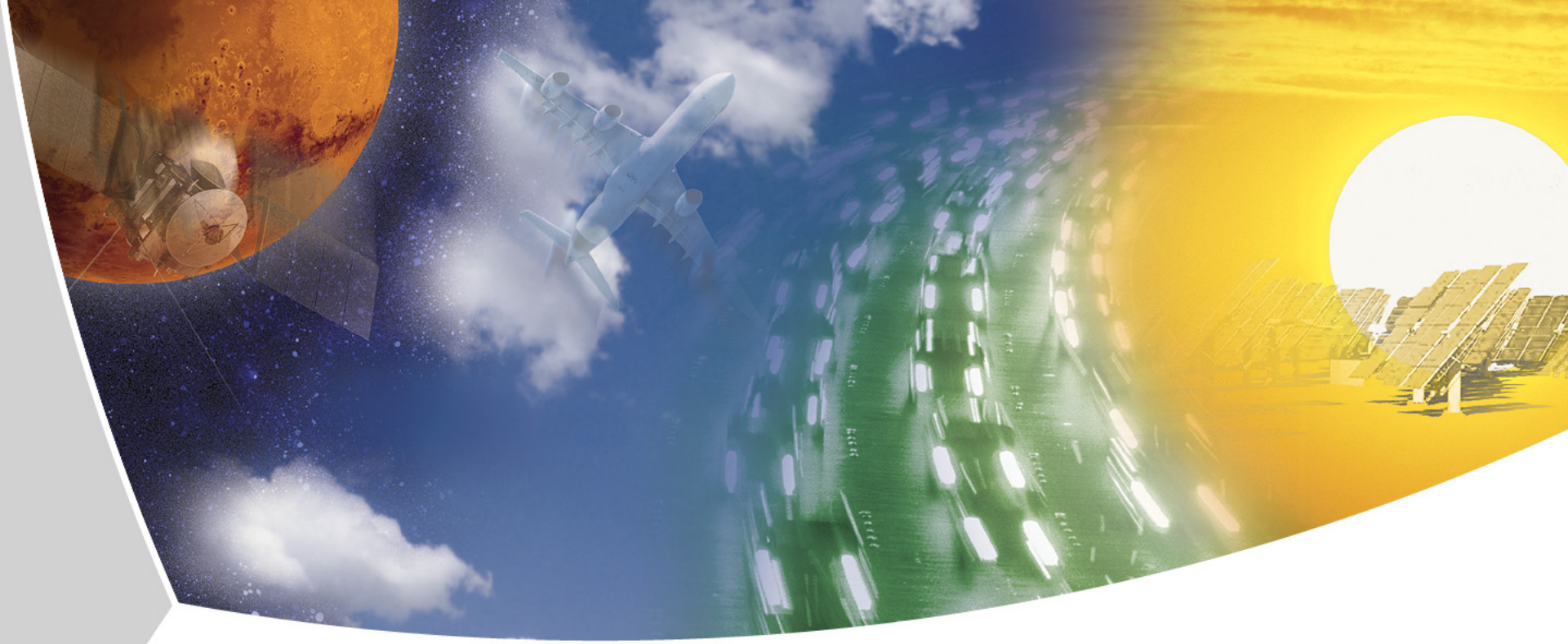


International Space Weather Status: Towards Space Situational Awareness

Frank Jansen

DLR Institute of Space Systems, Bremen, Germany

e-mail: frank.jansen@dlr.de

Deutsches Zentrum
DLR für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

DLR Institute of Space Systems, Bremen

established 26 January 2007, starting from scratch

today: more than 120 staffs

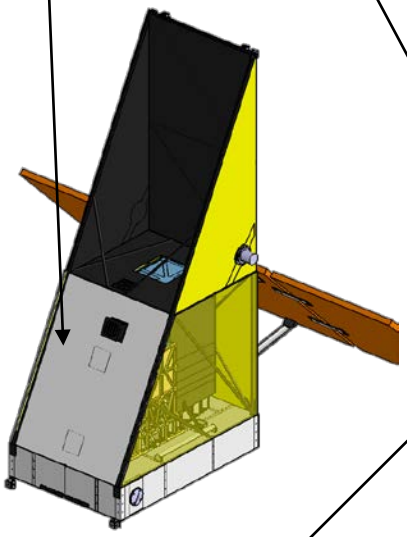
- **Concepts**
  - Development and evaluation of concepts for space missions with high visibility on national and international level.
  - Processing and generation of fundamental information for political decisions regarding the national and international astronautics strategy.
- **New Applications and Technologies**
  - Space based applications and technologies for scientific, commercial and security relevant needs.
  - Realization in cooperation with research institutions and industry.
- **Education**
  - Support of education at universities in space system engineering (student projects etc.).

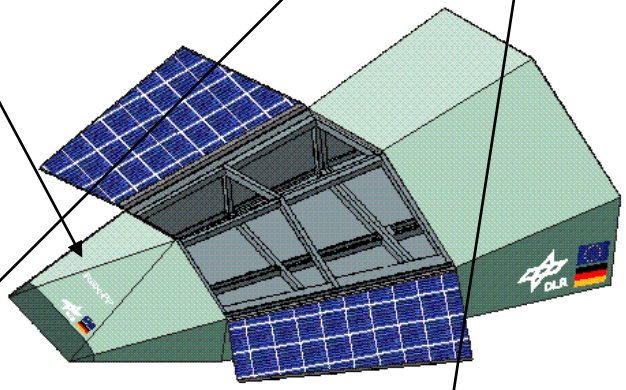


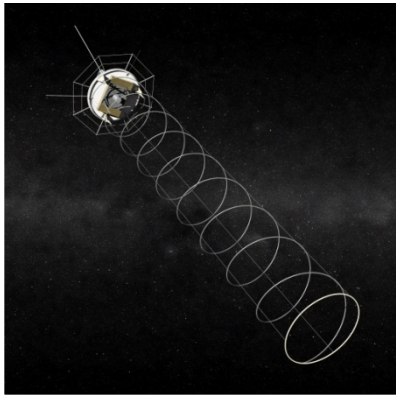

Views on u-shaped building of DLR Institute of Space Systems in Bremen including new laboratory building and drop tower.

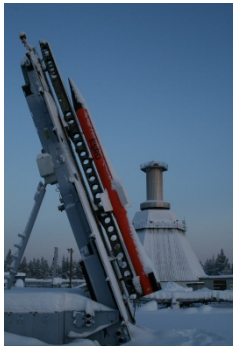
Examples of Activities at DLR Bremen

AsteroidFinder, REX-FF, AISat, BEXUS / REXUS, CEF, DLR School_Lab, GMDN









The Sun, **Cosmic Rays: Space Weather** => Politics

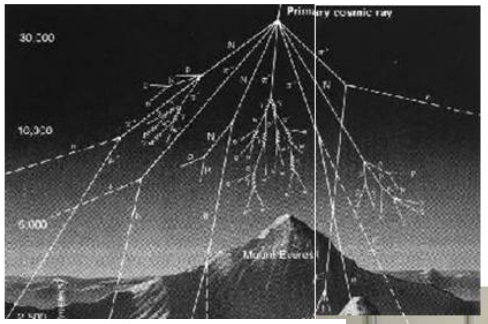
Towards SSA in Europe: First European SW Telescope MuSTanG (2004-2006)

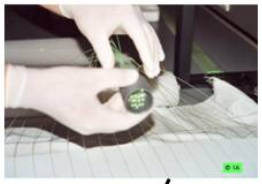
Funded by:

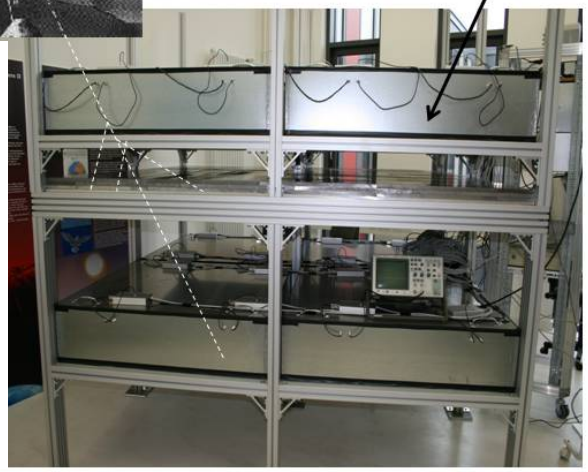
esa

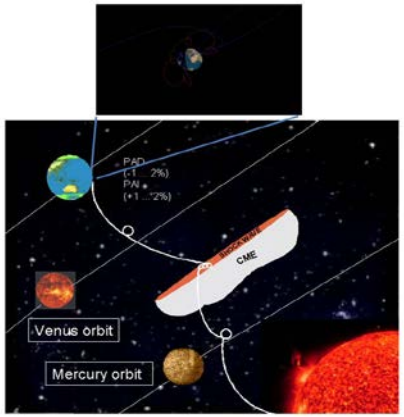
DLR

IEP SAS SPACE PHYSICS

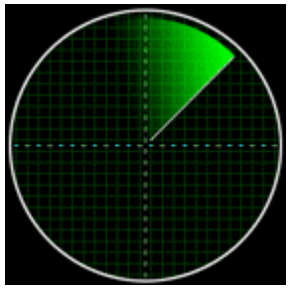






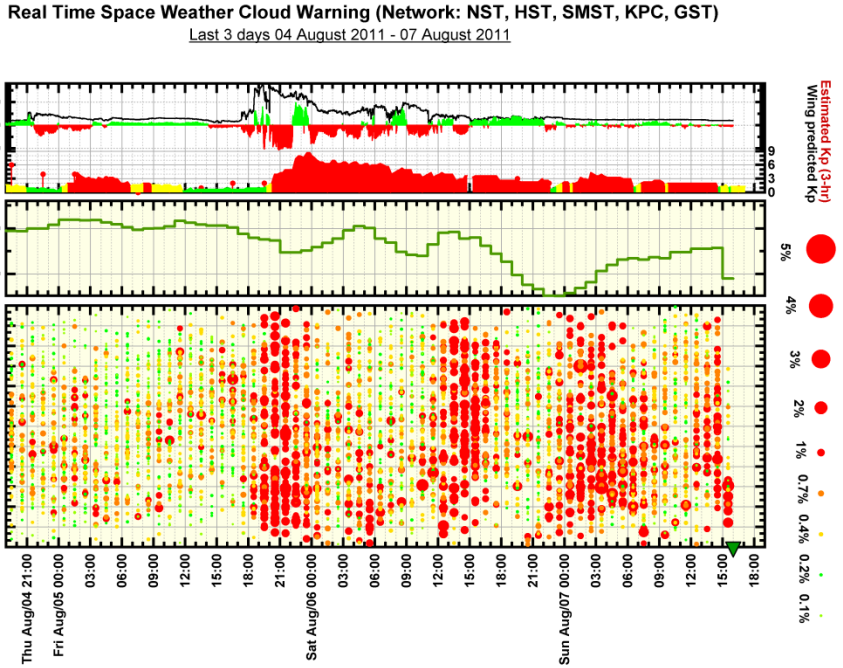


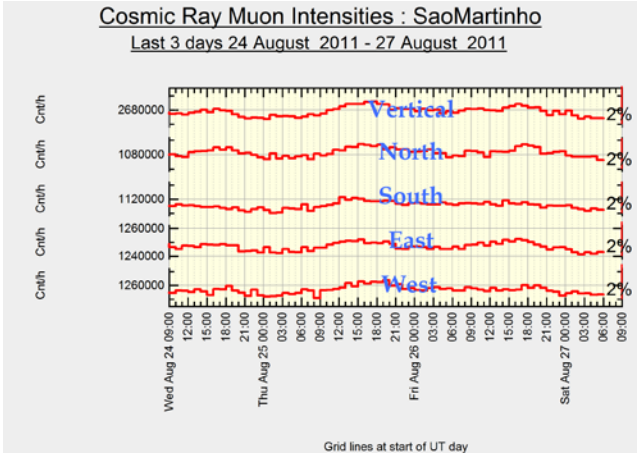
GMDN (Global Muon Detector Network) is like a cosmic ray radar.

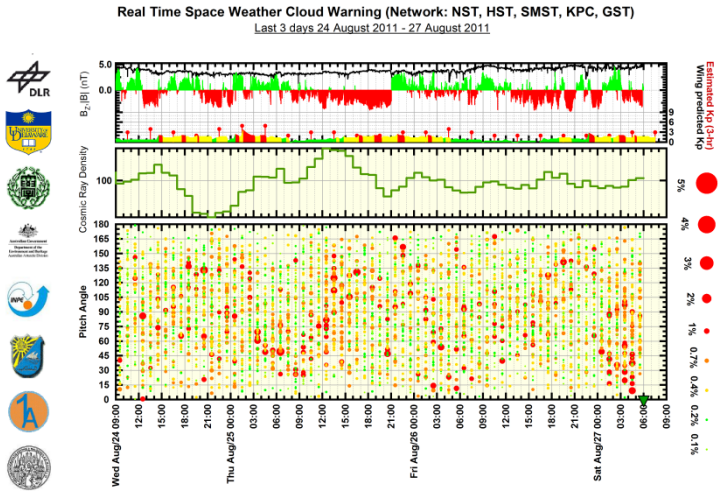


GMDN CME Data August 2011

DLR Bremen data processing: NST, HST, KPC, SMST, GST

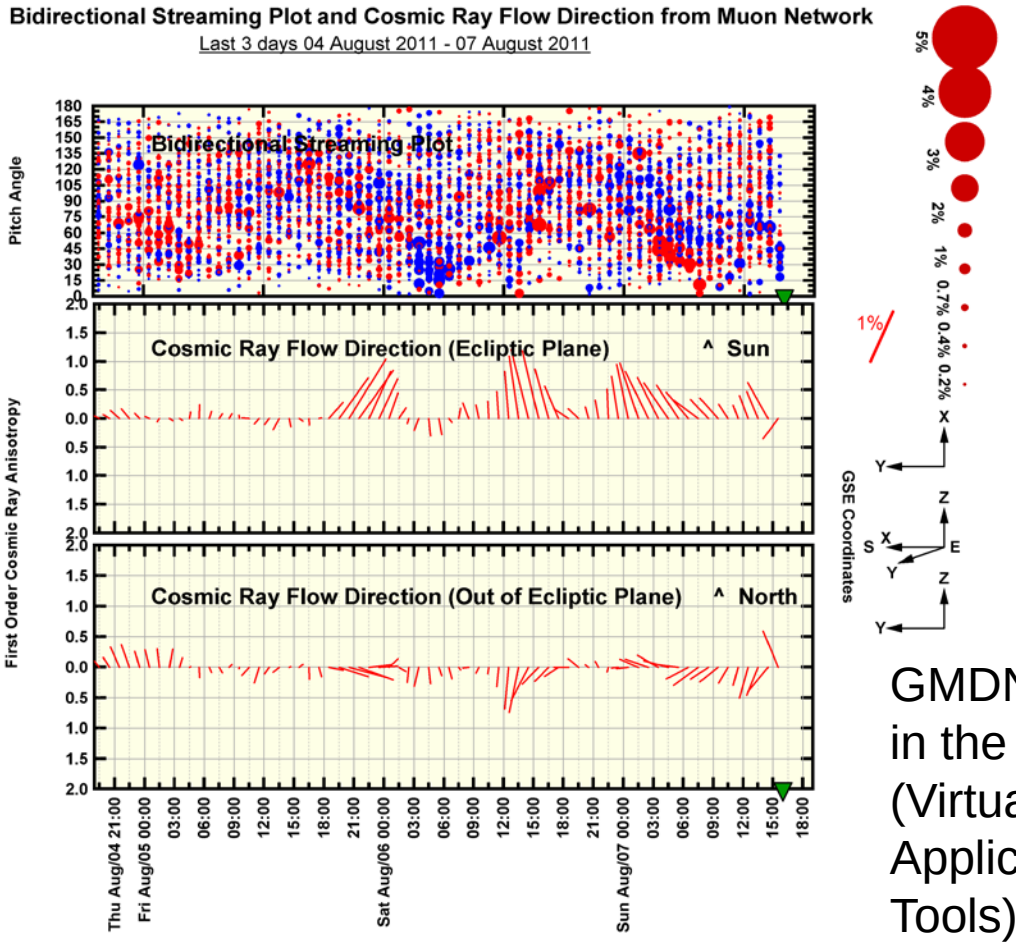






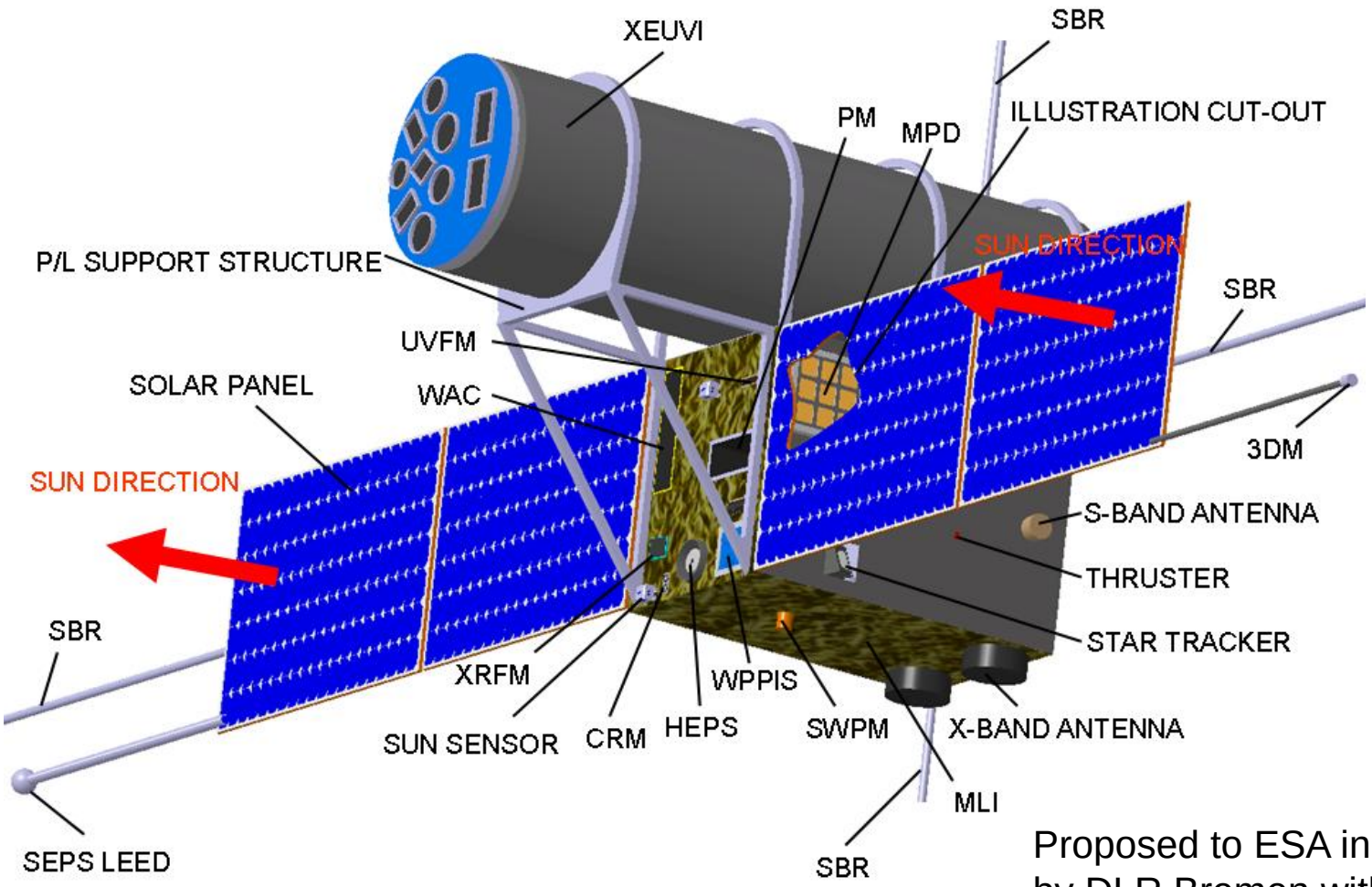
GMDN CME Data August 2011

DLR Bremen data processing: NST, HST, KPC, SMST, GST



GMDN will be a use case in the new ESA ViSpaNeT (Virtual Space weather Applications Network of Tools)!

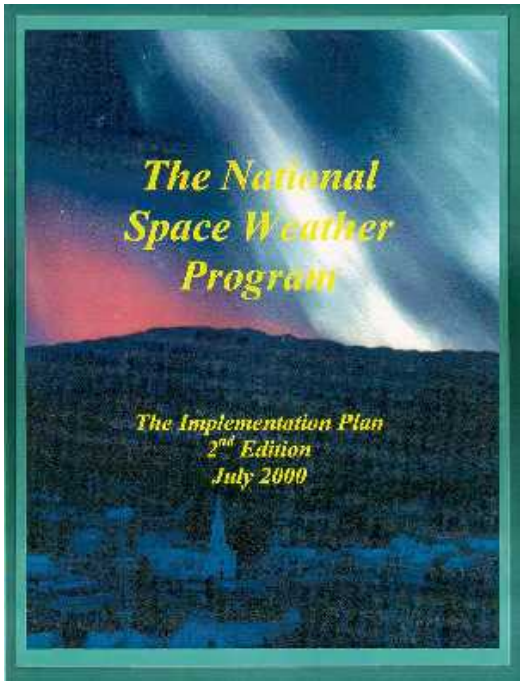
The Sun, Cosmic Rays: **Space Weather / SSA Satellite**



Proposed to ESA in 2010 by DLR Bremen within Kayser-Threde consortium.

The Sun, Cosmic Rays: **Space Weather => Politics**

How all started?



esa

ESA Space Weather Feasibility Studies
2001

CLRC

ALCATEL SPACE

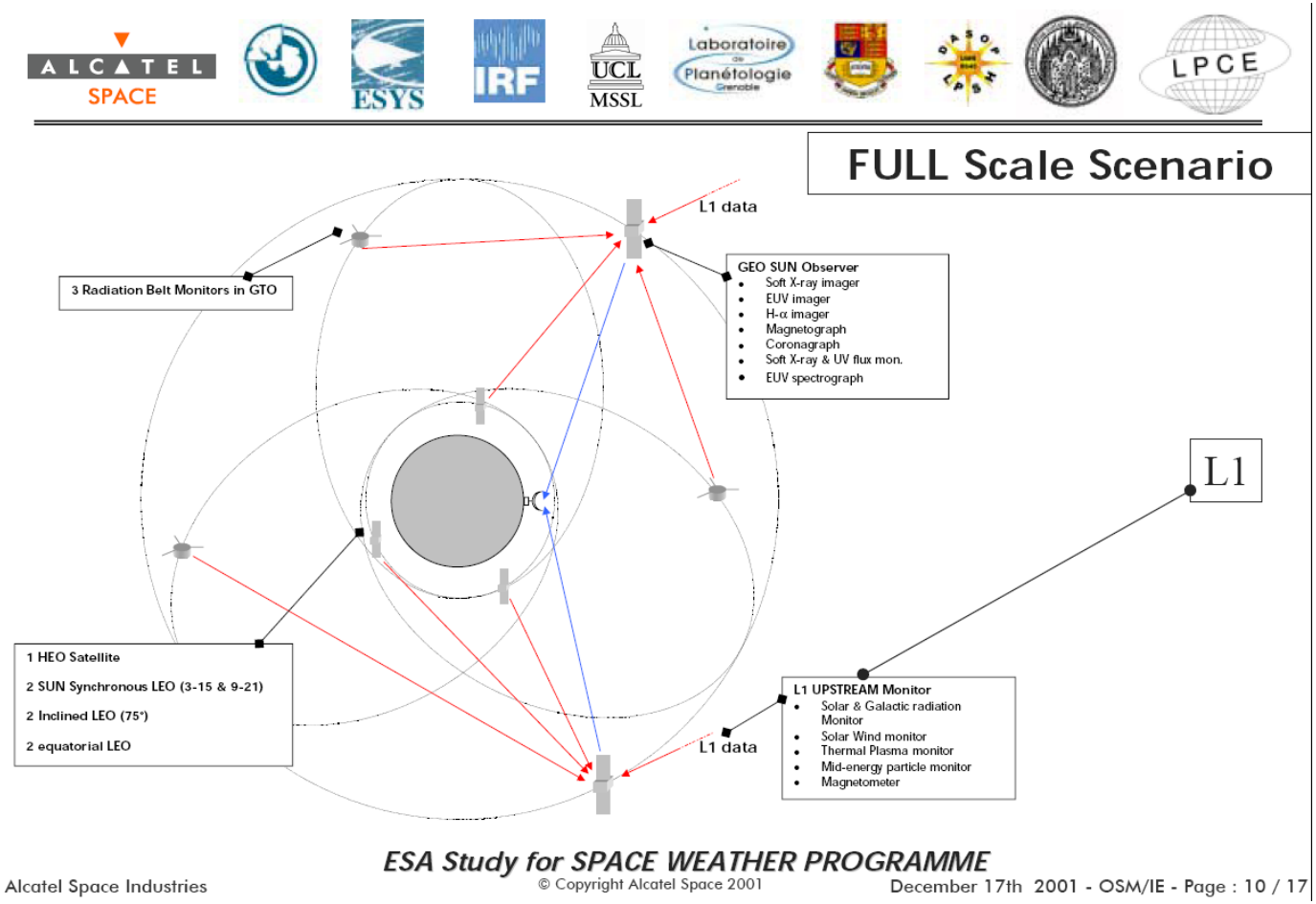
2003 – 2007 EU COST 724 Aktion:
Space Weather: Data, Models, Service

IEP SAS SPACE PHYSICS

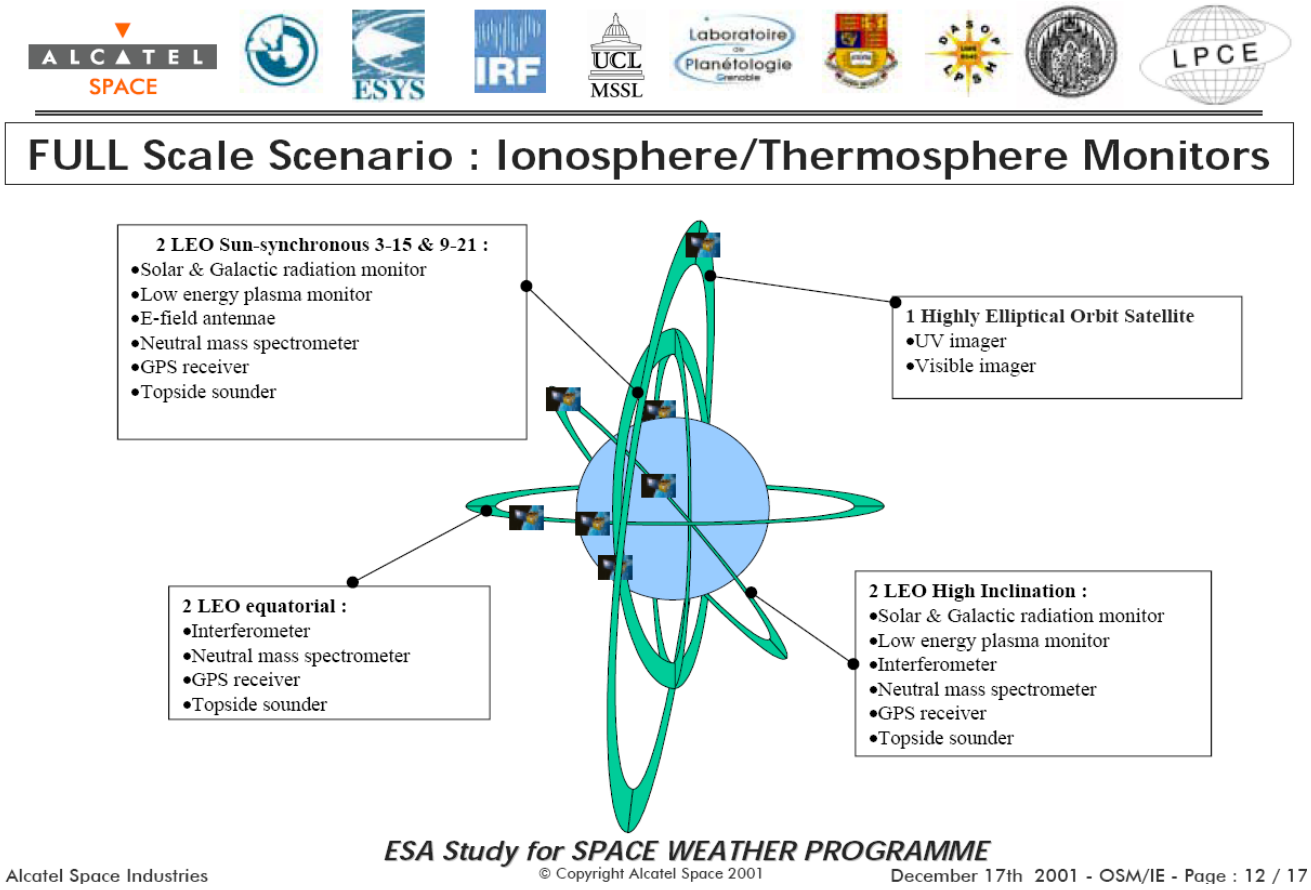
EU FP5 and FP6:
SWE and SWEETS

EU 2003: White Paper
ESA 2008: Space Situational Awareness (SSA)

The Sun, Cosmic Rays: Space Weather => Politics



The Sun, Cosmic Rays: Space Weather => Politics



The Sun, Cosmic Rays: Space Weather => Politics

Towards SSA in Europe: First European SW Telescope MuSTanG (2004-2006)

Operational Scenarios : Ground Segment

	Full Scale	Medium Scale	Low Scale
Solar observations	Broad frequency radio spectrographe (above 40 MHz) Radio imaging.	Broad frequency radio spectrographe (above 40 MHz) Radio imaging.	Broad frequency radio spectrographe (above 40 MHz) Radio imaging. Magnetograph network. Hα network.
Upstream (including interplanetary)	Broad frequency radio spectrograph. Radio imaging. Neutron and Muon detectors.	Broad frequency radio spectrograph. Radio imaging. Neutron and Muon detectors.	Broad frequency radio spectrograph. Radio imaging. Neutron and Muon detectors.
Magnetospheric monitoring	Covered under I/T monitoring	Covered under I/T monitoring	Covered under I/T monitoring
Ionosphere/thermosphere Monitoring	Magnetometer networks. Positioning networks SuperDARN network. F10.7cm	Magnetometer networks. Positioning networks SuperDARN network F10.7cm Ionosonde Network	Magnetometer networks. Positioning networks SuperDARN network F10.7cm Ionosonde Network

ESA Study for SPACE WEATHER PROGRAMME

Alcatel Space Industries

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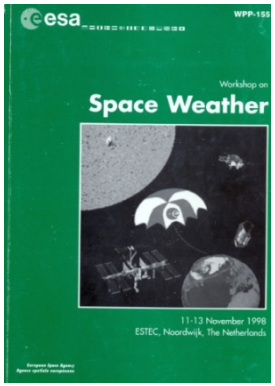
December 17th 2001 - OSM/IE - Page : 9 / 17

The Sun, Cosmic Rays: **Space Weather => Politics**



- European Space Policy (ESP) im White Paper (2003)
- Implementation of European Space Policy (ESP) via **ESA Space Situational Awareness (SSA) programme (2008 – 2018)**
- ESA Ministerial Conference **25 - 26 November 2008:**

  SSA domains: Space Weather, Space Debris, NEOs

  Next ESA Ministerial Conference in 2012 (SSA comparable with GALILEO?)!
- New Space Strategy of the German Government from December 2010
  (Sun, Space Weather, Space Debris, NEOs very often mentioned)

The Sun, Cosmic Rays: Space Weather => **Politics**

COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 11 November 2003
COM(2003) 673

WHITE PAPER

Space: a new European frontier for an expanding Union

An action plan for implementing the European Space policy

Only on page 17 of 59, but starting point for SSA in Europe.

A specific effort might also be needed to ensure that Europe has the capacity to supply to the different users critical information on solar flares, near Earth objects, space debris, ("space weather" prediction).

The Sun, Cosmic Rays: **Space Weather => Politics**

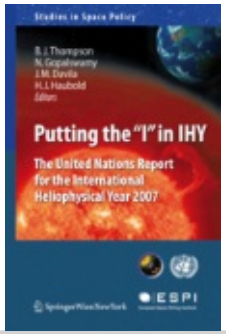
IP/11/398 Brussels, 4 April **2011**
A new space policy for Europe: Independence, competitiveness and citizen's quality of life…

Improving the safety and daily lives of European citizens thanks to radio navigation, guiding tractors by satellite for high-yield crops, optimizing response to humanitarian crisis… This is not science fiction but just a few examples of innovations related to space technologies developed today…

= > Protect space infrastructures against space debris, solar radiation and asteroids by setting-up a European Space Situation Awareness (SSA) system…

In addition for example:

1) European Space Policy Institute in Vienna: publication like International Heliophysical Year achievements towards ISWI
2) BBK (Federal Office of Civil Protection and Disaster Assistance) in Bonn: publication like – space weather as a new challenge for civil protection?
3) German Space Situational Awarneness Centre in Uedem



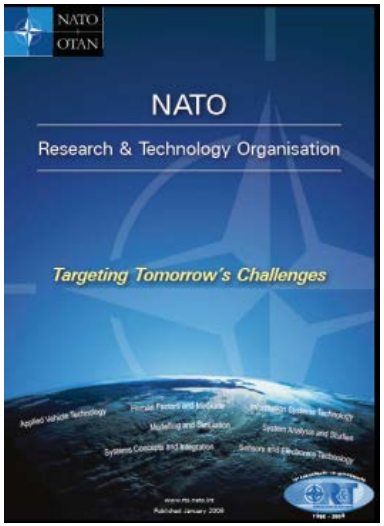
The Sun, Cosmic Rays: **Space Weather => Politics**

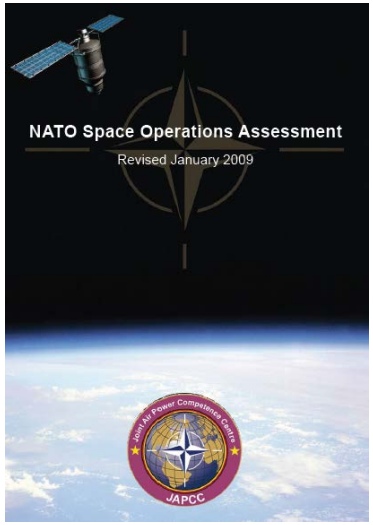
SSA and security aspects:

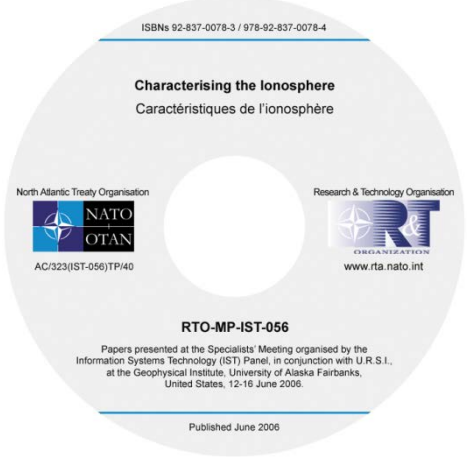
- publications from JAPCC (Joint Air Power Competence Centre) in Kalka
- NATO Research & Technology Organisation (RTO) activities related to the ionosphere (2006) and space environment support to NATO SSA (during solar maximum up to 2013 (see under http://www.rta.nato.int/activities.aspx?RestrictPanel=SCI), SCI – System Concepts and Integration meeting in 2009 at

AKADÉMIA OZBROJENÝCH SÍL
GENERÁLA MILANA RASTISLAVA ŠTEFÁNIKA
ARMED FORCES ACADEMY
OF GENERAL MILAN RASTISLAV ŠTEFÁNIK

(French Army General & Slovak Astronomer)







SSA – Space Situational Awareness in Europe

Domains:

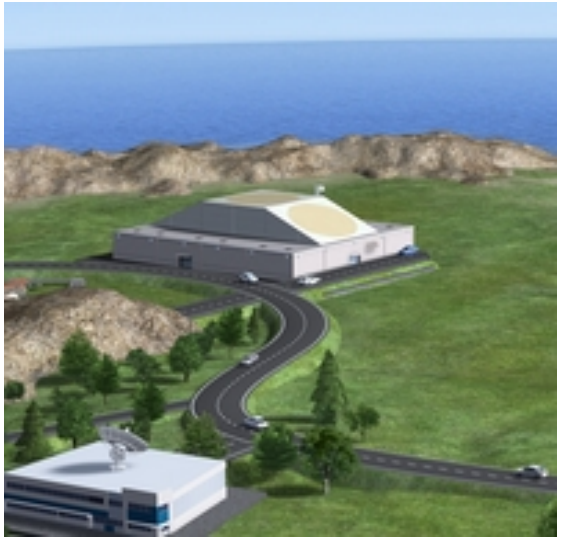
EISCAT

Space Weather

Space Debris

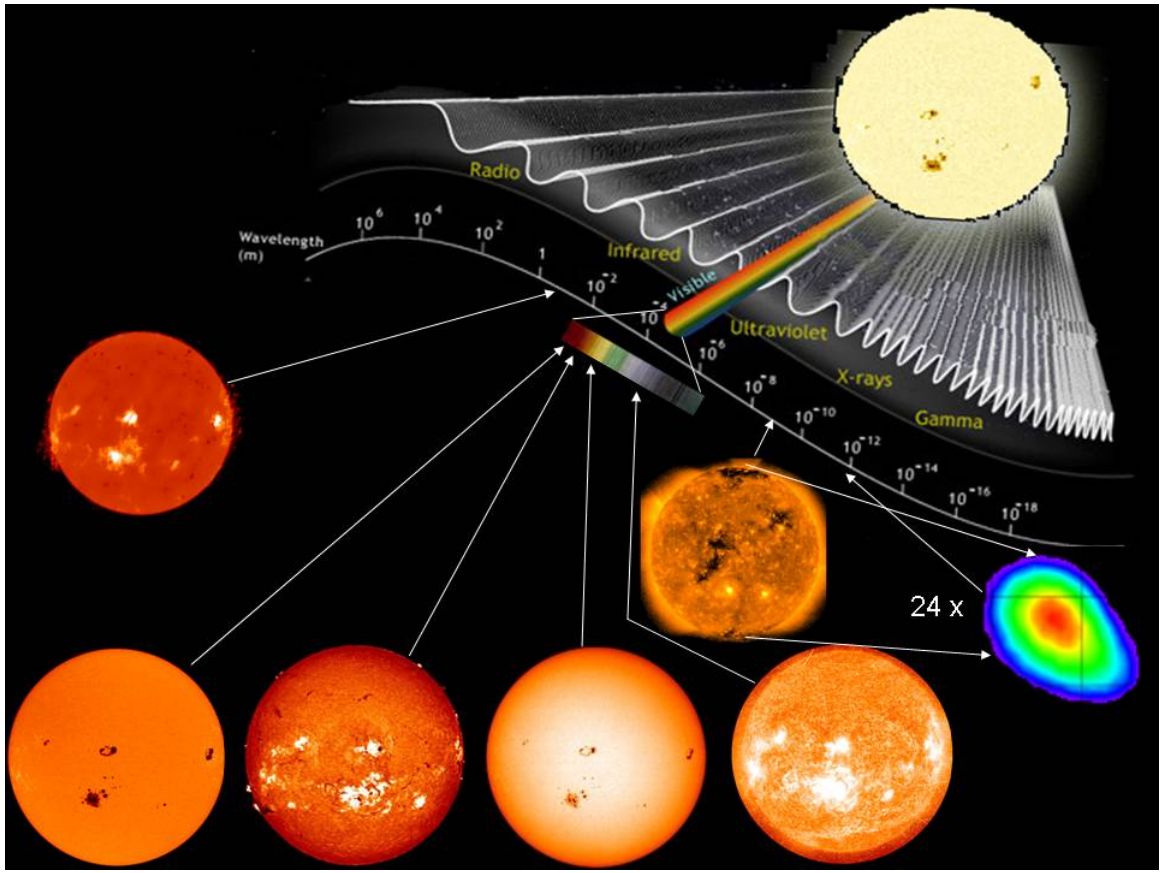
Near Earth Objects
(NEOs, NEAs, IEOs)

Radar



ESA SSA Radar

The Sun, Cosmic Rays: Space Weather => Politics



High resolution solar radio to X-ray images during Halloween storm in 2003**. Still open: high resolution gamma ray imaging of the Sun.**

October – November 2003

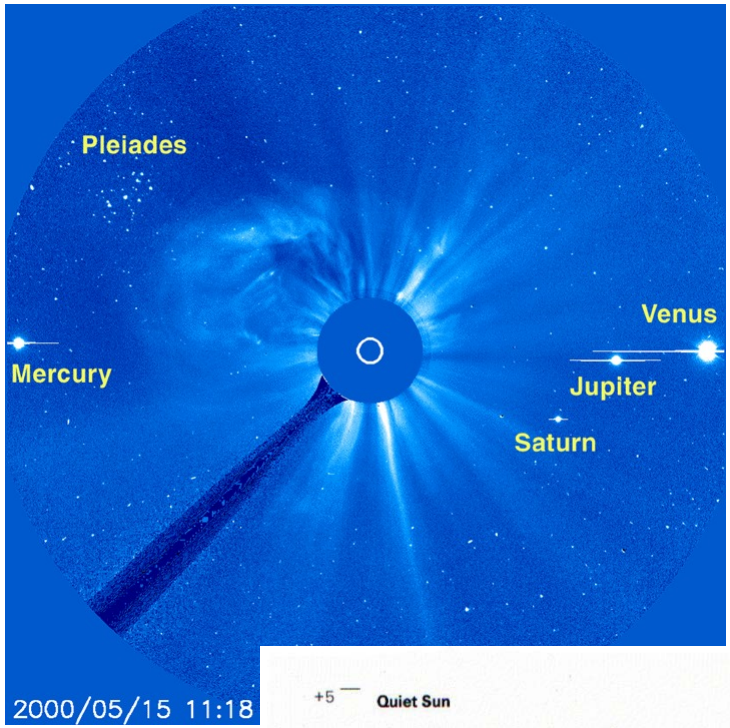
ESA, NASA, JAXA …

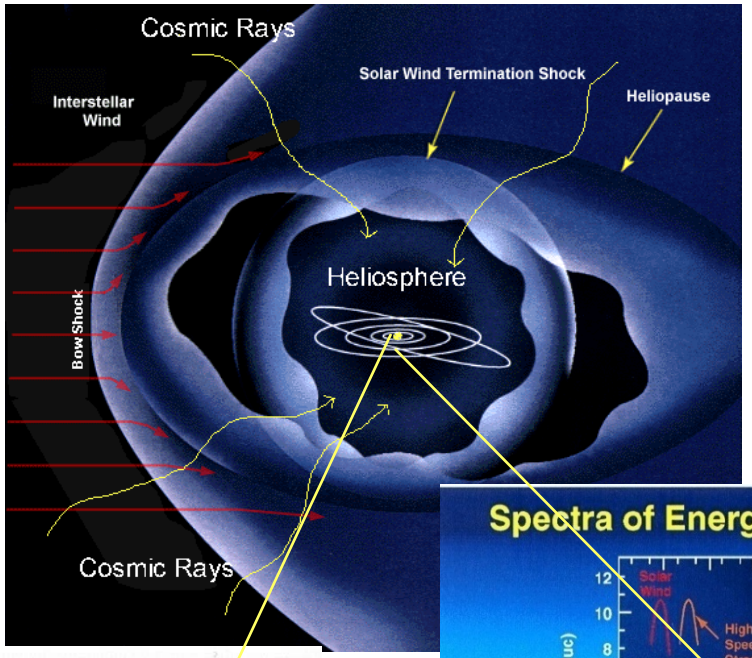
⇒ multi wavelength (space and ground based) observations of the Sun are necessary

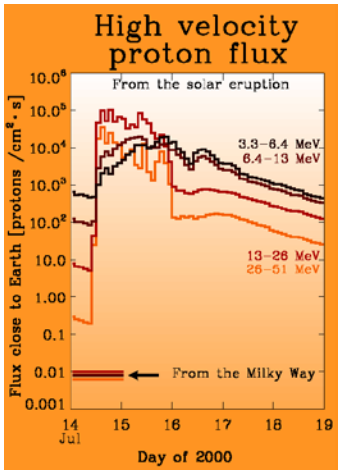
plus

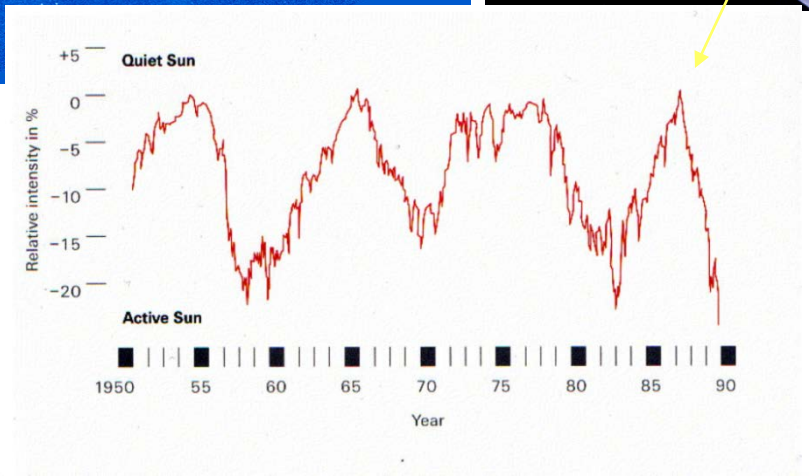
solar particle and cosmic ray observations

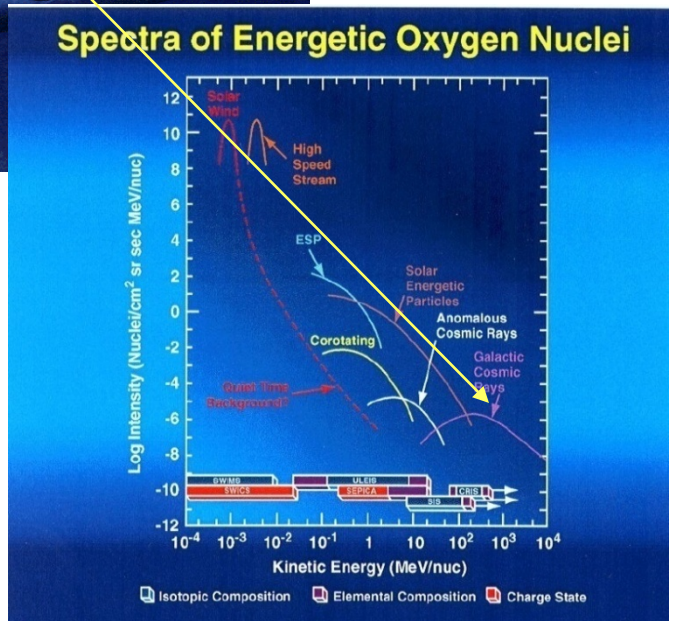
The Sun, **Cosmic Rays:** Space Weather => Politics



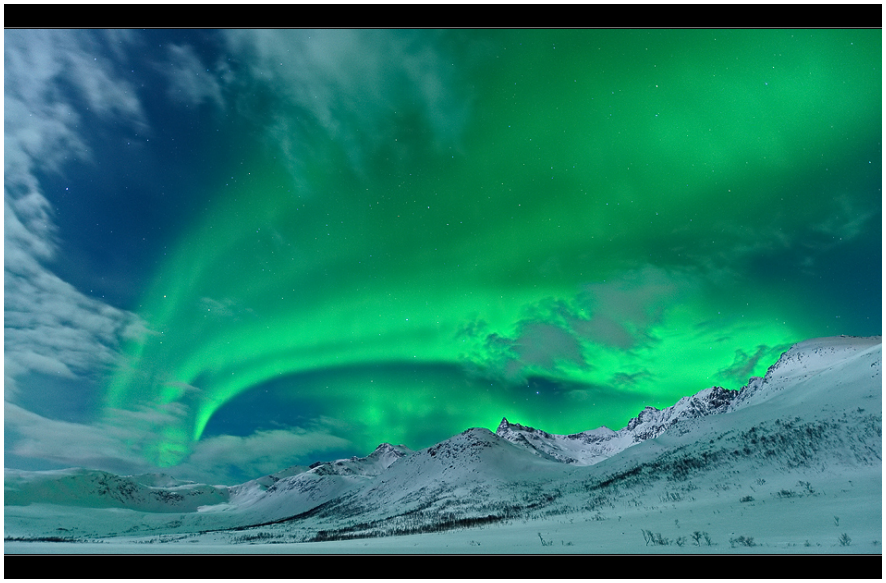




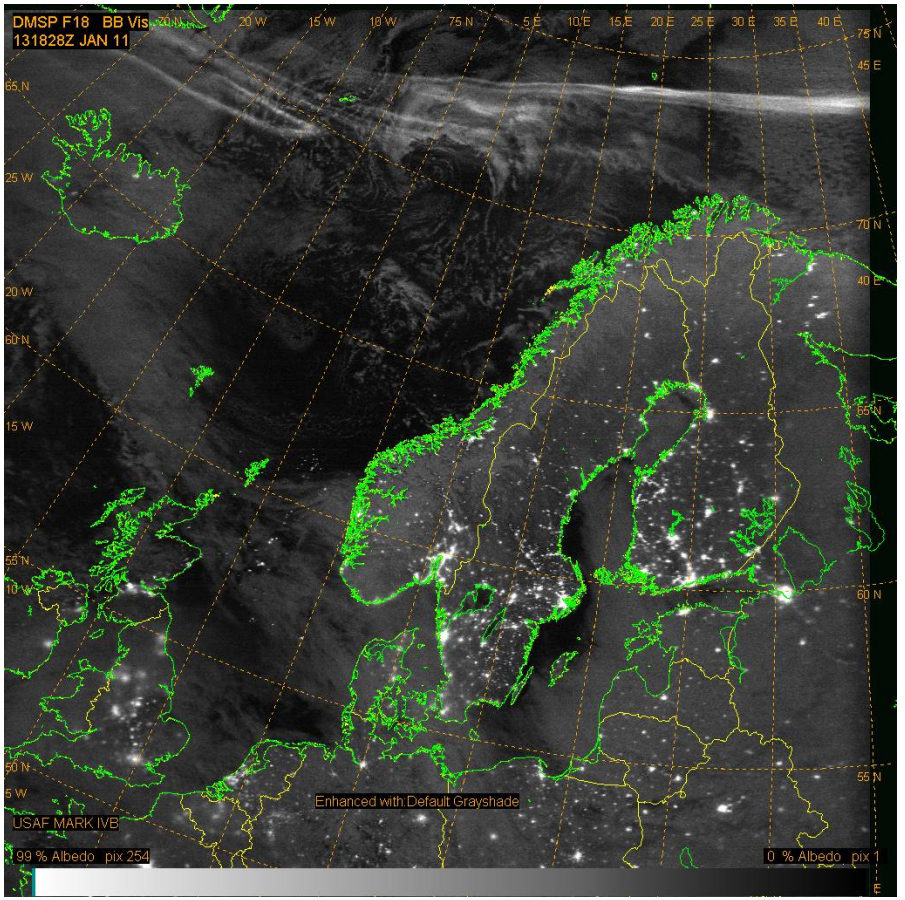




Most Visible Effect: Aurora (Polar Lights, Northern Lights…)

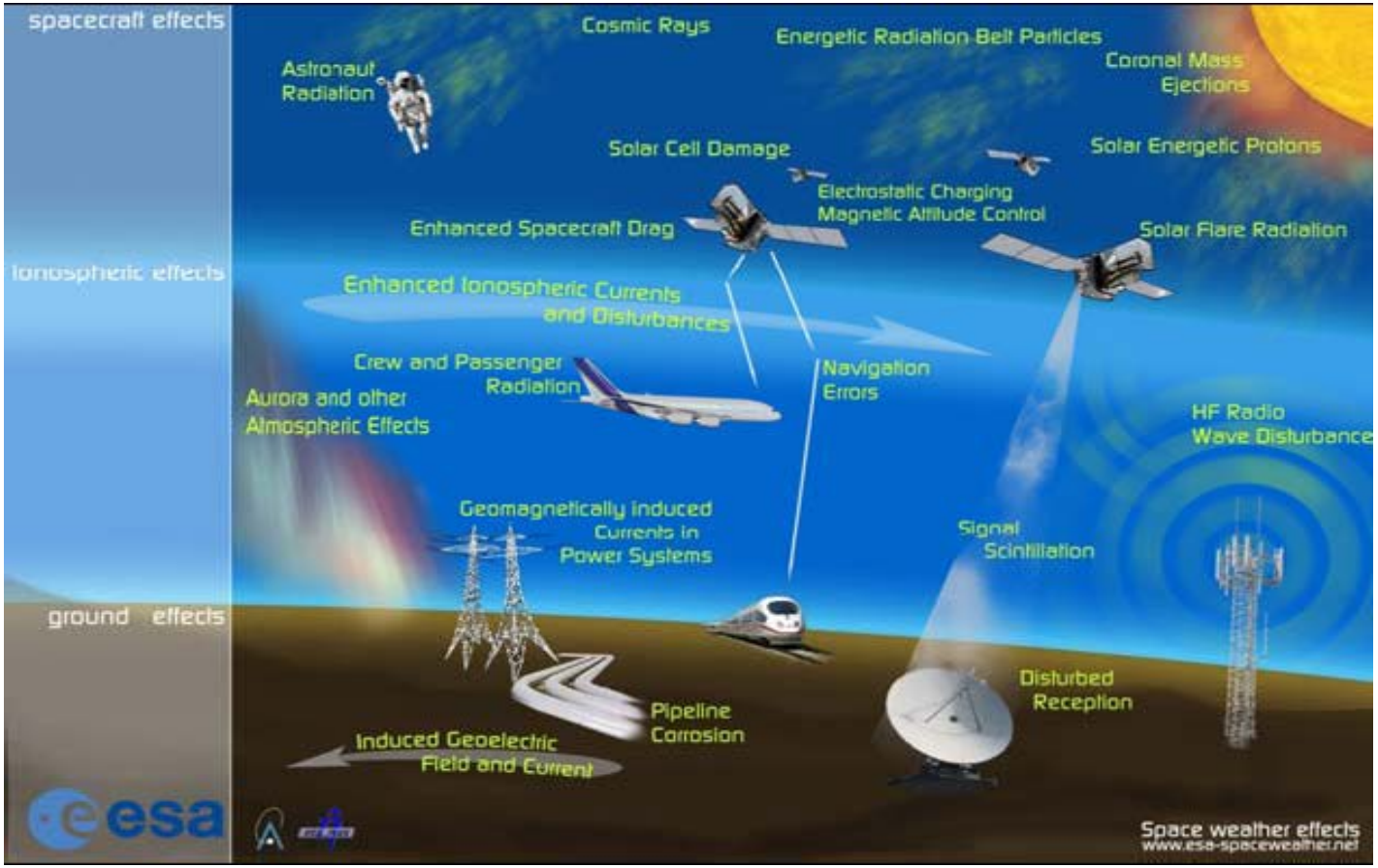


Northern light in Scandinavia (Thilo Bubek).



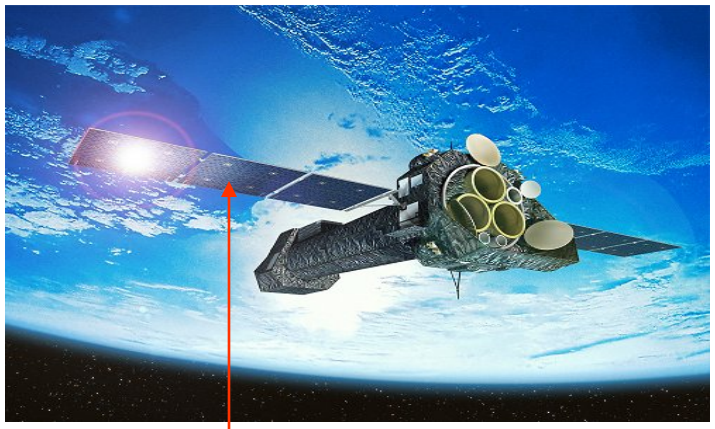
Satellite image of comparable brightness of city light and northern light in Europe.

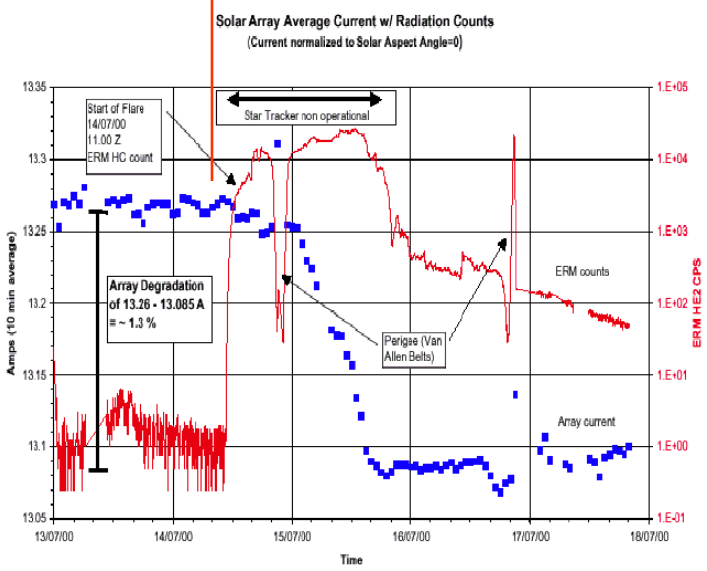
The Sun, Cosmic Rays: **Space Weather => Politics**



The Sun, Cosmic Rays: **Space Weather** => Politics

- Space industry: jobs…

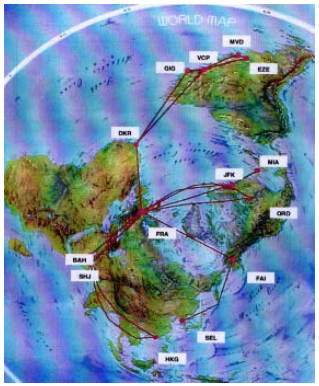


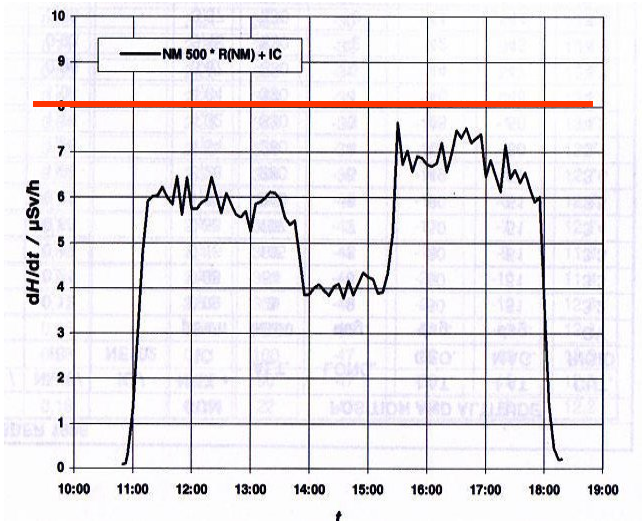


- 31 problems and total losses (12 total losses)
  Meteosat, ERS-1, XMM ...
  Equator-S, Anik 1&2,
  Telstar 401, ASCA ...
- financial losses in 4 years more than 500 Millionen US$

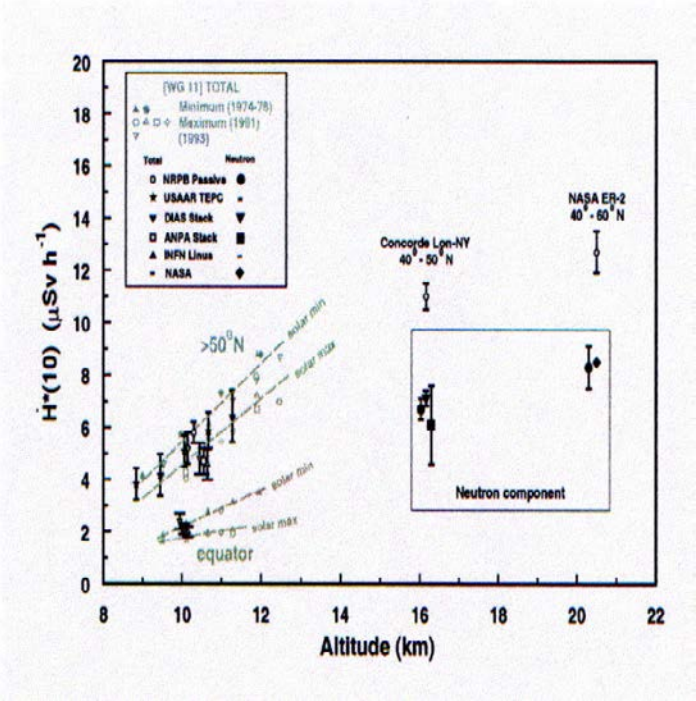
The Sun, Cosmic Rays: **Space Weather** => Politics

- Aircraft industry: jobs …





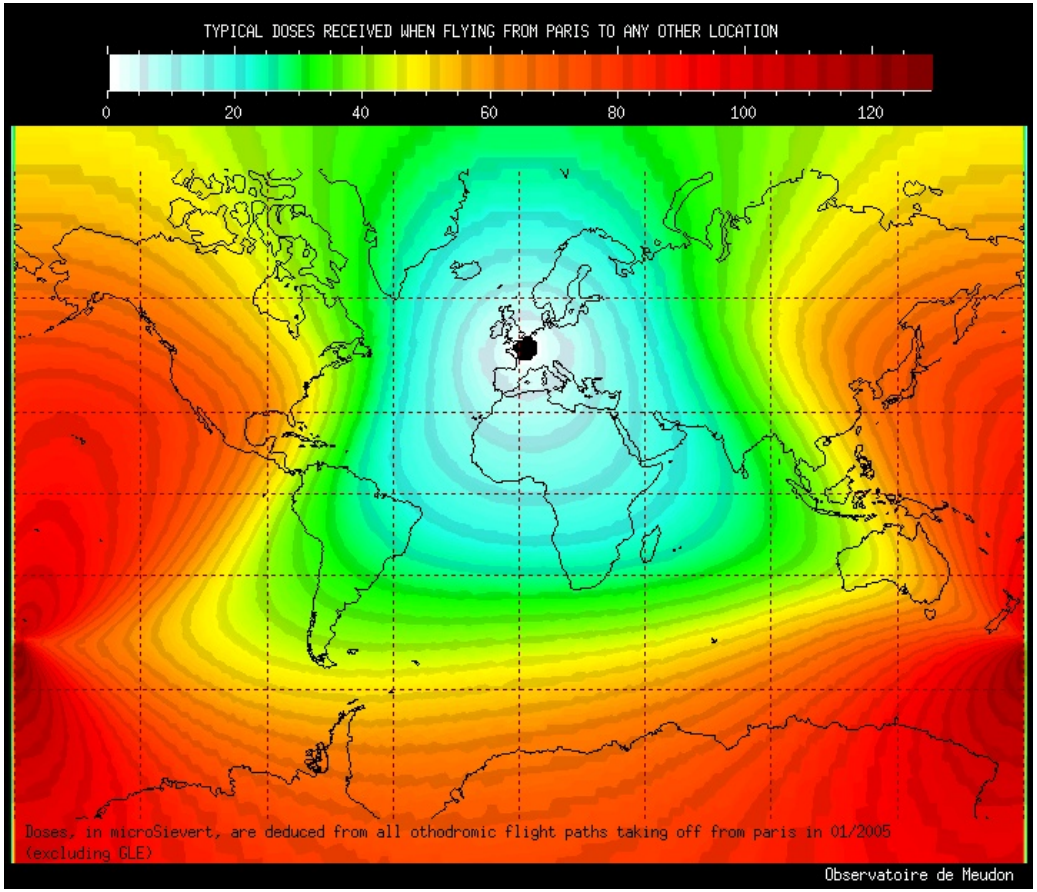
Flight Chicago – Frankfurt 4 Oct 98 (PTB)



- EC recommendation
- new radiation protection law (BfS, BMU)
  since 1 June 2001:
  for airlines estimation of radiation exposure
  (effective dose 1 mSv,
  upper limit 20 mSv per calendar year)

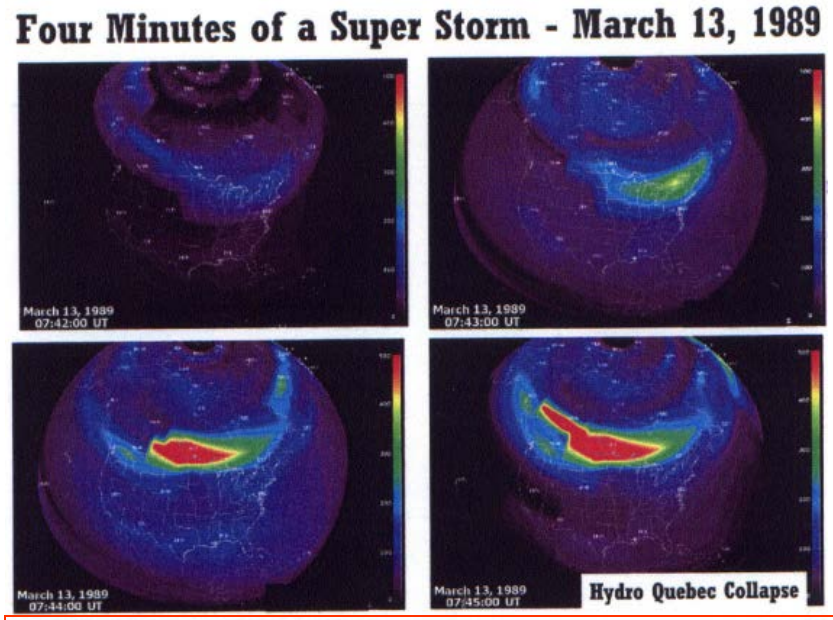
Which Risks Are Know?

Personal Flight Dose in the Web

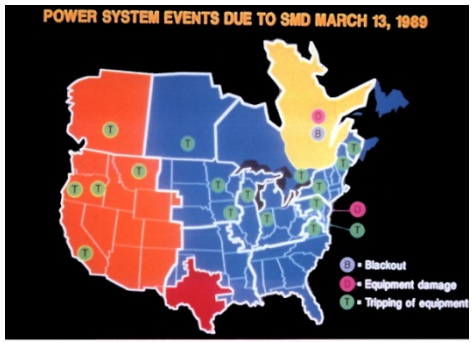


Which Risks Are Known?

Power supply 13 March 1989, US just before blackout

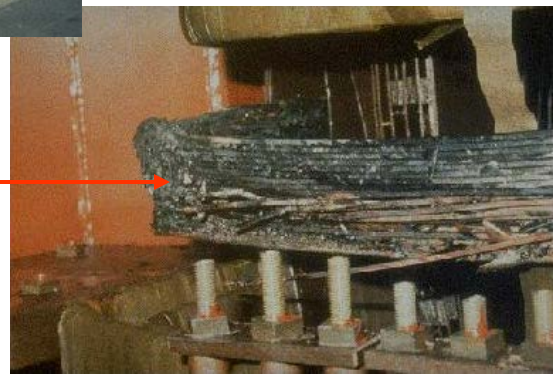


- Hydro Quebec: collapse time 90 sec ! (400nT/min)
  (9 hours power black out for Millions of humans in winter)
- Minnesota 865 nT/min was measured !



-normaly 3000 A
-several amps more,
unsufficient working regime
of the transformator
- measured in trans. 200 A

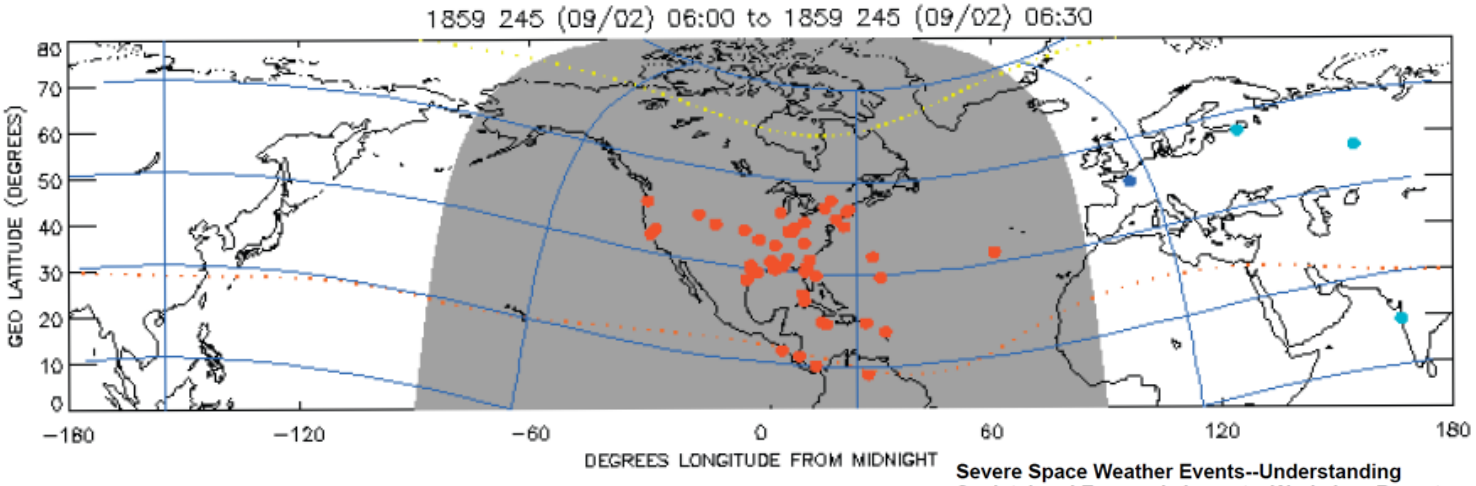
New Jersey



10^{10} US$

-Rep.: 10 Mill. US $ (up to 1 year, in this case only 6 weeks)
-Sweden: 6 130- kV-lines
-Cu-coils up to 3000 A
-April 94: 5 transformators in Chicago
-Finland: power lines with 143 A measured
-Sweden: 2003 – Malmö 50000 inhabitants

Power Failures: Super Storm 2 September 1859 and Today?



Severe Space Weather Events--Understanding Societal and Economic Impacts Workshop Report

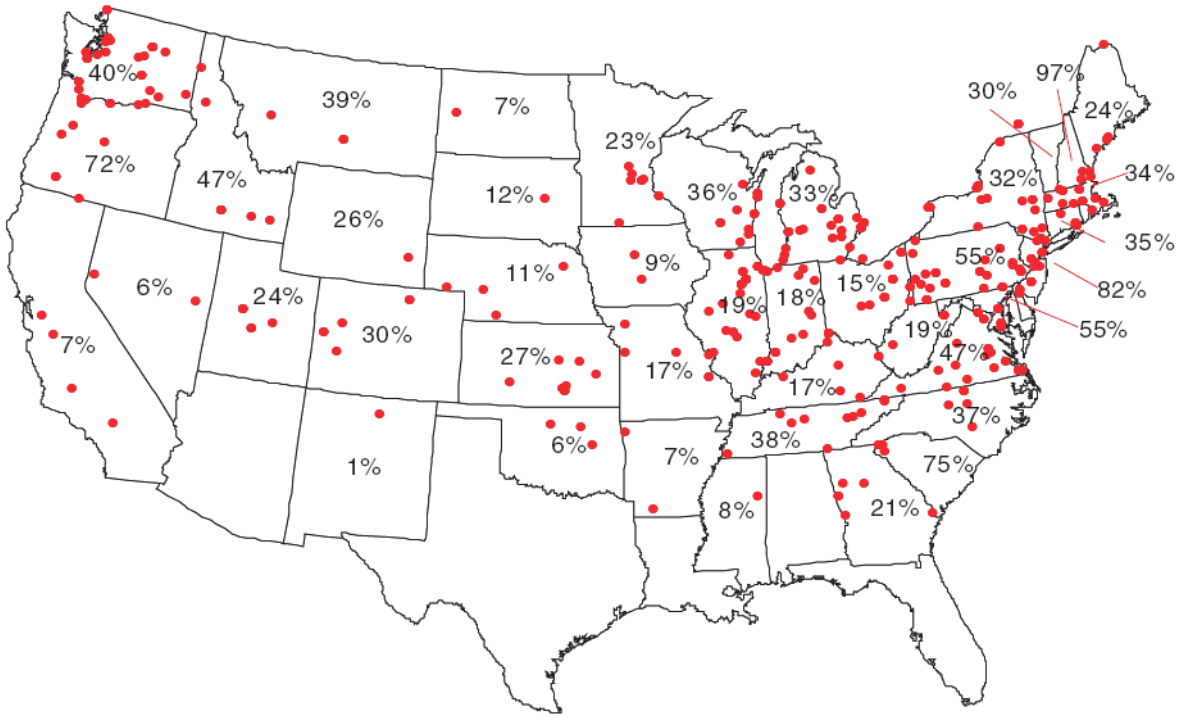
Committee on the Societal and Economic Impacts of Severe Space Weather Events:A Workshop, National Research Council

ISBN: 0-309-12770-X, 131 pages, 8 1/2 x 11, (2008)

This free PDF was downloaded from:
http://www.nap.edu/catalog/12507.html

- Catrina: 81 – 125 Bill. US $
- Space weather super storm: 1 – 2 Trillionen US $ in the first year
- 365 transformators are in danger (4800nT/min)
- regions in % with several years of power failure (4 – 10 years)
- effected population in the USA 130 millions

Power Failures: Results for Super Storm Today



Power failures: not only disrupted electrical light is a huge problem, but also not properly working cooling systems in hot or desert like areas are dangerous for humans.

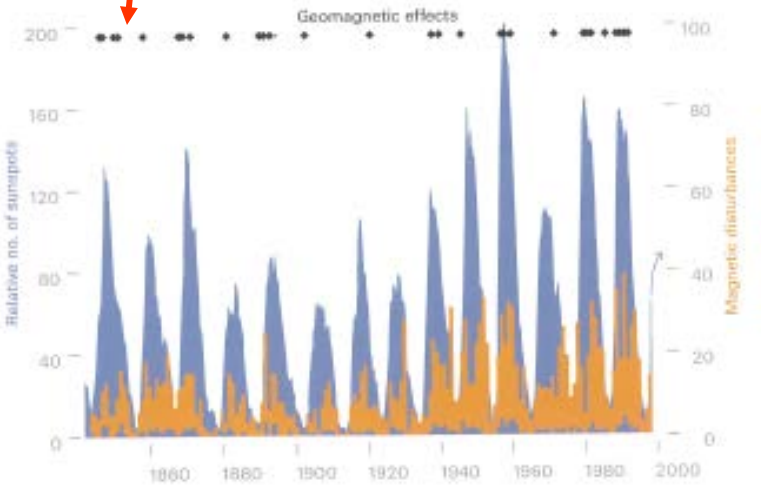
Which Risks Are Known?

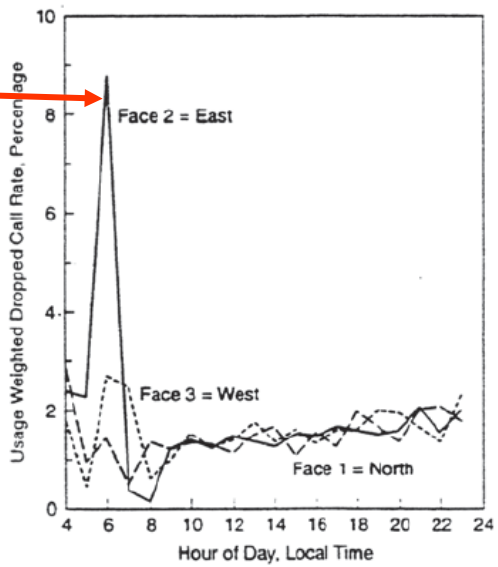
Telecommunication

Space weather effects in the pioneering days of telegraphy

- 17 November 1848: telegraphy lines between Pisa and Florence were disrupted
- September 1851: telegraphy lines in New England
- GICs made it possible that telegraphy lines worked without batteries:
  - Portland: "Please cut off your battery, let us see if we can work with the auroral current alone"
  - Boston: "I have already done so! How do you receive my writing?"
  - Portland: "Very well indeed - much better that with batteries"

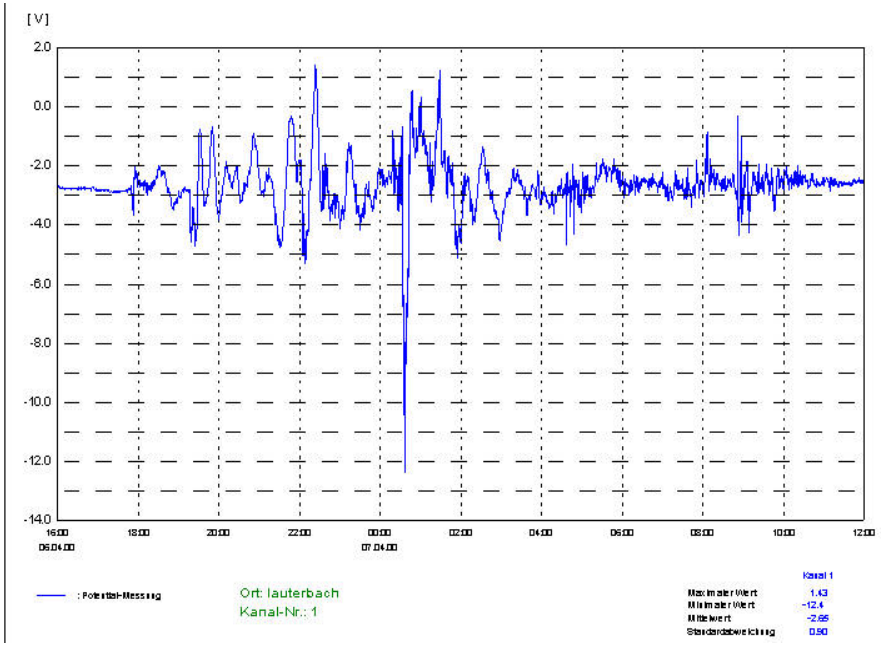
Past and current telecommunication systems (non-civil and civil (like mobile phones)) were and are effected by space weather.





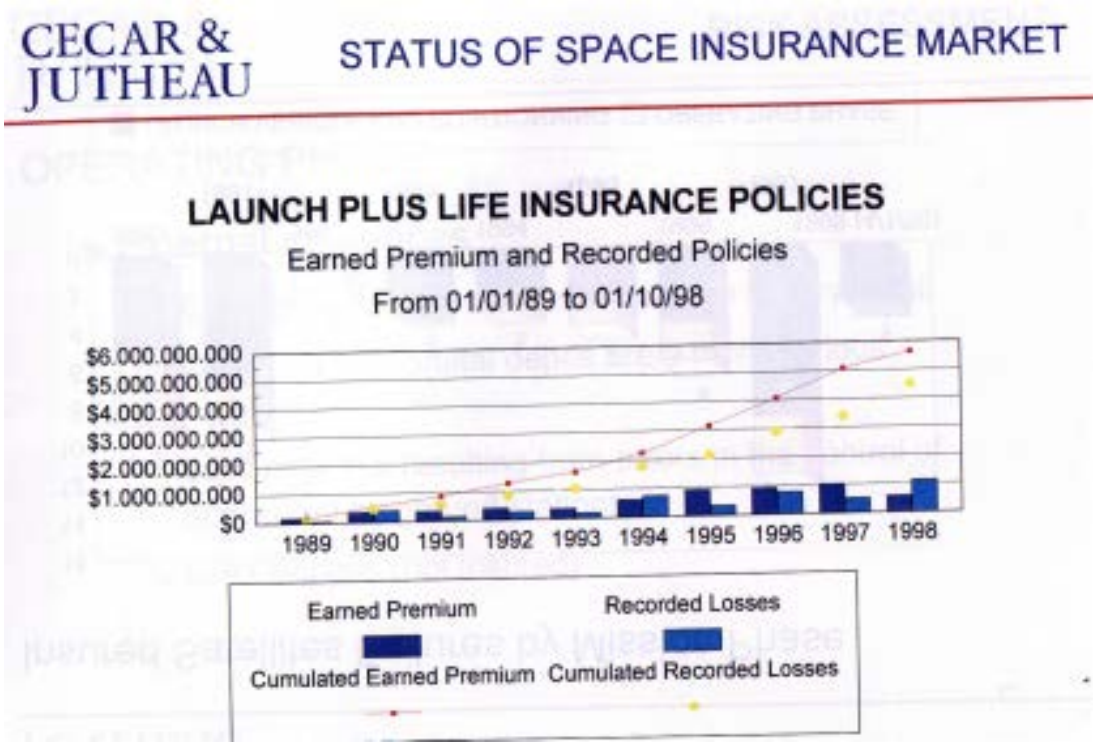
Which Risks Are Known?

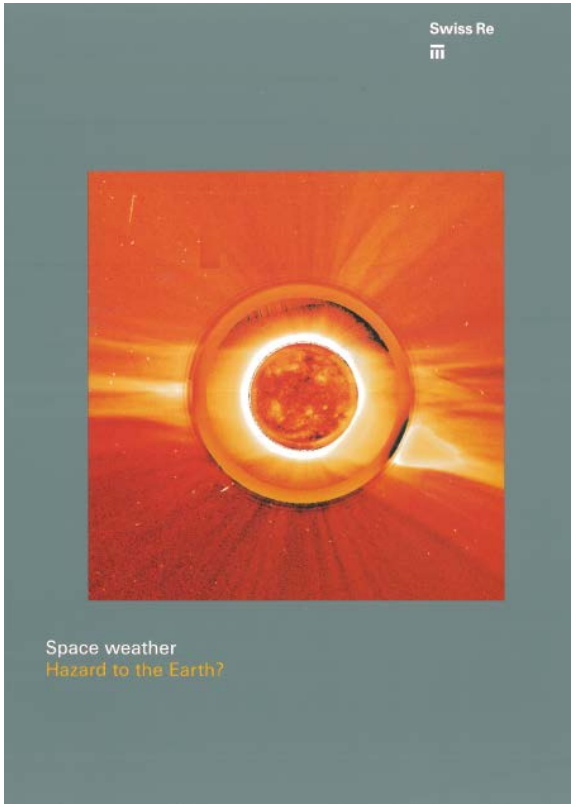
- **Gas- and oil industry**
  - **Ruhrgas pipelines**
  - **North Sea drilling**
  - **Alaska, Sweden, Finland**



Which Risks Are Known?

- **Space weather and insurances**

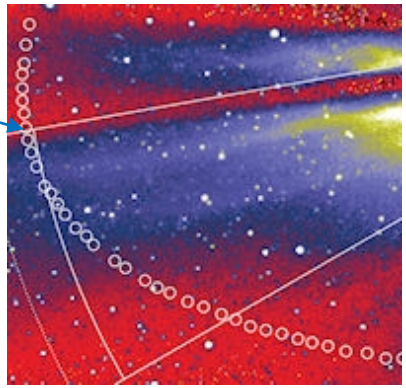


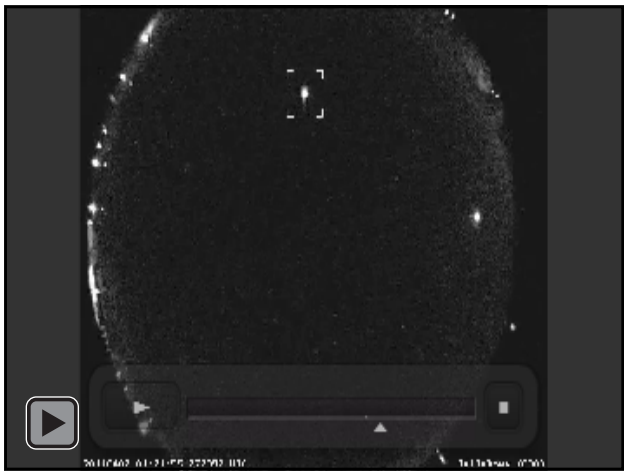


http://www.swissre.com/

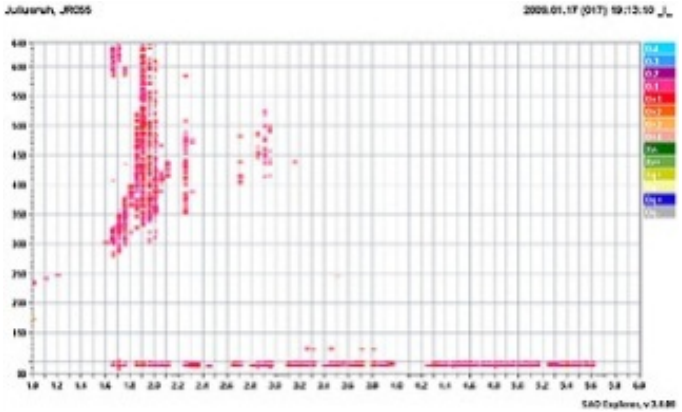
Observation of Meteors

- NASA / MSFC and DLR: full sky camera system
- Geminide Meteors (December) part of collision **on** asteroid Pallas
- 3200 Phaethon (see STEREO observation) is also due to collision on Pallas





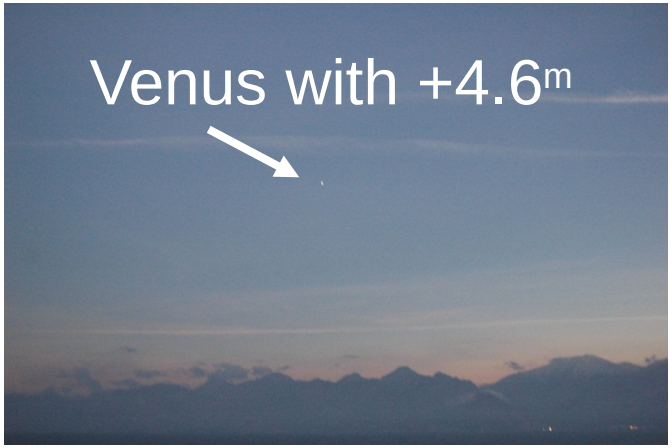
Click on the Meteor video.



Meteor in ionogram data of IAP.

Asteroids: DLR Bremen AsteroidFinder (AF)

29 Mar 2006 Antalya: total eclipse

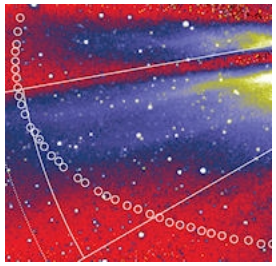


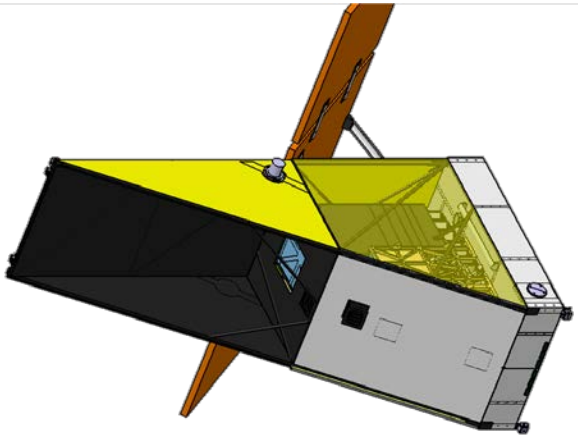
Not asteroids between Mars and Jupiter but with AF:

Inner Earth Asteroids (IEOs) down to visuell magnitude of -18.0^{m} => asteroids with magnitude 1.2x10^{-9} lower than maximal Venus magnitude in a solar distance of about ±60°

3 observations: new IEO

STEREO: IEO 3200Phaethon with -10…12.5^{m}





Space Shuttle Era (**12 April**19**81** – **21 July** 2011), Space Debris and LDEF (1984 – 1990)

Columbia

12 April 61 Gagarin's first (Soviet) manned space flight,
21 July 69 Armstrong/Aldrin (US citizen) first steps on the Moon

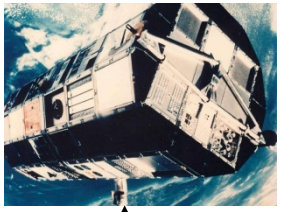
LDEF (Long Duration Exposure Facility) with Challenger in 1984.

(Challenger exploded on 28 January 1986)

NASA video: landing (21 July 2011) of space shuttle Atlantis on it's final flight.

69 monaths in space: LDEF and space debris

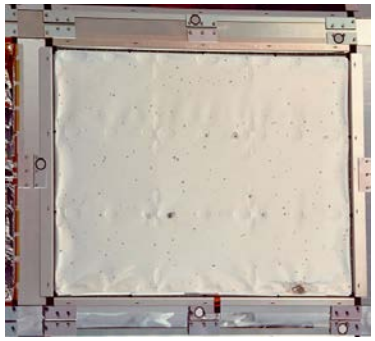
Long Duration Exposure Facility (LDEF): UHCRE for CR nuclei detection with Z = 1… 92

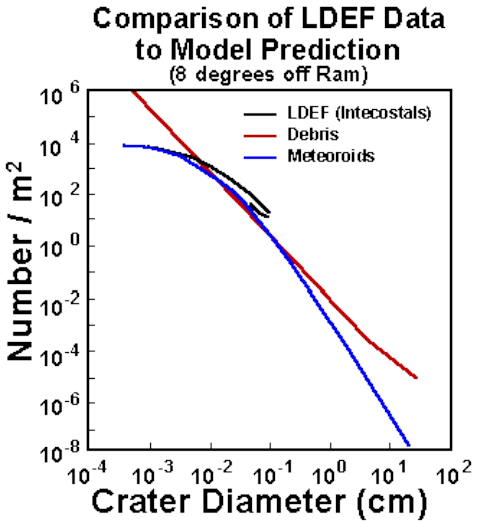


1984

1990

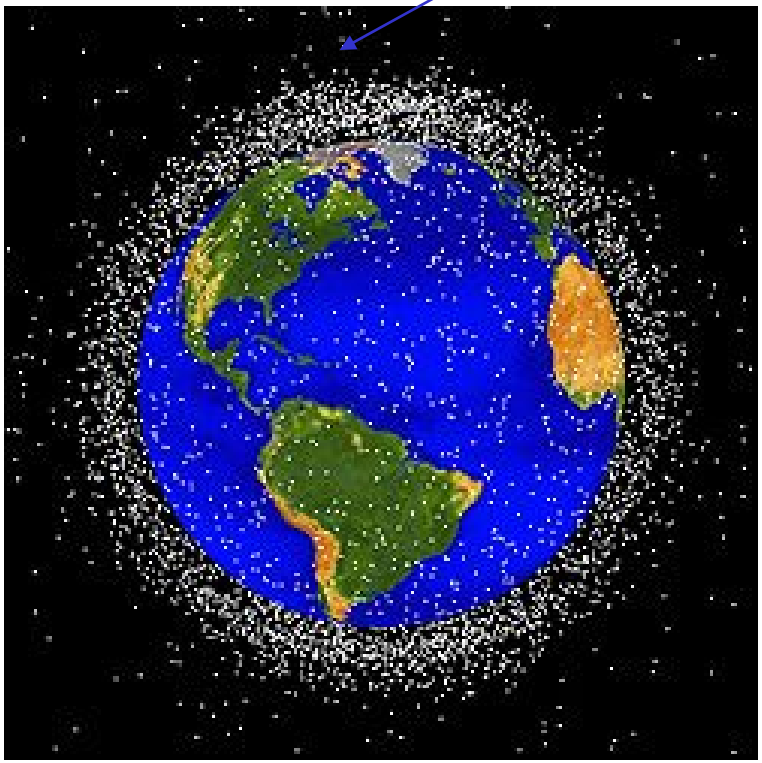
return with Space Shuttle Columbia (decay 1 Feb 2003) in January 1990
=> entire surface: spurs / holes from meteoroids and space debris





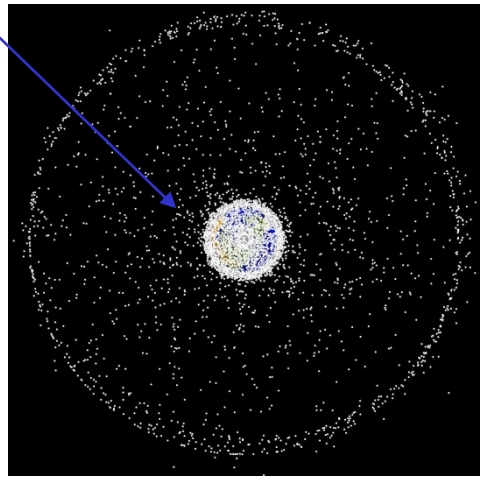
Space Debris Distribution in LEO/GEO and on Earth

LEO: 200 – 1200 km orbit
GEO: … up to 36000 km orbit

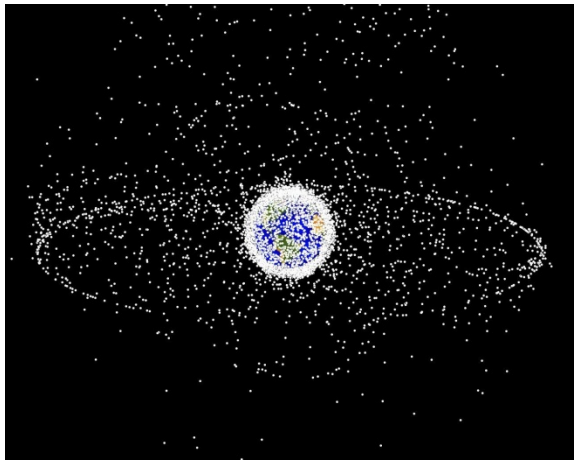


21 Jan 01 70 kg
Engine 3rd stage Delta 2 rocket
(Saudi Arabia)

Uruguay: **2 Jan 11** (like 21 Jan 01 – Delta 2… for new GPS (Navstar53) satellite!

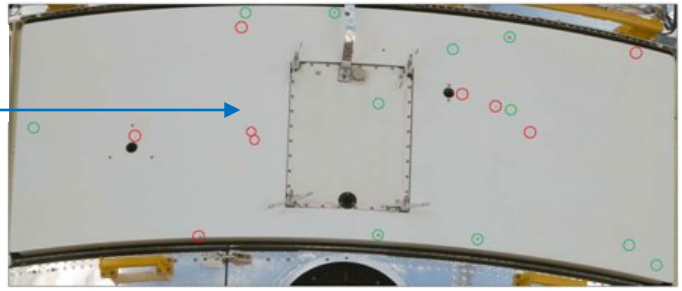


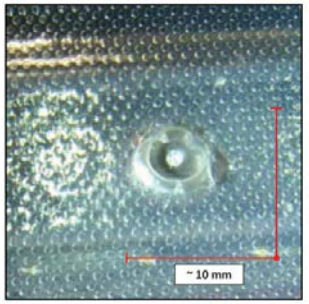
Top view



Equator view

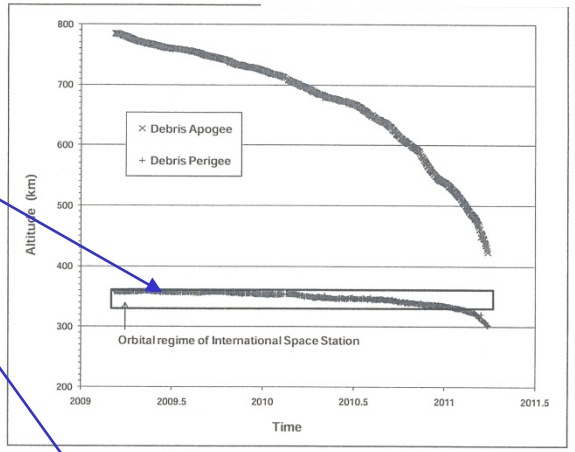
Space Debris on HST and ISS



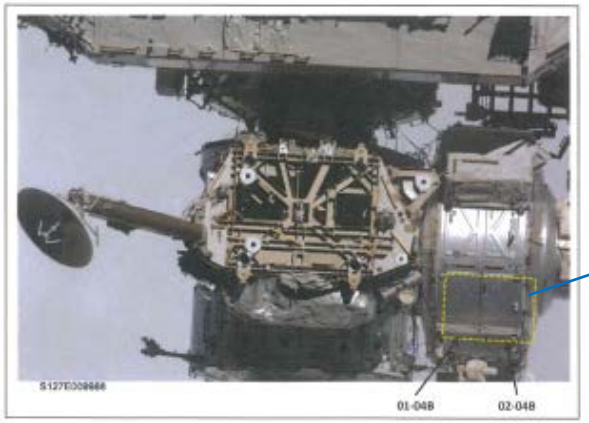


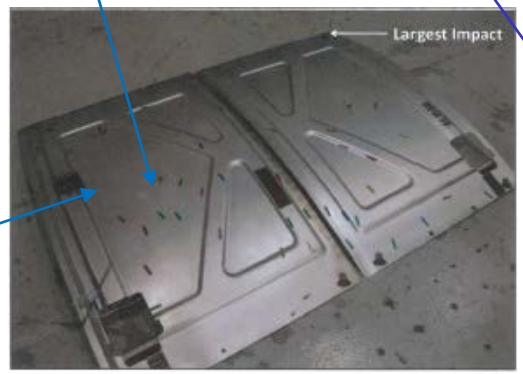
STS-128 inner side
of cargo bay door

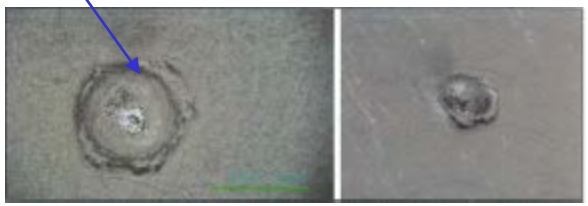
Reason for effects on
ISS in 2009 / 2011



58 crater with maximal
1.8 mm diameter







Code of Conduct for Space Debris

General Assembly

Distr.: General
10 January 2008

Sixty-second session
Agenda item 31

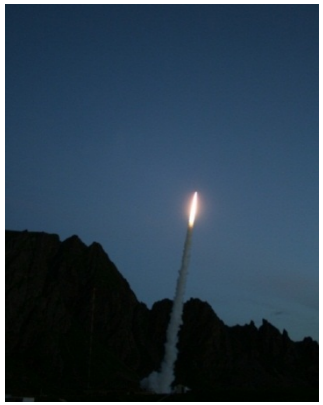
Resolution adopted by the General Assembly

[*on the report of the Special Political and Decolonization Committee (Fourth Committee) (A/62/403)*]

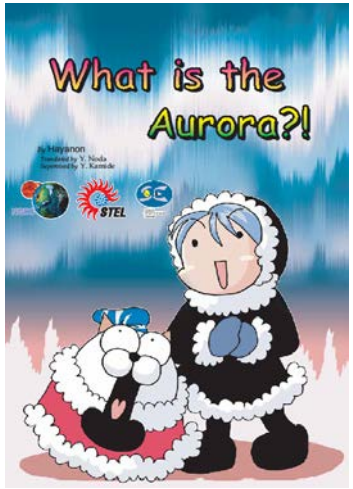
62/101. Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects

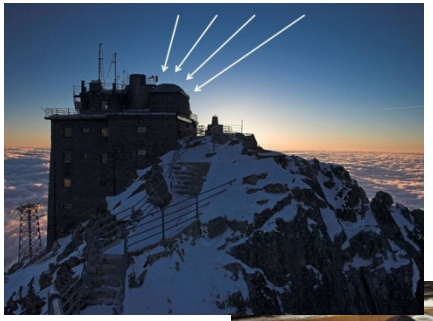
Space Weather and Europe – an Educational Tool with the Sun (SWEETS)

SWEETS Bus



SWEETS: Booklets, Poster, Planetarium & Dance Show, TV Film and DVD (next page)





IEP SAS
SPACE PHYSICS

MANY THANKS AND QUESTIONS?

The end of the lecture: video - dancing under **cosmic ray showers** (C. Timmermans Radboud University Nijmegen).

Space Weather DVD