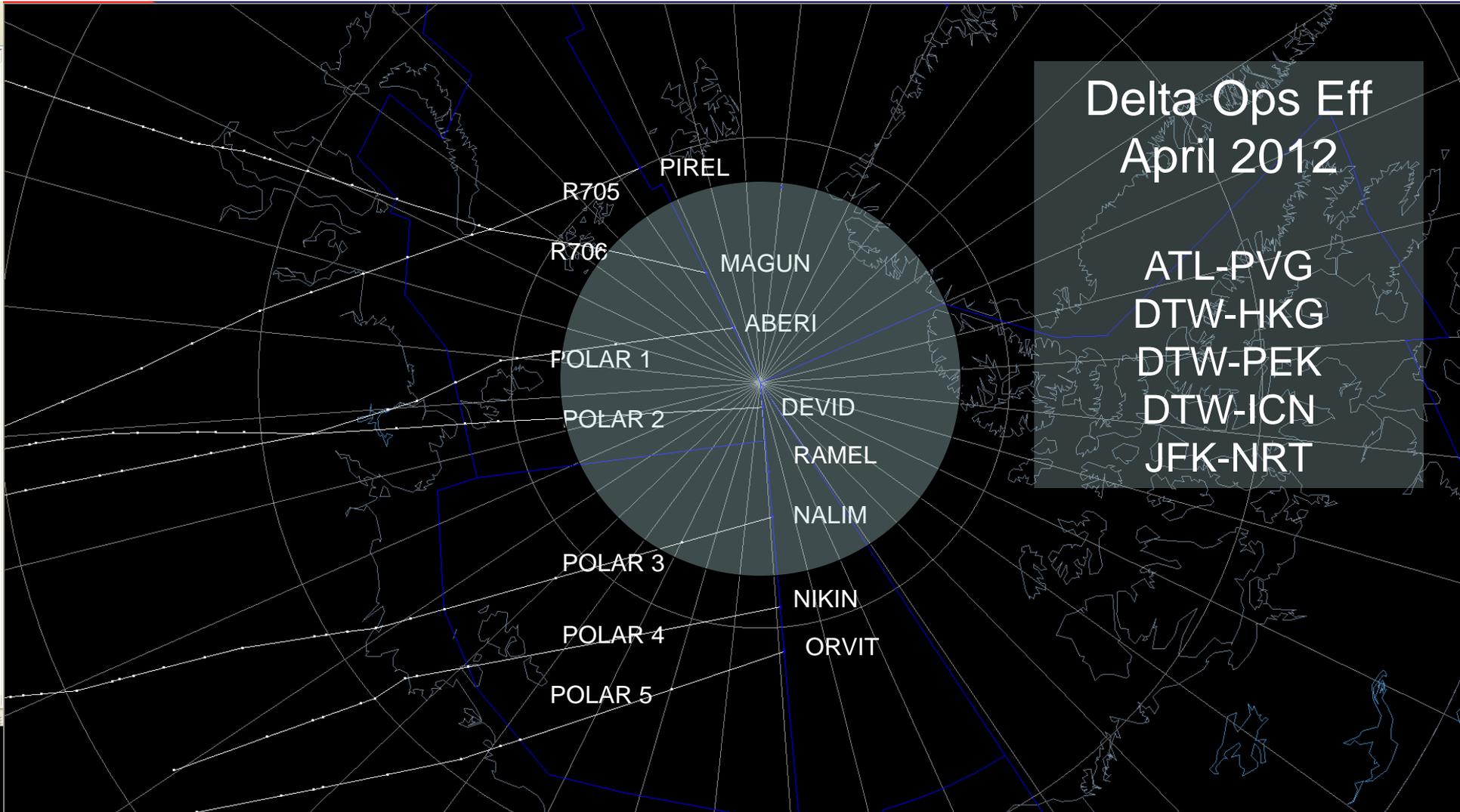


Delta Hazard Avoidance Procedures & Use of Space Weather Information

Space Weather Workshop
Aviation & Space Weather Session
24 April 2012
Boulder, CO
Tom Fahey & Gregg Scott

Polar Routes/Fixes & Delta Ops



Delta Ops Eff
April 2012

ATL-PVG
DTW-HKG
DTW-PEK
DTW-ICN
JFK-NRT

Delta Avoidance HF Comms & Health Related

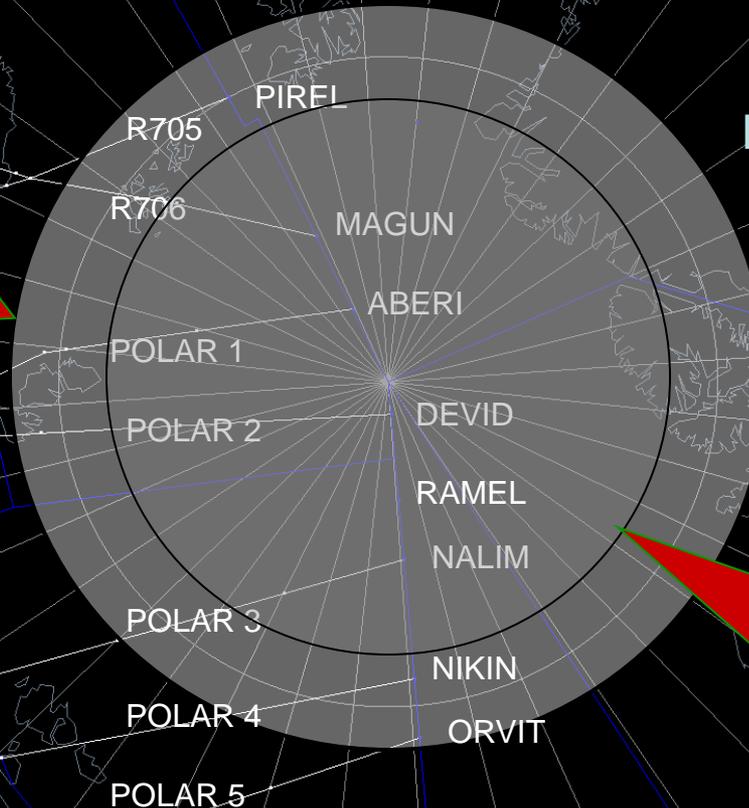
Each flt must maintain constant communication with ATC & with the company.

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
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
YELLOW
 - **Alert:** Adjust route preflight & en route provided no other operational limitations
ORANGE
 - **Avoid:** Adjust route preflight & en route
RED

Types and Hazard Intensity

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

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)



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)

Delta Meteorology Space Weather Activity and Forecast						
Date: Tuesday, March 08, 2011						
Valid: Tuesday, March 08, 2011			thru	Wednesday, March 09, 2011		
Fcstr: LATTERY						
Previous 24 hr Activity						
	Event 1		Event 2 (if needed)		Event 3 (if needed)	
	Scale	Valid Time	Scale	Valid Time	Scale	Valid Time
Geomagnetic Storms:	NONE		NONE		NONE	
Solar Radiation Storms:	S1		NONE		NONE	
Radio Blackouts:	R2		NONE		NONE	
Current Activity						
	Scale	Valid Time	See latest TPs issued for:			
Geomagnetic Storms:	NONE					G3, G4, G5
Solar Radiation Storms:	S1					S3, S4, S5
Radio Blackouts:	R1		R3, R4, R5			
Forecast Activity						
	Scale	Space Weather for the next 24 hours is expected to be minor.				
Geomagnetic Storms:	G1					
Solar Radiation Storms:	S1					
Radio Blackouts:	R1					

Space Weather Info

Storm Scales & Delta TP Product

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

Storm Scale	TP	Geomagnetic Storm Effects
G1		Communications: No Effect Satellite Navigation: No Effect
G2		Communications: Possible HF radio fade Satellite Navigation: No Effect
G3	Alert Issued	Communications: Possible intermittent HF radio outages Satellite Navigation: Possible intermittent satellite navigation problems
G4		Communications: Possible sporadic HF radio outages Satellite Navigation: Possible satellite navigation degraded for hours
G5		Communications: Possible HF radio outages for 1-2 days Satellite Navigation: Possible satellite navigation degraded for days
Storm Scale	TP	Solar Radiation Storm Effects
S1		Communications: Possible minor effects on HF Radio Satellite Navigation: No Effect Biological: No Effect
S2		Communications: Possible small effects on HF Radio Satellite Navigation: Possible navigation at polar cap affected Biological: Possible elevated radiation risk
S3**	Alert Issued	Communications: Possible HF radio degradation Satellite Navigation: Possible satellite navigation errors Biological: Possible elevated radiation risk
S4**		Communications: Possible blackout of HF radio for several days Satellite Navigation: Possible satellite navigation errors for several days Biological: Possible elevated radiation risk
S5**		Communications: Possible complete blackout of HF radio for several days Satellite Navigation: Possible satellite navigation errors for several days Biological: Possible elevated radiation risk
Storm Scale	TP	Solar Flare - Radio Blackout Effects
R1		Communications: Possible minor degradation to HF radio on sunlit side of Earth Satellite Navigation: No Effect
R2		Communications: Possible blackouts to HF radio for tens of minutes on sunlit side of Earth Satellite Navigation: No Effect
R3	Advisory Issued	Communications: Possible blackouts to HF radio for an hour on sunlit side of Earth Satellite Navigation: No Effect
R4		Communications: Possible blackouts to HF radio for 1-2 hours on sunlit side of Earth Navigation: Possible minor disruptions to satellite navigation on sunlit side of Earth
R5		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
<p>*** 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). ***</p>		

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)

TP AO26 241604Z

1.AO

2.* **ADVISORY** *

HAZ:SPACE WX

SOURCE:OBSERVED

CATEGORY:R3

LAT/LON:90.0N100.0W

RADIUS:480NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:SOLAR FLARE WITH

NO IMPACT TO

POLAR RTES KNOWN OR

FCST AT THIS TIME.

3.VALID 241604/241804Z

4.CANCEL NONE

TP AO30 241608Z

1.AO

2.* **ALERT** *

HAZ:SPACE WX

SOURCE:FORECAST

CATEGORY:S3

LAT/LON:90.0N100.0W

RADIUS:780NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:RCMND AVOIDING

ALL POLAR RTES.

3.VALID 241800/250400Z

4.CANCEL NONE

TP AO31 241609Z

1.AO

2.* **ALERT** *

HAZ:SPACE WX

SOURCE:FORECAST

CATEGORY:G3

LAT/LON:90.0N100.0W

RADIUS:480NM

TIME:POSN AT 24/1600Z

ALTS:FL300-500

INFO:RCMND AVOIDING

POLAR RTES N OF 82N.

3.VALID 241800/250400Z

4.CANCEL NONE

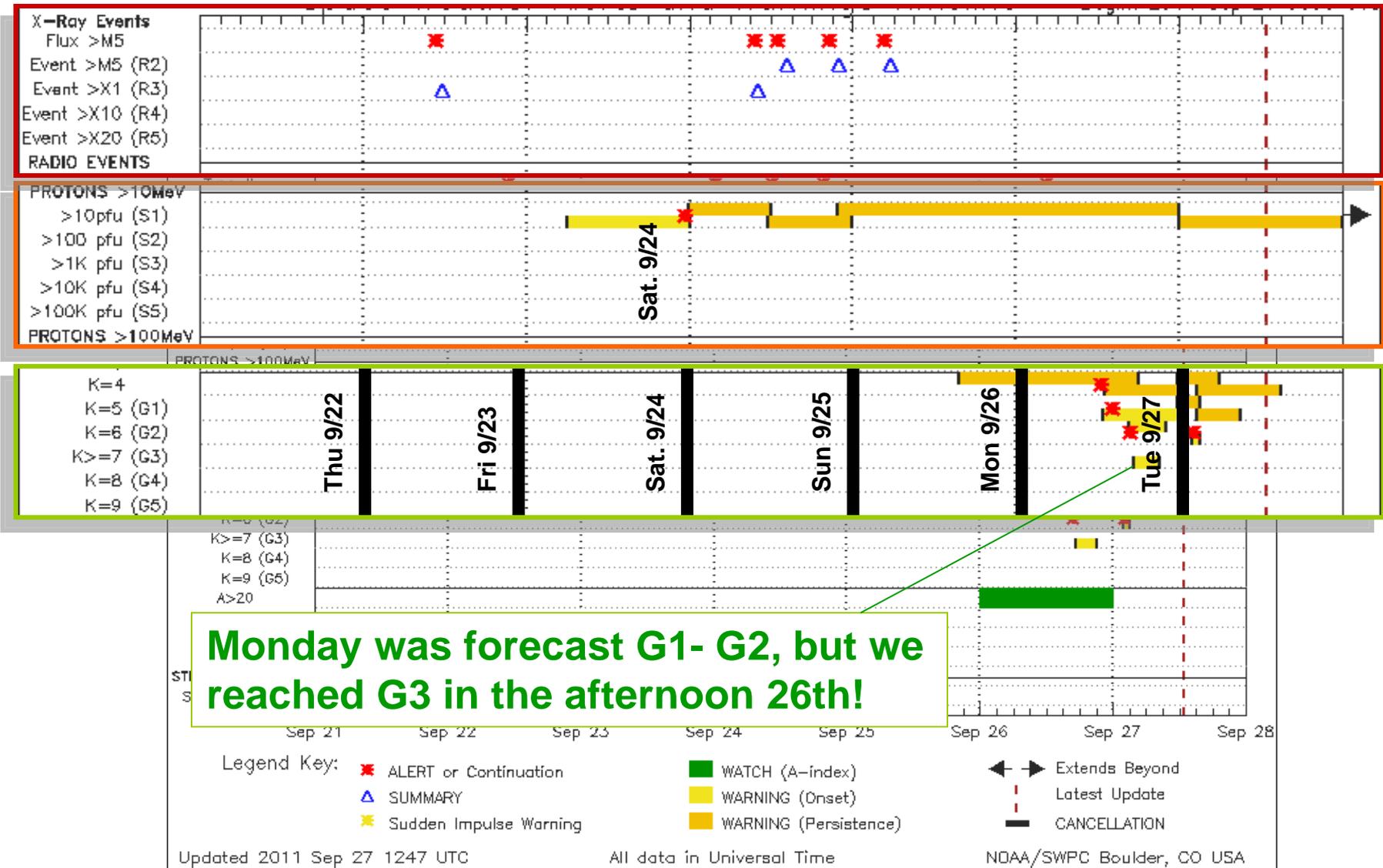


Space Weathr Info

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.

24-28 September 2011 Event





TP AO45 261751Z

1.AO

2.* ALERT *

HAZ:SPACE WX

SOURCE:OBSERVED

CATEGORY:G3

LAT/LON:90.0N100.0W

RADIUS:480NM

TIME:POSN AT 26/1750Z

ALTS:FL300-500

INFO:RCMND AVOIDING

POLAR RTES N OF

82N

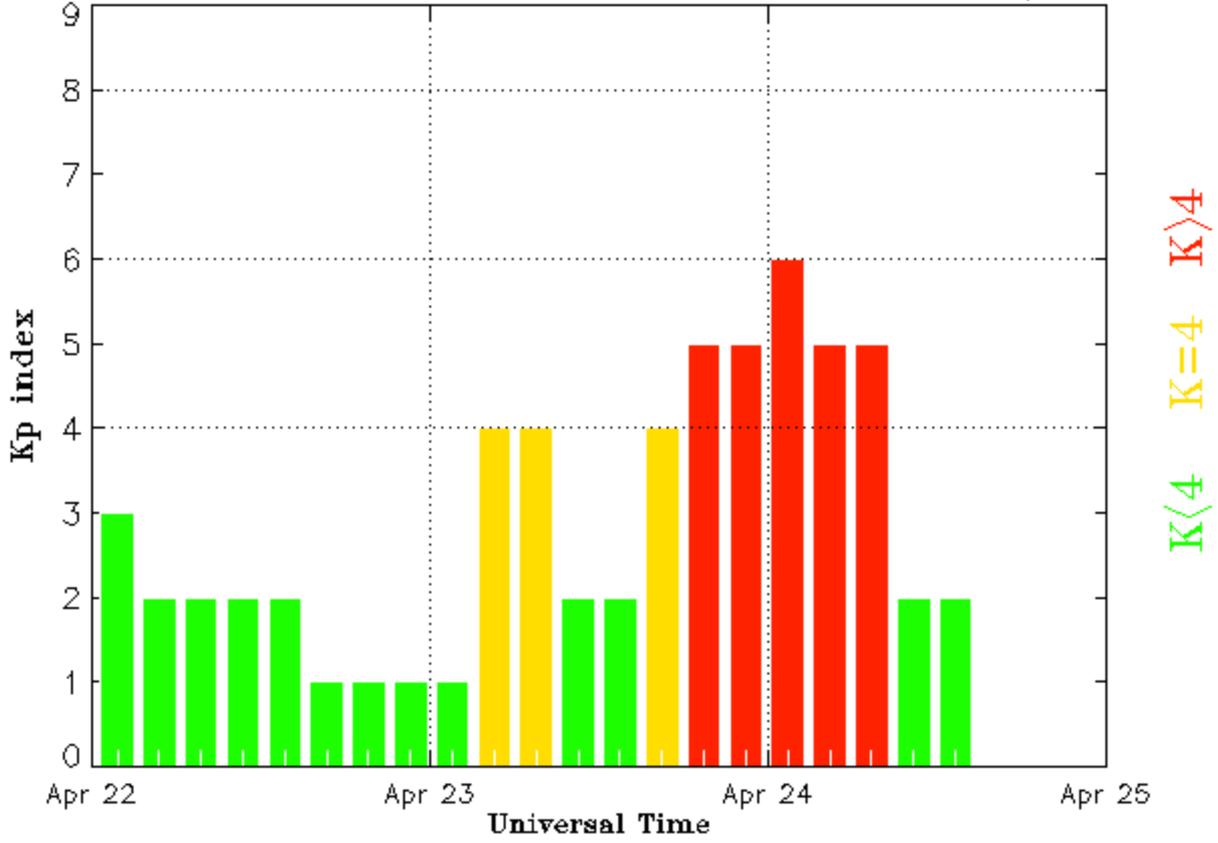
3.VALID 261751/262100Z

4.CANCEL NONE



Current Solar Cycle Geomagnetic Kp Estimate 22-24Apr12

Estimated Planetary K index (3 hour data) Begin: 2012 Apr 22 0000 UTC



Kp-index	NOAA Space Wx Scale Geomagnetic Storm Level
Kp=5	G1
Kp=6	G2
Kp=7	G3
Kp=8	G4
Kp=9	G5

Updated 2012 Apr 24 17:35:06 UTC

NOAA/SWPC Boulder, CO USA



SWPC Warning – 0205z 24 Apr12

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:90.0N100.0W

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

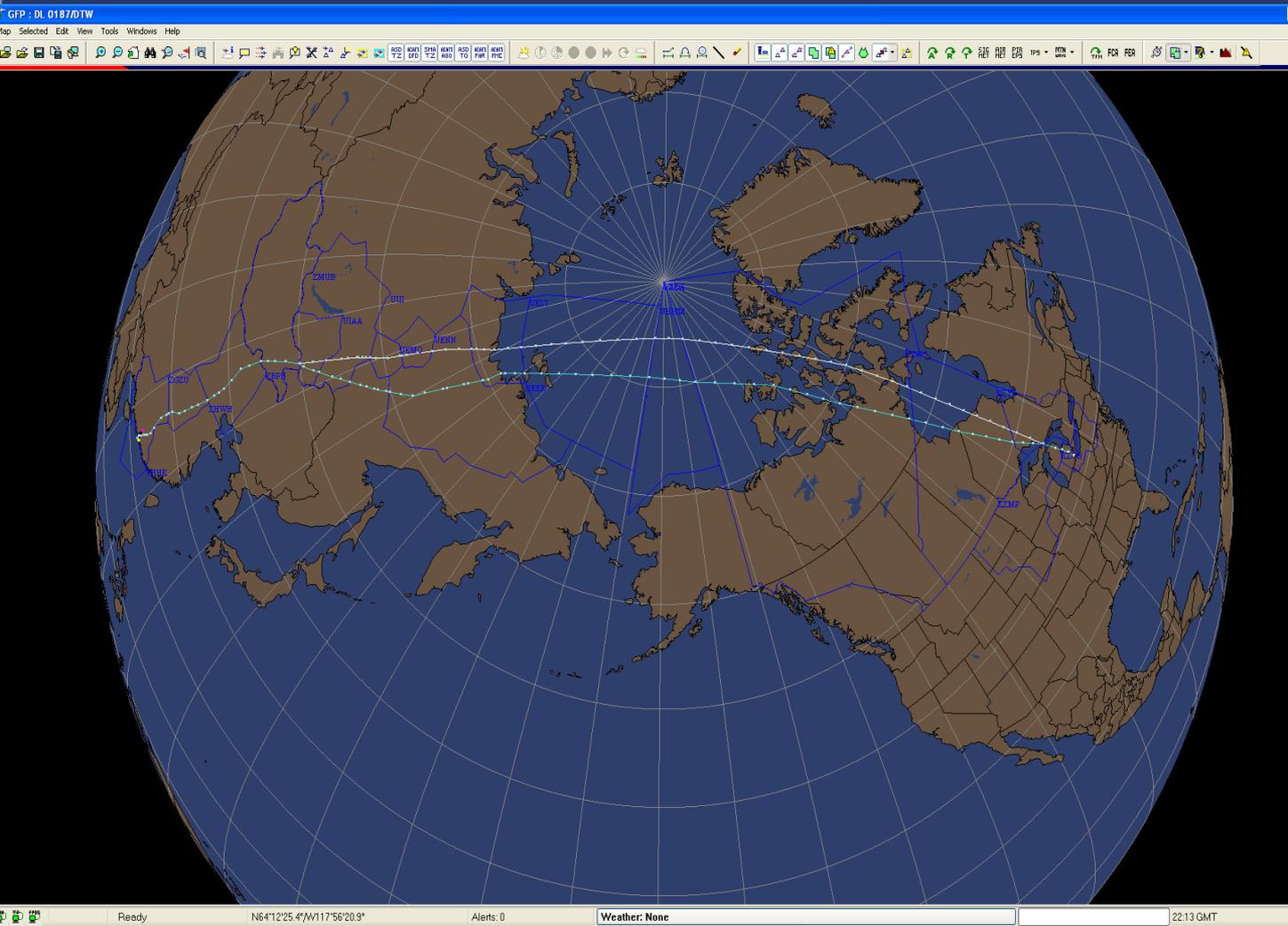
DTW-PEK Flt 189 rerouted South of 82N (RAMEL to ORVIT)

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**

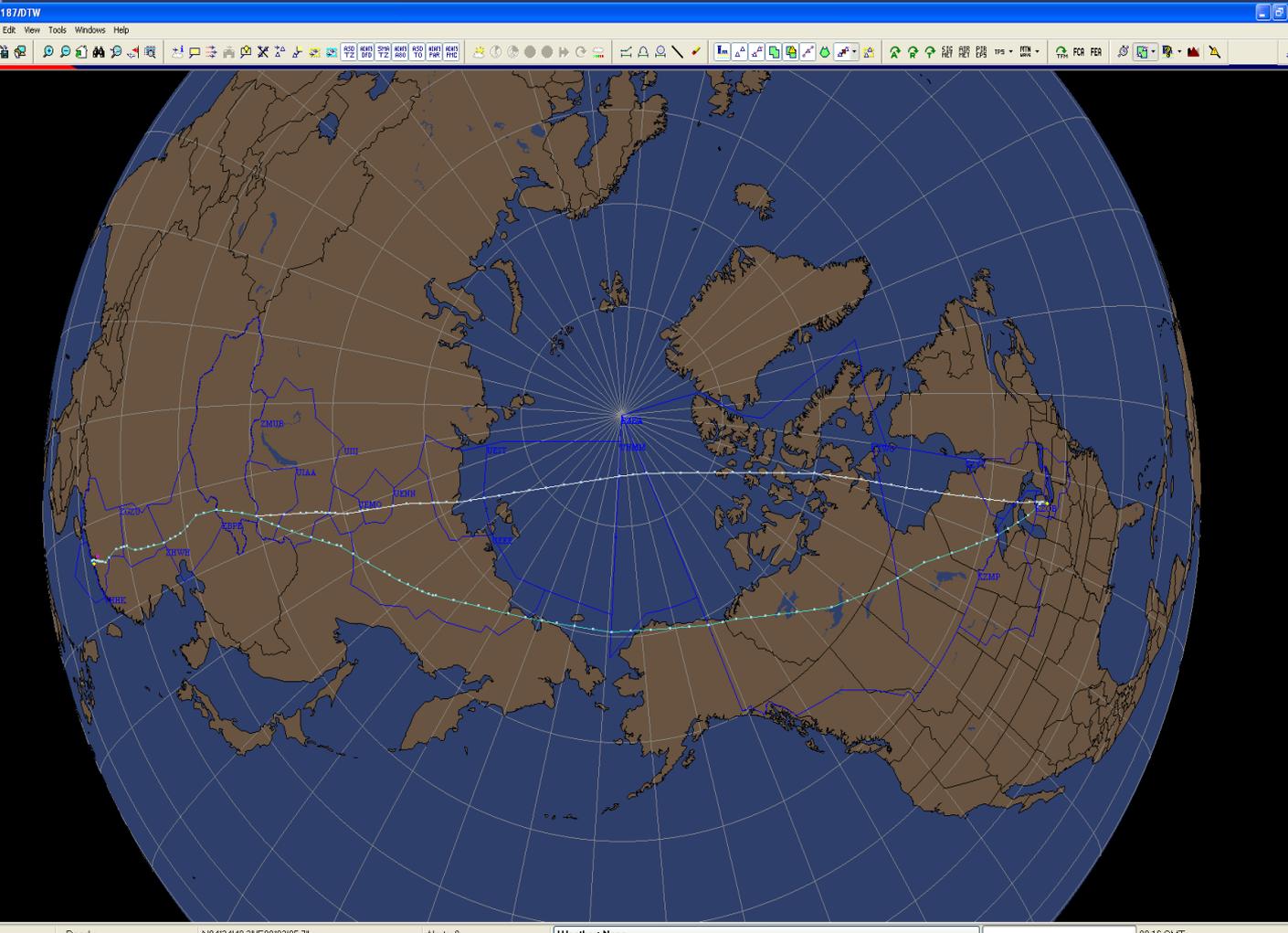
Delta Air Lines

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



**S scale
Scenario
Alert from Metro**

AVOID All Polar routes

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)

Impact	Cause	Space Weather Forecast Issue Times					Space Weather Related Events
		6-hour fcst	12-hour fcst	30-hour fcst	3-day fcst	7-day outlook	
Disruptions/loss of HF communications	Ionospheric Irregularities - Dayside Absorption - Polar Cap Absorption - Auroral Absorption	Every 2 hours starting at 00 UTC	Every 3 hours starting at 00 UTC	00, 06, 12, 18 UTC	Daily	Daily	Solar Flares Solar Particle Events Geomagnetic Storms
Verification		95%	95%	85%	75%	65%	

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