Delta Hazard Avoidance Procedures & Use of Space Weather Information

Space Weather Workshop
Aviation & Space Weather Session
24 April 2012
Boulder, CO
Tom Fahey & Gregg Scott
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 Storms Due psbl Health affect

**Communications**

Inmarsat SATCOM is not available North of 82N.

VHF ACARS is not available in the Polar Region.

No Ops North of 82N During Strong Geomagnetic Storms Due psbl loss HF
Weather Hazard Avoidance Philosophy

• Procedures apply to all Weather Hazards both:
  – Preflight Planning
  – En Route Adjustments

• For Both Pilot & Flight Dispatch Procedures
  – Advisory: No Action required Preflight or en route
  – Alert: Adjust route preflight & en route provided no other operational limitations
  – Avoid: Adjust route preflight & en route
SAFETY
Types and Hazard Intensity

TP Message Products

- Forecast Activity
  Used for Preflt Planning
- Current Activity
  Used En Route

Outlook/Summary Products

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

ALERT
- Moderate Icing
- Moderate Turbulence
- Moderate Mountain Wave
- Tstrms, Ozone, Space Weather (S & G)

ADVISORY
- Frontal Shear
- Light-Moderate Turbulence
- Space Weather (R)

Compliments TP Products
Used by Dispatcher as initial info

TP Message Products
- Forecast Activity
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  Used En Route

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ADVISORY
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Compliments TP Products
Used by Dispatcher as initial info
Space Weather Info
Delta Summary/Outlook Product

- **Used as Pre-flight Planning Tool:** All Green = Good
  (issued daily at 12z for westbound planning & if needed at 04z for eastbound)

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**Delta Meteorology Space Weather Activity and Forecast**

<table>
<thead>
<tr>
<th>Previous 24 hr Activity</th>
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<tbody>
<tr>
<td>Event 1</td>
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<tr>
<td>Scale</td>
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<tr>
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<tr>
<td>Geomagnetic Storms:</td>
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<tr>
<td>Solar Radiation Storms:</td>
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<td>Radio Blackouts:</td>
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<tr>
<th>Current Activity</th>
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<thead>
<tr>
<th>Forecast Activity</th>
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<tr>
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</table>
**Space Weather Info**

**Storm Scales & Delta TP Product**

Storm Scale of 3 or higher requires Delta TP Alert or Advisory

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

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

<table>
<thead>
<tr>
<th>Storm Scale</th>
<th>TP</th>
<th>Solar Flare - Radio Blackout Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td></td>
<td>Communications: Possible minor degradation to HF radio on sunlit side of Earth Satellite Navigation: No Effect</td>
</tr>
<tr>
<td>R2</td>
<td></td>
<td>Communications: Possible blackouts to HF radio for tens of minutes on sunlit side of Earth Satellite Navigation: No Effect</td>
</tr>
<tr>
<td>R3</td>
<td></td>
<td>Communications: Possible blackouts to HF radio for an hour on sunlit side of Earth Satellite Navigation: No Effect</td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td>Communications: Possible blackouts to HF radio for 1-2 hours on sunlit side of Earth Satellite Navigation: No Effect</td>
</tr>
<tr>
<td>R5</td>
<td>Advisory Issued</td>
<td>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</td>
</tr>
</tbody>
</table>

***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>
Summary of Delta’s Actions

• **R Scale (Level 3, 4 or 5)**
  - Advisory TP Issued: Only as an “Observed”
  - Action Required: None
    - Issued as an FYI only: Other events psbl. No restrictions.

• **S Scale (Level 3, 4 or 5)**
  - Alert TP Issued: As “Forecast” or “Observed”
  - Action Preflight: No Polar Routes (78N to Pole).
  - Action if En Route: Reroute or reducing altitude to FL310.

• **G Scale (Level 3, 4 or 5)**
  - Alert TP Issued: As “Forecast” or “Observed”
  - Action Preflight: No Routes between 82N to Pole.
  - Action if En Route & HF Problems: Try other HF freqs, use SATCOM, &/or reroute. Last resort, land short.
Monday was forecast G1- G2, but we reached G3 in the afternoon 26th!
TP AO45 261751Z
1.AO
2.* ALERT *
   HAZ: SPACE WX
   SOURCE: OBSERVED
   CATEGORY: G3
   LAT/LON: 90.0N 100.0W
   RADIUS: 480NM
   TIME: POSN AT 26/1750Z
   ALTS: FL 300-500
   INFO: RCMND AVOIDING POLAR RTES N OF 82N
3.VALID 261751/262100Z
4.CANCEL NONE
Current Solar Cycle
Geomagnetic Kp Estimate 22-24Apr12

Estimated Planetary K index (3 hour data)  

Begin: 2012 Apr 22 0000 UTC

<table>
<thead>
<tr>
<th>Kp-index</th>
<th>NOAA Space Wx Scale Geomagnetic Storm Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kp=5</td>
<td>G1</td>
</tr>
<tr>
<td>Kp=6</td>
<td>G2</td>
</tr>
<tr>
<td>Kp=7</td>
<td>G3</td>
</tr>
<tr>
<td>Kp=8</td>
<td>G4</td>
</tr>
<tr>
<td>Kp=9</td>
<td>G5</td>
</tr>
</tbody>
</table>

Updated 2012 Apr 24 17:35:06 UTC  
NOAA/SWPC Boulder, CO USA
WARNING: Geomagnetic K-Index of 7 or greater expected
Valid From: 2012 Apr 24 0205 UTC
Valid To: 2012 Apr 24 0600 UTC

Warning Condition: Onset
NOAA Scale: G3 or greater - Strong to Extreme

Potential Impacts: Area of impact primarily poleward of 50 degrees Geomagnetic Latitude.

Radio - HF (high frequency) radio may be intermittent.
Aurora - Aurora may be seen as low as Pennsylvania to Iowa to Oregon.
Current Solar Cycle
Product & Flight Routing Response

• Product: G-event TP Issued 0229z 24 Apr’12
  TP NP49 240229Z
  1. AO
  2. * ALERT *
    HAZ: SPACE WX
    SOURCE: FORECAST
    CATEGORY: G3
    LAT/LON: 90.0N 100.0W
    RADIUS: 480NM
    TIME: POSN AT 24/0230Z
    ALTS: FL300-500
    INFO: RCMND AVOIDING POLAR RTES N OF 82N
  3. VALID 240229/240600Z
  4. CANCEL NONE

• Delta Re-route Response
  DTW-PEK Flt 189 rerouted South of 82N (RAMEL to ORVIT)
Delta Air Lines

DTW-HKG 77LR RAMEL is econ track And ORVIT is south of 82N

RAMEL  15:23 en route time, Burn 250.1 block fuel 274.6 6961nm track distance

ORVIT  15:32 en route time, Burn 253.3 block fuel 278.0 7019nm track distance
cost $1350

G scale
Scenario
Alert from Metro

AVOID Polar route
North of 82 North
Delta Air Lines

DTW-HKG 77LR RAMEL econ and first “non-Polar” route is LISKI

RAMEL  15:23 en route time, Burn 250.1 block fuel 274.6 6961nm track distance
LISKI   15:46 en route time, Burn 259.7 block fuel 284.7 7101nm track distance
Cost $4507

AVOID All Polar routes

S scale
Scenario
Alert from Metro
Delta Air Lines

Impact first event January 24 and 28, 2012 approximately 8 flights pushed to non-Polar routes

Impact second event March 08-09, 2012 8 plus flights pushed to non-Polar routes or southerly Polar tracks

Overall impact DTW-HKG south of 82N

- $1350
- 3,550lbs of fuel
- 07 minutes longer flight time
- 58nm additional mileage

Overall impact DTW-HKG Avoid Polar

- $4507
- 9,950lbs of fuel
- 21 minutes longer flight time
- 140nm additional mileage
Delta Air Lines

- Impact first event January 24 and 28, 2012
  - Approx 8 flights pushed to non-Polar routes

- Impact second event March 08-09, 2012
  - 8+ flts pushed to non-Polar routes or southerly Polar tracks

Other unintended consequences

- Payload reduction
- Time (crew duty day)
- Additional green house gases
- Airframe costs
# ICAO Effort

## Space Weather Performance Values

**Draft Space Weather Forecast Performance Values for Aviation Support**

(an excerpt for HF communications)

<table>
<thead>
<tr>
<th>Impact</th>
<th>Cause</th>
<th>Space Weather Forecast Issue Times</th>
<th>Space Weather Related Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disruptions/loss of HF communications</td>
<td>Ionospheric Irregularities - Dayside Absorption - Polar Cap Absorption - Auroral Absorption</td>
<td>6-hour fcst</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12-hour fcst</td>
<td>Solar Flares Solar Particle Events Geomagnetic Storms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-hour fcst</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-day fcst</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-day outlook</td>
<td>Daily</td>
</tr>
<tr>
<td>Verification</td>
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<td>95%</td>
<td>95%</td>
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<td></td>
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<td>95%</td>
<td>85%</td>
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<td>75%</td>
<td>65%</td>
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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 High level & simplified as psbl for Aviation Ops Decisions
• Support “H” (Health Scale), but not implement until details addressed

Performance Values
• Thanks to all who have been working on Performance Values
• Request during future action:
  • Clear labeling that Perf Values are a goal not a mandate
  • Re-routes remain responsibility of Operator, not ANSP
  • Fcsting efforts should not over reach capabilities
  • A 30hr fcst accurate only 20% of the time is a disservice