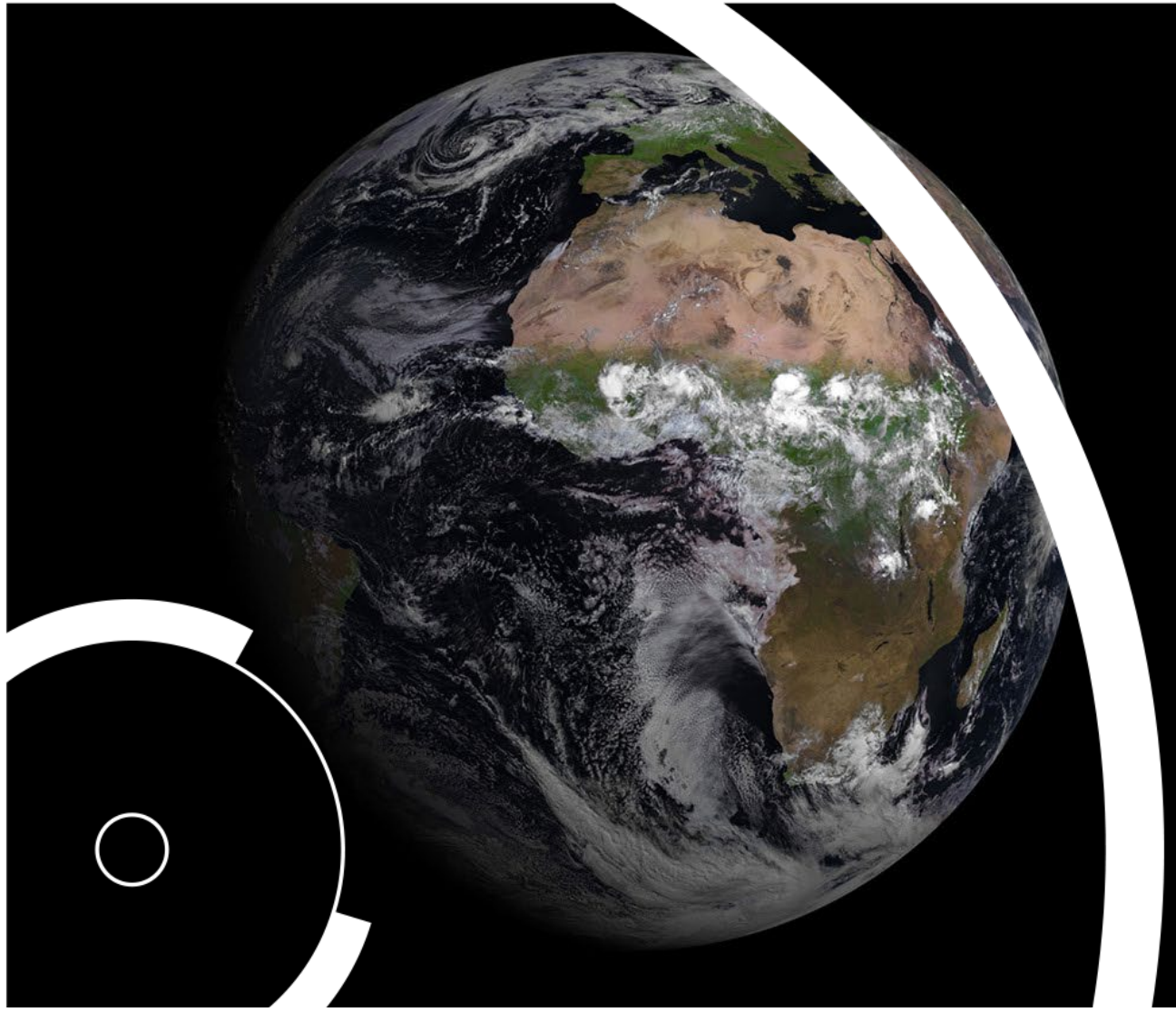


Inv-67359: EUMETSAT Microwave Sounding Constellation based on Arctic Weather Satellite

Presenter: *Alessio Canestri, AWS constellation Study Manager*
Co-Authors: *G. Kayal, C. Accadia, J. Ackermann, J.M. De Juana Gamo, P. Colucci, G. Karsli Demirbas, D. A. Taboada*

Living Planet Symposium 25 May 2022*- B5.01.4 Future Meteorological Missions*

Agenda

Introduction

Expected Benefits of the AWS Constellation

Scientific and Socio Economic studies

Status of EUMETSAT activities and roadmap to approval

AWS Constellation Mission objectives

Constellation Key Design Drivers

Constellation System Overview

Introduction

- Since December 2018 EUMETSAT identified small microwave sounding satellites complementing the reference EUMETSAT Polar System (EPS-SG) /Microwave Sounder (MWS) mission as a possible additional EUMETSAT contribution to the realisation of the WIGOS Vision 2040, in line with objective 4 of the EUMETSAT strategy “Destination 2030”:

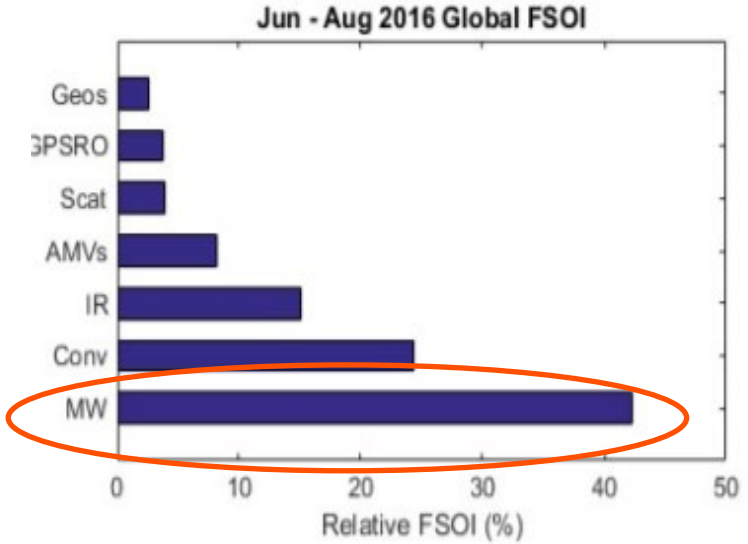
- In 2019, EUMETSAT prioritised relevant user requirements, starting from the agreed MWS user requirements and were used to define the Arctic Weather Satellite (AWS) observational requirements.

- The European Space Agency (ESA) Arctic Weather Satellite (AWS) programme was approved at the ESA ministerial Council in 2019 and is currently in its phase C.

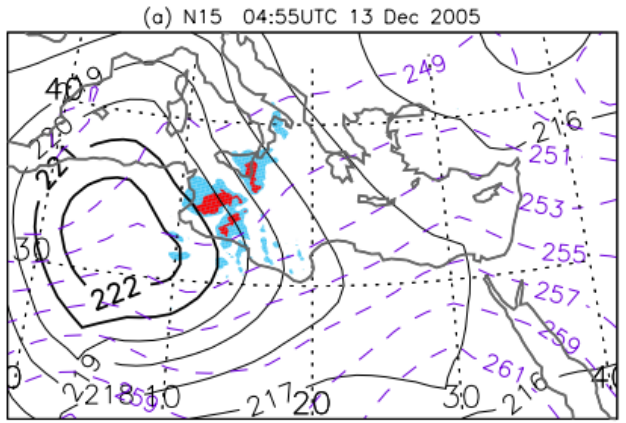
- A successful outcome of the AWS in-orbit demonstration in 2024-2025 would represent an opportunity for EUMETSAT to expand the products’ envelope of the EPS-SG mission for its users, and implement a constellation of microsatellites with microwave sounding capability.

Expected Benefits of the AWS Constellation

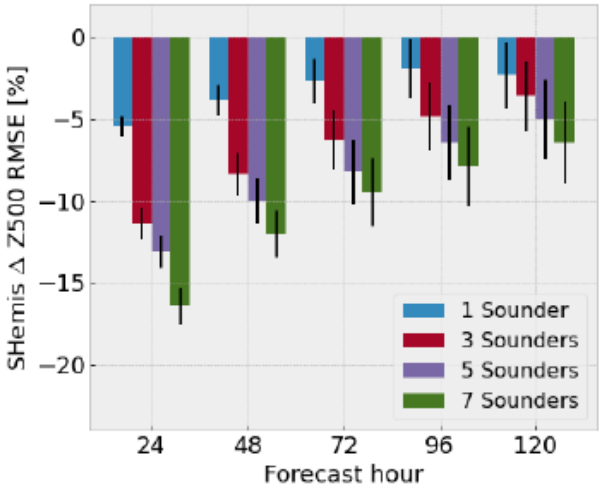
- Microwave Sounders are the first contributor to NWP observations
- The impact of additional observations from complementary orbit planes expected to be high- no saturation
  - High impact in forecasting rapidly evolving weather phenomena (extreme storms)
  - Highly flexible use of the AWS operational data, with unprecedented revisit time
  - The first operational constellation among satellite agencies, and an important complement to the international polar systems



Forecast Sensitivity to Observation Credit ECMWF



EUMETSAT AMSU and NOAA microwave rainfall band for Medicane of 13 Dec 2005 (Nat. Hazards Earth Syst. Sci., 10, 2199–2213, 2010)



Scientific and Socio Economic studies

Scientific Studies:

- **Assessment of the impact on Global Numerical Weather Prediction**
  - ECWMF on Ensemble Data Assimilation (EDA) impact assessment of AWS Constellation
  - Météo France Observing System Simulation Experiment (OSSEs) study with Arpège 4D-Var, complementary to ECMWF study
- **Assessment of the impact on regional NWP and Nowcasting** through case studies
  - Consortium led by Met NO, in collaboration with SMHI and FMI : impact on High-latitude and Arctic
  - Consortium led by ZAMG : impact on the Alpine region
- **Synergies with studies led by ESA**
  - ECMWF: Ensemble Data Assimilation evaluating forecast impact due to the use of various MW sensors in additional orbits
  - SMHI with FMI, DMI and Met NO: Performance evaluation of prototype data

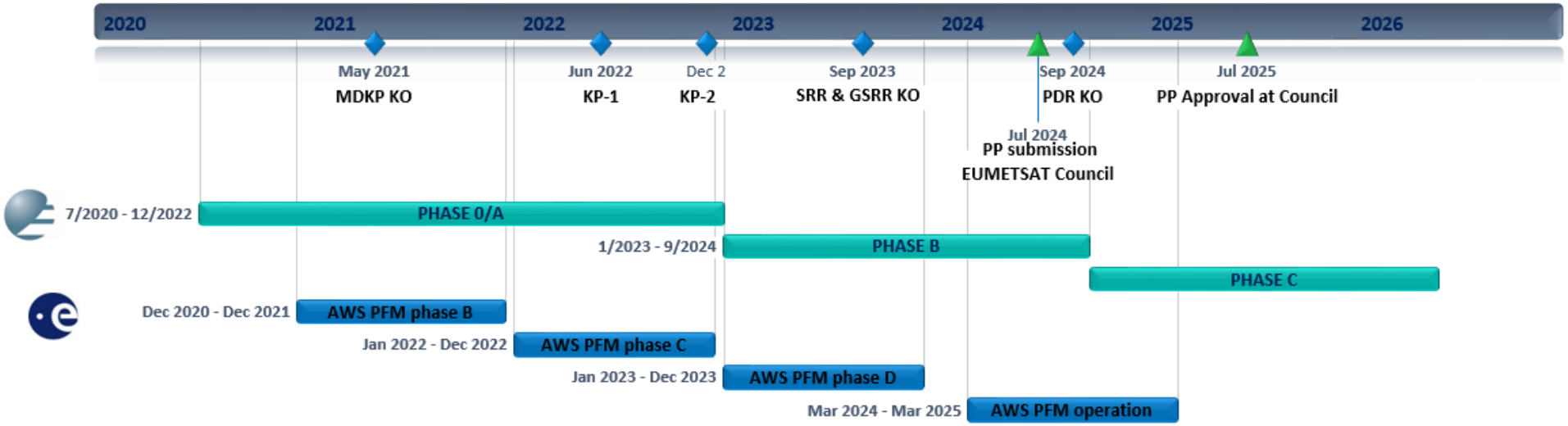
Socio Economic Benefit (SEB) studies:

- AWS SEB study using EPS-SG methodology
- AWS SEB study on Nowcasting in Northern region (FMI)
- AWS SEB study in the Alpine region (ZAMG)
- **Results expected by early 2023**

More Details provided in the presentation from J. Ackermann as part of B3.02.1

Status of EUMETSAT activities and roadmap to approval

- Phase 0 completed in 2021 with Mission Definition Key Point (MDKP)
- Phase A ongoing: Key point 1 in June
- Results of Scientific and Socio Economic Studies will be used for presenting Element of Programme Proposal in Spring 2023.
- Programme Approval targeted in 2025 after one year in orbit demonstration.
- The constellation will be developed in cooperation with ESA.
- Target launch date for the constellation 2029.



AWS Constellation mission objectives

- The AWS constellation will focus on:
  - Water vapor sounding
  - Temperature sounding
  - Cloud detection and geolocation

- The primary objectives of the AWS Constellation would be to:
  - Contribute to improved global and regional NWP accuracy
  - Complement the microwave observations from the Metop-SG and NOAA JPSS polar-orbiting, meteorological satellites;

  The mission will also to contribute to nowcasting applications over the Arctic region through the increase the frequency and availability of microwave observations.

  Climate monitoring is not a primary objective of the mission, however AWS is expected to contribute through the provision of long-term data records and implementation of the necessary capabilities.

- AWS Constellation will not only improve NWP in the Arctic region: The name of the constellation will be changed to reflect its global nature.

Constellation Key Design Drivers

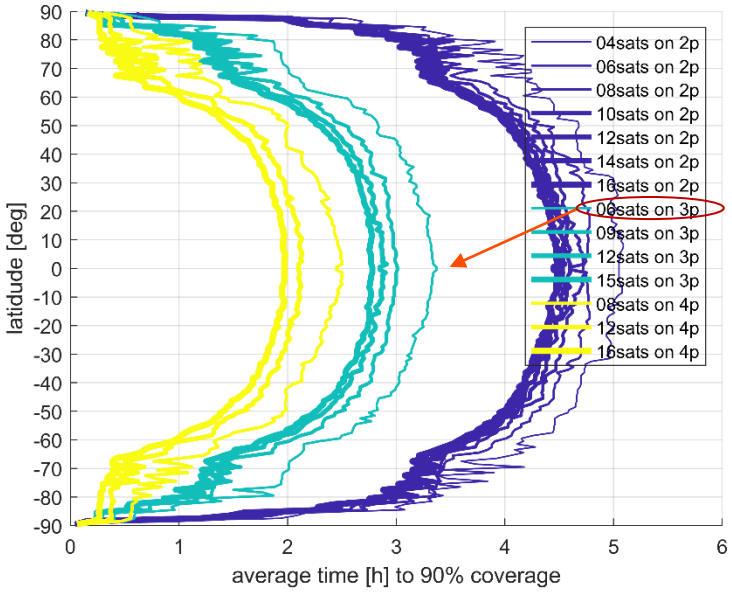
Main drivers for the AWS constellation :

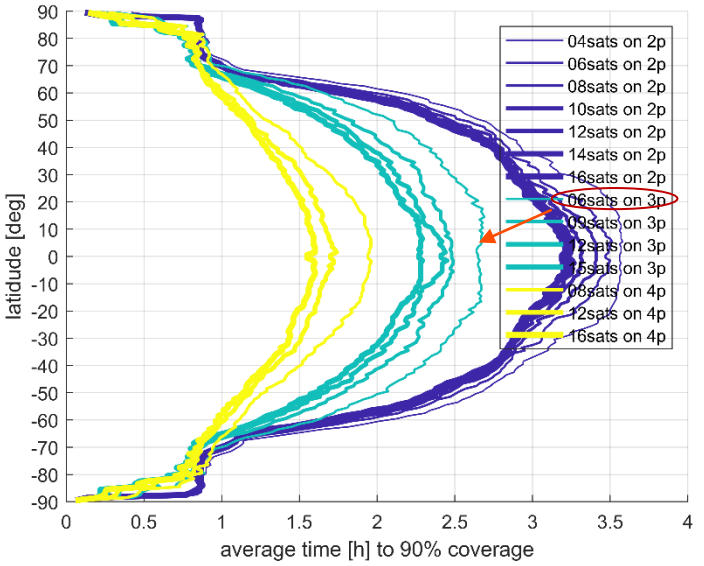
- **Affordability** : re-use of Prototype for constellation and re-use of EUMETSAT assets
- **Mission duration:** 13 years
- **Satellite Reliability :** 0.55 at 5 years
- **Time to achieve 90% global coverage** (5 hrs (Threshold), 4 hrs(Breakthrough), 3 hrs (Objective))

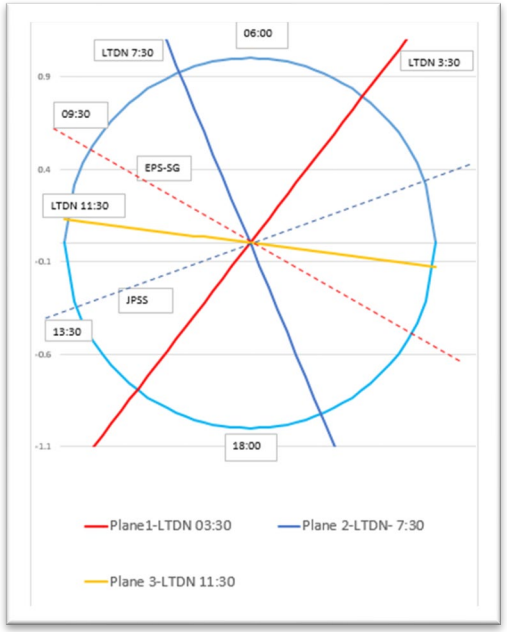
Constellation System Overview- Initial Constellation

Constellation Architecture:

- 3 Sun Synchronous at **600 km** altitude
- Inclination: **97°-98°**
- **LTDN 03:30, 07:30, 11:30** – complementary to EPS-SG and JPSS orbits
- 2 Satellites per each orbital plane
- Total number of satellites on initial constellation: **6**
- Time to achieve 90% coverage (AWS only) : **3.05 hours**
- Time to achieve 90% coverage (AWS+EPS-SG +JPSS): **2.32 hrs**



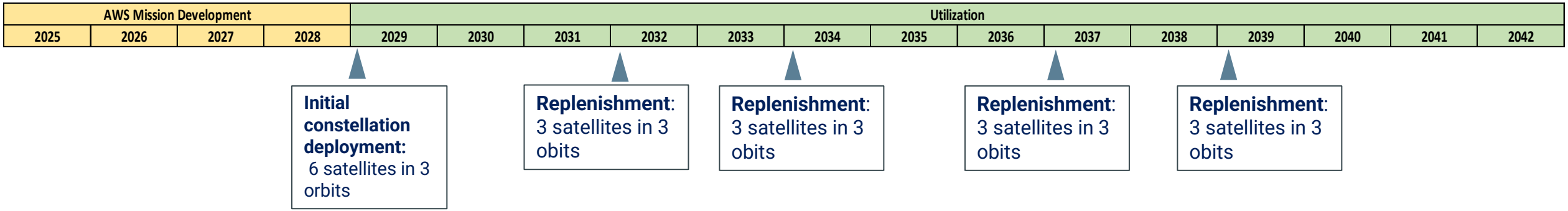




Constellation System Overview-Replenishment strategy

Deployment and replenishment strategy : driven by the satellite reliability i.e. **0.55 at 5 years**.

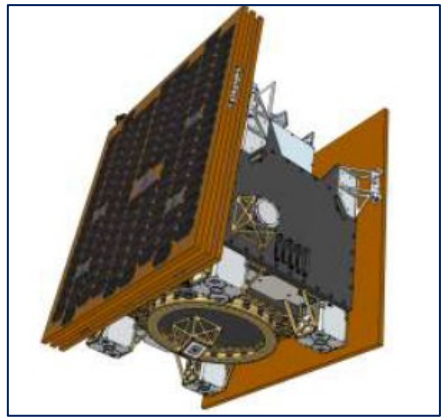
- The strategy maximises the probability of success of constellation considering reliability of the satellites.
- Total number of satellites launched: **18**
- Satellite spares will be required to cope with launcher failures
- The strategy will be adapted dynamically according to the health of the constellation.



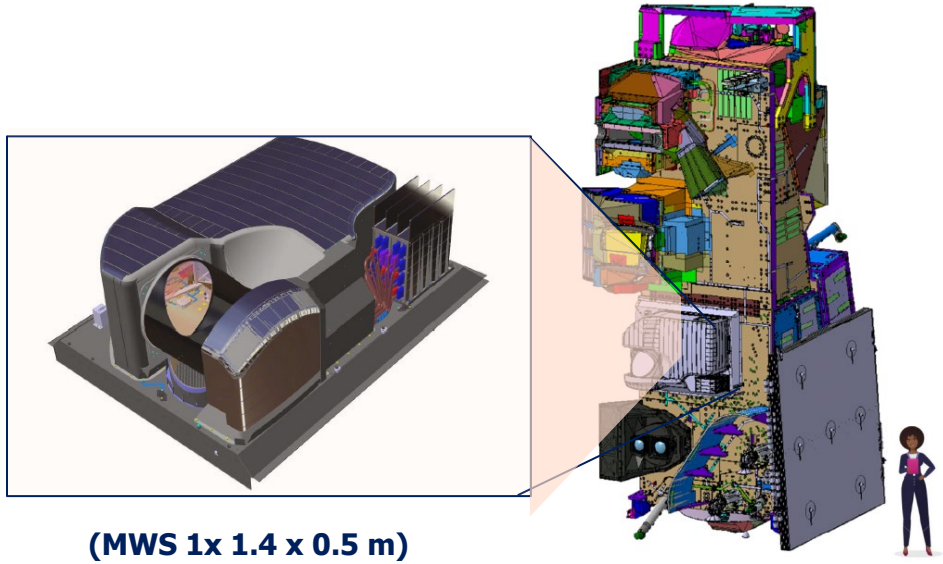
Constellation System Overview: Satellite and payload

- **Spacecraft-** three axis stabilised with electric propulsion :
  - Mass: 120-135 kg
  - Volume: 1.1x 0.7 x 0.8m
  - Power: 120 W
  - Science data: L band for both direct broadcast and stored mission data.
  - TM/TC: S band

- **Payload** : Passive Microwave Radiometer 19 channels (see back up slides)
  - Mass: 30 kg (MWS on EPS-SG ca.150 kg)
  - Power: 47 W (MWS ca.120W)
  - Data rate: 60 kbps
  - Scan rate 45 RPM, scan angle ±54.42°



(AWS satellite 1.1 x 0.7 x 0.8 m)

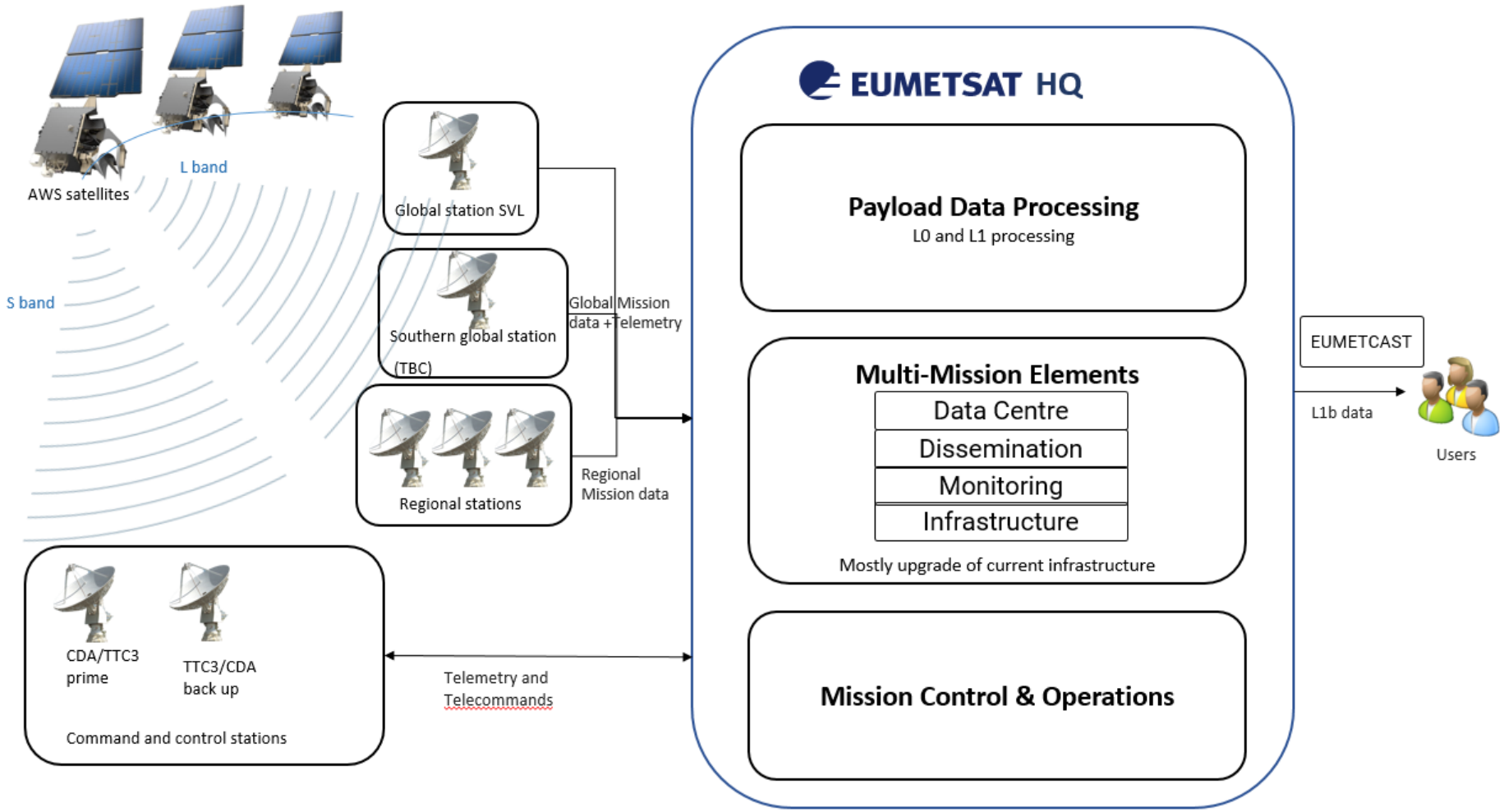


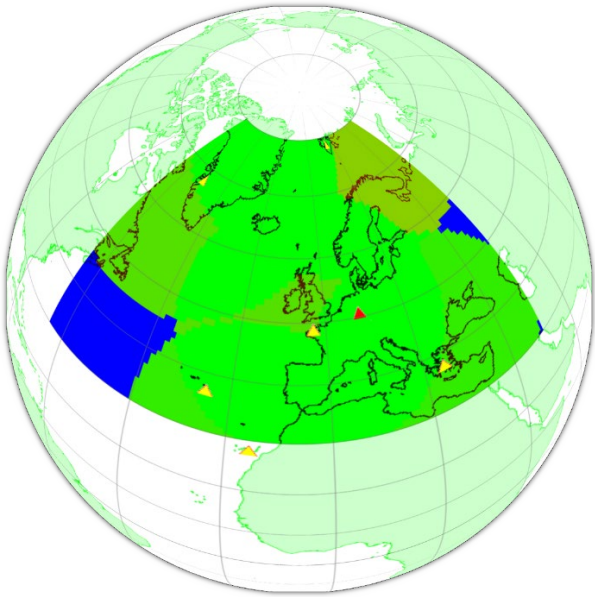
(MWS 1x 1.4 x 0.5 m)

See Inv-67573 - Arctic Weather Satellite Prototype for Future Constellation B5.01.4 Future Meteorological Missions, 25th of May 2022

Constellation System Overview: Ground Segment

- Three types of data service via L band : Global, Regional, Local





Regional network:

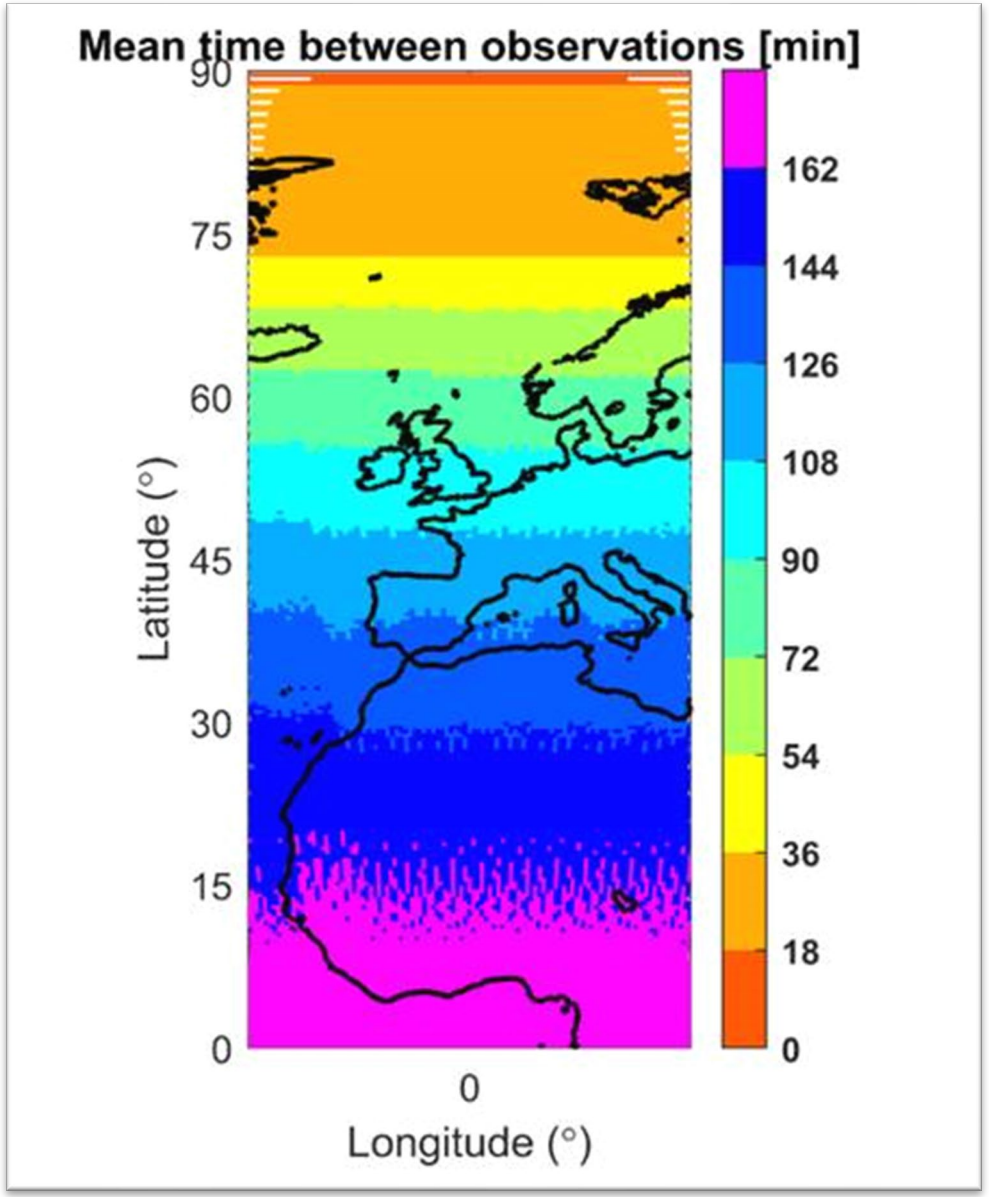
- Svalbard
- Kangerlussuaq
- Lannion
- Maspalomas
- Athens

Thank you!

Questions are welcome.

Back up slides

Mean Time between observations -6 satellites in 3 orbital planes



AWS payload channels and requirements

Channel	Frequency (GHz)	Bandwidth (MHz)	NEΔT (K)	Footprint (km)	Utilisation
AWS-11	50.3	180	<0.6	≤ 40 km	Temperature sounding
AWS-12	52.8	400	<0.4	≤ 40 km	Temperature sounding
AWS-13	53.246	300	<0.4	≤ 40 km	Temperature sounding
AWS-14	53.596	370	<0.4	≤ 40 km	Temperature sounding
AWS-15	54.4	400	<0.4	≤ 40 km	Temperature sounding
AWS-16	54.94	400	<0.4	≤ 40 km	Temperature sounding
AWS-17	55.5	330	<0.5	≤ 40 km	Temperature sounding
AWS-18	57.290344	330	<0.6	≤ 40 km	Temperature sounding
AWS-21	89	4000	<0.3	≤ 20 km	Window and Cloud detection
AWS-31	165.5	2800	<0.6	≤ 10 km	Window/humidity sounding
AWS-32	176.311	2000	<0.7	≤ 10 km	Humidity sounding
AWS-33	178.811	2000	<0.7	≤ 10 km	Humidity sounding
AWS-34	180.311	1000	<1	≤ 10 km	Humidity sounding
AWS-35	181.511	1000	<1	≤ 10 km	Humidity sounding
AWS-36	182.311	500	<1.3	≤ 10 km	Humidity sounding
AWS-41	325.15±1.2	800	<1.7	≤ 10 km	Humidity sounding/cloud detection
AWS-42	325.15±2.4	1200	<1.4	≤ 10 km	Humidity sounding/cloud detection
AWS-43	325.15±4.1	1800	<1.2	≤ 10 km	Humidity sounding/cloud detection
AWS-44	325.15±6.6	2800	<1	≤ 10 km	Humidity sounding/cloud detection