**Ninth Meeting of the Cross Polar Trans East Air Traffic Management Providers’ Work Group (CPWG/9)**

(Montreal, Canada, 28-30 April 2010)

**Agenda Item 6: Communications, Navigation, Surveillance (CNS) and Air Traffic Management (ATM) issues**

**INTEGRATING SPACE WEATHER OBSERVATIONS AND FORECASTS INTO AVIATION OPERATIONS**

(Presented by the Space Weather Sub-Group)

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| SUMMARY  Under the direction of the Cross Polar Working Group (CPWG) leadership, a sub-group was formed after CPWG/3 in 2007 to focus on space weather issues that pertain to CPWG activities. The first task of the sub-group was to identify user needs and then, with input and direction from the airlines, propose requirements for services. The document submitted now is the product of that effort for the group’s discussion. |

1. **Introduction**

# The opening of the polar air routes in the late 1990’s exposed commercial aviation to space weather conditions that heretofore were not a significant factor in their daily operations. Although Radio Blackouts had affected oceanic High Frequency (HF) communications for many years, Solar Radiation Storms, and the impacts to communications, navigation, and the radiation environment they cause, became a new concern. Geomagnetic storms also became an issue, but to a lesser extent. The recognition of these impacts brought space weather to the attention of the CPWG in 2007.

# Given the somewhat invisible nature of space weather, it was proposed that a sub-group consisting of industry and government representatives be formed to characterize the nature of the threats and recommend to the full CPWG, a reasonable set of requirements for services to the airlines. This activity was unique in that it pivoted on the expressed desires of the airline industry as they have led the de-facto activities that have already occurred in the definition of valuable products and services.

1.3 The impacted areas that need to be addressed by the CPWG are radio frequency (RF) communications (RF), which is primarily considered here, but also very high frequency (VHF), ultra high frequency (UHF) and Satcom), radiation (separated into avionics and humans) and satellite navigation (Global Navigation Satellite System [GNSS]) and are shown in the summary of main user service needs in **Attachment A**.

1.4 The first activity undertaken by the space weather sub-group was to perform a focused study and present a document that identifies the issues and proposes service requirements. This document has been re-titled “Integrating Space Weather Observations and Forecasts into Aviation Operations,” is at **Attachment B** to this working paper.

1. **Background**

2.1 To scale the task to a reasonable level, the sub-group focused on space weather issues that pertained to a “typical” polar flight, i.e., a Chicago to Hong Kong route. It then sought to identify what space weather conditions could impact that route, and then what space weather forecasts, specifications, and products would be necessary to facilitate a flight with minimal or no impact.

2.2 The issues that were considered to impact this selected flight included: communications; navigation; and radiation exposure. The sub-group then focused on defining, in terms of the particulars of the services (the cadence, spatial granularity, confidence levels, etc.), the types of products necessary to mitigate any adverse space weather effects.

2.3 The next phase of this effort was to assemble this document and present it to the full CPWG. The sub-group felt that the activity had to be as inclusive and as exhaustive as possible, enabling all carriers and air navigation service providers to have input that define the output of the process.

2.4 This activity, from the beginning, has at its core the goal of eliciting the desires of the carriers in building these requirements, to be as much or as little, as they see fit. To attain this goal, the document has been vetted at various stages, and now has been recast based on feedback prior to and during CPWG/8 in Atlanta in December 2009.

2.5 The expectation now is for continued iteration and refinement of the requirements. This activity is particularly timely as the new solar activity cycle, dubbed Cycle 24, has begun. Eruptive space weather will be more frequent, and intense, in the next few years, with maximum space weather conditions likely centered for a few years around 2013.

1. **Discussion**

3.1 The space weather events that concern the commercial air and space industries most are those that disrupt the operational systems and those that increase the radiation environment. The issues are economic, operational and safety related. The effects include degradation or loss of radio frequency (RF) communications and satellite navigation signals; navigation system disruptions; avionic errors and human health.

3.2 As noted earlier, the sub-group used the Chicago to Hong Kong Polar route operation to consider what space weather observations and forecasts are required for each of the impacted areas of the operation.

* 1. Aviation space weather decision information is required to be divided into three main types:
* Observations – Determined now and effective for several minutes or hours before subsequent observations overwrite the prior information. Observations should describe current space weather conditions. There should be three sub-types of observations:
* Warnings
* Alerts
* Updates (Now-casts and parameter changes)
* Forecasts – Describing future space weather conditions minutes, hours, or days into the future, forecasts should employ satellite data, space weather models and correlate multiple information sources to reveal expected future conditions for strategic planning.
* Climatology – Describing past space weather conditions that may be used by models to characterize events leading up to the current state and used to interpret space weather phenomena over time, and for post event analysis of commercial, operational, safety and technological impacts.
  1. When considering the requirements for future space weather observations, forecasts, and information, and in order to make the integration into aviation operations seamless, it is recommended that where possible, terrestrial aviation weather information and services format are utilized.

1. **Conclusion**

4.1 The Space Weather Sub-group would like to acknowledge the efforts of the CPWG members for their support and input in defining user requirements and creating this document. This document provides an opportunity for the aviation industry to define its requirements for space weather information and how it is incorporated into the operational decision making process. The development of user requirements that include input from air navigation service providers, airlines, users, and space weather experts ensures a comprehensive document that, it is envisioned, can be used outside of the CPWG forum. As space weather garners more attention in international forums, it is hoped that the final CPWG defined user requirements will be incorporated into other international documents to ensure harmonization throughout the regions.

1. **Action**

5.1 The meeting is invited to:

* 1. note and review the content in this paper and the attached documents;
  2. provide feedback and comments to Sub-group ([bryns.jones@solarmetrics.com](mailto:bryns.jones@solarmetrics.com)) on user requirements following the CPWG/9 meeting; and
  3. consider endorsement of the final version of the Integrating Space Weather Observations & Forecasts into Aviation Operations document at the CPWG/10 meeting.

| **Aviation User Need No. (AUN)** | | **User Need** | **Notes** | **Document Section reference** |
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| AUN-1 | | Define the Impacts | The impacted areas that need to be addressed are:  - Communications  - Disruption of HF  - Interruption of VHF  - Reduced performance of UHF  - Satellite communication  - Radiation  - Avionics  - Humans  - Satellite Navigation | Para 2.1, Table 2-1  (list of Aviation User Impacts) |
| AUN-2 | | Types of Information:  - Observations  - Forecasts  - Climatology | 3 sub-types of Observations:  - Warnings  - Alerts  - Updates | Para 2.2 |
| AUN-3 | | Text Reports | Follow similar conventions to terrestrial weather METARs and SPECIs | Para 2.2.1 |
| AUN-3.1 | | Format and Content:  - Type of report  - Releasing Station identifier  - Affected airspace or region  - Date, time stamp  - Body (the information) | International Civil Aviation Organization (ICAO) format identifier  Airspace or regions yet to be designated | Para 2.2.1.1 |
| AUN-3.1.1 | | Severity of Hazard | Should be described in standardized format and terminology | Para 2.2.1.1.1 |
| AUN-3.1.2 | | Timelines for reports to be stated:  - Valid from  - Duration of or valid to | Applicable for any report (i.e., forecast, warning, alert, update), and applicable to each hazard | Para 2.2.1.1.2 and Table 2-2 Report Timescales |
| AUN-3.1.2  (cont’d) | | - Ongoing changes within duration  Reports required:  - 7 day forecast  - 3 day forecast  - 30 hour forecast  - 12 hour forecast  - 6 hour forecast  - 6 hour warning  - Immediate alert  - Update  - Post-Event Analysis (PEA) | Issued:  - Once every 7 days  - Once every 24 hours  - 4 times a day 0000, 0600, 1200, 1800utc  - Once every 3 hours  - Once every 2 hours  - With every new forecast parameter change increase.  - Valid immediately and for a specified time period where the activity is forecast to remain above the parameter action level. New alert issued with further increasing activity that affects parameter action levels.  - For a prior alert parameter change where activity decreases below action levels  Requires data collection procedures |  |
| AUN-3.1.3 | | Reliability, % Confidence Levels, Probability of Event Occurring | Accuracy of information: a space weather information provider will be required to state, in their reports, in some way, the reliability or % confidence level of the information provided | Para 2.2.1.1.3  Table 2-3 |
| AUN-3.1.4 | | Regions, Boundaries, Volumes can be stated as:  - Latitude/Longitude  - Current airspace regions  - ATM  - Route traffic flow rate impacts  - ICAO Flight | The regions, boundaries and volumes (by defining altitudes and flight levels) that are applicable to the hazard contained within the report should be stated. | Para 2.2.1.1.4 |
| AUN-3.1.4  (cont’d) | | Information Regions (FIRs)  - International Space Environment Service (ISES) regions |  |  |
| AUN-4 | | Graphical Reports | Graphical Analysis Charts of space weather observations in a similar manner to current terrestrial Significant Weather charts. | Para 2.2.2 |
| AUN-4.1 | | Format and Content:  - Type of chart or report  - Releasing Station identifier  - Regions depicted on chart / report /affected FIR(s) or ATM regions  - Date, time stamp | ICAO format identifier | Para 2.2.2.1 |
| AUN-4.1.1 | | Severity of Hazard | Graphical charts / reports required to define:  - the type of hazard  - depict the distribution of severity | Para 2.2.2.2 |
| AUN-4.1.2 | | Timelines for reports | Graphical charts / information required to depict:  - “snapshot” of space weather, applicable to each hazard, expected at the specified valid time  - forecasted conditions at four (4) periods, 12-hours, 24-hours, 3-days, 7-days | Para 2.2.2.3 |
| AUN-4.1.3 | | Reliability, % Confidence Levels, Probability of Event Occurring | Charts / information required to contain reliability, % confidence levels or probability of event occurring within the time covered by the forecast | Para 2.2.2.4 |
| AUN-4.1.4 | | Combined Space and Terrestrial Weather Hazard Charts | A combined space and terrestrial weather chart should be considered for “big picture” planning | Para 2.2.2.5 |
| AUN-5 | | Communicating Space Weather Information  Integrated with Ops / Dispatch:  - Pushed  - Pulled  - “attention-getters” with Ops / Dispatch | Information, reports, charts required to be communicated:  - via all the currently available and regulatory approved transmission methods  - via regulated Internet methods (i.e., Qualified Internet Communications Provider)  - “pushed” or “pulled”  Warnings, Alerts, Parameter Alerts/Drop-offs, Text & Alert graphics  Forecasts, Analysis Chart graphics  Warnings, Alerts, Drop-offs | Para 2.2.3 |
| AUN-6 | | RF Communication |  | Para 2.2.4 |
| AUN-6.1 | | HF communications  - Severity  - Timescales  - Reliability, % Confidence Levels, Probability of Event | Information required:  - Signal strength/loss  - Clarity  - Best Useable Frequencies  - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – 65%  - 3 days – 75%  - 30 hours – 85% | Para 2.2.4.1  Table 2-4 |
| AUN-6.1  (cont’d) | | Occurring  - Regions / Boundaries / FIR  - Hazard cause | - 12 hours – 95%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries required to be defined, applicable to the hazard contained within the reports  Allows for differing operational responses |  |
| AUN-6.2 | | VHF communications  - Severity  - Timescales  - Reliability, % Confidence Levels, Probability of Event Occurring  - Regions / Boundaries / FIR | Information required:  - Signal strength/loss  - Clarity  - Susceptible Frequencies  - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – not required  - 3 days – not required  - 30 hours – 65%  - 12 hours – 85%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries of hazard required to be defined | Para 2.2.4.2  Table 2-5 |
| AUN-6.3 | | UHF communications  - Severity | Information required:  - Signal strength/loss  - Clarity  - Susceptible Frequencies | Para 2.2.4.3 |
| AUN-6.3  (cont’d) | | - Timescales  - Reliability, % Confidence Levels, Probability of Event Occurring  - Regions / Boundaries / FIR | - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – 65%  - 3 days – 75%  - 30 hours – 85%  - 12 hours – 95%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries of hazard required to be defined | Table 2-6 |
| AUN-6.4 | | Satcom  - Severity  - Timescales  - Reliability, % Confidence Levels, Probability of Event Occurring | Information required:  - Signal strength/loss  - Clarity  - Susceptible Frequencies  - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – not required  - 3 days – not required  - 30 hours – 65%  - 12 hours – 85%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99% | Para 2.2.4.4  Table 2-7 |
| AUN-6.4  (cont’d) | | - Regions / Boundaries / FIR | Regions, boundaries of hazard required to be defined |  |
| AUN-7 | | Radiation – Avionics  - Severity  - Timescales  - Reliability, % Confidence Levels, Probability of Event Occurring  - Regions / Boundaries / FIR  - Altitudes / Flight Levels / Volumes | Information required:  - Galactic radiation dose rates  - Solar radiation dose rates  - Rate of change of dose rates (up & down)  - Peak dose rates  - Avionics risk factor  - Particle spectra – for Post-Event Analysis  - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – 65%  - 3 days – 75%  - 30 hours – 85%  - 12 hours – 95%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries of hazard required to be defined  Required to be defined | Para 2.2.5  Table 2-8 |
| AUN-8 | | Radiation – Humans  - Severity | Information required:  - Galactic radiation dose rates  - Solar radiation dose rates  - Rate of change of dose | Para 2.2.6 |
| AUN-8  (cont’d) | - Timescales  - Reliability, % Confidence Levels, Probability of Event Occurring  - Regions / Boundaries / FIR  - Altitudes / Flight Levels / Volumes | rates (up & down)  - Peak dose rates  - Dose rate conversion to Human Exposure risk factor  - Event spectra – for Post-Event Analysis  - Valid from  - Duration or Valid to  - Ongoing changes  - Confidence levels  - Current Condition Reports  - 7 days – 65%  - 3 days – 75%  - 30 hours – 85%  - 12 hours – 95%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries of hazard required to be defined  Required to be defined | Table 2-9 |
| AUN-9 | Satellite Navigation  - Severity  - Timescales | Information required:  - Max horizontal & vertical inaccuracies  - Rate of onset  - Outages  - Airfield approach category drops  - WAAS, LAAS, RNP confidence levels  - Valid from  - Duration or Valid to  - Ongoing changes | Para 2.2.7 |
| AUN-9  (cont’d) | - Reliability, % Confidence Levels, Probability of Event Occurring  - Regions / Boundaries / FIR / Volume  - Airfields / Runways | - Confidence levels  - Current Condition Reports  - 7 days – 75%  - 3 days – 85%  - 30 hours – 95%  - 12 hours – 95%  - 6 hours – 95%  - Alerts – 95%  - Updates – 95%  - PEA – 99%  Regions, boundaries of hazard required to be defined  Required to be defined for each | Table 2-10 |
| AUN-10 | Operational Decision Processes | Requirement to define the appropriate operational and ATM decision-makers that should receive space weather information | Para 2.3, Table 2-11a and Table 2-11b |