SPACE WEATHER CUSTOMER REQUIREMENTS FOR THE ESA SPACE SAFETY PROGRAMME

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APPROVAL

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CHANGE LOG

Space Weather Customer Requirements for the ESA Space Safety Programme	Issue Nr	Revision Number	Date
Formatting adjustments	1	1	16/06/2023
For each Service Domain, the list of Services has been mapped against the corresponding Service Components	1	1	16/06/2023

CHANGE RECORD

Issue Number 1	Revision Number 1		
Reason for change	Date	Pages	Paragraph(s)
Update to include user feedback collected over the course of the SSA programme and start of the Space Safety Programme	28/02/2023	all	

DISTRIBUTION

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1. INTRODUCTION

1.1. SCOPE OF THIS DOCUMENT

This document contains the customer requirements for the Space Weather system under development as part of the ESA Space Safety Programme. The enclosed customer requirements are related to the monitoring of the state of the Sun, the interplanetary and planetary environments, and the solar and non-solar driven perturbations that affect them, and also at forecasting and nowcasting the potential impacts on biological and technological systems.

The document addresses the high-level service user requirements and identifies individual services as part of the applicable baseline for all Space Weather system design definition and development activities. These requirements shall be further broken down in the SWE System Requirements document and accompanying Product Specification Document which are the key documents for the qualification and acceptance of the service system. Qualification and acceptance will ultimately be done on the basis of the system's ability to meet the users' requirements for space weather information.

The requirements contained in this document are formulated from the perspective of the user and are thus directed to the output of services to be provided by the system. Implementation-level or design-related requirements are not within the scope of this document. However, a limited number of system level requirements have been included as far as they relate to the overall user experience expected from the system.

This issue of the document builds on the Space Situational Awareness Customer Requirements Document elaborated at the start of the ESA Space Situational Awareness Programme [AD-CRD], updated to take into account the transition to the ESA Space Safety Programme and incorporating the results of end user engagement activities taking place throughout the 3 periods of the SSA programme. In future is foreseen that this document will be the subject of regular updates, nominally once per Space Safety Programme period.

Services related to microparticles are not included in this issue of the document as they are considered to be provided by other services external to the Space Weather Service System. Where relevant, the Space Weather Service System may provide the user with guidance on where to find this information.

1.2. ROLE OF THIS DOCUMENT

This document is the starting point for the Space Safety Programme's space weather engineering activities and accordingly the system specifications will need to satisfy these requirements. The overall document hierarchy is given in Figure 1.

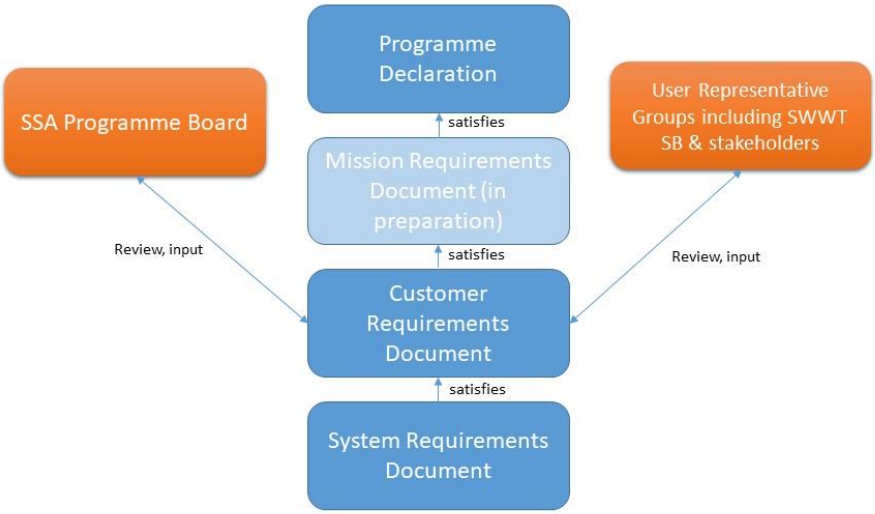

Figure 1: SWE CRD in the Space Safety Programme documentation hierarchy.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

Ref	Document Name	Issue
[AD-DEC]	Declaration on the Space Safety Programme	ESA/C-M(2019)12, Rev.1

[AD-PRO]	Space Safety Programme Proposal for Space19+	ESA-PB-SSA(2018)35, Rev4
[AD-ECSS]	ECSS Standards Documentation.	Available at: https://ecss.nl/
[AD-CRD]	Space Situational Awareness - Space Weather Customer Requirements Document	SSA-SWE-RS-CRD-1001, i4r5a, 28/07/2011

2.2. REFERENCE DOCUMENTS

Ref	Document Name	Issue
[See Annex 1]	End user consultation and requirement review carried out during the SSA Programme (list of inputs in Annex – more than 100 documents	n/a
[RD-ICAO1]	Manual on Space Weather Information in Support of International Air Navigation	Doc 10100, issue 1, 2019
[RD-ICAO]	Annex 3 to the Convention on International Civil Aviation: Meteorological Service for International Air Navigation.	i20, 09/2018
[RD-ETM]	European Union Council Directive 2013/59/EURATOM	12/2013
[RD-CBA]	A Cost Benefit Analysis of the SSA Programme study report, 2016	11/2016
[RD-UKS]	SSA P2-SWE-II Space Weather Data Centre Operations and Maintenance SSA-SWE-CRD UK Stakeholder Review	01/2018
[RD-COST]	COST Action 724 Final Report: Developing the Scientific Basis for Monitoring, Modelling and Predicting Space Weather	01/2008

[RD-VAL]	Guidelines for Common Validation in the SSA SWE Network	SSA-SWE-ESCDEF-TN-5401, 08/09/2020
[RD-ICRP]	Assessment of Radiation Exposure of Astronauts in Space	ICRP Publication 123, Ann ICRP 42(4)

2.3. ACRONYMS

AD	Applicable document
API	Application programming interface
CME	Coronal Mass Ejection
CRD	Customer Requirements Document
ECSS	European Co-operation for Space Standardisation
ESA	European Space Agency
EUV	Extreme Ultraviolet
EVA	Extra-Vehicular Activity
GCR	Galactic Cosmic Ray
GEO	Geostationary orbit
GIC	Geomagnetically Induced Currents
GNSS	Global Navigation Satellite System
HF	High Frequency
ICAO	International Civil Aviation Organisation, a Specialised Agency of the United Nations
IMF	Interplanetary Magnetic Field
IPR	Intellectual Property Rights
L1	First Lagrangian Point
L5	Fifth Lagrangian Point
LEO	Low Earth Orbit
MAG	Magnetometer

MEO	Medium Energy Orbit
NIEL	Non-ionising energy loss
PCA	Polar cap absorption
PNT	Positioning, Navigation and Timing
PSP	Pipe to Soil potential
RD	Reference Document
R&D	Research and Development
ROTI	Rate of TEC index
RTK	Real-time kinematic
s/c	Spacecraft
S2P	Space Safety Programme
SEE	Single Event Effect
SPASE	Space Physics Archive Search and Extract
SPE	Solar Particle Event, solar proton event
SRD	System Requirements Document
SSA	Space Situational Awareness
SSN	Sunspot Number
SWE	Space Weather
SWWT	Space Weather Working Team
TBC	To be confirmed
TBD	To be defined
TEC	Total Electron Content
TID	Travelling ionospheric disturbance
UHF	Ultra-high frequency
URG	User Representatives Group

2.4. DEFINITIONS

(see Annex 2)

3. MISSION OVERVIEW

The goal of the Space Safety Programme is to contribute to the protection of our planet, humanity and assets in space and on Earth from threats originating in Space and to contribute to Europe providing safety from such threats as a service to society. This goal encompasses the development and provision of timely and reliable space weather information and services to end users whose activities and infrastructures may be influenced by space weather phenomena.

Space weather is defined as the physical and phenomenological state of natural space environments. The associated discipline aims, through observation, monitoring, analysis and modelling, at understanding and predicting the state of the Sun, the interplanetary and planetary environments, and the solar and non-solar driven perturbations that affect them, and also at forecasting and nowcasting the potential impacts on biological and technological systems [RD-COST].

While moderate space weather events happen frequently during every 11-year solar cycle, strong events causing substantial impacts on the infrastructure take place less frequently. Extreme space weather events are very rare, but their impact on infrastructure may influence large sectors of society including critical infrastructure. Extreme events are statistically estimated to take place once within every 100 to 200 years and they may occur at any phase of the solar cycle. In a Cost/Benefit Analysis (CBA) study carried out by ESA in 2016 the estimated socio-economic cost of a single extreme event was estimated to be up to 15,000 M€ given economic conditions at the time.

Today, reliable operation of telecommunications satellites, accuracy of GNSS signals and their satellite-based augmentation systems are all influenced by space weather conditions. Navigation systems, the safe operation of power grids and telecommunication are all dependent on the services offered by space systems and are therefore potentially vulnerable to space weather events. The aviation sector also uses satellite data for navigation, communications and emergency notification. Furthermore, the radiation environment at commercial aviation flight altitudes and thus the health of aircraft crew and functioning of the avionics are also subject to space weather impacts. In the future, autonomous systems –

driving, shipping, safe rail traffic – to name just a few examples, will increasingly rely on satellite systems. Space weather monitoring and forecasting will thus play an increasing role in our society and economy in the coming years.

The Space Weather system in development within the ESA Space Safety Programme is intended to provide for its customers and end users a non-dependent source of space weather observed data and processed information based on relevant ground-based and space-based sensors and appropriate data processing elements. Space weather effects explicitly addressed include radiation and spacecraft charging hazards, spacecraft drag, ionospheric perturbations affecting communication and navigation, aircraft radiation hazards, geomagnetic disturbances and currents induced in large conductive networks such as power lines and pipelines.

The Space Weather system in development is intended to provide reliable information for users operating in all areas of the European region from the arctic through to the Mediterranean region as applicable, along with global information where required. Due to the nature of the phenomena considered, the effects of disturbed space weather conditions may be experienced very differently by a user operating in the Arctic in comparison to Southern Europe. It is recognised that a complete service system will need to take into account regional user needs. In some cases regional needs have been identified explicitly in the course of this document. If not specified, it shall be assumed that the full European region including Arctic and Mediterranean is considered.

3.1. HIGH LEVEL REQUIREMENTS

ESA’s Space Safety activities support effective space weather risk management through:

- ensuring availability of data through either dedicated or shared assets, and the capability to extract information from this data through end-to-end modelling and forecasting
- supporting the exploitation of the information gained and its distribution to users as well as technological advancements for protection and/or prevention

Consequently, the requirements elaborated in later sections of this document target the following capabilities:

- the provision of comprehensive knowledge, understanding and maintained awareness of the natural space environment and dynamic space weather conditions.
- the detection and forecasting of space weather conditions and resulting impacts and effects.
- the detection and understanding of space weather impacts and effects.
- the prediction and/or detection of permanent or temporary disruption of mission and/or service capabilities due to space weather conditions.
- the monitoring of the Sun, the solar wind, the radiation belts, the magnetosphere and ionosphere to the extent that it supports services related to effects that include radiation and spacecraft charging hazards, spacecraft drag, navigation, positioning and communication disruption, aircraft radiation hazards, solar radio interference with aviation radars, geomagnetic disturbances and current induced in large conductive networks such as power lines and pipelines.

The requirements have been expanded in this document taking additional sources into account including those documents in the RD list above and extensive consultation which has taken place throughout the ESA SSA Programme and S2P Period 1, with references listed in Annex 1.

4. INTRODUCTION TO THE REQUIREMENTS SECTION

4.1. ORGANISATION OF REQUIREMENTS

The user requirements in the CRD will obtain identifiers according to the following key:
SWE-CRD-BBB-XXXX

Where:

- SWE denotes the Space Weather domain and requirements addressing domain specific aspects of the service system
- SYS denoted system level requirements

- BBB is a three-letter service or component identifier,
- XXXX is a number, giving each requirement a unique **identifier**

Requirements or text marked (*) will have to go through a consolidation process which will be settled in the system definition phase. The consolidation process is necessary in order to iterate customer wishes together with the design process, feasibility and budget constraints.

Each user requirement has a list of attributes associated with it:

- *Service* refers to the service or component to which the requirement applies.
- *Priority* marks if the requirement is considered 'Essential', 'Highly Desirable' or 'Desirable'.

    - 'Essential' means that without fulfilling this requirement, the system is not working.
    - A 'Highly Desirable' requirement is one that would provide additional highly desirable functionality which may be implemented at extra cost. The cost for implementing optional requirements should be evaluated individually.
    - A 'Desirable' requirement is one that would provide additional functionality which may be implemented at extra cost. The cost for implementing optional requirements should be evaluated individually.

- *Justification* provides a justification for the requirement (if applicable)
- *Comment* provides a comment on the requirement (if applicable)
- *Source Requirements* refers to the parent MRD requirement (if applicable)[1]
- *Related Requirements* refers to requirements, which are in relation to the requirement
- *Verification Method* identifies the main method to perform acceptance test of the requirement

[1] The Space Safety Programme MRD is in preparation at the time of writing so these fields will be completed in a future issue.

4.2. SERVICE DOMAINS

The following service domains are identified:

(1) Spacecraft design

(2) Spacecraft operation

(3) Human space flight

(4) Launch operation

(5) Transionospheric radio link

(6) Space Traffic Coordination

(7) Power System Operation

(8) Pipeline Operation

(9) Aviation

(10) Resource Exploration and Exploitation

(11) Aurora Observation and Forecast

(12) General data services

4.3. CUSTOMERS AND END USERS

The CRD focuses on identification of the requirements of end users of the ESA Space Weather Service System.

The following table indicates the type of end user addressed by the following requirements.

Service Domain	End User
Spacecraft Design	Personnel involved in generating space environment specifications for the design of spacecraft
Spacecraft operation	Flight Control Teams, operations support engineers, and science operations centre teams of European and national space agencies, public and private spacecraft operators.
Human space flight	The operation and biomedical engineering teams supporting human spaceflight missions during launch, activities inside and outside of

	the ISS, future lunar missions and commercial tourism enterprises.
Launch operation	Personnel involved in launch operation including space agencies and commercial enterprises.
Communication and Navigation	Service users from space-based systems using electromagnetic waves propagating through the ionosphere and for which service performance may be affected by ionospheric disturbances due to space weather events. The main users are GNSS but also some satellite communication and earth observation services are included
Space Traffic Coordination	Surveillance and tracking centres, stations and services including collision warning services, and re-entry risk assessment services. Spacecraft operators for precise orbit determination.
Power Systems Operation	Personnel involved in the operation of power distribution networks
Pipeline Operation	Personnel involved in the operation of pipelines
Aviation	Airlines, pilots, dispatchers and aviation safety authorities.
Resource Exploration and Exploitation	Personnel involved in offshore resource exploration/exploitation.
Aurora Observation and Forecast	Personnel involved in the tourism sector and general public.
General Data Services	Expert users in all sectors including the scientific community, third party service providers providing tailored downstream services to end users, the education sector and the general public (including amateur radio/disaster monitoring-communication)

5. OVERARCHING REQUIREMENTS

5.1. COMMON REQUIREMENTS

5.1.1. FUNCTIONAL REQUIREMENTS

SYS-CRD-FUN-3189	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall provide alarms based on events (e.g. flare alert (without spatial info), flare alert (with spatial info), Halo CME alert, CME warning, coronal hole alert, CIR alert, geomagnetic storm onset alert, geomagnetic warning etc) for an agreed set of defaults. The accompanying alarm message shall incorporate relevant data and, whenever feasible, likely consequences (e.g. time of interplanetary shock reaching Earth).					
Justification:	Timely alarms support decision making. Standard thresholds support a general overview of current space weather conditions and alert users to potential hazards.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-FUN-3190	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall provide a subscription service allowing for tailored automated alarms on a particular parameter/dataset.					
Justification:	User defined thresholds allow the user to receive alarms only when thresholds of interest to their particular system are crossed. Automatic provision facilitates incorporation into the user's normal operational procedures.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-FUN-3191	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall clearly document the priority handling mechanisms that are implemented.					
Justification:					
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Inspection Test

SYS-CRD-FUN-3192	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall clearly document the procedures to alter the configuration of the priority handling.					
Justification:					
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Inspection Test

SYS-CRD-FUN-3193	Service:	FUN	Priority:	Desirable	SYS
All observational and intermediate data and all resulting products shall be stored and made available on request for a period of at least 50 years. This shall comprise sensor raw data, intermediate data, transmitted service products.					
Justification:	It may be required to reanalyse data for calibration or training purposes. Data shall also be made available for scientific use.				
Comments:	The 50 years are an initial starting assumption. The services for spacecraft designers will require analysis of historical data in the form of entire datasets which will have a timescale of >50 years. What is on-line or off-line depends on the technology available at a time and affordability. The archive shall be evolutive over this period of time, allowing to follow the technology				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-FUN-3194	Service:	FUN	Priority:	Essential	SYS
It shall be possible to browse and filter all "archived data" as required in SYS-CRD-FUN-3193. Filtering functions are intended customisable by users.					
Justification:	Required in order to retrieve datasets.				
Comments:	“Customizable” means that the user can specify exactly what data he wants to retrieve.				
Source Requirements:					
Related Requirements:				**Verification Method:**	

SYS-CRD-FUN-3195	Service:	FUN	Priority:	Essential	SYS
Any changes to the Space Weather System shall not interrupt the provision of the services available to the users.					
Justification:	Operational (sometimes time critical) activities rely on the continuity of the service.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-FUN-3196	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall provide training facilities for operators covering all services available at a given time.					
Justification:	New procedures and new personnel can be trained.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-FUN-3197	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall allow replaying processes associated with all services using archived data and recorded data exchange.					
Justification:	To support troubleshooting and handling of user requests and claims.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Test

SYS-CRD-FUN-3198	Service:	FUN	Priority:	Essential	SYS
The Space Weather System shall provide user support for all services.					
Justification:	Users may require support in accessing and using the information contained in the service. Support shall be able to respond to e.g. special requests, helpdesk, request for archived data, particular technical questions of interest, dedicated analysis requests etc.				
Comments:	Definition of the operational concept is not within the scope of this document.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-FUN-3259	Service:	FUN	Priority:	Essential	SYS
The user shall be able to access both operational services and new capabilities in testing/demonstration					
Justification:	In order to provide feedback on their usability and to support continued service improvement.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

5.1.2. PRESENTATION REQUIREMENTS

SYS-CRD-PRE-3199	Service:	PRE	Priority:	Essential	SYS
All service elements forming part of the Space Weather System shall be presented with a common look and feel.					
Justification:	Design harmonisation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-PRE-3200	Service:	PRE	Priority:	Essential	SYS
Services and products shall be presented as numerical data along with a visual representation.					
Justification:	Service output formats shall be defined in order to best support the user in reducing the time needed to take critical decisions.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

5.1.3. SYSTEM LEVEL REQUIREMENTS

SYS-CRD-SYS-3201	Service:	SYS	Priority:	Essential	SYS
The Space Weather System shall be designed to be maintainable. The selection of long-term maintainable components shall be preferred to new component adaptation/re-qualification.					
Justification:	The selection of long-term maintainable components is preferred to system adaptation/re-qualification w.r.t to new components.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis	

SYS-CRD-SYS-3202	Service:	SYS	Priority:	Essential	SYS
The Space Weather System shall incorporate and support the further development of Existing European assets, ensuring they satisfy the necessary requirements in terms of performance, data policy and availability.					
Justification:	Extensive assets and expertise exist within the ESA Member States. The aim of the programme is to build on and strengthen existing capabilities, with targeted development to fill key gaps. Duplication should be avoided wherever possible.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

SYS-CRD-SYS-3203	Service:	SYS	Priority:	Essential	SYS
The Space Weather System shall be designed to support an initial lifetime of 50 years.					
Justification:	In order to envisage architecture implications from the system lifetime, this initial assumption has been made.				
Comments:	The initial lifetime shall be counted from the start of service provision				
Source Requirements:					

Related Requirements:		**Verification Method:**	Analysis

SYS-CRD-SYS-3204	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System will be synchronised to a single common system time.					
Justification:	In order to provide a common reference, allowing interoperability and comparison.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-SYS-3205	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System shall use common reference coordinate systems.					
Justification:	Wherever possible, common reference coordinate systems shall be used to ensure compatibility of comparable data products within the Space Weather system and combination of multiple service elements within the system. Coordinate systems shall be selected in order to adequately describe the input parameters for a given application.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-SYS-3206	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System shall use units in line with international standards and common practice in the relevant user communities					
Justification:	In order to ensure consistency between the Space Weather system and other systems in terms of SI units and other units when interfacing with users systems requires this.				
Comments:	The values defined by the Committee on Data for Science and Technology (CODATA) shall be considered.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-SYS-3207	**Service:**	SYS	**Priority:**	Essential	SYS
The values of fundamental constants (e.g. the speed of light) shall be defined and used systematically and consistently throughout the Space Weather System.					
Justification:	In order to ensure consistency between different subsystems using the same fundamental constants.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-SYS-3208	Service:	SYS	Priority:	Essential	SYS
The Space Weather System shall have the capability of interfacing with external systems, such as contributing sensors or data centres, for the purpose of exchanging data.					
Justification:	The Space Weather system is expected to interface with external data providers such as NASA, NOAA and other international organisations/agencies for the purposes of data exchange.				
Comments:	The necessary interface control documents shall be agreed with the relevant parties.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-SYS-3209	Service:	SYS	Priority:	Essential	SYS
Interfaces between different components of the Space Weather System and between the Space Weather System and external entities shall be harmonised to maximise commonalities.					
Justification:	For maintenance, data analysis and future evolution purposes it is important that interfaces are as homogeneous as possible. Where possible, same fields will be available (even if they are empty for some specific interfaces) in the same place within the message and same protocols will be used.				
Comments:	It is not intended to change interfaces already defined/existing (e.g. for external entities or sensors already operational), the objective is to optimise new interfaces to be defined.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-SYS-3210	Service:	SYS	Priority:	Essential	SYS
The Space Weather System shall provide a simulation environment for training and validation processes that shall be independent of the operational environment and shall not interfere with the operational environment (specific resources, no disturbance to the operational environment).					
Justification:	Continuity and integrity of the services is to be guaranteed.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-SYS-3211	Service:	SYS	Priority:	Essential	SYS
The services provided by the Space Weather System to the users shall be accessible from the most common operating systems.					
Justification:	In order to ensure that the services provided by the Space Weather system can actually be accessed by the intended user community.				
Comments:	Access also via mobile devices shall be foreseen.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Test

SYS-CRD-SYS-3212	**Service:**	SYS	**Priority:**	Essential	SYS
The interface between the System and the users shall be such that it is possible for the user to develop their own tool to access the services via API.					
Justification:	In order to allow development of efficient third-party services (added value services) based on data provided by the Space Weather System through its services.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review

SYS-CRD-SYS-3213	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System Shall include mechanisms that allows priority of service element generation and dissemination to be defined, configured and implemented.					
Justification:	Need to allocate resources according to priority where multiple interfaces exist.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-SYS-3214	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System shall allow the operations teams to reconfigure the priority handling without interrupting normal operations.					
Justification:	Need to ensure continuity of service.				
Comments:					
Source Requirements:					
Related Requirements:	SYS-CRD-SYS-3213			**Verification Method:**	Inspection Test

SYS-CRD-SYS-3215	**Service:**	SYS	**Priority:**	Essential	SYS
The Space Weather System shall allow the active configuration of the priority handling to be readily visualised.					
Justification:	Supports efficient priority handling and adjustment as needed				
Comments:					
Source Requirements:					
Related Requirements:	SYS-CRD-SYS-3213			**Verification Method:**	Inspection Test

SYS-CRD-SYS-3216	**Service:**	SYS	**Priority:**	Essential	SYS
Uncertainties in the presented data shall be quantified in the form of quality flags.					

Justification:	While the service will be available continuously, uncertainties and ambiguities in the data must be presented to the user, particularly if data is to be used operationally.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Analysis Design Review

SYS-CRD-SYS-3217	**Service:**	SYS	**Priority:**	Essential	SYS
Uncertainties in the model outputs shall be quantified in the form of quality metrics.					
Justification:	While the service will be available continuously, uncertainties and ambiguities in the model output must be presented to the user, particularly if data is to be used operationally.				
Comments:	See [RD-VAL]				
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review	

SYS-CRD-SYS-3218	**Service:**	SYS	**Priority:**	Essential	SYS
All Space Weather System elements shall be supported by consistent metadata.					
Justification:	Consistent metadata supports searchability and interoperability within the service system.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**		

5.2. QUALITY ASSURANCE REQUIREMENTS

SYS-CRD-QUA-3219	**Service:**	QUA	**Priority:**	Essential	SYS
The Space Weather System shall provide information on the quality (reliability, availability, accuracy, latency …) of data, data sources, data products and services according to agreed metrics.					
Justification:	Needed for assessment of overall performance of the services.				
Comments:	See Annex 2 definitions.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

SYS-CRD-QUA-3220	**Service:**	QUA	**Priority:**	Essential	SYS
The Space Weather System shall maintain usage statistics.					
Justification:	Required in order to monitor service usage at system, service and component level.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review

SYS-CRD-QUA-3221	**Service:**	QUA	**Priority:**	Essential	SYS
The Space Weather System shall record all accesses to space weather information being either internal or external to the Space Weather system.					
Justification:	This is a precaution to be able to respond to legal issues.				
Comments:	Data shall be stored for a limited time of 6 months (*) only.				
Source Requirements:					
Related Requirements:	SYS-CRD-DAT-3239		**Verification Method:**	Design Review	

SYS-CRD-QUA-3222	**Service:**	QUA	**Priority:**	Essential	SYS
The overall performance of the Space Weather System shall be measured at regular intervals against a set of agreed KPIs. KPIs shall address the services ability to reach end users, increasing customer engagement, service user satisfaction, service quality, service maturity and operationality.					
Justification:	Required in order to monitor service and system performance.				
Comments:	KPIs shall be reviewed at least annually.				
Source Requirements:					
Related Requirements:			**Verification Method:**		

SYS-CRD-QUA-3223	**Service:**	QUA	**Priority:**	Essential	SYS
Datasets shall include information on their origin (including the information to the user about the nature of the source e.g. “operational system”, “science-quality source", ...) and their terms of usage.					
Justification:	Needed for assessment of accuracy of the services and to ensure correct usage.				
Comments:	Supported by the use of consistent metadata				
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Inspection	

SYS-CRD-QUA-3224	**Service:**	QUA	**Priority:**	Essential	SYS
For the data sources that provide calculated values (whether indices, derived parameters, extrapolations of basic parameters or any result from a calculation process), the Space Weather System shall provide accurate description of the model and parameters used for their generation as well as which exact information is provided by each parameter and its domain of applicability.					
Justification:	Needed for assessment of accuracy of the services, reproducibility, and interpretation of the results.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Inspection

SYS-CRD-QUA-3225	**Service:**	QUA	**Priority:**	Essential	SYS
Assessment of accuracy for each provided space weather data and data products shall be provided by the Space Weather System.					
Justification:	Required to determine domain of applicability.				
Comments:	For newly included data and products an estimate of the expected accuracy based on previous validation work may be presented. This may also include cross-validation with other similar products provided by the system. Continuous validation against an agreed reference utilising agreed metrics shall be encouraged wherever possible. See also SYS-CRD-QUA-3219. Accuracy may also be determined a posteriori for e.g. alerts as part of overall performance assessment.				
Source Requirements:					
Related Requirements:	SYS-CRD-QUA-3224		**Verification Method:**	Analysis Design Review Test	

SYS-CRD-QUA-3226	**Service:**	QUA	**Priority:**	Essential	SYS
The Space Weather System shall make its estimation of the accuracy of the provided services and data and make it available to the users.					
Justification:	Required to increase the level of confidence of the users in the system and assess the quality of data for specific uses.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review Test	

SYS-CRD-QUA-3227	**Service:**	QUA	**Priority:**	Essential	SYS
It shall be possible to know the status of each of the Space Weather System components and assets, including (whenever this information is provided) status of external entities, communication links and contributing sensors.					
Justification:	Knowledge of the status of the different components is essential for operations, failure detection and correction (increased system availability) and system analysis, which should be used in order to assess availability and integrity of the service provision along with potential improvement, evolution proposals, etc.				
Comments:	Where possible, it is desirable to be able to monitor elements external to the system so that it is possible to correlate system errors/unavailability with these entities. Obviously, it is only possible when the owner of the entities/assets provide this information.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SYS-CRD-QUA-3228	**Service:**	QUA	**Priority:**	Essential	SYS
Reports (alert, warning, etc.) generated by the Space Weather Services to end users shall contain a clear indication of the data they are based upon and the source and reliability of that data.					
Justification:	Needed for assessment of reliability of the services.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SYS-CRD-QUA-3229	**Service:**	QUA	**Priority:**	Essential	SYS
The Space Weather System shall be developed following the ECSS suite of standards for space engineering tailored as per the need of the programme and shall be compliant with ISO 9001 standards.					
Justification:	The development of the Space Weather System is an ESA project and shall therefore follow the usual standardised approach. This only refers to components to be developed in the frame of the programme.				
Comments:	Tailoring of the appropriate standards shall be utilised, depending on whether the component to be developed is expected to run operationally or function as e.g. an early capability demonstrator.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

5.3. SAFETY AND SECURITY REQUIREMENTS

SYS-CRD-SEC-3230	**Service:**	SEC	**Priority:**	Essential	SYS
The Space Weather System shall implement cybersecurity controls in line with the results of a threat and risk assessment and the corresponding risk treatment decisions.					
Justification:	In line with the ESA security framework, the Space Weather System will be subject to a regular cybersecurity threat and risk assessment. Any risks identified through this process will require a risk treatment decision by the appropriate space weather system stakeholders. Any such decision resulting in risk mitigation will result in requirements for cybersecurity controls to be implemented by the Space Weather System.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Inspection

5.3.1. HEALTH AND SAFETY REQUIREMENTS

SYS-CRD-HAS-3231	Service:	HAS	Priority:	Essential	SYS
The Space Weather System development and operations shall comply with applicable health and safety regulations and standards.					
Justification:	In order to ensure safe operations of all space weather related systems in compliance with the applicable safety standards of the development and operating entity(ies).				
Comments:	References to applicable safety standards are available at ESA sites. The list of applicable standards for the space weather operation is not defined at the present time. It will be defined at a later stage once the future Space Weather operating entity(ies) are known.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design review

SYS-CRD-HAS-3232	Service:	HAS	Priority:	Essential	SYS
For ground-based systems, all electrical devices forming part of the system shall be certified and labelled with a “CE” marking or "UKCA" as applicable.					
Justification:	In order to ensure that all electrical devices used within the Space Weather System are compliant with applicable EC Directives or UK law as applicable.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Inspection

SYS-CRD-HAS-3233	Service:	HAS	Priority:	Essential	SYS
For ground-based systems, all radiating components and their shelters, housings and sites shall follow the applicable national and EU laws and regulations whichever are more stringent.					
Justification:	In order to ensure that all radiating devices used within the Space Weather System are compliant with applicable EU laws and regulations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Inspection

SYS-CRD-HAS-3234	Service:	HAS	Priority:	Essential	SYS
For ground-based systems, the design, the development and operation of the Space Weather System shall be subject to the applicable safety standards of the relevant local, national, and international authorities.					

Justification:	In order to ensure that relevant local, national, and international safety standards are met be all components in the distributed Space Weather System.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review

5.3.2. DATA POLICY REQUIREMENTS

SYS-CRD-DAT-3235	**Service:**	DAT	**Priority:**	Essential	SYS
The Space Weather System shall be able to handle data while maintaining the Intellectual Property Rights of the data owner. Ownership and IPR issues shall be addressed by the Space Weather System.					
Justification:	Elements of the Space Weather System are expected to utilise existing data and/or assets for which the IPR is held by the data producer/provider (i.e. the data owner). It shall be ensured that these IPR are maintained and that the conditions under which these data and/or assets are provided to their system are clearly defined.				
Comments:	An example would be commercial use since some of the data providers are public institutes whose charter limits the potential exploitation of their data for commercial purposes.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis	

SYS-CRD-DAT-3236	**Service:**	DAT	**Priority:**	Essential	SYS
The Space Weather System shall be developed, operated, and maintained according to a clear data policy.					
Justification:	The data policy shall cover all foreseen uses of the data including but not limited to research, operational service provision and commercialisation.				
Comments:	IPR of the data owner shall be maintained at all times. Related to requirement SYS-CRD-DAT-3235.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

SYS-CRD-DAT-3237	**Service:**	DAT	**Priority:**	Essential	SYS
The Data Policy shall govern the acquisition of, production, access to, dissemination and use of Space Weather System data.					
Justification:					
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review

SYS-CRD-DAT-3238	**Service:**	DAT	**Priority:**	Essential	SYS
The Space Weather Data Policy shall cover data related to development, pre-operational and operational phases.					
Justification:					
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-DAT-3239	**Service:**	DAT	**Priority:**	Essential	SYS
The Space Weather Data Policy shall comply with the applicable regulations on privacy and personal data protection.					
Justification:	Personal data protection must be consistent with GDPR regulations.				
Comments:	ESA privacy framework provides equivalent protection. No sensitive personal data shall be handled by the system.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-DAT-3240	**Service:**	DAT	**Priority:**	Essential	SYS
Users' proprietary data shall be treated as commercial in confidence.					
Justification:	Some service functionalities may require the user to upload their own data in order to achieve the best results. In these cases, these data shall be accessible to the data owner only and not shared with other users.				
Comments:	Some elements of the system will require creation of dedicated user project/working areas in order to store results.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SYS-CRD-DAT-3241	**Service:**	DAT	**Priority:**	Essential	SYS
It shall be legally and technically possible to hand over operation of the system or parts of it (operation including maintenance) to third parties.					
Justification:	ESA may hand over the system, or parts of the system, after development to third-part(ies) for operations. IPR constraints of participating data and service providers shall be respected.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Analysis

SYS-CRD-DAT-3242	**Service:**	DAT	**Priority:**	essential	SYS
Access to the Space Weather services shall be on a registration basis.					
Justification:	registration is required in order to provide user tailoring of service content and related announcements of events/training, user online working areas and to maintain overall statistics of service access/usage.				
Comments:	Registration shall be open to all interested users including public users.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

SYS-CRD-DAT-3243	**Service:**	DAT	**Priority:**	essential	SYS
The Space Weather System shall make a representative overview of current and expected space weather conditions available to the general public without the need for registration.					
Justification:	An agreed subset of latest data and non-tailored environment forecast information shall be made available to highlight more advanced capabilities available following registration.				
Comments:	Registration shall be open to all interested users including public users.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

6. SERVICE DOMAIN #1 SPACECRAFT DESIGN

In orbit, spacecraft are exposed to a multitude of environments that are not present at the surface of the Earth, including UV irradiation, neutral particles, cold and hot plasma, and particle radiation.

Interaction with these environments may cause degradation of materials, thermal changes, contamination, excitation, spacecraft glow, charging, radiation damage and induced background interference. Variations (temporal and spatial) in the constituency and density of the environments, result in effects depending on the position and attitude of the spacecraft. Analysis of the hazardous space environment and its impacts on the spacecraft systems is therefore an important task during space mission design.

The services to be delivered by the Space Weather System to spacecraft designers are given in the table below:

6.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
Environment Specification: data archive	Provide statistical data to derive environments and effects on space systems	SWE-CRD-SCD-1507 SWE-CRD-SCD-1508
Post event analysis	Provide means to correlate a particular(spacecraft) event with measured or estimated space environment and effects data.	SWE-CRD-SCD-1509 SWE-CRD-SCD-1510
Space weather in the Solar System	Provide information supporting the specification and design of spacecraft that will operate within the heliospheric domain	SWE-CRD-SCD-1507 SWE-CRD-SCD-1508 SWE-CRD-SCD-1509

6.2. REQUIRED SERVCIE COMPONENTS TO BE DELIVERED

The following service products and capabilities shall be delivered:

SWE-CRD-SCD-1507	**Service:**	SCD	**Priority:**	Essential	SWE
The Space Weather System shall provide statistical information (median and other percentiles) for a spacecraft in any orbit as a function of time (in past and future) and location for the following space environment: ionising radiation, plasma, neutral particles, and UV.					
Justification:	Space environment specifications are needed for tailored design of space systems especially in relation to radiation protection and EMC considerations. Data will come from sensors in orbit and modelling to fill gaps.				
Comments:	Specification models must be applicable for short duration missions and phases (such as EOR) and long duration mission phases in excess of 15 years in some cases. Models therefore need to accommodate space weather and space climate variabilities and the underlying data needs to capture these for a range of orbits.				

	The microparticle environment and Total Solar Irradiance (TSI) are also required for a complete space environment specification according to the ECSS space environment standard. The SWE Services shall provide (guidance on) access to this information where relevant rather than providing this as part of the service.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCD-1508	**Service:**	SCD	**Priority:**	Essential	SWE
The Space Weather System shall provide statistical information (median and other percentiles) for spacecraft in any orbit as a function of time (in past and future) and location for the following space environment effects: dose, single event effects, sensor background, cumulated charge, spacecraft anomalies. The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used.					
Justification:	Environment specifications for future space missions include effects derived from environment models combined with effects tools and spacecraft-specific information (geometries, materials, operating conditions etc)				
Comments:	Specification models must be applicable for short duration missions and phases (such as EOR) and long duration mission phases in excess of 15 years in some cases. Models therefore need to accommodate space weather and space climate variabilities and the underlying data needs to capture these for a range of orbits.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCD-1509	**Service:**	SCD	**Priority:**	Essential	SWE
The Space Weather System shall provide a best estimate of the local environment that has been experienced by a spacecraft either through measurements or reconstruction (ionising radiation, plasma, neutral particles, and UV) for in-flight validation of specifications of environments and effects.					
Justification:	Provide feedback for model improvement and update of environment specifications and effects predictions.				
Comments:	Limitations of accuracy may occur in the service due to the need to strongly extrapolate from measurements, in particular in regions where measurements are highly variable in space and time: the resulting uncertainties shall be provided to the user.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCD-1510	**Service:**	SCD	**Priority:**	Essential	SWE

The Space Weather System shall provide to the user data and tools to analyse the space environment at a given time and/or location, allowing the user to correlate it with effects and anomaly events on specific spacecraft, equipment or components.			
Justification:	Provide information on vulnerability of components, equipment or spacecraft that can be used for future spacecraft models or versions. Relevant tools (e.g., superposed epoch analysis, data mining) shall be defined in a later phase.		
Comments:	Service shall operate within the limitations brought by data confidentiality of the spacecraft information. The data requirements included in the related data requirements field provide a minimum set of data to be considered and refined along with the user. This requirement shall be understood to also support analysis for missions operating in the solar system.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

6.3. HIGH LEVEL DATA REQUIREMENTS

Data on the following primary components of the space environment and their effects shall be made available to the end users:

SWE-CRD-SCD-1512	**Service:**	SCD	**Priority:**	Essential	SWE
High energy (>1 MeV) proton energy spectrum					
Justification:	A factor in a wide range of TID, NIEL and single-event related effects. Protons in the range 1-10 MeV affect solar cells. A possible upper bound is 300 MeV.				
Comments:	Differential and integral spectra required. Pitch angle resolution required.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCD-1513	**Service:**	SCD	**Priority:**	Essential	SWE
High energy (>1 MeV/nuc) ion energy spectrum					
Justification:	A factor in a wide range of single-event related effects. For rad-hard components ions are the dominant source for single event effects.				
Comments:	Highest priority to E > 10 MeV/nuc. Differential and integral spectra required. Pitch angle resolution required.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCD-1514	**Service:**	SCD	**Priority:**	Essential	SWE
High energy (>30keV) electron energy spectrum					
Justification:	A factor in a wide range of TID, NIEL and internal charging related effects.				
Comments:	Highest priority to E > 100 keV. Differential and integral spectra required. Pitch angle resolution required. Also to be considered number of energy bins, cadence and averaging to adequately sample the local environment.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1515	**Service:**	SCD	**Priority:**	Essential	SWE
High energy (> 30 keV and < 1 MeV) ion energy spectrum					
Justification:	A factor in a wide range of degradation effects of surfaces and sensitive components such as CCDs.				
Comments:	Differential and integral spectra required. Pitch angle resolution required.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1516	**Service:**	SCD	**Priority:**	Essential	SWE
Thermal and superthermal electrons energy spectrum (0-30 keV)					
Justification:	A factor in a wide range of charging and current collection effects.				
Comments:	Differential and integral spectra required. Pitch angle resolution required.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1517	**Service:**	SCD	**Priority:**	Essential	SWE
Thermal ions (0-30keV) density and temperature					
Justification:	A factor in a wide range of charging, current collection and surface erosion effects.				
Comments:	Differential and integral spectra required. Pitch angle resolution required.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1518	Service:	SCD	Priority:	Essential	SWE
Ultraviolet light and soft X-ray. Spectral range (*)					
Justification:	A factor in a wide range of charging and current collection effects.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1519	Service:	SCD	Priority:	Essential	SWE
Atmospheric density					
Justification:	Principally important because of its effect on spacecraft drag.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1520	Service:	SCD	Priority:	Essential	SWE
Ionising and non-ionising dose					
Justification:	Effect measurement for radiation damage on a platform.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1521	Service:	SCD	Priority:	Essential	SWE
Internal charging current					
Justification:	Effect measurement for charging hazards.				
Comments:	evaluated for common geometries (e.g. planar, cylindrical) and materials				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1522	Service:	SCD	Priority:	Highly Desirable	SWE
Anomalies on equipment					
Justification:	Measurement of component sensitivity which may have a variety of causes depending on location.				
Comments:	Availability of anomaly information also of high value to confront specified effects quantities with in-space observations in order to validate and improve environmental effects tools.				

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Inspection

SWE-CRD-SCD-1523	**Service:**	SCD	**Priority:**	Essential	SWE
Atomic oxygen density					
Justification:	Leads to surface erosion in low Earth orbits.				
Comments:	This is closely related to SWE-CRD-SCD-1519 since atomic oxygen is the principal component of the upper atmosphere, except perhaps during major magnetic storms.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1526	**Service:**	SCD	**Priority:**	Desirable	SWE
Floating spacecraft potential for specified spacecraft					
Justification:	Effect measurement of spacecraft charging.				
Comments:	Should be configurable for different spacecraft designs in a variety of orbits.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-3166	**Service:**	SCD	**Priority:**	Essential	SWE
Smoothed Sunspot number (SSN)					
Justification:	To provide statistical information of solar cycle evolution.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-3167	**Service:**	SCD	**Priority:**	Essential	SWE
Solar flux density from entire solar disk at 10.7 cm (F10.7)					
Justification:	To provide statistical information of solar cycle evolution.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

6.4. PERFORMANCE REQUIREMENTS

SWE-CRD-SCD-2635	Service:	SCD	Priority:	Essential	SWE
The users shall be allowed to specify freely the orbits and time spans for their historical de-archiving and/or reconstitution requests, within the maximum ranges covered by the services.					
Justification:	The user shall be able to extract all relevant data according to the time range and orbit of interest.				
Comments:	The user shall be able to specify the orbit using a series of two line elements, classical ephemerides or trajectory upload depending on the tool in use. Mission profiles supported shall include electric orbit raising.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCD-1527	Service:	SCD	Priority:	Essential	SWE
Maximum service interruption time shall not exceed 1 working day (except for scheduled maintenance). The service shall not be offline for more than 3-4 days per year.					
Justification:	99% is required for the credibility of the service. This allows 3-4 days of downtime a year. One day is the usual time scale to provide first assessment of in-orbit failure analysis.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Test

SWE-CRD-SCD-1528	Service:	SCD	Priority:	Essential	SWE
Environmental data shall be available for the statistical service products at most 1 week after retrieval on ground.					
Justification:	Latency time is driven by the service for spacecraft anomaly analysis.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Test

SWE-CRD-SCD-1529	Service:	SCD	Priority:	Essential	SWE
Environmental data shall be available for the local spacecraft environment products at most 1 day after retrieval on ground.					
Justification:	This is to respond to urgent analysis requests for critical spacecraft failures.				
Comments:	The local data may be onboard environment or effects monitoring where available, but this may be substituted by a reconstruction based on modelling where this is not available. This is to respond to short-term analysis requests for critical spacecraft failures.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Test

7. SERVICE DOMAIN #2 SPACECRAFT OPERATION

Space weather conditions must be considered on an event-by-event basis during the operations phase of a mission. For example, cosmic rays (GCRs) and solar energetic particles (SEPs) are known causes of single event upsets (SEUs) such as latch-ups in onboard electronics systems, which may disrupt instruments and potentially platforms. In the worst case, this can result in terminal damage. Solar energetic particle events can disrupt telecommanding and telemetry as a result of the interference in data systems, and the data itself may suffer from high levels of noise due to possible impacts on sensors. Trapped radiation in the radiation belts leads to degradation of components as a result of prolonged dose, with processors, detectors and solar cells particularly vulnerable. A satellite passing through energetic charged plasma will experience a range of charging effects, both on the surfaces and internally within electrical systems, and these charge differentials can lead to sudden discharges and subsequent failure of electrical systems. Less energetic plasma also poses problems, with discharge and sputtering often leading to secondary electron emission and subsequent associated charging problems. The neutral atmosphere may also present a hazard, with neutral atomic oxygen known to lead to surface erosion of the platform materials, potentially compromising the surface and leading to surface charging.

The services to be delivered by the Space Weather system to spacecraft and payload operators and the related service products are given in the table below:

7.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
In-orbit environment and effects monitoring	Provide near real-time estimate of the environment and its effects actually experienced	SWE-CRD-SCO-1530 SWE-CRD-SCO-1531 SWE-CRD-SCO-1535

		SWE-CRD-SCO-1536 SWE-CRD-SCO-1539 SWE-CRD-SCO-1540 SWE-CRD-SCO-1546 SWE-CRD-SCO-3093 SWE-CRD-SCO-3011
Post-event analysis	Provide means to correlate a particular (spacecraft) event with space environment data	SWE-CRD-SCO-1534 SWE-CRD-SCO-1536 SWE-CRD-SCO-1537 SWE-CRD-SCO-1538 SWE-CRD-SCO-1542
In-orbit environment and effects forecast	Provide forecast of the environment and of its effects.	SWE-CRD-SCO-1532 SWE-CRD-SCO-1533 SWE-CRD-SCO-3088 SWE-CRD-SCO-3089 SWE-CRD-SCO-3091 SWE-CRD-SCO-3092
Mission risk analysis	Provide mission risk analysis based on expected space environment conditions and mission susceptibility assessment.	SWE-CRD-SCO-1538 SWE-CRD-SCO-1544 SWE-CRD-SCO-1545 SWE-CRD-SCO-3146
Space Weather in the Solar System	Provide forecasts, nowcasts and alerts related to space weather in the heliosphere supporting mission operators who require information, at locations away from the Earth, in order to make informed decisions on the planning and execution of spacecraft operations.	SWE-CRD-SCO-1530 SWE-CRD-SCO-1531 SWE-CRD-SCO-1532 SWE-CRD-SCO-1541 SWE-CRD-SCO-3090

7.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

The following service products and capabilities are required:

SWE-CRD-SCO-1530	Service:	SCO	Priority:	Essential	SWE
The Space Weather System shall provide near real-time quantitative assessment of the space environment.					
Justification:	Continuous real-time monitoring of the space weather environment conditions provides the relevant information to take informed decisions related to spacecraft operations and help in the correlation of results in future analysis.				
Comments:	For SCO the space environment data required in real-time relate to sudden effects that could occur on the spacecraft, SEE, ESD, errors in magnetorquing and sudden drag-induced orbit changes in LEO.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1531	Service:	SCO	Priority:	Essential	SWE
The Space Weather System shall provide near real-time monitoring of space weather events (including as a minimum: magnetic storm, substorms, high-speed streams, solar energetic particle events, Earth-directed CMEs) that can lead to potentially hazardous effects on spacecraft, with a minimum level of latency.					
Justification:	A qualitative description of significant changes in the space environment (such as solar flares, CMEs) provides useful information for warnings/alarms.				
Comments:	This may be provided as a first level processing with a given accuracy provided with minimum latency during those events, and with improved accuracy following further processing.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1532	Service:	SCO	Priority:	Essential	SWE
The Space Weather System shall provide forecasts over a TBD period with estimates of probability of occurrence of space weather events (including as a minimum: geomagnetic storm, solar energetic particle events, Earth-directed CMEs) and of “All-quiet conditions”, with users being given the confidence level of the forecast.					
Justification:	To put staff on alert, and consequently help to lower the risk for spacecraft and payloads. Useful also to plan critical orbital manoeuvres including at end of launch operations.				
Comments:	The TBD can be understood to be based on the users operational scenario and may be campaign based to cover an extended period providing an indication of overall risk, updating with increasing confidence level as the forecast lead time decreases. User's systems should be seen to accept inputs in terms of lead-time and accuracy.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1533	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of effects for the user spacecraft in any orbit as a function of time and location for the following space environment effects: single event effects, expected radiation dose in spacecraft sensitive components, charge build-up.					
Justification:	Allows forecasting of the expected accumulated radiation dose due to ionising radiation leading to e.g. reduction in solar cell power. A forecast of the likelihood of internal charging leading to discharge and the likelihood of single event effects can be used to take preventive measures and prepare recovery measures in case of disruption.				
Comments:	Component information, together with shielding geometry, is needed prior to launch, preferably at the start of the project. The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality. Any orbit includes electric orbit raising where spacecraft may spend 6 months in high radiation exposure.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1534	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide the capability to correlate pre-selected subsets of user relevant spacecraft housekeeping data with space environment parameters, in the case the user has agreed to provide those data.					
Justification:	Useful to monitor the spacecraft health and identify anomalies. The inclusion of real measured data allows correlation with the forecast data and consequently evaluation of the performance and accuracy of the forecasting models. This information could be retrieved e.g, from ESA data dissemination systems. Only a sub-set of housekeeping data is required so it does not duplicate the mission control system but a link to it may be considered. The relevant housekeeping data has to be defined on a case-by-case basis.				
Comments:	The requirement is dependent on data availability and is only applicable to those missions that agree to provide their housekeeping data. The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality. ECSS-E-TM-10-20A product data exchange is applicable.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1535	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of effects on the user spacecraft as a function of time and location, in the case the user has agreed to provide the inputs allowing the modelling of the spacecraft. The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality.					
Justification:	Provide real-time assessment of space weather risk on spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1536	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
The Space Weather System shall generate and distribute to the authorized users reports of spacecraft anomalies detected across a predefined spacecraft fleet.					
Justification:	Other spacecraft anomalies may be used as an estimate of risk to user's spacecraft. In practice, the quality of this proxy may be limited by difference of orbits and of manufacturers.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1537	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide data for post-event analysis by allowing the user to retrieve (or display) space weather environmental data and compare them with the spacecraft conditions (e.g. effects) and housekeeping data at any past time and spacecraft location and annotate further data/information.					
Justification:	Useful to identify space weather events responsible for anomalies.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1538	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide access to historical space weather environment data, spacecraft effects, and space weather events data.					
Justification:	Used to perform correlation of spacecraft effects with environmental parameters.				

	Also used for science planning: the optimisation of payload scientific planning requires a proper characterisation of the radiation environment and its effects on scientific instruments.		
Comments:	Data may also include post-event reconstruction of space environment data via modelling.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1539	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide a near real-time assessment of the effects of ionospheric disturbances on spacecraft operations.					
Justification:	Spacecraft operations are affected by ionospheric effects for e.g. positioning or for communication and data link.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1540	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
The Space Weather System shall provide a nowcast of the atmospheric data required for drag calculation.					
Justification:	Increased atmospheric drag can cause unplanned orbital decay or in extreme cases early re-entry, which leads to additional fuel needed to correct the orbit. Required for mission planning and scheduling.				
Comments:	This may be provided as a 4D data cube.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1541	**Service:**	SCO	**Priority:**	Desirable	SWE
The Space Weather System shall provide nowcasts of atmospheric density for drag calculation on Mars, Venus and other relevant planets.					
Justification:	Large atmospheric density variations can impact spacecraft orbit. Note that this may require information on the longitudinal distribution of activity on the solar surface, including the far side as seen from Earth.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1542	Service:	SCO	Priority:	Essential	SWE
The Space Weather System shall provide data and tools to correlate the space environment with anomaly events on specific spacecraft, equipment or components.					
Justification:	Provide information on vulnerability of components, equipment or spacecraft that can be used for future spacecraft models or versions.				
Comments:	Requires spacecraft and/or component specific information from user.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SWE-CRD-SCO-1544	Service:	SCO	Priority:	Highly Desirable	SWE
The Space Weather System shall be able to provide, upon request, an assessment of mission/system susceptibility before the operations phase for a given spacecraft.					
Justification:	Awareness of conditions before a new operation phase begins helps to increase the level of confidence of the spacecraft operators.				
Comments:	The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality. See Section 20 for the definition of susceptibility.				
Source Requirements:					
Related Requirements:	All SCO data requirements are relevant for this product			**Verification Method:**	Design Review Test

SWE-CRD-SCO-1545	Service:	SCO	Priority:	Highly Desirable	SWE
The Space Weather System shall be able to provide, upon request, an assessment of mission/system risks before operations phase for a given spacecraft.					
Justification:	Awareness of conditions before a new operation phase begins helps to increase the level of confidence of the spacecraft operators.				
Comments:	The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality. System risk is based on whether susceptibility to the various effects listed under the definition of Susceptibility in Section 19 exceeds levels that would be of concern, e.g. whether probability of destructive SEE is significant over the mission duration, whether surface potentials and internal charging fields exceed ESD thresholds, whether Dose and NIEL degradation would exceed performance margins (including solar				

	array power margin) and whether deviations in magnetic torque and orbit changes would exceed control limits.		
Source Requirements:			
Related Requirements:	All SCO data requirements are relevant for this product	**Verification Method:**	Design Review Test

SWE-CRD-SCO-1546	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of solar activity indices.					
Justification:	These data are often used for models run by the end users.				
Comments:	The list of such indices is to be defined in the SRD.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-3011	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of effects for the user spacecraft in any orbit as a function of time and location for the following space environment effects: single event effects, radiation dose in spacecraft sensitive components and charge build-up.					
Justification:	Allows near real-time estimates of spacecraft environment impacts.				
Comments:	Component information, together with shielding geometry, is needed prior to launch, preferably at the start of the project. The user shall be informed of the limitations of service that may occur due to variability of effects as a function of the materials and designs actually used if they could not declare all the materials and designs of their spacecraft due to data confidentiality.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-3088	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide a forecast of the effects of ionospheric disturbances on spacecraft operations.					
Justification:	Spacecraft operations are affected by ionospheric effects for e.g. positioning or for communication and data link.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-3089	**Service:**	SCO	**Priority:**	Highly Desirable	SWE

The Space Weather System shall provide a forecast of the atmospheric data required for drag calculation.			
Justification:	Increased atmospheric drag can cause early re-entry, which leads to additional fuel needed to correct the orbit. Required for mission planning and scheduling.		
Comments:	This may be provided as a 4D data cube.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-3090	**Service:**	SCO	**Priority:**	Desirable	SWE
The Space Weather System shall provide a forecast of atmospheric properties for drag calculation on Mars, Venus and other relevant planets.					
Justification:	It is important to know the properties of the atmosphere in order to predict the impacts on the orbit driven by large density variations. Note that this may require information on the longitudinal distribution of activity on the solar surface, including the far side as seen from Earth.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-3091	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of solar activity indices.					
Justification:	These data are often used for models run by the end users.				
Comments:	The list of such indices is to be defined in the SRD.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-3092	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of geomagnetic activity indices.					
Justification:	These data are often used for models run by the end users.				
Comments:	The list of such indices is to be defined in the SRD.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-3093	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of geomagnetic activity indices.					
Justification:	These data are often used for models run by the end users.				

Comments:	The list of such indices is to be defined in the SRD.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-3146	**Service:**	SCO	**Priority:**	Essential	SWE
The Space Weather System shall provide a long-term solar cycle prediction of 1-2 cycles (with a quantification of the forecast uncertainties) including at least Sunspot Number, Solar EUV Flux, F10.7, expected flare activity level, mean and standard deviation of interplanetary magnetic field strength, median and upper/lower sextiles of solar wind pressure.					
Justification:	Several spacecraft effects exhibit solar cycle variation which has a ~11-year timescale.				
Comments:	The forecast period will depend on the parameter.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

7.3. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-SCO-1548	**Service:**	SCO	**Priority:**	Essential	SWE
Measurements of solar flares, CMEs, solar energetic particle events, coronal holes, and solar magnetic fields					
Justification:	Required to predict changes in the environment induced by solar eruptive phenomena and coronal holes. Note that space weather services around planets other than Earth require information on the longitudinal distribution of activity on the solar surface, including the far side as seen from Earth.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1549	**Service:**	SCO	**Priority:**	Essential	SWE
Data from spacecraft radiation monitors					
Justification:	Provide local spacecraft radiation data (when available) and information on distribution and propagation of solar particle radiation in space.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1550	Service:	SCO	Priority:	Essential	SWE
Orbital data of spacecraft carrying space weather instruments					
Justification:	Needed to ingest the space weather data into models along with spatial information.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-2637	Service:	SCO	Priority:	Essential	SWE
Information on the space weather instruments carried by relevant spacecraft					
Justification:	Provides the user with information on the data available for a given environment/location.				
Comments:	New CR created from SWE-CRD-SCO-1550.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1551	Service:	SCO	Priority:	Essential	SWE
A subset of the spacecraft housekeeping telemetry data that users have accepted to make available through the Space Weather System.					
Justification:	Operators are interested in visual correlation between spacecraft telemetry and space weather environment data.				
Comments:	The requirement is dependent on data availability and is only applicable to those missions that agree to provide their housekeeping data.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-2650	Service:	SCO	Priority:	Essential	SWE
Geomagnetic storm conditions					
Justification:	Required to determine risk of internal charging leading to discharge. This can be based on geomagnetic indices. The forecast is required to take preventative measures and prepare recovery measures in case of disruption.				
Comments:	Formerly SWE-CRD-SCO-1552, accidentally deleted and recreated as new requirement with different numbering.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1553	Service:	SCO	Priority:	Essential	SWE

Electron and ion energy spectra in the range 0 to 30 keV			
Justification:	Required to determine likelihood of surface charging leading to discharge.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1554	**Service:**	SCO	**Priority:**	Essential	SWE
Proton flux spectra from radiation belts in the range from 1 MeV up to 400 MeV					
Justification:	Required to determine likelihood of internal charging leading to discharge, single event effects and long-term radiation dose.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1555	**Service:**	SCO	**Priority:**	Essential	SWE
Electron flux spectra environment along the orbit (50 keV to 8 MeV)					
Justification:	Required to determine likelihood of internal charging leading to discharge, single event effects and long-term radiation dose.				
Comments:	Electron energies higher than 4 MeV have very low fluxes and are less important.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1556	**Service:**	SCO	**Priority:**	Essential	SWE
Solar ultraviolet light and soft X-rays. Spectra (*)					
Justification:	This is a factor in a wide range of charging and current collection effects.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1557	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
Spacecraft anomalies and events					
Justification:	Spacecraft anomalies and events can be cross correlated to the occurrence of space weather events. Service is required to study cause-effect of space weather events.				

Comments:	Date, location, and nature of anomaly/event may be subject to dissemination restriction.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1558	**Service:**	SCO	**Priority:**	Essential	SWE
Magnetospheric and solar energetic particle fluxes (electrons and protons)					
Justification:	Required to determine likelihood of internal charging leading to discharge, single event effects and long-term radiation dose. The forecast is required to take preventative measures and prepare recovery measures in case of disruption.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1559	**Service:**	SCO	**Priority:**	Essential	SWE
Ground based geomagnetic field					
Justification:	Required to determine risk of energetic plasma injection along field line.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1560	**Service:**	SCO	**Priority:**	Essential	SWE
Cosmic ray energy and ion-species flux spectra					
Justification:	Required to monitor the spacecraft health and identify anomalies. Instead of flux spectra LET spectra can be considered.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1561	**Service:**	SCO	**Priority:**	Essential	SWE
Altitude dependent TEC (Total Electron Content) maps					
Justification:	For ionospheric correction for satellites with a single frequency GNSS receiver. Shall provide information on TEC above the satellite.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1562	Service:	SCO	Priority:	Essential	SWE
Absolute measurements of electron density height profiles (ionosonde data)					
Justification:	Provide ionospheric density as a function of the altitude and other critical parameters.				
Comments:	c.f. also TIO domain user requirements.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1563	Service:	SCO	Priority:	Essential	SWE
Ionospheric scintillation, location and intensity					
Justification:	Required by navigation/positioning to reschedule operations dependent on precision measurements. Required to identify signal disruption caused by TEC variations, in order to accommodate the ionospheric irregularities by adjusting the signal filter.				
Comments:	c.f. also TIO domain user requirements.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1564	Service:	SCO	Priority:	Essential	SWE
Geomagnetic indices (such as Kp, Ap, Dst), solar indices (such as R, F10.7, F30, S10, E10, M10, Y10) and other indices such as IG12, IMF					
Justification:	Required in orbit determination to desired accuracy. Required for mission planning and scheduling. Also required as input to several forecast models.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1565	Service:	SCO	Priority:	Essential	SWE
Global and local neutral density and neutral winds as a function of altitude, latitude and longitude (local time)					
Justification:	For instance, for LEO missions is important to know the status of the atmosphere in order to predict the impacts on the orbit driven by large density variations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1566	Service:	SCO	Priority:	Essential	SWE
Solar Wind velocity, density and magnetic field					
Justification:	Required to forecast many space environment parameters and as input to near real-time models.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1567	Service:	SCO	Priority:	Essential	SWE
Ionising dose					
Justification:	Effect measurement for radiation damage.				
Comments:	Dose for a variety of shielding thicknesses for simplified geometries e.g. solid sphere, slab				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1568	Service:	SCO	Priority:	Essential	SWE
Net electrical current to spacecraft surface					
Justification:	Effect measurement for charging hazards.				
Comments:	Result of model runs when the plasma environment may be more extreme than that given by the specification models used by the spacecraft design and data at the location of the satellite may not be available to determine, e.g., the cause of an anomaly.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1569	Service:	SCO	Priority:	Essential	SWE
High energy >1 MeV proton flux spectra					
Justification:	A factor in a wide range of dose, NIEL and single-event related effects.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1570	Service:	SCO	Priority:	Essential	SWE
High energy (>1 MeV) ion flux spectra					
Justification:	A factor in a wide range of dose, NIEL and single-event related effects.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1571	**Service:**	SCO	**Priority:**	Essential	SWE
High energy (>30 keV) electron flux spectra					
Justification:	A factor in a wide range of dose, NIEL and internal charging related effects. A possible upper limit is 5 MeV.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1572	**Service:**	SCO	**Priority:**	Essential	SWE
Thermal and superthermal (0-30 keV) electron flux spectra					
Justification:	A factor in spacecraft charging and other spacecraft plasma interactions effects.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-2636	**Service:**	SCO	**Priority:**	Essential	SWE
The user shall be allowed to specify freely the orbits and time spans for their historical de-archiving and/or reconstitution requests, within the maximum ranges covered by the services.					
Justification:	Used to perform correlation of spacecraft effects with environmental parameters over suitable timescales. Also used for science planning: the optimisation of payload scientific planning requires a proper characterisation of the radiation environment and its effects on scientific instruments over suitable timescales.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-3260	**Service:**	SCO	**Priority:**	Essential	SWE
1MeV equivalent electron flux					
Justification:	used for solar cell degradation estimation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

7.4. PERFORMANCE REQUIREMENTS

SWE-CRD-SCO-1575	**Service:**	SCO	**Priority:**	Essential	SWE
Maximum service interruption time shall not exceed 1 working day (except for scheduled maintenance that shall be announced to the users with a 30 day forewarning). The service availability shall be 99%. Scheduled maintenance shall be postponed if an active event is in progress. Missing data shall be recovered after service offline periods. Interruption of part of the service e.g. if a specific data stream is interrupted, shall be clearly indicated.					
Justification:	99% is required for the credibility of the service. This allows 3-4 days of downtime a year. One day is the usual time scale to provide first assessment of in-orbit failure analysis.				
Comments:	This requirement describes how we measure whether the availability of the service is acceptable. Clearly 100% availability is desired but not liable to be achieved and it seems unrealistic to single out solar monitoring for 100% availability.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Test

SWE-CRD-SCO-1576	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
A subset of spacecraft payload data relevant to Space Weather Services (e.g. from radiation monitors) shall be made available to the users within 10 minutes in spacecraft telemetry reception mode.					
Justification:	The usability and usefulness of data correlations (spacecraft conditions, effects, and space weather environment and events) depends on the timely availability to the final users.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review Test

SWE-CRD-SCO-1577	**Service:**	SCO	**Priority:**	Essential	SWE
The space weather environment data shall be available to the end user in near real-time.					
Justification:	To allow real-time assessment of space weather threats on spacecraft in routine mode.				
Comments:	This may include a subset of spacecraft payload data relevant to Space Weather Services (e.g. from radiation monitors)				
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review Test

SWE-CRD-SCO-1578	Service:	SCO	Priority:	Essential	SWE
Data forecasts shall be calculated immediately after reception of the input data that is required for the models.					
Justification:	The usability and usefulness of data forecast depends on the timely availability to the final users.				
Comments:	Forecasts of space environment data as input to radiation belt models should, at minimum, cover the next 24 hours.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1579	Service:	SCO	Priority:	Essential	SWE
The outputs of the forecasting models shall be made available to users as soon as they can be produced.					
Justification:	The usability and usefulness of the forecast data depends on the timely availability to the final users.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1580	Service:	SCO	Priority:	Desirable	SWE
The Space Weather System shall provide to the user an estimated response delay for each data request that is submitted.					
Justification:	To allow the users to specify their requests according to their data needs vs their timeliness requirements.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1581	Service:	SCO	Priority:	Desirable	SWE
It shall be possible to retrieve the data already stored in the Space Weather System at sampling rates lower than the rate at which the primary data is available.					
Justification:	The users will be able to specify their requests according to their data needs vs their timeliness requirements.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1582	Service:	SCO	Priority:	Essential	SWE

Any request to retrieve large volumes of data already stored in the Space Weather System shall have a maximum response time delay of 10 minutes. This applies only to data that do not require computation after the request.			
Justification:	Performance is a critical requirement for the usefulness of the Space Weather System.		
Comments:	Requests for small quantities of data should be retrievable faster than the baseline 10 minutes.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Analysis Design Review Test

SWE-CRD-SCO-1583	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
The forecast of "All-quiet conditions" and “End-of-quiet” conditions for all space weather parameters shall be provided 3 to 7 days in advance along with their confidence level.					
Justification:	The usability and usefulness of the forecasted data depends on its quality and the timely availability to the final users.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review Test	

SWE-CRD-SCO-1584	**Service:**	SCO	**Priority:**	Essential	SWE
Nowcasts of space weather events or potentially dangerous conditions shall be provided in near real-time, and at most within the following delays after measurement: 60min for CME onset, 5min for SEP, 5min for radio bursts 5min for high-speed stream arrival at Earth, 5min for solar flare detection.					
Justification:	The usability and usefulness of the data depends on the timely availability to the final users. Current timeliness requirements if for routine spacecraft operations. Stronger timeliness requirements may apply for human spaceflight, launch operation or some critical operations.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review Test	

SWE-CRD-SCO-1585	**Service:**	SCO	**Priority:**	Essential	SWE
The forecasts or risk estimate of hazardous space environment conditions and of the atmospheric environment shall be provided for the following days, in advance within the following time ranges:					

48hours for CME onset, 48 hours for (I)CME or other interplanetary transient structure arrival at L1, up to 27 days for high-speed stream arrival at Earth, 24-28 hours for solar flares.			
Justification:	For a forecast service to be useful, the anticipation in time must be longer than the time required to configure the instruments in safe-mode: e.g. for XMM-Newton it means 10-30 minutes.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-1586	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
The forecasts of spacecraft effects shall be provided as a minimum 1 to 2 days in advance.					
Justification:	The usability and usefulness of the forecasted data depends on the timely availability to the final users.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCO-1587	**Service:**	SCO	**Priority:**	Highly Desirable	SWE
The anomaly information shall be made available after detection with a target of within 48hours.					
Justification:	The usability and usefulness of the data depends on timely availability to the final users.				
Comments:	This relates to SWE-CRD-SCO-1536 and defines the timeliness of accessing the anomaly data. This requires an agreement with operators who would supply information (in all likelihood anonymously) on actual anomalies, e.g. spurious commands, uncommanded instrument switch-off, increased SEU-induced error rate, spacecraft entering non-nominal states. Depending on the agreement with the operator, the information could be made public or distributed only to authorised recipients.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review Test	

SWE-CRD-SCO-1588	**Service:**	SCO	**Priority:**	Essential	SWE
The nowcast shall be continuous.					
Justification:	Data persistence and the possibility to “replay” past conditions are required to conduct post-event analysis and identify possible causes for spacecraft anomalies and effects.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCO-2638	**Service:**	SCO	**Priority:**	Essential	SWE
As a minimum, space weather environmental data covering the time spent from the start of the mission to present shall be available.					
Justification:	Data persistence and the possibility to “replay” past conditions are required to conduct post-event analysis and identify possible causes for spacecraft anomalies and effects.				
Comments:	New CR created from SWE-CRD-SCO-1588.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1589	**Service:**	SCO	**Priority:**	Essential	SWE
The forecast of uncertainties caused by the ionosphere shall be available 1 hour (TBC) in advance.					
Justification:	The usability and usefulness of the forecasted data depends on the timely availability to the final users. The uncertainties mean potential problems due to ionosphere, atmospheric scintillation impacting telecommunication with satellites.				
Comments:	Knowing TEC variations 1 hour in advance seems difficult to achieve for transient events at equator.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCO-1590	**Service:**	SCO	**Priority:**	Essential	SWE
The ionospheric service products shall have TBD update rates					
Justification:	The usability and usefulness of the forecasted data depends on the timely availability to the final users.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review Test

SWE-CRD-SCO-1591	**Service:**	SCO	**Priority:**	Essential	SWE
Daily forecasts, 3-day forecast, 14-day forecast and 27-day forecast of the atmospheric environment shall be available.					
Justification:	The usability and usefulness of the forecast data depends on the timely availability to the final users.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

8. SERVICE DOMAIN #3 HUMAN SPACEFLIGHT

The services to be delivered by the Space Weather system to users within the human spaceflight domain such as biomedical engineers and flight surgeons are given in the table below, noting that space agencies place a strong focus on minimising the occupational radiation exposure of crew. As such the space weather services shall support justification and minimisation of such exposure for crew members as part of their activities. Tools and products shall support the users in applying the ALARA (as low as reasonably achievable) principle and they may be made available both continuously and on a tailored campaign basis to support a given mission/activity. Services shall be designed to support human spaceflight activities from LEO through to lunar orbit including surface operations.

As commercial spaceflight is developing with new commercial operators entering into the domain with both professional crew and, in some cases passengers, it is expected that monitoring and assessing radiation exposure for both crew and passengers will be an important consideration for commercial operators and the services shall also be developed with this emerging user community in view.

8.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
In flight crew radiation exposure	Provide near real-time estimate of the radiation dose received by a person in space.	SWE-CRD-SCH-3087 SWE-CRD-SCH-3258
Cumulative crew radiation exposure	Provide estimate of the past radiation dose accumulated by a person in space.	SWE-CRD-SCH-1595 SWE-CRD-SCH-1596 SWE-CRD-SCH-3081 SWE-CRD-SCH-3084

Increased crew radiation exposure risk	Provide estimate of the risk of increased level of radiation along trajectory	SWE-CRD-SCH-1592 SWE-CRD-SCH-1593 SWE-CRD-SCH-1594 SWE-CRD-SCH-3080 SWE-CRD-SCH-3082 SWE-CRD-SCH-3083

8.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

In addition to the products and capabilities for the Spacecraft Operation service domain the following data products and capabilities shall be delivered:

SWE-CRD-SCH-1592	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a forecast estimate of SEP onset with protons/ions with lower energy limits of >10 MeV, >30 MeV, >100 MeV and >300 MeV above given flux threshold. An evolving forecast should be provided with lead time from a few hours (3-6) to several (up to 3) days.					
Justification:	Alert operators of possible increase in exposure for astronauts on EVA and inside vehicles.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-1593	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a daily solar activity forecastas as an evolving forecast with lead time from a few hours (3-6) to several (up to 3) days.					
Justification:	To put staff and astronauts on alert.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-1594	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide an "All-quiet conditions" forecast for 48 hours, extending to 7 days.					
Justification:	EVA scheduling flexibility.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-1595	Service:	SCH	Priority:	Essential	SWE
The Space Weather System shall provide post-event analysis with the reconstruction of the environment at a given time and location to allow the accurate evaluation of doses inside human bodies.					
Justification:	Maintain accurate records of local area radiation fluxes combined with spacecraft and human phantom shielding geometry models and onboard passive or active dosimeter data (e.g. thermoluminescent dosimeters [TLDs], tissue equivalent proportional counters [TEPCs]).				
Comments:	On board the ISS each crew member has their own personal dosimeter.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-1596	Service:	SCH	Priority:	Essential	SWE
The Space Weather System shall provide the estimated mission related exposure from the start to end of a given mission and highlight activities that could result in increased exposure like vehicle altitude changes, EVAs and ESPEs.					
Justification:	Maintain estimated exposure record during mission operation, to ensure exposure remains within acceptable levels. For comparison with actual exposure following mission conclusion.				
Comments:	On board the ISS each crew member has their own personal dosimeter. Each data point will represent the daily cumulated measurements.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-1598	Service:	SCH	Priority:	Essential	SWE
All products for the Spacecraft Operation service domains shall also be made available to the users of Human Spaceflight service domain.					
Justification:	Human spaceflights are a particular category of spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SWE-CRD-SCH-3080	Service:	SCH	Priority:	Essential	SWE
The Space Weather System shall provide a daily geomagnetic activity forecast					
Justification:	Understand how the cut-off rigidity changes with respect to vehicle path and expected exposure. Put staff on alert in case of anticipated activity.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCH-3081	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide weekly reports collating information on solar activity, geomagnetic conditions, estimated dose and UV exposure.					
Justification:	Support retrospective weekly reporting of estimated exposure.				
Comments:	Dose quantities provided shall follow ICRP practice for radiological protection and may include the following as applicable: Dose equivalent in organ or tissue, HT,Q (defined in units of sieverts, Sv), Effective dose equivalent, HE [Sv], Gray-equivalent dose, GT (defined in units of [Sv] or [Gy-Eq]).				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-3082	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a 24-hour forecast of UV exposure.					
Justification:	Used to provide recommendations on the maximum duration a crew member can remain at a vehicle window.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-3083	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a pre-EVA summary of expected conditions including solar activity, geomagnetic conditions and estimated dose for the EVA period with lead times of 7 days and 24 hours.					
Justification:	Support EVA planning.				
Comments:	Typical EVA duration is 6.5 hours. The first estimated forecast to be provided 7 days in advance to support planning changes. The second 24 hours in advance to include impacts to changes in start time and duration. Dose quantities provided shall follow ICRP practice for radiological protection and may include the following as applicable: Dose equivalent in organ or tissue, HT,Q (defined in units of sieverts, Sv), Effective dose equivalent, HE [Sv], Gray-equivalent dose, GT (defined in units of [Sv] or [Gy-Eq]).				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-SCH-3084	**Service:**	SCH	**Priority:**	Essential	SWE

The Space Weather System shall provide a post-EVA summary of expected conditions including solar activity, geomagnetic conditions and estimated dose for the EVA period.			
Justification:	Exposure assessment supporting overall mission related exposure calculation.		
Comments:	Dose quantities provided shall follow ICRP practice for radiological protection and may include the following as applicable: Dose equivalent in organ or tissue, HT,Q (defined in units of sieverts, Sv), Effective dose equivalent, HE [Sv], Gray-equivalent dose, GT (defined in units of [Sv] or [Gy-Eq]).		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-SCH-3087	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a notification of SEP onsets with protons/ions with lower energy limits of >10 MeV, >30 MeV, >100 MeV and >300 MeV above given flux threshold.					
Justification:	Alert operators of possible increase in exposure for astronauts on EVA and inside vehicles.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-3258	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather System shall provide a near real-time estimate of the dose for a given mission profile					
Justification:	Supports monitoring of crew radiation exposure				
Comments:	Dose quantities provided shall follow ICRP practice for radiological protection and may include the following as applicable: Dose equivalent in organ or tissue, HT,Q (defined in units of sieverts, Sv), Effective dose equivalent, HE [Sv], Gray-equivalent dose, GT (defined in units of [Sv] or [Gy-Eq]).				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

8.3. HIGH LEVEL DATA REQUIREMENTS

Data on the following primary components of the space environment and their effects shall be made available to the end users in addition to the data required for the Spacecraft Operation service domain:

SWE-CRD-SCH-1599	Service:	SCH	Priority:	Essential	SWE
Near real-time high energy >10MeV protons and ions in interplanetary medium					
Justification:	Indicate whether there is an ongoing solar particle event.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1600	Service:	SCH	Priority:	Essential	SWE
Plasma and fields in the interplanetary medium (preferably significantly sunward of Earth and distributed in solar longitude)					
Justification:	Interplanetary field topology for SEP propagation.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1601	Service:	SCH	Priority:	Essential	SWE
Solar disk imaging: X-ray, EUV, visible, including magnetogram					
Justification:	Information for the forecast of solar particle events. Magnetic field boundary conditions.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1602	Service:	SCH	Priority:	Essential	SWE
Wide-angle coronagraph imaging					
Justification:	Used for CME observations.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1603	Service:	SCH	Priority:	Essential	SWE
Local area radiation flux					
Justification:	Provides energetic particle fluxes outside the spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1604	Service:	SCH	Priority:	Essential	SWE
Near real-time geomagnetic indices					
Justification:	Input data for radiation propagation calculation to the vehicle via a model (Kp is enough for altitudes above 100 km).				
Comments:	Use as input for geomagnetic cut-off.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1605	Service:	SCH	Priority:	Essential	SWE
All data for the Spacecraft Operation service domain shall also be made available to the users of the Human Spaceflight service domain.					
Justification:	Human spaceflights are a particular category of spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

SWE-CRD-SCH-3085	Service:	SCH	Priority:	Essential	SWE
Provision of doses inside and outside the spacecraft.					
Justification:	Monitor exposure of crew				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-3086	Service:	SCH	Priority:	Essential	SWE
Near real-time UV flux					
Justification:	Monitoring exposure data for times spent near to a window.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-3246	Service:	SCH	Priority:	Essential	SWE
Measurements of solar flares, CMEs, solar energetic particle events, coronal holes, and solar magnetic fields					
Justification:	Required to predict changes in the environment induced by solar eruptive phenomena and coronal holes. Note that space weather services around planets other than Earth require information on the longitudinal distribution of activity on the solar surface, including the far side as seen from Earth.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

8.4. PERFORMANCE REQUIREMENTS

SWE-CRD-SCH-1606	**Service:**	SCH	**Priority:**	Essential	SWE
During crewed operations, the maximum service interruption shall not exceed 30 minutes for the SEP forecast and 5 minutes for the real-time notification of SEP onset.					
Justification:	The maximum downtime is driven by operational response times for the forecast, and the assumption of a near real-time alerting service notifying the operator of a threshold crossing.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Analysis Design Review Test	

SWE-CRD-SCH-1607	**Service:**	SCH	**Priority:**	Essential	SWE
Forecast of SPE onset shall be calculated for the next 24 hours and, during EVA scheduling, updated every 30 minutes during a time window to be agreed prior to EVA start.					
Justification:	The lead time and update time are driven by the lead time required for taking decisions on scheduling an EVA.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1608	**Service:**	SCH	**Priority:**	Essential	SWE
The Space Weather Service provision of real-time solar X-ray levels, solar X-ray/UV image, and energetic proton/electron fluxes should have a downtime of at most 5 minutes.					
Justification:	The maximum downtime is driven by the acceptable dose level that can be received by astronauts in EVA during downtime.				
Comments:	The resolution is at most equal to the maximum downtime acceptable.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-SCH-1609	**Service:**	SCH	**Priority:**	Essential	SWE
Information on the local spacecraft energetic proton and electron environment shall be provided every minute.					

Justification:	Interplanetary is not enough because of transport effects through magnetic field (e.g., for LEO) and effects of neighbouring planetary bodies.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

9. SERVICE DOMAIN #4 LAUNCH OPERATION

High energy radiation is considered to be the main space weather hazard faced during the launch procedure. Energetic solar ions and protons may pose a significant single event upset threat to sensitive and complex electronics systems. The risk is highest during solar energetic particle events, so for a given launch the operator may opt to define a threshold beyond which the launch may be postponed.

It should be noted that these requirements do not yet take into account the recent development of the microlauncher market. Consultation is ongoing and any adaptation will be included in a future issue of this document.

The services to be delivered by the Space Weather system to launch operators are given in the table below.

9.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
Radiation Environment Monitoring	Provide near real-time estimate of the radiation environment in the vicinity of the launcher	SWE-CRD-LAU-2683 SWE-CRD-LAU-3013
Estimate of radiation effects in sensitive electronics	Provide estimate of past radiation effects in sensitive electronics along trajectory	SWE-CRD-LAU-1617

Forecast of radiation storms	Provide estimate of the risk of increased level of radiation along trajectory	SWE-CRD-LAU-1614 SWE-CRD-LAU-1615 SWE-CRD-LAU-1616 SWE-CRD-LAU-1618
Risk estimate of service disruption caused by ionospheric scintillations	Provide estimate of potential disruption to GNSS positioning information	SWE-CRD-LAU-1619

9.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

The following products and capabilities shall be delivered.

SWE-CRD-LAU-1614	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide a forecast estimate of Solar Particle Event onset with ions (including protons and heavy ions) with energy above pre-defined thresholds in the range 1MeV/nuc to 1000MeV/nuc.					
Justification:	Higher confidence in SEE risk. The requirement for energy range 1-10MeV comes from teams conducting radar and rocket campaigns in the Arctic region and relates to ionospheric conditions rather than SEEs.				
Comments:	Thresholds to be agreed with the user. For high energy heavy ions where the flux cannot easily be measured (threshold to be defined) an extrapolation method may be used.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1615	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide a solar activity forecast for the next 72 hours, including at a minimum X-ray flux, sunspot number, SPE, current active regions, and solar activity evolution.					
Justification:	Put staff on alert.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1616	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide "All-quiet conditions" forecasts.					
Justification:	Higher confidence in SEE risk				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-LAU-1617	**Service:**	LAU	**Priority:**	Essential	SWE
Post-Event Analysis: recreate environment at a given time and location to accurately evaluate SEEs in launcher electronics					
Justification:	Retrieve information to analyse flight data.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1618	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide an atmospheric density forecast along the trajectory of the launcher up to TBD km altitude (*).					
Justification:	Monitor and forecast the density for fairing ejection.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1619	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide ionospheric scintillation forecast.					
Justification:	Forecast possible GNSS positioning disruptions.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1622	**Service:**	LAU	**Priority:**	Essential	SWE
All products for the Spacecraft Operation service domains shall also be made available to the users of Launch Operation service domain.					
Justification:	Launchers are a particular category of spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SWE-CRD-LAU-2683	**Service:**	LAU	**Priority:**	Desirable	SWE
The Space Weather System shall provide in-flight monitoring of radiation effects in sensitive electronics					

Justification:	Provide a near real-time estimate of the radiation effects in sensitive electronics along a trajectory.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-LAU-3013	**Service:**	LAU	**Priority:**	Essential	SWE
The Space Weather System shall provide near real-time information on the space radiation environment including protons and heavy ions with energies above a pre-defined threshold in the range 1MeV to 300MeV.					
Justification:	Provides latest information on conditions potentially impacting sensitive electronics.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

9.3. HIGH LEVEL DATA REQUIREMENTS

Data on the following primary components of the space environment and their effects shall be made available to the end users.

SWE-CRD-LAU-1623	**Service:**	LAU	**Priority:**	Essential	SWE
High energy >1MeV protons and ions at 1 AU					
Justification:	Inform whether there is a solar particle event on-going.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-LAU-1624	**Service:**	LAU	**Priority:**	Essential	SWE
Solar disk imaging (X or EUV), visible light including magnetogram, H-alpha, imaging of solar far-side and radio observations					
Justification:	It will be possible to inform users of the probability of solar particle events using these data. It is important to consider not only solar disk monitoring but also the details relative to a given active region that may be at the origin of an eruption. Moreover, not only the observations are needed but also their interpretation in terms of e.g. flare magnitude, active region magnetic classification, radio burst type... Data relative to the present status of solar activity is important.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-LAU-1625	**Service:**	LAU	**Priority:**	Essential	SWE
Near real-time geomagnetic indices					
Justification:	Input data for radiation propagation calculation to the launcher via a model.				
Comments:	The list of indices to be checked against the intended use.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-LAU-1626	**Service:**	LAU	**Priority:**	Essential	SWE
All data for the Spacecraft Operation service domain shall also be made available to the users of Launch Operation service domain.					
Justification:	Launchers are a particular category of spacecraft.				
Comments:					
Source Requirements:					
Related Requirements:	See section 7.3		**Verification Method:**	Design Review	

SWE-CRD-LAU-2684	**Service:**	LAU	**Priority:**	Desirable	SWE
In-flight monitoring data of radiation effects on sensitive electronics					
Justification:	Provide a near real-time estimate of the radiation effects in sensitive electronics along a trajectory.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-LAU-3012	**Service:**	LAU	**Priority:**	Essential	SWE
Ionospheric scintillation, location and intensity					
Justification:	Required to monitor potential impact of ionosphere on GNSS signals in the vicinity of the launcher.				
Comments:	c.f. also TIO domain user requirements.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-LAU-3016	Service:	LAU	Priority:	Essential	SWE
Ionospheric scintillation nowcast					
Justification:	Monitor possible GNSS positioning disruptions.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-3094	Service:	LAU	Priority:	Essential	SWE
Near real-time solar indices (e.g. F10.7, sunspot number) and EUV/X-ray flux					
Justification:	Input data for ionospheric scintillation forecasts.				
Comments:	The list of indices to be checked against the intended use.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-3247	Service:	LAU	Priority:	Essential	SWE
Wide-angle coronagraph imaging					
Justification:	Used for CME observations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-3248	Service:	LAU	Priority:	Essential	SWE
Measurements of solar flares, CMEs, solar energetic particle events, coronal holes, and solar magnetic fields					
Justification:	Required to predict changes in the environment induced by solar eruptive phenomena and coronal holes. Note that space weather services around planets other than Earth require information on the longitudinal distribution of activity on the solar surface, including the far side as seen from Earth.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

9.4. PERFORMANCE REQUIREMENTS

SWE-CRD-LAU-1627	Service:	LAU	Priority:	Essential	SWE

The service shall be continuously available from 2 weeks prior to launch. Maximum service interruption shall not exceed 30 minutes during the 2 days prior to launch.			
Justification:	2 days is the critical period for decision on whether to launch or not when space weather conditions will be taken into account. A maximum downtime of 30 minutes is compatible with the refresh rate requirement.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Analysis Design Review Test

SWE-CRD-LAU-1628	**Service:**	LAU	**Priority:**	Essential	SWE
Forecast of SPE onset shall be calculated for the next 72 hours and updated every 30 minutes from 72 hours to 48 hours ahead of launch to 5 minutes during the last 48 hours before launch.					
Justification:	The lead time and update rate are driven by the lead time required for taking a decision on scheduling the launch.				
Comments:	A requirement on the avoidance of false alarms may be needed.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1629	**Service:**	LAU	**Priority:**	Essential	SWE
Information on current solar activity including interplanetary high energy protons and heavy ions fluxes shall be provided every 30 minutes for spacecraft launches and 5 minutes for sounding rocket campaigns.					
Justification:	The update time is driven by the lead time required for taking a decision on scheduling a launch. An analysis of the more potentially eruptive active regions at higher resolution than 1 day, ideally every 2 hours, is relevant when their morphology or structure are changing (surface, magnetic complexity, eruption classification…).				
Comments:	The requirement for updating rates <30 min comes from Arctic end users (teams conducting radar and rocket campaigns) and relates to conditions under study rather than to SEE risk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1630	**Service:**	LAU	**Priority:**	Essential	SWE
Energetic proton and electron environment shall be monitored with a five-minute resolution.					
Justification:	Allow accurate identification of the onset time of a solar particle event for post-event analysis.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-LAU-1631	**Service:**	LAU	**Priority:**	Essential	SWE
The solar activity forecast shall be provided for the preceding 2 weeks on a daily basis, then refined during the 48 hours ahead of launch on a schedule to be agreed with the user in advance.					
Justification:	This lead time allows short term planning of launch activities.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1632	**Service:**	LAU	**Priority:**	Essential	SWE
Kp and EUV flux forecast shall be available as time series from 48 hours before launch to 3 hours after launch using measured data where available and forecast data where not.					
Justification:	This lead time allows the update of the drag estimates available for the launch period.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-LAU-1621	**Service:**	LAU	**Priority:**	Essential	SWE
Accuracy of the provided services and data shall be available to the users.					
Justification:	Required to increase the level of confidence of the users in the system and assess the integrity of data for specific uses. This can be possibly provided through quality flags.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review Test

10. SERVICE DOMAIN #5 COMMUNICATION AND NAVIGATION

This section focusses on communication and navigation users requiring radio signal propagation through the ionosphere.

Ionospheric disturbances, such as scintillation, are an important factor influencing signal propagation between ground- and space-based systems, and also between different space-based systems.

The services set out below are structured in Section 10.1 below according to ionospheric phenomena. However, the constituent service components presented to the user are expected in many cases to also translate this information into estimates of the resulting effects. This is particularly true in the positioning domain e.g. presenting the VTEC map and corresponding position error map.

The following user types are assumed:

User Types	Characteristics
SWE-CRD-TIO-USR-01	Users of GNSS Single frequency services with average accuracy, no integrity (e.g. typical GNSS mass market user)
SWE-CRD-TIO-USR-02	Users of GNSS Single frequency services with average accuracy, using integrity (e.g. EGNOS user)
SWE-CRD-TIO-USR-03	Users of multi-frequency GNSS systems with average multifrequency accuracy, no integrity (commercial services, PRS)
SWE-CRD-TIO-USR-04	Users of multi-frequency GNSS systems with average accuracy, integrity (aeronautical multifrequency)
SWE-CRD-TIO-USR-05	Users of multi-frequency GNSS systems with very high accuracy (e.g. GNSS geodetic users, RTK)
SWE-CRD-TIO-USR-06	Users of satellite data communications with high availability / continuity (e.g. Search-and-Rescue, Air Traffic Control/Management via Satellite, high availability/continuity data networks such as Galileo Ground Segment Data Network). Other space-based services/products users affected by the ionosphere (UHF - C-band radars, GNSS-R altimetry, UHF/low microwave radioastronomy and deep space communications)

The services to be delivered by the Space Weather system to (trans-ionospheric) communication and navigation system users are given in the table below.

10.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
Near real-time TEC maps	Provide near real-time TEC maps	SWE-CRD-TIO-1633
Forecast TEC maps	Provide forecasted TEC maps	SWE-CRD-TIO-1637 SWE-CRD-TIO-3028
Quality assessment of ionospheric correction	Provide information on whether standard corrections to GNSS signal are applicable.	SWE-CRD-TIO-1634 SWE-CRD-TIO-1637 SWE-CRD-TIO-2652
Near real-time ionospheric scintillation maps	Provide near real-time estimate of scintillation conditions.	SWE-CRD-TIO-1635
Monitoring and forecast of ionospheric disturbances	Provide monitoring and estimate of the occurrence risk of ionospheric disturbances	SWE-CRD-TIO-1636 SWE-CRD-TIO-1637 SWE-CRD-TIO-2652 SWE-CRD-TIO-3027 SWE-CRD-TIO-3029 SWE-CRD-TIO-3030 SWE-CRD-TIO-3031

10.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

The following products and capabilities shall be delivered.

SWE-CRD-TIO-1633	**Service:**	TIO	**Priority:**	Essential	
The Space Weather System shall provide near real-time TEC core products for different service users as defined in SWE-CRD-TIO-1650, SWE-CRD-TIO-1651 and SWE-CRD-TIO-1652.					
Justification:	Most transionospheric effects affecting signal propagation are related to Total Electron Content, therefore, real-time maps serve to estimate high-level description of the state of the ionosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1634	**Service:**	TIO	**Priority:**	Essential	SWE

The Space Weather System shall provide for TEC core products specified in SWE-CRD-TIO-1633 a posteriori and estimated parameters together with near real-time alarms to indicate the level of degradation of ionospheric correction models with respect to the actual state of the ionosphere. Update rate for different service users will be considered as defined in SWE-CRD-TIO-1650, SWE-CRD-TIO-1651 and SWE-CRD-TIO-1652.			
Justification:	Space systems affected by ionospheric propagation many times implement ionospheric correction models. Estimating, on the basis of real-time alarms, the degradation of ionospheric corrections will serve to verify system performance.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-TIO-1635	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide near real-time measurements of the ionospheric scintillation Index (S4) and sigma phase error (Sphi) for frequencies from UHF to C band (30 MHz to 5 GHz) for different service users as defined in SWE-CRD-TIO-1650, SWE-CRD-TIO-1651 and SWE-CRD-TIO-1652.					
Justification:	Ionospheric Scintillations may affect the availability and continuity of service of GNSS and other systems, therefore timely detection and nowcasting is of primary importance.				
Comments:	Spectral parameters from scintillation receivers would be useful for engineering community designing and assessing receiver performance.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-TIO-1636	**Service:**	TIO	**Priority:**	Essential	SWE
The system shall provide monitoring and detection of ionospheric phenomena causing local and regional disturbances of electron density in the European region. These shall explicitly include: trough, Travelling Ionospheric Disturbances (TIDs), patches, Tongues of Ionization (TOIs), plasma bubbles, depletions and D-region absorption.					
Justification:	Local and narrow disturbances in the ionosphere (trough, TIDs, patches, TOIs, plasma bubbles, depletions, D-region absorption) affect system performance in localised regions which are difficult to detect and mitigate by the system.				
Comments:	Data from North Africa may be advantageous for products targeting Southern Europe, including the Mediterranean.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-TIO-1637	**Service:**	TIO	**Priority:**	Essential	SWE

The Space Weather System shall provide detection of geomagnetic storms and local geomagnetic events.			
Justification:	Geomagnetic storms often generate abnormal disturbances of the ionosphere resulting in service performance degradation difficult to estimate. It must be noted however that a metric should be defined to characterise ionospheric storms as the ionospheric effects of geomagnetic storms are very diverse.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-TIO-2652	**Service:**	TIO	**Priority:**	Highly Desirable	SWE
The Space Weather System shall provide nowcast of 3D electron density grids.					
Justification:	Radio propagation applications may need 3D electron density grids.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-TIO-3027	**Service:**	TIO	**Priority:**	Highly Desirable	SWE
The Space Weather System shall provide forecasts of 3D electron density grids.					
Justification:	Radio propagation applications may need 3D electron density grids.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-TIO-3028	**Service:**	TIO	**Priority:**	Essential	
The Space Weather System shall provide forecasts preferentially over 7 days, but at least with 1-2 day lead times. TEC core products for different service users as defined in SWE-CRD-TIO-1650, SWE-CRD-TIO-1651 and SWE-CRD-TIO-1652.					
Justification:	Most transionospheric effects affecting signal propagation are related to Total Electron Content, therefore, forecast maps serve to estimate high-level description of the state of the ionosphere.				
Comments:	For RTK applications short lead times of 5 minutes are considered useful with the caveat that a very high confidence level (>90%) would be required. For longer lead time forecasts lower confidence levels may be acceptable.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-TIO-3029	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide a 24-hour forecast of the ionospheric scintillation Index (S4) and sigma phase error (Sphi) for frequencies from UHF to C band (30 MHz to 5 GHz) for different service users as defined in SWE-CRD-TIO-1650, SWE-CRD-TIO-1651 and SWE-CRD-TIO-1652.					
Justification:	Ionospheric Scintillations may affect the availability and continuity of service of GNSS and other systems.				
Comments:	This forecast may be based on a probabilistic approach. For SWE-CRD-TIO-USR-05 forecasts of scintillation periods (>1s) would be beneficial.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3030	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide a 24-hour forecast of ionospheric phenomena causing local and regional disturbances of electron density in the European region. These shall explicitly include: trough, Travelling Ionospheric Disturbances (TIDs), patches, Tongues of Ionization (TOIs), plasma bubbles, depletions and D-region absorption.					
Justification:	Local and narrow disturbances in the ionosphere (trough, TIDs, patches, TOIs, plasma bubbles, depletions, D-region absorption) affect system performance in localised regions which are difficult to detect and mitigate by the system.				
Comments:	Data from North Africa may be advantageous for products targeting Southern Europe, including the Mediterranean.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3031	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide a 24-hour forecast of geomagnetic storms and local geomagnetic events.					
Justification:	Geomagnetic storms often generate abnormal disturbances of the ionosphere resulting in service performance degradation difficult to estimate. It must be noted however that a metric should be defined to characterise ionospheric storms as the ionospheric effects of geomagnetic storms are very diverse.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-TIO-3254	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide monitoring of ionospheric parameters for sub-ionospheric radio transmission.					
Justification:	Continuous monitoring of the ionosphere, including quiet conditions, is relevant for sub-ionospheric radio applications.				
Comments:	This requirement covers the provision of URSI parameter values and riometer measurements.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3255	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide a 24-hour forecast of ionospheric parameters for sub-ionospheric radio transmission.					
Justification:	Forecasting of the ionosphere, including quiet conditions, is relevant for sub-ionospheric radio applications.				
Comments:	This requirement covers the modelling and forecasting of URSI parameter values.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3256	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcast of expected impact on land HF communications due to solar flares and/or energetic particles events.					
Justification:	Solar flares and energetic particle events may impact HF communication.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3257	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast of expected impact on land HF communications due to solar flares and/or energetic particles events.					
Justification:	Solar flares and energetic particle events may impact HF communication.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

10.3. HIGH LEVEL DATA REQUIREMENTS

Data on the following primary components of the space environment and their effects shall be made available to the end users.

SWE-CRD-TIO-1639	**Service:**	TIO	**Priority:**	Essential	SWE
Total Electron Content					
Justification:	An important characteristic for analysis of ionospheric effects.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1640	**Service:**	TIO	**Priority:**	Essential	SWE
Scintillation indices and parameters (S4, sigma_phi, fading depth, fade duration, time between fades, spectral)					
Justification:	Data required to characterise ionospheric scintillation events allowing to estimate performance degradation due to those events.				
Comments:	Performance degradation is highly system dependent, thus general estimates on availability/accuracy due to scintillation are limited.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1642	**Service:**	TIO	**Priority:**	Essential	SWE
Geomagnetic storm indices: global, local auroral, mid-latitude and ring current					
Justification:	A factor to estimate general disturbances of the ionosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1643	**Service:**	TIO	**Priority:**	Essential	SWE
Smoothed Sunspot number (SSN)					
Justification:	A parameter proportional to level of ionisation in the ionosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1644	Service:	TIO	Priority:	Essential	SWE
Solar flux density from entire solar disk at 10.7 cm (F10.7)					
Justification:	A parameter related to level of ionisation in the ionosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1645	Service:	TIO	Priority:	Essential	SWE
URSI ionospheric parameter values					
Justification:	foF2 and M(3000)F2, fmin, and fbE are important characteristics to accurate estimate transionopheric propagation from URSI recommendations. fmin is the minimum useable frequency. This becomes significant during strong solar activity, both as short spikes from flares and a long-lived effect when the solar X-ray background is enhanced. hmF2 and ITEC are derived from true-height analysis of ionosonde data: a) hmF2, the height of the F2 layer peak density. This parameter is a valuable input and constraint on real-time models of the ionosphere. b) ITEC, the vertical total electron content of the ionosphere. This is valuable for comparison and validation against GPS TEC measurements.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1646	Service:	TIO	Priority:	Essential	SWE
Vector measurements of local geomagnetic field					
Justification:	Provide direct values of geomagnetic field in various locations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1647	Service:	TIO	Priority:	Desirable	SWE
Riometer data					
Justification:	Detect D region absorption events.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1648	Service:	TIO	Priority:	Essential	SWE
X-ray flares and SEP fluxes					
Justification:	Cause D region absorption.				
Comments:					
Source Requirements:					
Related Requirements:				Verification Method:	Design Review Test

SWE-CRD-TIO-3025	Service:	TIO	Priority:	Essential	SWE
Solar radio bursts					
Justification:	Affects GNSS signals and L-band satellite tracking.				
Comments:					
Source Requirements:					
Related Requirements:				Verification Method:	Design Review Test

SWE-CRD-TIO-3026	Service:	TIO	Priority:	Essential	SWE
CME arrival time, solar wind speed values					
Justification:	Provides input to assessment of ionospheric disturbance risk.				
Comments:					
Source Requirements:					
Related Requirements:				Verification Method:	

SWE-CRD-TIO-3032	Service:	TIO	Priority:	Desirable	SWE
Volumetric electron density					
Justification:	Used as input to radio wave propagation calculations.				
Comments:	Based on radar imaging of the ionosphere.				
Source Requirements:					
Related Requirements:				Verification Method:	Design Review Test

SWE-CRD-TIO-3033	Service:	TIO	Priority:	Essential	SWE
Ionospheric electron density profile					
Justification:	Used for data assimilation purposes for 3D ionospheric modelling.				
Comments:	May include radio occultation data, ionosonde and/or radar observations.				
Source Requirements:					
Related Requirements:				Verification Method:	Design Review Test

10.4. PERFORMANCE REQUIREMENTS

SWE-CRD-TIO-1649	Service:	TIO	Priority:	Essential	SWE
Maximum service interruption time shall not exceed 5 minutes (except for scheduled maintenance). The service shall not be offline for more than 3-4 days per year.					
Justification:	The maximum service downtime depends on the users but is driven by the most demanding users.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Test

SWE-CRD-TIO-1650	Service:	TIO	Priority:	Essential	SWE
For user SWE-CRD-TIO-USR-01 data shall be obtained globally with a 5x2.5 degrees longitude-latitude 2D grid with an update not larger than 15 minutes.					
Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.				
Comments:	Adaptation of grid resolution in case of data gaps (e.g. for scintillation monitoring). SWE-CRD-TIO-USR-01 indicated preference for a 1x1 degree lat-lon grid if possible.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1651	Service:	TIO	Priority:	Essential	SWE
For users SWE-CRD-TIO-USR-02, SWE-CRD-TIO-USR-03, SWE-CRD-TIO-USR-04, SWE-CRD-TIO-USR-05, SWE-CRD-TIO-USR-06 data shall be obtained globally with a 1x1 degrees lat-lon 2D grid with an update not larger than 5 minutes.					
Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.				
Comments:	SWE-CRD-TIO-USR-02 indicated preference for 0.5x0.5 degree lat-lon grid if possible. SWE-CRD-TIO-USR-06 indicated preference for 10-25km spatial resolution. Users have indicated an update rate of not larger than 1 min would be beneficial.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-1652	Service:	TIO	Priority:	Essential	SWE
3D grid data shall be obtained for specific regions with a 1x1 degree spatial resolution and vertical resolution of ~100 km with an update not larger than 5 minutes.					

Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.		
Comments:	90 km - 20,000 km altitude range should be considered. Upgrading the updating rate to 1 min would be beneficial for refraction and group delay calculations for radar measurements (EISCAT and SST applications).		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-TIO-1654	**Service:**	TIO	**Priority:**	Essential	SWE
For SWE-CRD-TIO-1641, SWE-CRD-TIO-1645 and SWE-CRD-TIO-1646, the data shall be available with an update not larger than 1 hours.					
Justification:	Takes into account spatial scale of disturbances affecting the user.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-TIO-3024	**Service:**	TIO	**Priority:**	Essential	SWE
The Space Weather System shall translate information from the physics domain (e.g. scintillation maps) to the position domain that is relevant for the end user.					
Justification:	Users typically assess uncertainty in terms of position.				
Comments:	All user groups are aiming for spatial accuracies below decimetre scales. For SWE-CRD-TIO-USR-01 the target is <5 m, preferentially <1 m.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3267	**Service:**	TIO	**Priority:**	Highly desirable	SWE
Provision of precise ionospheric information along with uncertainties					
Justification:	Users including e.g. EGNOS in SWE-CRD-TIO-USR-02 may need precise maps provided along with associated uncertainties to check whether the broadcast ionosphere is giving misleading information. Furthermore, for navigation techniques such as PPP-RTK or Fast PPP (SWE-CRD-TIO-USR-05) not only the value of the ionosphere is important but the uncertainty in it. This is because the ionosphere is used in multi-frequency systems for convergence of the position				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

11. SERVICE DOMAIN #6 SPACE TRAFFIC COORDINATION

Accurate tracking and orbit propagation is essential to ensure safe operation of satellites and to avoid collisions. Orbit propagation models take into account forces acting on an orbiting object including atmospheric drag which influences objects in orbits below ~1500km altitude. Atmospheric density is strongly influenced by space weather activity over both short and long (solar cycle) timescales, with an individual geomagnetic storm having the potential to increase thermospheric density in LEO by several 100% within hours. Consequently, accurate monitoring and forecast of these parameters are an important factor in ensuring safe operation on-orbit.

The end users targeted by the services within this service domain are personnel involved in surveillance and tracking activities including catalogue providers, collision warning services and re-entry risk assessment services. Spacecraft operators are also users of these services for precise orbit determination.

More specifically the following end users are foreseen:

User Types	Characteristics
SWE-CRD-SST-USR-01	Surveillance and tracking centres, sensors and services, researchers and space agencies supporting regulators
SWE-CRD-SST-USR-01a	Catalogue (service) providers
SWE-CRD-SST-USR-01b	Collision warning services
SWE-CRD-SST-USR-01c	Re-entry risk assessment services
SWE-CRD-SST-USR-02	Spacecraft Operators (orbit determination)

11.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components

Atmospheric estimates for drag calculations	Estimate of atmospheric density in the past years and predicted in near real-time	SWE-CRD-STC-3015 SWE-CRD-STC-3095 SWE-CRD-STC-3099 SWE-CRD-STC-3096
Archive of geomagnetic and solar indices for drag calculation	Database of past values of solar and geomagnetic indices relevant to drag calculation.	SWE-CRD-STC-3095 SWE-CRD-STC-3099 SWE-CRD-STC-3101 SWE-CRD-STC-3103
Nowcast and forecast of geomagnetic and solar indices for drag calculation	Provide nowcast and forecast of geomagnetic and solar induces for drag calculation	SWE-CRD-STC-3014 SWE-CRD-STC-3100 SWE-CRD-STC-3102
Nowcast of ionospheric group delay	Provide nowcast of ionospheric group delay to estimate effects on radar signal	SWE-CRD-STC-3097 SWE-CRD-STC-3098

11.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

The following products and capabilities shall be delivered.

SWE-CRD-STC-3014	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide either a long-term (100-200 year) forecast of solar and geomagnetic indices or a long-term atmospheric density forecast for the same period, with the forecast updated annually. Uncertainties must be provided as part of the product(s).					
Justification:	Required in order to assess the long-term evolution of the space debris environment.				
Comments:	A possibility of ad-hoc analysis shall be foreseen in case of major unexpected changes to the environment. It should be noted that very large uncertainties are expected to be associated with such a long term forecast.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3015	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide relevant environmental data for the user to compute drag of spacecraft.					
Justification:	Solar and geomagnetic indices are required as model inputs.				

Comments:	This includes latest and archive solar and geomagnetic indices.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-STC-3095	**Service:**	STC	**Priority:**	Highly Desirable	SWE
The Space Weather System shall provide atmospheric density estimate for at least one year.					
Justification:	Used to include drag effect in computing objects trajectory back in time.				
Comments:	Longer term archives for periods >1year should be foreseen and may be maintained offline if needed.				
Source Requirements:					
Related Requirements:	SWE-CRD-STC-3099		**Verification Method:**	Design Review Test	

SWE-CRD-STC-3096	**Service:**	STC	**Priority:**	Highly Desirable	SWE
The Space Weather System shall provide atmospheric density forecast.					
Justification:	Used to include drag effect in computing objects trajectory in the future.				
Comments:	This can be based on multiple models, result to be provided with confidence level.				
Source Requirements:					
Related Requirements:	SWE-CRD-STC-3099		**Verification Method:**	Design Review Test	

SWE-CRD-STC-3097	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide relevant environmental data to estimate ionospheric refraction of radio waves.					
Justification:	Used to correct positions derived by radar tracking. Data utilised by radar operators or catalogue providers when building catalogue.				
Comments:	Refraction can shift the apparent position perpendicular to the radar line-of-sight. It is dependent on the slant electron content between the radar and the tracked object.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3098	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide relevant environmental data to estimate ionospheric group delay.					
Justification:	Used to correct positions derived by radar tracking. Data utilised by radar operators or catalogue providers when building catalogue.				

Comments:	Group delay can shift the apparent position parallel to the radar line-of-sight. It is dependent on the slant electron content between the radar and the tracked object.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-STC-3099	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide the user with thermospheric density estimates to compute drag of spacecraft at altitudes below which drag exceeds 1% of the overall forces acting on the spacecraft.					
Justification:	Provides input to spacecraft drag calculation.				
Comments:	In case the altitude is not known, 1500km may be taken as a reference upper threshold. 100km is considered to be the lower threshold.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3100	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast values of geomagnetic activity indices used in atmosphere models (e.g., Ap, Kp, Dst and other indices depending on the models used by the user) with associated confidence level.					
Justification:	Allow forecasting of high-altitude density or its effect from a model usually run by the user.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3101	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide an archive of geomagnetic indices for at least one year.					
Justification:	Most often the user already has an in-house model and requires input data such as geomagnetic indices.				
Comments:	Longer term archives for periods >1year should be foreseen and may be maintained offline if needed.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3102	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast values of solar activity indices used in atmosphere models (R, F10.7, F30, S10, E10, M10, Y10 and other indices depending on the models used by the user)					

Justification:	Allow forecasting of high-altitude density or its effect from a model usually run by the user		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-STC-3103	**Service:**	STC	**Priority:**	Essential	SWE
The Space Weather System shall provide an archive of solar indices for at least one year.					
Justification:	Most often the user already has an in-house model and requires input data such as solar indices.				
Comments:	Longer term archives for periods >1year should be foreseen and may be maintained offline if needed.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3272	**Service:**	STC	**Priority:**	Essential	SWE
All products for the Spacecraft Operation service domains shall also be made available to the users of Space Traffic Coordination service domain.					
Justification:	Supports effective space traffic coordination measures				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

11.3. HIGH LEVEL DATA REQUIREMENTS

Data on the following primary components of the space environment and their effects shall be made available to the end users.

SWE-CRD-STC-3104	**Service:**	STC	**Priority:**	Essential	SWE
Solar activity indices used in atmosphere models (e.g., R, F10.7, F30, S10, E10, M10, Y10 and other indices depending on the models used by the user) for at least the last year					
Justification:	Allow computation of high-altitude density or its effect from a model usually run by the user.				
Comments:	Longer term archives for periods >1year should be foreseen and may be maintained offline if needed.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-STC-3105	Service:	STC	Priority:	Essential	SWE
Geomagnetic activity indices used in atmosphere models (e.g., Ap, Kp, Dst and other indices depending on the models used by the user) for at least the last year					
Justification:	Allow computation of high-altitude density or its effect from a model usually run by the user.				
Comments:	Longer term archives for periods >1year should be foreseen and may be maintained offline if needed.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-STC-3106	Service:	STC	Priority:	Essential	SWE
Ionospheric electron density as a function of altitude					
Justification:	Allow computation of ionospheric effects on radar.				
Comments:	Could be provided by vertical incidence sounding or 3D density maps (e.g., from path delay measurements).				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

11.4. PERFORMANCE REQUIREMENTS

SWE-CRD-STC-3107	Service:	STC	Priority:	Essential	SWE
Forecast of all specified data for SWE-CRD-STC-USR-01 users shall be made for hours, days, weeks and months ahead with hourly update.					
Justification:	Update rate should be greater or equal to the update rate of the user's orbit calculation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-STC-3108	Service:	STC	Priority:	Essential	SWE
Forecast of all specified data for SWE-CRD-STC-USR-02 users shall be made daily for the coming 27 days and monthly for the coming 11 years.					
Justification:	Update rate should be greater or equal to the update rate of the user's orbit calculation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-STC-3109	Service:	STC	Priority:	Essential	SWE
Forecast of all specified data for SWE-CRD-STC-USR-1b users shall be possible from 1 hour ahead with hourly provision of data to 1 month ahead with daily provision of data.					
Justification:	Update rate should be greater or equal to the update rate of the user's collision/conjunction warning				
Comments:	All data must include uncertainties and indicate how the uncertainties change over time.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-STC-3110	Service:	STC	Priority:	Essential	SWE
Forecast of all specified data for SWE-CRD-STC-USR-1c users shall be possible from 1 hour ahead with hourly provision of data to 5 years ahead with daily provision of data.					
Justification:	Time scales of re-entry encompass 1 hour during event to 5 years for prediction.				
Comments:	All data must include uncertainties and indicate how the uncertainties change over time.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-STC-3111	Service:	STC	Priority:	Essential	SWE
Maximum service interruption time shall not exceed 1 day (except for scheduled maintenance). The service shall not be offline for more than 3-4 days per year.					
Justification:	99% is required for the credibility of the service. Maximum downtime is driven by acceptable error in the drag correction.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Test

12. SERVICE DOMAIN #7 POWER SYSTEM OPERATION

Geomagnetic storms due to space weather disturbances produce enhanced currents that flow in the magnetosphere-ionosphere system which induce electric fields in long conductors at the earth's surface. These electric fields drive electric currents (GICs) through power systems where they can produce a variety of effects that are detrimental to system operation.

12.1. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-POW-3057	Service:	POW	Priority:	Essential	SWE
The Space Weather System shall provide network maps showing geomagnetically induced currents throughout the power system.					
Justification:	GIC estimate supports anomaly identification, analysis and response.				
Comments:	Requires information on grid from user. Access to maps may be limited to the affected user for confidentiality reasons.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3058	Service:	POW	Priority:	Essential	SWE
The Space Weather System shall offer a tailored service for specific users providing a table of modelled GIC values for the users' network in the last minute and peak GIC in the last 60 mins.					
Justification:	Products indicating recent GIC history are required for fast anomaly identification and resolution.				
Comments:	Both modelled and measured GIC values will be available to users. Requires information on grid from customer.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3059	Service:	POW	Priority:	Essential	SWE
The Space Weather System shall provide forecast of dB/dt at specific user-defined locations.					
Justification:	Short-term and long-term forecasts are needed for power systems operators for proper immediate correction and further planning.				
Comments:	Products will be determined in consultation with the system operator in each case.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3060	Service:	POW	Priority:	Essential	SWE
The Space Weather System shall provide nowcast of dB/dt at specific user-defined locations.					
Justification:	Nowcast is needed for power systems operators for proper immediate correction and further planning.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3061	Service:	POW	Priority:	Essential	SWE
The Space Weather System shall provide alerts of dB/dt at specific user-defined locations and thresholds.					

Justification:	Alerts are needed for power systems operation rapid response.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-POW-3066	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide accurate warnings and alerts from 15 minutes up to 2-3 days ahead of local conditions potentially leading to severe GIC levels.					
Justification:	Advanced warning of conditions likely to lead to enhanced GIC.				
Comments:	This may include establishment of regional disturbance scales.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3067	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide a global 27-day outlook of geomagnetic activity.					
Justification:	Advanced warning of conditions likely to lead to enhanced GIC.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3068	**Service:**	POW	**Priority:**	Desirable	SWE
The Space Weather System shall provide a risk index for GICs.					
Justification:	GIC estimate based on data and modelling shall be available for customer grid.				
Comments:	Requires information on grid from customer and thresholds of interest.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3069	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of transient and recurrent IMF Bz features with a 5-day lead time.					
Justification:	Advanced warning of conditions likely to lead to enhanced GIC.				
Comments:	It should be noted that providing an accurate forecast with 5-day lead time is currently extremely challenging, particularly for transient structures. Consultation with the end user should ensure that they are aware of the accuracy of such a forecast and uncertainties should be provided. A shorter lead time may be agreed.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-POW-3071	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast network maps showing geomagnetically induced currents throughout the power system including plotting GIC by substation for specific users.					
Justification:	GIC forecast supports advanced planning.				
Comments:	Requires information on grid from user. Access to maps may be limited to the affected user for confidentiality reasons.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3072	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide maps of nowcast geoelectric field variations in the vicinity of the users ground infrastructure.					
Justification:	Allows monitoring of geomagnetic disturbance level in the vicinity of the users ground infrastructure.				
Comments:	Includes full length of transition lines as well as substations.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3073	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast maps of geoelectric field variations in the vicinity of the users ground infrastructure.					
Justification:	Provides advanced information on expected geomagnetic disturbance level in the vicinity of the users ground infrastructure.				
Comments:	Includes full length of transition lines as well as substations.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3112	**Service:**	POW	**Priority:**	Essential	SWE
The Space Weather System shall provide data and tools to support power grid operators in post-event analysis.					
Justification:	Needed for investigation of anomalies.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

12.2. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-POW-3062	**Service:**	POW	**Priority:**	Desirable	SWE
Network of magnetometer measurements in vicinity of customer power grid site					
Justification:	Used in combination with Earth model to derive local electric field and then in combination with network map, GICs.				
Comments:	Target spatial resolution is approx. 100km				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3064	**Service:**	POW	**Priority:**	Desirable	SWE
Magnetotelluric data on ground impedance tensor in the vicinity of customer power grid lines					
Justification:	Used to estimate geoelectric fields given observed geomagnetic variations in the region of users infrastructure				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3113	**Service:**	POW	**Priority:**	Essential	SWE
Solar wind bulk velocity at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3114	**Service:**	POW	**Priority:**	Essential	SWE
Solar wind bulk density at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-POW-3115	**Service:**	POW	**Priority:**	Essential	SWE
Interplanetary magnetic field at L1					

Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-POW-3116	**Service:**	POW	**Priority:**	Essential	SWE
Solar disk imaging					
Justification:	Monitor solar activity in order to provide information on enhanced solar activity that could lead to geoeffective CMEs and high speed streams.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3118	**Service:**	POW	**Priority:**	Essential	SWE
Solar coronal imaging					
Justification:	Observe coronal structures as they propagate outwards through the corona.				
Comments:	For example, coronagraph imaging.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3249	**Service:**	POW	**Priority:**	Essential	SWE
Provision of geomagnetic indices.					
Justification:	Provide access to latest planetary indices such as Kp, Ap and archive.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3261	**Service:**	POW	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

12.3. PERFORMANCE REQUIREMENTS

SWE-CRD-POW-3070	**Service:**	POW	**Priority:**	Essential	SWE
Forecasts of transient and recurrent IMF Bz features should be provided with a target accuracy of +/- 6 hours.					
Justification:	Advanced warning of conditions likely to lead to enhanced GIC.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-POW-3119	**Service:**	POW	**Priority:**	Essential	SWE
GIC nowcasts shall be provided in as close to near real-time as possible.					
Justification:	Operators require maximum time to react following detection of GIC exceeding threshold for safe operation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

13. SERVICE DOMAIN #8 PIPELINE OPERATION

Long-distance oil and gas pipelines are also affected by geomagnetic disturbances. GICs create galvanic effects that may lead to rapid corrosion of the pipeline if it is not protected properly leading to a reduction of the expected lifetime of the pipeline.

13.1. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-PPL-3000	**Service:**	PPL	**Priority:**	Essential	SWE
The Space Weather System shall offer a tailored service for specific users providing a table of modelled GIC values for the users' network in the last minute and peak GIC in the last 60 mins.					
Justification:	Products indicating recent GIC history are required for fast anomaly identification and resolution.				
Comments:	Both modelled and measured GIC values will be available to users. Requires information on grid from customer.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-PPL-3001	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide information on current densities and corrosion rates in users pipelines.					
Justification:	This product would support the user in assessing the impact of Space Weather on the lifetime of their pipelines.				
Comments:	Requires information on pipeline infrastructure to provide information on corrosion.				
Source Requirements:					
Related Requirements:			**Verification Method:**		

SWE-CRD-PPL-3002	Service:	PPL	Priority:	Desirable	SWE
The Space Weather System shall offer a tailored service for specific users providing Pipe-to-soil potential difference (PSP) variations in the users' pipe network.					
Justification:	Allows monitoring of cathodic protection system on long-distance pipeline.				
Comments:	Requires information on pipeline from customer.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3003	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide global monitoring of geomagnetic activity.					
Justification:	Allows monitoring of conditions for users who do not want to share the information about their system configuration.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3004	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide forecast of dB/dt at specific user-defined locations.					
Justification:	Short-term and long-term forecasts are needed for pipeline operators (pipe-to-soil potential) for proper immediate correction and further planning.				
Comments:	Products will be determined in consultation with the system operator in each case.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3005	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide nowcast of dB/dt at specific user-defined locations.					
Justification:	Nowcast is needed for pipeline operators (pipe-to-soil potential) for proper immediate correction and further planning.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3006	Service:	PPL	Priority:	Desirable	SWE
The Space Weather System shall provide alerts of dB/dt at specific user-defined locations and thresholds.					
Justification:	Alerts are needed for pipeline operator (pipe-to-soil potential) situational awareness.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3135	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide global forecast of geomagnetic activity from 15 min ahead up to 27 days ahead.					
Justification:	Advanced warning of conditions likely to lead to enhanced GIC.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3136	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide a tailored service for specific users providing time-dependent maps of geoelectric field variations for the users' ground infrastructure.					
Justification:	Allows monitoring of geomagnetic disturbances level close to affected ground infrastructure.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3137	Service:	PPL	Priority:	Essential	SWE
The Space Weather System shall provide data and tools to support pipeline operators in post-event analysis.					
Justification:	Used for investigation of anomalies.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

13.2. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-PPL-3007	**Service:**	PPL	**Priority:**	Essential	SWE
Provision of geomagnetic indices.					
Justification:	Provide access to latest planetary indices such as Kp, Ap and archive.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3063	**Service:**	PPL	**Priority:**	Desirable	SWE
Network of magnetometer measurements in vicinity of customer pipeline site					
Justification:	Used in combination with Earth model to derive local electric field in vicinity of pipeline.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3065	**Service:**	PPL	**Priority:**	Desirable	SWE
Magnetotelluric data on ground impedance tensor in the vicinity of customer power grid lines					
Justification:	Used to estimate geoelectric fields given observed geomagnetic variations in the region of users infrastructure				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3138	**Service:**	PPL	**Priority:**	Essential	SWE
Solar wind bulk velocity at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3139	Service:	PPL	Priority:	Essential	SWE
Solar wind bulk density at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3140	Service:	PPL	Priority:	Essential	SWE
Interplanetary magnetic field at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3141	Service:	PPL	Priority:	Essential	SWE
Solar disk imaging					
Justification:	Monitor solar activity in order to provide information on enhanced solar activity that could lead to geoeffective CMEs and high speed streams.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3142	Service:	PPL	Priority:	Essential	SWE
Solar X-ray flux nowcast					
Justification:	Monitor D-region absorption for communication in HF (shortwave fadeout events) and contribute to SEP and global activity forecast.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-PPL-3143	Service:	PPL	Priority:	Essential	SWE
Solar coronal imaging					

Justification:	Observe coronal structures as they propagate outwards through the corona.		
Comments:	For example, coronagraph imaging.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-PPL-3262	**Service:**	PPL	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

13.3. PERFORMANCE REQUIREMENTS

SWE-CRD-PPL-3144	**Service:**	PPL	**Priority:**	Essential	SWE
GIC nowcasts shall be provided in as close to near real-time as possible.					
Justification:	Operators require maximum time to react following detection of GIC exceeding threshold for safe operation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

14. SERVICE DOMAIN #9 AVIATION

In the case of the aviation industry, a range of space weather phenomena can impact aviation operations. Effects include degradation or loss of HF radio transmission and satellite navigation signals; navigation system disruptions; avionics errors and increased radiation dose at aviation altitudes.

The International Civil Aviation Organisation introduced space weather as part of the ICAO Annex 3 – Meteorological Service for International Air Navigation [RD-ICAO] in 2018 with several consortia since established in order to deliver structured space weather advisories.

The requirements listed in this section include the information currently included as part of these advisories along with additional information collected through end user consultation. It is anticipated that any future changes in the ICAO requirements will be reflected in an update of the requirements included in this section.

The European Union's Basic Safety Standards Directive [RD-ETM] sets out safety standards for the protection of workers including aircrew and the general public against the effects of ionising radiation. The Space Weather system targets the provision of information supporting individuals and organisations involved in aviation in monitoring and assessing relevant exposure to space radiation.

14.1. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-AVI-3039	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of radiation storms with energies affecting crew and passengers (6, 12, 18, 24 hours ahead).					
Justification:	in order to support decision making in terms of whether or not to fly, which route and/or flight level to use.				
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3040	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of expected impact for HF communications (6, 12, 18, 24 hours ahead).					
Justification:	Solar flares and energetic particle events may impact HF communication.				
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO. Some aircraft may re-route to lower latitude routes if no HF available with a decision usually made during pre-flight checks utilising all available data to hand.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3041	**Service:**	AVI	**Priority:**	Essential	SWE

The Space Weather System shall provide forecasts of expected impact for satellite communications (6, 12, 18, 24 hours ahead).			
Justification:	Ionospheric scintillation may impact satellite communications.		
Comments:	Included in requirements for the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3042	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of expected impact on GNSS (6, 12, 18, 24 hours ahead).					
Justification:	Inform operators of ionospheric effects that may lead to GNSS errors in positioning and navigation.				
Comments:	Included in requirements for the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3043	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcast of radiation storms with energies affecting crew and passengers.					
Justification:	in order to support decision making in terms of whether or not to fly, which route and/or flight level to use.				
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3044	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcast of expected impact for HF communications.					
Justification:	Solar flares and energetic particle events may impact HF communication.				
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3045	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of expected impact for satellite communications.					

Justification:	Ionospheric scintillation may impact satellite communications.		
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3046	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of expected impact on GNSS.					
Justification:	Inform operators of ionospheric effects that may lead to GNSS errors in positioning and navigation.				
Comments:	Currently provided as part of the ICAO space weather advisory service for aviation. Thresholds to be consistent with those used by ICAO.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3049	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide a graphical forecast including intensity, onset, duration and boundary of degraded HF and SATCOM communications for polar routes (6, 12, 18, 24 hours ahead).					
Justification:	Assists with route selection and management, emergency response.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3050	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide post-event information on radiation levels on a series of pre-defined routes used by commercial airlines (<1 week delay if significant activity).					
Justification:	Allows computation of crew exposure, according to European the current ICRP recommendations.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3051	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide maps of probability of losing communication and maps of degree of navigation signal degradation.					
Justification:	Inform operators of ionospheric effects that may lead to GNSS errors in positioning and navigation.				

Comments:	Numerical data in addition for display on electronic systems. IWXXM (ICAO meteorological information exchange model) format.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3053	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide monitoring and detection of ionospheric phenomena causing local disturbances of electron density. These shall explicitly include: trough, Travelling Ionospheric Disturbances (TIDs), patches, depletions and D-region absorption and post-storm depression.					
Justification:	Local disturbances in the ionosphere affect communication and navigation performance.				
Comments:	In some cases, global geomagnetic indices may provide a suitable proxy in absence of direct measurements (e.g. auroral absorption)				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3054	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide near real-time solar radio measurements and notifications on frequencies that could affect aviation operations 1-2GHz.					
Justification:	Solar emission on this frequency range by solar radio bursts may impact the primary and secondary air traffic control radar.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3055	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall give an estimation of the potential impact of solar radio emissions on aviation radar.					
Justification:	Solar emission on this frequency range by solar radio bursts may impact the air traffic control radar.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3056	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide Prediction of the radiation dose during the GLE in the extent of hours					
Justification:	In combination with existing medical data, supports crew change and/or flight				

	plan change.		
Comments:	The forecasts may be based e.g. on satellite data, neutron monitor data, on-board radiation measurements.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3120	**Service:**	AVI	**Priority:**	Desirable	SWE
The Space Weather System shall provide cosmic ray dose forecasts of up to one year for a given airline flight defined by the user.					
Justification:	Allows estimate of crew radiation exposure, in particular at high latitudes.				
Comments:	Estimate refers to model of galactic cosmic rays with a lead-time of up to 1 year, to allow estimation of background radiation dose for airline crew members.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3121	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide short term (<30mins) warnings of radiation storms with energies affecting crew and passengers.					
Justification:	Allows mitigation procedures to limit doses.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3122	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide statistical information on the radiation environment at aircraft altitude for avionics.					
Justification:	Input to avionics design for aircraft.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3123	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide radiation and ionospheric data for post-event analyses for aircraft operators.					
Justification:	Support anomaly resolution and dose reconstruction in case of observed in-flight avionics errors.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3244	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide global near real-time TEC maps on medium and large scales.					
Justification:	Alert operators to ionospheric effects that may lead to GNSS errors during precision approach and landing. Correct for effects of TEC on positioning data and, where applicable, variation on altimeter data.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3245	**Service:**	AVI	**Priority:**	Essential	SWE
The Space Weather System shall provide global forecast TEC maps on medium and large scales.					
Justification:	Alert operators to ionospheric effects that may lead to GNSS errors during precision approach and landing. Correct for effects of TEC on positioning data and, where applicable, variation on altimeter data.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

14.2. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-AVI-3048	**Service:**	AVI	**Priority:**	Desirable	SWE
Dosimeter data on board aircraft					
Justification:	Supports reporting of estimated exposure.				
Comments:	Data should be made available as soon as possible.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3052	**Service:**	AVI	**Priority:**	Essential	SWE
Near real-time and archive 2 MeV to >100 MeV protons					
Justification:	Monitor solar energetic particle events and resulting dose received by aircrew and possible interaction with avionics. Also, monitor for PCA (polar cap absorption) events affecting communications at high latitudes.				

Comments:	For long term prediction (> 1 hour) of strong SEP events capable of causing a GLE, measurements, even at L1, would probably not be enough, as protons of ~500 MeV need only ~13 minutes to travel from the Sun to the Earth. Sun observation with statistical analysis of various observed phenomena may improve the situation.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3124	**Service:**	AVI	**Priority:**	Essential	SWE
Solar wind bulk density at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3125	**Service:**	AVI	**Priority:**	Essential	SWE
Interplanetary magnetic field at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3126	**Service:**	AVI	**Priority:**	Essential	SWE
Solar disk imaging					
Justification:	Monitor solar activity in order to provide information on enhanced solar activity that could lead to geoeffective CMEs and high speed streams.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3127	**Service:**	AVI	**Priority:**	Essential	SWE
Solar X-ray flux nowcast					
Justification:	Monitor D-region absorption for communication in HF (shortwave fadeout events) and contribute to SEP and global activity forecast.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3128	**Service:**	AVI	**Priority:**	Essential	SWE
Solar coronal imaging					
Justification:	Observe coronal structures as they propagate outwards through the corona.				
Comments:	For example, coronagraph imaging.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3129	**Service:**	AVI	**Priority:**	Essential	SWE
Near real-time and archived measurements of atmospheric neutrons					
Justification:	Monitor ground level and aircraft altitude level events caused by solar particle events.				
Comments:	Requires reliable near real-time data with suitable geographic coverage in order to underpin service provision.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3131	**Service:**	AVI	**Priority:**	Essential	SWE
Total Electron Content					
Justification:	Measure of ionospheric influence on signal for GNSS and SATCOM.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3132	**Service:**	AVI	**Priority:**	Essential	SWE
Scintillation indices (S4, sigma_phi, fading depth, fade duration, time between fades)					
Justification:	Measure performance degradation of GNSS due to scintillation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AVI-3250	**Service:**	AVI	**Priority:**	Essential	SWE
Solar radio bursts					
Justification:	Affects GNSS signals and L-band satellite tracking.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3251	**Service:**	AVI	**Priority:**	Essential	SWE
Smoothed Sunspot number (SSN)					
Justification:	To provide statistical information of solar cycle evolution.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3252	**Service:**	AVI	**Priority:**	Essential	SWE
Solar flux density from entire solar disk at 10.7 cm (F10.7)					
Justification:	To provide statistical information of solar cycle evolution.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3263	**Service:**	AVI	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3268	**Service:**	AVI	**Priority:**	Essential	SWE
Improved anisotropy for nowcast of radiation dose during GLE events					
Justification:	required for accurate dose estimation				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

14.3. PERFORMANCE REQUIREMENTS

SWE-CRD-AVI-3047	**Service:**	AVI	**Priority:**	Essential	SWE

Updated information on space weather phenomena shall be issued as necessary but at least every six hours until such time as the space weather phenomena is no longer detected and/or is no longer expected to have an impact.			
Justification:	Notification during disturbed conditions is essential for the user.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AVI-3133	**Service:**	AVI	**Priority:**	Essential	SWE
Data relating to airline critical communications shall be obtained for specific regions with an update not larger than 30 minutes.					
Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3134	**Service:**	AVI	**Priority:**	Essential	SWE
Data relating to precise location determination shall be obtained for specific regions with a narrow 3D volumetric grid with an update not larger than 30 minutes.					
Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.				
Comments:	New CR created from SWE-CRD-NSO-1773.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AVI-3269	**Service:**	AVI	**Priority:**	Essential	SWE
Altitude range for radiation nowcast and forecast products shall extend to 100km altitude					
Justification:	Extended altitude range takes into account radiation dose dur to GCR for sub-orbital space tourism.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

15. SERVICE DOMAIN #10 RESOURCE EXPLORATION AND EXPLOITATION

Resource exploitation activities that may be sensitive to space weather effects include offshore drilling and surveying activities.

Directional drilling involves making non-vertical boreholes in Earth's surface sometimes of several kilometres length and is considered a standard procedure in the petroleum industry. The trajectory of a well should be determined as exactly as possible through measuring its length and direction compared to the gravitational and magnetic fields at short intervals.

During periods of increased geomagnetic activity in the Arctic region, deviations in the field of several degrees in direction and hundreds of nano-Tesla in field strength are often experienced which may exceed the accuracy required to accurately measure the trajectory. Monitoring the magnetic disturbances field and possibly correct for them are thus of considerable importance to achieve precise wellbore trajectories.

Magnetic surveys to produce maps of the local magnetic field are standard procedure when searching for mineral resources as well as oil and gas, on land as well as offshore. In the petroleum industry, maps of the magnetic field are also important in order to improve well-bore navigation. Aeromagnetic surveys are subject to disturbances in the magnetic field created by currents in the ionosphere and magnetosphere and ionospheric irregularities giving rise to uncertainties in space-based positioning systems.

The Space Weather system will aim to provide space weather information supporting resource exploration/exploitation users throughout the European region.

15.1. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-RES-3074	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide a nowcast of local geomagnetic activity for aeromagnetic surveys.					
Justification:	Monitor activity during survey.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-RES-3075	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts (0-8hr, 24-48hr) of local geomagnetic activity for aeromagnetic surveys.					
Justification:	Reschedule survey in case of strong activity.				
Comments:	The 8-hour forecast window includes a typical 6-hour survey flight duration plus up to 2 hours flight preparation time.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3077	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide an "All-quiet conditions" geomagnetic forecast with an 8-hour lead time.					
Justification:	Used during planning of aeromagnetic surveys.				
Comments:	The 8-hour forecast window includes a typical 6-hour survey flight duration plus up to 2 hours flight preparation time.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3078	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide a nowcast of local geomagnetic activity for directional drilling.					
Justification:	Mainly used to verify outlier points in survey rather than measurement interruption.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3079	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts (0-6hr, 24-48hr) of local geomagnetic activity for directional drilling.					
Justification:	Mainly used to verify outlier points in survey rather than measurement interruption.				
Comments:	Rescheduling campaigns is a cost driver and so high confidence levels are required for forecast values.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-RES-3168	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcasts of global ionospheric scintillation maps.					
Justification:	Required for precise location determination during resource exploration/surveying activities.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3169	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide global near real-time TEC maps on medium and large scales.					
Justification:	Correct for effects of TEC on positioning data and, where applicable, variation on altimeter data.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3170	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide forecasts of global ionospheric scintillation maps.					
Justification:	Provide advanced notification of conditions likely to cause ionospheric scintillation.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3171	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide alerts and data of global ionospheric scintillation maps.					
Justification:	Required for precise location determination during resource exploration/surveying activities.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-RES-3172	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide global forecast TEC maps on medium and large scales.					

Justification:	Provide advance notification of TEC enhancements or depletions.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-RES-3173	**Service:**	RES	**Priority:**	Essential	SWE
The Space Weather System shall provide data and tools to support drilling operators in post-event analysis.					
Justification:	Investigation of anomalies				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

15.2. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-RES-3076	**Service:**	RES	**Priority:**	Desirable	SWE
Network of magnetometer measurements in vicinity of customer drilling/survey site.					
Justification:	Used to verify outlier points in case of drilling or to delay measurements in case of aeromagnetic survey.				
Comments:	Target spatial resolution is approx. 100km. In some cases this may imply locating magnetometers offshore in the vicinity of major gas / oil fields.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3174	**Service:**	RES	**Priority:**	Essential	SWE
Solar wind bulk velocity at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3175	**Service:**	RES	**Priority:**	Essential	SWE
Solar wind bulk density at L1					

Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.		
Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-RES-3176	**Service:**	RES	**Priority:**	Essential	SWE
Interplanetary magnetic field at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3177	**Service:**	RES	**Priority:**	Essential	SWE
Solar disk imaging					
Justification:	Monitor solar activity in order to provide information on enhanced solar activity that could lead to geoeffective CMEs and high speed streams.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3178	**Service:**	RES	**Priority:**	Essential	SWE
Solar X-ray flux nowcast					
Justification:	Monitor D-region absorption for communication in HF (shortwave fadeout events) and contribute to SEP and global activity forecast.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3179	**Service:**	RES	**Priority:**	Essential	SWE
Solar coronal imaging					
Justification:	Observe coronal structures as they propagate outwards through the corona.				
Comments:	For example, coronagraph imaging.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-RES-3180	**Service:**	RES	**Priority:**	Essential	SWE
Total Electron Content					
Justification:	Measure of ionospheric influence on signal for GNSS and SATCOM.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3181	**Service:**	RES	**Priority:**	Essential	SWE
Scintillation indices (S4, sigma_phi, fading depth, fade duration, time between fades)					
Justification:	Measure performance degradation of GNSS due to scintillation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3253	**Service:**	RES	**Priority:**	Essential	SWE
Provision of geomagnetic indices.					
Justification:	Provide access to latest planetary indices such as Kp, Ap and archive.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-RES-3264	**Service:**	RES	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

15.3. PERFORMANCE REQUIREMENTS

SWE-CRD-RES-3182	**Service:**	RES	**Priority:**	Essential	SWE
Data relating to precise location determination shall be obtained for specific regions with a narrow 3D volumetric grid with an update not larger than 30 minutes.					

Justification:	Takes into account spatial and temporal scales of disturbances affecting the user.		
Comments:	New CR created from SWE-CRD-NSO-1773.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

16. SERVICE DOMAIN #11 AURORA OBSERVATION & FORECAST

The Aurora Borealis are caused by the interaction of energetic particles with the Earth's atmosphere. They often appear to the observer as curtains of light, but they may also appear as arcs or spirals. Most appear green in colour, but sometimes other colours are visible including pink, red, violet and white depending on the molecules with which the energetic particles are interacting. The lights typically are seen in the far North, but strong geomagnetic activity can lead to them being visible as far South as mainland Europe.

Auroral observation and forecast services are used by the tourism sector including hotels and tour operators visiting the auroral region and the general public in order to maximise the possibility of successful viewing. They are also of considerable interest in understanding ionospheric modifications which affect radio propagation. This service outline focuses on the former user group with radio propagation impacts considered within other sections of this document.

16.1. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-AUR-3008	**Service:**	AUR	**Priority:**	Essential	SWE
The Space Weather System shall provide forecast of the probability of visible auroras (>18hours, >12 hours, >6 hours, >3 hours).					
Justification:	Alert aurora watchers of the probability of visible aurora during the planning of an auroral expedition.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AUR-3009	Service:	AUR	Priority:	Essential	SWE
The Space Weather System shall provide a daily bulletin to describe Space Weather conditions for the next 18 hours.					
Justification:	Provide situational awareness for aurora watchers to aid in planning of upcoming expeditions.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AUR-3271	Service:	AUR	Priority:	Essential	SWE
Auroral activity nowcast					
Justification:	Alert aurora watchers of the probability of visible aurora during an auroral expedition.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

16.2. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-AUR-3010	Service:	AUR	Priority:	Essential	SWE
Solar coronal imaging					
Justification:	Observe coronal structures as they propagate outwards through the corona.				
Comments:	For example, coronagraph imaging.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AUR-3183	Service:	AUR	Priority:	Essential	SWE
Solar wind bulk velocity at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-AUR-3184	Service:	AUR	Priority:	Essential	SWE
Solar wind bulk density at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AUR-3185	Service:	AUR	Priority:	Essential	SWE
Interplanetary magnetic field at L1					
Justification:	Detection of transient or recurrent structures in the solar wind in order to advise of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AUR-3186	Service:	AUR	Priority:	Essential	SWE
Solar disk imaging					
Justification:	Monitor solar activity in order to provide information on enhanced solar activity that could lead to geoeffective CMEs and high speed streams.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AUR-3187	Service:	AUR	Priority:	Essential	SWE
Solar X-ray flux nowcast					
Justification:	Contribute to SEP and global activity forecast.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-AUR-3188	Service:	AUR	Priority:	Essential	SWE
Auroral visible imaging					
Justification:	Input to tourism-oriented services: ground based or space based data applicable.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-AUR-3265	**Service:**	AUR	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

16.3. PERFORMANCE REQUIREMENTS

17. SERVICE DOMAIN #12 GENERAL DATA AND MODELLING SERVICES

The output of this service domain will support the activities of a wide range of users including expert users, ground and space system operators, third party service developers/providers in a range of domains, the education sector and the general public. This service domain gives users the maximum amount of flexibility to use the Space Weather system data and components according to their needs, in conjunction with the tailored services where appropriate. The availability of data products and model outputs shall be guaranteed to the same level as tailored services for this purpose. Caveats relating to model accuracy will be provided as needed. The users include external users as well as the Service Domains described in previous sections of this document as "users" internal to the Space Weather system utilising service components.

17.1. LIST OF DOMAIN SERVICES

Service	Description	Service Components
Space weather data repository	Repository of all available European space weather data	SWE-CRD-GEN-1678 SWE-CRD-GEN-2673 SWE-CRD-GEN-2674

		SWE-CRD-GEN-2675 SWE-CRD-GEN-2676 SWE-CRD-GEN-2677 SWE-CRD-GEN-2678 SWE-CRD-GEN-2679 SWE-CRD-GEN-2680 SWE-CRD-GEN-1685
Latest data guaranteed service	Provide agreed set of guaranteed data required to provide input to tailored service and non-tailored customer service.	SWE-CRD-GEN-1672 SWE-CRD-GEN-2659 SWE-CRD-GEN-2657 SWE-CRD-GEN-2655
Space weather nowcast and forecast products	Provide nowcast/forecast space weather parameters	SWE-CRD-GEN-1673 SWE-CRD-GEN-2665 SWE-CRD-GEN-2666 SWE-CRD-GEN-1674 SWE-CRD-GEN-2670 SWE-CRD-GEN-2671 SWE-CRD-GEN-2672 SWE-CRD-GEN-1675 SWE-CRD-GEN-1676 SWE-CRD-GEN-1679 SWE-CRD-GEN-2653 SWE-CRD-GEN-1680 SWE-CRD-GEN-2642 SWE-CRD-GEN-1686
Event based alarms	Alarms on an as-needed basis (flare, CME, SPE, magnetic storm onset, etc). Incorporate relevant data and where feasible rapid model outputs indicating likely consequences (e.g. time of interplanetary shock reaching Earth). Agreed set of default alarms. Subscription service will allow for tailored	SWE-CRD-GEN-1672 SWE-CRD-GEN-2658 SWE-CRD-GEN-2656 SWE-CRD-GEN-2655 SWE-CRD-GEN-2654 SWE-CRD-GEN-1673 SWE-CRD-GEN-2667 SWE-CRD-GEN-2668 SWE-CRD-GEN-2669

	automated alarms on a particular parameter/dataset.	SWE-CRD-GEN-2643
Virtual space weather modelling system	Service geared towards end-to-end space weather modelling. Model integration and validation as part of a coordinated framework. Service will aim to provide the best possible end-to-end space weather simulation, coupling European modelling assets in order to simulate propagation of space weather phenomena from the Sun. Both users and developers will benefit from this service as incorporation of models into a coherent framework will stimulate further development of targeted models. The system shall also be utilised for end-to-end modelling underpinning event arrival and impact forecasting. Models shall be available both in combination through a single interface as part of the system and also individually as required to underpin user driven services.	SWE-CRD-GEN-1682 SWE-CRD-GEN-2645 SWE-CRD-GEN-2646 SWE-CRD-GEN-2647 SWE-CRD-GEN-1683 SWE-CRD-GEN-1685
Space Weather Training and Support Material	Space weather training and associated educational material, also including web based content	SWE-CRD-GEN-1681

17.2. REQUIRED SERVICE COMPONENTS TO BE DELIVERED

SWE-CRD-GEN-1672	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide the latest values for an agreed set of guaranteed data.					
Justification:	"Guaranteed" w.r.t. the system reliability shall be defined by the service level agreement with the customer. "Guaranteed" w.r.t the data served should be a list of the data that shall be provided by the system.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2659	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide the latest data with a maximum delay agreed with the customer for each dataset.					
Justification:	In many cases timeliness of data provision to the user is a critical element of a service, allowing decision making based on current information.				
Comments:	All GEN data requirements are relevant for this product				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2658	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide an alert to registered users if the latest value for a dataset is older than a given threshold, i.e. stale. The alert will be in machine and human processable form.					
Justification:	Relevant if providing input to tailored service and non-tailored customer services.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2657	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall guarantee provision of latest data values for specific users, either by pushing it to the customer, notification to the customer that new data is available or RSS type feed.					
Justification:	Guaranteed system can/needs not be provided in all cases.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2656	Service:	GEN	Priority:	Essential	SWE

The Space Weather System shall be able to provide Event based alarms for any of the latest values produced in SWE-CRD-GEN-2657.			
Justification:	Provides alerts on the latest data generated. These alarms shall be in a format to provide for processing by both human and machines (to allow for the automated initiation by the customer of their event processing models).		
Comments:	All GEN data and model requirements are relevant for this product.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-2655	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall define a general set of alarms for latest values for each Service Domain.					
Justification:	Alarms can be tailored to thresholds appropriate for a given User Domain.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2654	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall allow users to define their own event-based alarms for latest values.					
Justification:	In cases where users have a particular interest/sensitivity, this will allow them to tailor the alarms received accordingly.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1673	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide nowcast products based on data and modelling for specific datasets.					
Justification:	The system shall make use of data and modelling in order to provide a nowcast as close as possible to the actual situation encountered by the user's system/asset.				
Comments:	The initial list of product types should be defined in the SRD. The available products will grow over time, it is important that the types of products be specified in the SRD, so that their interface peculiarities can be addressed in the interface definition. It is unlikely that a complete list of products will ever be available, but the type of products can be specified. All GEN data and model requirements are relevant for this product.				

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-2665	**Service:**	GEN	**Priority:**	Essential	SWE
The nowcast service shall be able to cover a diverse range of data products.					
Justification:	Nowcasts will include several different types of data product.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2666	**Service:**	GEN	**Priority:**	Essential	SWE
Nowcast parameters shall include and be grouped according to the following categories: solar activity, solar wind key parameters (density, magnetic field), geomagnetic, radiation environment (at GEO, MEO, LEO), ionospheric propagation conditions, neutral density and indices.					
Justification:	Nowcasts of different parameters are required by users in several different domains.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2667	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall be able to provide event-based alarms for any of the nowcast products produced in SWE-CRD-GEN-2666 in machine and human readable form.					
Justification:	Alarms/alerts are to be in machine readable and human readable form to permit triggering of automated processing.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2668	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall define a general set of alarms for nowcasts for each Service Domain in machine and human readable form.					
Justification:	Alarms/alerts are to be in machine readable and human readable form to permit triggering of automated processing.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2669	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall allow users to define their own event-based alarms for nowcasts.					
Justification:	Alarms/alerts are to be in machine readable and human readable form to permit triggering of automated processing.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1674	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide forecasts for a list of data products based on data and modelling.					
Justification:	The system shall make use of data and modelling in order to provide a forecast as close as possible to the actual situation encountered by the user's system/asset.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2670	Service:	GEN	Priority:	Essential	SWE
The forecast service shall be able to cover diverse types of data products.					
Justification:	Forecasts will include several different types of data product.				
Comments:	The service needs to be generic enough to incorporate new datasets. No specific list of datasets needs to be defined in the CRD. All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2671	Service:	GEN	Priority:	Essential	SWE
Forecast parameters shall include the following categories: solar activity, solar wind key parameters (density, magnetic field), geomagnetic, radiation environment (at GEO, MEO, LEO), ionospheric propagation conditions, neutral density and indices.					
Justification:	Forecasts of different parameters are required by users in several different domains.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2672	Service:	GEN	Priority:	Essential	SWE

The Space Weather System shall provide forecasts with validities for 3, 6, 12, 24, 48, 72 hours, depending on parameter and models applied.			
Justification:	A wide range of forecast lead times are needed for different user groups.		
Comments:	This is not valid for some parameters e.g. solar cycle. All GEN data and model requirements are relevant for this product.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1675	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide daily forecasts for a list of data products with 1 day, 2 days and weekly outlook.					
Justification:	Collected distribution of key forecast parameters. Outlook to extend to recurrent features such as coronal holes. Of use to a wide range of users who may use the forecast to provide alarms or to decide whether to look more closely at a certain parameter. In wide use via the ISES network.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1676	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide a daily activity report (plus last 24 hours) summarising reported disturbances.					
Justification:	Reported disturbance summary: include all from solar, through magnetospheric, ionospheric to ground based. Standard format using as reference NOAA scales to categorise events.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1678	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide a long-term archive of space weather data.					
Justification:	Long-term archive including sensor data and derived products such as model runs, an event catalogue, related forecasts, warnings and alerts. This will support generation of new indices and further understanding of long-term trends, supporting development of improved models and forecast tools.				
Comments:	Data provision and distribution agreements are required. Archive will be compatible and cross-referenceable with VO activities (e.g. VSO, Virbo).				

	All GEN data and model requirements are relevant for this product.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-2673	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive interface shall serve as a central access to archived data and service products generated in other services.					
Justification:	The archive shall serve as an archive for information generated by the SWE Services.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2674	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive shall include and provide access to derived products including model runs and an event catalogue.					
Justification:	The archive shall serve as an archive for information generated by the SWE services.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2675	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive shall store and provide access to data generated by sources external to the SWE System and those data provided to the SWE System through an SLA or other collaboration agreement.					
Justification:	The archive shall provide a centralised access point for relevant space weather data, facilitating analysis.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2676	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive shall provide a mechanism to support addition and/or generation of new indices.					
Justification:	Analysis of longer-term trends can support generation of new indices and future planning.				
Comments:	All GEN data and model requirements are relevant for this product.				

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-2677	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive shall provide a mechanism to support the reprocessing and versioning of the data.					
Justification:	This may be required for example in the case of recalibration or implementation of a new index algorithm.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2678	**Service:**	GEN	**Priority:**	Essential	SWE
The long-term archive shall provide mechanisms to support the further understanding of long-term trends.					
Justification:	Analysis of longer-term trends can support generation of new indices and future planning.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2679	**Service:**	GEN	**Priority:**	Essential	SWE
The archive shall include any data used in any service of the SWE Domains.					
Justification:	The archive shall provide a centralised access point for relevant space weather data, facilitating analysis.				
Comments:	All GEN data requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2680	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall allow the user to identify the origin and main characteristics of the dataset.					
Justification:	Appropriate metadata will be available such that the user can immediately identify the main characteristics and origin of the datasets prior to incorporating them into any decision-making process.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1679	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide weekly and monthly reports collating information on reported disturbances in the given period.					
Justification:	Collation of information covering the period in question. Used in post-event analysis in order to identify periods of interest.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2653	Service:	GEN	Priority:	Essential	SWE
The weekly/monthly reports shall include as a minimum: TBD					
Justification:	Collation of information covering the period in question. Used in post event analysis in order to identify periods of interest.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1680	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide a notification on "All-quiet conditions" indicating long periods of low activity forecast.					
Justification:	Indication of long (several days) periods of low activity applicable to several user domains including spacecraft operators and human spaceflight.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2642	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall define the "All-quiet conditions" separately for each user domain.					
Justification:	Thresholds and/or key dataset on which the all-quiet threshold is set may vary according to user domain.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-2643	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall provide an “End-of-quiet” alert.					

Justification:	Indication of the end of long (several days) periods of low activity applicable to several user domains including spacecraft operators and human spaceflight.		
Comments:	All GEN data and model requirements are relevant for this product.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1681	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide access to web-based educational courses, material and tutorials for Space Weather.					
Justification:	Tutorials covering aspects of space weather geared towards users and customers.				
Comments:	All GEN data and model requirements are relevant for this product. Information on the types of products available, associated caveats and lessons learned in their usage shall be included.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1682	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide a Virtual Space Weather Modelling System to provide predictions (~30 minutes to days) of space weather events.					
Justification:	Using physical models to predict the propagation of phenomena enables short and long-term forecasting of the environment and effects.				
Comments:	All GEN model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2645	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall allow the integration and validation of models as part of a coordinated framework.					
Justification:	Models must be tested and compared with developer versions to verify installation and configuration.				
Comments:	All GEN model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-2646	**Service:**	GEN	**Priority:**	Essential	SWE

The Space Weather System shall provide a coherent framework to allow coupling of European modelling assets and access to relevant data in order to simulate propagation of space weather phenomena from the Sun to the Earth.			
Justification:	Coupling of models covering domains from the Sun to the Earth is needed to produce reliable predictions for users.		
Comments:	All GEN model requirements are relevant for this product.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-2647	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide tools for validating the respective models based on measurements and by other means (e.g. comparison with other global model coupling efforts).					
Justification:	Accuracy and reliability are important for users of space weather modelling predictions.				
Comments:	All GEN model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1683	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide an interface allowing graphical visualisation (3-D visualisation, 2-D maps and time animation) of combined results of model simulation outputs and subsets thereof.					
Justification:	The scales and complexity of the models involved in an end-to-end simulation make it difficult to grasp the scope of the simulation outcomes from tabulated data. The service shall provide easy to use visualisation tools to ensure maximum usability of these results.				
Comments:	All GEN model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1685	**Service:**	GEN	**Priority:**	Essential	SWE
The user shall be able to configure automated data retrieval/distribution requests.					
Justification:	Allow adaptation to evolving user needs.				
Comments:	All GEN data and model requirements are relevant for this product.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SWE-CRD-GEN-1686	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall provide a long-term solar cycle prediction of 1-2 cycles (with a quantification of the forecast uncertainties) including at least Sunspot Number, Solar EUV Flux,					

F10.7, expected flare activity level, mean and standard deviation of interplanetary magnetic field strength, median and upper/lower sextiles of solar wind pressure.			
Justification:	Useful for many long-term activities including spacecraft design, mission planning.		
Comments:	The forecast period will depend on the parameter.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

17.3. HIGH LEVEL DATA REQUIREMENTS

SWE-CRD-GEN-1687	**Service:**	GEN	**Priority:**	Essential	SWE
EUV images of Sun					
Justification:	Monitor solar activity and input to prediction models.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1688	**Service:**	GEN	**Priority:**	Essential	SWE
Solar magnetograph images					
Justification:	Monitor evolution of solar magnetic fields in advance of solar activity. Input to modelling and forecast.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:	SWE-CRD-GEN-3148		**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1689	**Service:**	GEN	**Priority:**	Essential	SWE
White light solar imaging					
Justification:	Input to calculation of international sunspot number.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1690	**Service:**	GEN	**Priority:**	Essential	SWE
H-alpha images of Sun					
Justification:	Monitor solar flare and quiescent filament development for activity prediction.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1691	**Service:**	GEN	**Priority:**	Essential	SWE
Soft X-ray images of the Sun					
Justification:	Monitor solar activity and input to modelling activities.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1692	**Service:**	GEN	**Priority:**	Essential	SWE
Stereoscopic solar images of CMEs and Corotating Interaction Regions					
Justification:	Monitor solar activity (e.g. CME eruption) from non-L1 positions, e.g. from L5, as input to forecast.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1693	**Service:**	GEN	**Priority:**	Essential	SWE
Solar far-side maps					
Justification:	Identify formation and evolution of large solar active regions on the far side of the Sun. Extends forecast validity period to up to 14 days.				
Comments:	Use helioseismology technique to plot magnetic activity on the far side of the Sun.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1694	**Service:**	GEN	**Priority:**	Essential	SWE
Ly-alpha images					
Justification:	Identification of solar active regions on the far side of the sun through illumination of interplanetary Hydrogen atoms.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1695	**Service:**	GEN	**Priority:**	Essential	SWE
White-light coronagraph images					
Justification:	Monitor coronal mass ejections as they extend out into the extended corona (~1-20 solar radii)				
Comments:	Measurements of the Earth-facing solar disk.				

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1696	**Service:**	GEN	**Priority:**	Essential	SWE
Solar X-ray flux					
Justification:	Monitor full sun integrated X-ray flux at 0.1-0.8nm, 0.05-0.4nm for monitoring and identifying solar flares.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1697	**Service:**	GEN	**Priority:**	Essential	SWE
Solar EUV integrated flux					
Justification:	Monitor full sun integrated flux for input to upper atmosphere models.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1698	**Service:**	GEN	**Priority:**	Essential	SWE
Solar UV flux					
Justification:	Monitor full sun integrated flux for input to upper atmosphere models				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1699	**Service:**	GEN	**Priority:**	Essential	SWE
Solar radio bursts					
Justification:	Monitor solar radio bursts as a means of tracking solar activity and input to forecast models.				
Comments:	Measurements of the Earth-facing solar disk.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1700	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind bulk velocity at L1					
Justification:	Monitor solar wind parameters upstream of the Earth in order to advise of upcoming activity.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1701	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind bulk density at L1					
Justification:	Monitor solar wind parameters upstream of the Earth as input to nowcast and forecast of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1702	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind temperature at L1					
Justification:	Monitor solar wind parameters upstream of the Earth as input to nowcast and forecast of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1703	**Service:**	GEN	**Priority:**	Essential	SWE
Interplanetary magnetic field at L1					
Justification:	Monitor solar wind parameters upstream of the Earth as input to nowcast and forecast of upcoming activity.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1704	**Service:**	GEN	**Priority:**	Essential	SWE
1 MeV to >100 MeV interplanetary protons					
Justification:	Associated with dose, NIEL and SEE effects on spacecraft.				
Comments:	To be considered number of energy bins, cadence and averaging to adequately sample the local environment noting the importance of higher energies (>400, >500MeV) for the aviation sector. Measurements from L1 vantage point.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1705	**Service:**	GEN	**Priority:**	Essential	SWE
1 MeV to >100 MeV interplanetary ions					
Justification:	Associated with dose, NIEL and SEE effects on spacecraft.				

Comments:	Measurements from L1 vantage point.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1706	**Service:**	GEN	**Priority:**	Essential	SWE
0.2-50 MeV solar electrons					
Justification:	Shown to precede some solar proton events. Monitor and provide alarm if significant enhancement observed.				
Comments:	Measurements from L1 vantage point.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1707	**Service:**	GEN	**Priority:**	Essential	SWE
Auroral UV imaging					
Justification:	Identify strength and extent of auroral region during active periods. Inputs to magnetospheric modelling.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1708	**Service:**	GEN	**Priority:**	Essential	SWE
Auroral particle precipitation					
Justification:	Inputs to upper atmospheric modelling.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1709	**Service:**	GEN	**Priority:**	Essential	SWE
Auroral visible imaging					
Justification:	Identify strength and extent of auroral region during active periods. Inputs to magnetospheric modelling.				
Comments:	Both space-based and ground-based cameras are expected to contribute.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1710	**Service:**	GEN	**Priority:**	Essential	SWE
Auroral kilometric radiation (AKR)					
Justification:	Measurement of disturbance above auroral regions.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1711	**Service:**	GEN	**Priority:**	Essential	SWE
Magnetospheric magnetic field					
Justification:	Monitoring spacecraft environment and disturbances.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1712	**Service:**	GEN	**Priority:**	Essential	SWE
In-situ magnetospheric E field					
Justification:	Monitoring plasmasphere and ring-current dynamics. Input to models of inner magnetosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1713	**Service:**	GEN	**Priority:**	Essential	SWE
1-400 MeV protons in radiation belt					
Justification:	Factor into a wide range of dose, NIEL and internal charging effects.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1714	**Service:**	GEN	**Priority:**	Essential	SWE
1-30 keV, 30 keV - 8 MeV electrons in magnetosphere and radiation belts					
Justification:	Factor into a wide range of surface charging (lower energies), dose, NIEL and internal charging effects.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1715	**Service:**	GEN	**Priority:**	Essential	SWE
Neutral density in thermosphere					
Justification:	Monitor for input to spacecraft drag calculations.				
Comments:					

Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1716	**Service:**	GEN	**Priority:**	Essential	SWE
Neutral wind in thermosphere					
Justification:	Monitor for input to spacecraft drag calculations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1717	**Service:**	GEN	**Priority:**	Essential	SWE
Geomagnetic Data from Ground based Observatories					
Justification:	Monitor disturbances for input to nowcast and forecast models of the magnetosphere and upper atmosphere. Determination of dB/dt, monitoring disturbance levels leading to geomagnetically induced currents in power lines. Generation of indices. Determination of magnetospheric plasma density through magnetospheric seismology.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1718	**Service:**	GEN	**Priority:**	Essential	SWE
Ionospheric electron density profile					
Justification:	Used for data assimilation purposes for 3D ionospheric modelling.				
Comments:	May include radio occultation data, ionosonde and/or radar observations.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1719	**Service:**	GEN	**Priority:**	Essential	SWE
Near real-time measurement of atmospheric neutrons					
Justification:	Monitor ground level and aircraft altitude level events caused by solar particle events or observe anisotropies in the background distribution caused by CME propagation in the solar wind.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1720	Service:	GEN	Priority:	Essential	SWE
Near real-time measurements of atmospheric muons					
Justification:	Observe anisotropies in the background distribution caused by CME propagation in the solar wind.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1721	Service:	GEN	Priority:	Essential	SWE
Provision of planetary geomagnetic indices					
Justification:	Provide access to latest planetary indices such as Kp, Ap, Polar Cap index and archive. All form key inputs to modelling activities.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3017	Service:	GEN	Priority:	Desirable	SWE
Data on soil conductances (telluric measurements)					
Justification:	Determination of Earth's electrical conductivity structure for estimating geomagnetic threats by GICs to power lines.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3018	Service:	GEN	Priority:	Essential	SWE
Provision of solar indices					
Justification:	Provide access to latest solar indices (R, R12, F10.7, F30, S10, E10, M10, Y10) and archive. All form key inputs to modelling activities.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3020	Service:	GEN	Priority:	Desirable	SWE
Interplanetary scintillation data					
Justification:	Interplanetary scintillation data will be useful for forecasts of solar wind velocity with longer lead times as available from L1 observations.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3021	Service:	GEN	Priority:	Essential	SWE
Ionospheric Hall and Pedersen conductances					
Justification:	Input parameters for estimating Joule heating and impact of auroral precipitation in the ionosphere.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3022	Service:	GEN	Priority:	Essential	SWE
Global high-latitude convection/electric field					
Justification:	Input to electron density forecasts, for estimating Joule heating and for strength of auroral electrojets in global scales.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3023	Service:	GEN	Priority:	Desirable	SWE
Neutral atmosphere temperature					
Justification:	Input parameter for models which estimate atmospheric drag				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3034	Service:	GEN	Priority:	Essential	SWE
Ionospheric TEC measurements					
Justification:	Useful input for data assimilation in ionospheric modelling. Monitoring of signal propagation conditions for nowcast and forecast.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3038	Service:	GEN	Priority:	Essential	SWE
Provision of local geomagnetic indices					
Justification:	Provide access to local geomagnetic indices in realtime and high temporal resolution together with their archive.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3145	Service:	GEN	Priority:	Desirable	SWE
Radio measurements in the VLF band					
Justification:	Changes of phase recorded on long VLF radio paths from transmitters spatially separated provide information on flare intensity.				
Comments:	This detection method may be more robust during high flaring activity when other detectors may experience saturation.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3147	Service:	GEN	Priority:	Essential	SWE
EUV images of Sun					
Justification:	Monitor solar activity and input to prediction models.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3148	Service:	GEN	Priority:	Essential	SWE
Solar magnetograph images					
Justification:	Monitor evolution of solar magnetic fields in advance of solar activity. Input to modelling and forecast.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3149	Service:	GEN	Priority:	Highly Desirable	SWE
White light solar imaging					
Justification:	Input to calculation of international sunspot number.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3150	Service:	GEN	Priority:	Highly Desirable	SWE
H-alpha images of Sun					
Justification:	Monitor solar flare and quiescent filament development for activity prediction.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-3151	**Service:**	GEN	**Priority:**	Highly Desirable	SWE
Soft X-ray images of the Sun					
Justification:	Monitor solar activity and input to modelling activities.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3152	**Service:**	GEN	**Priority:**	Essential	SWE
White-light coronagraph images					
Justification:	Monitor coronal mass ejections as they extend out into the extended corona (~1-20 solar radii)				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3153	**Service:**	GEN	**Priority:**	Highly Desirable	SWE
Solar X-ray flux					
Justification:	Monitor full sun integrated X-ray flux at 0.1-0.8nm, 0.05-0.4nm for monitoring and identifying solar flares.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3154	**Service:**	GEN	**Priority:**	Highly Desirable	SWE
Solar EUV integrated flux					
Justification:	Monitor full sun integrated flux for input to upper atmosphere models.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3155	**Service:**	GEN	**Priority:**	Highly Desirable	SWE
Solar UV flux					
Justification:	Monitor full sun integrated flux for input to upper atmosphere models				

Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-3156	**Service:**	GEN	**Priority:**	Highly Desirable	SWE
Solar radio bursts					
Justification:	Monitor solar radio bursts as a means of tracking solar activity and input to forecast models.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3157	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind bulk velocity away from the Sun Earth Line (SEL).					
Justification:	Monitor solar wind parameters away from the Sun Earth Line (SEL) in support of forecasting, modelling and supporting missions operating in the heliosphere.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3158	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind bulk density away from the Sun Earth Line (SEL).					
Justification:	Monitor solar wind parameters away from the Sun Earth Line (SEL) in support of forecasting, modelling and supporting missions operating in the heliosphere.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3159	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind temperature away from the Sun Earth Line (SEL).					
Justification:	Monitor solar wind parameters away from the Sun Earth Line (SEL) in support of forecasting, modelling and supporting missions operating in the heliosphere.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3160	Service:	GEN	Priority:	Essential	SWE
Interplanetary magnetic field away from the Sun Earth Line (SEL).					
Justification:	Monitor solar wind parameters away from the Sun Earth Line (SEL) in support of forecasting, modelling and supporting missions operating in the heliosphere.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3161	Service:	GEN	Priority:	Highly Desirable	SWE
1 MeV to >100 MeV interplanetary protons					
Justification:	Associated with dose, NIEL and SEE effects on spacecraft.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3162	Service:	GEN	Priority:	Highly Desirable	SWE
1 MeV to >100 MeV interplanetary ions					
Justification:	Associated with dose, NIEL and SEE effects on spacecraft.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3163	Service:	GEN	Priority:	Highly Desirable	SWE
0.2-50 MeV solar electrons					
Justification:	Shown to precede some solar proton events. Monitor and provide alarm if significant enhancement observed.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3164	Service:	GEN	Priority:	Essential	SWE
Plasmapause location					
Justification:	Used as input to radiation belt and plasmasphere models.				

Comments:	It is an important factor in the ordering of of several space weather phenomena (e.g. the outer radiation belt inner boundary, inner limit for spacecraft charging risk…)		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-3165	**Service:**	GEN	**Priority:**	Desirable	SWE
Plasmaspheric TEC					
Justification:	Removal of the contribution of PTEC to TEC provides an improved estimation of ionospheric disturbances that may impact e.g. communications.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3266	**Service:**	GEN	**Priority:**	Essential	SWE
Heliospheric imaging					
Justification:	Observe coronal structures as they propagate outwards through the heliosphere.				
Comments:	Measurements away from the Sun Earth Line (SEL) e.g. L5.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3270	**Service:**	GEN	**Priority:**	Essential	SWE
Database of GLE measurements					
Justification:	Supports model validation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-3270	**Service:**	GEN	**Priority:**	Essential	SWE
Database of GCR measurements					
Justification:	Supports model validation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

17.4. HIGH LEVEL MODEL REQUIREMENTS

SWE-CRD-GEN-1724	**Service:**	GEN	**Priority:**	Essential	SWE
Solar activity, flare and CME onset.					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1725	**Service:**	GEN	**Priority:**	Essential	SWE
CME propagation through heliosphere					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1726	**Service:**	GEN	**Priority:**	Essential	SWE
Solar particle events					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1727	**Service:**	GEN	**Priority:**	Essential	SWE
Solar wind interaction with magnetosphere					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:	The package should include also a model for high latitude convection (using L1 solar wind data as input) in order to enable forecasts on ionospheric electron density variations.				
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1728	**Service:**	GEN	**Priority:**	Essential	SWE
Radiation belts					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					

Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1729	**Service:**	GEN	**Priority:**	Essential	SWE
Geomagnetic cut-off					
Justification:	For incorporation into end-to-end space weather simulation and estimation of radiation levels at aircraft altitude.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1730	**Service:**	GEN	**Priority:**	Essential	SWE
Magnetosphere-Ionosphere coupling					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1731	**Service:**	GEN	**Priority:**	Essential	SWE
Ionosphere-Thermosphere coupling					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1732	**Service:**	GEN	**Priority:**	Essential	SWE
Global data assimilation models of ionospheric TEC and scintillation including cosmic ray ionisation of upper atmosphere models.					
Justification:	For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1733	**Service:**	GEN	**Priority:**	Essential	SWE
Rate of change of magnetic field components at Earth's surface (dB/dt) and sudden impulse or storm sudden commencement events detection, as well as ground electrical conductivities.					
Justification:	For input to GIC calculations and for incorporation into end-to-end space weather simulation.				

Comments:			
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review Test

SWE-CRD-GEN-1734	**Service:**	GEN	**Priority:**	Essential	SWE
Model for meteoroid stream fluxes					
Justification:	For input to impact risk calculation.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-1735	**Service:**	GEN	**Priority:**	Essential	SWE
Model for debris cloud evolution					
Justification:	For input to impact risk prediction.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3019	**Service:**	GEN	**Priority:**	Essential	SWE
Solar global magnetic field model					
Justification:	For incorporation into end-to-end space weather simulation. Allows characterisation of the solar coronal global structure.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3035	**Service:**	GEN	**Priority:**	Essential	SWE
Ambient solar wind conditions (without eruptive phenomena).					
Justification:	To enable solar wind driven forecasts on high-latitude ionospheric phenomena (e.g. polar cap patch propagation) with longer lead times than available based on L1 observations. For incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review Test	

SWE-CRD-GEN-3036	**Service:**	GEN	**Priority:**	Essential	SWE

Ray-tracing code for RF wave propagation, with the opportunity to use realistic polar ionosphere (based on observations) as the propagation environment.			
Justification:	RF propagation depends on the signal frequency and therefore tailored forecasts for the propagation conditions are needed for different applications probing the ionospheric conditions. For incorporation into end-to-end space weather simulation.		
Comments:			
Source Requirements:			
Related Requirements:	SWE-CRD-GEN-3034 SWE-CRD-GEN-3035	**Verification Method:**	Design Review Test

SWE-CRD-GEN-3037	**Service:**	GEN	**Priority:**	Essential	SWE
High latitude convection (using L1 solar wind data as input)					
Justification:	To enable forecasts on ionospheric electron density variations and for incorporation into end-to-end space weather simulation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

17.5. PERFORMANCE REQUIREMENTS

SWE-CRD-GEN-1736	**Service:**	GEN	**Priority:**	Essential	SWE
Appropriate values of maximum outage duration, minimum time between outages, and maximum time to repair in case of outage shall be established for all services.(*)					
Justification:	These services shall be made operationally available both for direct use and for use as input to third party service providers who also need to guarantee the reliability of their service products. Consequently, the services, the data and products should be available on as near to a continuous 24-7 basis as possible and any unexpected outages shall be guaranteed to be dealt with in an agreed time period.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review

SWE-CRD-GEN-1737	**Service:**	GEN	**Priority:**	Essential	SWE
The services provided by the Space Weather System shall incorporate strategies for handling gaps in data availability for critical datasets.					
Justification:	These services shall be made operationally available both for direct use and for use as input to third party service providers who also need to guarantee the reliability of their service products.				

	The solution shall be selected on a case-by-case basis by considering what is most suitable to each case. The solutions may include: (a) switch to backup sensors, (b) extrapolation from the last measured data value towards values from an appropriate climatological model, with the model being reached over a typical correlation time for data series. The services should include a status flag to indicate the nature of the delivered data.		
Comments:	Strategies for handling gaps shall be identified as for any data source.		
Source Requirements:			
Related Requirements:		**Verification Method:**	Design Review

SWE-CRD-GEN-1738	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall take measures to ensure that the services can continue to function in all space weather conditions.					
Justification:	In particular, space weather sensors should be designed so they continue to provide useful information during solar energetic particle events, and under disturbed ionospheric conditions.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1739	**Service:**	GEN	**Priority:**	Essential	SWE
Space and ground segments shall include calibration information for provided data.					
Justification:	Good calibration of data is required with a view to standardisation.				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Analysis Design Review Inspection

SWE-CRD-GEN-1741	**Service:**	GEN	**Priority:**	Essential	SWE
The Space Weather System shall simulate phenomena faster than real-time to provide forecasts subject to data availability. Forecasts will be updated nearer the event/disturbance arrival time based on new data such as that detected in-situ at L1.					
Justification:	Running physical models of the solar-interplanetary-magnetospheric-ionospheric environment is required for forecasting and future architecture optimisation				
Comments:					
Source Requirements:					
Related Requirements:				**Verification Method:**	Design Review Test

SWE-CRD-GEN-1742	Service:	GEN	Priority:	Essential	SWE
The Space Weather System shall offer browsing facilities and appropriate visualisation tools and functionality in order to view simulation outputs					
Justification:	The scales and complexity of the models involved in an end-to-end simulation make it difficult to grasp from tabulated data, the scope of the simulation outcomes. The service shall provide easy to use visualisation tools to ensure maximum usability of these results.				
Comments:					
Source Requirements:					
Related Requirements:			**Verification Method:**	Design Review	

18. TRACEABILITY MATRIX

Traceability to MRD to be provided in a later issue.

19. ANNEX 1: ADDITIONAL REFERENCE DOCUMENTATION

Document Reference	Scope/Comment
SSA-SWE-MetOffice-MIN001_Statnett_EUM	Minutes from meeting with Statnett (Oslo, Norway) 22/08/2017
SSA-SWE-MetOffice-MIN002_MSB_EUM	Minutes from meeting with Swedish Civil Contingencies Agency (Stockholm, Sweden) 25/08/2017
SSA-SWE-MetOffice-MIN003_SVKEUM	Minutes from the meeting with Svenska Kraftnat (Sundyberg) 24/08/2017
SSA-SWE-MetOffice-MIN005_Eirgrid_EUM	Minutes from meeting with Eirgrid (Dublin, Ireland) 10/10/2017
SSA-SWE-MetOffice_REE_EUM	Minutes from meeting with Red Electra de España (Madrid, Spain) 11/10/2017
SSA-SWE-MetOffice-MIN012_SPEnergy_EUM	Minutes from the meeting with SP Energy Networks (Glasgow, Scotland) 05/12/2017
P3-SWE-I-ESWW14-LunchMeeting_Power	This working lunch took place on 1st December 2017 during the 14th European Space Weather Week following the conference session

	'Ground-based Operational and Infrastructure Impacts of Space Weather'.
SSA-SWE-P3SWEXXIIM_MOM_EDF	Minutes from meeting with EDF Energy (London, England) 11/02/2020
SSA-SWE-MetOffice-MIN004-Stobart_EUM	Minutes from meeting with Stobart Air (Dublin, Ireland) 10/10/2017
SSA-SWE-MetOffice-MIN009_EASA_EUM	Minutes from the meeting with European Aviation Safety Agency (Cologne, Germany) 19/10/2017
SSA-SWE-MetOffice-MIN010_BeCA_EUM	Minutes from meeting with Belgian Cockpit Association (Brussels, Belgium) 24/10/2017
SSA-SWE-MetOffice-MIN013_Rollsroyce_EUM	Minutes from meeting with Rolls-Royce Civil Aerospace (Derby, UK) 06/12/2017
SSA-SWE-MetOffice-MIN014_TAGAviation_EUM	Minutes from meeting with TAG Aviation (Farnborough, UK) 07/12/2017
P3-SWE-I EUL-minutes-Aviation_281117	This working lunch took place on 28th November 2017 during the 14th European Space Weather Week following the conference session 'Aviation Meets Space Weather - Roadmap Towards Space Weather Services for Aviation'.
SSA-SWE-P3SWEXVII-MIN001-ETHNO	Summary of an end-user ethnography session held at TAG Aviation, Farnborough Airport, 27/03/2019
SSA-SWE-P3SWEXVII-MIN002-ETHNO	Summary of an end-user ethnography session held at ESWW15 KU Leuven campus, Leuven, 27/03/2019
SSA-SWE-P3SWEXVII-MIN004-LFV	Minutes from meeting with LFV, the air navigation services of Sweden (LFV, Sweden) 22/03/2019
SSA-SWE-MetOffice-MIN007_Munichre_EUM	Minutes from the meeting with Munich Reinsurance (Munich, Germany) 17/10/2017
SSA-SWE-MetOffice-MIN008_Tesat_EUM	Minutes from the meeting with TeSat Spacecom (Backnang, Germany) 18/10/2017
SSA-SWE-MetOffice-MIN011_EUTELSAT_EUM	Minutes from meeting with EUTELSAT (Paris, France) 26/10/2017

SSA-SWE-MetOffice-MIN015_MoD_EUM	Minutes from meeting with Airbus/Ministry of Defence (Corsham, UK) 09/12/2017
SSA-SWE-P3SWEXVII-MIN003-Telenor	Minutes from meeting with Telenor Satellite Broadcasting (Telenor, Oslo) 21/03/2019
SSA-SWE-SSCC-INS_Mars_Missions_Training_Feedback	Minutes from a dedicated end user feedback session on SSA SWE Mars Missions Training Course
SSA-SWE-P3SWEXII-MIN_MEXmeeting_HJL	Minutes from meeting with ESA Spacecraft Operators regarding Mars Express & SWE Services (Online) 08/04/2020
SSA-SWE-P3SWEXXII-MIN_EUMETSATmeeting	Minutes from an end-user discussion following a training day at EUMETSAT (Darmstadt, Germany) 27/02/2020
SSA-SWE-P3SWEXXII-MIN002	Minutes from meeting with CER (Community of European Railway and Infrastructure) (Brussels, Belgium & online) 11/03/2020
SSA-SWE-XIX-RP-SATELLITE2016	2nd International Conference and Exhibition on Satellite & Space Missions: Meeting Report
SSA-SWE-XIX-RP-SESAR2016	The Sixth SESAR Innovation Days: Meeting Report
SSA-SWE-XIX-RP-ENC2016	ENC2016 Helsinki: Meeting Report
SSA-SWE-XIX-RP-EUROCORR2016	Eurocorr 2016 European Congress: Meeting Report
SSA-SWE-P3SWEXVII-MIN-EUL_EndUsers	Summary of the end-user lunch held at ESWW15 on severe space weather events and end user experiences
SSA-SWE-P3SWEXVII-MIN-EUL_SatRisk	Summary of the end-user lunch held at ESWW15 on satellite environment risk prediction
End User Lunch ESWW9 - Final Version	ESWW9 End User Lunch: Spacecraft Operations and Space Weather
ESWW10 User Lunch Operations	ESWW10 End User Lunch: Spacecraft Operations and Space Weather
SSA-SWE6-TN-0002+EUL-Operation_FINAL	Spacecraft Operations and Space Weather: ESWW11 Service User Dialogue on All-Electric Spacecraft
ssa-swe-swe19.r-Technical Note-00021-i1r1	ESWW13 - Service User Dialogue: Space Weather and Operational Post Event Analysis

ssa-swe-swe19.r-Technical Note-00022-i1r1	ESWW13 - Service User Dialogue: Space Weather effects on GNSS and precise positioning
SSA-SWEXIX-TN-0001+EUL-PowerGrid_i1r2	ESWW12 Service User Dialogue: Power Grid Operations
SSA-SWEXIX-TN-0002+EUL-Operation_i1r2	ESWW12 Service User Dialogue: Spacecraft Operations
DD0005_User_Engagement_Report_i1r1	Summary of the P3-SWE-I SSA Project End-User engagement activities
DD0005_Final User Feedback Report	Document summarising the End User Engagement activities as part of SSA project P3-SWE-XVII
SSA-P3-SWE-I-DD0006-TN01-i1r2	Network Impact Assessment and Recommendations: Summary of the SSCC activities including comments and feedback received from users during meetings, user support campaigns, and from the monthly SSCC helpdesk activity reports
SSA-P3-SWE-XVII-DD-00006-TN01-i1r2	Network Impact Assessment and Recommendations: Summary of the SSCC activities including comments and feedback received from users during meetings, user support campaigns, and from the monthly SSCC helpdesk activity reports
DD0005-RP-CAMPAIGN-AVIATION-i2r3	Summary of the user feedback collected during the User Support Campaign for Aviation that was initiated during SSA P2-SWE-XIX and continued during the SSA P3-SWE-I SSA activity.
DD0005-RP-AVIATION-CAMPAIGN-i1r1	Summary of the user feedback collected during the User Support Campaign for Aviation collected as part of P3-SWE-XXII
SSA-P3-SWE-XVII-RP-AVIATION-CAMPAIGN-i1r3	Summary of all the user feedback collected during the user support campaign for Aviation Service Users that has been carried out within the SSA P3-SWE-XVII activity.
DD0005-RP-SPACECRAFT-OPERATION-CAMPAIGN-i1r1	Summary of the user feedback collected during the User Support Campaign for Spacecraft Operations during the SSA P3-SWE-I activity.

SSA-P3-SWEXVII-RP-MARS-CAMPAIGN-i1r0	summary of the user feedback collected for the ESA Mars mission SWE service demonstrator that has been developed within the SSA P3-SWE-XVII activity.
SSA-P3-SWEXXII-TN-Support_to_GAIA_manoeuvre-i1r1	TN describing the support to the ESA GAIA spacecraft manoeuvre including a section on user feedback.
SSA-P3-SWEXVII-RP-GNSS-CAMPAIGN-i1r3	Summary of all the user feedback collected during the user support campaign for GNSS Service Users that has been carried out within the SSA P3-SWE-XVII activity.
SSA-SWE-SWE1s-RP-4001	User Test Campaign Report - Proba 3 operations support campaign 30/06/2017
SSA-SWE-SWE1s-RP-4002	User Test Campaign Report - Proba 2 operations support campaign 30/06/2017
SSA-SWE-P3SWEII-UTCRP-4100+S105d	User Test Campaign Report - Real Time Light curves of Solar Radio Flux product (S105d) 24/10/2019
SSA-SWE-HESC-RP-0011	Mission User Test Campaign Report of H-ESC activities taking place during P2-SWE-I and corresponding results. 11/07/2017
SSA-SWE-HESC-RP-0291 [not final]	User Test Campaign report of H-ESC EUHFORIA Test & Assessment 01/07/2019
SSA-SWE-SWE1.3-RP-0110	User Test Campaign Report of R-ESC Space Radiation User Test Campaign Report 03/06/2017 (SCO & SCD services)
SSA-SWE-P3SWEIII-RP-0070	User Test Campaign Report of R-ESC Space Radiation 21/10/2019 (SCO & SCD & Aviation services)
P2-SWE-XIII_User_Workshop Minutes	Summary of two user workshops for SCO regarding the Radiation Belt Prototype Forecasting Service (SaRIF)
SSA-SWE-ESCION-TN-0110	User Test Campaign Report for I-ESC provided products on the ESA portal 08/09/2017
SSA-SWE-ESCION-TN-0111	User Test Campaign Report for I-ESC provided products on the ESA portal 20/03/2019
SSA-SWE-GESC-TCR-0100	User Test Campaign Report for G-ESC 04/09/2017

20181016-1600-1730-E4-How_to-KSJ_Report	ESC Thematic Workshop minutes and conclusions: How to combine existing products to provide added value to user
20181017-1115-1130-Carlo_Scotto_Summary_of_feedbacks_and_gaps	Session Products and Tools for the aviation sectors: Summary of feedbacks and gaps from the User Test Campaign, covers the I.ESC product feedback
TN01_SSA-P2-SWE-XII_v9	P2-SWE-XII: Arctic Region User Requirements Study: SWE Customer Requirement Document enhancement proposals
ssa-swe-med-TN01_i1r2	P3-SWE-XXIII: Mediterranean Region User Requirements - SWE Customer Requirement Document enhancement proposals
P3-SWE-XXIII.2_SWUNMed-01-0001	P3-SWE-XXIII: Mediterranean Region User Requirements - SWE Customer Requirement Document enhancement proposals
SLXDE-SRASO-MM-WS - End-User Workshop - 01.00	End-User Workshop meeting minutes
TS-UCPD-RB-FAN-IASB	End-User Workshop Synthesis
SSA-SWE-PLASMA-TN-0001-i1r2+WorkshopReport	Summary of the user workshop help for the PLASMA project to collect use-cases for plasmaspheric products.
P2-SWE-II DD-0008_i001-r001 - Test Campaign Reports	Test Campaign Reports
P2-SWE-II User Workshop Report	P2-SWE-II User Workshop Report
P2-SWE-II Academic Workshop	P2-SWE-II 2nd Workshop (Academic Workshop)
SSA-SWE-SWIGPAD-TN-0002-i1r2+UCD_UseCaseDefinition	Summary of 13 bilateral meetings covering 6 different GNSS user groups discussing their requirements and data needs.
SSA-SWE-HESC-DDP-0001_i6r0	H-ESC DDP including definition of services for users in the solar system
Update recommendations for products-to-services matrix	Products recommended for inclusion in the Aviation dashboard that are currently not part of the products to services matrix: SSCC project output based on user engagement work

SSA-SWE-HESC-RP-0012_1_1- CRD Update Rec Rep DD-012	H-ESC CRD update recommendations to SCO and SCD & SEG that relate to the former.
ssa-swe-resc-ddp-0100-i3r1+DefinitionDevelopmentPlan-SpaceRadiation_P3-SWE-XXVI.1_10082021	R-ESC DDP: recommendations for SCO+SCD improvements
P2-SWE-X, SWE-OHB-TN-01	Recommendations for measurement requirements away from the Sun-Earth line
ssa-swe-swe1.3-tn-0134-i1r1+LAU_Roadmap_Proposed_Updates	SWE Roadmap update proposals
ssa-swe-swe1.3-tn-0173-i1r1+NSOair_Roadmap_Proposed_Updates	SWE Roadmap update proposals
ssa-swe-swe1.3-tn-0131-i1r1+SCD_Roadmap_Proposed_Updates	SWE Roadmap update proposals
ssa-swe-swe1.3-tn-0132-i1r0+SCO_Roadmap_Proposed_Updates	SWE Roadmap update proposals
ssa-swe-swe1.3-tn-0133-i1r1+SCH_Roadmap_Proposed_Updates	SWE Roadmap update proposals
SSA-SWE-STR-RM-0100-i2r2+Roadmap_Spacecraft_Design	SWE Roadmap
SSA-SWE-HESC-RM-0001-i1r4_Roadmap_SCD-PLA	SCD/pla roadmap
SSA-SWE-HESC-RM-0002-i1r3_Roadmap_SCO-PLA	SCO/pla roadmap
ssa-swe-escion-rd-0001_i1r1a+SWE Roadmaps TIO SST	SWE Roadmap
SSA-SWE-STR-RM-0800-i1r0	SWE Roadmap
SSA-SWE-STR-RM-0800-i2r2+Roadmap_NSOaird	SWE Roadmap
SSA-SWE-STR-RM-0700-i1r0	SWE Roadmap
SSA-SWE-STR-RM-0400-i2r1+Roadmap_Launch_Operation	SWE Roadmap
SSA-SWE-STR-RM-0300-i2r1+Roadmap_Human_spaceflight	SWE Roadmap

SSA-SWE-STR-RM-0200-i2r1+Roadmap_Spacecraft_Operation	SWE Roadmap
SSA SWE Human Spaceflight Domain Requirements Review	Report from meeting with EAC biomedical engineering team

20. ANNEX 2: DEFINITIONS

Concept	Definition
Product Specific Terminology	
Accuracy of data	An estimate of the closeness of agreement between measured data and the observable being measured. In practice this is reflected by an uncertainty value taking into account all known and quantifiable sources of error in the data.
Alarm	Near real-time notification issued when a dangerous condition occurs.
Alert	Timely notification to the user that conditions of interest are taking place or are expected to take place.
Data	Model output, raw or processed measurements of any space weather parameter.
Forecast	Description of the space environment at a future date based on actual data, proxies and models
Index	A set of derived variables frequently used to parameterise space weather conditions and as input to models. The default sets of indices are: • Solar Activity and geomagnetism:, Ap, Kp, Dst, AE, Polar Cap Index, IG12, IMF, R, R12, F10.7, F30, S10, E10, M10, Y10; • Ionospheric scintillation: S4, Sigma_phi, fading depth, fade duration, time between fades
Model	A representation of a physical phenomenon built on data (measured and/or theoretical). There are three types of model:

	• Empirical: A model that is based on observations. • Physics-based: A model that is based on first principles. It relies on mathematical descriptions of specific physical phenomena. • Semi-empirical: A model that is partially based on observations and partially on first principles
Near Real-time	Statement that an action is occurring as close as possible to the same rate at which an observable is measured/observed
Nowcast	Reconstruction in near real-time of a description of the present space environment based on actual data, proxies and models
Product interface	The means by which a particular product is accessed, examples of which are a user interface (GUI, web form, menu driven) or an API. Usually, the product interface will conform to some well-defined standard in order to aid interoperability and re-use
Real-time	Statement that an action is occurring at the same rate at which an observable is measured/observed
Report	This class of product consists of summary reporting tailored towards user needs describing ongoing, past or expected conditions and provided as part of a service. Reports build on products and expertise available within the SWE Service System. Reports are considered to be products where these are produced as part of the SWE Services.
Space Weather Guaranteed Dataset	A set of different variables delivered by an entity that verifies and guarantees, to the extent possible, not only the health and reliability of each individual datum but also the consistency of the set.
Warning	Near real-time notification of a potentially hazardous situation.
Space Weather Service Definitions	

Accuracy of service	An estimate of the closeness of agreement between service output and the associated observable conditions. In practice this is reflected by an uncertainty value based on known performance statistics.
Operational	A product, tool or service that has been validated and certified suitable for use in the intended operational context
Pre-operational	A product tool or service that has been validated against the criteria for use in the intended operational context but is not yet being demonstrated to meet operational use.
Product	Derived data generated using one or more space weather tool or model. A Product is a digital file(s) delivered to members of a user community from an operational element of the system that has a defined format and is archived and is reproducible. The generation of a product or a family of products is part of a service of the SWE Service System or to the SWE Service System. Software tools made available to users or a technical report are not considered as products.
Reliability	The ability of an element of the SWE service network to perform its required functions under its given operational conditions. The reliability of an element of the system is considered “undetermined” until it has been evaluated. When the element fulfils all predetermined criteria, it can be considered “reliable”.
Service	A service is a collection of derived data products, software tools, technical reports and associated user support addressing the high-level requirements of a specific group of users as defined by the Customer Requirements Document
Tool(kit)	A software application which provides the end user with the facility to retrieve and/or process and further modify a given set of products according to their needs as part of a SWE Service.

User requirement	The specification of what the user expects of the product, service or system to provide in order to fulfil their needs.
Validation	Validation is a process which demonstrates that the product is able to accomplish its intended use in the intended operational environment. The status of the product following validation is "validated". Verification is a pre-requisite for validation.
Verification	Verification is a process which demonstrates through the provision of objective evidence that the product is designed and produced according to its specifications and the agreed deviations and is free of defects. Verification can be accomplished by one or more of the following methods: • analysis (including similarity), • test, • inspection, • review of design. The status of the product following verification is "verified".
Roles Referred to in this document	
Customer	Entity responsible for procuring the establishment of the SWE Service System.
End user	A SWE service (end) user is anyone, a person/institution or an electronic system, that accesses or receives SWE products or services.
Third Party Service Provider	Entity (research institute or commercial) developing and establishing a service based on data provided by the Space Weather system through an individual customer-service agreement that goes beyond the scope of the other SWE tailored services.
Space Weather Domain Definitions	
Coronal Mass Ejection	An outflow of plasma from or through the solar corona. CMEs are often, but not always, associated with erupting prominences, disappearing solar filaments,

	and/or flares. CMEs vary widely in structure, density, and velocity. Large and fast CMEs can approach masses of 1.6 × 10^12 kg and approach velocities over 2000 km/s. Earth impacting CMEs can result in significant geomagnetic storms. Types of coronal mass ejections launched toward Earth are called "halo CMEs" because as they approach Earth, they appear larger than the Sun, making a halo of bright coronal emission completely around it.
Cosmic Rays	General term comprising galactic cosmic rays, anomalous cosmic rays and solar cosmic rays (e.g. solar energetic particles). • Galactic cosmic rays: High-energy charged particles (up to 10^21 eV) originating from outside the solar system. • Anomalous cosmic rays: Charged particles (approx. 10-100 MeV) originating from neutral interstellar atoms that have been ionised by solar UV radiation after entering the heliosphere. • Solar energetic particles: Charged particles (from a few keV up to GeV) originating in at least two distinct locations, namely the solar flare and the coronal mass ejection-driven interplanetary (IP) shock. Commonly referred to as solar energetic particles when they are observed in IP space and near Earth.
Interplanetary Shock	Interplanetary shocks are a type of collision-less shock - ones where particles transfer energy through electromagnetic fields instead of directly bouncing into one another.
Single Event Effects	With reference to the effects of energetic particles on spacecraft microcircuits - an unexpected change in the logic state of a single digital bit. SEUs can be either soft (the microcircuit is not damaged and can be rewritten to either state), or a latch up, which cannot easily be reset

Solar activity	The collective term for all active phenomena on the Sun, including sunspots, faculae, active regions, plages, active prominences, and flares.
Solar energetic particle (SEP) event	A solar energetic particle event is a sudden release of particles (protons, electrons and heavy ions) with energy ranging from a few tens of keV to GeV and associated with solar eruptive phenomena or interplanetary coronal mass ejections.
Solar Flare	A solar flare is an intense burst of radiative energy across the entire EM spectrum, with the largest enhancements in the X-ray, EUV and radio portions. Powerful flares are often, but not always, accompanied by a CME. Flares are labelled with a letter and number. The letter is the flare class and indicates the peak intensity in W/m2 of X-rays in the 0.1-0.8nm wavelength range as measured at Earth by the GOES spacecraft. The weakest one is A class followed by the classes B, C, M and X, each letter represents a 10-fold increase in energy output. Within each letter class there is a finer scale from 1-9 although X-class flares could be higher.
Spacecraft anomaly	Anomalous or unexpected behaviour of a spacecraft or any of its subsystems.
Spacecraft Effects	Effects observed as a result of the interaction of a spacecraft or device with the local space environment. Examples include radiation dose, single event effects, sensor background accumulated charge and spacecraft anomalies.
Space Weather	Space Weather is the physical and phenomenological state of natural space environments. The associated discipline aims, through observation, monitoring, analysis and modelling, at understanding and predicting the state of the Sun, the interplanetary and planetary environments, and the solar and non-solar driven perturbations that affect them, and also at forecasting and nowcasting the potential

	impacts on biological and technological system**s**
Space Weather Event	A time-limited condition of the space environment (e.g. Solar Flare, Solar energetic particle event, Substorm). Often this involves a propagating disturbance (e.g. CME or interplanetary shock).
Susceptibility	The response of a material or substance to a change in conditions. In the spacecraft case, this may be characterised by e.g. • SEP susceptibility: Rate of destructive and non-destructive SEEs in specified components under specified shielding levels due to an SEP event • Surface charging susceptibility: Surface potentials of defined materials due to ambient plasma • Internal charging susceptibility: Internal charging levels of specified dielectric components under specified shielding • Degradation due to radiation susceptibility: Dose and NIEL degradation of specified components under specified shielding (including solar cell degradation) • Satellite attitude change susceptibility: Deviations in magnetic torque • Satellite orbit change susceptibility: Orbit alteration due to drag enhancement in LEO • EM interference susceptibility: • Telecommunications interference (TBC)