Impact on Aviation: Severe Space Weather and EMP

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Solar Storms: Space Weather Hazards

Solar Flares  Coronal Mass Ejections (CMEs)  Geomagnetic Storms

Interested in….
- High energy solar outputs
- Magnetic orientation

& effect upon….
- Radiation environment
- Technology & operations

Dose rate @35,000ft from background cosmic radiation
Impact on Aviation: Space Weather Effects

- Satellite navigation (GPS)
  - Position errors
  - System availability
- Communications loss
- Avionics upsets/failures
- Human exposure
Impact on Aviation: FAA GPS system outage

WAAS Outage

Oct 2003
• 15 hours

Nov 2003
• 10 hours

Apr 2010
• Galaxy 15 lost
Impact on Aviation: GPS outage

IGS Network, 6 December 2006

19:14:46 UTC

Failure  Operational

Owens Valley Solar Array RHCP SRB Power (1.6 GHz)
Impact on Aviation: Avionics

Avionic upsets, failures
- Fewer radhard components
- More advanced electronics = more susceptibility

Upset rate/hr in memory chip (avg 2.5/hr)
(Dyer et al)
- Sep 1989 – 84.7/hr
- Feb 1956 – 493/hr
- Sep 1859 – ?

(Dyer et al)
Impact on Aviation: Ordinary v Severe Doses

Calm(!!) radiation environment
London – Los Angeles 0.065mSv

Solar Storm Doses (Dyer et al.)
Jul 2000 – 0.031mSv
Oct 1989 – 0.25mSv
Sep 1989 – 1.33mSv
Feb 1956 – 2.27mSv
Sep 1859 – ?

Biggest storms in Digital Age: 1983-2010
30th October 2003: 656 nT/min
(dX/dt=+621,dY/dt=-213), 42A

Events 1-3 are mentioned in a 2002 scientific/industry paper as ‘causing problems’ in the UK power system.
Impact on Aviation: Operations, Safety

**North Atlantic Track System (Sep 2010)**
- 110 aircraft/hour peak
- 1200 aircraft/day

**19th Sep 10 15:30**
≥36,000ft (11km) - 41 aircraft

**Strong Solar Storm (2hrs warning!)**
- Loss of HF communications
- Double time separation
- ~ 40 aircraft/hour
- Severe disruption 4-5 hours

**Severe Solar Storm**
- Loss of ADS
- Loss of Datalink communications
- Closure of airspace
Impact on Aviation: Operations, Safety

Polar Routes – Economic Drivers

Polar 3 (Flight time: 14:32)
316 Pax
2200kg (5000 lbs) Cargo

Russia (15:41)
246 Pax
No Cargo

NOPAC (17:18)
No Pax
No Cargo

2005 - $186M extra fuel used due space weather
Impact on Aviation: EMP

Most electronic reliant transport

Safety-of-Flight electronics
- Non-hostile/natural EM
- Significant redundancy (4 levels)

EMP vulnerability
- All aircraft at significant risk
- ATC systems, radars at risk
- Months or greater to restore
Mitigation: International Coordination

International Civil Aviation Organization (ICAO)

World Meteorological Organization (WMO)
Impact on Aviation: Severe Space Weather and EMP

EIS Summit, Westminster Hall, London, 20th Sep 2010

- Space weather impacts current global operations and safety
- Severe solar storms could curtail or shutdown operations
- All commercial aircraft and ATC systems prone to EMP effects
- Advancing technology = increasing vulnerability to space weather

International coordination in progress, more required