ESA Space Weather User 's Workshop

ALCATEL/LPCE Summary Presentation

ESA STUDY for a SPACE WEATHER PROGRAMME

ESTEC-Noordwijk, December 17th, 2001

CONSORTIUM Members

- Team Members (1/2)
  - ALCATEL Space (Fr) : Prime contractor, Space Segment
  - LPCE (Orléans-Fr) : Scientific Prime contractor
  - IRF-Lund (Suède) : Services & Prototyping
  - British Antartic Survey (UK) : User 's assessment .
  - MSSL (UK) : Space Instrumentation and System requireme
  - ESYS (UK) : Market Analysis

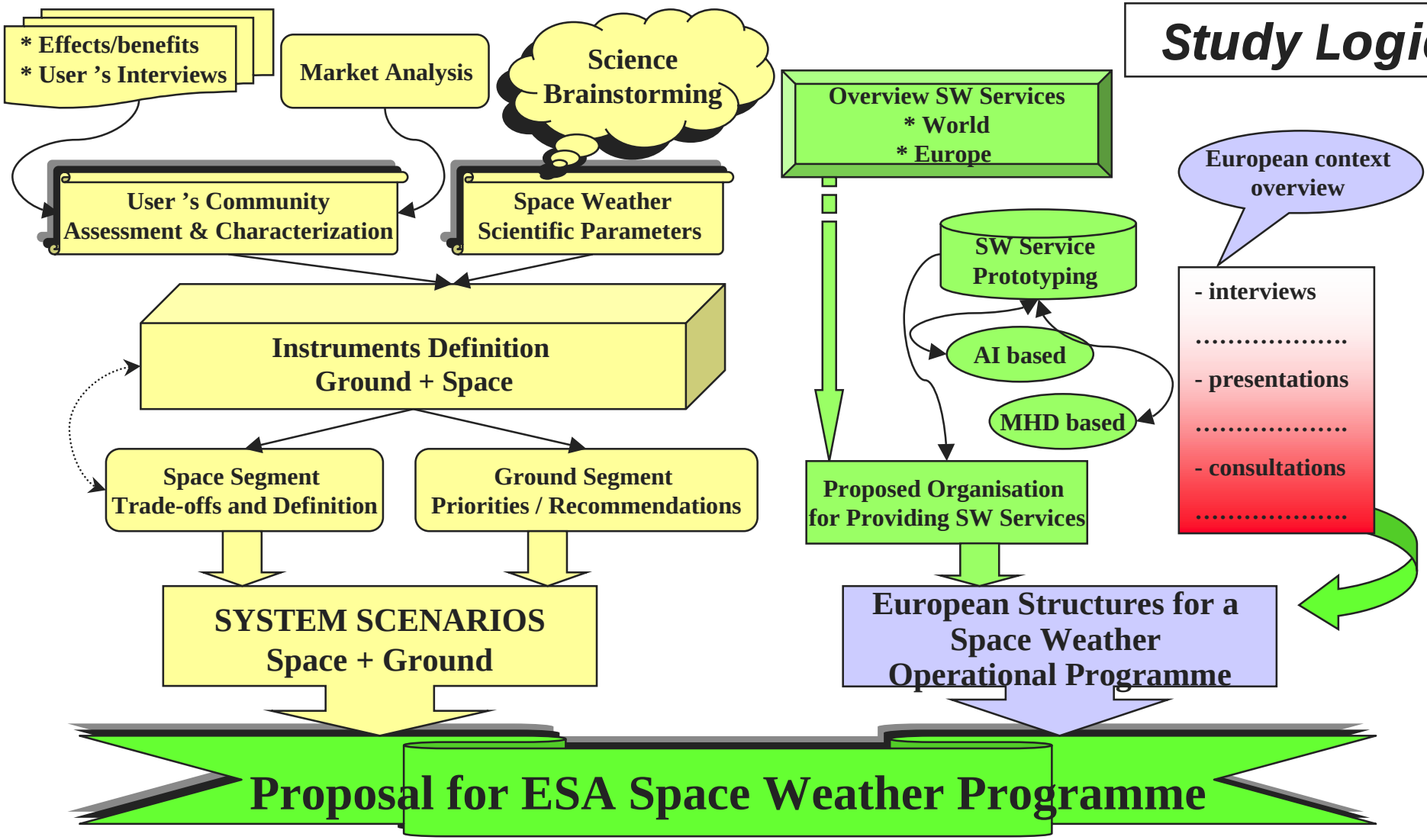
CONSORTIUM
Members

- Team Members (2/2) :
  - LPG (Grenoble-Fr) : Parameters and mo
  - LPSH/ Obs de Paris(Meudon-Fr) : Ground Segment & Sun Observation
  - Imperial College (UK) : Prototyping and Modelling
  - Université Greifswald (D) : SW Paramete

STUDY DRIVERS

- Overview of Current knowledge & understanding
  - Science
  - Space Weather Parameters
  - User 's Interest
- Flexibility and Options
  - Space instruments
  - Ground Instruments
  - Ground Data Handling
- European Autonomy / Use of European Assets
- Operational System

Study Logic



STUDY MAIN ACHIEVEMENTS (1/2)

- Investigation of User 's Needs and Market :
  - Classification
  - Characterization
  - Quantification
  - Parametrization

- Reference / Synthetic Tables
  - Space Weather Parameters
  - Instruments for each Parameter (Space + Ground)
  - Models Overview
  - Space Weather Forecast Capabilities

STUDY MAIN ACHIEVEMENTS (2/2)

- Prototypes of services
  - AI Based predictions
  - Physical-models based predictions
- Multiple System Scenarios
  - Different levels of fulfillment of the requirements
  - Different levels of fundings
- Action plan for a European Programme
  - Guidelines for Structures
  - Priorities
  - Key Elements

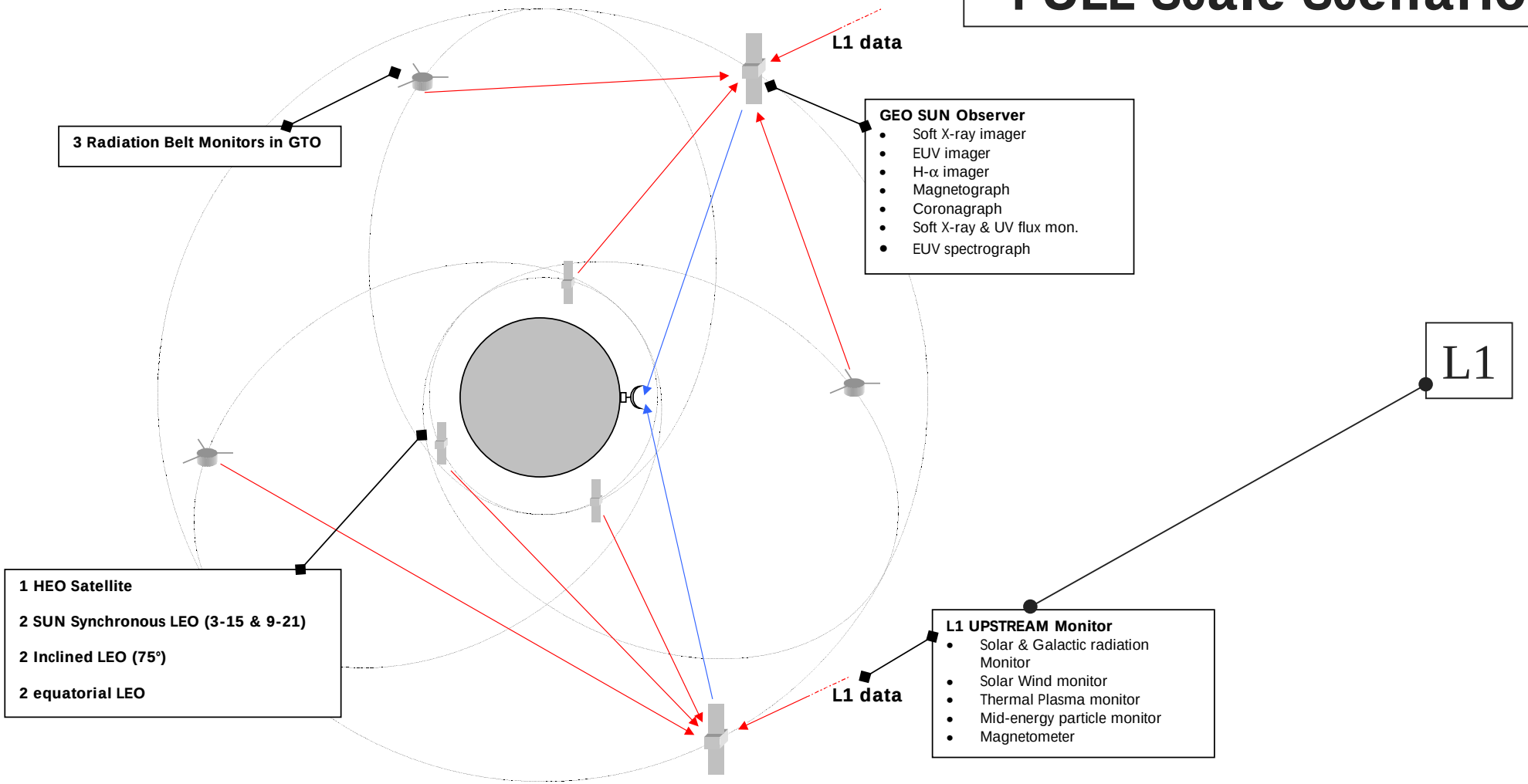
Operational Scenarios : Space Segment

	Full Scale	Medium Scale	Low Scale
Solar Observation	(1) 2 Geosynchronous Spacecrafts with full intrumentation (2) L1 Instruments on Upstream Monitor : radio-spectrograph (<40 MHz min; up to 200 MHz if feasible)	(1) L1 Observer with low freq. Radio-spectrograph(<40MHz) (2) H-α imager with reduced TM rate (3) Suppression of SXI	(1) LEO satellite, with limited instruments : • EUV Imager • Coronagraph • EUV Flux • EUV Spectrometer
Solar Wind-heliosphere	(1) Upstream Monitor at L1 with full Instruments and including radio-spectrograph	(1) Upstream Monitor at L1 combined with Solar observation (separated if less costly / more heritage)	1. Upstream Monitor at L1 with full Instruments
Magnetosphere Monitoring (Radiation Belts)	1. Three Equatorial spacecrafts in GTO 2. Hitch-hikers on GEO/MEO s/c	1. Three Equatorial spacecrafts in GTO 2. Hitch-hikers on GEO/MEO s/c	1. One Equatorial spacecraft in GTO 2. Hitch-hikers on GEO/MEO s/c
Ionosphere / Thermosphere	1. High Excentric Spacecraft 2. Two Sun-synchronous LEO 3-15 & 9-21 LT (600km) 3. Two inclined LEO (75°) on the same orbit 4. 1 pair of equatorial LEO on the same orbit	1. Two Sun-synchronous LEO at 600km 3-15 & 9-21 LT 2. Hitch-hikers for radiation belt	

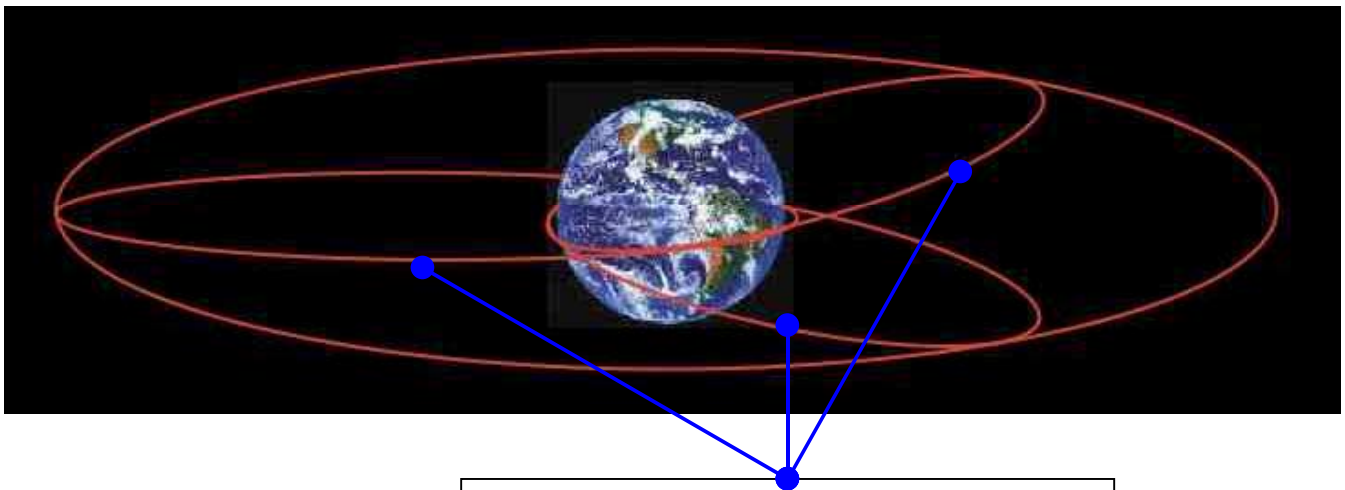
Operational Scenarios : Ground Segment

	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

FULL Scale Scenario



FULL Scale & MEDIUM Scale Scenarios
Magnetosphere Segment Radiation Belts Monitors



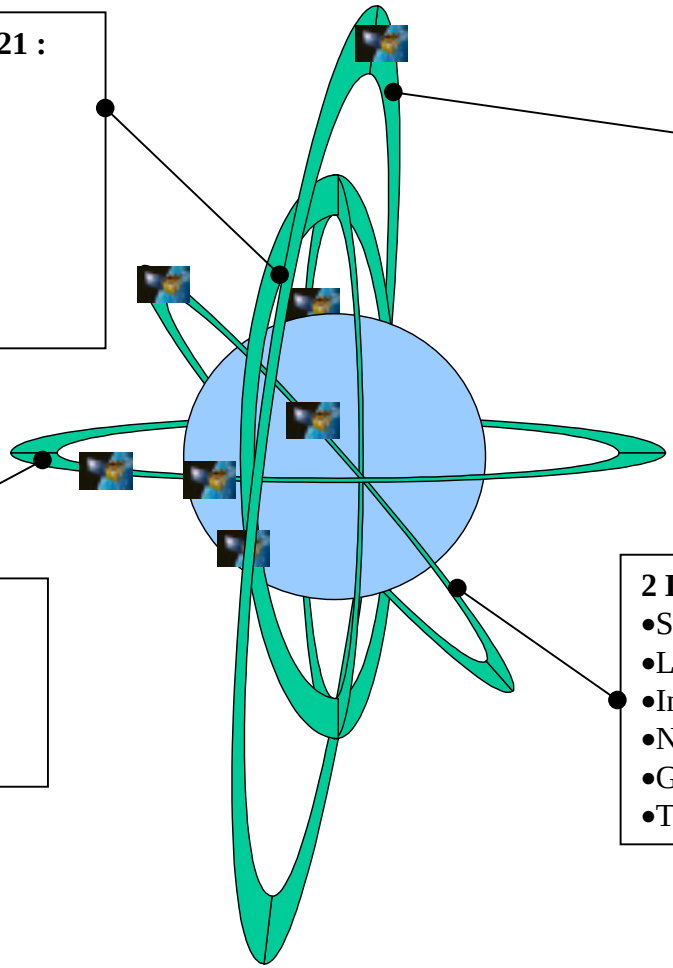
Radiation Belt Monitors on 3 GTO-type orbits

- Thermal Plasma monitor
- Mid-energy particle monitor
- Magnetometer
- Waves

FULL Scale Scenario : Ionosphere/Thermosphere Monitors

2 LEO Sun-synchronous 3-15 & 9-21 :
- Solar & Galactic radiation monitor
- Low energy plasma monitor
- E-field antennae
- Neutral mass spectrometer
- GPS receiver
- Topside sounder

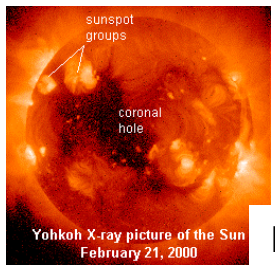
1 Highly Elliptical Orbit Satellite
- UV imager
- Visible imager



2 LEO equatorial :
- Interferometer
- Neutral mass spectrometer
- GPS receiver
- Topside sounder

2 LEO High Inclination :
- Solar & Galactic radiation monitor
- Low energy plasma monitor
- Interferometer
- Neutral mass spectrometer
- GPS receiver
- Topside sounder

LOW Scale Scenario



L1

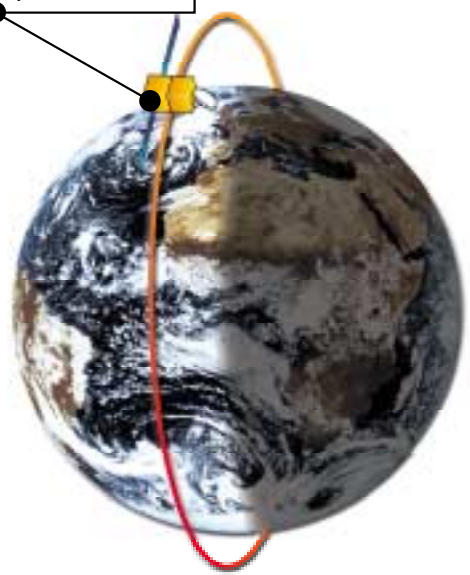
X

Upstream L1 Monitor :

- Galactic & cosmic rays detector
- Solar Wind monitor
- Thermal Plasma monitor
- Mid-energy particle monitor
- Magnetometer
- Low frequency radio-spectrograph (<40MHz)

SUN LEO Observer :

- EUV Imager
- EUV Flux Monitor
- EUV spectrometer
- Coronagraph



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1 Radiation Belts Monitor

Space Segment Pilot Projects

- Pilot Project 1 : **UPSTREAM L1 Monitor**
  - **Platform/Orbit : dedicated spinned satellite in L1**
  - **Rationale :**
    - in-situ Solar Wind monitoring
    - service continuity => replace ACE

- Pilot Project 2 : **SUN LEO Observatory**
  - **Platform/Orbit : LEO Mini-satellite class**
  - **Rationale :**
    - SUN monitoring critical (i.e. EUV)
    - service continuity => replace SOHO
    - low cost ,***quick operability***

- Pilot Project 3 : **Radiation Belt GTO Monitors**
  - **Platform/Orbit : 3 Mini-Sat in 3 diff. GTO-type equatorial orbit**
  - **Rationale :**
    - big gap in Space Weather monitoring
    - Direct application to Space Environment
    - Ideal Cooperation (3 Orbits)

Main Outcomes from ESA Space Weather Study

- User 's Classification / Requirements Assessment & Parametrization
  - Essential TOOL for User 's
- Several Scenarios exist to meet User 's Needs
- OPERATIONAL SPACE WEATHER Service is Within Reach
- PRIORITIES Given in the Perspective of an Operational Use
  - Space Segment :
    - ***L1 Upstream Monitor ; SUN Leo Observation ;Radiation Belts GTO Monitors ;***
  - Ground Segment :
    - ***Get Networks Operational espcially for Sun Observation***
    - ***Develop Radio-Imaging/Spectro_Ionosondes_Superdarn***
  - Models development per Segment

ESA Study for SPACE WEATHER PROGRAMME

Main Issues for a European Space Weather Programme

- Follow-on of Activities to Consolidate :
  - User 's Requirements
  - Services development & demonstration
- Constitute a European Leadership
  - FEDERATE European Initiatives / efforts / actions
  - To Interface NOAA/SEC Boulder
- Trigger Support
  - **Provide Demonstration/Reference Cases of Space Weather Impacts/Risks**
- Prioritorize Projects for ensuring the continuation of current initiatives in development of Space Weather Prediction Services
  - Models
  - Space & Ground Measurements

Events	Forecasting the event	Forecasting the time of the event	Quantify the event's importance
Events at SUN			
No event	Y(U)	Y(D)	-
Coronal mass ejections (Halos)	Y(D)	N(D)	N(D)
Proton events	Y(D)	N(D)	Y(U)
Coronal holes	Y(U)	Y(U)	Y(D)
Solar activity/flares/X-ray, EUV radiation	Y(U)	N(D)	N(D)
Interplanetary events at L1			
Interplanetary CMEs and shocks	Y(D)(S)	Y(D)(S)	N(D)(S)
High speed plasma streams	Y(U)(S)	Y(U)(S)	Y(D)(S)
Earth's atmosphere			
Outer radiation belt electrons	Y(M)(L1)	Y(M)(L1)	Y(M)(L1)
Inner belt electrons and protons	Y(M)(L1)	Y(M)(L1)	Y(M)(L1)
Geomagnetic storms and substorms	Y(U)(L1)	Y(U)(L1)	Y(U)(L1)
Aurora	Y(D)(L1)	Y(D)(L1)	Y(D)(L1)
Ionospheric disturbance	Y(U)	Y(D)	Y(D)
Ionospheric scintillation	Y(U)	Y(U)	Y(U)
Thermospheric density increase	Y(U)	Y(U)	Y(U)

Effects on technological systems	Identification	Forecast-ing the event	Forecasting the time of the event	Quantify the event's importance
Satellite anomalies	N(D)	Y(D)	Y(D)	N(D)
Increased drag on satellite	Y	Y(U)	Y(D)	Y(D)
Communication distrurbannce	Y	Y(U)	Y(U)	Y(U)
Geomagnetically induced currents	Y	Y(U)	Y(U)	Y(U)

Legend

- Y= Yes, N=No, M=Mature, U=Useful, D=In Development
- Identification means whether or not we have identified the source of the space weather effect
- S=means that the forecast is basedon solar data.

L1=means that the forecast is based on data measured at L1.