

# Rationale and Requirements for a European Space Weather Service

## Part 1

Richard B. Horne  
British Antarctic Survey  
Cambridge, UK

(Alcatel Consortium)

- Market assessment
- Identify user problems
- General user requirements

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## Market assessment

- Aide Memoire
  - Sent to more than 72 contacts
- Personal interview
- Telephone/email
- Conferences

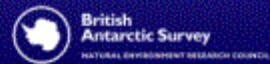
Country	Response
UK	18
France	11
Germany	4
Sweden	6
Canada	4
USA	7
Total	50





## Market sector response

Market Sector	Response
Satellite design	4
Satellite Operators: Communications Broadcasting Remote sensing Navigation Science	6
Space Agencies Man in space	2
Launch operators	1
Defence: HF communications Over the horizon radar, Surveillance, Navigation, Submarine Communications	4



## Market sector response

Market Sector	Response
Ground based systems	
Power generation and supply,	6
Prospecting for minerals oil and gas	1
Oil and gas pipeline distribution	2
Railways	1
Space Insurance	4
Tourism	1
Scientific Research	5
US Space weather/Education	2
Other	4
Total	50





## Classification of SW Users

Type of user	Object	Driving Force
Commercial Companies	Provide goods and services	Cost-benefit
Commercial Companies Agencies Organisations	Protect life and health Provide services	Health and Safety
Defence	Maintain effective capability	Need to know
Research	Problem solve Understanding	Interesting, challenging problems relevant to society
Tourism/Public	Enjoyment and Understanding	Curiosity Impact

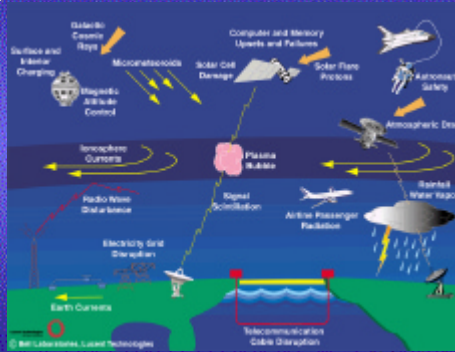
## General drivers

- Growth of markets
    - E.g., space communications, broadcasting, navigation
    - Teall Group forecast 900 commercial satellites over 10 years worth US\$80B
    - Telecoms satellites - Europe won 16 orders US 13 in 2000
    - Insurance – more than 60% is insured through London
  - Deregulation of markets
    - Financial imperatives – work closer to margins
    - Push existing technology to limits
  - Competitive markets
    - New design/new systems
    - Extended design life
    - More reliability
    - Protection of systems
  - New technology
  - EU legislation
    - Health and safety
  - Need to know
    - Defence
- Space weather impacts all the above



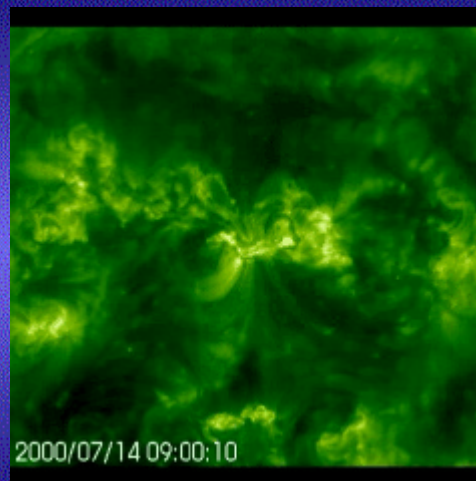
## Issues

- Market fragmentation
  - Loss of expertise
  - Turnover of people – 11 year cycle
- Lack of knowledge of SW
  - Lack of cost benefit analysis
- Commercial sensitivity
  - E.g. anomaly data on commercial spacecraft is not available
  - Commercial spacecraft different to scientific
- Conflicting interests
  - E.g. Satellite operators and space insurance



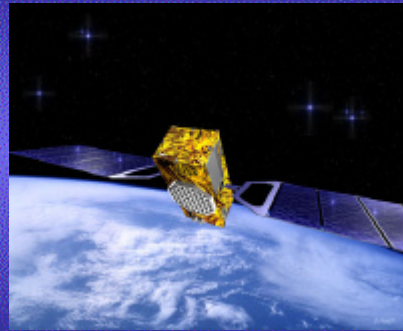
## User problems related to SW

- Spacecraft design
  - Internal charging – ESD
  - Surface charging – ESD
  - Single event effects SEE
  - Sensor interference
  - Cumulative radiation effects
    - Degradation of components
    - Reduction in solar cell power
  - Surface erosion
  - Mechanical damage
    - micro-particle impacts



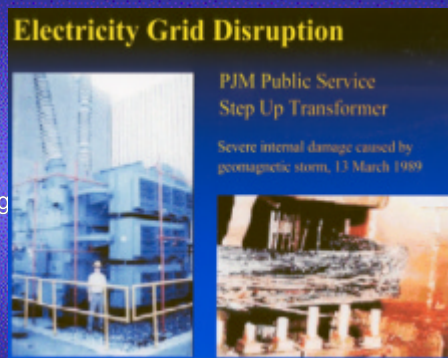
## User problems related to SW

- Satellite operators
  - Satellite anomalies
    - Minor - reset
    - Loss of service – temporary/partial
    - Catastrophic failure
  - Atmospheric drag
    - Loss of pointing
    - Loss of stability
    - Uncontrolled re-entry
    - Collision with space debris
    - Launch trajectory errors
  - Scintillations and ionospheric irregularities
    - Loss of navigation signal phase and amplitude lock
- Space Insurance
  - Problems as for satellite design and satellite operators



## User problems related to SW

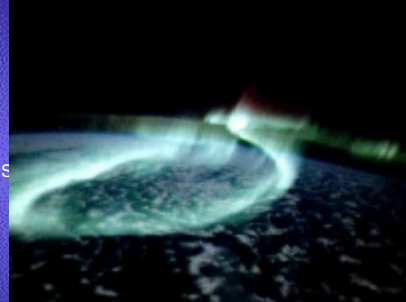
- Space Agencies
  - Radiation dose to humans
  - Other problems as for operators
- Aviation
  - Radiation dose to aircrew
  - Radiation damage to avionics
  - Errors in aircraft position for landing
  - Disruption of HF communications
- Power generation and supply
  - Geomagnetically induced currents GIC
    - Power surges
    - Interrupt network supply
    - Transformer damage
    - Reduced component lifetime





## User problems related to SW

- Defence
  - Ionospheric irregularities/disturbances
    - Loss of HF communications
    - Loss of HF direction finding
    - Clutter in over the horizon radar
      - Reduced early warning capability
    - Reduced accuracy in navigation
      - Targeting
    - Disruption to ELF/VLF communications
      - Submarines
  - Auroral light emissions
    - Increased noise in optical sensors
      - Reduced detection of missile launch
- Other problems as for design and operation
- Warning enables vigilance and use of alternative systems



## User problems related to SW

- Pipeline distribution
  - GIC
    - Disruption to protection systems
    - Enhanced corrosion
    - Reduced lifetime
- Aerial Surveying for minerals oil and gas
  - Variations in Earth's magnetic field
    - Corrupt data
- Drilling for oil and gas
  - Variation in Earth's magnetic field
    - Errors in navigating drill heads



## Economic Impact

- Assessment by ESYS Consulting plc :

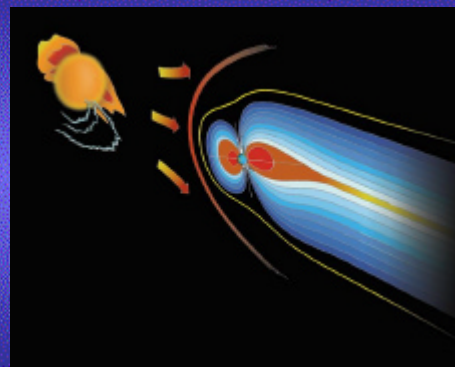
Loss estimates highly uncertain, poor primary data

Sector	Magnitude of individual events	Annualised loss estimate
Satellite operations	Total loss: €100-200M Service outage: €100K	€70-100M
Power distribution	Catastrophic event: €6B Transformer loss: €1-2M	€100M
Communication	Service outage: €100K	€10M
Total		€180-210M

- European share of losses estimated at 30-40% by GDP equivalent to €55-85M per annum
- Social impacts
  - human effects on aircrew and astronauts
  - satellite navigation services
    - >250 million users of GPS
    - European Galileo system will improve global sat-nav services
  - indirect impacts of satellite and power network failure

## General user requirements

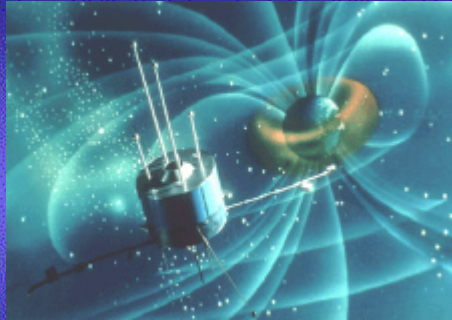
- Data on the sun-earth system - David Rodgers talk to follow
- Better characterisation of the system
  - Static
  - Dynamic
- Determination of
  - Extremes
  - Probability of occurrence
  - Duration and location
- Better predictions and quantification
  - Data
  - Models
- Education





## Synthesis of User Requirements

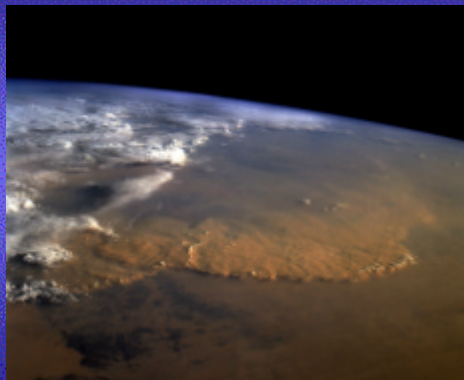
- Prediction of SW events
- Prediction of physical quantities that directly impact the users
  - Risk
- Continuous measurements of the sun-earth system
- Post event analysis
  - Feedback into design
  - Development of models
  - For research and understanding
  - Essential for real progress



## Prediction Service Requirements

### Users Require

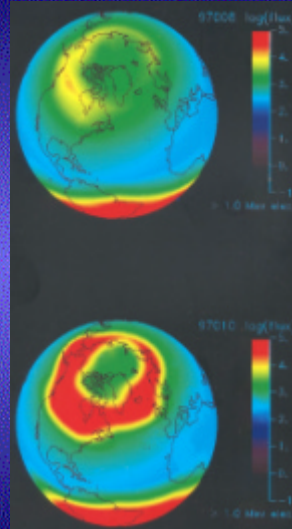
- Continuous coverage
- Continuous access to data
- Reliable data
- Back-up and redundancy
- Reliable predictions
- Timely predictions
- Understandable predictions
- Visualisation
- Authoritative predictions
- Coordinated and quality control
- Tailored predictions
- All clear predictions





## Timescales and Reliability

- Users say they want Target reliability
- Warning 2-3 days 65%
- Warning 3-6 hours 65-95%
- Warning 1 hour 95%
- Nowcast now 95%
- Only a nowcast can give 95% reliability at present
- Nowcast still enables mitigation, e.g.,
  - Radiation belts enhanced 2-3 days after a storm
  - SEP events last for 2-3 days
- We can do something now !



## Basic Research Required

- Research enables
  - Basic understanding
  - Linkages
  - Better models
  - Better predictions
  - Better design
- Physics of CMEs
- Acceleration of the solar wind
- Evolution of the solar wind
- Triggering of magnetic storms and substorms
- Acceleration and loss of radiation belt particles
- Coupling between the magnetosphere and ionosphere
- Ionospheric irregularities



## Education and publicity

### Who ?

- Commercial companies
- Decision makers
- Research Community
- Schools and Universities
- General public
- News media

### Why ?

- To identify problems
- Quantify the effects
- For realistic cost-benefit analysis

### Recommend

- User Groups, e.g.,
  - Satellite anomalies
  - Space radiation on humans
  - GIC - ground based systems



## Summary

- 88% of users support a European SW programme
- While data is freely available
  - Payment for specialist services only
- They say they require
  - More complete data
  - More analysis to characterise the system
  - Better models, static and dynamic
  - More reliable predictions
  - Education and understanding
- Research is required to achieve these requirements
- User involvement is essential to define clear goals and an effective programme that serves their needs



- Users would benefit from a European SW programme
  - Reduced loss
  - Improved health and safety
- Europe would derive benefits from a SW programme