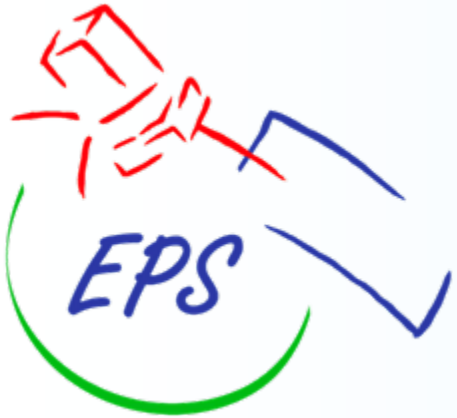

Post-EPS Overview

Peter Schlüssel

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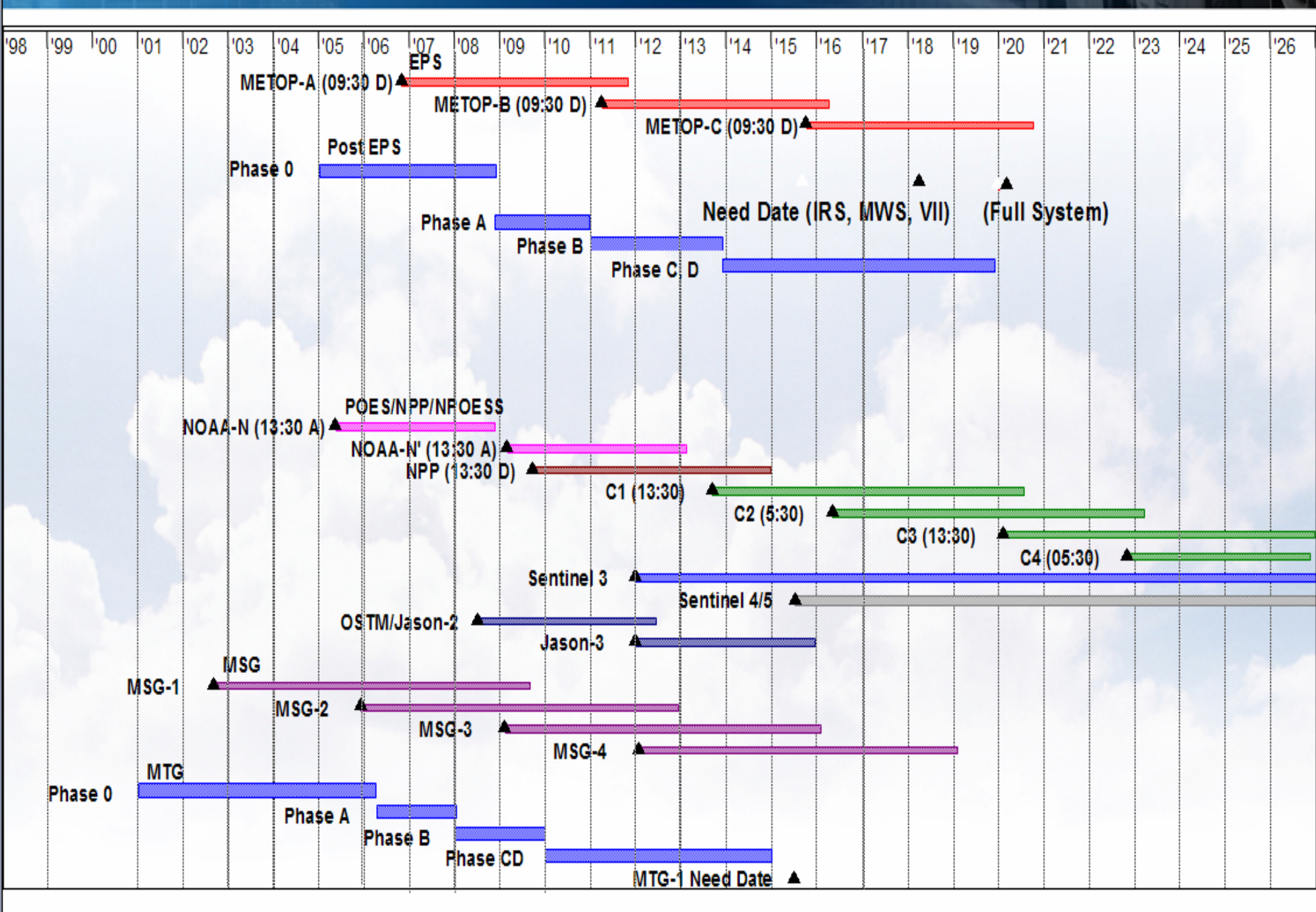
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EPS
METOP-A (09:30 D)
METOP-B (09:30 D)
METOP-C (09:30 D)
Post EPS
Phase 0
Need Date (IRS, MWS, VII)
(Full System)
Phase A
Phase B
Phase C, D
POES/NPP/NPOESS
NOAA-N (13:30 A)
NOAA-N' (13:30 A)
NPP (13:30 D)
C1 (13:30)
C2 (5:30)
C3 (13:30)
C4 (05:30)
Sentinel 3
Sentinel 4/5
OSTM/Jason-2
Jason-3
MSG
MSG-1
MSG-2
MSG-3
MSG-4
MTG
Phase 0
Phase A
Phase B
Phase CD
MTG-1 Need Date

EUMETSAT mandate for Post-EPS

EUMETSAT's Objectives

Operational Meteorology

Climate Monitoring

Mandatory Programmes

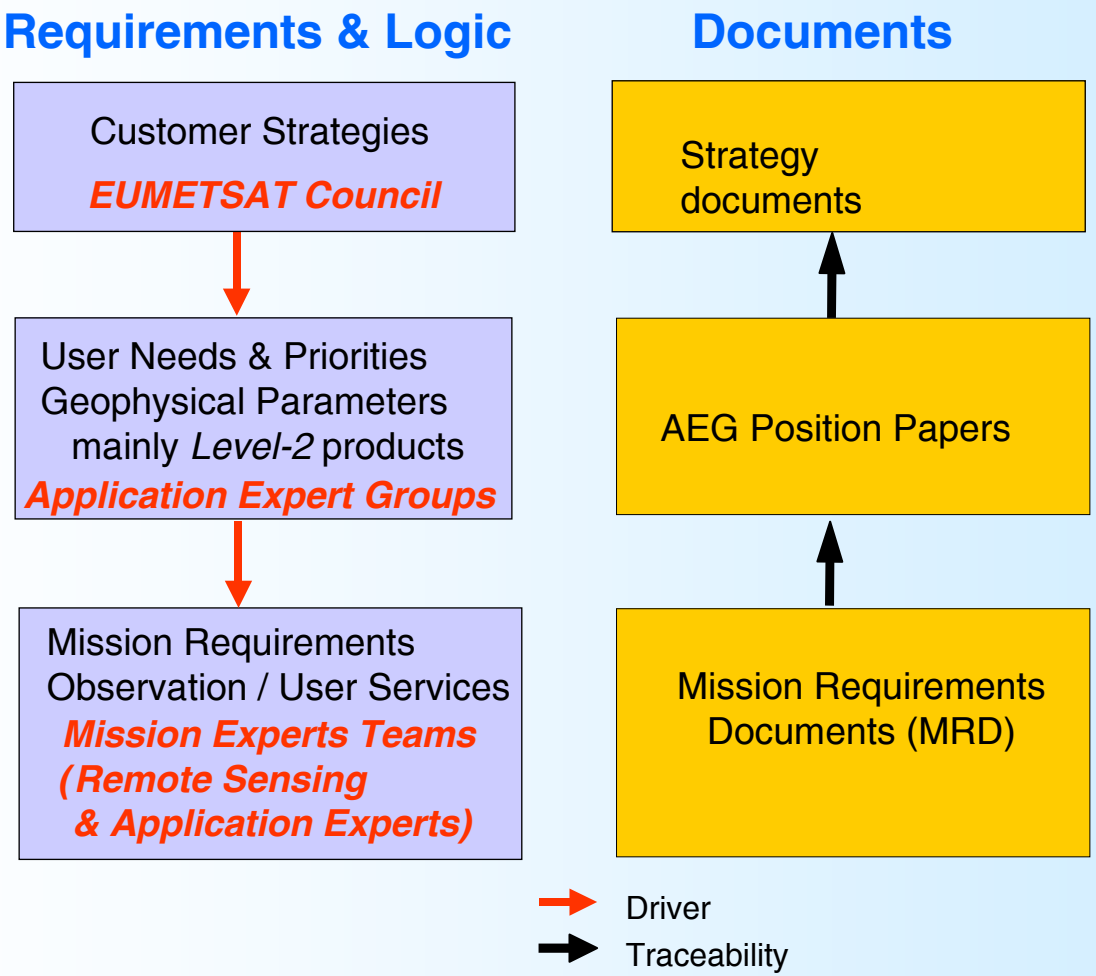
Continuation of observations from geostationary and polar orbits

25 Year Strategy

Environmental services (oceans, atmosphere, land, biosphere, natural disasters – if driven by or driving meteorology and climate)

In the early stages (Phase 0/A), EUMETSAT has the goal to establish the European Requirements as a basis for constructive discussions with Partners for future cooperation

Requirements drivers and traceability



Post-EPS preparatory activities

- Establishment prioritised user requirements
  - Start from MTG user consultation
  - Add requirements relevant for "new services" not covered before
  - Recognize evolution in target application areas
  - Add requirements dedicated to polar regions
- Derivation of mission requirements and preliminary system concepts
- Instigation of scientific studies in support to the system concept studies.
- Formulation of constraints
  - Budgetary
  - Co-operation with partner agencies (ESA, NOAA)
- Need dates
  - 2020
  - 2018 for minimising risks in EPS regarding core missions: mid-morning sounding and imaging

European contribution and commitment to environment and climate observations is evolving

- Development of the European initiative of Global Monitoring for Environment and Security (GMES) places space-based observations at the heart of future European activities for managing the European environment

- GMES is identified as the main European contribution to international initiatives such as Global Earth Observation System of Systems (GEOSS)

- EUMETSAT operational satellite systems are key elements of established space-based observing system coordinated by WMO, i.e. existing elements of a GEOSS

- EUMETSAT programmes are a sine-qua-non for space- based observing systems

Tentative missions

- Atmospheric sounding
- Wind profiling
- Ocean imaging, including sea ice and surface winds
- Ocean surface topography
- Cloud, precipitation, and large-scale land surface imaging
- Atmospheric chemistry

+ Climate monitoring (to be supported within above missions)

What is new in terms of high-level needs for Post-EPS?

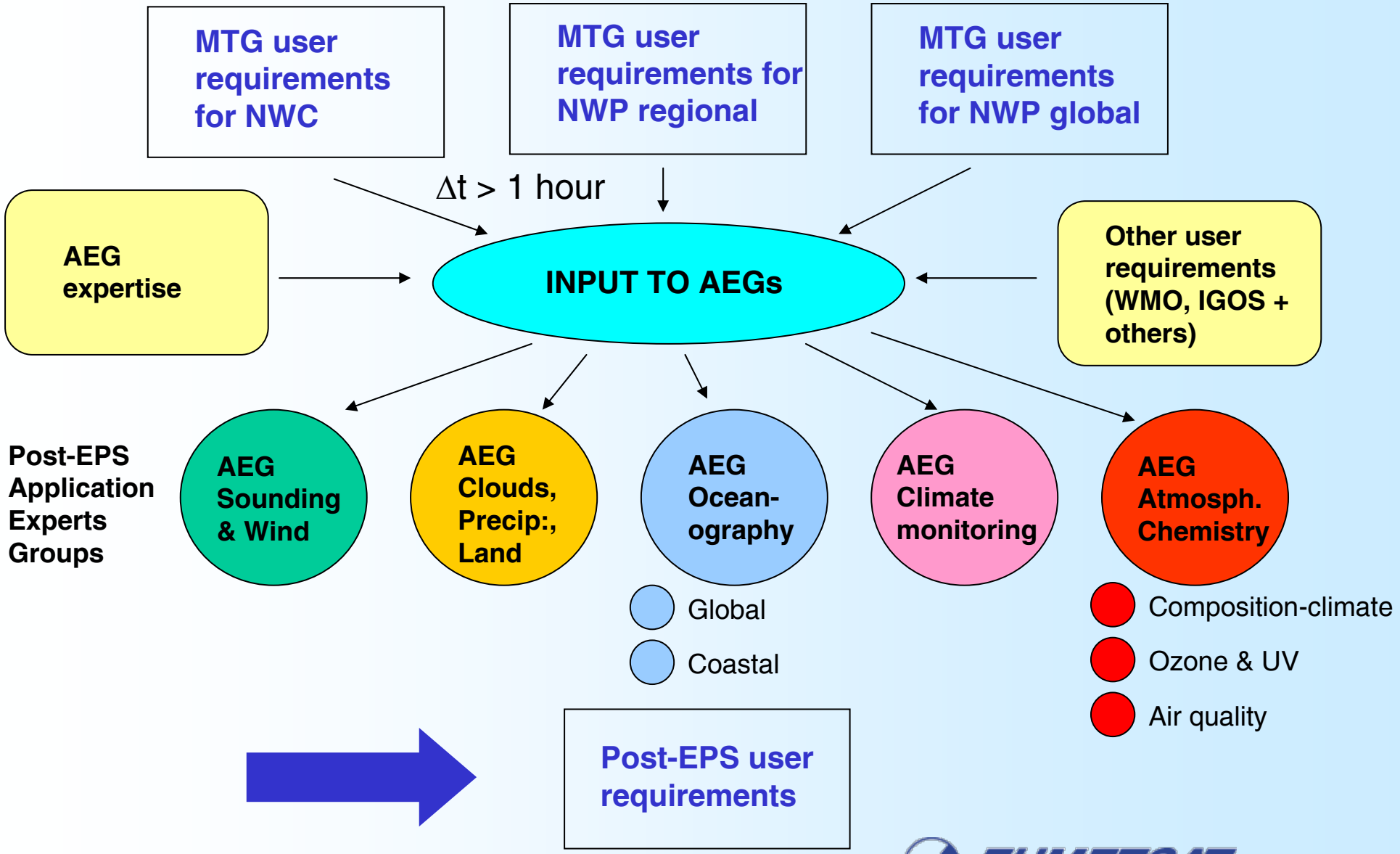
- Trend in the evolution of numerical weather prediction and climate models, to more accurately represent the Earth system as a whole, create broader set of observational requirements for Post-EPS covering
  - Atmosphere, including physics and chemistry
  - Ocean
  - Land surface analysis at large scale
  - Cryosphere
  - Hydrology

- Trend towards the assimilation of cloudy radiances in numerical weather prediction creates the need for microphysical cloud and precipitation observations for supporting sub-grid scale parameterisations

- Need to monitor the influence of human activity on the composition of the atmosphere creates user needs for observations supporting monitoring of climate and atmospheric chemistry

User Requirements Definition

- List of objective and threshold requirements in terms of geophysical parameters
  - Objective: Observation goal
  - Breakthrough level: Expected to make a delta improvement in the targeted service
  - Threshold: Minimum level for usefulness
- Accuracy
- Spatial sampling
- Temporal sampling
- Reporting delay
- Priority


MTG user requirements for NWC
MTG user requirements for NWP regional
MTG user requirements for NWP global
Δt > 1 hour
AEG expertise
INPUT TO AEGs
Other user requirements (WMO, IGOS + others)
Post-EPS Application Experts Groups
AEG Sounding & Wind
AEG Clouds, Precip:, Land
AEG Ocean-ography
AEG Climate monitoring
AEG Atmosph. Chemistry
Global
Coastal
Composition-climate
Ozone & UV
Air quality
Post-EPS user requirements

Towards Candidate Observation Missions

- On the basis of the user needs, candidate observation missions and requirements were identified with the support of the Post-EPS Mission Experts Team (**PMET**) -> post-EPS Mission Requirements Document (**MRD**)
- Due to the breadth of the user requirements, as many as **20 missions** could be needed!
- Approach taken to implement of a suite of '**baseline**' missions covering a wide range of applications rather than fewer sophisticated missions, covering only a few applications
- The **baseline** level of performance is determined by the driving requirements and further moderated by feasibility and maturity of the observation techniques
- The primary missions have been identified by extent to which they fulfil the EUMETSAT mandate and strategy, the maturity of the observation technique and the continuation of heritage missions, in particular EPS missions

Candidate Observation Missions (1/2)

Name / Heritage Instruments	Main Products
High-Resolution Infrared Sounding (IRS) **IASI, AIRS**	Temperature and water-vapour profiles surface temperature, trace gases
Microwave Sounding (MWS) **AMSU-A, MHS**	Temperature and water-vapour profiles
Radio Occultation Sounding (RO) **GRAS, COSMIC**	Temperature and water-vapour profiles
Differential Absorption Lidar (DIA)	Water vapour profile
Doppler Wind Lidar (DWL) **ADM/Aeolus**	Horizontal wind vector profile
VIS/IR Imaging (VII) **AVHRR, MODIS**	Clouds: type, cover profile, optical depth, top temperature, top height Water-vapour imagery Aerosol optical depth (total and gross profile)

Candidate Observation Missions (2/4)

Name / Heritage Instruments	Main Products
Microwave Imaging (MWI) **SSM/I, SSMIS, AMSR-E, SMOS**	Cloud liquid water/ice water content (total and gross profile) Cloud cover profile Precipitation profile and rate at the ground Water vapour imagery Sea, ice, land surface temperature Soil moisture Snow cover, water equivalent, depth, wet/dry status Sea ice coverage, type Sea surface salinity
Cloud and Precipitation Profiling Radar Mission (CPR) **Cloudsat-CPR, Earthcare-CPR**	3D precipitation intensity and type 3D cloud water and ice content
Radiant Energy Radiometry (RER) **CERES, BBR**	Solar reflected and terrestrial emitted radiation

Candidate Observation Missions (3/4)

Name	Main Products
Dual View Radiometry (DVR) **ATSR, AATSR**	Sea and sea ice surface temperature
Ocean Colour Imaging (OCI) **SeaWiFS, MERIS**	Chlorophyll, Yellow substance, Water sediment Oil-spill cover
Scatterometry (SCA) **ASCAT, QSCAT**	Ocean surface wind vector
Radar Altimeter (ALT) **Jason-2**	Sea surface height Significant wave height
Nadir viewing UV/VIS/NIR - SWIR Sounding (UVNS) **GOME-2, SCIAMACHY, OMI**	O_3 profile, total column of SO_2, NO_2, H_2O, CO, CH_4 Aerosol optical depth

Candidate Observation Missions (4/4)

Name	Main Products
Limb Millimetre-Wave (MMW) **MLS**	Profiles of H_2O, O_3, CO in UT and LS
Limb Infra-Red (LIR) **MIPAS**	Profiles of H_2O, O_3, CH_4 in UT and LS and above Temperature profile in stratosphere and cloud free UT
Aerosol Profiling Lidar (APL) **CALIOP, ATLID**	Aerosol optical thickness profile
Multi-Viewing Multi-Channel Multi-Polarisation Imaging (3MI) **POLDER**	Aerosol optical depth, particle size, type, height index
Total Solar Irradiance Monitoring (TSIM) **SORCE**	Incoming total solar irradiance

Synergy and co-registration of missions

Name	Essential Co-registration	Desired Synergy
IRS	VII (only 6 channels)	MWS, 3MI
MWS		IRS
DIA		IRS
VII		MWI, 3MI
MWI		VII, SCA, CPR
CPR	MWI	APL
RER		3MI
DVR		OCI
ALT	MWI (only 2 channels)	
OCI		DVR
SCA		MWI
UVNS	VII	IRS, APL, 3MI
LIR		MMW
APL		UVNS, IRS, VII
3MI		VII

Mission requirements and prioritisation

- Mission requirements provide geometrical, spectral and radiometric requirements in terms of threshold, breakthrough, and objective requirements on the basis of user requirements listed in the AEG Position Papers
- Mission requirements are prioritised within each mission, giving a ranking among the requirements (e.g. geometrical versus spectral resolution)
- Beyond the baseline further prioritised requirements are given
- Mandatory and desired synergies of observation missions have been identified
- Observation missions have been prioritised according to their general weight in the various application areas and the demand for continuity

IASI Follow-on: NWP (1/2)

Mission Band	Wave number (cm^{-1})	Purpose	Prior.	Spectral Resolution (cm^{-1}) (T/B/O)	Radiometric Noise (K) @ 280 K
IRS-0	550 - 645	WV profile	4	0.5/0.3/0.1	0.5/0.3/0.2
IRS-1	645 - 770	T profile	1	0.5	0.3/0.2/0.1
IRS-2	770 – 1000	T and WV profiles, SST, Surface and cloud properties	1	0.5	0.15/0.1/0.05
IRS-3	1000 – 1070	O_3 column	2	0.5/0.3/0.1	0.5/0.3/0.1
IRS-3a	1030 – 1080	O_3 profile	2	0.15/0.1/0.075	0.1/0.075/0.05
IRS-4	1070 – 1150	Surfaces and cloud properties	2	0.5/0.3/0.2	0.1/0.075/0.05

IASI Follow-on: NWP (2/2)

Mission Band	Wave number (cm^{-1})	Purpose	Prior.	Spectral Resolution (cm^{-1}) (T/B/O)	Radiometric Noise (K) @ 280 K
IRS-5	1150 – 1650	Water vapour profile	1	0.5/0.25/0.1	0.15/0.075/0.05
IRS-5b	1280 – 1360	T profile, and N_2O, CH_4 columns	2	0.3/0.15/0.1	0.2/0.1/0.05
IRS-6	1650 – 2100	WV profile, NO_2 Column	1	0.5/0.25/0.1	0.15/0.075/0.05
IRS-8	2160 – 2250	T profile, and N_2O, CO_2 columns	2	0.5/0.3/0.1	0.3/0.2/0.1
IRS-9	2250 – 2420	T profile	1	0.5/0.3/0.1	0.3/0.2/0.1
IRS-10	2420 – 2700	SST, surface and cloud properties	2	0.5/0.3/0.1	0.3/0.2/0.1

IASI Follow-on: AC (1/2)

Mission Band	Wave number (cm^{-1})	Purpose	Prior.	Spectral Resolution (cm^{-1}) (T/B/O)	Radiometric Noise (K) @ 280 K
IRS-2a	800 – 850	C_2H_6	3	0.5/0.25/0.1	0.1/0.075/0.05
IRS-2b	860 – 900	HNO_3, CFC	2	0.15/0.1/0.075	0.1/0.075/0.05
IRS-3 (only if IRS-3a not available)	1000 – 1070	O_3 column	1	0.5/0.3/0.1	0.5/0.3/0.1
IRS-3a	1030 – 1080	O_3 profile	1	0.15/0.1/0.075	0.1/0.075/0.05
IRS-4a	1120 – 1160	Volcanic SO_2	2	0.5/0.25/0.1	0.1/0.075/0.05
IRS-4b	1130 – 1200	PAN	3	0.5/0.25/0.1	0.1/0.075/0.05
IRS-5a	1340 – 1380	Volcanic SO_2	4	0.5/0.25/0.1	0.1/0.075/0.05

IASI Follow-on: AC (2/2)

Mission Band	Wave number (cm^{-1})	Purpose	Prior.	Spectral Resolution (cm^{-1}) (T/B/O)	Radiometric Noise (K) @ 280 K
IRS-5b	1280 – 1360	T profile, and N_2O, CH_4 columns	2	0.3/0.15/0.1	0.2/0.1/0.05
IRS-6	1650 – 2100	WV profile NO_2 column	3	0.5/0.25/0.1	0.15/0.075/0.05
IRS-7 (only if IRS-7a not available)	2100 – 2150	CO column	1	0.5/0.25/0.1	0.3/0.2/0.1
IRS-7a	2140 – 2180	CO profile	1	0.15/0.1/0.075	0.15/0.1/0.05
IRS-8	2160 – 2250	T profile, N_2O and CO_2 columns	2	0.5/0.3/0.1	0.3/0.2/0.1
IRS-11	2700 – 2760	CH_4 column	3	0.5/0.3/0.1	0.3/0.2/0.1
IRS-12	2760 – 2900	CH_4 column	4	0.5/0.3/0.1	0.3/0.2/0.1

IASI Follow-on

- Bias: < 0.5 K, stable over any one orbit and over lifetime: 0.1…0.5 K
- On-ground IFOV diameter at nadir: O/B/T = 5 km /8 km / 12 km
- On-ground sampling at nadir: O/B/T = 10 km / 15 km / 50 km
- Synchronisation with a multi-spectral imager to aid scenes analysis

Next steps

- During the next stages, feasibility, cost drivers, value, affordability and possible commitments of potential customers and partners will be assessed

- Concept architecture (phase 0) studies at instrument and system level will shortly commence with the support of ESA, industry, and representatives of the user and science communities

- Following national initiatives (CNES: IASI follow-on, DLR: optical imager)

Phase 0	Concepts and feasibility studies	2005 – 2008
Phase A	Definition	2009 – 2010
Phase B	Preliminary design	2011 – 2013
Phase C, D	Detailed design and production	2014 – 2019
Phase E	Utilisation	from 2018/2020

Acklowledgements

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Post-EPS Mission Experts Team

is gratefully acknowledged