EPS-SG System

Post-EPS 3rd User Consultation Workshop

3rd *Post-EPS* User Consultation Workshop

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Introduction

- In the following some elements of the EPS-SG System are presented. The focus is on EPS-SG System requirements / concepts which:
  - **are different from EPS,**
  - **are specifically relevant for data / products being provided to Users, and**
  - **deal with products derived from instruments on Metop-SG.**
- System concepts are based on the “Post-EPS System Requirements Document” (SRD), derived from the “Post-EPS Mission Requirements Document” (MRD).

  Upon consolidation of the “End User Requirements Document” (EURD), the SRD will be traced to the EURD.
- *In Phase A, requirements and concepts are evolving in an iterative way. The next formal “rendez-vous” point is the System PRR.*
- Structure of the presentation:
  - **Key system requirements**
  - **Satellite constellation**
  - **Data rates**
  - **Global and regional missions**
  - **Local mission**

Key System Requirements for EPS-SG (1/2)

Scope of Post-EPS missions

- The overall scope of the observation and support missions (even wider than for EPS), with a large number of instruments to be embarked, drive the satellite constellation in terms of number of satellites, with associated impacts on the system concepts and operations.

Data & product characteristics (radiometric/spectral/geometric)

- The requirements for signal-to-noise, spectral and spatial resolution are in many cases more demanding than for the corresponding instruments on Metop (in many cases “twice as good”).
- This leads to significantly increased data rates, which drive the concepts and sizing for data handling elements and for space-to-ground and on-ground links and the whole production chain.
- In addition there are several requirements for co-registration between instruments, which have an impact on the satellite constellation.

Key System Requirements for EPS-SG (2/2)

Availability and lifetime

- The design lifetime is 8.5 years per satellite, compared to 5 for EPS. The minimum mission lifetime is 15 years, compared to 14 for EPS.
- The end-to-end availability requirement is 95% for each of the global, regional and local missions. This is equivalent to EPS and achievable, provided care is taking to minimise service outages caused, e.g., by on-board failures.

NRT timeliness for global & regional products

- The threshold for global data is more demanding than for EPS (level 1 products: max. 120 minutes; level 2 products: max. 130 minutes), but could be achieved (as for EPS) with a single ground station in Svalbard.
- However, there are also breakthrough requirements for EPS-SG and furthermore specific NRT requirements for a regional mission (Europe / N. Atlantic), which require additional means for data acquisition and / or priority processing schemes.

Scope of Local Mission

- As a target all data shall be directly broadcast at full resolution, which is driving for the selection of the S/G link.
- In view of the data rates, L-band as used for EPS, is no longer possible; X-band will be used.

Satellite Constellation (1/2)

- **The current baseline is a system with two satellites, Sat-A and Sat-B.**

- The **driving requirement** for the allocation of instruments to one satellite or the other are the mission requirements for temporal co-registration of IASI-NG, 3MI, S-5 and CERES F/O with MetImage.

  The temporal co-registration needs are a threshold of 10 or 30 s, depending on the instrument, with target requirements of up to 0.5 s.

- **MetImage, IASI-NG and ATMS** need to be on the same satellite as they need to be launched at the same time in view of continuity of critical EPS missions.

Instruments	Sat-A	Sat-B	Rationale for Allocation
MetImage	X		
LLI (TBC)	X		Co-registration with MetImage (TBC)
IASI-NG	X		Co-registration with MetImage
MWS (ATMS)	X		Same need date as MetImage and IASI-NG
RO	X	X	On both satellites to increase number of occultations
MWI		X	
ICI		X	
SCA		X	
3MI	X		Co-registration with MetImage
CERES F/O (TBC)	X		Co-registration with MetImage
Sentinel-5	X		Co-registration with MetImage and IASI NG
A-DCS		X	Could actually be on either satellite
S&R		X	Could actually be on either satellite
SEM-N (TBC)		X	Could actually be on either satellite

Satellite Constellation (2/2)

- EPS-SG orbit as for EPS: **continuity of EPS measurements** of prime importance for Users.

  The reference orbit is thus 9:30 a.m. (Mean Local Solar Time (MLST), descending node).

- To define the phasing it is assumed that up to 4 Metop-SG satellites need to be supported (2 Sat-A + 2 Sat-B):
  * one set of Sat-A / Sat-B in routine operations,
  * one Sat-A and/or one Sat-B under commissioning.

  Note that initially the in-orbit constellation could consist of two Metops (e.g., Metop-B and Metop-C) plus one Metop-SG Sat-A plus one Metop-SG Sat-B.

- In terms of **optimisation of Post-EPS ground segment design (such as sharing of antennas) and operations** a homogeneous phasing of satellites around the orbit is favoured, i.e. a nominal separation of 25 minutes.

- In addition the SRD caters for a **growth potential** of the system, by requesting
  - that Metop-SG satellites shall actually be built to allow operation with a minimum phasing of 15 minutes; this is considered feasible – a separation of 15.8 min. would avoid “eye” contact;
  - that the ground segment shall have the growth potential to support satellites with a minimum phasing of 15 minutes.

Data Rates

- EPS-SG instruments: in general higher spectral and spatial resolution and better Signal-to-Noise Ratios than EPS/Metop instruments.
- Metop sensing data rate is around 3.4 Mbps.
- Compared with the current Phase A rates of around 75 Mbps, Metop-SG data rates are about 20 times higher than Metop.

  Actions are underway to drastically reduce data rates. Positive feedback already received for S-5.

- This leads to a data volume per orbit of (rounded values): - 330 Gbits for Sat-A
  - 50 Gbits for Sat-B
- The required dumping rates are (rounded values):
  - 830 Mbits/s for Sat-A
  - 130 Mbits/s for Sat-B

  This is required in order to dump all data from one orbit over Svalbard for each orbit.

Instrument data rates (Mbits/s) - RAW DATA

	DAY	NIGHT
MetImage	19.500	6.800
MWS	0.032	0.032
IASI-NG	6.000	6.000
SCA	5.000	5.000
MWI	0.250	0.250
ICI	0.100	0.100
3MI	6.500	0.000
RO	1.000	1.000
CERES	0.010	0.010
S-5	30.000	3.000
A-DCS	0.039	0.039
S&R	0.010	0.010
SEM-N	0.030	0.030
LLI	2.000	2.000

Satellite

A	B
MetImage	
MWS	
IASI-NG	
	SCA
	MWI
	ICI
3MI	
RO	RO
CERES	
S-5	
	A-DCS
	S&R
	SEM-N
LLI	

Global and Regional Missions (1/7)

Timeliness requirements

Global Mission:

To send L1b global (worldwide) products to end users within end-to-end breakthrough timeliness of 60 min (50th percentile) to 70 min (100th percentile *)

	Threshold		Breakthrough	
Data received	**50%**	**100%**	**50%**	**100%**
Global	110min	120min	**60min**	**70min**

Regional Mission:

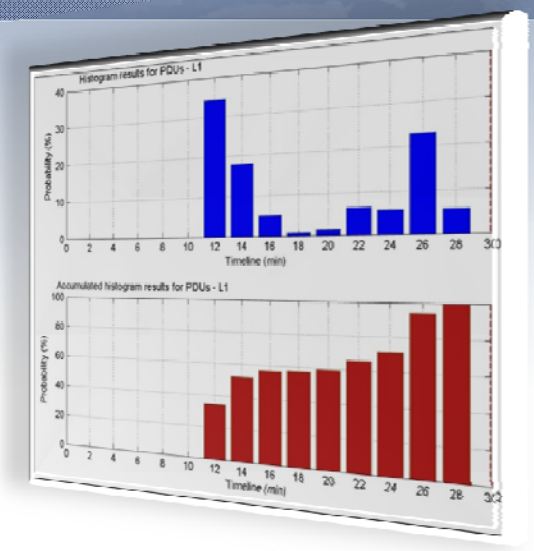
To send L1b regional (sensed over Europe / N. Atlantic) products to end users within end-to-end breakthrough timeliness of 20 min (50th percentile) to 30 min (100th percentile *)

	Threshold		Breakthrough	
Data received	**50%**	**100%**	**50%**	**100%**
Regional	30 min	110 min	**20 min**	**30 min**

* **The MRD defines the timeliness requirements as 95% of the data as it takes into account the target data availability .**
At SRD level the end-to-end mission availability of 95% is covered in a dedicated requirement, separate from NRT timeliness.

Global and Regional Missions (2/7)

Timeliness requirements (cont.)

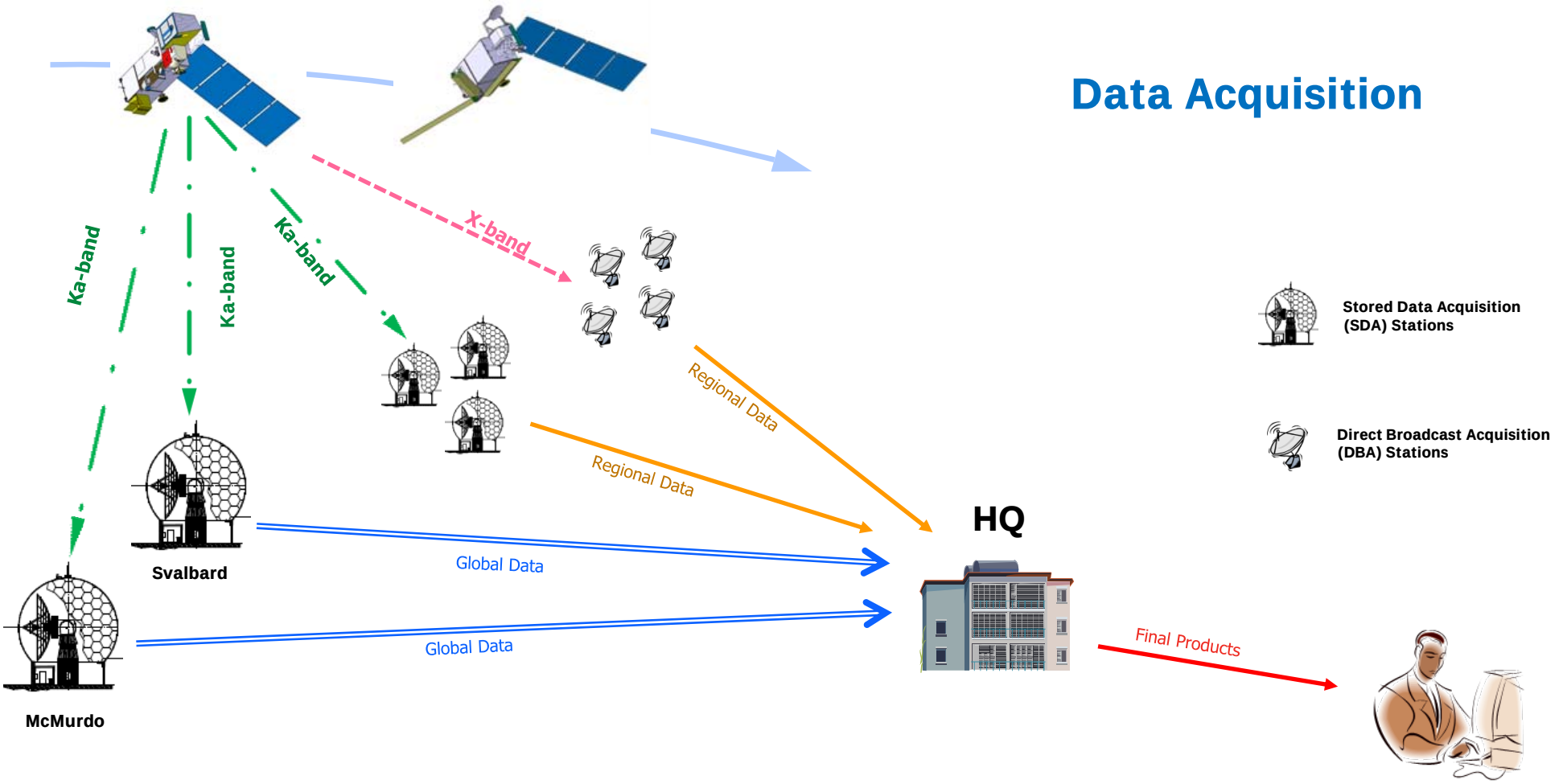


- The timeliness requirements are of statistical nature, whereas EPS has only a 'max' requirement.
- The requirements, as in the MRD, do not specify over which period the timeliness statistics of 50% shall apply.
- The 50% and 100% specs are understood to apply to the 'number' of products and/or granules of data.
- The timeliness requirements, as in the MRD, do not differentiate between instrument chains or products (although the initial Post-EPS position papers did).

  I.e. all products are to be treated with same priority?

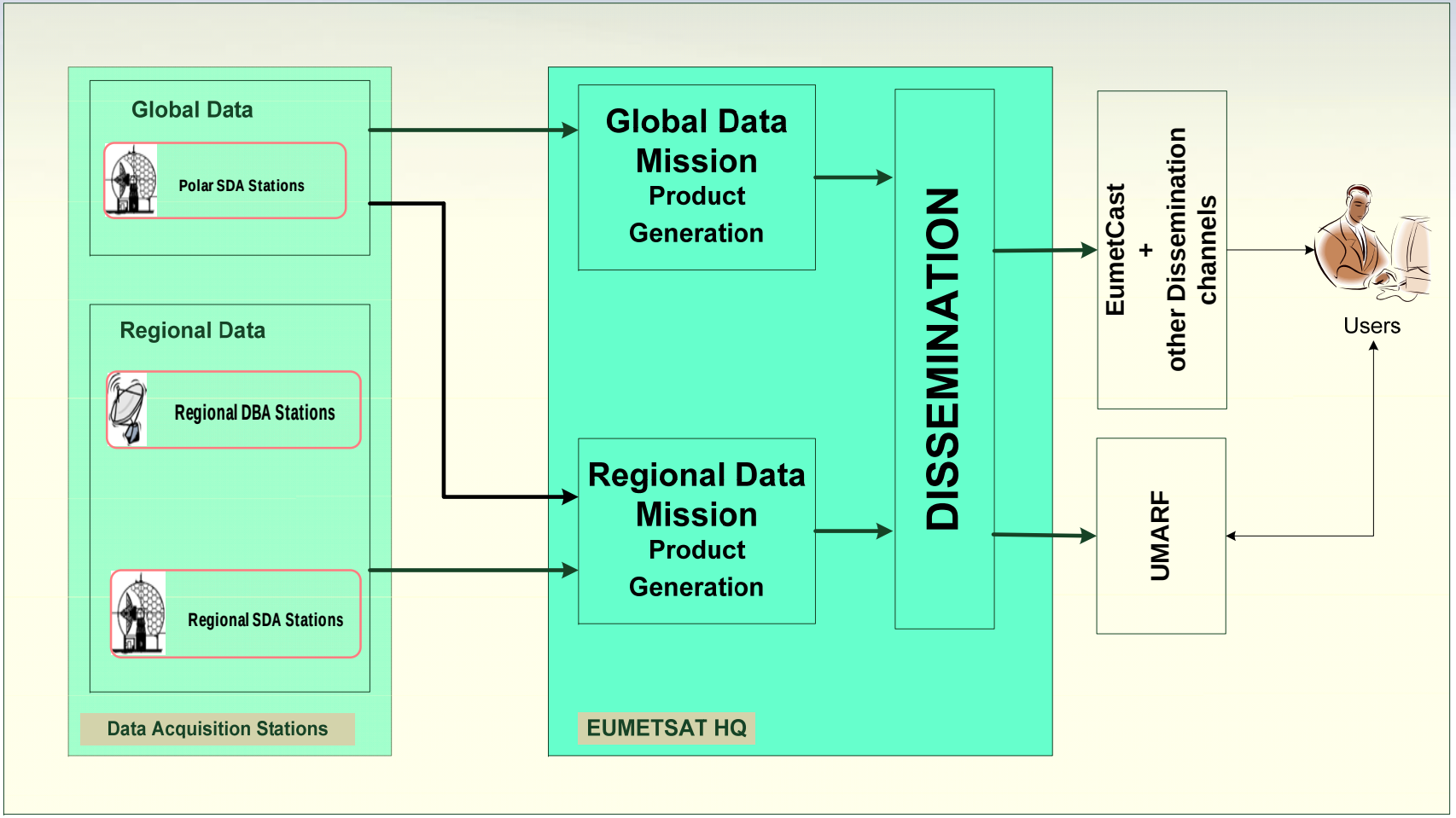
  See later slide for potential need of optimization!

Global and Regional Missions (3/7)



Global and Regional Missions (4/7)

Data acquisition and dissemination



Global and Regional Missions (5/7)

Data Acquisition (cont.)

Global Mission:

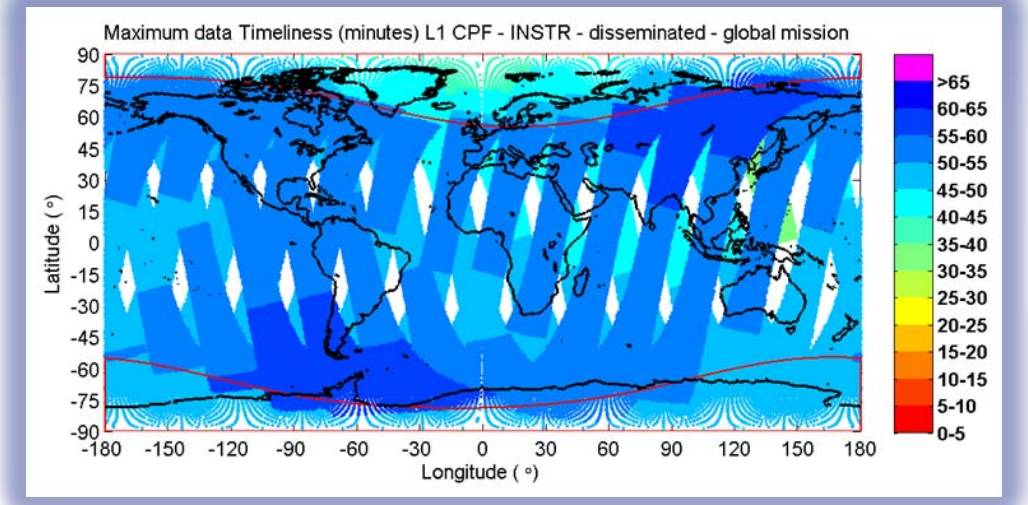
- Threshold timeliness: Svalbard only.
- Breakthrough timeliness: Svalbard and McMurdo.

Regional Mission:

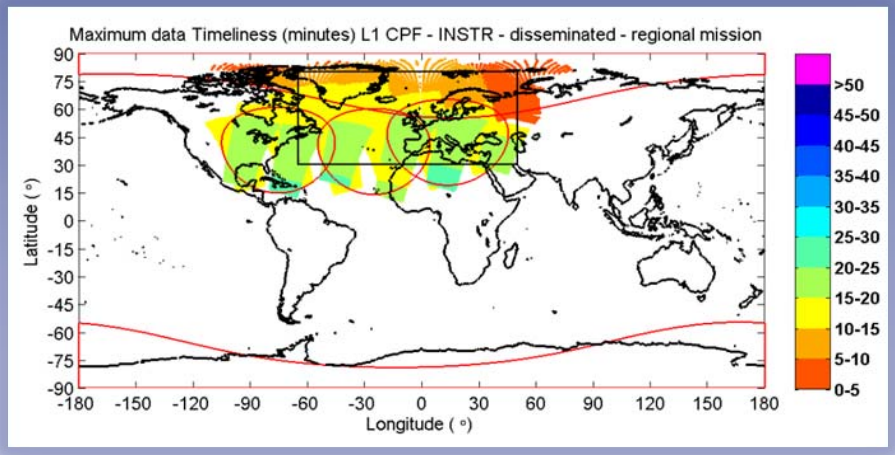
- Dedicated stations are required to acquire Europe / N. Atlantic data soon after observation.
- One concept is to deploy 3 – 4 X-band **Direct Broadcast Acquisition (DBA)** stations.
- A second concept is to acquire “mini-dumps” of on-board stored data via dedicated **Stored Data Acquisition (SDA)** stations.
- A dedicated trade-off at all levels (System, Space Segment and Ground Segment) is being performed for Direct Broadcast vs. mini-dumps.

Global and Regional Missions (6/7)

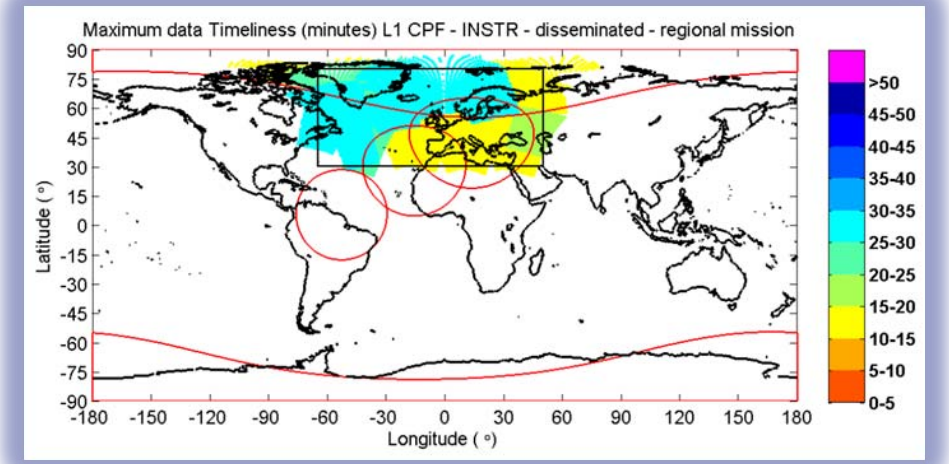
Timeliness Performance



Global end-to-end Timeliness in minutes (Svalbard + McMurdo)



Regional end-to-end Timeliness in minutes (Svalbard + 3 DBA Stations)

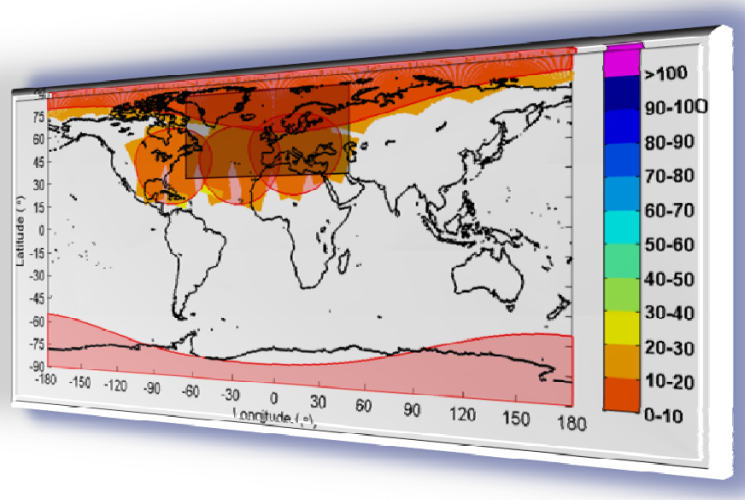


Regional end-to-end Timeliness in minutes (Svalbard + 3 SDA Stations)

Global and Regional Missions (7/7)

Questions to Users:

- Repatriating all raw data at sufficient speed to achieve the required breakthrough timeliness performance could be problematic for some stations such as McMurdo.
  - ⚖ Selection of instruments (or channels) which would need to be only acquired at Svalbard (with impact on timeliness).
- Regional Area of Interest – AoI: Europe and North Atlantic cover the regions bound by 50°E - 65°W, 30°N - 80°N.
  - ⚖ There could be some constraints for the regional NRT timeliness in the AoI (e.g., at the borders), depending on the number and location of stations.
- Preliminary system concepts foresee to process, disseminate and archive the full set of Global Mission products, with a high degree of availability, reflecting the reliability of the polar stations.



  - ⚖ Availability of Regional Mission products needs to be further analysed and traded w.r.t Global Mission products; regional stations may not achieve reliability of Svalbard.

Local Mission

- In view of the large data rate, the Direct Broadcast service will be implemented in X-band (7.80 – 7.85 GHz will be used (TBC); possible extension to 7.90 GHz).
- On-going Space Segment studies confirm that all instrument data can be transmitted at full resolution.
- The data rate will be about 75 Mb/s for Sat-A (daytime rate – night time is lower) and about 7 Mb/s for Sat-B.
- The estimated on-ground antenna size would be typically 3.5 to 4 m. The required G/T is 22.7 dB/K at 5° elevation.
- This antenna size and G/T should also be appropriate for receiving Direct Broadcast data from NPP and JPSS satellites.
- As for EPS, there will be the possibility to send Direct Broadcast data in clear or in encrypted mode.
- Local user stations would need to be upgraded for EPS-SG. EUMETSAT will prepare a reference design in due time.

Conclusion

EPS-SG is more demanding in terms of number and scope of missions to be supported. The key differences between the EPS System and the EPS-SG System are:

Satellite constellation

- A set of two satellites (Sat-A / Sat-B) will embark the instruments. Infrastructure at ground stations would benefit from a phasing of 25 minutes or larger.

Data rates

- At this time no technical feasibility issue has been identified (apart from potential constraints for links from McMurdo), however rates will drive costs for repatriation, processing, dissemination and archiving.
- Also applications by the Users have to deal with the data rates. **Actions on-going to reduce the data rates.**

S/G link for mission data

- For stored mission data, use of Ka-band instead of X-band (driven by data rates) ⟶ larger sensitivity to atmospheric conditions (in particular rain), with seasonal variation of losses.
- The system has to be robust to losses, and also, in spite of the losses, has to meet end-to-end availability.
- For Direct Broadcast data, use of X-band instead of L-band.

Data acquisition for global / regional mission

- The data acquisition concept will be more complex than for EPS – in addition to Svalbard other ground stations will be required. Again less of a technical issue (but see point on McMurdo above), but a cost factor.