

Space Weather Considerations for Civil Aviation and Suborbital Operations



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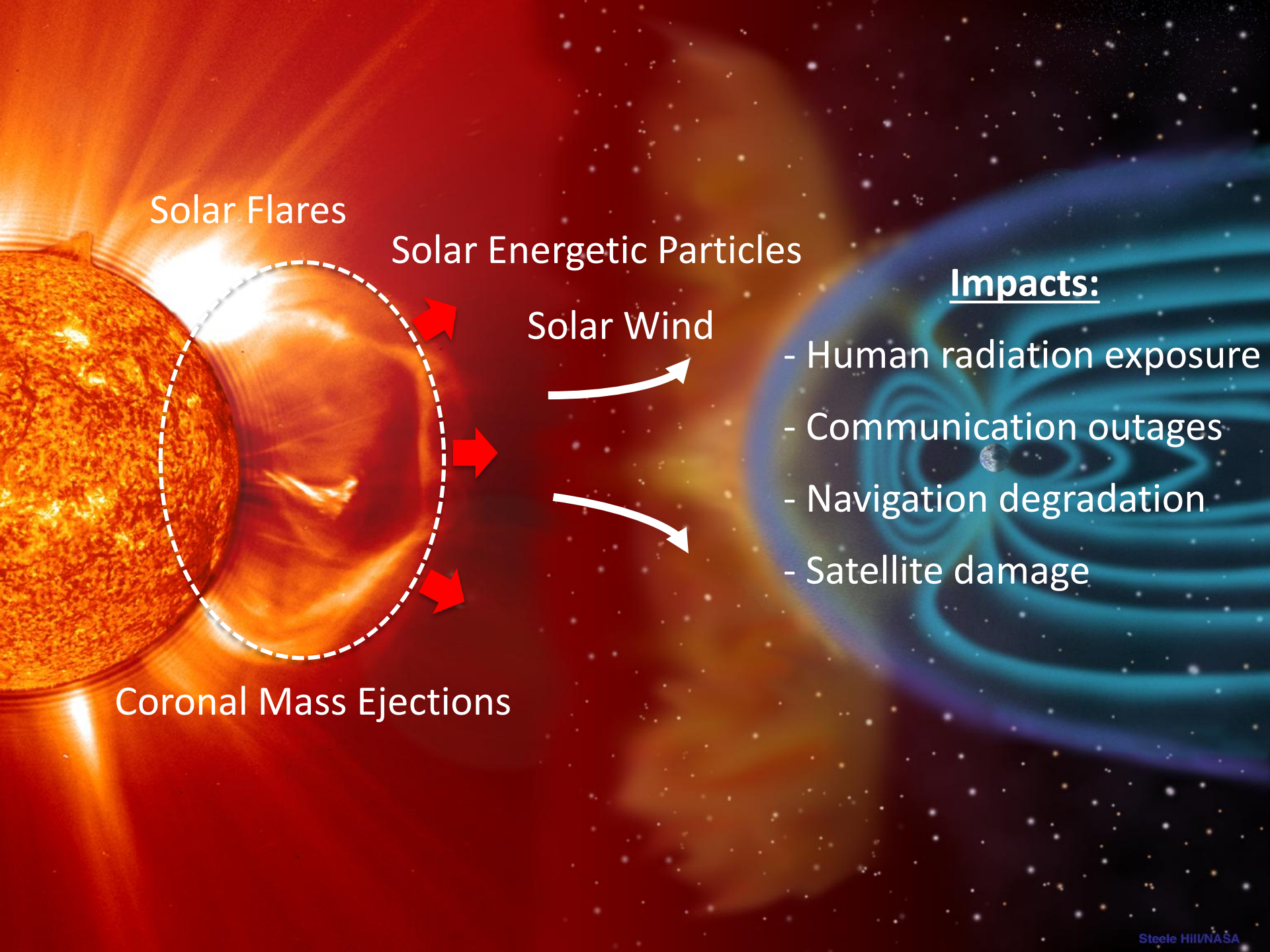


Main Points



- Space weather overview
- Impacts on aviation and space operations
- International mitigation efforts





Solar Flares

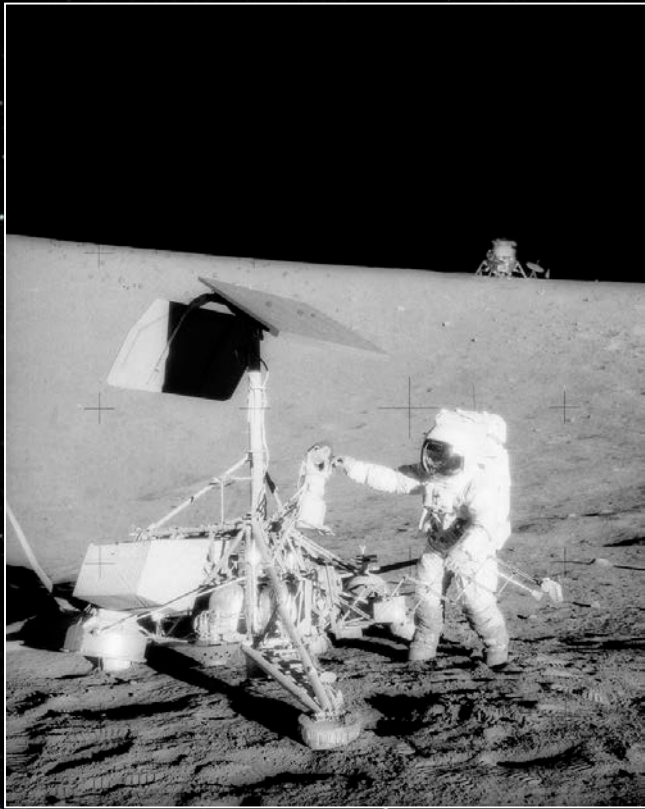
Solar Energetic Particles

Solar Wind

Coronal Mass Ejections

Impacts:

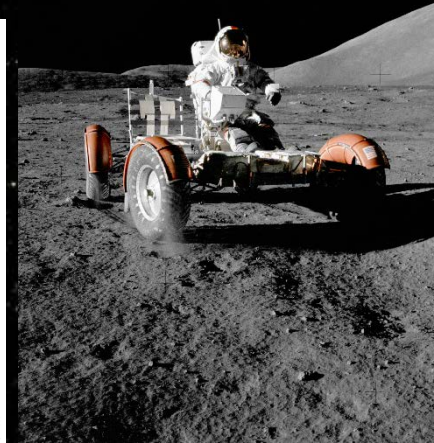
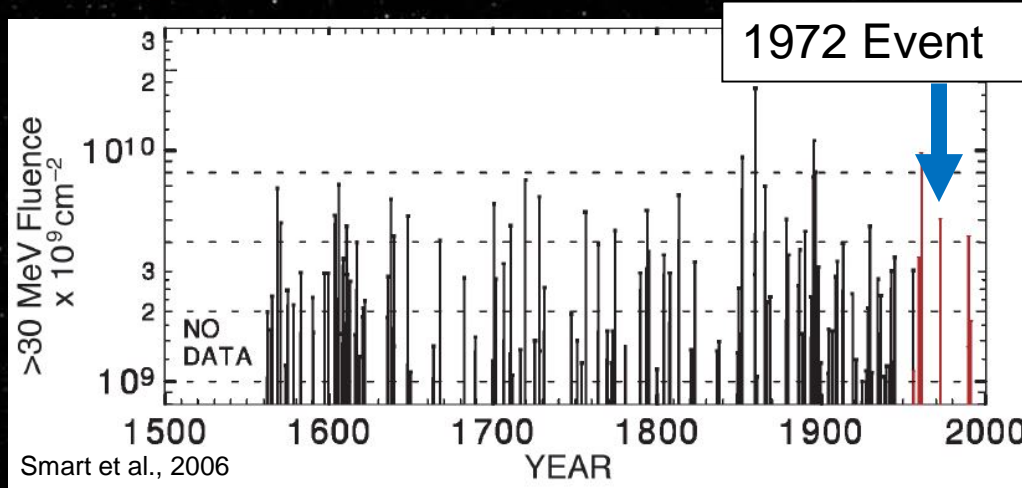
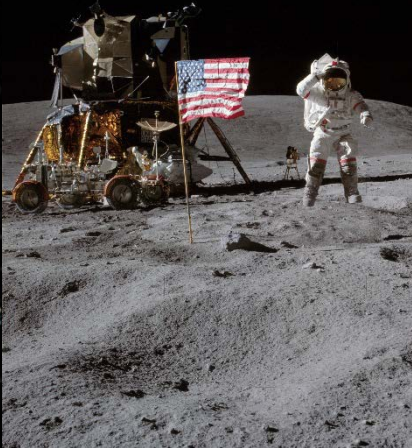
- Human radiation exposure
- Communication outages
- Navigation degradation
- Satellite damage



Apollo Moon Landings 1969 - 1972

Apollo 16

Apollo 17



Event would have caused
Acute Radiation Sickness,
without shielding and medical
countermeasures



April, 1972

August, 1972

December, 1972

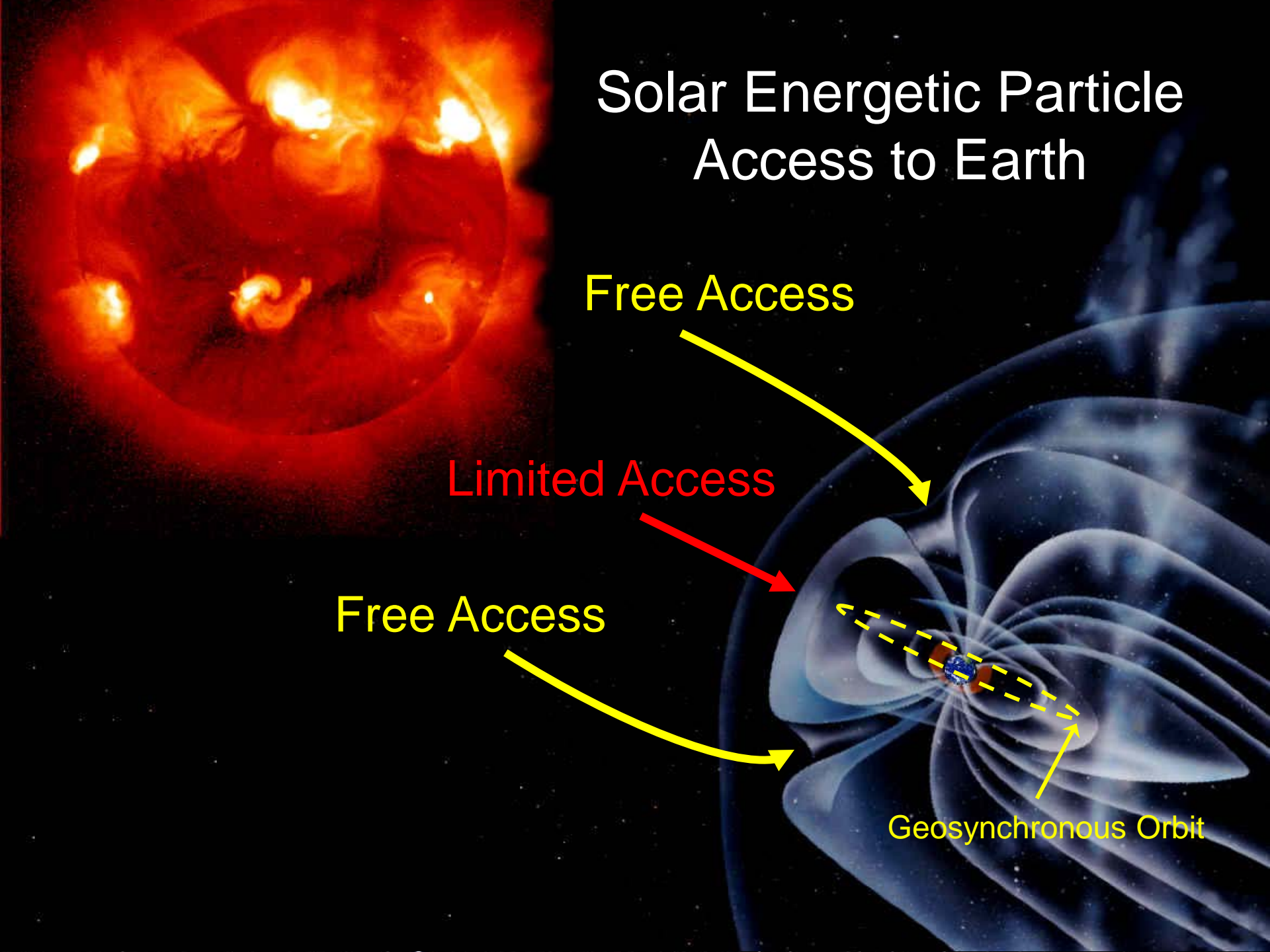
Solar Energetic Particle Access to Earth

Free Access

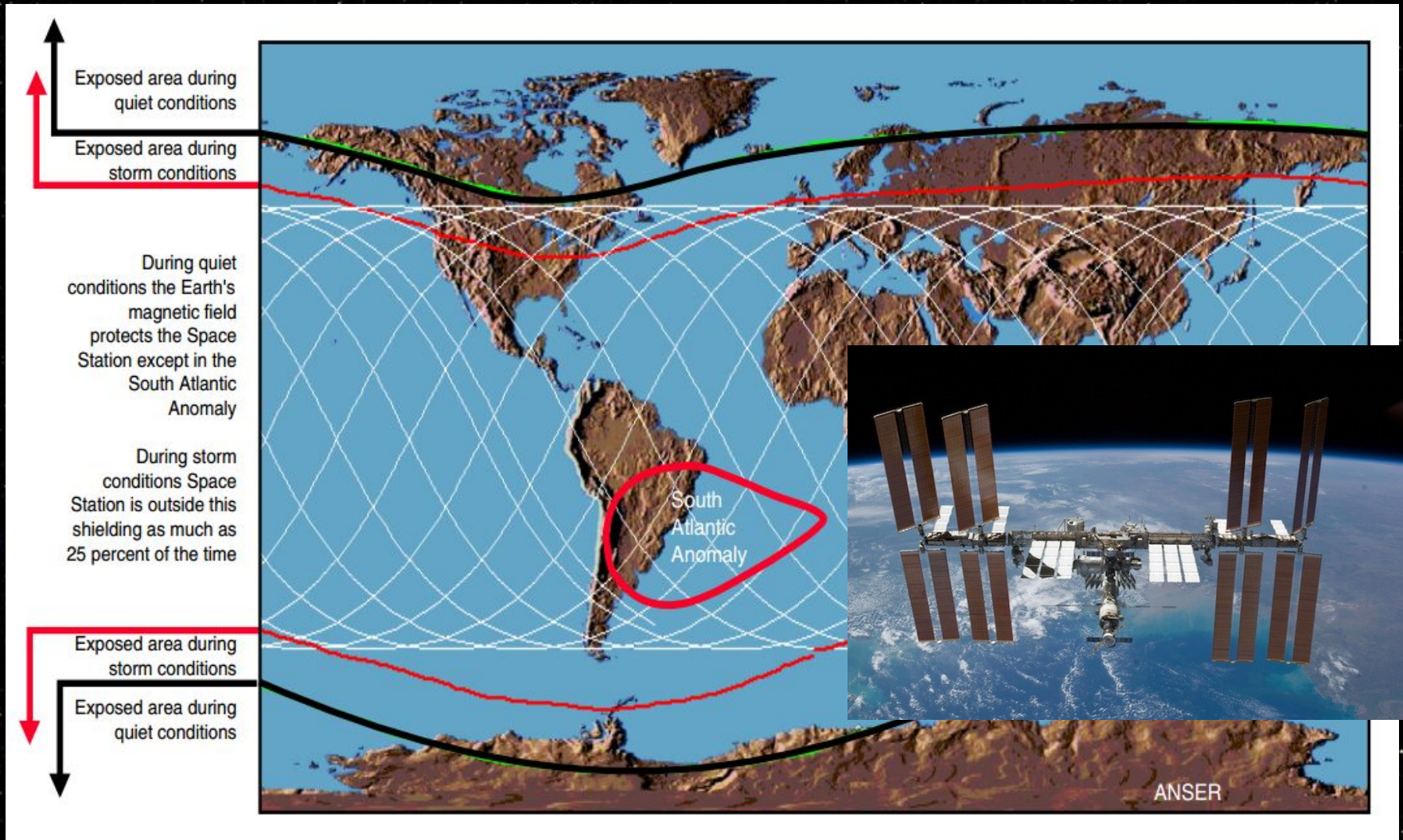
Limited Access

Free Access

Geosynchronous Orbit



Proton Exposure versus Geomagnetic Activity

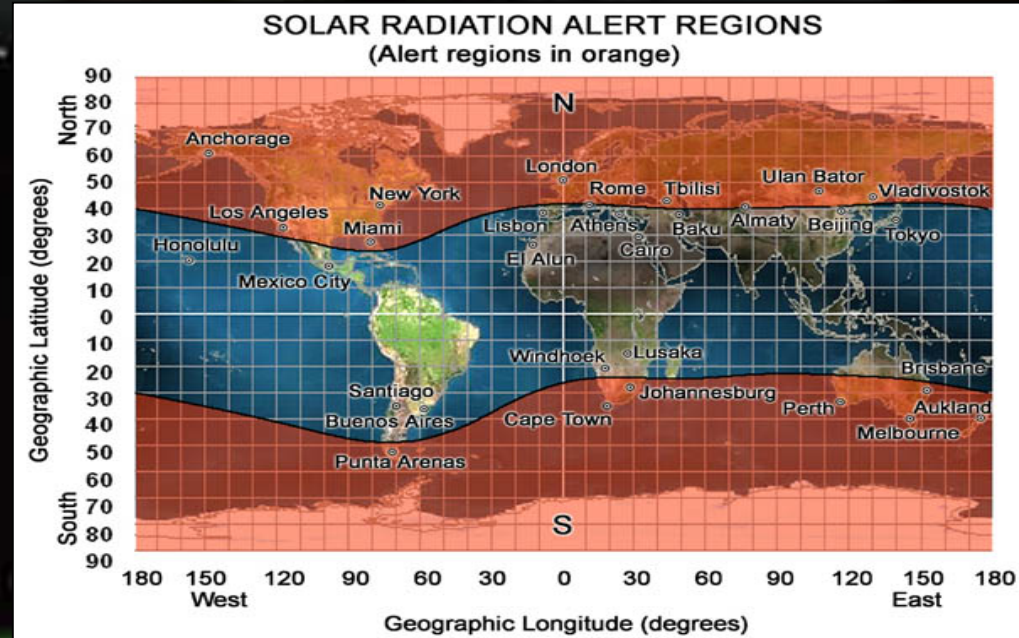


Alert Issued for Airline Radiation

ALERT: Solar Radiation Alert at Flight Altitudes Conditions Began: 2003 Oct 28 2113 UTC

Comment: Satellite measurements indicate unusually high levels of ionizing radiation, coming from the sun. This may lead to excessive radiation doses to air travelers at Corrected Geomagnetic Latitudes above 35 degrees north, or south.

(Federal Aviation Administration)



RESEARCH ARTICLE

OPEN ACCESS

Economic impact and effectiveness of radiation protection measures in aviation during a ground level enhancement

Daniel Matthiä^{1,*}, Martin Schaefer², and Matthias M. Meier¹

2015



- Radiation dose reduced by 42% with 5% fuel increase and 30 min flight delay
- Prompt changes in altitude and velocity not compliant with Air Traffic Mgmt System



Spacecraft Operations and Aviation Impacts

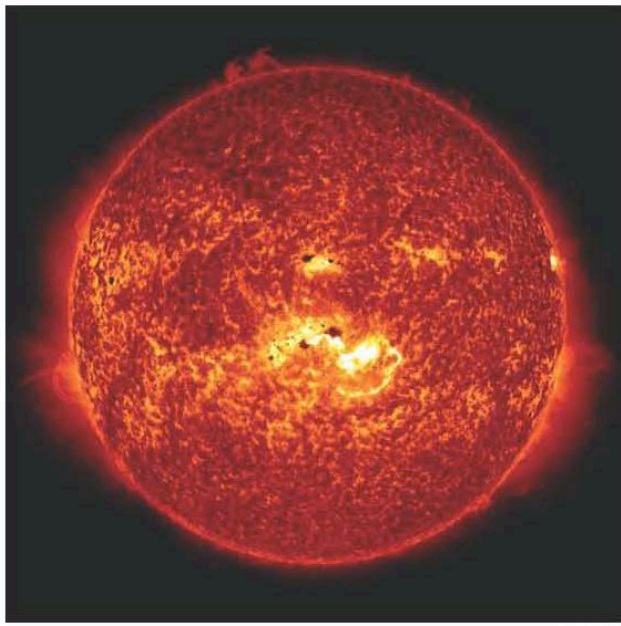
January 8, 2014

NBCnews.com

Huge solar flare delays private rocket launch to Space Station

Tariq Malik, Space.com

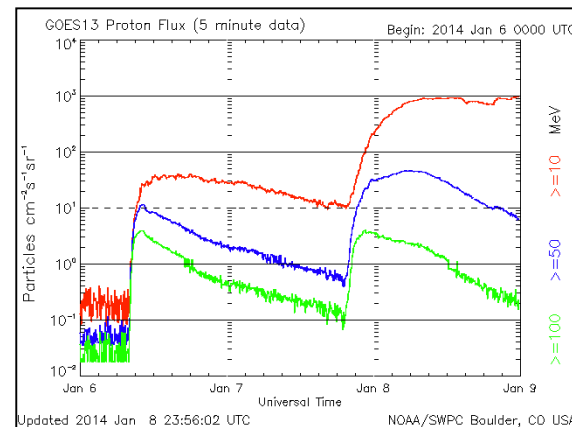
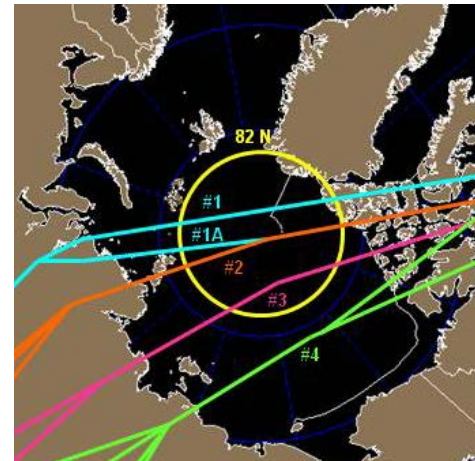
35 minutes ago



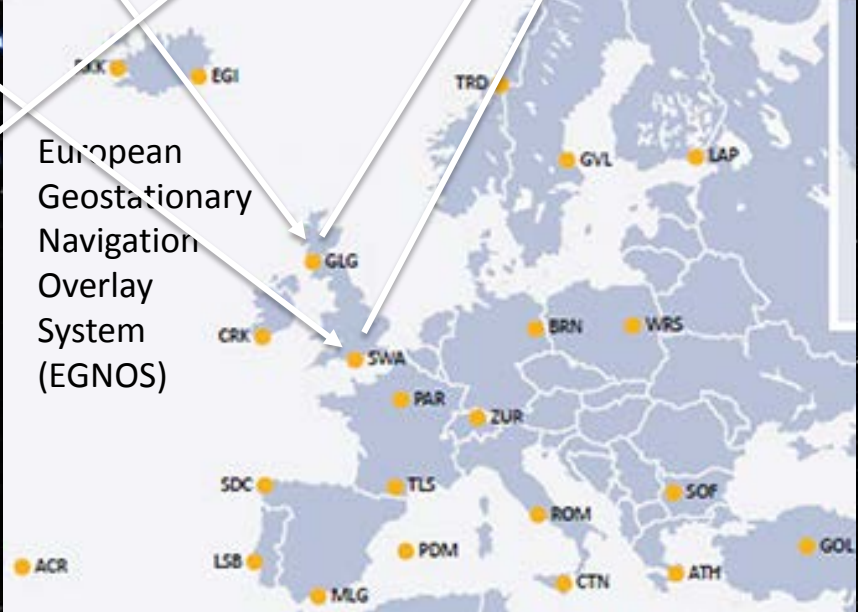
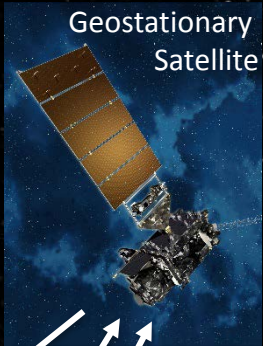
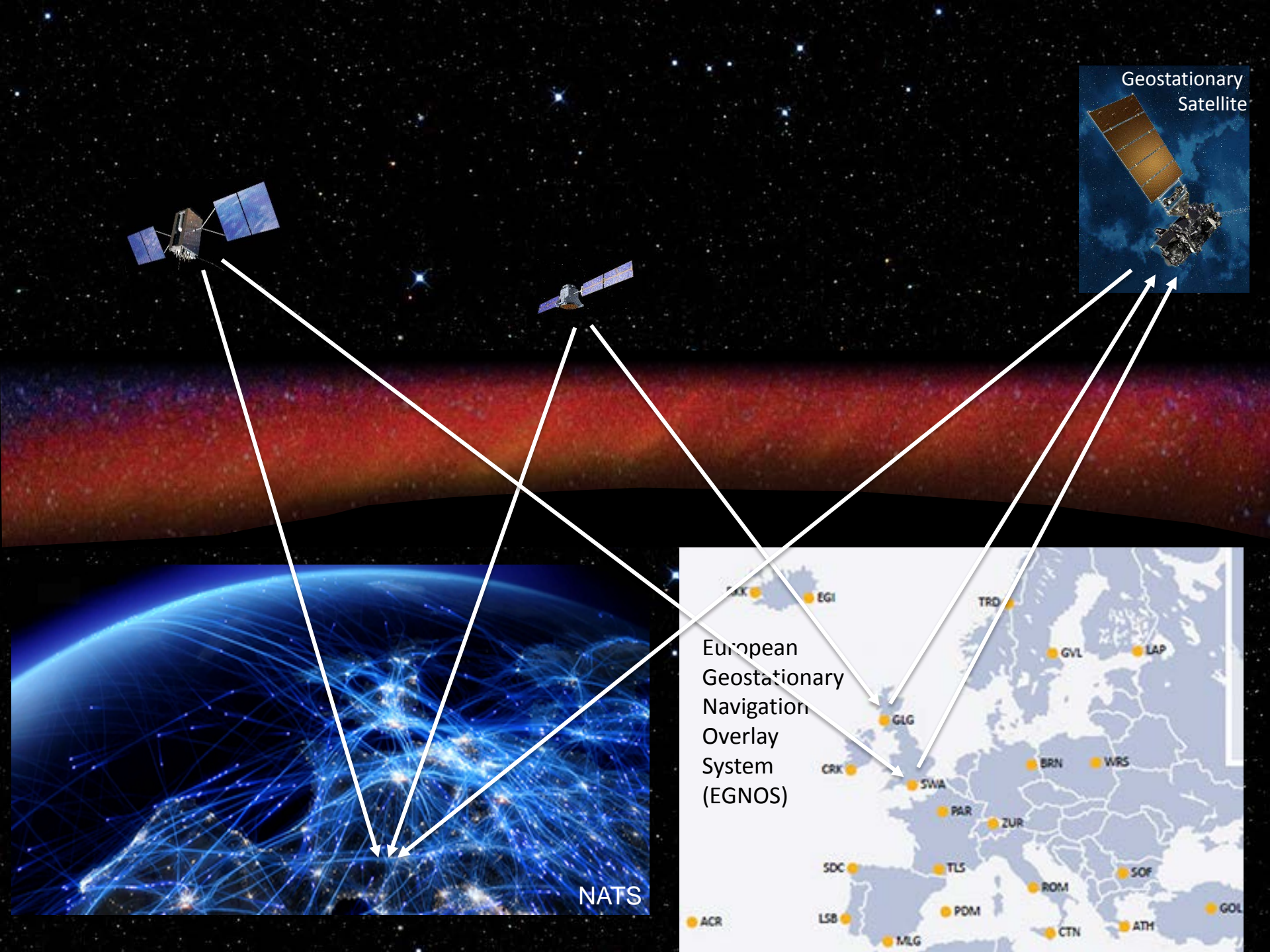
NASA/SDO

Orbital Sciences cargo delivery to International Space Station

Polar Airline Flights Re-routed



Energetic Proton Flux
Geostationary Orbit



European Geostationary Navigation Overlay System (EGNOS)



SPACE NEWS

Home Launch Contracts Civil Military **Satellite Telecom** Ear

04/18/10 02:33 PM ET

Intelsat Loses Contact with Galaxy 15 Satellite

SPACE NEWS

Home Launch Contracts Civil Military **Satellite Telecom** Ear

04/20/10 02:05 PM ET

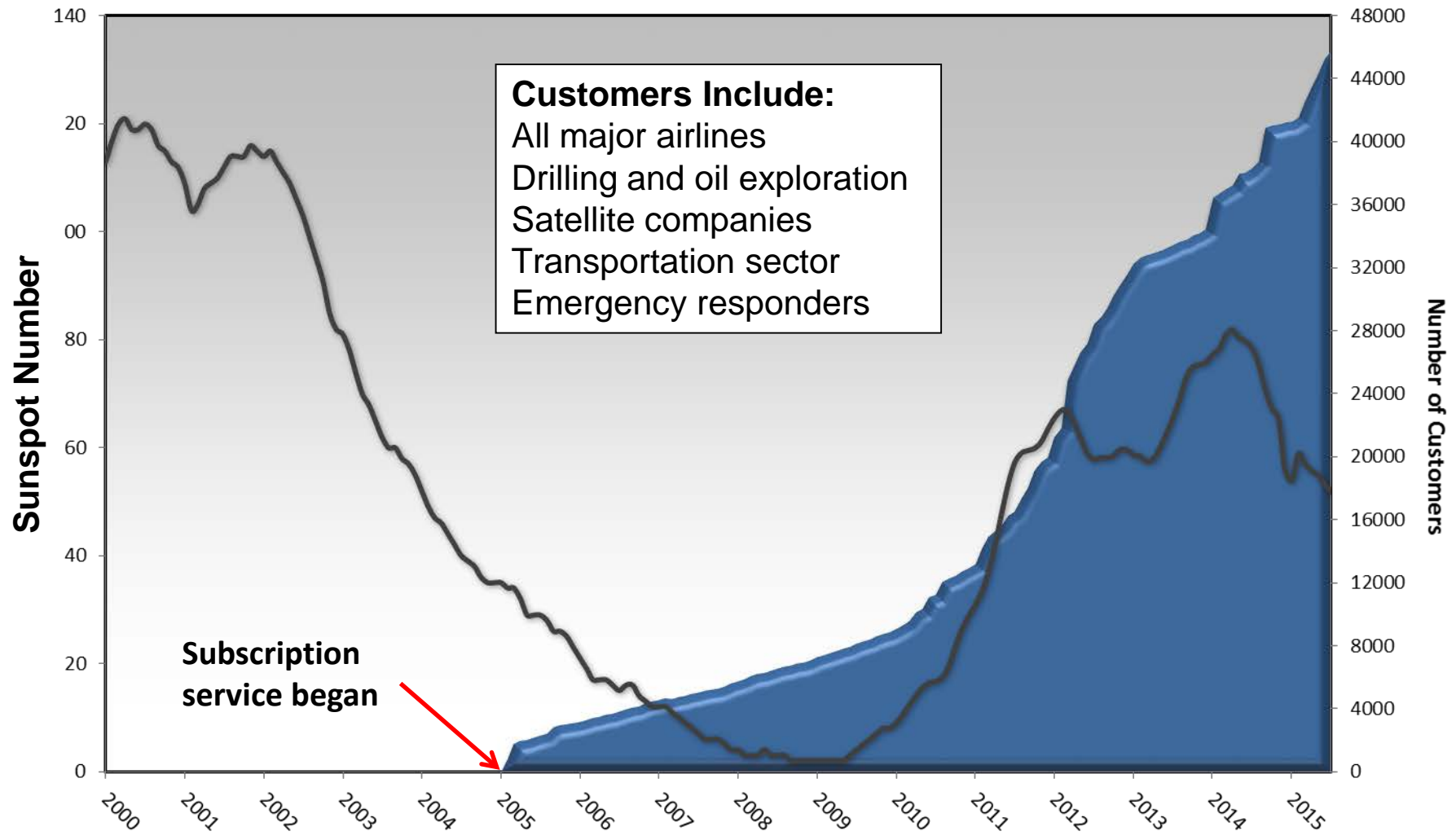
Orbital Blames Galaxy 15 Failure on Solar Storm



Galaxy 15

Customer Growth

NOAA Space Weather Prediction Center – Product Subscription Service





Space Weather Risks are Recognized - National Mitigation Plans are being Developed

South Korea:

- Space Weather included in National Risk Profile
- Roles and responsibilities of agencies and ministries defined



Korea Space Weather Center

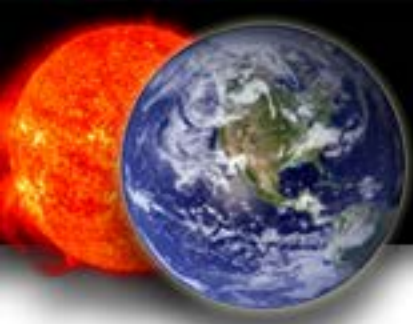
United Kingdom:

National Register Recognizes
Space Weather Risks

 **CabinetOffice**

National Risk
Register of
Civil Emergencies

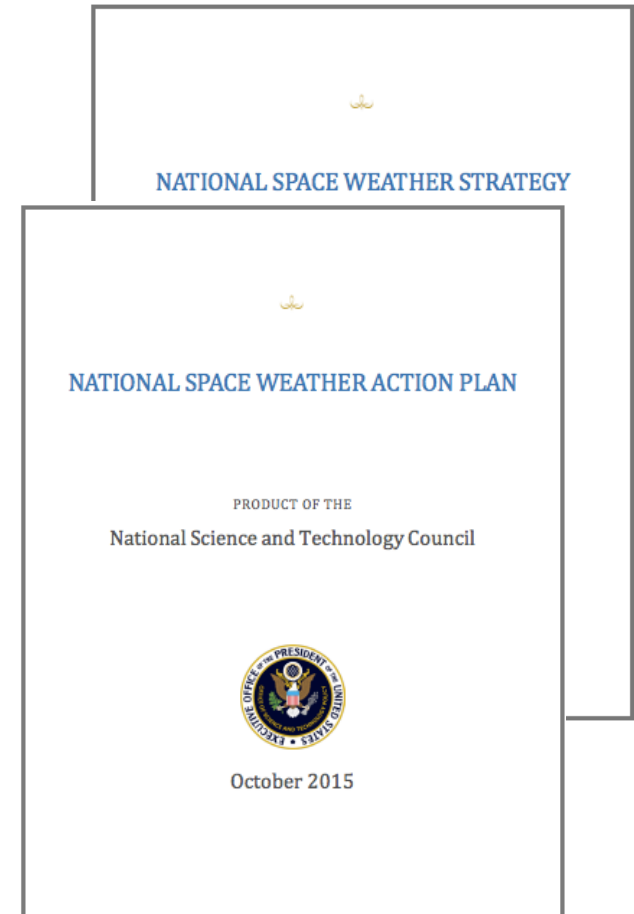
2012 edition



Space Weather Risks are Recognized - Mitigation Plans are being Developed

U.S. National Strategy and Action Plan released October, 2015

- Benchmarks for commercial space and aviation radiation
- Benchmarks for ionosphere (GNSS)
- Observing requirements for aviation services
- Model development for aviation services
- National and international actions





Space Weather is an additional hazard to aircraft operations

- Service requirements under development
- Communication, navigation and radiation are being addressed
- Global and regional coordination are essential

**International
Civil
Aviation
Organization**

NATS



Summary

- Space weather is an integral part of our economic and security infrastructures
- Aviation and space operations are impact by space weather in numerous ways: communication, navigation, radiation
- Demand for services is increasing
- National and international actions are helping to establish an integrated, global effort
- ICAO/UNOOSA Symposia are essential for investigating the risks and developing effective mitigation strategies