**Interview Protocol for Space Weather Advisory Group User Survey**

**GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) SECTOR**

**Interview Information**

Interview time/date (all times Eastern):

Interviewers: [Add before interview.]

Interviewee: [Add before interview.]

Affiliation of Interviewee: [Add before interview.]

Title of Interviewee: [Add before interview.]

**Introduction Protocol**

Hello [Interviewee name]

My name is [name] and I am a member of the Space Weather Advisory Group also known as the SWAG. I am joined by [name] for today's conversation who is assisting by taking notes as we go along. Thank you so much for agreeing to participate in this interview and taking time out of your busy schedule to chat with us.

The purpose of this interview is to understand how space weather affects your work and what forecasts, products, and services you would like to see.

The SWAG will use the information gathered to identify the space weather research, observations, forecasting, prediction, and modeling advances required to improve space weather products.

The PROSWIFT Act, which led to the SWAG’s formation, also laid out the topics for the user survey. We will be asking you questions about current use and future needs for space weather information, technological systems, components, or elements affected by space weather, and current and future risk reduction and resilience activities.

Thank you again for your time and cooperation. Before we begin, do you have any questions for me?

Space weather describes changes in the near-Earth environment from approximately 4 miles (6 km) above the Earth’s surface to the surface of the sun. These changes can affect radio frequency signals including GNSS signals (e.g., GPS). The effects on GNSS signals can range from signal degradation and disruption resulting in errors in positioning/navigation/timing (PNT) to complete loss of positioning/navigation/timing information (e.g., signal jamming).

**Let’s begin with current technological systems or components potentially affected by space weather:**

**[Both Timing and Positioning/Navigation]**

1. Which GNSS constellations or other Radio Navigation systems or GNSS augmentation systems (e.g., SBAS) are currently used and are expected to be used in the future? (Ask the frequency they use if they know) Note: Investigate Iridium for PNT information (what frequency?)
2. What type of receiver is used?
   1. What is the tracking algorithm? (i.e., single/dual frequency, automotive, chip vs. self-contained receiver)
3. Which components/systems depend on GNSS?
4. At what point in the technological system or application is GNSS timing used?
   1. At what point is it obtained?
5. At what point in the technological system or application is GNSS positioning/navigation used?
   1. At what point is it obtained?

**[For Timing]**

1. What is the order of magnitude of the accuracies/precision for timing **required** by the technological system and/or application? (e.g., minutes, seconds, microseconds)
2. What is the order of magnitude of the accuracies/precision timing **currently achieved** by the technological system and/or application? (e.g., minutes, seconds, microseconds)

**[For Positioning/Navigation]**

1. What is the order of magnitude of the accuracies/precision for positioning/navigation **required** by the technological system and/or application? (e.g., meters, cm, nm)
2. What is the order of magnitude of the accuracies/precision for positioning/navigation **currently achieved** by the technological system and/or application? (e.g., minutes, seconds, microseconds)
3. What is the order of magnitude of the sampling rate **required** by the technological system and/or application for either positioning/navigation or time? (e.g., Hz, MHz)
4. What is the order of magnitude of the sampling rate **currently achieved** by the technological system and/or application? (e.g., Hz, MHz)

**Let's talk about next generation technologies, research, instrument, and models to address space weather:**

1. Are there any new technologies related to the application/component being developed that will mitigate known space weather impacts?
2. Are there any current or planned collaborations with the environmental research communities focusing on improving the resilience of the application/component?
3. What educational tools, formats or vehicles would best assist the aviation sector to better understand space weather?
4. How does your enterprise or operation foresee enhancements or changes to current information dissemination?

**The next set of questions are related to current risk reduction and resilience activities:**

**[Both Timing and Positioning/Navigation]**

1. What are the most common technological vulnerabilities or risks to the system/application utilizing GNSS information?
2. What **technological mitigation** strategies are used to reduce general vulnerabilities or risk?
3. What **operational changes/mitigation** are used to respond to adverse conditions?

**[For Timing]**

1. How does the technological system or application identify degradation in GNSS **timing** values? (e.g., flag data, inform end user/operator)
2. How often is a timing degradation identified?
   1. How often does it prevent the application from meeting minimum performance?
3. What happens when the timing error exceeds the operational threshold?
4. How does the system/technology depend on or use any other source of timing information to backup or complement GNSS?
5. What other steps, not yet discussed, do you take to reduce risk and increase resilience to the system/application?

**[For Positioning/Navigation]**

1. How does the technological system or application specifically note degradation in GNSS positioning/navigation values?
2. How often is a degradation in **positioning/navigation** noted?
   1. How often does it prevent the application from meeting minimum performance?
3. What happens when the positioning/navigation error exceeds the operational threshold?
4. Does the system/technology depend on or use as a backup any other source of positioning/navigation information? If yes, what?
5. What other steps, not yet discussed, do you take to reduce risk and increase resilience

**The next set of questions are related to future risk reduction and resilience activities:**

**[For both Timing and Position/Navigation]**

1. How can operations be modified to compensate for periods of predicted or known space environment variations?
2. What are limiting factors to the proposed operation modifications? (e.g., lead-time, max operation mode duration, 24/7 in-person monitoring, etc.)
3. Are there any known barriers or challenges to implementing any of the proposed mitigations?
4. What other steps, not yet discussed, do you plan to take to reduce risk and increase resilience for space weather events?

**[For Timing]**

1. How can operations be modified to compensate for periods of predicted or known timing errors?
2. What software/data system improvements are required to compensate for timing errors? (e.g., quality threshold changes, optimizing timing accuracy needs with required performance)
3. What hardware system improvements are required to compensate for timing errors? (e.g. multi-GNSS timing values, reduced network latency, etc.)
4. Are these actively being pursued? If so, what is the timeline to implementation (i.e., 3-year, 5-year, 10-year, etc.)

**[For Positioning/Navigation]**

1. How can operations be modified to compensate for periods of predicted or known positioning/navigation errors?
2. What software/data system improvements are required to compensate for positioning/navigation errors? (e.g., quality threshold changes)
3. What hardware system improvements are required to compensate for positioning/navigation errors? (e.g. multi-GNSS usage, base-stations, etc.)
4. Are these actively being pursued? If so, what is the timeline to implementation (i.e., 3-year, 5-year, 10-year, etc.)

**Our next group of questions focus on current use of space weather observations, information, and forecasts**

1. How does space weather directly affect your operations and/or technological system?
   1. [Probe: How often are operations and/or technological systems adversely affected by space weather events?]
2. Which general aspects of the system and/or operations are known to be affected by space weather?
3. Which environmental conditions and parameters are important for your application/system/component and/or operations? Include terrestrial and space weather.
4. How does your application/system/component consider space weather conditions?
   1. What specific information do you use? (e.g., Kp, sunspot number, etc.)
   2. Where do you get the space weather information? (e.g., NOAA SWPC, Coast Guard, FEMA, etc.)
   3. How do you get the space weather information? (e.g., website, social media, etc.)

**The next group of questions are about future space weather information required (communication methods, observations, and forecast products (format, etc.):**

1. What type of parameters/products, lead-times, and accuracies should be included in space weather forecasts and products that are necessary to implement future operational mitigations?
2. What specific type of information related to GNSS timing issues or space/upper atmosphere conditions would be useful for operational mitigations, or technical mitigations, or both?
3. What is your preferred way of receiving/obtaining space weather information (including format, image vs data, etc.)?

**We will turn now to new or non-traditional sources of space weather data**

1. How does your application/system/component monitor environmental conditions?
2. What conditions/parameters are monitored and how are they currently used?
   1. How long is the information and/or data kept?
3. Can this information be shared outside of the application, company, or community?
   1. If yes, what is the process for obtaining? If not, what are the challenges in doing so (e.g., cost, anonymization)?

**Last Question**

1. Are there any other things that we have not asked about that you wish to share?

**Wrap Up**

Those are all the questions we have for you. Let us know if you are interested in keeping in touch and please let us know who else to speak with as part of this effort. We hope to have initial results from the SWAG User Survey by AGU and AMS. Thank you once again for your time and energy.

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