EUMETSAT

Destination 2030

Foreword

According to its Convention, the primary objective of EUMETSAT, as an intergovernmental organisation, is to establish, maintain and exploit European systems of meteorological satellites, taking into account as far as possible the recommendations of the World Meteorological Organization (WMO).

A further objective is to contribute to the operational monitoring of the climate and the detection of global climatic changes.

This strategy provides the direction and scope of activities to be undertaken by EUMETSAT over the next decade.

EUMETSAT in a fast-changing environment: European and global context

Since the adoption of the previous Challenge 2025 Strategy, in June 2016, the external environment has evolved in a number of respects that require a response from EUMETSAT.

Our society and economy demand further improvements of weather forecasts and warnings, calling for more and better observational inputs from space.

The value of weather information.

In our changing climate, more than ever, our societies are increasingly sensitive to the impact of weather and are becoming less and less tolerant of inaccurate observations, forecasts and warnings. Our societies are now actively managing weather and climate risks as a core task.

The first three risks identified in the 2020 World Economic Forum Risk Report are weather and climate-related. Since 2017, extreme weather has been continuously identified as the biggest global risk in terms of likelihood and is in the top five in terms of impact. In addition, failure to implement climate change mitigation actions and natural disasters are second and third-ranked risks respectively, both in terms of impact and likelihood.[1]

The general public is also increasingly aware of the value of forecasts now widely available in the media, on the Internet, via apps and social media, and is demanding more weather information for safety and private use.

Most importantly, accurate forecasts and timely warnings save lives and avoid a significant proportion of the potential economic losses due to high-impact weather and natural or technological hazards, which are driven or influenced by weather (e.g. floods, droughts, wild fires).

The value of weather data continues to grow and its importance and utilisation is recognised in almost all sectors - economic, public safety and natural resources sectors. Indeed, economic studies[2,3] indicate that 25-30 percent of the gross domestic product (GDP) of highly-developed economies is weather-sensitive and that the socio-economic benefits of weather forecasts are proportional to GDP.

Globally, from 1980 to 2018, a total of 16,585 meteorological, hydrological and climatological events accounted for €3.3 trillion of economic losses and 885,106 fatalities. The rate of losses is accelerating, as more than 40 percent of the total economic losses in this period are attributed just to events between 2010-2018[4].

In the US alone, if fully monetised, the value of weather data to all industries equates to USD 13 billion and the demand for value-added weather services is projected to grow by 10-15 percent a year[5]. An IBM report indicated that 20 percent of executives of companies scoped the potential value of better weather-related insights to revenue growth opportunities of between 2 and 5 percent, and a

1 *WEF Global Risk Report 2020, Figure I. Online at:* ***http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf***
2 *US 2012 GDP, World Bank, AGS, NCAR and NSF study*
3 *"The Case for the Eumetsat Polar System (EPS)/Metop Second-Generation Programme: Cost Benefit Analysis" - Hallegatte, Stéphane (et al.) in "Yearbook on Space Policy 2011/2012: Space in Times of Financial Crisis" (Editors: Al-Ekabi, C., Baranes, B., Hulsroj, P., Lahcen, A.)*
4 *Id. p. 12*
5 *NOAA: Success Stories on User Engagement, 2018. p.6. (data from older studies, however, apparently still relevant). Online at:* ***https://www.ncei.noaa.gov/sites/default/files/weather_service_providers_final_508c.pdf***
6 *IBM Institute for Business Value: Just add weather - How weather insights can grow your bottom line, 2018. p. 7.*
7 *Munich Re NatCastService*
8 *WMO: Statement on the State of the Global Climate in 2019, p. 28. Online at:* ***https://library.wmo.int/doc_num.php?explnum_id=10211***
9 *WMO: The Global Climate in 2015 - 2019, p.12. Online at:* ***https://library.wmo.int/doc_num.php?explnum_id=9936***

quarter of respondents believed that better insights could reduce their operating costs by between 2 and 5 percent. More than half of all executives said that better insights could provide the same cost reduction for annual legal, insurance and risk mitigation costs[6].

In EUMETSAT member states alone, in the same 2010-2018 period, relevant weather-related events claimed more than 7,100 lives and caused €114 billion of overall economic loss. Half of all losses were caused by meteorological events, 34 percent by hydrological events and 15 percent by climatological events.

The costliest events were droughts in 2018, floods in 2010 and 2013, a hailstorm in 2013, and the cold spell in 2017. In terms of fatalities, 97.3 percent of these were caused by meteorological events,[7] namely heatwaves, which have the strongest impacts particularly in locations where they occur in the context of aging populations, urbanisation and urban heat island effects.[8] Even from a global perspective, heatwaves together with tropical cyclones, were the deadliest meteorological hazards in the period analysed.[9]

In the UK, the Met Office's general review of 2015 indicated that the benefit to cost ratio of their weather services was 14.1:1. The main benefitting sectors of this study were the perceived value to the public, aviation, other public services such as land transport, storm and flood damage avoidance and climate change information services.[10]

More accurate forecasts and earlier warnings are therefore extremely valuable for the global economy and for growth in Europe. They are also a key contribution to the achievement of the UN 2030 Agenda for Sustainable Development, to the Sendai Framework for Disaster Risk Reduction 2015-2030, and to the realisation of the Paris Agreement.

A European response

Therefore, in order to rise to the challenge of sustainable development in the next decades and beyond, and to meet the expectations of governments, citizens and industries, the members of the European Meteorological Infrastructure (EMI)[11] need to further improve their forecasts and early warnings of high-impact weather, and to take a multidisciplinary approach with other institutions involved in disaster reduction in order to tailor their products.

The members of the European Meteorological Infrastructure (EMI)[12] are therefore trying to develop coherent strategies which, in their respective areas of competence, will continue to efficiently respond to the evolving requirements from their user communities.

In their 2021-2025 strategy[13], European NMHS forming the core membership of the EMI reaffirmed that their mission is *"To serve society by … supporting the delivery of high-quality and innovative weather and climate data, information, products and services"* [14].

For its part, the ECMWF Strategy 2021-2030 has the vision *"To produce cutting-edge science and world-leading weather predictions and monitoring of the Earth system in close collaboration with the members of the EMI, for a safe and prosperous society"* [15].

As weather forecasts rely on the optimum combination of observations, numerical weather prediction (NWP) and human expertise, parallel and consistent improvements in all three areas are needed. In particular, more and better observations from space are required from EUMETSAT, because observations from meteorological satellites are critical for nowcasting (NWC) and to build the best possible initial state for numerical forecasts. Thus, EUMETSAT's raison d'être will continue to be to operationally deliver observations to its member states, the ECMWF and global NWP centres in member states, and users worldwide, as critical inputs to forecasting and warnings of high-impact weather.

This calls for the delivery of seamless observations of weather, aerosols and atmospheric chemistry, oceans, sea-ice, the cryosphere and land parameters by EUMETSAT, combining the frequent observations from geostationary orbits with the less frequent, but global and more comprehensive, observations from low-Earth orbits (LEO).

Indeed, the ECMWF has increased the number of satellite instruments used as sources of data ingested into its global NWP model from 12 to 70 over the past years, and recent studies have shown that satellite observations account for 64 percent of the reduction of errors in day-1 numerical forecasts[16]. Today, the EUMETSAT Metop satellite system alone, with 3 satellites in orbit, accounts for 25 percent of the total network, and is by far the dominant observing system assimilated by the ECMWF. However, studies have consistently shown that international cooperation and exchange of satellite observations is critical to maintain the unprecedented levels of forecast accuracy the ECMWF enjoys today. EUMETSAT, by providing the technical infrastructure to disseminate third-party data, has a key role in brokering such exchanges.

A similar trend is observed at global NWP centres operated by EUMETSAT member states. The contribution of Metop data to Arpège 24-hour forecast skill is estimated by Météo-France to be 32 percent. From 2000 to 2020, the Met Office increased the number of satellite instruments providing data for use in its global NWP system from ~20 to ~80. At the end of 2020, satellite data were responsible for 78 percent of the reduction in the error variance in the 24-hour global forecast, with data from the Metop satellites accounting for 25 percent of this reduction.

*10 Met Office – General Review (London Economics 2015) - **https://londoneconomics.co.uk/wp-content/uploads/2016/03/METOffice-General-Review-Final-Published.pdf.***

11 The European Meteorological Infrastructure (EMI) is formed by the European National Meteorological and Hydrological Services (NMHSs), their EUMETNET grouping, the European Centre for Medium-Range Weather Forecasts (ECMWF) and EUMETSAT.

12 Fellow members of the EMI are the European Meteorological Network (EUMETNET), the European Centre for Medium-Range Weather Forecasts (ECMWF), EUMETSAT and the Member States' National Meteorological and Hydrological Services (NMHS).

13 Adopted on 17 May 2021

14 "2021-2025 Strategy of the European National Meteorological and Hydrological Services"

*15 **https://www.ecmwf.int/en/about/what-we-do/strategy.***

16 "The impact of Metop and other satellite data with MET Office NWP system using an adjoint-based sensitivity method", S. Joo, J. Eyre and R. Marriot, UKMO, 2012

Over the next decade, satellite data will need to fulfil the requirements of very-high-resolution, convection-resolving NWP models that will become available across all NMHS and will be increasingly used for very-short-range forecasts (VSRF), in conjunction with real-time observations. The ongoing development of seamless Earth system prediction systems that will address short- to extended-range forecasts of weather, atmospheric composition, the ocean, the cryosphere and land, on regional to global scales, is another driver of the requirements.

With MTG and EPS-SG, EUMETSAT will soon operate advanced sensors to meet such needs. Furthermore, the spatial and temporal scales at which global NWP models operate are now approaching those once associated with limited area models. Accordingly, new and demanding requirements on instrument resolutions, refresh cycles (MTG-IRS) and timeliness of data are becoming ever more important. From the other direction, NWP is stretching boundaries with longer and longer forecasts, extending out to the seasonal scale. Here the current state and future evolution of the ocean is key, and hence the observations of the ocean provided by EUMETSAT have never been so critical.

NWP and satellite development are both at the frontier of (and indeed pushing) what is possible. Therefore, the relationship and collaboration between EUMETSAT, the ECMWF and global NWP centres in member states is absolutely critical to best serve these evolving developments and requirements.

By EUMETSAT making new products available, with global NWP centres assisting with the CAL/VAL of new sensors, they will together put in place an observing system for the future that will be fit for purpose.

The primary response of EUMETSAT over the next decade will be to extract more and better products from its current satellite systems, together with the establishment of new and even more capable systems through the realisation of the new EUMETSAT programmes approved by its member states in 2011-2015, in particular the Meteosat Third Generation (MTG), EUMETSAT Polar System - Second Generation (EPS-SG) and Jason-CS (Continuity of Service) programmes. The EPS-SG system is particularly innovative as the combination of cutting-edge microwave sensors will provide the most comprehensive ever view of hydrometeors (cloud, rain, ice) in the atmosphere. The properties of these are still one of the major unknowns in NWP and climate models, and we should expect some scientific breakthroughs.

MTG (FCI and IRS) will primarily be used by NWP for capturing atmospheric dynamics, but on a finer spatial and temporal scale than ever before. Indeed, the positioning of MTG at 0° will also allow the early and detailed observation of the genesis of Atlantic tropical cyclones, and provide advanced guidance about their transition to hurricanes.

EUMETSAT will also leverage further benefits for its member states through its involvement in the European Union (EU) Copernicus Earth observation programme and cooperation with international partners to cover additional requirements including, for example, more frequent observational coverage of the Arctic, a region that is becoming increasingly important for weather forecasts over Europe.

Integrated weather and climate services for mitigation and adaptation to climate change

Changes to the climate system with adverse effects on our societies are evident and pervasive[17,18,19,20]. Risks by the end of the century (2081-2100) will be greater under high greenhouse gas emission scenarios, compared with low emission scenarios. Mitigation policies remain vital to contain global emissions and the magnitude of climate change in the long term. Risks need to be managed through suitable local adaptation policies. The Paris Agreement[21], adopted on 12 December 2015 by the 21st Conference of the Parties to the United Nation Framework Convention on Climate Change (UNFCCC), acknowledges both requirements and captures supportive legal commitments. As a result, the role of systematic observations and their usage gains increased importance for monitoring collective progress towards achieving the purpose of the Paris Agreement and its long-term goals.

Adaptation and mitigation strategies require a full combination of operational weather and climate information services built on solid scientific foundations, including observations, seasonal and decadal predictions, climate projections, climate analyses and assessments of impacts.

Mitigating climate change and adapting to the impacts of weather extremes and changing environmental conditions require detailed information on all relevant scales, and tailored predictions for a broad variety of user needs. These demands can only be addressed through a seamless approach to Earth observation and prediction that encompasses the processes acting on the various scales and in all compartments of the Earth system - including human-induced changes - and their interactions. Advancing Earth system observation, analysis, and prediction capabilities as an international community, and providing valuable information for the benefit of society, are the foundations for all services that EUMETSAT member states deliver.

Tackling and reducing the risks of present and future hazards depends increasingly upon our capacity to characterise extreme events, their physical behaviour and their impacts on our complex society.

17 *IPCC Special Report Global Warming of 1.5°, 2018, available at:* ***https://www.ipcc.ch/sr15/***
18 *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019,* ***https://www.ipcc.ch/srocc/***
19 *IPCC Special Report Climate Change and Land, 2019, available at:* ***https://www.ipcc.ch/srccl/***
20 *The State of the Global Climate 2020 | World Meteorological Organization (wmo.int), April 2021*
21 ***http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf***

EUMETSAT ensures, through the combination of satellites in geostationary and polar orbit, the timeliness, granularity, accuracy, and flexibility of the information that is required for successful decision-making processes, and for consistency of climate applications.

With the launch of the Sentinel-6 Michael Freilich satellite in November 2020, EUMETSAT continues to participate in the international high-precision ocean altimetry mission, strengthening the capabilities of its member states to integrate new data into the modelling chain, to ensure the long-term sea level climate record and to deliver new services for marine and coastal regions.

The sustained involvement of EUMETSAT in global observations of key ocean variables reflects the crucial role of the oceans in the climate system and the carbon cycle, as well as for the purpose of extended-range forecasting, as oceans are a driver of the predictability of the variability of the atmosphere from weeks to seasons and years. This is an essential part of the necessary bridge between weather and climate services.

A de-carbonised society will require accurate monitoring of mitigation and adaptation measures. The future carbon-monitoring missions will have an important role for EUMETSAT and the ECMWF with its responsibility to run the Copernicus Climate Change Service on behalf of the EU. The monitoring of adaptation measures, in order to check the status and to evaluate future directions for investments, will be uncharted territory. It will require a multidisciplinary approach with exploitation of synergies across different satellite platforms and fusion methods with other data sources, and investments in artificial intelligence technology.

NMHS' weather and climate services provide the operational backbone to bridge weather and climate services, thereby enabling the provision of authoritative real-time early warning systems, and well-informed decisions on disaster risk reduction. The collaboration amongst EUMETSAT member states, and between EUMETSAT and the ECMWF under the EMI umbrella, will effectively optimise their specific strengths, addressing the challenge of monitoring climate and variability, including extremes, and optimally implement weather and climate services within both the European and international context. Retrospective analysis of the past climate (reanalysis) plays an important role for both the attribution of extreme events and the characterisation of actual high-impact weather events. EUMETSAT supports this with real-time data for weather forecasting, and long, high-quality climate records for reanalysis. The longest climate records, such as those derived from Meteosat data, approach lengths of 40 years, making them useful for climate analysis.

The same principle can be applied to air quality monitoring and prediction that is performed in retrospective and forecast mode using seamless modelling and data assimilation approaches. Whilst this is used to provide Europe with air quality forecasts, this framework will also be used to assimilate the measurements from the planned Copernicus Anthropogenic Carbon Dioxide Monitoring (CO2M) mission. This will allow the joint contributions of EUMETSAT, the ECMWF and its member states to support national emission estimates and emission hotspot detection, both capabilities being relevant for the global stocktakes for the Paris Agreement.

The Copernicus Sentinels -4 and -5 will deliver important data into this framework as well, allowing an almost complete consideration of atmospheric chemistry which is important to understand greenhouse gas-related climate forcing.

The Paris Agreement and the increasing importance of green policies

The parties to the Paris Agreement, including all EUMETSAT member states, have committed to nationally determined contributions (NDCs) as part of a global effort for reducing or removing CO_2 emissions and to report on progress at global "stocktakes" organised at five-yearly intervals, starting in 2023.

The integration of spaced-based observations of greenhouse gas concentrations, land use, phytoplankton, vegetation, and other drivers or proxies of carbon emissions or uptake, in-situ measurements and existing emission inventories into Earth system models simulating the carbon cycle, has the full potential for establishing global services for retrieving and monitoring anthropogenic emissions from global to mega-city scales.

When deployed as a result of large-scale targeted research and development programmes, such services will provide reference information available to all parties in support of the assessment of the level of nationally determined contributions, and to validate reporting at the UNFCC global stocktakes.

With the wealth of observations of the atmosphere, ocean, cryosphere and land that will be available from the next-generation MTG and EPS-SG satellite systems, the planned contribution to the second phase of the EU Copernicus programme, and data exchange agreements with international partners, EUMETSAT has the ambition to be a major source of observational inputs for the development and exploitation of such services.

Being part of the European Meteorological Infrastructure, also comprising the ECMWF, European national meteorological and hydrological services and their EUMETNET grouping, which together control and develop a large part of the European Earth system modelling and in-situ observation capacity, EUMETSAT is ideally placed to support the necessary integration of different types of observations and numerical modelling.

In general, delivering nationally determined contributions is part of broader, integrated governmental policy framework, that also targets adaptation to climate change, protection of the environment, the health and safety of citizens, and the development of a competitive green economy, with one illustration being the EU Green Deal.

As the national provider of weather and climate information services, each European national meteorological and hydrological service is responsible for delivering multifaceted contributions for the implementation of the green policies of its government.

Therefore, another ambition of EUMETSAT is to assist the NMHS of its member states in the fulfilment of their national contributions to the environment-friendly policies of their governments, through the delivery of high-quality data and support services.

The WMO Vision for the Global Observing System in 2040 and Open Consultation Platform

This Vision for the WMO Integrated Global Observing System (WIGOS) in 2040, adopted by the 18th WMO Congress in June 2019 *"presents a likely scenario of how user requirements for observational data may evolve over the next 20 years, and an ambitious, but technically and economically feasible vision for an integrated observing system that will meet them. It provides high-level targets to guide the evolution of the WIGOS in the coming decades"*.

A key principle is that the WIGOS Vision 2040 responds to user and application requirements. The primary guidance therefore comes from the WMO Rolling Review of Requirements, in which observational requirements for all 14 WMO application areas are gathered, vetted, recorded and reviewed against observational capabilities. The WIGOS Vision 2040 also foresees the implementation of an operational carbon-monitoring system to monitor climate change and assist in mitigation efforts in support of the Paris Agreement.

In summary, the main thrust of the WIGOS Vision 2040 is to provide more, better and new observations from all orbits. In addition, to complement the unique capacity of the full ring of geostationary satellites and to provide very frequent observations, the Vision recommends to increase the frequency of global observations of the many parameters that are only observable from low-Earth orbit.

The proposed space component of WIGOS builds on programmes composed of series of multiple large satellites, providing a stable long-term foundation, expected to be complemented with programmes of smaller satellites with shorter lifecycles, limited scope, experimental payloads, and with faster, more flexible decision processes.

The WIGOS Vision 2040 relies on four sub-components ranging from backbone systems with specified or open orbital configurations and measurement approaches, to operational pathfinders and technology and science demonstrators responding to research and development needs and further capabilities covering additional contributions by WMO members, as well as from the academic and private sectors.

WIGOS 2040 will remain the overall framework for multilateral and bilateral cooperation within the Coordination Group for Meteorological Satellites (CGMS). The CGMS will provide regular and formal opportunities to address joint planning, coordination and cooperation issues, and will be the framework to address possible contributions from new actors, e.g. from the research or private sectors.

The future contribution of EUMETSAT will involve global, multilateral and bilateral cooperation to leverage further benefits to member states and users through data exchange – with the objective to better fulfil the requirements of the WMO, as foreseen by its convention.

In doing so, EUMETSAT will take into account the work of the Open Consultative Platform (OCP) launched at the 18th WMO Congress as a mechanism *"for addressing collaboratively the grand challenges before the global weather enterprise*[22] *in an open, constructive and participatory way"*.

As the WIGOS Vision 2040 foresees that *"observational data provided by WIGOS are expected to be made available for free and unrestricted international exchange among WMO Members"*, EUMETSAT will also carefully consider the outcome of the discussions started by the WMO on the definition of a unified data policy covering the entire Earth system (WMO Res.42).

In the new space era, a sustained operational core observing system is more necessary than ever

The emergence of new players in the space arena, using innovative approaches in industrial processes and business models to reduce costs, and integrating the entire added-value chain for observations to service delivery, has led to the concept of "new space"[23]. This is challenging the way space programmes are developed and implemented.

In the operational meteorological environment to which EUMETSAT belongs, where the continuity of services is key and the use of the data heavily relies on scientific excellence, the contribution of new space to future observing systems and data services cannot be ignored, but it has to be thoroughly assessed, comparing the expected benefits to the potential costs and risks.

It is likely that, in the future, it will be important to maintain operational core observing reference systems, with rigorous instrument characterisation to achieve improved uncertainty on observations and ensure measurement traceability for climate applications. These core observing systems might be complemented by additional observations from diverse sources relying on the new space approach and realised through new programmes in operational space agencies, or acquired directly from the private sector. A possible architecture of future operational meteorological programmes could be a "system of systems", combining these two approaches and LEO and GEO observations.

22 The Global Weather Enterprise is defined as a public-private partnership gathering public institutions, academia and the private sector.
23 In New Space Journal, Vol. 8, No. 2 (June 2020), based on a review of recent literature, Ken Davidian proposes a definition of New Space , a possible New Space can be defined "New Space pursues common, nongovernmental market goals bounded primarily by market forces (resulting in cost and time pressures, exposure to multiple sources of risk, possibly with the initial support of governmental demand), executing activities in an entrepreneurial way (i.e., engaging in risk-taking activities based on private financing, experimenting with competence destroying or disruptive innovations, or commercial-off-the-shelf innovations sourced from other industries)"
24 WIGOS Vision 2040 made the following assumptions with regard to the evolution of satellite programmes "i) The space-based observing system will continue to rely on both operational and research and development missions pursuing different objectives and having different priorities; ii) Growing numbers of satellites and space-faring nations will lead to increased diversity of data sources, which will require improved documentation, processing and real-time data delivery mechanisms."
25 NOAA-NESDIS-2018-0053-0002
*26 **https://www.nesdis.noaa.gov/content/2020-community-meetings-presentations***

In addressing the evolution of the space-based component of the WIGOS, the Vision 2040 already outlined this approach, by segmenting the observing system into four sub-components; from backbone systems to additional capabilities provided by, amongst others, the private sector[24]. The LEO component of the WIGOS Vision 2040 is sometimes presented as a 3+X system, with three reference orbits complemented by X sources of additional observations.

The NOAA Satellite Observing System Architecture (NSOSA) study released in 2018 [25], which considered nearly 100 different constellations fulfilling NOAA user requirements, concluded that none of the radical alternatives significantly departing from the current architecture would be cost competitive compared to the legacy architecture. In the study, the "legacy continuation", whereby the current architecture can be complemented by smart investments in new capabilities over time, and the "hybrid solutions", whereby the system relies on a mixture of US government satellites and hosted payloads, were identified as the most attractive architectures. The "legacy continuation" is considered as the most risk-averse and the "hybrid solutions" might provide greater benefits but is considered to also involve greater risks. For both architectures, NOAA would continue to operate a set of "core observatories", complemented by ancillary observations from different orbits or using different deployment strategies, i.e. micro-satellites. NOAA has started to implement such an approach by releasing studies on GEO-XO, its future geostationary observing systems, and on Sounder Sat, which will be a component of its future LEO observing system, providing sounding data from small to medium instruments observing 3D winds, ocean surface vector winds, precipitation data, and low light imagery[26].

From its side, the China Meteorological Administration (CMA) has started a requirement analysis for 2025-2040 [27], and is proposing to respond to the WIGOS Vision 2040 with a **2+X** contribution, based on multiple-function large satellites in the mid-morning and afternoon orbits (i.e. FY-5A/B/C) plus a to-be-defined "**X**" number of single function small satellites or constellations.

These assumptions were taken into account by the EUMETSAT Council in 2018, when the opportunities arising from the evolution of the observation system needed to realise the WIGOS Vision 2040 and the possible elements of the EUMETSAT response were discussed. Activities have started in EUMETSAT to assess how additional observation capacities and capabilities could complement the MTG and EPS-SG systems for the remainder of their planned lifetime, using innovative approaches such as a constellation of micro-satellites, or the procurement of data from commercial providers.

Copernicus 2.0, a unique opportunity for integration and synergy of EUMETSAT and Copernicus assets for mutual benefits

The combination of the EUMETSAT weather and climate monitoring satellite systems and Copernicus constitutes an unrivalled European global operational Earth observation capacity.

This makes synergy and integration not only an opportunity, but also an obligation for the mutual benefit of the member states of EUMETSAT and the European Union, their policies, economies and citizens.

As the second phase of the EU Copernicus programme starts, EUMETSAT is in an ideal position to meet this challenge in the next seven years, being already a stakeholder in Copernicus, exploiting the Jason-3 and Sentinel-3 marine missions on behalf of the EU and a trusted operational partner of the Copernicus Marine, Atmosphere and Climate services.

Synergy and integration will take on a new dimension in the area of monitoring atmospheric composition, with the deployment of the dedicated Copernicus Sentinel-4 and Sentinel-5 missions as integral parts of the EUMETSAT new-generation EPS-SG and MTG systems.

This synergy and integration needs to be across the geostationary and low-Earth orbits, combining the unique set of observations of emission sources like wildfires, aerosols, chemically active and greenhouse gases acquired by co-orbiting Copernicus and EUMETSAT instruments in the full optical spectrum, from the UV to the thermal infrared, and integrating the EUMETSAT and Copernicus portfolio of products and digital services.

The deployment of a Copernicus greenhouse gas monitoring mission supporting the implementation of the Paris Agreement, planned for the mid-2020s, will offer a further opportunity for combining new measurements of CO_2 and CH_4 with measurements of CO, NO_x and aerosols to distinguish anthropogenic emissions from natural emissions.

Digital and data strategies

Building a "Europe fit for the digital age" is one of the six priorities of the European Commission under President Ursula von der Leyen and the recent release of the Digital Services Act (DSA) and the Digital Markets Act (DMA) confirmed the EC ambition *"to create a safer digital space in which the fundamental rights of all users of digital services are protected" and "to establish a level playing field to foster innovation, growth, and competitiveness, both in the European single market and globally"* [28].

An instrument for implementing this policy will be "Digital Europe", a programme focused on building the strategic digital capacities of the EU and on facilitating the wide deployment of digital technologies. The "Action Plan on Synergies between Civil, Defence and Space Industries[29]" identifies Digital Europe as one of the EU programmes which will scale up investment in technologies for civil, defence and space applications under the 2021-2027 Multi-annual Financial Framework, together with other programmes such as Horizon Europe, the Connecting Europe Facility (CEF), the Internal Security Fund, the European Defence Fund and the Space programme.

*27 Presented at the Fourth International Strategic Consultative (ISCC) Meeting on China's Meteorological Satellite Programs Hangzhou, China, on 6-10 November 2017 - **http://www.nsmc.org.cn/en/nsmc/Contents/100251.html***

*28 **https://ec.europa.eu/digital-single-market/en/digital-services-act-package***

29 COM (2021) 70 final 22.02.21

In the 21st century, space has become a key element of European digital sovereignty[30]. With the growth of the digital dimension, space-based observations have entered the value chain of several digital ecosystems. The development of the "big data" agenda, involving cloud technologies, artificial intelligence, machine learning and other new paradigms will influence the way organisations like EUMETSAT interface with their users.

The use of these new digital technologies will not only influence the way we interact with our users in a more efficient and transparent way, but it will also open the way to the development of many new applications.

In their 2021-2025 Strategy[31], European NMHS forming the core membership of the EMI promote the development of a coordinated *"data centric approach based on cloud technologies to handle the ever-increasing amounts of data (data federation) necessary to deliver their services, and to increase the efficiency in use of the computational resources available within the community (cloud federation)"*. The development by EUMETSAT and the ECMWF of a European Weather Cloud, enabling federation with the infrastructures of EMI members, is an important step in this direction. The exploitation of information technologies is also a prominent part of the "science and technology" strategic action of the ECMWF strategy 2021-2030 [32].

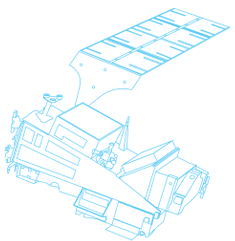
In the context of EU-led programmes, the further development of the Copernicus WEkEO platform by EUMETSAT, the ECMWF, Mercator Océan International and the EEA, to become the platform of choice for accessing environmental data from Copernicus satellites and services, is an important target. The contribution to the Destination Earth (DestinE) initiative started by DG CONNECT as part of the EU Digital Europe programme is another pillar of EUMETSAT's support for the EU Digital Agenda.

Being an actor of the EU Space and Digital Agenda, EUMETSAT will contribute to ensuring that Europe will achieve *"technological sovereignty"* in these domains, which is part of the geo-political priorities of the European Commission.

Responding to an unprecedented economic crisis in Europe and worldwide

The unprecedented global economic crisis arising in the wake of the Covid-19 pandemic will affect the first years of the 2021-2030 decade, and have sustained impacts on some economic sectors, including civil aviation, tourism and international trade.

At European and national levels, the response of governments combines massive recovery plans for maintaining the solvency of industry with large investment programmes preparing for a worldwide competition on disruptive digital and green technology, in a globalised data economy.



The launch of five next-generation satellites in the first years of the decade will realise the massive investments of the 30 EUMETSAT member states and provide a wealth of digital observations offering new opportunities to the post Covid-19 economy, either directly or after ingestion into weather and environmental prediction systems and other digital twins of the Earth.

Realising this potential and maximising the return on the investments of member states will involve leveraging EUMETSAT's participation in the European Meteorological Infrastructure and its digital agenda, federated by the European Weather Cloud initiative.

This calls for the fast expansion of the portfolio of observational products from the new generation of satellite systems, building upon the integration of the expertise of its network of satellite application facilities and research cooperation with academia.

A broader portfolio of outputs will improve the efficiency of EUMETSAT, but in these difficult times, reductions in the cost of operations of the new-generation systems need to follow after a few years of in-orbit experience, through the planned optimisation of ground systems, maintenance and services to users.

At the same time, even if the financial contributions of member states continue to decrease after the contribution peak in 2018, affordability will remain an important factor in the assessment of proposals for additional programmes, calling for the reuse of existing assets in order to contain costs as far as possible.

Finally, the experience gained in the management of the COVID-19 crisis may drive changes in working patterns and arrangements at EUMETSAT, taking also mental health, security and efficiency requirements into consideration.

30 *Jean-Pierre Darnis, "Space as a Key Element of Europe's Digital Sovereignty", Notes de l'Ifri, Ifri, December 2020*
31 *Adopted on 17 May 2021*
32 ***https://www.ecmwf.int/en/elibrary/19880-ecmwf-strategy-2021-2030***

VISION

The vision of EUMETSAT is to be the leading user-driven operational agency in Europe and a trusted global partner for weather and Earth system monitoring from space.

In realising this vision, the first priority of EUMETSAT shall be to fulfil in the most efficient manner, through its own satellite programmes, the essential requirements of its member states for observations, data and support services for operational weather and Earth system monitoring and forecasting, and for climate services.

The second priority shall be to establish additional, or shared, capabilities in partnership with the European Union and other satellite operators for the common benefit of EUMETSAT's member states and partners.

POLICY PRINCIPLES

EUMETSAT will implement this vision taking the following policy principles into account:

1. EUMETSAT's activities shall bring socio-economic benefits, be affordable to its member states, and be implemented in a manner that achieves best value for money and cost effectiveness;

2. For the benefit of its member states, EUMETSAT shall continuously adapt its operational systems and services in response to evolving user requirements and technology;

3. EUMETSAT shall contribute to increasing the overall capacity and efficiency of the European Meteorological Infrastructure;

4. EUMETSAT shall take maximum advantage of science and technologies developed in its member states;

5. EUMETSAT shall continue to rely on ESA for the development of the space segment of its mandatory programmes;

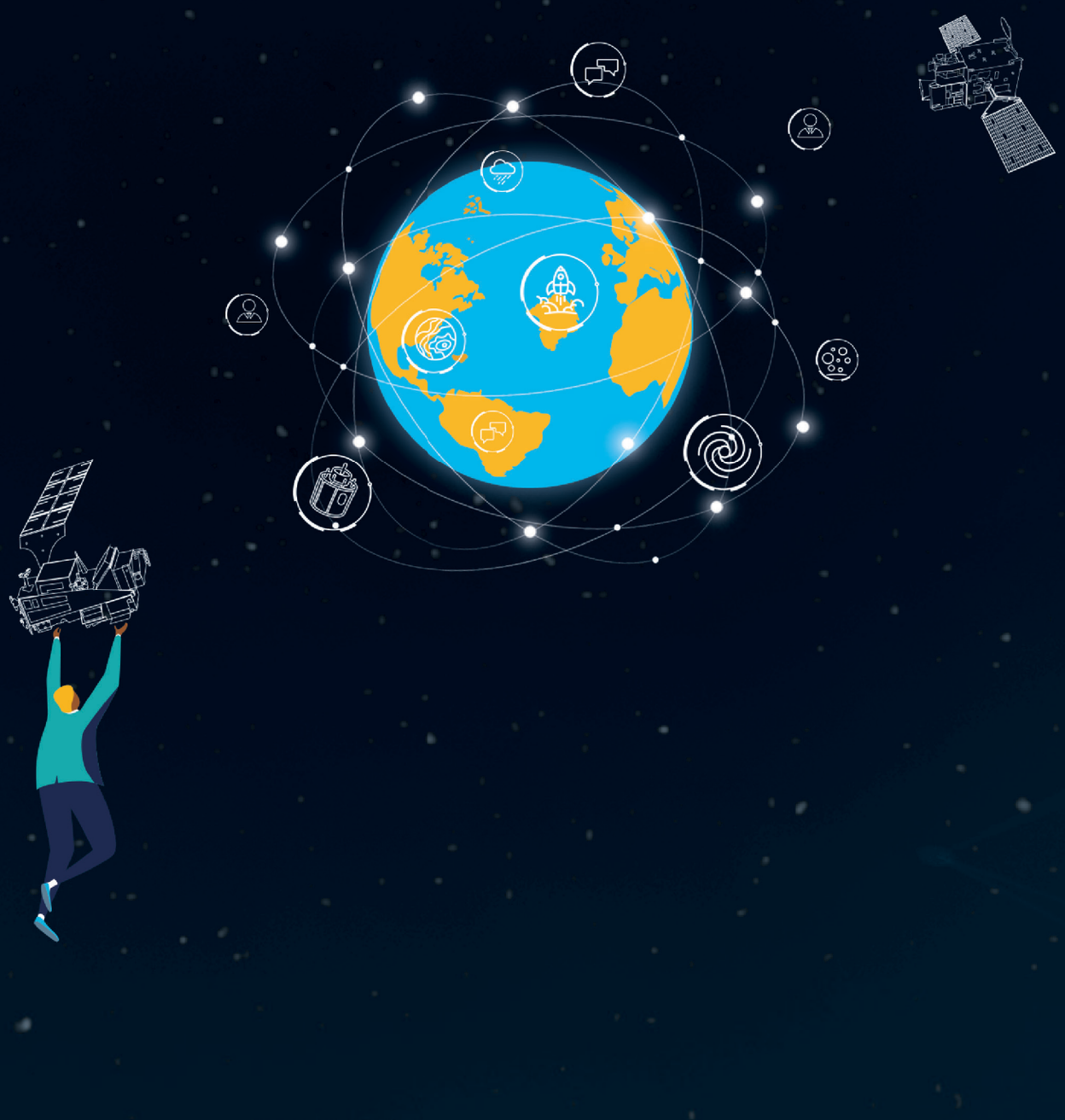
6. EUMETSAT shall continue to contribute to the space component of the WMO Integrated Global Observing System (WIGOS) and other relevant WMO programmes;

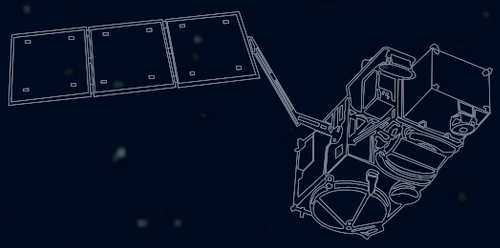
7. EUMETSAT shall consider supporting EU programmes that provide benefits to its member states, whilst mobilising a proportionate share of its overall resources; and

8. EUMETSAT shall make extensive use of international cooperation to increase efficiency, broaden and extend the benefits of its programmes.

STRATEGIC OBJECTIVES

1. Deploy the new Meteosat Third Generation and EPS-Second Generation satellite systems and maximise their benefits to member states and users
2. Deliver operational services responding to evolving user requirements, based on the continuous infusion of science and cost-effective infrastructures and operations
3. Establish and exploit a federative European Weather Cloud infrastructure in partnership with the ECMWF and European national meteorological and hydrological services
4. Consolidate EUMETSAT's contribution to the realisation of the Vision 2040 of the WMO Integrated Global Observing System and plan future satellite systems





5. As a partner of the Space Strategy for Europe, deliver Copernicus ocean and atmospheric composition monitoring missions and contribute to collaborative research and innovation projects for the common benefit of EUMETSAT and EU member states

6. Cooperate with other satellite operators and contribute to global partnerships for monitoring weather, the climate and greenhouse gases from space to meet additional needs of member states

7. Expand the user base for EUMETSAT-provided data, products and services

8. Continuously improve management and risk management processes

9. Remain an attractive employer for diverse, skilled, talented and engaged people

STRATEGIC OBJECTIVES

1 Deploy the new Meteosat Third Generation and EPS-Second Generation satellite systems and maximise their benefits to Member States and users

Deploy the full capacity of the MTG and EPS-SG systems

The successful launch of Meteosat-11 and Metop-C, the last geostationary and polar-orbiting satellites of the current generation, and the continued very good performance of all satellites in orbit, have secured the continuity of service across the transition with the next-generation systems.

This transition started in 2020 with the launch of Sentinel-6 Michael Freilich, the first satellite of the Jason-CS programme, but will only be completed after the deployment of the full capacity of the Meteosat Third Generation and EPS-Second Generation systems, with the launch of five satellites from 2022 to 2025.

Both systems will bring forecasting of weather, air quality and marine environment, and climate monitoring into a new era for Europe and worldwide, with huge potential for developing new products and applications during two decades of operations.

Together with Copernicus, they constitute an unrivalled European global operational Earth observation capacity.

MTG will collect very frequent imagery from the geostationary orbit to support weather forecasting from minutes to a few hours over Europe, Africa and adjacent seas, while EPS-SG will deliver global observations from the mid-morning polar orbit as the prime source of observational inputs into numerical prediction models used for short- to medium-range forecasts.

Both systems include one Copernicus instrument for monitoring atmospheric chemistry in synergy with co-orbiting instruments and will deliver observation capabilities enabling the monitoring of 30 of the 54 essential climate variables (ECV) observable from space identified by the Global Climate Observing System.

MTG comprises two types of geostationary satellites exploited simultaneously. The MTG-I imaging satellite improves the current Meteosat imagery mission and adds a lightning detection capability, while the MTG-S sounding satellite line provides a hyperspectral infrared sounding (IRS) capability of unprecedented performance from the geostationary orbit that delivers vertical profiles of temperature and moisture every 30 minutes over Europe. Combined together on board the MTG-S spacecraft, the IRS and the Copernicus Sentinel-4 ultraviolet and near infrared (UVN) sounder provide a unique, integrated capability to observe ozone, carbon monoxide, sulphur dioxide and other trace gases in support of air quality, pollution and climate monitoring.

The EPS-SG system also comprises two types of Metop-SG satellites exploited simultaneously, Metop-SGA and Metop-SGB. Metop-SGA is an atmospheric sounding and imaging satellite with a suite of infrared and microwave instruments sounding temperature, moisture and trace gases in the atmosphere, complemented by the Copernicus Sentinel-5 ultraviolet and near- and short-wave infrared sounder and by two visible/infrared imagers. Metop-SGB is a microwave imagery mission, delivering radar observations of ocean-surface wind and soil moisture and all-weather imagery of precipitation. Both satellites will be equipped with a GNSS radio-occultation instrument for high vertical resolution limb soundings of temperature and moisture.

The deployment of the MTG and EPS-SG systems is the most important strategic objective of EUMETSAT in the next five years, and part of its raison d'être.

This requires:

- The completion of the challenging development of both systems in cooperation with ESA and other development partners, containing as far as possible remaining development risks and the associated launch slippage and additional costs;
- The timely release to users of validated physical (level 1) products, day 1 geophysical (level 2) products and user software packages with the support of satellite applications facilities;
- Creating all conditions necessary for the maintenance and smooth routine operations of both systems and the delivery of high-performance services to users.

Preparedness of primary users

The NMHS of member states, the ECMWF, regional NWP consortia and the Copernicus Atmosphere Monitoring Service need support to get prepared for validating MTG and EPS-SG products, and for using validated products in their operational weather and air quality forecasting suites as soon as possible.

This is a priority for maximising the benefits of both programmes, because these primary users are next to EUMETSAT in the value-adding chain, and will deliver most of the benefits of the new data to citizens and the economy.

For this purpose, EUMETSAT will:

- Deliver relevant test data as they become available during the development of both systems;
- Support and coordinate the preparedness projects of primary users, with the participation of satellite applications facilities developing user software packages;
- Facilitate interfaces with industry offering MTG and EPS-SG-capable data acquisition and ingestion systems to the user community;
- Develop training material and train scientists and technical experts involved in operations and development of application suites at primary user entities.

EUMETSAT will reuse training material and tools for training a broader user community.

Initial impact assessment, short-term improvements and planning for day 2 products

After the initial deployment of the full capacity of both systems, EUMETSAT will support and coordinate the assessment of the impact of the new data on forecasting and other applications, the sharing of lessons learnt and the identification and prioritisation of necessary improvements to products and services.

The deployment of day 2 and additional products will then be re-planned with the satellite applications facilities.

Integrating benefits of legacy and new-generation systems

In order to optimise the benefits to member states, EUMETSAT needs to extend as far as possible the useful lifetime of the Meteosat and EPS legacy systems and maximise their outputs.

In practice, EUMETSAT will:

- Continue to invest in improvements of products from legacy systems;
- Seek workarounds to irrecoverable anomalies of ageing spacecraft;
- Strive to exploit the residual capacities of ageing satellites to maximise the benefits for users.

Planning the optimum deployment of recurrent MTG and Metop-SG satellites

After some years of operations, EUMETSAT will re-assess the predicted lifetime of the first satellites in the series, and establish a first plan for the deployment of the recurrent satellites to assure continuity of services.

2 Deliver operational services responding to evolving user requirements, based on the continuous infusion of science and cost-effective infrastructures and operations

EUMETSAT will take advantage of the latest advances in remote sensing, algorithmic sciences and information technology to respond in the most efficient manner to evolving user requirements for products and services.

Atmosphere, ocean, ice and land surfaces: a seamless portfolio of observational products

EUMETSAT will feed Earth system prediction systems delivering short- to extended-range forecasts of weather, air quality, the ocean and the cryosphere, on regional to global scales, with a seamless portfolio of global, regional and local observational products of the atmosphere, ocean, ice and land surfaces, including snow cover.

EUMETSAT will pursue this objective through the optimum combination and processing of frequent observations from the geostationary orbit and global, more comprehensive observations from low-Earth orbit collected by EUMETSAT, Copernicus and the satellite missions of partner agencies.

The EUMETSAT network of satellite applications facilities: a strategic asset

In order to develop innovative environmental products that realise the full potential of space-based observations, EUMETSAT will continue to fund and rely on its network of satellite applications facilities (SAFs), each specialised in one application area, as this allows the best use

of resources and expertise available across member states and the fastest response to evolving application requirements.

In particular, EUMETSAT will mobilise the full potential of its SAF network to expand the portfolio of new MTG and EPS-SG products.

Infusing science to deliver more and better observational products

The continuous infusion of science into operational processing chains will be the main ingredient of the evolution of EUMETSAT's product portfolio.

For this purpose, EUMETSAT and its network of SAFs will develop, share and integrate their scientific expertise, to:

- Maintain, through structured interactions with NMHS, Copernicus service providers and user communities, an in-depth understanding of satellite observations, their use in various applications and user requirements and priorities for enhanced or new products;
- Improve methods for calibrating satellite data, using in-situ fiducial reference measurements when appropriate, and thus improve the quality of all downstream products;
- Sustain interactions with the remote sensing research community, including through visiting scientists at EUMETSAT and SAF premises;
- Implement enhanced and new products through day-to-day interactions between scientists and engineers;
- Validate enhanced and new products in cooperation with users.

EUMETSAT will cooperate with other satellite operators and international partners to foster the exchange of knowledge and the cross-fertilisation of ideas.

EUMETSAT will also reinforce interactions with academia, hosting selected research and demonstration projects on its cloud infrastructure for evaluation of the operational potential of new retrieval algorithms, processing techniques and pathfinder products.

Supporting climate services

EUMETSAT will use its archive of more than 40 years of data, together with observations collected by satellites in the next decade, to extend existing climate records and initiate new ones.

This will support the development of climate services by the NMHS of member states, the Copernicus Climate Change Service (C3S) and dedicated capacity building projects, especially in Africa.

In practice, EUMETSAT will:

- Maintain and expand its unique archive of space-based observations of the atmosphere, ocean and land surfaces collected by missions exploited by EUMETSAT and partners;
- Rescue, recalibrate and reprocess series of satellite observations to produce consistent fundamental climate data records (FCDR) of physical variables, including quality indicators and uncertainty estimates;
- Process series of physical variables to produce thematic climate data records (TCDR) of geophysical essential climate variables (ECVs);
- Extend existing climate records into the present time for the purpose of real-time climate monitoring;
- Participate in collaborative climate research projects and cooperate with the scientific community to validate climate records and stimulate their use for reanalyses and other innovative climate services;
- Ensure easy access to a broad range of documented climate records, including for cloud-based post-processing;
- Organise dedicated workshops, webinars and massive open online courses aimed at stimulating the uptake of climate records by climate information services.

An agreement with the ECMWF will cover EUMETSAT's support to the Copernicus 2.0 Climate Change Service (C3S).

EUMETSAT's support to climate services will be embedded in international initiatives led by the WMO, CGMS and CEOS and will make use of the infrastructure, resources and expertise available at its premises and across its network of SAFs, with the Climate Monitoring SAF (CM-SAF) playing a leading role.

Funding of EUMETSAT's support to climate services will continue to be based on a mix between EUMETSAT, Copernicus and other third-party sources, e.g. the EU Horizon Europe Research and Innovation Framework Programme.

Continuity of service and cost-effectiveness will remain drivers

EUMETSAT operations will fulfil service continuity requirements and target continuous efficiency gains.

Permanent evolutions of ground systems will remove obsolescence, maintain high availability over decades and integrate more efficient and scalable IT solutions to allow for capacity increases at minimum cost, when needed to exploit more satellites in orbit.

EUMETSAT will lower the cost of operations of the MTG and EPS-SG systems through the convergence of software solutions across ground segments and cost-efficient upgrades of existing multi-mission systems and services.

Further improvements in the energy efficiency of the technical infrastructure will reduce electricity consumption and the carbon footprint.

For the development and delivery of new products, EUMETSAT will seek a cost-effective balance between contributions from its central facilities and the SAF network, along with the best possible quality of the products generated.

3 Establish and exploit a federative European Weather Cloud infrastructure in partnership with the ECMWF and European national meteorological and hydrological services

EUMETSAT's core mission includes the delivery of time-critical data to users scattered across its member states and worldwide.

Therefore, one key objective will continue to be achieving the shortest possible latency and offering a high level of service at low cost, using advanced digital technology to accommodate increasingly large data volumes, and implementing the new paradigm of bringing users to the data.

EUMETSAT will bring big data services to full operational status in 2021, with the entry into operations of new multi-channel, near-real-time data access services, and the distributed and federative European Weather Cloud platform jointly deployed with the ECMWF.

The new multi-channel data access services will combine EUMETCast data multicast services using high bandwidth satellite and terrestrial networks with an integrated set of online data services ("Data Store", "Data Tailor" and OGC-compliant[33] Web Map Services), all fed by the same large scale "data lake", which will also support more efficient offline services from the Data Centre.

EUMETSAT will thus cope in a cost-effective manner with vastly increasing data volumes and will increase service resilience through multiple back-ups, whilst offering a variety of data access options to users, with more flexibility and scalability for responding to diverse and evolving user needs.

All EUMETSAT and Copernicus real-time and offline data access services will be accessible from a modernised Earth Observation Portal offering online registration, search, discovery, visualisation functionalities and licensing.

Building on the concepts of distributed and federative cloud services demonstrated by the WEkEO Copernicus Data and Information Access (DIAS) platform, the European Weather Cloud platform will provide a missing cloud component to the European Meteorological Infrastructure (EMI), shared by all its components, i.e. EUMETSAT, the ECMWF, European NMHS and their EUMETNET grouping, and supporting an integrated digital strategy.

The platform will allow data federation across the EMI and bring to all components the greatest benefits of cloud technology, i.e. access to large data lakes for hosted processing, applications and projects.

EUMETSAT will offer this capacity to its satellite application facilities as an option for hosting their development and operations, starting in 2022-2027 with their fourth Continuous Development and Operations Phase.

The WEkEO Copernicus DIAS and the European Weather Cloud platforms will contribute to the broader European digital agenda, e.g. through interfaces with the proposed Destination Earth (DestinE) infrastructure.

EUMETSAT will continuously assess new digital concepts and technologies, including artificial intelligence and machine learning, to further improve service performance and offer new functionalities and services to users.

4 Consolidate EUMETSAT's contribution to the realisation of the Vision 2040 of the WMO Integrated Global Observing System and plan future satellite systems

Exploring further contributions to the Global Observing System in the MTG and EPS-SG era

EUMETSAT will assess opportunities for further contributions to the realisation of the Vision 2040 of the WMO Integrated Global Observing System through additional observation capacities and capabilities complementing the MTG and EPS-SG systems for the remainder of their planned lifetime.

These opportunities include a Doppler wind lidar mission adding a missing wind profiling capability to the EPS-SG system to increase positive impacts on numerical weather prediction, and a constellation of micro-satellites expanding the EPS-SG microwave sounding capacity, for the same purpose and for providing frequent soundings for nowcasting at Arctic latitudes not covered by MTG observations.

33 *Open Geospatial Consortium*

EUMETSAT will study both opportunities with ESA, building on the heritage of the ESA Earth Explorer Aeolus lidar mission and Earth Watch Arctic Weather Satellite (AWS) programme, and will conduct trade-offs on a variety of arrangements for the operations of the constellation of AWS satellites in cooperation with industry.

Costs and expected benefits, both in terms of impacts on forecasts and early demonstration of architectural elements considered for next-generation systems, as well as affordability, will drive decisions on whether to proceed with either opportunity, taking into account also the cooperation or synergy opportunities, in particular in the context of the evolution of the Joint Polar System shared with NOAA.

Space weather observations and meteorological observations of the Arctic from highly elliptical orbits will be considered depending on cooperation opportunities with ESA and/or international partners.

As an ancillary activity, EUMETSAT may also purchase supplementary data services on behalf of its member states from commercial providers using European technology after assessing the quality and impact of data, and subject to suitability of data rights and affordability.

Planning for next-generation systems

As an operational agency, EUMETSAT must plan for the next generation of systems [i.e. Meteosat 4th Generation (M4G) and EPS-Third Generation (EPS-TG)] as future mandatory programmes needed to replace MTG and EPS-SG in the 2040s.

ESA will remain the development and procurement agency of choice for the space segment of the EUMETSAT mandatory programmes based on the proven cooperation model that makes best use of respective competencies. Under this model, ESA develops satellites fulfilling user and system requirements defined by EUMETSAT, and procures recurrent satellites on EUMETSAT's behalf. EUMETSAT develops the ground systems, procures launch services and operates the full system for the benefit of users.

This does not preclude the establishment of bilateral arrangements with other space agencies for specific developments or activities, but considering third-party provided instruments as an exception, and only after a timely assessment of specific risks.

Likewise, EUMETSAT will rely on ESA, other development agencies and international partners for assessing the maturity of new concepts (e.g. hosted payloads, proof of concept missions like ESA Earth Explorers) and technologies (e.g. miniaturisation and digitalisation of sensors, hosted payloads, on board artificial intelligence, etc.) and their relevance to its next- generation systems.

For future ground and service segments, EUMETSAT will, resources permitting, assess the relevance of new concepts, architectures and digital technologies to the development of cost-efficient, scalable and maintainable, yet highly reliable ground systems, and compare possible efficiency gains and risks with those of reusing and upgrading existing multi-mission infrastructure and software solutions.

The approach for the development of level 1 data processing systems will be reviewed based on lessons learnt from the EPS, MTG, EPS-SG and Jason-CS development programmes, taking due account of the unavoidable dependency on the space segment development.

Finally, EUMETSAT will explore different models for managing operations in partnership with industry, taking into account the experience of the private sector, in particular for the operations of constellations.

When planning the M4G and EPS-TG development programmes with ESA, EUMETSAT will consider requirements for service continuity with MTG and EPS-SG and how to de-phase the M4G and EPS-TG development programmes to lower the peaks of financial contributions and optimise the use of human resources.

Based on lifetime predictions for the Metop-SG and MTG satellites, member states will decide which system to develop first and whether to procure additional recurrent satellites for the other system, if this remains possible at an affordable cost.

Member states may also consider procuring an additional MTG-S satellite to increase the resilience of the MTG sounding capability.

Likewise, member states will decide the minimum period of operations for each next- generation system, or elements thereof, and the corresponding number of successive satellites to include in the programme. This will take into consideration achievable lifetimes for different types of satellite, service continuity requirements and mitigation of launch failure risks, the pace of technological evolutions, and the magnitude and frequency of reinvestment cycles.

This may drive the approval cycles for mandatory programmes, or impose approval in slices or phases, under pre-determined conditions. In addition, for the sake of efficiency, member states may consider reserving blocked amounts in a given programme envelope to facilitate timely Council approval and the start of preparatory activities for the next programme, in phase with ESA space segment phase A/B1 activities, without pre-empting future Council decisions.

The planning process for the M4G and EPS-TG programmes will start with broad and inclusive user consultation planned for 2027-2028.

Ahead of the consultation, a sustained dialogue with the NMHS, other user entities of member states, the ECMWF and Copernicus services will keep under review technology-independent observational requirements of weather, ocean and air quality forecasting and climate services.

The review of requirements for space weather observations will build on the experience available in member states and at NOAA, also taking into account requirements expressed by the aviation community at the International Civil Aviation Organisation and at European level, and by a possible EU space situational awareness initiative.

The user consultation process will produce prioritised requirements in terms observation capability, accuracy, co-registration, revisit, timeliness etc. and identify candidate remote sensing techniques for delivering relevant observations from geostationary and/or low-Earth orbits.

On this basis, EUMETSAT and ESA will assess how well a handful of contrasted space segment architectures could fulfil prioritised user requirements, and, if possible, identify associated risks and lifecycle cost drivers. This may include trading or combining the geostationary orbit and low-Earth orbit constellations for fast repeat observations, or large multi-sensor observatories and constellations of small satellites for global observations from low-Earth orbits.

The requirements and architectural design for the first next-generation system development should be established at the latest in 2030, to enable the start of preparatory activities (phase A/B) in partnership with ESA.

5 As a partner of the Space Strategy for Europe, deliver Copernicus ocean and atmospheric composition monitoring missions and contribute to collaborative research and innovation projects for the common benefit of EUMETSAT and EU Member States

EUMETSAT as a partner of the European Space Strategy and other European strategies

As an operational, user-governed agency, EUMETSAT brings to Europe a unique, resilient capability to deliver global observations, data and user support services around the clock, based on the combination of scientific and engineering skills and experience of day-to-day interactions with multiple user communities.

As stressed by the Space Strategy for Europe[34] published in 2016 by the European Commission, this has made EUMETSAT a trusted partner of the European Union for the effective implementation of the Copernicus Programme, delivering the Copernicus Jason-3 and Sentinel-3 ocean monitoring missions, and high availability data access services embedded in its unique multi-mission infrastructure.

At the same time, the EUMETSAT involvement in Copernicus brings substantial benefits to all its member states, including high quality observations of the ocean, wild fires and aerosols, productive synergies with EUMETSAT's own missions, user training programmes, and invaluable early experience of distributed cloud platforms.

The objective of EUMETSAT will be to ensure the most efficient contribution to Copernicus 2.0, in synergy with its own missions, under a Contribution Agreement with the EU, and to create the broadest possible range of opportunities to users and providers of downstream services, in a business-neutral approach, for the mutual benefits of EUMETSAT and EU member states.

Although Copernicus is expected to be the main area of cooperation with the EU, EUMETSAT will consider opportunities under the EU Space Programme, e.g. in relation to space situational awareness, including the monitoring of space weather.

EUMETSAT will support the Commission in the space dialogues established with non-European countries, inform the dialogues of cooperation established with partners in these countries, and promote opportunities for amplifying cooperation for mutual benefit.

EUMETSAT will monitor the development of other relevant EU strategies, including the Green Deal, the European Digital Agenda, the White Paper on Artificial Intelligence and the EU Comprehensive Strategy with Africa, and seize opportunities to participate in the implementation of the Horizon Europe, Digital Europe, Development Aid and other EU programmes implementing these strategies, when this benefits member states.

EUMETSAT will coordinate with the Commission to promote research and innovation using innovative MTG and EPS-SG observation capabilities, and consider participating in EU-funded cooperative research projects enhancing products, services and their applications e.g. using cloud and artificial intelligence technology.

EUMETSAT will be key partner and offer its unique experience of open, federative cloud platforms and services to the proposed Destination Earth (DestinE) initiative, and deploy an EU-funded European Earth observation data lake that it would operate in support of Digital Twins of the Earth. EUMETSAT could ensure proper interfaces with the WEkEO Copernicus DIAS and the European Weather Cloud platforms to facilitate the use of the Destination Earth (DestinE) infrastructure by the EMI and Copernicus.

Monitoring the ocean, atmospheric chemistry and greenhouse gases in the Copernicus 2.0 era

EUMETSAT will contribute to the second phase of EU Copernicus programme (Copernicus 2.0) through an EU-funded third-party programme implementing a contribution agreement with the European Commission.

34 COM (2016) 705 final

The focus will remain the deployment and operations of Copernicus ocean and atmospheric composition monitoring missions, delivery of relevant EUMETSAT and third-party data, data access and user support services, following the priorities of member states and the cooperation scenario agreed with ESA for joint contributions to Copernicus 2.0.

The synergy with EUMETSAT's own missions, multi-mission infrastructure and data services will deliver integrated data streams and services that create the broadest possible range of opportunities and benefits to all users in EUMETSAT and EU member states.

In the area of *ocean monitoring,* EUMETSAT will continue to deliver the Copernicus Sentinel-3 marine mission and the cooperative Jason-3 and Jason-CS/Sentinel-6 missions in partnership with ESA and NASA/NOAA, support the deployment of two more satellites, Sentinel-3C and Sentinel-6B, and prepare for the deployment of Sentinel-3D.

In parallel, EUMETSAT will contribute to the definition and development and prepare for the timely deployment of the Sentinel-3 and Jason/Sentinel-6 next-generation missions, split into an optical imaging mission (Sentinel-3 NG OPT) and a cooperative ocean altimetry mission covering both the reference non-synchronous (Sentinel-6 NG) and high inclination orbits (Sentinel-3 NG TOPO) involving NASA/NOAA.

As foreseen by the cooperation scenario for joint ESA-EUMETSAT contributions to Copernicus 2.0, EUMETSAT plans to develop the integrated ground segment of the ocean altimetry constellation, under a low-cost Jason-CS follow-on programme of its own. Subject to EU funding, it will also deploy processing chains for extracting additional ocean products from the global observations of the CRISTAL and CIMR polar environment monitoring high priority candidate missions.

In the area of *atmospheric chemistry and greenhouse gas monitoring,* EUMETSAT will deploy, and start to operate, the first operational Copernicus missions, building on unique synergies with the MTG and EPS-SG imagery and hyperspectral infrared sounding capabilities.

The multi-orbit Sentinel-4/Sentinel-5 ultraviolet, near and shortwave infrared sounding mission implemented by Copernicus instruments added to the Metop-SG A and MTG-S payloads will start operations in 2023-2024, as part of the EUMETSAT EPS-SG and MTG systems.

Moreover, EUMETSAT will engage with ESA in the development of the CO2M mission designed to monitor atmospheric concentration of greenhouse gases in support of the Paris Agreement, focusing on the deployment of the data processing system and the preparations for the launch, commissioning and operations of a system comprising up to three satellites, scheduled for launch in 2025-2027.

In parallel, EUMETSAT will support the European research and development roadmap for the phased development of an Earth system modelling system for retrieving anthropogenic emissions, through the provision of input data from third-party precursor CO_2 monitoring missions and participation in targeted EU-funded cooperative projects.

In the area of *data and information access services*, EUMETSAT will use its multi-mission, multi-channel data access system to deliver near-real-time products from Copernicus missions to the providers of the Copernicus Marine Environment (CMEMS) and Atmosphere (CAMS) Monitoring Services and other users, together with selected products from EUMETSAT or acquired through cooperation with international partners.

The distributed and federative WEkEO Copernicus DIAS platform will evolve in scope and capacity, in partnership with the ECMWF, Mercator Ocean International and industry, and continue to provide a unique framework for online access to the full collection of Copernicus data and information, and for hosting processing, applications, projects and services. Further partnerships and federation agreements may expand its use and accessible data universe.

EUMETSAT will maintain sustained operational interactions with the CMEMS and CAMS service providers, to collect feedback and address evolving requirements e.g. through enhanced or new products or third-party data services, and coordinate user training programmes.

6 Cooperate with other satellite operators and contribute to global partnerships for monitoring weather, climate and greenhouse gases from space to meet additional needs of Member States

As no single country can provide sufficiently global and frequent observational coverage from space on its own, EUMETSAT will consolidate a consistent portfolio of bilateral cooperation agreements with other satellite operators, which is seen as a strategic asset.

Cooperation based on reciprocity will meet additional requirements from member states for observations of weather, ocean, atmospheric composition and climate, broaden EUMETSAT's user base outside Europe and, through synergies between orbits, missions or instruments, will improve the overall capacity, coverage and sampling of the global observing system.

In a dynamic technical and political environment, the implications of evolutions of the respective system architectures require discussions with key partners.

EUMETSAT will continue to share low-Earth orbit satellite systems with the United States' National Oceanic and Atmospheric Administration (NOAA), under the firmly established Long-Term Cooperation Agreement.

Within the Joint Polar System, the EUMETSAT EPS-SG system will provide observations from the mid-morning orbit, while the NOAA Joint Polar Satellite System covers the afternoon orbit, with both systems sharing ground stations in the Arctic and the Antarctic.

EUMETSAT will assess with NOAA cooperation opportunities and the long-term implications of the hybrid architectures studied by NOAA for its future high- and low-Earth orbit systems, and the EUMETSAT/ESA studies of a Doppler wind lidar capability and a constellation of microwave sounding satellites.

Likewise, EUMETSAT, whilst sharing operations of the Copernicus Jason-3 and Sentinel-6 altimetry missions with NASA/NOAA, will promote the extension of the Copernicus cooperation with the United States to the next-generation altimetry missions and explore other opportunities in the context of the US Decadal Strategy for Earth Observation from Space.

The well-established cooperation with China's Meteorological Administration will continue to coordinate the respective assets in polar and geostationary orbits, and amplify coordination in the areas of science and exchange of data with the substantial new opportunities offered by the respective new-generation FY-4, FY-5, MTG and EPS-SG systems, and the launch of FY-3 polar-orbiting satellites into the unpopulated early morning orbit.

Cooperation with China's National Space Agency and State Oceanic Administration will continue on the acquisition and exchange of data from ocean and greenhouse gas monitoring satellites.

EUMETSAT will further develop cooperation on science, data acquisition, exchange and processing with partner agencies in Canada, India, Japan, Korea and Russia to deliver third-party data services to its users and make its own data available to users outside Europe.

Cooperation with research and development space agencies will focus on research missions delivering data usable for weather and ocean forecasting and the monitoring of greenhouse gases.

EUMETSAT will promote and contribute to the exchange of observations of greenhouse and other gases, for research and support for air quality forecasting and for the implementation of the Paris Agreement, building when appropriate on Copernicus agreements between the European Commission and third countries.

Another key objective is to exchange observations of the Arctic, for improving weather forecasting over Europe and the understanding of ongoing climate change, through the combination of observations from highly elliptical orbits available or contemplated by Russia and Canada, a possible EUMETSAT constellation of microwave sounding satellites and the planned CIMR and CRISTAL Copernicus 2.0 missions.

Finally, EUMETSAT will seek access to space weather data and forecasts from international partners to meet increasing demand from member states for such information.

Global partnerships

The EUMETSAT Convention foresees that the organisation shall take into account, as far as possible, the requirements of the WMO.

Therefore, the WMO and its Integrated Global Observing System (WIGOS) and Information System (WIS) will continue to be the overarching international framework for EUMETSAT activities and their articulation with those of other operators of meteorological satellites.

EUMETSAT will remain the Permanent Secretary and an active member of the Coordination Group for Meteorological Satellites (CGMS), the WMO-supported forum for developing multilateral coordination across meteorological satellite operators from an end-to-end perspective that facilitates shared access to products, and promotes the development of applications.

EUMETSAT will support the coordinated realisation of the approved "WMO Vision for the Global Observing System in 2040" setting inter alia the target for the system space component, and contribute substantially through its MTG and EPS-SG programmes together with possible further contributions.

The organisation will encourage substantial and complementary contributions from other satellite operators and the private sector and assess the value of such contributions to its member states and the implications for its future programmes. It will also support the CGMS-wide assessment of risks arising from the failed or delayed deployment of satellites and identification of mitigation actions.

At the same time, EUMETSAT will participate in the WMO Open Consultative Platform preparing a new integrated WMO resolution on data exchange covering meteorological, hydrological and climate data, and supporting interactions with the private sector.

In this framework and within CGMS, EUMETSAT will promote shared, free and open access to all satellite products identified by the WMO as critical for numerical weather prediction for all NWP centres, as a community service.

Furthermore, EUMETSAT will encourage all satellite operators to provide data access and training to developing countries for enhancing their service delivery capacity, as a contribution to the WMO Strategic Plan 2020-2030, and will participate in the effort, in particular in Africa and around Europe.

For this and other purposes, EUMETSAT will contribute to the WMO Information System (WIS) and its planned evolutions, through its data access systems and services.

EUMETSAT also will be active in the Committee for Earth Observation Satellites (CEOS) as the preferred framework for the space community to address requirements of the Sendai Framework for Disaster Risk Reduction and for leveraging mutual benefits from the integration of operational and research missions into virtual constellations.

EUMETSAT will continue to support the intergovernmental Group for Earth Observation (GEO).

EUMETSAT, through the "Global Architecture for Climate Monitoring from Space" coordinated by CGMS and CEOS, will continue to contribute to the "monitoring and observations" pillar of the Global Framework for Climate Services (GFCS) and to fulfilling the requirements of the Global Climate Observing System.

This includes the coordinated planning and deployment of an operational multi-orbit CEOS-CGMS constellation for monitoring greenhouse gases from space, combining dedicated satellites and capacities from meteorological satellites, to which EUMETSAT will contribute through the frameworks of Copernicus 2.0 and its MTG and EPS-SG programmes.

In addition, sustained interactions with the World Climate Research Programme will promote the integration of EUMETSAT's satellites in climate observation strategies and the use of its climate records for research.

EUMETSAT's participation in other global partnerships will focus on activities creating added value to its missions and benefits to its member states.

7 Expand the user base for EUMETSAT-provided data, products and services

EUMETSAT membership

Having now 30 member states, EUMETSAT will assess potential requests for accession on a case-by-case basis, with the understanding that the focus for considering additional accessions should be on EU member states.

EUMETSAT may also consider specific arrangements for projects supported by the WMO.

Data and service policy

The WMO resolutions on the exchange of hydrological, meteorological and climate data, and its planned follow-on resolution on WMO unified policy for the international exchange of Earth system data will remain the reference for the EUMETSAT data and service policy, which will continue to offer full and non-discriminatory access to the worldwide user community under documented licensing conditions that ensure visibility of EUMETSAT member states' investments.

Following the Oslo Declaration, endorsed by all constituents of the EMI, EUMETSAT will offer more and better products free of charge, thus sharing the benefits of its more capable MTG and EPS-SG systems with all users.

The evolution of the EUMETSAT data and service policy will offer benefits of online cloud-based services to the full user community, as illustrated by the adoption of a latency-driven policy providing free of charge access to the full resolution, full frequency Meteosat imagery three hours after sensing.

EUMETSAT will also consider the GEO data-sharing principles and the promotion of a full, free and open data policy in Europe, together with the impact of the emergence of commercial providers of meteorological observations on data exchange within the WMO. EUMETSAT will continue to grant licences free of charge for official duty use to less wealthy countries, to countries involved in EU-funded capacity building initiatives supported by EUMETSAT and to NMHS of countries involved in the EU enlargement process and supported by the EU Neighbourhood, Development and International Cooperation Policy. Whilst promoting the use of its own products by Copernicus and other third-party programmes, EUMETSAT will ensure that third parties acknowledge its ownership, e.g. via digital object identifiers, and establish arrangements for authorising redistribution in compliance with its data and service policy.

User training

In order to realise the full return on the strategic investments of its member states in advanced satellite systems, EUMETSAT will continue to provide and support user training, as part of an integrated cooperative effort mobilising expertise and resources across the EMI and WMO and an international network of experts on satellite products and applications.

The first priority of EUMETSAT-funded training activities will be that personnel of NMHS from member states maintain and develop the necessary skills to exploit satellite data for forecasting, climate monitoring and enhancing services to end-users.

A second priority will be to extend the user base in member states beyond the meteorological user community and to provide training to users in Africa and at the periphery of Europe as part of capacity-building initiatives funded by third parties.

EUMETSAT will continue to provide Copernicus user training in cooperation with the providers of Copernicus information services, with maximum synergy with its own training programme. Cooperation with NMHS or academia will reinforce the science base on the user side, through the Research Fellowship and Visiting Scientist programmes, annual Satellite User Conferences, Copernicus events and other mechanisms.

Capacity Building

EUMETSAT will support the operational plans of the WMO in Africa and at the periphery of Europe, and help the user communities to get access to, and make best use of, an expanding portfolio of EUMETSAT and Copernicus products and services, with the support of instruments of the EU Neighbourhood, Development and International Cooperation policy.

EUMETSAT will amplify cooperation with the European Commission and the African Union Commission and other African stakeholders to seize opportunities arising from the new EU comprehensive Strategy

with Africa and the unprecedented amount of weather, environment and climate information available to Africa from the MTG, EPS-SG and Copernicus systems.

One goal will be *"the strengthening of African capacities [...] to ensure a smooth transition to MTG [...] and for generation of Africa-tailored satellite products answering to African requirements"* targeted by the "Abidjan Declaration on new generation of meteorological satellite products" signed in 2018 by the African Union Commission, the African Ministerial Conference on Meteorology (AMCOMET) and other African stakeholders.

At the periphery of Europe, EUMETCast stations already deployed in Western Balkans, Eastern European, Caucasian and Central Asian countries with the support of NMHS of EUMETSAT member states, will provide data access services enabling the development of national or regional projects coordinated by the WMO and eligible for EU funding, when responding to weather-related EU policy priorities.

8 Continuously improve management and risk management processes

Management

EUMETSAT will consolidate its matrix organisation making flexible use of human resources across operations and developments and allowing efficient operations of at least four more satellite systems in the next decade.

The emphasis will remain on the continuous improvement of processes and procedures, including simplification and digitalisation wherever possible.

This will include the digitalisation of administration processes for the sake of efficiency and better protection of personal data, and expanding the use of enterprise resource planning for management support purposes.

EUMETSAT will seek to maintain compliance of its Quality Management System (QMS) with the ISO 9001 standard, and consider additional standards, if appropriate.

Quality assurance processes will improve, in particular for the processing of anomalies and the assessment of software quality and security, and the lessons learnt process will be harmonised and reinforced to provide a 360-degree assessment at the end of each development sub-cycle of programmes.

The procurement process will remain driven by the objective of best value for money, through full open competition whenever practicable, but with a clear preference for European industrial solutions, where the capabilities exist and European solutions are competitive. Notwithstanding the European preference, EUMETSAT needs to keep flexibility in deciding on its procurements of launch services and to probe the market.

The procurement procedures will remain, as far as possible, compliant with the EU rules on public procurements, and will be reviewed on a regular basis to further increase efficiency and transparency, based on lessons learnt and best practices.

The procedures for procuring skill-based support services and the scope of such procurements will evolve to reduce administration costs, allow for the faster conclusion of contracts in volatile markets and offer flexibility to accommodate unforeseeable additional needs.

A competence planning process assessing three years in advance the need for transferring competences at the end of a cycle of a development programme to operations or to another development programme will augment the human resource planning process. Improvements to accounting, budgeting and financial planning processes will continue to be made, in compliance with international standards, and will simplify the presentation of financial information to member states.

EUMETSAT will maintain its headquarters facilities in a cost-effective manner taking into account the coexistence of ageing and new buildings, and safety, health and security standards applicable in Germany. The organisation will assess alternative working patterns, including proportionate teleworking, in relation to the use of office space, taking into account business and efficiency requirements and considerations on mental health and corporate cohesion.

EUMETSAT will continue, under its green policy, to contain its carbon footprint through carbon neutral constructions, using green energy, further improving the energy efficiency of its data centre and containing flight travel. All those working at EUMETSAT will be encouraged to contribute to reducing CO2 emissions on an individual responsibility basis, and be offered opportunities to do so in relation to their work, taking into account relevant policies adopted by German federal and local authorities.

The internal IT services will evolve to maintain the level of service required by a modern organisation whilst containing costs, based on the introduction of new standard solutions and competitive procurements. Assessments against benchmarks will be organised on a regular basis.

EUMETSAT will continuously adapt its external communication to a fast-evolving external environment, to remain the authoritative European voice on monitoring weather and climate from space.

EUMETSAT will present itself to decision makers and the public as a scientific, high technology, cost-effective operational organisation that brings value to society within a complex value-adding chain involving the NMHS of its member states, the ECMWF and Copernicus service providers.

Risk management

Risk management is central to all EUMETSAT activities, in view of the large investments involved and of the criticality of the continuity of data services for the protection of life and property and for the economy.

EUMETSAT will continue to improve its cross-organisational risk management, composed of a classical risk management system tailoring the ISO 31000 standard, an Information Security Management System (ISMS) implementing the ISO IEC 27001 standard to respond to specific, continuously evolving threats to information security, and a Business Continuity Management System (BCMS) for post-disaster recovery of critical systems and functions. Additional investments will enhance the ISMS, in particular in the areas of identity and access management, vulnerability management, and in the scope of available computer emergency response services.

In the operations area, the avoidance of collisions with space objects using space situational awareness (SSA) services, the processing of anomalies and information security management will remain priorities, in order to preserve the integrity of assets, minimise data outages and maintain the continuity of core data services even in the event of a disaster at EUMETSAT premises.

EUMETSAT will continue to protect its intellectual property and the ownership of data and intangible assets through relevant licensing and clauses in contracts and agreements, and through regular screening of third party intellectual property rights attached to software delivered by industry for operations or reuse.

State-of-the art methods and best practices will apply to the management of risks throughout the development cycle of new systems, together with a reinforced lessons learnt process.

EUMETSAT will coordinate with the WMO, member states and other space agencies for the protection of vital frequencies in the context of the International Telecommunication Union.

Internal controls will involve line management, the Director-General and the Council, and will continue to evolve gradually from a priori controls towards audits.

The approach to risks will remain proportionate, considering likelihood and severity, and the affordability of mitigation actions.

9 Remain an attractive employer for diverse, skilled, talented and engaged people.

A vital asset of EUMETSAT is its people and the variety and depth of their skills and know-how.

EUMETSAT will ensure that it continues to have access to the highly skilled workforce we require during long programme lifecycles through the continued recruitment of high-potential early career professionals, particularly in the digital technology areas. To manage our broader portfolio of programmes and projects, we will continue to recruit highly experienced technical and science managers and place increased emphasis on the development of staff within the organisation through mentoring, training and support in career development.

Whilst seeking to recruit the best candidates through open competition, EUMETSAT will facilitate internal mobility by offering managerial or expert career perspectives to qualified employees.

Planned and prioritised staff training and development will ensure the timely availability of required skills and prepare staff for current and future roles.

EUMETSAT has identified five core values[35] that underline all its projects and programmes, and are aligned with the organisation's mission and vision outlined in this strategy. They define the work ethics and environment that should prevail at EUMETSAT to ensure a safe, efficient, and collaborative professional space for all. The core values will be proactively communicated and the EUMETSAT working practises will be aligned with them if required, to ensure they are the basis of our management culture. This will ensure that everyone working at EUMETSAT, as well as its partners, will be confident and empowered to act in alignment with them. An independent Ethics Officer will also be recruited to support this process and report to the Director-General.

As a member of the Coordinated Organisations, EUMETSAT will maintain attractive remuneration and pension benefits whilst ensuring that non-remuneration aspects continue to be a key element of EUMETSAT's attractiveness.

The latter include a gender balance and diversity policy and a family policy including flexitime and the deployment of an on-site childcare facility.

EUMETSAT remains committed to maintaining excellent employee relations through a variety of communication and feedback mechanisms, including regular staff engagement surveys, and an open and constructive partnership with the Staff Association Committee (SAC).

35 *Integrity, Excellence, Collaboration, Open-mindedness and Empowerment.*

EUMETSAT

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