy agenda.

Today's EO model very much relies on institutions owning the infrastructure. It is a model that has proven to be successful in the past (e.g., Meteosat and Copernicus). European and national programmes are thus considered to be essential and a stepping stone for the future development of the EO market.

The economic perspectives for EO are positive and a new paradigm and a new era of services is emerging. The evolution towards a hybrid or full delegation of services model is very much welcomed by the private sector, provided that it is a sustainable and gradual to avoid investment and revenue disruptions. As such, the European sector, which can today rely on an expansive technology base to support innovative solutions for the future needs anticipation and planning to be flexible, risk-prone and competitive enough to deliver game-changing products to its customers.

Panel highlights

Today, the model is patrimonial, where the institutions own the infrastructure. We see the evolution in the mid to long term towards a hybrid or full delegation of services model.

The shift to anchor tenancy for data and services must be a slow and gradual transition to avoid investment and revenue disruptions. And it has to be sustainable with big anchor contracts with a very long and stable delegation timeline (i.e., 10-15 years minimum) allowing industry to invest and to deliver.

The economic perspectives for EO are positive and a new paradigm and a new era of services is emerging. In the race for the future, we see that on-board processing starts to be one of the new interests of the market. It will also be key to rely on new technologies such as AI, quantum and edge computing as well as the data fusion of EO and non EO layers.

Dominant trends, emerging opportunities etc of interest/relevance:

- expanding potential for mid-level EO satellites (ie between Copernicus/Explorer high performance systems and basic cube-sat low quality data) designed to be fit nor purpose as opposed to leading edge research missions. These are the basis for constellations of EO satellites
- developments outside of space sector that open up possibilities for expanded markets and new space capabilities (on-board AI etc)

- potential for changing interaction between civilian EO and security related activities within Europe
- new policies driving expanded demand among instutional customers and changing nature of the demand (outsourcing etc)
- expanded uptake of EO derived information among private sector customers but in many cases with no visibility that information products are derived from satellite EO (so no immediate connection to space based data collection)
- increasing interaction/consolidation within supply chains and increasing diversity of actors involved
- primary geographic demand expected to be North America and Asia

Highlighted critical elements to ensure

- new procurement processes where ESA is one of a number of institutional anchor tenants to stimulate new developments that can then be more widely exploitated. This is complemented by different pricing models for systems, data and services
- enable effective B2B solutions including space based information and embedding of EO into customer processes supported by a strong, flexible supply chain
- effective complementarity between different investments, effectively aligning R&D investment and industrial policy to capture commercial opportunities for Europe
- an ecosystem that is highly favourable to innovation and supports a diversity of utilization and actors
- data policy - how does an expanded commercial exploitation of European EO fit with the "free and open" Copernicus data policy?

Opportunities and issues

- public sector driven by green deal, sustianable development etc will demand more volume and scope of information provided from space (however with no sensitivity to the underlying complexity - eg requirements for multiple acquisitions to ensure delivery of a single parameter)
- private sector driven by easier access, enabling technologies (platforms) and business models (eg as-a-service type approaches, universal interoperability)
- expanded fusion of EO and non-EO data, effective exploitation of leading edge AI , on board/edge processing etc

How does Future EO contribute to industrial competitiveness on this timescale?

- building initial capabilities, both upstream and downstream
- testing new concepts and protyping integration of new (and often non-EO) datasets
- early engagement critical new stakeholders from other market domains

Panel D - Technologies/systems/architectures to better answer users' needs and to win on the open markets

Summary

EO programmes offer the widest range of technology domains for satellite applications, with complex measurements from a large variety of observation techniques in a very wide range of RF frequencies (from a few 10s of MHz to THz) and optical wavelengths (up to ultraviolet) . They are also moving fast towards the applicability of new sensors, and the range of observable phenomena is growing fast. EO programmes thus provide a unique array of opportunities for technology development and evolution. The only caveat is the growing criticism of technology push and data complexity where systems evolve faster than the ability of users to take in and absorb the new technology for multi-sensor data fusion and analytics into operational products and services.

It is generally acknowledged that Europe has a leading edge in state of the art civil applications of EO technologies and systems.

EO Systems are evolving very fast due to the appealing services / applications they provide.

Technical efforts and Specific developments need to be oriented towards innovation and keeping the European leading edge, while implementing observation systems based on the concept of complementing institutional missions with the New Space Economy and for providing sustainable EO services to the European community. The verticalization of systems and the development of "as a service" user-centric approaches is also a major drive.

Technology trends will address innovative and cost-efficient spacecraft and payload systems, the data processing and delivery into value added information, the ground system, with its data repositories, live updates, cloud and networking abilities and computing abilities. Increasingly the EO missions will be supported by systems of systems architectures integrating a variety of technical solutions.

Key development areas:

- **Enablers for innovative and higher performance sensors**: advancing sensors with the highest spatial, spectral and radiometric resolution, large swaths, as well as miniaturisation where it leads to better system affordability
- **Enablers for high frequency revisit**, including constellations: cost reduction manufacturing technologies, series approach, standardisation and modularity, low cost components...
- **Enablers for smart and autonomous systems**: agility solutions, smart tasking, autonomous data selection and processing, higher connectivity space-to-ground and among heterogeneous EO systems to increase information timeliness, ...
- **Enablers for data rate growth:** big data management, cloud solutions, smart storage, edge computing, data sorting and selection, high data rate transfers, data relay solutions, data compression...
- **Enablers for high data processing**: distributed systems, processors, AI, software, machine learning, inter-satellite links
- **Enablers for customer access:** data centres, interfacing with commercial clouds, on-demand and satellite tasking, real-time data access, edge computing
- **Core technologies** for sensors, subsystems, software and intelligent systems.

Panel highlights

There are **many challenges in leveraging EO data, from the three key stakeholder groups**.

- **Policy Makers/Society challenges**: Strategical autonomy, Sustainability, Standardization, Market competitivity, Usage promotion.
- **Users challenges**: Data availability, Several platforms, clouds and data sources, Data consistency (temporal and spatial), Diverse access methods, Download times/reliability, Limited processing capacity, Tools availability, Vendor lock-in, Complex data licensing
- **Data providers**: growing data volume, growing number of datasets, Downlink bandwidth, Reach customers, Keep costs reasonable

There are **three pillars for EO technology** development.

- **At component and equipment level we see certain dependence situations in Europe**, and we shall consider the whole supply chain, including foundry availability and component sourcing. This market has been disrupted in recent years, in particular by China. US based solutions in contrast are more difficult to source and more expensive. From a Europe perspective we still depend on the US on EEE components, in the future we will have to reassess the situation and make this issue of strategically high importance. This issue is partially specific to Earth Observation (e.g. for optical detectors), but it often goes beyond EO and ESA (e.g. for deep sub-micron and efforts made within Member States, the EC and EDA).
- **Digitalisation with higher on-board intelligence, autonomy, flexibility and faster-time-to-market,** through a higher use of SW solutions including System-On-Chip and, Edge computing, as well as higher connectivity for its utilisation in upcoming missions to enable Saas. Europe could act fast enough to become a leader.
- **Multi-sensor data fusion and analytics,** including Machine Learning and underlying technologies**:** this is another area where Europe shall carefully address its shortcomings on this downstream technology area to develop capabilities and AI engines that are European.

There are **many axis for EO infrastructure development:**

- **Innovative EO sensors**, to keep the leading European competitive edge
- **Distributed and heterogeneous satellite systems** with critical architecture challenges, including modularity with compatible Interfaces (I/F) and standardisation, as the digital complexity and need to collaborate and federate grows: this applies both upstream (e.g. IP cores, HW and SW module I/F) and downstream (for multi-sensor data fusion and information exchanges).
- **Constellations**: the key points are availability (e.g. higher duty cycles, timely tasking and information delivery), competitiveness and cost efficiency and increased revisit frequency, complementing and interacting with other systems of a large EO architecture
- **Real-time** communications, data access everywhere and on time in combination with smarter sensors and higher autonomy to deliver timely information to end-users
- **Intelligent payloads** generating more data need to be able to **process and derive information on board** and reduce the throughput requirements for a timely delivery to end users.
- **From data to actionable information** for the users
    - Greater federation of data, resources and users
    - Data storage, indexing, catalogs, licensing
    - Data fusion, analytics and value added creation
    - Semantic layers supplementing data and to make data accessible and discoverable
- **Ground segment,** databases, networks, and data clouds
    - Resource and dynamic Planning and Network Orchestration
    - Operations in more distributed challenging environments (remote locations, extreme climate)
    - Optimization of storage, computing and network consumption in federated environment

Innovative and smart sensorsis the future of EO. One of the main issues we need to address is the improvement and higher integration of the analogue capabilities of EO sensors (e.g. sometimes with higher resolution, others with high miniaturisation or a better supply chain) with the digital improvements (e.g. with Edge processing) needed to derive useful and timely data and actionable information to feed the cloud.

Panel E - From science to applications: how to ensure ROI while not killing the goose that lays the golden eggs?

Summary

This panel aimed at finding a balance between reaching technology excellence and allowing for R&D&I investments to enhance the competitiveness of the European space industry in the context of ESA programmes.

There currently are ESA programmes that are trying to enable both scientific findings and to promote commercialisation of technologies. However, the panel presented requirements for R&D&I to be fully effective: being user-driven, ensuring that the supply chain is mature enough to receive those new technologies and that the innovation remains cost effective, that R&D and operational projects remain distinct and conducted in full transparency.

Since the cooperation between Science and Industry is crucial to reach technology excellence, ESA has a role to play in EO as both an anchor customer thus de-risking innovation and an enabler of commercial services in new innovative application domains brought by climate change or meteorology.

Panel highlights

"We need to find a balance between scientific applications and commercial applications. How do we accompany the move from the institutional framework to the commercial framework?"

The challenges faced by both ESA and the Industry on innovation can be summarized as a need for a balance between science and the commercialisation of technologies in the context of an increasing demand for EO data associated to a ramp up of private investment.

Both ESA and the Industry should therefore address innovation in a competitive way, which could be done by:

- **Identifying market opportunities for space in various sectors** (e.g. the carbon data market;
- **De-risking pre commercial development** to encourage innovation and lead to breakthrough**s**;
- **Adopting a user-driven approach, adding intelligence to data to make them directly useable, of R&D&I.**

Finding such a balance also depends on the readiness of the supply chain and its ability to industrialise the new technology developed.

Both industrial and ESA has considered that the Agency could play a part in the development f the commercial of EO by:

- **Fostering industrial R&D that harmonizes science and technologies** (with the continuation of InCubed 2, Aelous 2) ;
- **Fostering the participation of Industry in innovation through dialogue,** challenging both Science and Industry;
- **Reducing the process' lifecycle, its constraints and formality** to accelerate the time needed to market an innovation;
- **Stimulating the technical and industrial capability available at ESA and in the Industry** (EO upper stream) to assess the feasibility of developing novel EO instruments and observation techniques, focusing on excellence and high quality systems.

Panel F - Attractiveness of ESA programmes: what is it that Industry truly desire?

Summary

EO is the most important programmatic area for the European industry, the EO programme of ESA, and its co-funded components with the EU and Eumetsat, is the most attractive programme for industry.

The EO programme provides the widest scope of satellite activities, embraces a large range of technology areas, supports state of the art developments as well as operational missions with recurrent programme opportunities, and it provides a stable and recurrent demand for European launch services operators. EO programmes, furthermore, contribute to the development of a wide array of applications and services and has pioneered large scale European data distribution, and cloud based services, with a public private partnership approach. The EO segment promotes vertical and horizontal cooperation schemes that embrace the full array of the European supply and value added chain, from large and small space system companies, to RTOs and labs, and involving ground, data, IT and value added service suppliers.

Synergies on system- and technology- level between ESA-institutional programmes and commercial markets allow European industry to play a competitive role on the global market. To extend this success story into the future, EO-programmes have to be ambitious and adequately financed, taking into account the increasing investments in EO systems and technologies outside Europe and an increasing global competition in this application. They also need to take better and more into account industry needs, by adopting new requirements (technical as well as programmatically). And last but not least the need to reduce dependence on critical technologies from non-European sources and to adequately invest in the complete spectrum of EO-missions and technologies, to be ready for the future.

In the end what industry needs is a really stable and profitable business environment. Each EO programme must be profitable in its own specific scheme. This has to embrace the specific situation of the diverse companies in the sector, acknowledging the concerns expressed by lower tier and midcap payers with regard to the peculiarities and shortcomings or the negative bias introduced by the parallel procurements and the best practices or full consortium approaches.

Panel highlights

In the end **what industry needs is a really stable and profitable business environment;** ESA is requested to provide a long term view to support a vision of usefulness and potential profit beyond initial investment. Each EO programme must be profitable in its own specific scheme. **Industry is also often asked to support by investing this is fine but only if there is a very tangible business case to look forward to**.

Making the case for EO:

- Re-thinking the budget / risk / reward for scientific & demonstration missions
- Make pull-through pathways to operationalisation clearer (not fully in ESA's hands)
- Support the preparation of the competitiveness of the whole industrial chain
- Clarify the programme – overcome the suspicion that there is fat or "hobby activities"
- Be responsive to MS and industry who cannot address the whole envelope - provide early visibility to prepare future involvement.
- There should be more opportunities for small scale agile missions and more turnaround on smaller missions; allow to introduce innovation and risky ideas; more frequent in orbit demonstrations
- Early involvement of users: In early phases discuss user needs and requirements trilateral between Users-ESA-industry, in order to converge faster on feasible missions (in terms of cost-schedule-performance) - develop technologies that are really needed for the programmes.

Contractual context:

- ESA should be ready to accept more risks, to avoid micro-management in projects and to transfer more responsibilities to industry, in order to accelerate projects.
- Reduce ITT over complexity and over-deterministic context (e.g. implementing partially contradicting boundary conditions, Design-to cost vs re-use, Geo-return, SME-clauses, Core size limitations..)
- Need to anticipate the definition of the industrial procurement rules. Industrial procurement rules should be defined during Phase A system study tentatively for the PCR. This is key to set up Phase B1 in order to effectively prepare the B2/C/D/E1 bid phase
- The funding of the early definition phases (mainly in Phases 0&A) is still not adequate in view of the requested scope of work and the huge amount of deliverables.
- Increasing request for "externalization" and full consortium approach have important impacts on prime/payload responsible in terms of profitability decrease vs contract value and bid cost
- **Copernicus:** to increase efficiency and significantly reduce development time, risks and non-recurrent costs, promote adequate level of flexibility to allow synergies between HPCM and Sentinels NG in terms of industrial team composition and common platform implementation.
- **Earth Explorers:** do not impose a binding cap for the mission cost as soon as the call for ideas/missions phase, base the mission selection process on a balanced compromise among science attractiveness, technological maturity and financial and programmatic aspects
  - There is still a gap between selection of future candidate missions and the budgetary constraints given to industry for their implementation, leading to non-feasible candidates after industry study and extreme financial pressure for remaining candidates
  - The funding of the early definition phases (mainly in Phases 0&A) is still not adequate in view of the requested scope of work and the huge amount of deliverables.
- For newcomers and smaller entities:
  - Simplify the **tendering process is also very complicated**, (and provide more feedback and communication opportunities on top of training opportunities)
  - IP friendly contracts
  - Speeding up time-to-contract & "project start date" visibility

Workshare: LSIs, MicDaps, SMEs...

- There are growing requests to find the right solution for sharing the work between companies typologies. The diverse contractual schemes implemented in the EO programmes managed by ESA make them particularly relevant for a variety of pilot schemes and experimentations.

Explore the Security component of applications:

- The implementation of EO security applications is potentially a great benefit for EU citizens and a concrete opportunity for the European space industry, it also opens a new field for the programme
- In view of CMIN22 design a roadmap for EO security services implementation (e.g. addressing the MDA Civil Security from Space and the accelerator 2 Rapid and Resilient Crisis Response initiative)