



## *ESA Space Weather User 's Workshop*

### **ALCATEL/LPCE Summary Presentation**

# ***ESA STUDY for a SPACE WEATHER PROGRAMME***

**ESTEC-Noordwijk, December 17<sup>th</sup>, 2001**

***ESA Study for SPACE WEATHER PROGRAMME***

# 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 Antarctic Survey (UK) : User 's assessment .



- MSSL (UK) : Space Instrumentation and System requirements



- 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

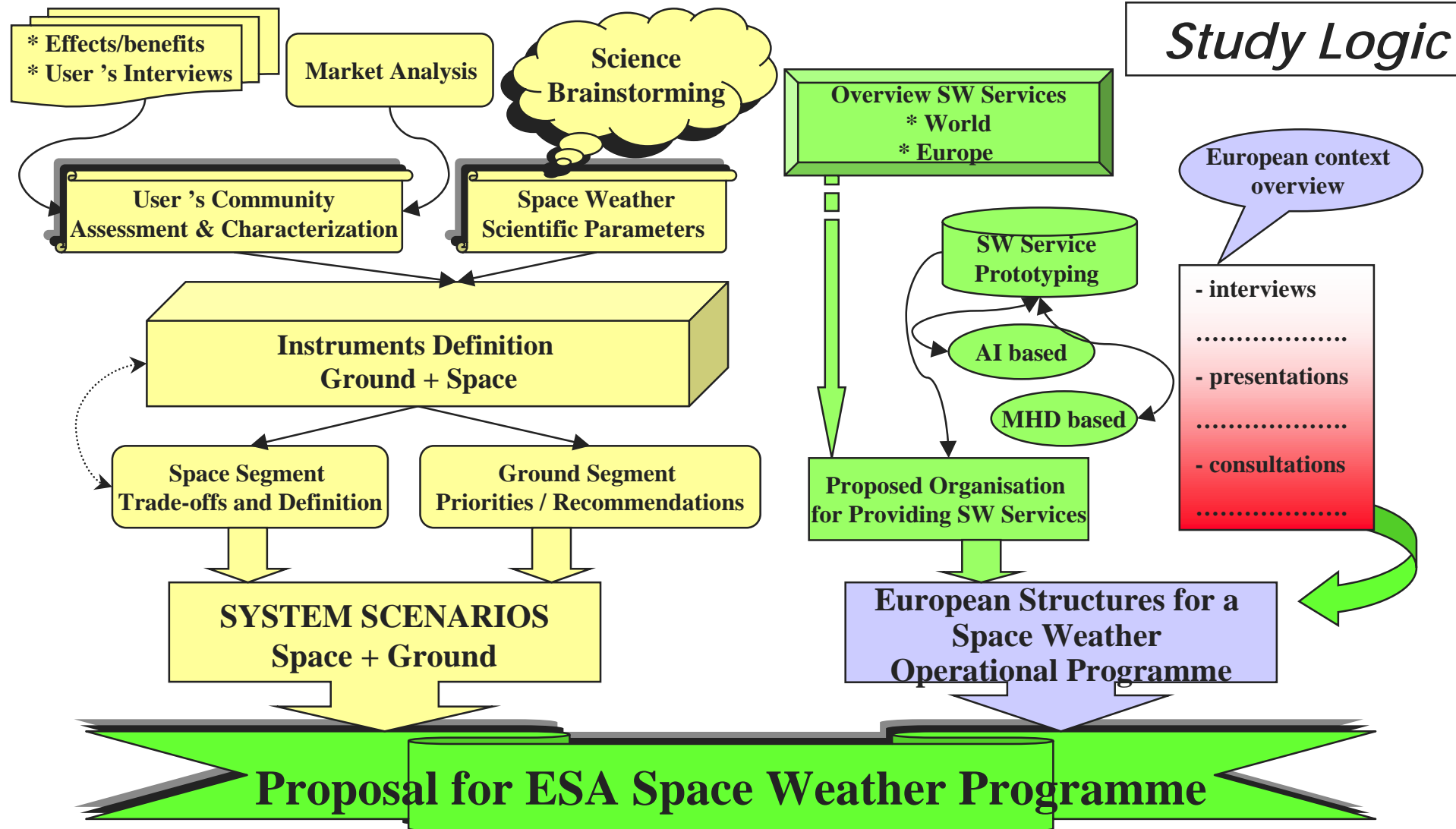


- Université Greifswald (D) : SW Paramete



## 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 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

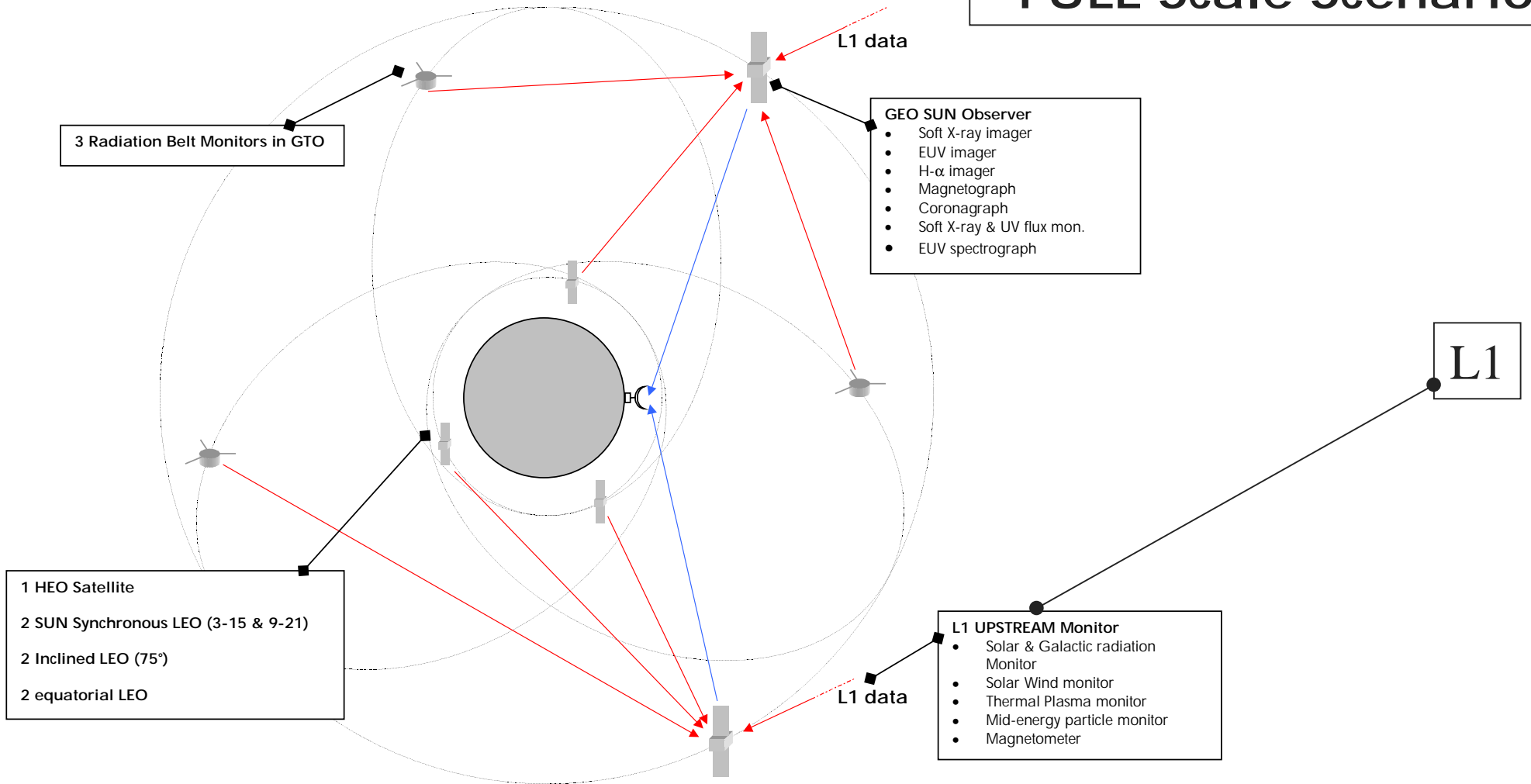
# Operational Scenarios : Space Segment

	Full Scale	Medium Scale	Low Scale
<b>Solar Observation</b>	(1) 2 Geosynchronous Spacecrafts with full instrumentation (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- $\alpha$ imager with reduced TM rate (3) Suppression of SXI	(1) LEO satellite, with limited instruments : <ul style="list-style-type: none"> <li>• EUV Imager</li> <li>• Coronagraph</li> <li>• EUV Flux</li> <li>• EUV Spectrometer</li> </ul>
<b>Solar Wind-heliosphere</b>	(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
<b>Magnetosphere Monitoring (Radiation Belts)</b>	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
<b>Ionosphere / Thermosphere</b>	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	

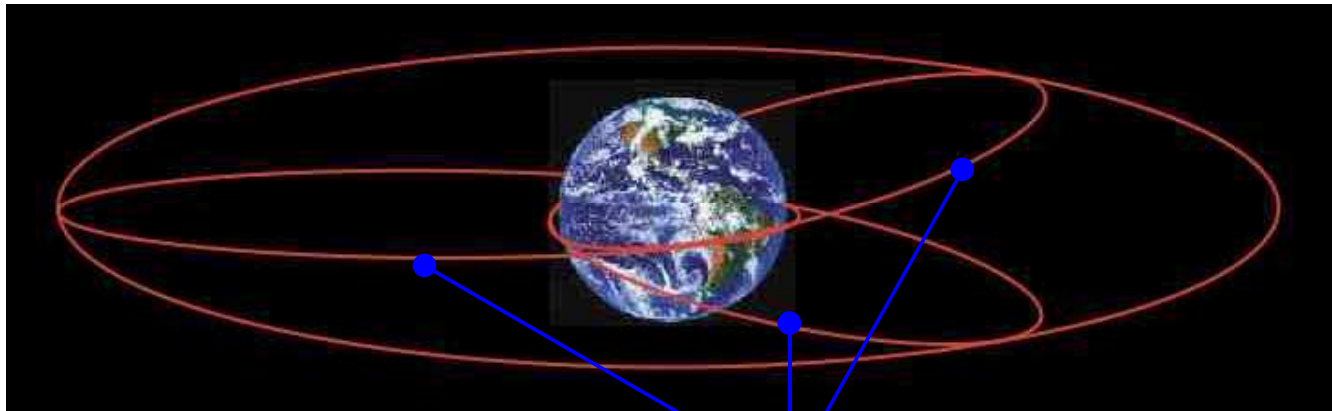
# Operational Scenarios : Ground Segment

	Full Scale	Medium Scale	Low Scale
<b>Solar observations</b>	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. H $\alpha$ network.
<b>Upstream (including interplanetary)</b>	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.
<b>Magnetospheric monitoring</b>	Covered under I/T monitoring	Covered under I/T monitoring	Covered under I/T monitoring
<b>Ionosphere/thermosphere Monitoring</b>	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



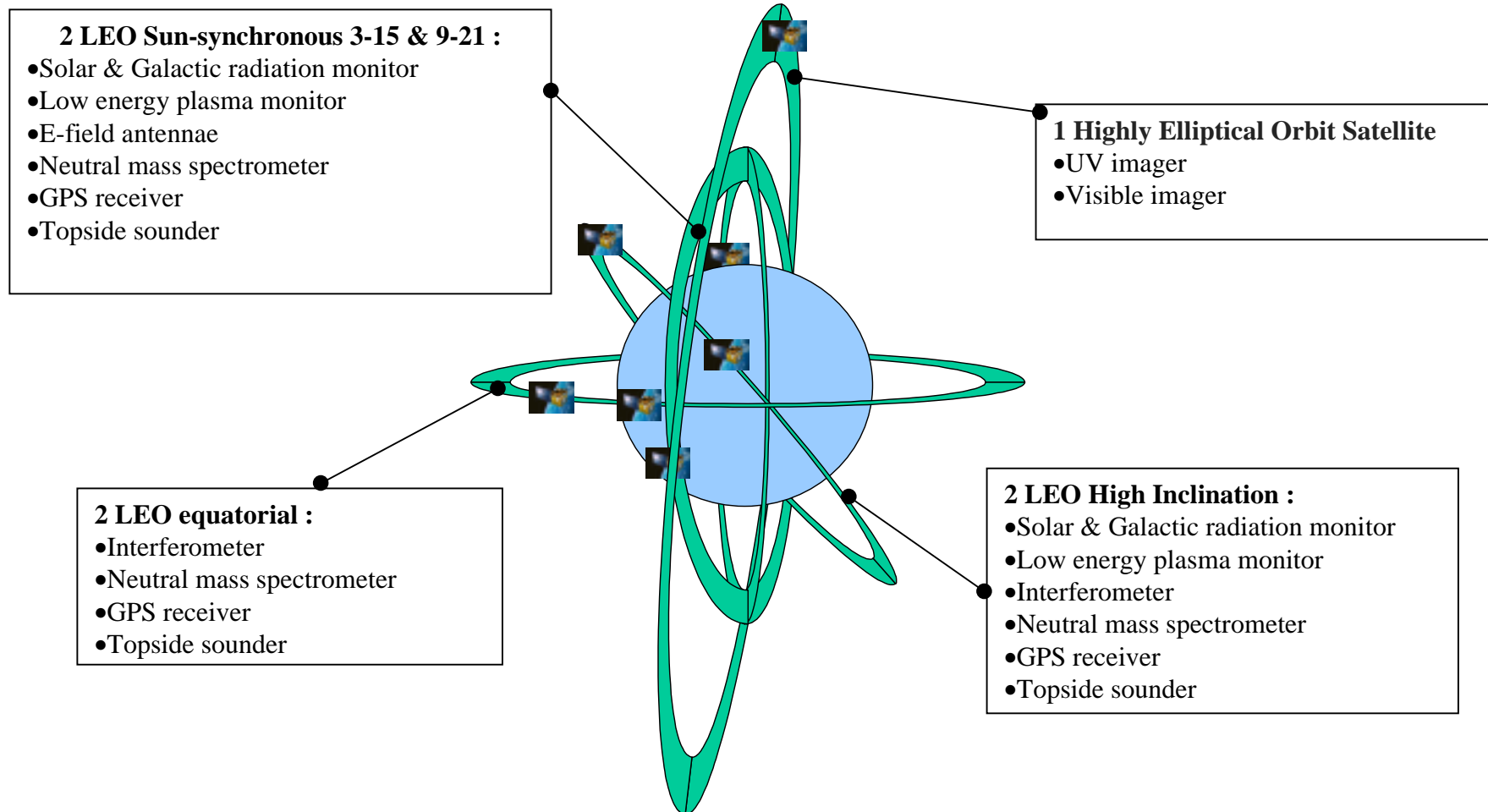
# FULL Scale & MEDIUM Scale Scenarios Magnetosphere Segment Radiation Belts Monitors



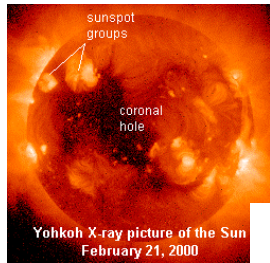
## Radiation Belt Monitors on 3 GTO-type orbits

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

# FULL Scale Scenario : Ionosphere/Thermosphere Monitors



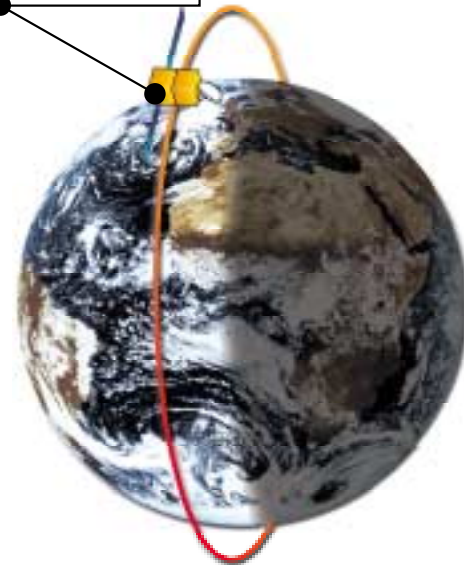
# LOW Scale Scenario



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



+  
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 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)

### ▼ 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*

## 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 especially for Sun Observation*
    - *Develop Radio-Imaging/Spectro\_Ionosondes\_Superdarn*
  - Models development per Segment

## 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
- ▼ Prioritize 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
<b>Events at SUN</b>			
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)
<b>Interplanetary events at L1</b>			
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)
<b>Earth's atmosphere</b>			
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	Forecasting 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 disturbance	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 based on solar data.
- L1=means that the forecast is based on data measured at L1.

## ESA Study for SPACE WEATHER PROGRAMME