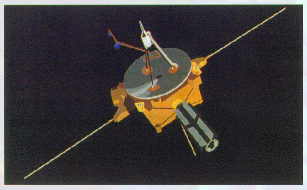
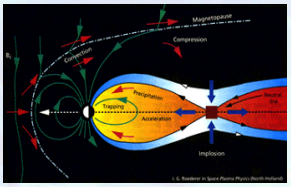
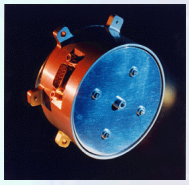






Measurement Requirements

D.J.Rodgers, L.M.Murphy, C.S.Dyer

QinetiQ

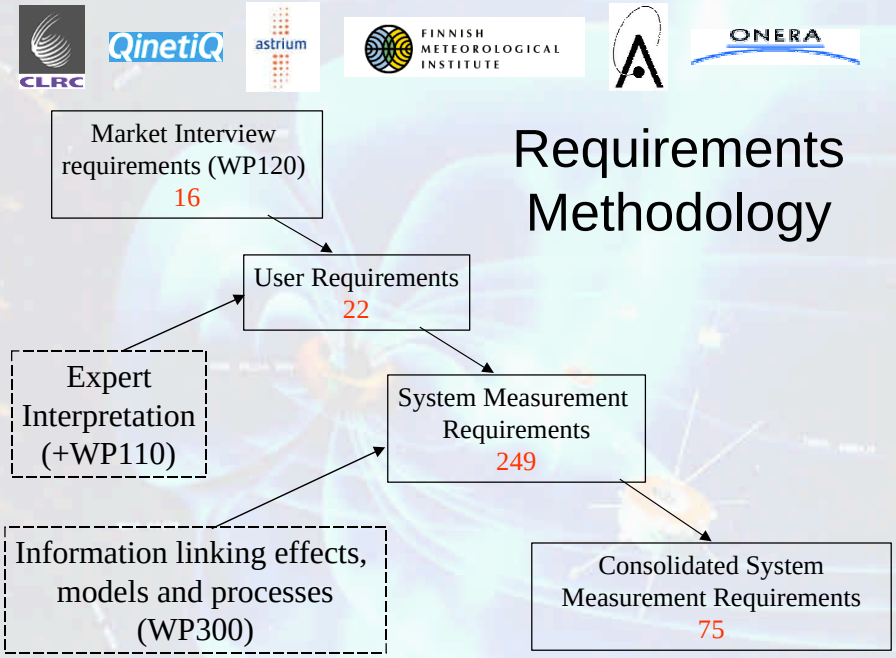
ESA Space Weather Programme study

Final Presentation - December 2001

Aims

- Study requirements include consideration of programmes of different scale (in terms of technical complexity, level of benefit to users and cost). In particular :
  - A 'full scale' space segment requiring development of new instruments and spacecraft platforms.
  - The addition of 'hitchhiker' space weather payloads (standard plasma, field or radiation environment monitors) to planned European spacecraft.
  - Use of existing and planned space assets developed under the space programmes of ESA member states.
- The requirements must cover the ‘full scale’ system but provide information to allow trade-offs to be made in smaller systems.
  - A key objective has been to ensure that the system measurement requirements are traceable to user requirements

Requirements Methodology



No.	User requirement
	Airlines and air safety organisations
1	Forecasts of hazardous radiation levels at altitudes and on routes used by commercial airlines, that may be dangerous to aircrew or may affect avionics systems.
2	Now-casts of hazardous radiation levels at altitudes and on routes used by commercial airlines, that may be dangerous to aircrew or affect avionics systems.
3	Post-event information on radiation levels at altitudes and on routes used by commercial airlines to allow calculation of crew (and passenger) radiation exposure and investigation of equipment anomalies.

Electric power transmission organisations (also pipeline operators and railways and telephone companies)

4 Spatially resolved forecasts of large geomagnetically induced currents, to allow mitigation measures to be taken to protect distributed conductor networks e.g. power grids

5 Spatially resolved now-cast information on large geomagnetically induced currents.

6 Spatially resolved post-event information on geomagnetically induced currents of all sizes.

Geological prospectors and military

7 Forecasts of perturbations in the geomagnetic field

8 Now-cast of perturbations in the geomagnetic field

Geological prospectors and drilling industry

9 Post-event knowledge of perturbations in the geomagnetic field

RF systems (civil and military)

10 Forecasts of ionospheric disturbances leading to loss of range, degradation and outage of radio communications e.g. fadeout, polar cap absorption and scintillation

11 Now-casts of ionospheric reflection properties for HF frequency selection

GNSS location systems and radar systems (civil and military)

12 Now-casts of ionospheric total electron content

Satellite operators (civil and military) and insurance and financial services

13 Post-event information on environments affecting operational satellite systems, e.g. radiation and charging environment

14 Forecasts of hazardous environments affecting operational satellite systems.

15 Now-casts of hazardous environments affecting operational satellite systems

16 Now-casts of atmospheric drag affecting LEO spacecraft

Tourism

17 Forecasts of auroral Intensity, duration and location

Space Agencies

18 Forecasts of all hazardous environments affecting humans in space

19 Now-casting of all hazardous environments affecting humans in space

20 Post-event knowledge of radiation environments affecting humans in space

Launch Providers

21 Forecasts of severe SPE/SEPE affecting spacecraft launch operations

22 Post-knowledge of SPE/SEPE affecting spacecraft launch operations

Space-based measurements

Solar images

- Solar EUV / X-ray images
- Solar coronagraph images
- Stereo visible or UV images of Sun-Earth space

Auroral measurements

- Auroral imaging
- Auroral oval, size, location and intensity

Solar X-ray and UV fluxes

Solar wind properties

- Vsw, Nsw
- IMF (+ solar surface field)

Magnetospheric magnetic field

Plasmaspheric bulk density

Electron and ion fluxes

- 1-10keV electrons spectra
- 10-100keV electrons spectra
- Relativistic electrons (>0.3MeV).
- >10MeV protons (trapped)
- >10MeV ions (SPE/SEPE)
- >100MeV ions (GCR)

Debris and meteoroid properties

- Size and velocity distributions

Dose measurements

- Dose rate and LET spectrum
- Total dose

Interplanetary radio emissions

Ground-based measurements

Auroral measurements

- Auroral imaging
- Auroral equatorward boundary

Solar 10.7 cm radio emission

Secondary neutron fluxes (GCR)

Geomagnetic indices

- Kp, Ap, Dst

Sunspot number

IMF (solar surface magnetic field)

Geomagnetic field variations

Interplanetary radio scintillation

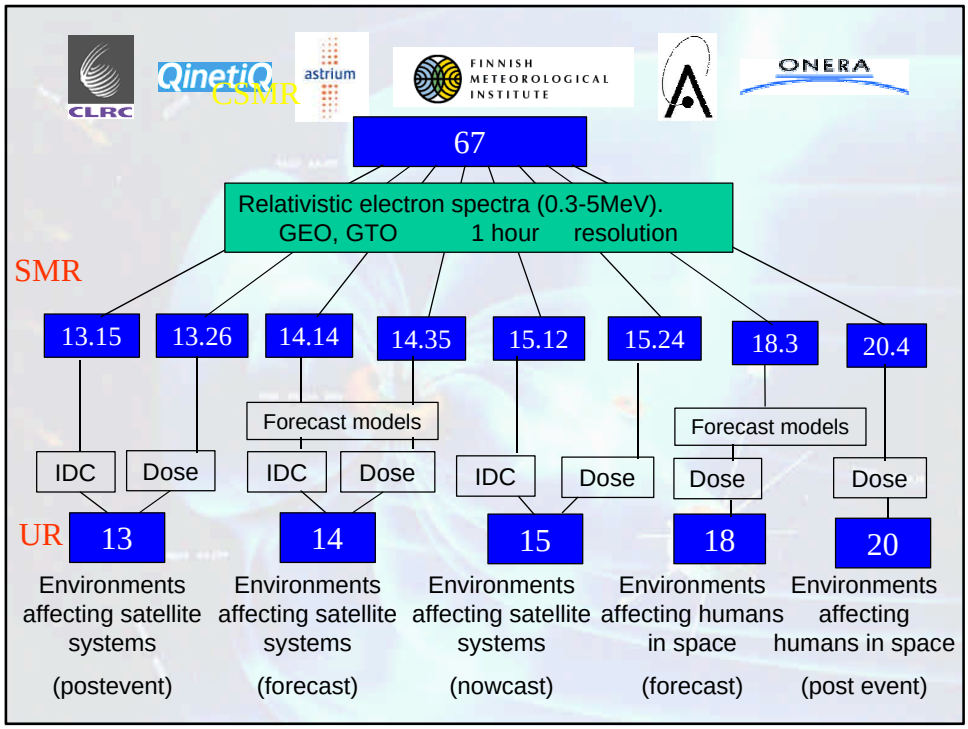
Ionospheric measurements

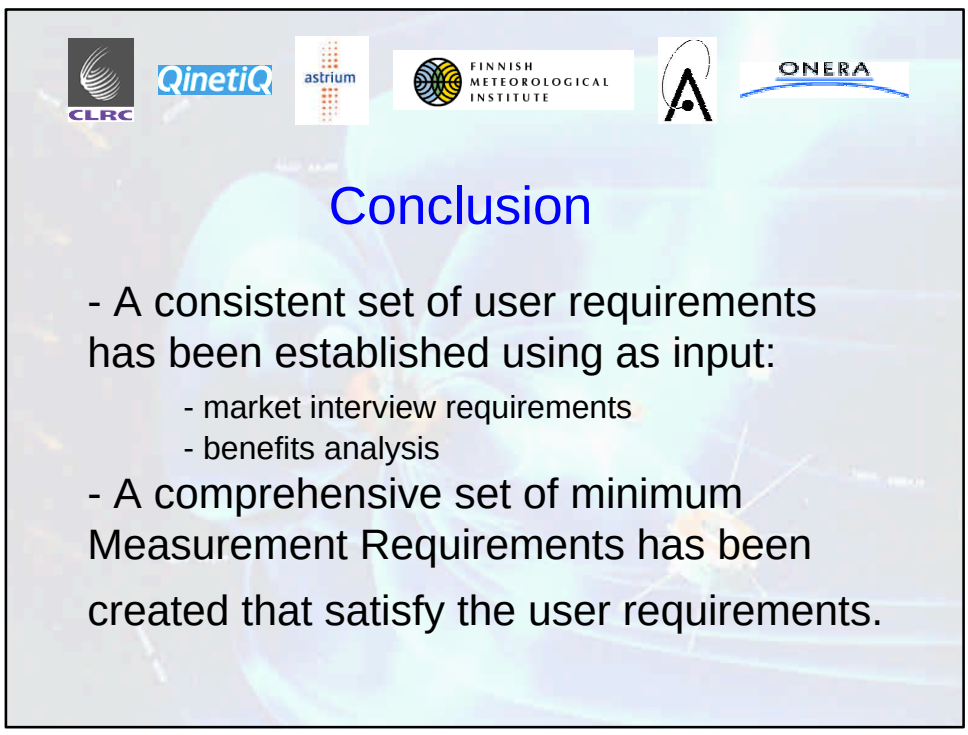
- critical frequencies
- total electron content

Cross-tail electric field / ionospheric drift

Atmospheric scale height (spacecraft tracking)

Debris and meteoroid properties





Conclusion

- A consistent set of user requirements has been established using as input:
  - market interview requirements
  - benefits analysis
- A comprehensive set of minimum Measurement Requirements has been created that satisfy the user requirements.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