

SPACE RADIATION EFFECTS NOWCAST PLATFORM *USER QUESTIONNAIRE*

Introduction

The Space Radiation Effects Nowcast (SREN) platform is an under development system for the near-real-time calculation and visualization of radiation environment and effects providing a new class of services & products to end users from the satellite industry. SREN GUI will provide suitable interfaces for assessing and visualizing the space environment and its effects for both near-real-time and historical analysis. As a result, satellite operators and radiation effects analysts will have quick access to qualitative & quantitative information on present and past critical events.

- The purpose of this User Questionnaire is to allow the SREN team to harvest relevant input from potential end users within the space industry, space agencies and other national/international institutions, spacecraft operators, academic and research institutions.
- The responses to this questionnaire will allow the team to assess current and future needs regarding the near-real time monitoring, nowcasting and potentially forecasting of space radiation environments and effects to support the wide range of potential users.

As a result SREN team will be able to prioritize the efforts to be made in the initial de-risk phase of the work and generate a thorough and more comprehensive catalogue of features and functionalities to be supported by the follow-on, fully fledged development of the SREN Platform.

Contextual Notes

The most value will be gained from the questionnaire responses if the User takes a wide view of his or her potential needs and Use Cases, as opposed to a rather more narrow view based on his or her current role, project definition and recent experiences. In order to explain this more clearly, the User is asked to consider the following bullet points when completing the questionnaire:

- **Variability of Space Weather and the Space Environment.** The User is asked to consider Space Weather and the Space Environment within a historical context: the current solar cycle (Solar Cycle 24), has been very benign in terms of those before it and it is potentially easy for Users to become complacent and forget the more severe conditions that have occurred previously and which will surely occur again in the future. Most Space Weather issues that have occurred during the present solar cycle have been associated with Coronal Hole High-Speed Stream related energetic electron enhancements causing Internal Charging; Galactic Cosmic Ray (GCR) related Single Event Effects (SEE) or Surface or Shallow Charging / ESD (e.g., the Galaxy 15 anomaly). There have been only historically insignificant Geomagnetic Storms, nothing like the 2003 Halloween Storms or those which occurred in the 1989-1991 and 2000-2001 timeframes. There have been very few significant Solar Flare / Solar Particle Events (SPE): at Geosynchronous Orbit there has been NO measurable Solar Flare / SPE related solar array degradation since October / November 2003, although such events were quite common in the period 2000 – 2003. Clearly the SREN team would like Users to feedback on their needs for less benign times.

Confidential Information: Yes: No:

- **Evolution of the Space Industry in terms of new orbits and missions.** The User is asked to consider how his business or activities may change and the effect that this will have on his/her space environment monitoring requirements. For instance, traditional Satellite Operators such as SES, Inmarsat, Eutelsat and Telesat have predominantly used the Geostationary Orbit and launched their spacecraft using conventional launchers and short duration (7-20 days) chemical orbit raising missions. This paradigm has defined their exposure to Space Weather / Space Environment effects and limited their interest to Surface and Internal Charging / ESD, occasional episodes of Solar Array Degradation and Single Event Effects (SEE) due to Solar Particle Events (SPE) and SEE due to Galactic Cosmic Rays (GCR). Increasingly, however, these operators are using lower capability launchers, resulting in long duration (>100 days, occasionally >200 days) Electric Orbit Raising missions traversing the inner radiation belt and the peak of the outer radiation belt. The same operators are now procuring and building constellations which will operate in orbits for which they themselves have little heritage: equatorial low – MEO (~8000 km), inclined low – MEO, inclined LEO, polar LEO. Thus, their spacecraft hardware will be exposed to very different Space Weather / Space Environment conditions and effects than they are used to. Whilst these orbital regimes have and are used considerably, the experience and knowledge gained tends to be focused within a very few Government / Institutional agencies (NOAA, NASA, ESA). Additionally, the vast majority of Space Weather service / forecasting infrastructure is focused on the GEO region, with very few services or providers supporting these ‘new’ or ‘novel’ operational orbit regimes.
- **Evolution of spacecraft technology.** Historically speaking, the Space Industry has traditionally been very conservative in terms of the technologies, components, materials and practices used to design and manufacture spacecraft. Increasingly, however, Commercial Off The Shelf (COTS) components are being considered and used in the so called NewSpace industry and constellations such as OneWeb etc. These components may be less robust to the space radiation etc environment, and in many cases are much more complicated than the components traditionally used. Some examples are the increased usage of complex FPGAs, very high speed processors and mass memories. Novel technologies such as planar phased array antennas are finding application in spacecraft hardware, this potentially introduces new concerns regarding, for example Surface Charging / ESD and radiation degradation of material properties. The User is asked to consider the impact of this industry evolution on his or her future space environment monitoring / nowcasting / forecasting needs.

Basic Information

Name	
Affiliation	
Postal address	
Email address	
Skype id	
Tel number	
Mobile number	

Additional Contact with the SREN platform team

How you wish to communicate with the SREN Platform team in the future?

- Would you be interested in completing additional questionnaires in the future, related to specific aspects of SREN requirements / functionality?
- Would you be interested in participating in a WEBEX / telecon regarding specific aspects of SREN requirements / functionality?
- Would you be interested in participating as a Test User of the SREN Platform?
- Would you be interested in participating in a SREN related Splinter Session at a relevant conference, such as the European Space Weather Week (ESWW)?

SREN interest context

The purpose of the following questions is to allow the SREN team to assess the way in which you as a user will potentially benefit from the SREN Platform and build up a picture of the overall potential user domain.

How many years has your organization been active / interested in the Space Weather / Space Environment domain?		
How many years have you personally been active / interested in the Space Weather / Space Environment domain?		
<p>Please indicate in which ways, if any, you are responsible for advising operations staff or other decision makers on Space Weather / Space Environment issues.</p> <div style="border: 1px solid black; padding: 10px; min-height: 150px;"> <p>Comments:</p> </div>		
<p>Please briefly describe the role of your institution.</p> <div style="border: 1px solid black; padding: 10px; min-height: 150px;"> <p>Comments:</p> </div>		
<p>Overall, how to you best classify your institution?</p> <p>[Choose one]</p>	Industrial (e.g. satellite manufacturer)	<input type="checkbox"/>
	Commercial (e.g. satellite operator)	<input type="checkbox"/>
	Governmental (e.g. space agency)	<input type="checkbox"/>
	Academic (e.g. research institute, university)	<input type="checkbox"/>

In terms of your personal work, how do you classify your role within your organization?	Support to spacecraft operations	<input type="checkbox"/>
	Spacecraft mission design	<input type="checkbox"/>
	Spacecraft procurement	<input type="checkbox"/>
	Spacecraft design	<input type="checkbox"/>
	Spacecraft manufacture	<input type="checkbox"/>
	Space science / space environmental modeling	<input type="checkbox"/>
	Space Weather Forecasting	<input type="checkbox"/>

Please describe briefly the role that you have in analyzing Spacecraft Anomalies and Spacecraft Performance monitoring.

Comments:

Please describe briefly any role you have in defining Spacecraft Requirements and Specifications.

Comments:

Orbits / Missions of Interest & Application Domain

The purpose of the following questions is to allow the SREN team to assess which types of orbit / mission and industrial / commercial / scientific application domains that you are interested in.

Which mission/orbit types are of main interest to you?

	at present	in the future
Interplanetary	<input type="checkbox"/>	<input type="checkbox"/>
LEO, equatorial or inclined (<50°)	<input type="checkbox"/>	<input type="checkbox"/>
LEO, polar (>50° inclination)	<input type="checkbox"/>	<input type="checkbox"/>
Low MEO (>2000 km, <10000 km altitude)	<input type="checkbox"/>	<input type="checkbox"/>
High MEO (eg: GNSS orbits)	<input type="checkbox"/>	<input type="checkbox"/>
GEO – traditional chemical orbit raising	<input type="checkbox"/>	<input type="checkbox"/>
GEO – Electric Orbit Raising	<input type="checkbox"/>	<input type="checkbox"/>
Other.....please elaborate in the box below:		

Comments:

Which application domains are of main interest to you?

	at present	to the future
Telecommunications - broadcasting	<input type="checkbox"/>	<input type="checkbox"/>
Telecommunications – messaging / data	<input type="checkbox"/>	<input type="checkbox"/>
GNSS	<input type="checkbox"/>	<input type="checkbox"/>
Science / astronomy	<input type="checkbox"/>	<input type="checkbox"/>
Earth Observation / meteorology	<input type="checkbox"/>	<input type="checkbox"/>
Manned spaceflight	<input type="checkbox"/>	<input type="checkbox"/>
Other.....please elaborate in the box below:	<input type="checkbox"/>	<input type="checkbox"/>

Comments:

User experience/interest in space weather/environment effects

The purpose of the following questions is to allow the SREN team to understand your previous experience and interest in specific aspects of Space Weather / Space Environment Effects on spacecraft systems, and how the SREN Platform could be of use to you in the future.

Please tick the boxes, to indicate your relative experience and whether you would be interested to receive a suitable service from SREN platform:

Total Dose: Total dose degradation of EEE components is considered during the design process. All such components have a Total Dose Sensitivity which should not be exceeded during the mission, otherwise the system performance may be at risk.

- User Direct Experience**
- User Interest in Nowcast/Warning**
- User Interest in Post Event Analysis**

➤ *Using electron & proton measurements from suitable sensors, SREN could predict the instantaneous dose rate and accumulated dose for EEE components behind different thicknesses of aluminium equivalent spacecraft shielding*

Spacecraft Surface Charging/ESD: Surface Charging related ESD anomalies have led to serious spacecraft anomalies and even failures in the past (such as the Telstar 402 and Galaxy 15 anomalies). Other less significant anomalies which could nonetheless degrade spacecraft performance and reliability may also be caused by Surface Charging / ESD.

- User Direct Experience**
- User Interest In Nowcast/Warning**
- User Interest In Post Event Analysis**

➤ *Now-casting/post-analysis of Surface charging conditions is complicated but could be achieved by SREN using a combination of low energy electron flux measurements, ground based magnetometer measurements and the use of a suitable low energy electron model.*

Spacecraft Internal Charging/ESD: Internal charging related ESD anomalies are well documented and correlate well with high energy electron flux measurements. These events tend to occur during the declining phase of the solar cycle, as a response to enhancements due to the influence of Coronal Hole High Speed Streams.

- User Direct Experience**
- User Interest In Nowcast/Warning**
- User Interest In Post Event Analysis**

➤ *Now-casting/post-analysis of Internal Charging conditions is relatively simple for SREN to achieve, using inputs from suitable sensors into a charging effects code or simple model of the charging process.*

Solar Array Degradation: Solar array degradation during large SPEs may result in a loss of 0.5 – 1.5% of solar array power (typical number from the October / November 2003 Halloween Storms event). Previous events occurred in 2000, 2001 and before. No such events have been experienced at GEO since the 2003 Halloween Storms

- User Direct Experience**
- User Interest In Nowcast/Warning**
- User Interest In Post Event Analysis**

- *SREN could provide a nowcast warning of the onset of such an event, and an ongoing prediction of the expected solar array degradation using a representative solar cell laydown (such as 100um CMX coverglass, DC93500 adhesive, Azur 3G30 solar cell) using suitable proton measurements and effects tool.*
- *Given a suitable sensor data feed from a low MEO operational spacecraft or a spacecraft in an EOR, SREN could provide a similar nowcast using the trapped proton environment that the MEO / EOR spacecraft would experience.*

Single Event Effects (SEE): SEE (such as memory or register ‘bit flips’, Spontaneous Switch Off of power supplies, miscellaneous units etc) are caused by GCRs, high energy protons at LEO in the South Atlantic Anomaly region and occur also during SPE events. The rate of these upsets in a Worst Case event would be very interesting to understand for Commercial Telecommunications Satellite Operators using the complex processed payloads now being developed.

- User Direct Experience**
- User Interest In Nowcast/Warning**
- User Interest In Post Event Analysis**

- *SREN could provide a nowcast warning of such conditions for a simple and commonly used device such as a UC1864 PWM controller, behind a typical shielding thickness and based on SREM / NGRM proton / heavy ion channels. Alternatively the functionality could be kept more generic, with the user entering the saturation cross section and LET threshold of a generic device that is of interest.*
- *SREN could provide a nowcast warning of such conditions for a representative / tested configuration of a complex device such as a Xilinx Virtex FPGA, behind a typical shielding thickness and based on SREM / NGRM proton / heavy ion channels. Alternatively the functionality could be kept more generic, with the user entering the saturation cross section and LET threshold of a generic device that is of interest.*

Sensor / Camera / Imager Noise: The same proton fluxes causing Solar Array Degradation and Single Event Effects can have a significant effect on the noise ('glitch rate') affecting spacecraft Earth & Star Sensors used on many spacecraft, and imagers / cameras used by Scientific / Earth Observation / Meteorological spacecraft.

User Direct Experience

User Interest In Nowcast/Warning

User Interest In Post Event Analysis

➤ *SREN could provide a nowcast warning of such conditions, based on SREM / NGRM proton / heavy ion channels.*

Targeted Flux Products: Generally useful information for a satellite operator to have is an idea simply of the evolution of the radiation environment in the specific orbit of interest – statistics such as peak & mean flux, and time integrated fluence, over the orbit (or over a given time). This allows the user to have a feeling for the actual environment exposure that the spacecraft is experiencing – relative to that it was designed for.

User Interest In Targeted Flux Products

➤ *SREN could provide Targeted Flux Products, based on SREM / NGRM electron, proton and heavy ion channels.*

Space environment/effects analysis tools/data/services

The purpose of the following questions is to allow the SREN team to understand which of the currently available tools, datasets and services you use for your work.

Please indicate which of the following tools / services you use:

- SPENVIS (web based)
- OMERE standalone package
- GEANT4 / MULASSIS
- DICTAT / MCICT / NUMIT
- SCREAM
- NASCAP (NASCAP 2000 is US only access)/ SPIS / MUSCAT
- Other.....please elaborate in the box below:

Comments:

Please indicate which of the following datasets you use:

- GOES EPEAD >0.8 MeV integral electron flux / fluence
- GOES EPEAD >10 / 50 / 100 MeV integral proton flux / fluence
- GOES 13/14/15 MAGED electron fluxes
- GOES 13/14/15 MAGPD proton fluxes
- PROBA-V EPT electron / proton / alpha fluxes
- POES MEPED electron fluxes
- INTEGRAL / PROBA-1 SREM particle counts
- Kp & other geomagnetic indices
- GOES magnetometer
- Ground based magnetometer
- Other.....please elaborate in the box below:

Comments:

- Would you be interested in participating in a Splinter Session at ESWW-17 (2020, Glasgow) to discuss the utility of these and other datasets in Spacecraft Anomaly investigations and Spacecraft Operations support?

Please indicate which of the following Space Weather forecasting services you use:

- UK MOSWOC Plain Language or Technical Forecasts
- SWPC Forecast Discussion
- SIDC Ursigram
- UK MOSWOC Warnings / Alerts
- SWPC Warnings / Alerts
- SIDC Warnings / Alerts
- Other.....please elaborate in the box below:

Comments:

Any Other Comments:

Thank You

On behalf of SREN Team,

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Confidential Information: Yes: No: