

Space Weather Prediction Center activities are driven by user requirements. To determine those requirements, and incorporate them into the planning and implementation of SWPC activities, however, it is not a simple process. Because of the physical and cyclical nature of the sun, and its subsequent impact on space weather, it is difficult to determine the needs of users over time. Using information gathered from the user community at large, as well as feedback from a variety of methods, SWPC attempts to keep the following list as current as possible.

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## AVIATION

**Note: NextGen Requirements at bottom of document**

<b>User Requirement</b>	<b>Timeliness</b>	<b>Customer</b>	<b>Rationale</b>
Forecasts (text or graphics) of radiation storms (proton events) at energy levels that could create a radiation hazard for aircrew and passengers	6, 12, and 18 hours	Airlines/General/Business	Forecasts need to be good enough to plan a crew change (for a stop in route) and/or flight-plan. 18 hours is best but a lesser lead time will still aid in the decision making
Space Weather Outlook: A text discussion on potential space weather impacts on aviation.	7-day outlook, updated daily	Aviation agencies	Identified by airlines as a very useful planning product
Nowcasts (text or graphic) of radiation storms (proton events) at energy levels that could create a radiation hazard for aircrew and passengers	Near real-time (<30 minutes)	Airlines	Will enable mitigation procedures to reduce dose during extreme radiation storms
Graphical forecast product to include intensity, onset and duration, and boundary of degraded communication areas for Polar routes	12 to 24-hours Updated every 6 hours	NavCanada (Air Traffic Control)  Airlines	Accurate predictions will help with route selection and management, emergency response, and other critical decision making processes at the control centers
Forecasts and specification of HF outage areas at low and middle latitudes	Any prediction capability of this impact is wanted; probability forecasts are of limited use.	Communications agencies  Airlines	Communications agencies will enable back-up procedures when HF communication is unusable over the oceans.

## ELECTRIC UTILITIES

User Requirement	Timeliness	Customer	Rationale
K-7 Geomagnetic Storm Warnings	Minutes to hours  Operators want as much lead time as possible, but any lead time is considered useful	North America Electricity Reliability Corp.  Midwest Independent System Operator  Electricity Reliability Coordinators	The Midwest Independent System Operator receives the K-index forecast. If the index is K-7 or higher, MISO notifies all NERC reliability coordinators concerning the level and expected duration of the specific event. These forecasts are shared with all power system operating entities throughout North America so that those power systems that are particularly susceptible to this phenomenon can institute preventive procedures
Geomagnetic Storm Warnings/Watches	1-2 days >50% accuracy	Various Power Companies	Allows maintenance procedures that shut down some facilities to be rescheduled, thus maintaining the full reserve for emergency situations.
Geomagnetic Storm Warnings (K-5 through K-9)	2-3 hours >80% accuracy	Various Power Companies	Bring reserve or maintenance generation on line
Geomagnetic Storm Warnings (K-5 through K-9)	15-30 minutes >90% accuracy	Various Power Companies	Reduce loading: use more conservative margins
Geomagnetic Storm Warnings (K-5 through K-9)	5 minutes >99% accuracy	Various Power Companies	Desensitize SVAR device protective relay setting. These circuits are used in power grids to isolate problems that are unrelated to GICs but can also be tripped by a secondary reaction to GICs when the GIC magnitude is large but not in itself damaging.
Geomagnetic storm outlook	3-Day	Various Power Companies	Valuable tool for planning purposes
Real-time geomagnetic monitoring data for GIC confirmation.	Every 15 minutes	Various Power Companies	Real-time measurements from sensors located regionally would better assess the GIC threat for any given station
Graphical Products - Regional Auroral Electrojet	Updating in real time	Various Power Companies	Improved determination of the electric fields produced during geomagnetic disturbances by including the effect of the structured source fields produced by the auroral electrojet

## ELECTRIC UTILITIES - continued

Graphical Forecast Products of real-time GIC flow throughout the power system	Updating in real time	Various Power Companies	Needed to determine the GIC distribution regionally across the system, and examination of factors affecting transformer saturation, harmonics that are produced and where they flow in the system.
Geo-alert status	As needed	Various Power Companies	Continual updating of geo-alert status so that power system operations can return to normal as soon as possible.
Spatially resolved forecasts of large geomagnetically induced currents, to allow mitigation measures to be taken	>1 hour (1-2 days preferred)	Various Power Companies	1-2 days warning is preferred since it allows rescheduling of generator and circuit downtime. However, useful mitigation can be taken based on warnings at shorter notice.

## GEOPHYSICAL OPERATIONS

User Requirement	Timeliness	Customer	Rationale
Forecasts of perturbations in the geomagnetic field	>1 day	Geophysical surveyors  Mining and drilling operations	Long lead time needed for planning surveys. Shorter warnings will ensure poor quality surveys are avoided. Some users request data 1-3 days in advance.
Post-event knowledge of perturbations in the geomagnetic field	<1 day	Geophysical surveyors and drilling industry	It is estimated that correction of magnetically oriented drilling requires a time-scale of about 1 day to prevent drilling errors from becoming unacceptable.

## RADIO FREQUENCY SYSTEMS

User Requirement	Timeliness	Customer	Rationale
Forecasts of ionospheric disturbances leading to loss of range, degradation and outage of radio communications e.g. fadeout, polar cap absorption and scintillation	> 1 day	RF systems (civil and military)	RF systems include radar and comms to and from spacecraft. Timeliness requirements depend strongly on the user. 1 day is taken as a typical time for alternative communications to be arranged.
Now-casts of ionospheric reflection properties for HF frequency selection	< 5 minutes	RF systems (civil and military)	Frequency selection to include density profile, not just f0F2. These data also give real-time information on over-the-horizon radar range and blind-spots.

## GNSS APPLICATIONS

User Requirement	Timeliness	Customer	Rationale
Now-casts of ionospheric total electron content, accurate to better than 1 TEC unit	< 5 minutes	GNSS location systems Radar systems. (civil and military) GNSS/GBAS Drilling operations Surveying Navigation systems GPS chip makers (i.e., SiRF,....)	Real-time data are needed for correction of GNSS positions. Radar systems are affected. Radio tracking of satellites and radio-location of emergency beacons are similarly affected.
Forecasts of ionospheric total electron content, accurate to better than 2 TEC units	>1 hour	GNSS location systems Radar systems. (civil and military) Drilling operations Surveying Navigation systems GPS chip makers (i.e., SiRF,....), WAAS	Accurate predictions of a disturbed ionosphere will ensure GNSS systems users postpone or modify operations dependant on precision measurements
Post-event information on environments affecting operational satellite systems, e.g. radiation and charging environment	< 1 day	Satellite operators (civil and military) and Insurance and financial services GBAS	Post-knowledge is considered valuable for diagnosis of anomalies.

<b>SATELLITE OPERATIONS</b>			
<b>User Requirement</b>	<b>Timeliness</b>	<b>Customer</b>	<b>Rationale</b>
Forecasts of hazardous environments affecting operational satellite systems. Energetic particle events and geomagnetic storm conditions of varying intensities	>1-2 days	Satellite operators (civil and military)	Enables preventative measures to be initiated and recovery procedures prepared. Spacecraft vulnerabilities vary.
Now-casts of hazardous environments affecting operational satellite systems. Energetic particle events and geomagnetic storm conditions of varying intensities	< 5 minutes	Satellite operators (civil and military)	Now-casts are useful since disturbed environments are often long-lasting and it is often not too late to enable preventative measures to be taken and recovery procedures prepared, Spacecraft vulnerabilities vary.
Now-casts of atmospheric drag for LEO spacecraft	< 5 minutes	Satellite operators (civil and military) (and ballistic missile defense)	A LEO requirement only. Drag information is needed for orbit, re-entry and attitude perturbation calculations. In military use, LEO spacecraft orbit calculations are required as a part of ballistic missile defense.
Localized environmental assessments at given satellite orbits	Real-time	All satellite agencies	Critical need for anomaly assessments and orbital determination (LEO).

<b>SATELLITE LAUNCH OPERATIONS</b>			
<b>User Requirement</b>	<b>Timeliness</b>	<b>Customer</b>	<b>Rationale</b>
Prediction and specification of >10 MeV proton flux	Two days before launch to four minutes before launch.	Integrated Flight Test launch (IFT) vehicles (IFT13 and 14 vehicles)	>10 MeV proton flux must be less than 10 pfu for launch
Prediction and specification of >50 MeV protons and, if available, heavy ions	Two days before launch to four minutes before launch.	Satellite launch companies	Launch teams are concerned with the possibility of a proton event causing single-word multiple upsets in the rocket control circuitry during launch. The warning provides situational awareness for spacecraft launch operations. They will monitor the proton flux closely and they will hold the launch if they see more than 100 PFU at > 50 MeV. Warnings of severe events more than 1 day ahead would allow a planned launch delay.

## NASA/DEEP SPACE OPERATIONS

<b>User Requirement</b>	<b>Timeliness</b>	<b>Customer</b>	<b>Rationale</b>
Onset time for a SEP event	Hours to one day	NASA  International space agencies  Commercial space providers	Numerous serious potential impacts on crew and hardware
Predictions of the temporal evolution profile of the SEP event at selected energies with associated probabilities.	Hours	NASA  International space agencies  Commercial space providers	Very important to properly assess radiation dose and dose equivalent impacts
Peak flux and intensity profile from the actual event at the selected energies in real time.	Hours to one day	NASA  International space agencies  Commercial space providers	Same as above – but also significant for low LET events
The capability to refine the temporal profiles and associated probabilities as the data arrive in real time.	Minutes to hours	NASA  International space agencies  Commercial space providers	Mission planning issues related to radiation impacts

## NASA/DEEP SPACE OPERATIONS - continued

Reliable forecasts of no solar activity of interest— i.e., all-clear forecasts.	Days to weeks	NASA  International space agencies  Commercial space providers	Mission planning
An all-clear forecast following a major SEP event or geomagnetic storm so that normal operations can be resumed.	As needed	NASA  International space agencies  Commercial space providers	Mission planning
Anisotropy in the particle velocity distribution	Hours	NASA  International space agencies  Commercial space providers	Mission planning

## INTERNATIONAL SPACE STATION/SHUTTLE

Command & Data Handling, Comm & Track, Environment & Life Support, Power, Robotics, Thermal Control

User Requirement	Timeliness	Customer	Rationale
Prediction and specification of differential energy particle spectra as a function of time inside / outside magnetosphere <ul style="list-style-type: none"> <li>• ion species (z=1 to 28) (spectra for selected elements would be acceptable - helium, protons, oxygen, iron)</li> <li>• energy (10 to 2000 MeV/n)</li> </ul>	Hours	NASA/ESA/JAXA	>400 equipment items susceptible to Single Event Latch-up (it is recommended these be powered down during large proton event) Space Station needs time to prepare shut down equipment
Prediction and Specification of geomagnetic field– Geomagnetic index (Kp) - onset and progression	Hours	NASA/ESA/JAXA	Understanding the extent of the auroral zone