Space Weather - An Airline Perspective -

2017 Space Weather Workshop
Broomfield, CO
11:40AM-Noon Wednesday 03 May

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Tom Fahey, mgr. Meteorology
Delta Air Lines, Inc.
NOAA’s solar activity categories:
1. Radio Blackouts (R) Storm
2. Solar Radiation (S) Storm
3. Geomagnetic (G) Storm

Aviation Impacts:
• Radio Communications
• Health Affects
## Solar Storms

<table>
<thead>
<tr>
<th>Type of Storm</th>
<th>Sun → Earth</th>
<th>Duration</th>
<th>Affects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abbv.</td>
<td>Travel Time</td>
<td>Average</td>
</tr>
<tr>
<td>Radio Blackout</td>
<td>R Storm</td>
<td>8 minutes</td>
<td>A few Hours</td>
</tr>
<tr>
<td>Solar Radiation</td>
<td>S Storm</td>
<td>Approx. &lt; 1 hour</td>
<td>&lt; 1 day</td>
</tr>
<tr>
<td>Geomagnetic</td>
<td>G Storm</td>
<td>Approx. 18-24hrs</td>
<td>1-2 days</td>
</tr>
</tbody>
</table>

## Flight Superintendent Actions

<table>
<thead>
<tr>
<th>Type of Storm</th>
<th>Storm Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abbv.</td>
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<td>Radio Blackout</td>
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<td>S Storm</td>
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<td>Geomagnetic</td>
<td>G Storm</td>
</tr>
</tbody>
</table>
Space Weather

Delta Meteorology Products

• Activity & Forecast Summary
• Threat Plot (TP) Messages
Space Weather Activity & Forecast Summary

2. Mouse-over Forecast Products
3. Click on “Space Weather”

The current “Space Weather Activity & Forecast” summary will display
Activity & Forecast Summary

Summary Produced 2 X’s EVERY Day

- Always Includes a Detailed Legend
Delta Threat Plot (TP) Procedures & Storm Scales

### TP Issued ONLY When Needed

**G or S Storm Scale of 3 or higher - required - Delta TP Alert**

**R Storm Scale of 3 or higher - Optional - Delta TP Advisory**

#### TP Issued

<table>
<thead>
<tr>
<th>Storm Scale</th>
<th>TP</th>
<th>Geomagnetic Storm Effects</th>
</tr>
</thead>
</table>
| G1          | No TP Issued | Communications: No Effect  
Satellite Navigation: No Effect |
| G2          | No TP Issued | Communications: Possible HF radio fade  
Satellite Navigation: No Effect |
| G3**        | Alert Issued (Required) | Communications: Possible intermittent HF radio outages  
Satellite Navigation: Possible intermittent satellite navigation problems |
| G4          | Alert Issued (Required) | Communications: Possible sporadic HF radio outages  
Satellite Navigation: Possible satellite navigation degraded for hours |
| G5          | Alert Issued (Required) | Communications: Possible HF radio outages for 1-2 days  
Satellite Navigation: Possible satellite navigation degraded for days |

#### Solar Radiation Storm Effects

<table>
<thead>
<tr>
<th>Storm Scale</th>
<th>TP</th>
<th>Solar Radiation Storm Effects</th>
</tr>
</thead>
</table>
| S1          | No TP Issued | Communications: Possible minor effects on HF Radio  
Biological: No Effect |
| S2          | No TP Issued | Communications: Possible small effects on HF Radio  
Biological: Possible elevated radiation risk |
| S3**        | Alert Issued (Required) | Communications: Possible HF radio degradation  
Satellite Navigation: Possible satellite navigation errors  
Biological: Possible elevated radiation risk |
| S4**        | Alert Issued (Required) | Communications: Possible blackout of HF radio for several days  
Satellite Navigation: Possible satellite navigation errors for several days  
Biological: Possible elevated radiation risk |
| S5**        | Alert Issued (Required) | Communications: Possible complete blackout of HF radio for several days  
Satellite Navigation: Possible satellite navigation errors for several days  
Biological: Possible elevated radiation risk |

#### Solar Flare - Radio Blackout Effects

<table>
<thead>
<tr>
<th>Storm Scale</th>
<th>TP</th>
<th>Solar Flare - Radio Blackout Effects</th>
</tr>
</thead>
</table>
| R1          | No TP Issued | Communications: Possible minor degradation to HF radio on sunlit side of Earth  
Satellite Navigation: No Effect |
| R2          | No TP Issued | Communications: Possible blackouts to HF radio for tens of minutes on sunlit side of Earth  
Satellite Navigation: No Effect |
| R3**        | Advisory Issued (if needed) | Communications: Possible blackouts to HF radio for an hour on sunlit side of Earth  
Satellite Navigation: No Effect |
| R4          | Advisory Issued (if needed) | Communications: Possible minor disruptions to satellite navigation on sunlit side of Earth  
Satellite Navigation: No Effect |
| R5          | Advisory Issued (if needed) | Communications: Possible complete blackout to HF radio for several hours on sunlit side of Earth  
Satellite Navigation: Possible satellite navigation errors for several hours on sunlit side of Earth |

**Radio Blackouts impact the entire sunlit side of the earth. They also serve as a warning for potential Geomagnetic storms or Solar Radiation storms (1/2hr-1 day from Sun to Earth).**
## Space Weather Info

### Delta TP Product Examples

To Support Pre-flight Planning & En Route Decision Making:

Meteorology will issue TP Messages for R3 or greater as “Advisory”

S & G scale 3 or greater are “Alerts” (action may be needed)

<table>
<thead>
<tr>
<th>TP AO26 241604Z</th>
<th>TP AO30 241608Z</th>
<th>TP AO31 241609Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. AO</td>
<td>1. AO</td>
<td>1. AO</td>
</tr>
<tr>
<td>2. * ADVISORY *</td>
<td>2. * ALERT *</td>
<td>2. * ALERT *</td>
</tr>
<tr>
<td>HAZ: SPACE WX</td>
<td>HAZ: SPACE WX</td>
<td>HAZ: SPACE WX</td>
</tr>
<tr>
<td>CATEGORY: R3</td>
<td>CATEGORY: S3</td>
<td>CATEGORY: G3</td>
</tr>
<tr>
<td>LAT/LON: 90.0N100.0W</td>
<td>LAT/LON: 90.0N100.0W</td>
<td>LAT/LON: 90.0N100.0W</td>
</tr>
<tr>
<td>RADIUS: 480NM</td>
<td>RADIUS: 780NM</td>
<td>RADIUS: 480NM</td>
</tr>
<tr>
<td>TIME: POSN AT 24/1600Z</td>
<td>TIME: POSN AT 24/1600Z</td>
<td>TIME: POSN AT 24/1600Z</td>
</tr>
<tr>
<td>ALTS: FL300-500</td>
<td>ALTS: FL300-500</td>
<td>ALTS: FL300-500</td>
</tr>
<tr>
<td>INFO: SOLAR FLARE WITH NO IMPACT TO POLAR RTES KNOWN OR FCST AT THIS TIME.</td>
<td>INFO: RCMND AVOIDING ALL POLAR RTES.</td>
<td>INFO: RCMND AVOIDING POLAR RTES N OF 82N.</td>
</tr>
<tr>
<td>3. VALID 241604/241804Z</td>
<td>3. VALID 241800/250400Z</td>
<td>3. VALID 241800/250400Z</td>
</tr>
<tr>
<td>4. CANCEL NONE</td>
<td>4. CANCEL NONE</td>
<td>4. CANCEL NONE</td>
</tr>
</tbody>
</table>
SAFETY

Types and Hazard Intensity

**AVOID**
- Sev Icing
- Volcanic Ash
- Strong Mtn Wave
- > Moderate Turbc

**ALERT**
- Moderate Icing
- Moderate Turbulence
- Moderate Mtn Wave, Tstrms, Ozone
- Space Weather (S & G level 3 or >)

**ADVISORY**
- Frontal Shear
- Light-Moderate Turbulence
- Space Weather (R level 3 or greater)

**TP Message Products**
- Forecast Activity
  - Used for Preflt Planning
- Current Activity
  - Used En Route

**Outlook/Summary Products**
- Compliments TP Products
  - Used by Dispatcher as initial info
Delta Avoidance
HF Comms & Health Related

Each flt must maintain constant communication with ATC & with the company.

Delta’s Primary Comms Method: ACARS using VHF or SATCOM
Delta’s Secondary Comm Method: Voice Communications using HF Radio or SATCOM

**Health**

No Ops on all Polar Routes During Strong Solar Radiation (S) Storms Due psbl Health affect

**Communications**

Inmarsat SATCOM is not available North of 82N. ACARS or Voice SATCOM

VHF ACARS is not available in the Polar Region. Voice HF Radio only option

No Ops North of 82N During Strong (G) Geomagnetic Storms Due psbl loss HF
Dispatcher ACTIONS:

• The *Space Weather Activity & Forecast* product is referenced daily by dispatch.
  o Also consulted for aircraft operating in theaters other than the Polar Theater that are not equipped with SATCOM & rely on HF radio for communications

• *TP Messages* are only issued when significant Space Weather affects Delta flts.
  o If a Space Weather TP indicates geomagnetic or solar radiation storms of level 3 or higher, Polar routes will be avoided (G Storm: 82N or above & R Storm: 78N or above).

• *All Polar Operations* regardless of Space Weather Threats:
  o Due to extreme cold temperatures North of 78 degrees, Delta samples the fuel density at departing stations (MSP/DTW/ATL) to derive actual fuel freeze limits.
  o Adjustment is made to fly an Off-Optimum (time/cost) Route if fuel freeze threat exists.

Crew Members’ OPTION:

• A crew member on a Reserve Flight Schedule can opt out of flying on a city pair that may use Polar Routes if they are pregnant.
Delta Air Lines

Conclusions

Delta’ Ops Concerns:
• HF Radio Communication disruption is a concern
• Improved Space Wx Fcsting needed for both safety & efficiency

Space Wx Info Needs
• As simplified as psbl for Aviation Ops Decisions
• Support “H” (Health) Scale. Implement after details addressed.

Performance Values for Space Weather Forecasting
• There has been a lot of work on Performance Values
• Delta’s Requests:
  • Clear labeling that Perf Values are a goal not a mandate
    • Re-routes remain responsibility of Operator, not ANSP
  • Forecasting efforts should not over reach capabilities
    • An inaccurate 30hr forecast is a disservice
Questions