

Appendix 2

EDRS

European Data Relay Satellite System

The ESA Data Relay Satellite Service Requirements

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1 Introduction

This document summarises the Data Relay Service requirements coming from ESA. Two main missions are considered for the basis of the ESA EDRS needs, the GMES SENTINEL system and the International Space Station which are considered the most needed missions. Additional DRS services for ESA or national initiatives of EDRS Participating States may be required in the future. Such services are not yet identified but would be also subject to SLAs to be defined and agreed with the EDRS operator at a later stage.

Although focussed on the service provision, the requirements also encompass other technical requirements coming directly from the envisaged technical solution for the GMES SENTINEL system as well as from ISS ISL capability, putting specific constraints on the technical features of the future EDRS system.

2 Requirement specification

The requirements have been referenced according to the following structure

Example: "GMES - BAS - SERV - xx - M:"

GMES - BAS : Denomination of the service (GMES Basic Service)

SERV: level of the requirement (Service), GEN for General , OP for operational, SYS for system, PER for performance, SLA for Service Level Agreement

xx: sequential number of the requirement

M: Mandatory : identified as a mandatory requirement

D: Desirable: identified as a possible requirement or recommend scheme/solution but alternative can be considered

O: Option : identified as a possible additional capability, or a alternative configuration to be considered

3 GMES DRS service requirements

3.1 Introduction

This section summarises the Data Relay and Communication Service requirements in support to the constellation of the Sentinel satellites of the GMES Space Component (GSC) Programme. The Sentinels system data relay requirements originate from Sentinel-1A/-1B and Sentinel-2A/-B, whereas for communications requirements Sentinel-3A/B are also included. Requirements of GMES contributing missions, e.g. national missions or EUMETSAT missions such as Meteosat Third Generation are not included at present.

It is understood that the EDRS services will be complementary to the GMES SENTINEL system baseline using X-Band ground stations and ground communication networks.

The EDRS service requirements are divided in 2 main categories:

- Baseline service: Data Relay (DR) services providing a direct link from SENTINEL satellite via the EDRS GEO satellite to Processing and Archiving Centers (PACs) of the GMES system
- The extended services corresponding to 2 different missions. Extended services may be provided through either the EDRS dedicated spacecraft or through another own operator spacecraft.
 - Repatriation services - Transfer of data from GMES X-Band ground stations to the GMES Processing and PACs.
 - Dissemination services - Transfer of processed data from PACs to end users

3.2 GMES system description

The GSC includes all space-based Earth Observation missions which are required to satisfy the GMES observation needs. These Earth Observation missions include a series of national and Eumetsat contributing missions. The Sentinels currently considered as users of EDRS are:

- **Sentinel-1** a C-band interferometric radar mission;
- **Sentinel-2** a multispectral optical imaging mission;
- **Sentinel-3** a mission with wide-swath low-medium resolution optical and infrared radiometers and a radar altimeter package;

User platform's name	Sentinel-1	Sentinel-2	Sentinel-3
Launch date(s)	Nov 2011	Dec 2012	October 2012
Life duration	7 year (renewed every 6.5 years)		
Customer	ESA		
Network of ground stations	To be defined (3 to 4)		
Payload description	SAR	Optical payload (MSI)	Multiple Instrument
Orbit parameters			
Type	Sun synchronous	Sun synchronous	Sun synchronus
Mean altitude	693 km	786 km	814 km
Repeat cycle	175 revs per cycle	143 rev per cycle	385 rev per cycle
Inclination	98.6 deg	98.6 deg	98.6 deg
Local time	18:00 at ascending node	10:30 a.m. at asc node	10:00 a.m. at asc node
Revisit frequency	12 days	10 days	27 days
Geographical coverage	Global		
Min expected duration delivery	100 min from sensing to download (due to orbit) 1 hour from download to users		

Table 1: SENTINEL 1 and 2 characteristics

When two satellites of the same family will be available (i.e. Sent-1A and Sent-1B) they will be phased 180 deg apart (same applies to Sent-2A/-2B). The B models will be launched 30 months after the A models. Given the 7 year design life, the satellites are renewed every 6.5 years. The C and D models correspond to replacement satellites of A and B models. E and F will replace the C and D. The current requirements relate to the period from the launch of the first A-Model Sentinel up to the end of in-orbit operational life of the last C/D-Model Sentinel.

Data volume /orbit	600 Gbit/orbit (S1) 800 Gbit/orbit (S2) 200 Gbit/orbit (S3) (only considered for extended EDRS services)	This is the overall data volume collected. It will be downloaded partly via X band direct downlink and partly via the DRS. It is important to underline that the Sentinels will use the same on board memory interface and mission planning for controlling the data downlink either via X band or via EDRS (overall EDRS channel capacity at the same rate as X band rate, i.e. 2x260 Mbit/sec transmission rate over the channel, data can be routed to either of the 2 parallel channels)
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Table 2: SENTINELS data volumes per orbit

3.3 General requirements

GMES - GEN - SERV - 10 - M:

The EDRS services shall be available in support to the commissioning phase of each SENTINEL and during subsequent operational phases. The start of the EDRS services shall be January 2012 for the first SENTINEL satellite and shall be rolled out following the launches of the subsequent satellites.

GMES - GEN - SERV - 20 - M:

EDRS services life time shall be at least 15 years

GMES - GEN - SERV - 30 - O:

EDRS service life time shall be at least 20 years

The GMES SENTINEL system is expected to be operational for a period of at least 20 years.

3.4 Basic Service: Data Relay Service requirements

3.4.1 Service definition and operation requirements

The service consists of transferring the data acquired by SENTINEL Satellites directly to PACs and specific customer premises.

The EDRS space infrastructure is assumed to be a GEO based solution. References to “GEO” in the following requirements correspond to the in orbit EDRS facility. References to “LEO” in the following requirements correspond to the SENTINEL satellites.

GMES - BAS - SERV - 40 - M:

The DR Service shall provide a real time transfer of EO data acquired by the instruments on board the SENTINEL satellites to the specified ground area via an inter-satellite link (ISL) through the EDRS space infrastructure.

GMES - BAS - SERV - 50 - M:

The EDRS service management interface to GMES shall be the ESA GMES Mission Management authority.

GMES - BAS - SERV - 60 - M:

DR Service shall be provided to the Sentinels 1A, 1B, 2A and 2B satellites as well as following replacement satellites Sentinels 1C, 1D and 2C and 2D. The service shall support the simultaneous operations of four Sentinels at any given time

This requirement does not imply simultaneous data transmission from the four Sentinel satellites

GMES - BAS - SERV - 70 - M:

The DR Service shall be provided at least during the period of the orbit when the SENTINEL satellites are passing over Africa and Asia. The service shall be extendable to include other world regions (TBC), within the limits of the selected EDRS GEO positions.

GMES - BAS - SERV - 80 - D:

The DR Service shall be provided during the period of the orbit when the SENTINEL satellites are passing over the Middle-East, Far East and South American areas of the world.

GMES - BAS - SERV - 90 - M:

The DR service ground area for downloading the SENTINEL satellites data shall cover Europe and in particular the following geographical regions: southern Germany, south-west France, southern UK, central Italy, central Spain.

GMES - BAS - OP - 100 - M:

The EDRS receiving ground stations shall be operated under the SENTINEL system responsibility (TBC). The service interface and the service quality parameters at the ground station shall be defined.

GMES - BAS - OP - 110 - M:

The operation (TM/TC) of the ISL EDRS terminal on board the LEO satellite shall be under the SENTINEL system responsibility

3.4.2 System and performance related service requirements

GMES - BAS - SYS - 120 - M:

The LEO-GEO orbit visibility shall be ensured for Sentinel 1 and 2 orbit parameters provided in Table 1 and considering Field-of-view limitations of the Laser Communication Terminal (LCT) on-board of the Sentinels.

GMES - BAS - SYS - 130 - M:

DR Service will imply technical interfaces between the GMES and the EDRS system which are TBD

It is expected that there will be several interface points (at least one between GMES and EDRS operational Centres and possibly with respective Flight operations Centre and Satellite Control Centres)

GMES - BAS - SYS - 140 - M:

The EDRS system shall provide in orbit redundancy for the GEO EDRS payloads (on separate spacecrafts)

3.4.3 Service Level Agreement

At this stage, most of these requirements should be used as guidelines on the type of SLA expected to be put into place between the GSC Space Segment Programme, as Mission Management authority on behalf of the GMES users, and the EDRS Service provider.

GMES - BAS - SERV - 150 - M:

The DR Service shall be provided to GMES community according to specified Service Level Agreement

GMES - BAS - SLA - 160 - M:

The channel transmission of the DR Service “goodput” rate shall be 520 Mbit/sec (2x260Mbit/sec) to match the SENTINEL satellite capability

Here “goodput” refers the information data rates generated by the SENTINEL satellite for transmission. Higher channel bit rate may be implemented for the actual ISL link to transmit the goodput rate.

GMES - BAS - SLA - 170 - M:

The DR service shall carry at least 50% of each of the Sentinel 1A, 1B and Sentinel 2A, 2B generated data at average per orbit. Conditions for providing this capacity are to be defined at a later stage.

GMES - BAS - SLA - 180 - M:

The DR service shall include additional capacity during the commissioning of replacement satellites while four Sentinels will be in operation. This capacity shall be limited in time to 3-5 months per Sentinel and limited in volume to 10% (TBC) of the nominal operational data volume. Conditions for providing this capacity are to be defined at a later stage.

GMES - BAS - SLA - 190 - O:

The DR service shall provide additional spare capacity to allow for growth potential including other GMES missions, or increased Sentinel 1 and 2 traffic up to 100%. Conditions for providing this additional capacity shall be defined at a later stage.

GMES - BAS - SLA - 200 - M:

The scheduling of LEO-to-GEO contact windows for every orbit and orbit repeat cycle and multiples thereof shall be predefined in advance and follow a fixed schedule in line with the

Sentinels data downlink schedule. Changes to this schedule shall be implemented within 24 hours from the request time.

Scheduling services for Sentinels will be deterministic and known weeks in advance (the actual data flowing during the contacts will be scheduled more frequently but this will be transparent to EDRS system)

GMES - BAS - SLA - 210 - O:

The scheduling of LEO-to-GEO contact windows for every orbit and orbit repeat cycle and multiples thereof shall be predefined in advance and follow a fixed schedule in line with the Sentinels data downlink schedule. Changes to this schedule shall be implemented within 6 hours from the request time.

This optional requirement shall not rely on rapid tasking of the LEO via the EDRS system.

GMES - BAS - SLA - 220 - M:

The DR services shall be provided with a service availability of at least 99.5 % (TBC)

This availability excludes non-availabilities of Sentinels but assuming nominal Sentinel operations it includes the Sentinel-EDRS link, the EDRS S/C (except complete loss), the EDRS-to-ground link up to the interface point to the ground.

Measures to increase the service availability shall be defined

A link is also declared unavailable if Severely Errored Second (SES) occurs at the receiving end of the link for 3 consecutive seconds or more. The SES still need to be defined and agreed (cell loss, frame loss, ect).

GMES - BAS - SLA - 230 - M:

In case of complete loss of an EDRS S/C, switch-over to another EDRS S/C shall be possible within 1 day (TBC). Any reduced service resulting from such failure and switch-over shall be defined.

GMES - BAS - SLA - 240 - M:

Any total service outage due to failures of the EDRS infrastructure (ground or space except complete S/C loss), shall be less than 3 hours, with a maximum cumulative duration over one year of 4.5 (TBC) hours.

GMES - BAS - SLA - 250 - M:

Service interruption duration due to programmable event (e.g. System re-configuration) shall be less than 2 hours (TBC) and shall be scheduled to minimise any reduction in contact time with the Sentinels, e.g. shall be performed outside defined contact windows.

GMES - BAS - SLA - 260 - M:

The total duration of service interruption due to programmable event shall be less than 4 hours (TBC) per year.

GMES - BAS - SLA - 270 - M:

The duration of service interruption due to predictable but not programmable event (e.g. Antenna Sun Blinding) shall be less than 30 minutes (TBC) per day. The scheduling of contacts shall minimise the impact of predictable events.

GMES - BAS - SLA - 280 - M:

The total duration of service interruption due to predictable but not programmable event shall be less than 12 hours(TBC) per year

GMES - BAS - PER - 290 - M:

The channel transmission BER shall be less than 10^{-9} from LEO to ground through the GEO including a RF link margin of 3dB

GMES - BAS - PER- 300 - M:

The channel transmission link availability from LEO to ground through the GEO shall be better than 99.9% (TBC). The performance shall be achieved over specific sites (TBD) within the coverage area

GMES - BAS - SLA - 310 - M:

The DR Service shall be transparent to any data security scheme implemented by the GMES SENTINEL

GMES - BAS - SLA - 320 - M:

Conflict free access from the Sentinels to GEO shall be over at least 60% of time. This time shall be allocated to the individual Sentinels according to their orbit parameters and the areas and times of contact required to optimise the time available to each Sentinel individually.

GMES - BAS - SLA - 330 - M:

The system shall be capable of providing the full DR service outside the nominal contact times of the SENTINEL with the X band ground stations (average 16 minutes per orbit TBC) It shall be outside the coverage of ground stations located at Svalbard and Maspalomas and two more ground stations in Europe and Canada with location TBD.

Final selection of stations locations is still TBC.

GMES - BAS - SLA - 340 - M:

The system shall allow to also provide DR services during nominal contact time if required.

GMES - BAS - SLA - 350 - M:

The minimum required contact duration shall be more than 8 minutes per SENTINEL satellite per orbit.

GMES - BAS - SLA - 360 - M:

The DR Service shall not be pre-emptible, ie other EDRS customer can not take priority over the services already provided to the GMES system according to this SLA.

GMES - BAS - SLA - 370 - M:

The DR service shall be operational 24/7

GMES - BAS - SLA - 380 - M:

The helps desk shall be available 8 hours a day, 7 days a week in case of necessary trouble shooting exercise.

GMES - BAS - SLA - 390 - O:

The helps desk will be available 24/7 in case necessary trouble shooting exercise.

GMES - BAS - SLA - 400 - M:

The DR service shall include a monitoring function in order to be able to report back on the status of the various elements of the transmission and receiving chain if necessary. The monitoring parameters and the reporting mechanism shall be defined. They shall include as a minimum reporting on scheduled vs. performed contacts, link quality parameters, non-availability statistics.

3.5 Extended Services

The extended services corresponds to 2 different missions

- Repatriation services - Transfer of raw data from GMES X band stations to the Processing and Archiving Centres (PACs) of the GMES system
- Dissemination services - Transfer of data and products to end users

3.5.1 Repatriation services

GMES - REP- SERV - 410 - M:

The Repatriation Service shall provide the GMES SENTINEL system with a satellite communication link to carry the Sentinels data still received at X band ground stations to the Processing Archiving Centres.

GMES - REP- SERV - 420 - M:

The uplink coverage area shall be:

- From two specific X band station in Europe. For system design purposes, two ground stations shall be assumed at Svalbard and Maspalomas.

Final selection of stations locations is still TBC.

GMES - REP- SERV - 430 - O:

An additional uplink coverage areas shall be

- From one X band ground station in Canada. For system design purposes, a ground station shall be assumed at Prince Albert or Gatineau.

GMES – REP- SERV - 440 - M:

The downlink coverage areas shall be

- Europe and in particular the following geographical regions: southern Germany, south-west France, southern UK, central Italy, central Spain

GMES – REP- SYS - 450 - D:

The transmit stations antenna diameter shall not be larger than 5 meters (TBC)

Measures to keep the antenna diameter as small as possible shall be defined

GMES – REP- SYS - 460 - D:

The receiving stations antenna diameter shall not be larger than 5 meters (TBC)

Measures to keep the antenna diameter as small as possible shall be defined

GMES – REP- SLA - 470 - M:

The service shall provide a link capacity of 220 Mbps (goodput) from Europe to Europe

The target performance characteristics are subject to adjustment to match the granularity of typical transponder capacity granularity. The service is expected to use latest transmission air interfaces such as DVB-S2.

GMES – REP- SLA - 480 - O:

The service shall provide a link capacity of at least Mbps (goodput) from Canada to Europe

The target performance characteristics are subject to adjustment to match the granularity of typical transponder capacity granularity. The service is expected to use latest transmission air interfaces such as DVB-S2.

GMES – REP - SLA - 490 - M:

The service availability shall be better than 99.5 % (TBC) including any type outages.

Measures to increase the service availability shall be defined

GMES - REP - PER - 500 - M:

The channel transmission BER shall be less than 10⁻⁹ from ground to ground through the GEO including a link margin of 3dB

GMES - REP - PER- 510 - M:

The channel transmission link availability from ground to ground through the GEO shall be better than 99.9% (TBC)

GMES – REP- SYS - 520 - D:

The Repatriation Service shall be provided in the Ku or Ka band provided that the availability target is achieved

GMES - REP- SERV - 530 - O:

As an alternative to supplying an end to end solution, the repatriation link shall be provided to the GMES SENTINEL system as available transponder bandwidth and power. In this case, the Transmitting and Receiving ground stations shall be owned and operated by the GMES SENTINEL system

The actual transmission channel and ground segment sizing for these links will be assessed by the service provider in order to suggest air interface and ground station solutions.

3.5.2 Dissemination services

This service corresponds to the delivery of processed data from the PACs to user premises in Europe.

GMES – DIS- SERV - 540 - M:

The Dissemination Services shall provide the GMES SENTINEL system with satellite communication link to carry data and products from PACs and other designated points in Europe to GMES end users in designated downlink service areas

GMES – DIS- SERV - 550 - M:

The uplink coverage shall include the geographical area as shown on the contour plot below (TBC).



Figure 1: Dissemination service uplink coverage area (TBC)

GMES – DIS- SERV - 560 - M:

The European downlink coverage shall include the geographical area as shown on the contour plot below (TBC).



Figure 2: Dissemination service downlink coverage area (TBC)

GMES – DIS- SYS - 570 - D:

The Dissemination Service over Europe shall be provided in the Ku or Ka band provided that the availability target is achieved

GMES – DIS- SYS - 580 - M:

The transmit stations an antenna diameter shall be no larger than 5 meters (TBC)

Measures to keep the antenna diameter as small as possible shall be defined

GMES – DIS- SYS - 590 - M:

The receiving stations an antenna diameter shall be no larger than 90 cm.

GMES – DIS- SYS - 600 - M:

The receiving stations shall not cost more than 2500 €(including the computer)

GMES – DIS- SYS - 610 - M:

The service shall provide a link capacity of 110 Mbps (goodput)

The target performance characteristics are subject to adjustment to match the granularity of typical transponder capacity granularity. The service is expected to be provided using latest transmission air interfaces such as DVB-S2 standard.

GMES – DIS- SYS - 620 - M:

The service availability shall be better than 99.5% (TBC) including any type outages.

Measures to increase the service availability shall be defined

GMES - DIS - PER - 630 - M:

The channel transmission BER shall be less than 10^{-9} from ground to ground through the GEO including a link margin of 3dB

GMES - DIS - PER- 640 - M:

The channel transmission link availability from ground to ground through the GEO shall be better than 99.7% (TBC)

GMES – DIS- SERV - 650 - O:

As an alternative to providing an end to end IP solution, the repatriation link will be provided to the GMES SENTINEL system as available transponder bandwidth and power. In this case the Tx and Rx ground stations will be owned and operated by the GMES SENTINEL system

The actual transmission channel and ground segment sizing for these links will be assessed by the service provider in order to suggest air interface and ground station solutions.

4 International Space Station DRS service requirements

This section summarises the Data Relay Service requirements in order to serve the ISS needs. The service consists in providing the ISS with real time bi directional communication link with the Earth.

ISS - SYS - 10 - M

The EDRS shall support the ISS in its LEO circular orbit, with an orbital inclination of 51.6° and an altitude around 350km.

ISS - SYS - 20 - M

The EDRS shall provide bi-directional communications to the ISS, including a Forward channel and a Return channel from and the Earth designated coverage area.

ISS - SYS - 30 - M

The Earth designated coverage area is TBD

ISS - SYS - 40 – M

The EDRS shall provide support to the ISS communications in Ka band, with centre frequencies within 22.55 to 23.55 GHz (Forward channel) and 25.25 to 27.5 GHz (Return channel) and bit rates up to 3Mbps (Forward) and 50Mbps (Return).

The ISS requirements are in the process of being completed



5 Additional DRS services for ESA stakeholders

Additional DRS services for ESA or national initiatives of EDRS Participating States may be required in the future. Such services are not yet identified but would be also subject to SLAs to be defined and agreed with the EDRS operator at a later stage.