



# GALILEO INTERIM SUPPORT STRUCTURE

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## GALILEO System Update



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GALILEO Interim Support Structure - Brussels

European CGSIC Meeting - EUROCONTROL  
5-6 December 2002 - Brussels



## GALILEO INTERIM SUPPORT STRUCTURE

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# The Political Context of the GALILEO Program



# The Political Context of GALILEO

- Satellite navigation is considered to become worldwide the primary means for navigation
- EC and ESA started cooperating in 1995 on the definition and implementation of an European strategy for GNSS in two stages:
  - First stage: EGNOS (1995-2004)
  - Second stage: GALILEO (1999-2008)
- Full operational capability of the GALILEO program is foreseen to be reached in 2008
- Total cost of design, in-orbit validation, and full deployment of GALILEO: 3,4 B€



# GNSS with GALILEO for Civil Aviation

- Key interests for civil aviation is a GNSS service, relying on redundant, interoperable, and multi-frequency GALILEO and GPS constellations
- Certifiable for Safety of Life applications
- Provision of integrity information with the Signal in Space (GPS relies on regional augmentation systems to provide such information)
- Increased accuracy in vertical and in horizontal direction
- Greater availability in Northern Latitudes
- Interoperability with GPS to allow simultaneous use for a robust world-wide GNSS (Availability of both systems together will be up-to 100%)
- GALILEO is a civil operated system



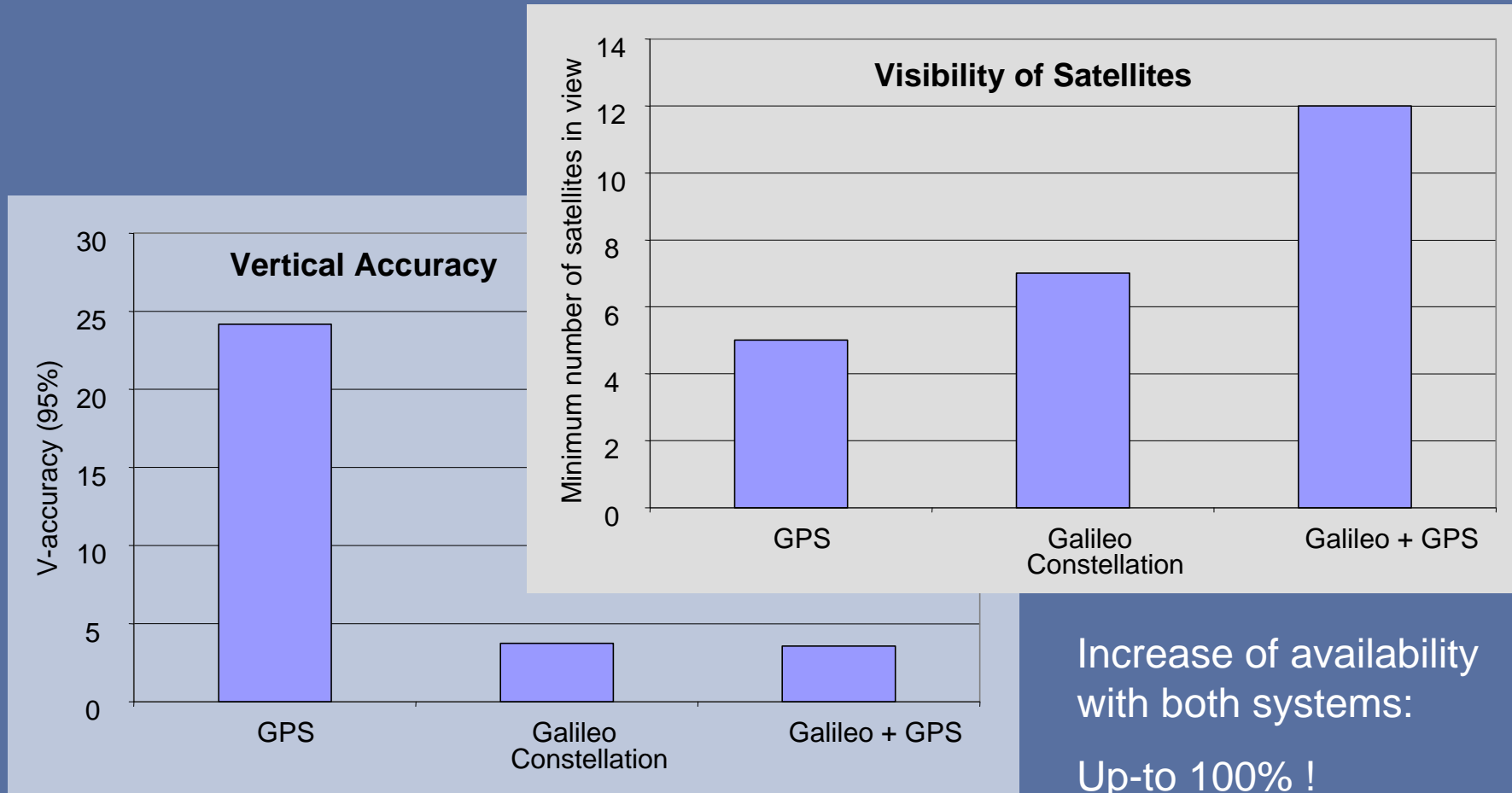
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## Improvement of GNSS with GALILEO & GPS



Increase of availability with both systems:

Up-to 100% !

Source: GMV GALILEO and GPS Performance Analysis Report



## GALILEO INTERIM SUPPORT STRUCTURE



# **GALILEO is open to Co-operation**

- Galileo has been designed as global system with build-in regional and local enhancement capabilities
- Negotiations with the United States and Russia are underway
- China is about to become full negotiation partner
- Other parties expressed interest and some participated already in the definition studies





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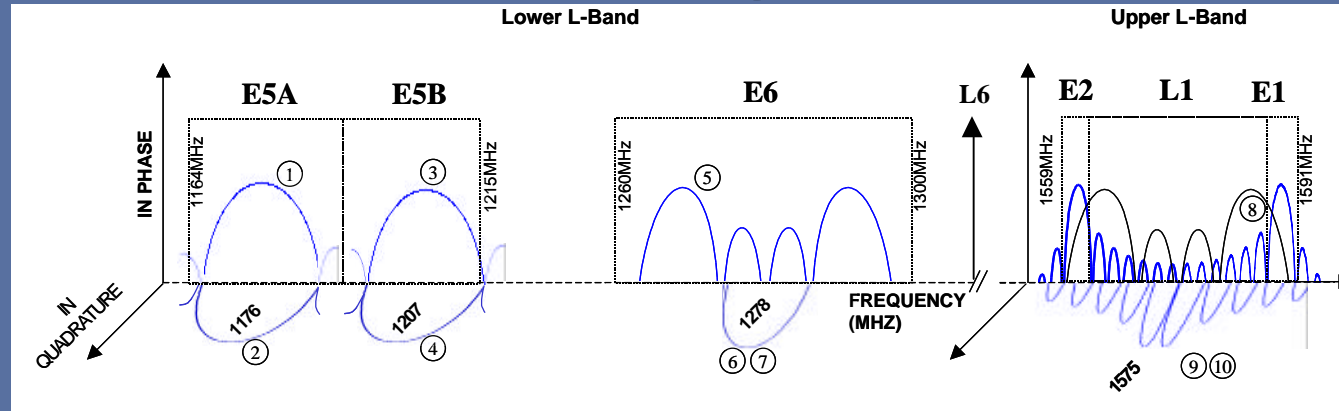


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**The Signals and Services provided  
by the GALILEO System to Users**

## The GALILEO Signal Structure

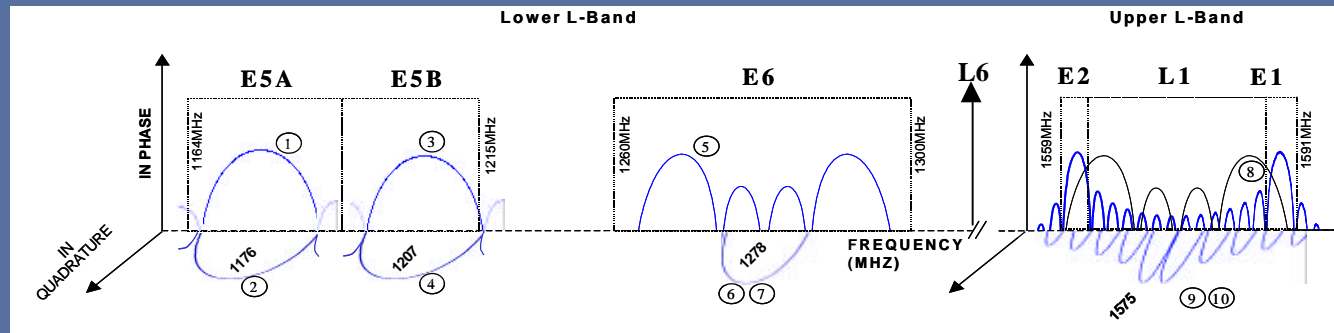


- Galileo will provide 10 signals in the Radio Navigation Satellite Service (RNSS) allocated frequency bands:
  - Two pairs (data & pilot signals) in the 1164-1215 MHz (E5A and E5B) bands
  - Three signals (one split spectrum & one pair) in the 1215-1300 MHz (E6) band
  - Three signals (one split spectrum & one pair) in the 1559-1592 MHz (E2-L1-E1) band
- One signal for SAR service in the L6 band ( 1544 MHz)



## GALILEO Signal – Services Allocation

- The following signal / service allocation is foreseen:



Navigation Service	Signal Allocation
Open Services	E5A, E5B, L1 (Id's: 1,2,3,4,9,10)
Commercial Services	E6 (Id's: 6,7)
Safety-Of-Life Services	E5A, E5B, L1 (Id's: 1,2,3,4,9,10)
Public Regulated Services	E6, L1 (Id's: 5,8)

- The SAR broadcast is transmitted in the 406 MHz and in the L6 (1544MHz) bands



# The GALILEO Services

### Navigation Related:

- Open Service (OS)
- Commercial Service (CS)
- Safety-Of-Life Service (SAS)
- Public Regulated Service (PRS)

### Non-navigation Related:

- Search and Rescue Service (SAR)

### Further:

- Locally Assisted Service
- EGNOS Service
- Combined Services (e.g. GPS, UMTS)



# The GALILEO Services

- Open Service (OS)
  - Free service; no service guarantees; no integrity information
- Commercial Service (CS)
  - Managed by service providers; to be paid; value added functions added; integration with GSM, UMTS; service guarantees provided; integrity information through service provider
- Safety-Of-Life Service (SAS)
  - Optimized for critical applications (e.g. aircraft, marine, train); integrity information provided; service guarantees provided
- Public Regulated Service (PRS)
  - Exclusively for public applications (police, fire-brigades); very robust; encrypted signal; service guarantees; integrity information
- Search and Rescue Service (SAR)
  - Service not related to navigation, but for augmentation of the existing COSPAR-SARSAT system



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## GALILEO Open Service

Coverage	Global	
Accuracy (95%)	H: 15m V: 35m	H: 4m V: 8m
Integrity Alarm Limit	<b>Not Applicable</b>	
Time-To-Alarm		
Integrity Risk		
Continuity Risk	8 x 10 <sup>-6</sup> / 15 sec	
Timing Accuracy wrt UTC/TAI	Not defined	50 nsec
Certification/Liability	No	No
Availability	99.5%	
	Single Freq.	Dual Freq.



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# **GALILEO Commercial Service**

- **The performance data of the GALILEO Commercial Services are at least similar to those of the Open Services**
- **The GALILEO Operating Company will determine and guarantee the performances**
- **Commercial Services will include:**
  - **Dissimination of data (500 bps)**
  - **Broadcasting of two signals separated in frequency from Open Services**
  - **High precision navigation through local means**
  - **Utilization of pilot signal for integration of positioning applications and of wireless communication networks**



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## GALILEO Safety Of Life Service

<b>Coverage</b>	Global	
<b>Accuracy (95%)</b>	H: 4 m V: 8 m	
<b>Integrity Alarm Limit</b>	H: 12 m <sup>1</sup> V: 20 m	H: 556 m <sup>2</sup>
<b>Time-To-Alarm</b>	6 sec	10 sec
<b>Integrity Risk</b>	1.5x10 <sup>-7</sup> /150sec	10 <sup>-7</sup> /hour
<b>Continuity Risk</b>	8x10 <sup>-6</sup> /15 sec	10 <sup>-4</sup> - 10 <sup>-8</sup> /hour
<b>Timing Accuracy wrt UTC/TAI</b>	50 nsec	
<b>Certification/Liability</b>	Yes	
<b>Availability</b>	99.8%	

- 1 Integrity data for critical level
- 2 Integrity data for non-critical level



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# GALILEO Public Regulated Service

<b>Coverage</b>	Global
<b>Accuracy (95%)</b>	H: 6.5 m V: 12 m
<b>Integrity Alarm Limit</b>	H: 12 m V: 20 m
<b>Time-To-Alarm</b>	10 sec
<b>Integrity Risk</b>	$3.5 \times 10^{-7} / 150 \text{sec}$
<b>Continuity Risk</b>	$10^{-5} / 15 \text{sec}$
<b>Timing Accuracy wrt UTC/TAI</b>	100 nsec
<b>Certification/Liability</b>	Under Analysis
<b>Availability</b>	99% - 99.9%



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# GALILEO Search And Rescue Service

<b>Capacity</b>	Each satellite capable to relay signals from 150 simultaneous active beacons
<b>Forward System Latency Time</b>	Comms from beacon to S&R ground station less than 10 min
<b>Quality of Service</b>	Bit Error rate $< 10^{-5}$
<b>Acknowledgement Data Rate</b>	6 messages of 100 bits each per minute
<b>Availability</b>	$> 99\%$





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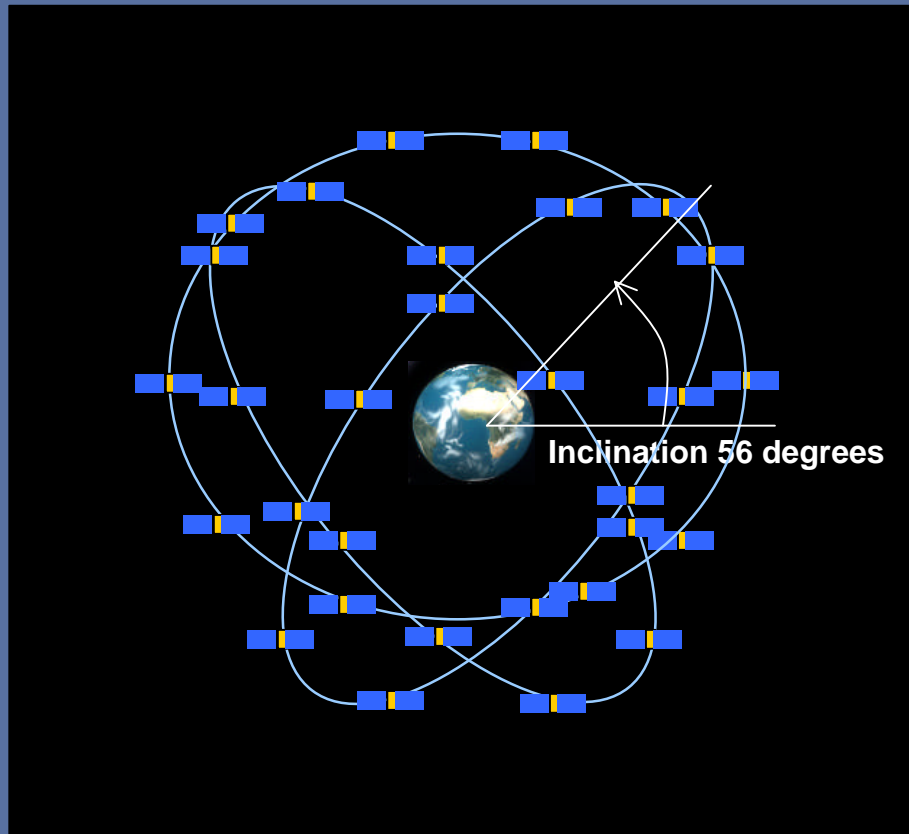
## The Architecture of the GALILEO System - GALILEO Space Segment



# The GALILEO Space Segment

- Objective for the constellation design is to provide global services with respect to the navigation signal, the integrity signal and SAR services
- Constellation shall be very robust even when a satellite fails, in order to maintain service guarantees
- Constellation shall be as good for the professional areas (e.g. aviation) as for the civil mass markets; this influences the optimization with respect to the visibility
- Optimization of the constellation has been carried out with respect to affordability

## The GALILEO Satellite Constellation



- 30 satellites in three Medium Earth Orbit MEO planes at 23616 km altitude
- 1 satellite per orbital plane is a spare
- Inclination of orbital planes 56 degrees
- One revolution 14 hours 4 min
- Ground track repeat 10 days



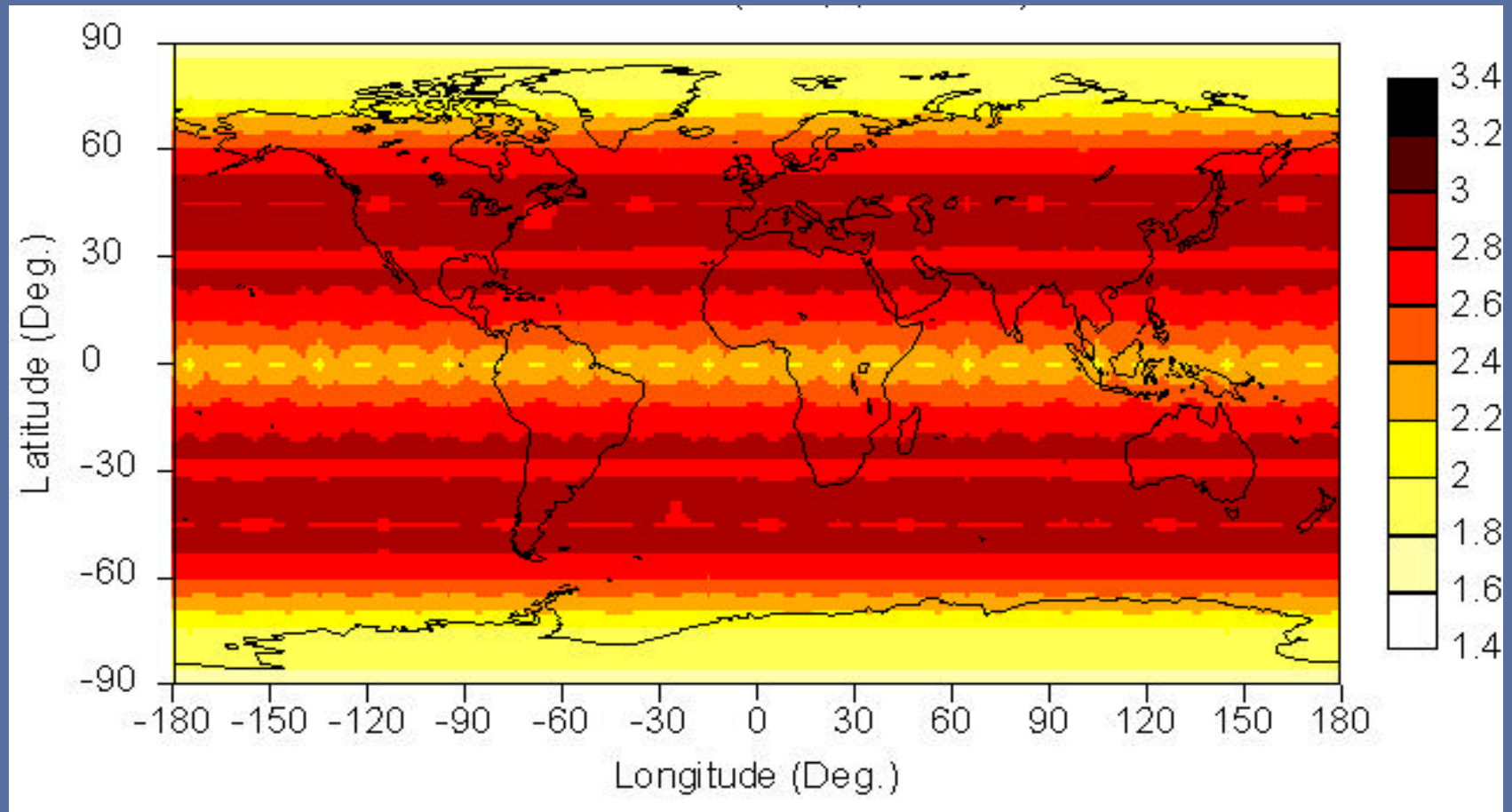
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## GALILEO Horizontal Accuracy



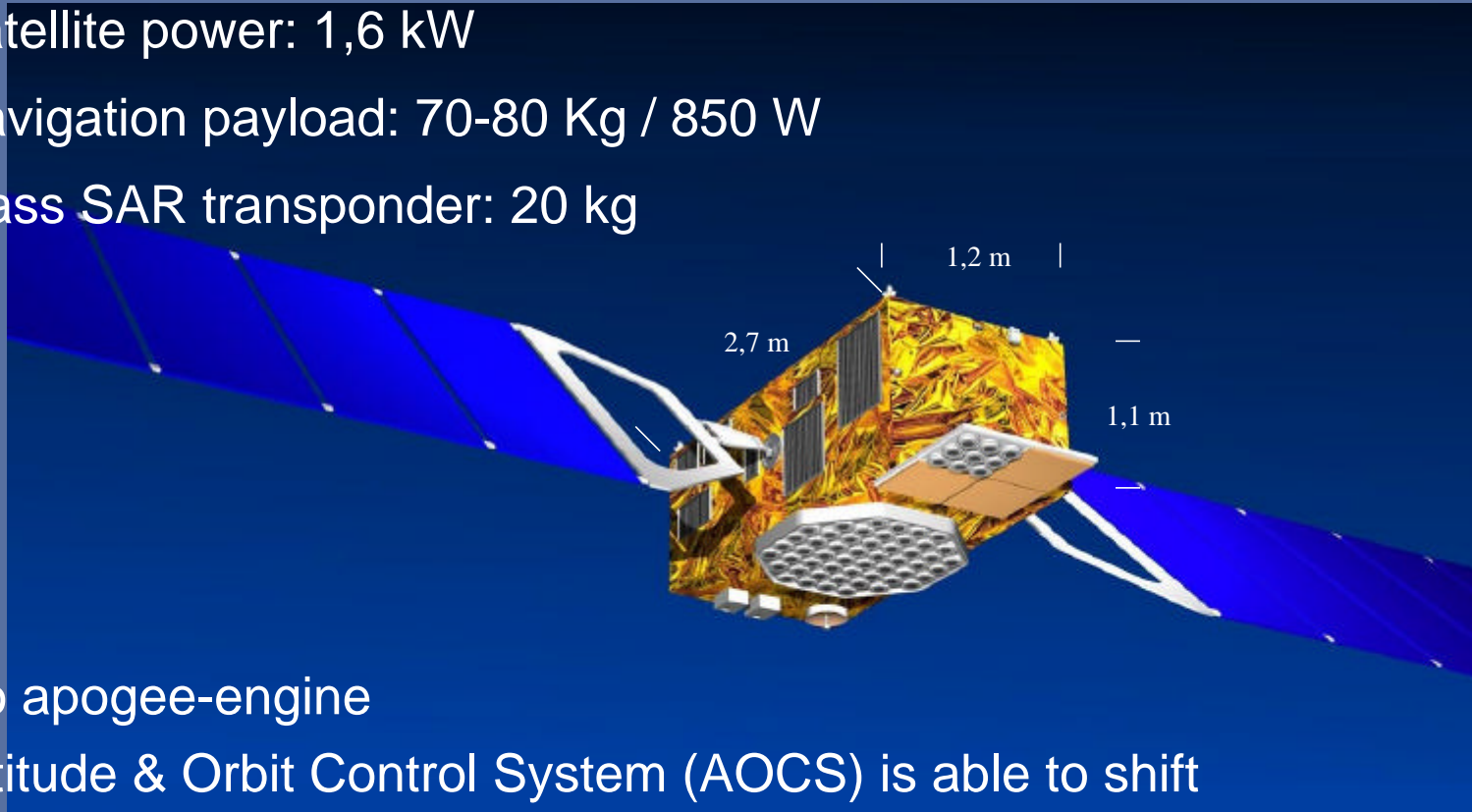


## GALILEO INTERIM SUPPORT STRUCTURE



# The GALILEO Satellite

- Satellite mass: 680 kg
- Satellite power: 1,6 kW
- Navigation payload: 70-80 Kg / 850 W
- Mass SAR transponder: 20 kg



- No apogee-engine
- Attitude & Orbit Control System (AOCS) is able to shift the satellite position within the orbit plane (spare S/C)



# GALILEO INTERIM SUPPORT STRUCTURE

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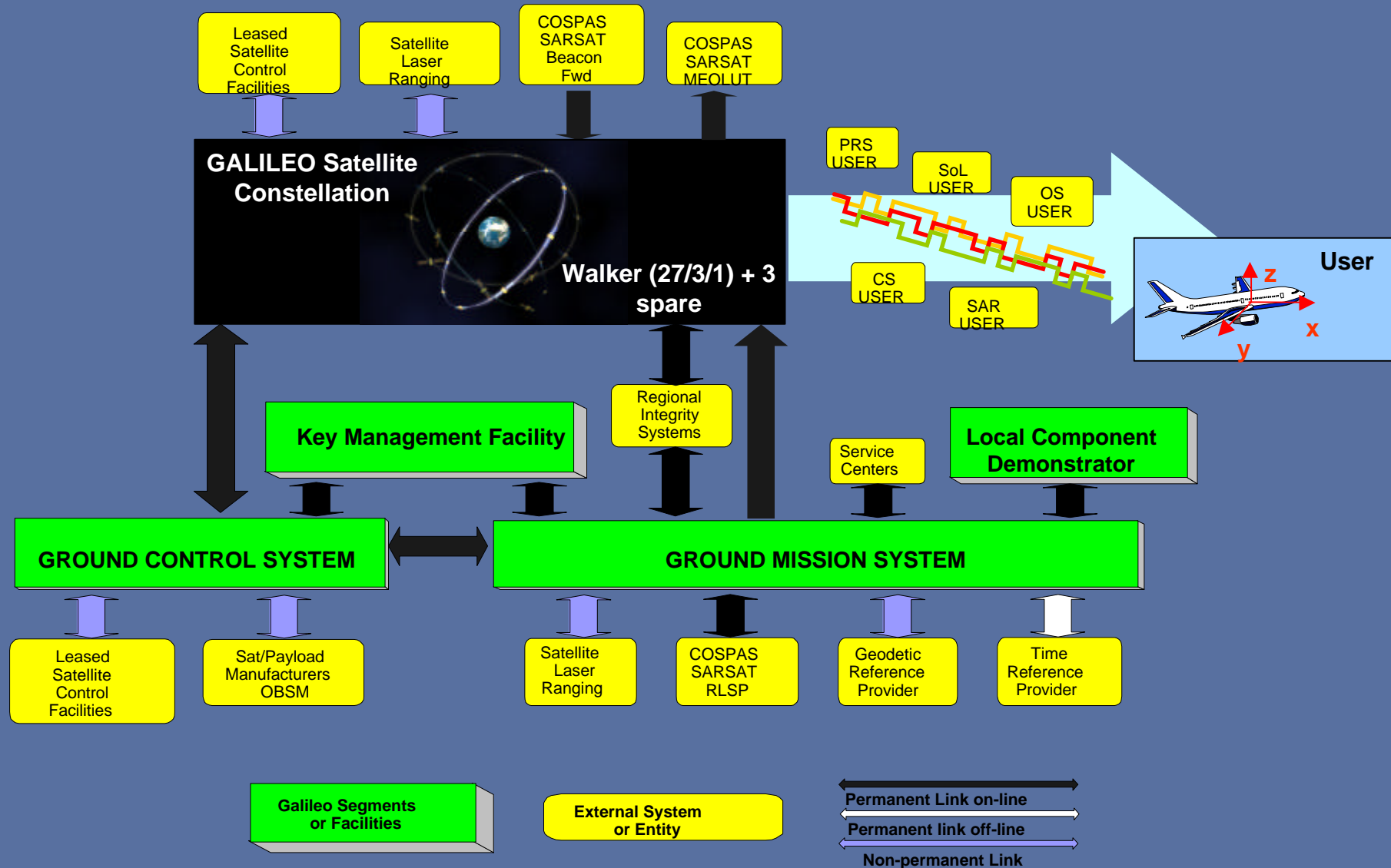
## The Architecture of the GALILEO System - GALILEO Ground Segment



# GALILEO Ground Segment

- 2 redundant GALILEO Control Centers
- 5 S-Band TT&C Stations (One 13m S-Band antenna per station)
- 9 C-Band Mission Up-link Stations (Four 3.2m C-band antennae per station)
  - 26 antennae cover the integrity information of the full constellation, 5 cover the navigation services
- 30 Sensor Stations (each station contains a double receiving chain, one for navigation, one for integrity)

## The GALILEO Architecture







# The GALILEO Ground Segment Locations

- The locations of the GALILEO ground segment elements are chosen with respect to system security
- Depending on the criticality and vulnerability of the element, the locations are selected as follows:
  - Control centers on European mainland
  - TT&C, Uplink Stations and Sensor Stations worldwide on European ground and in countries with bilateral agreements (e.g. ESA Network)
- The protection level of the ground stations will be at least the same as for civil aviation infrastructures



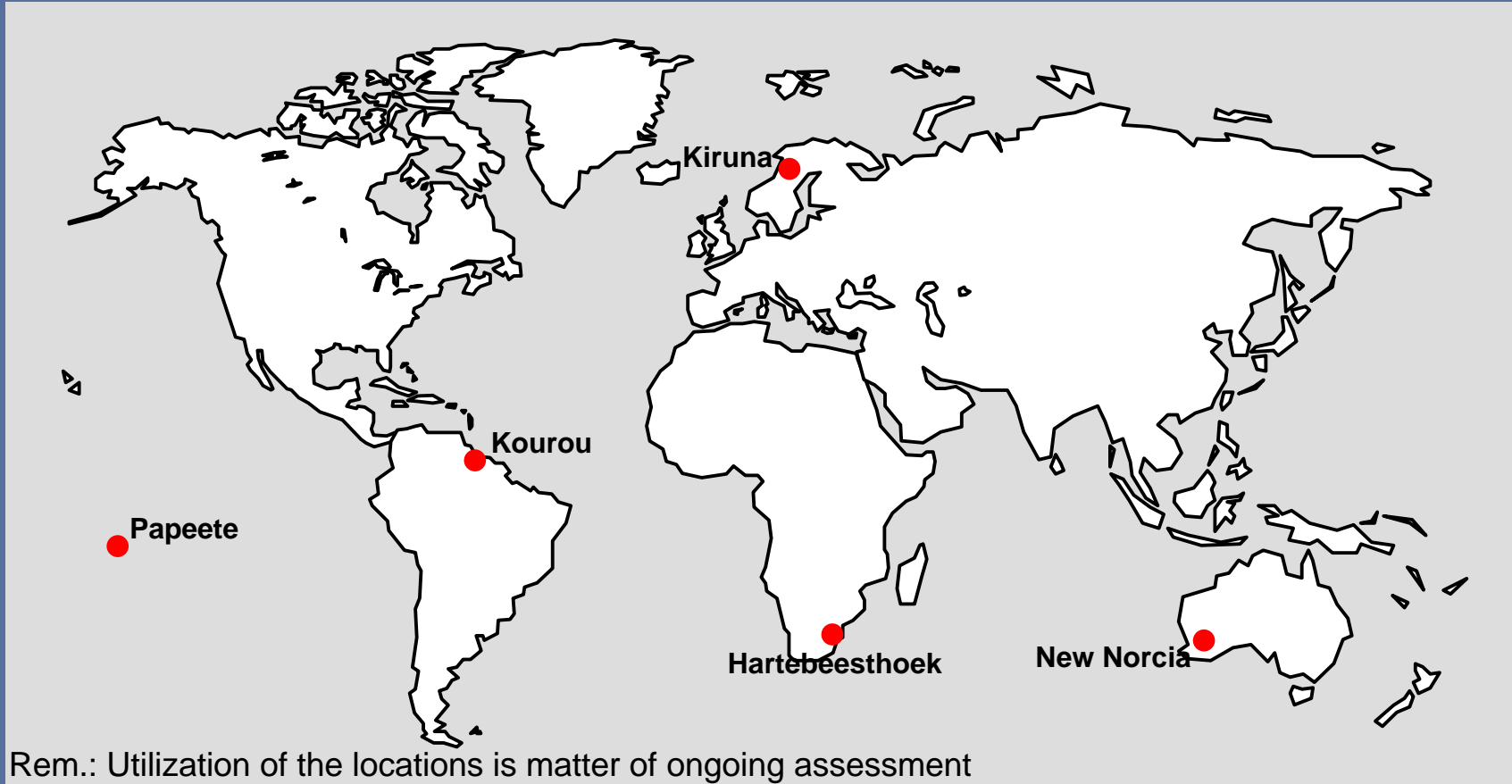
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## Proposed GALILEO TT&C Stations





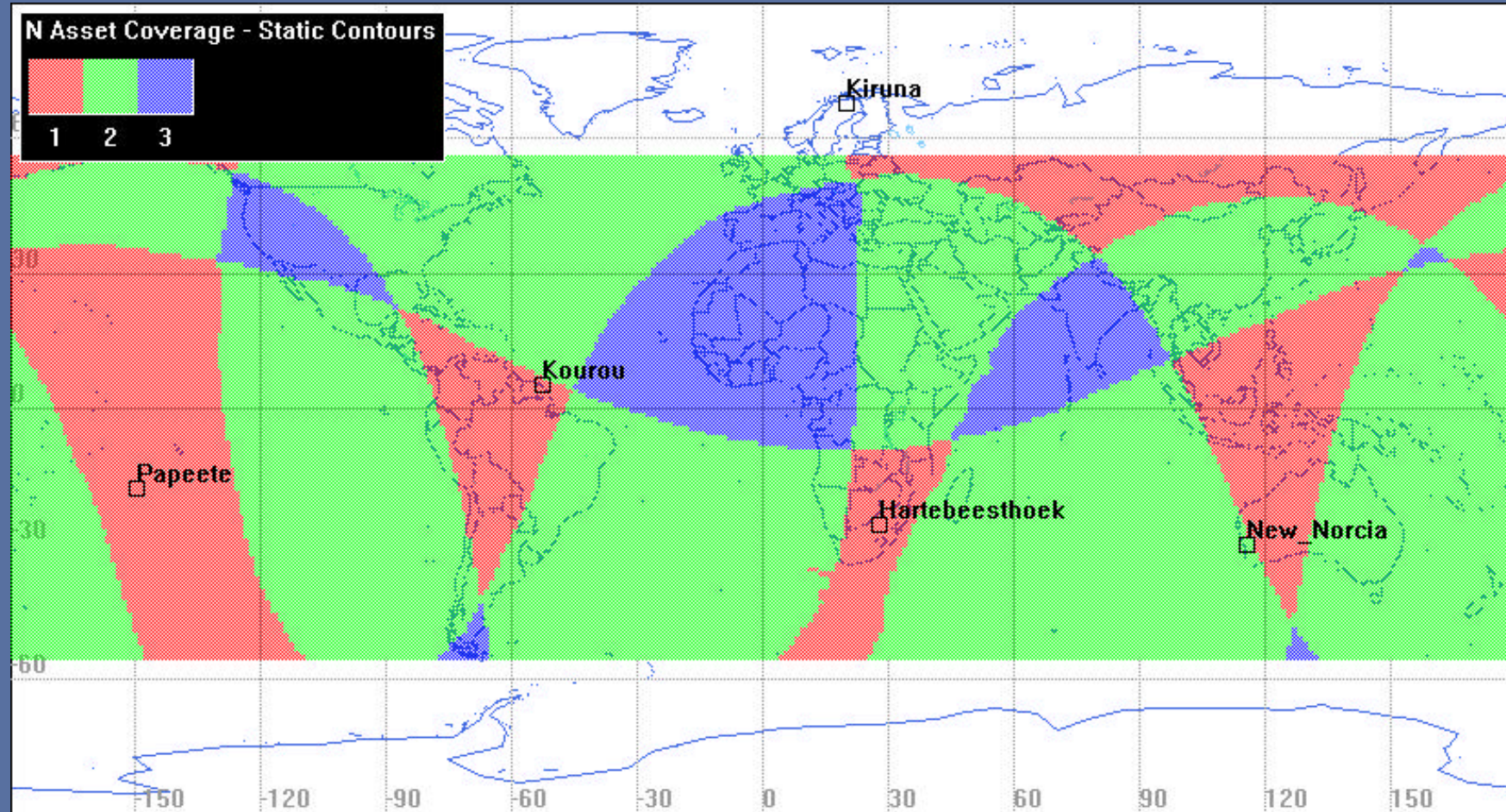
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## Location of GALILEO TT&C Stations





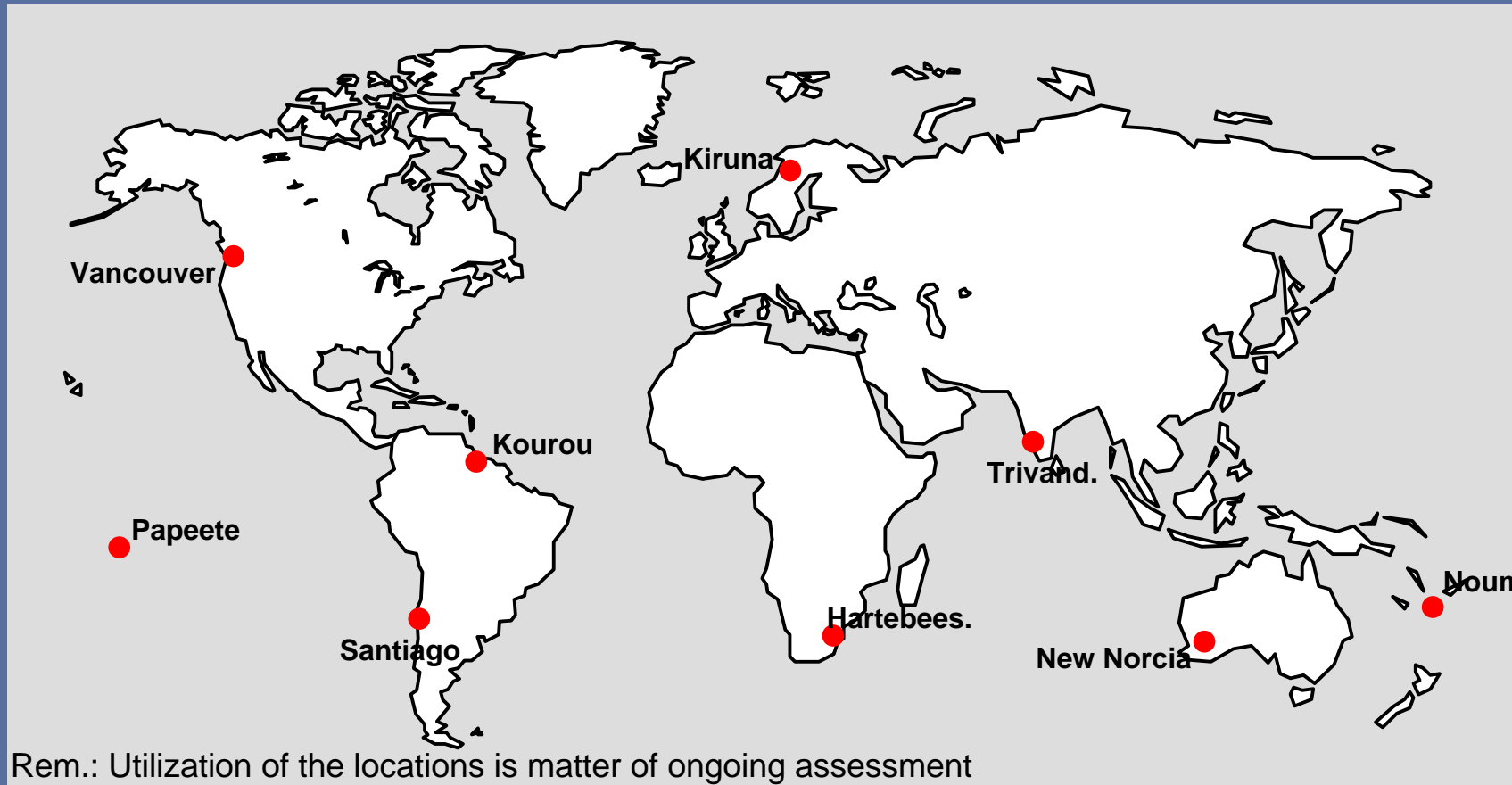
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## Proposed GALILEO Up-Link Stations





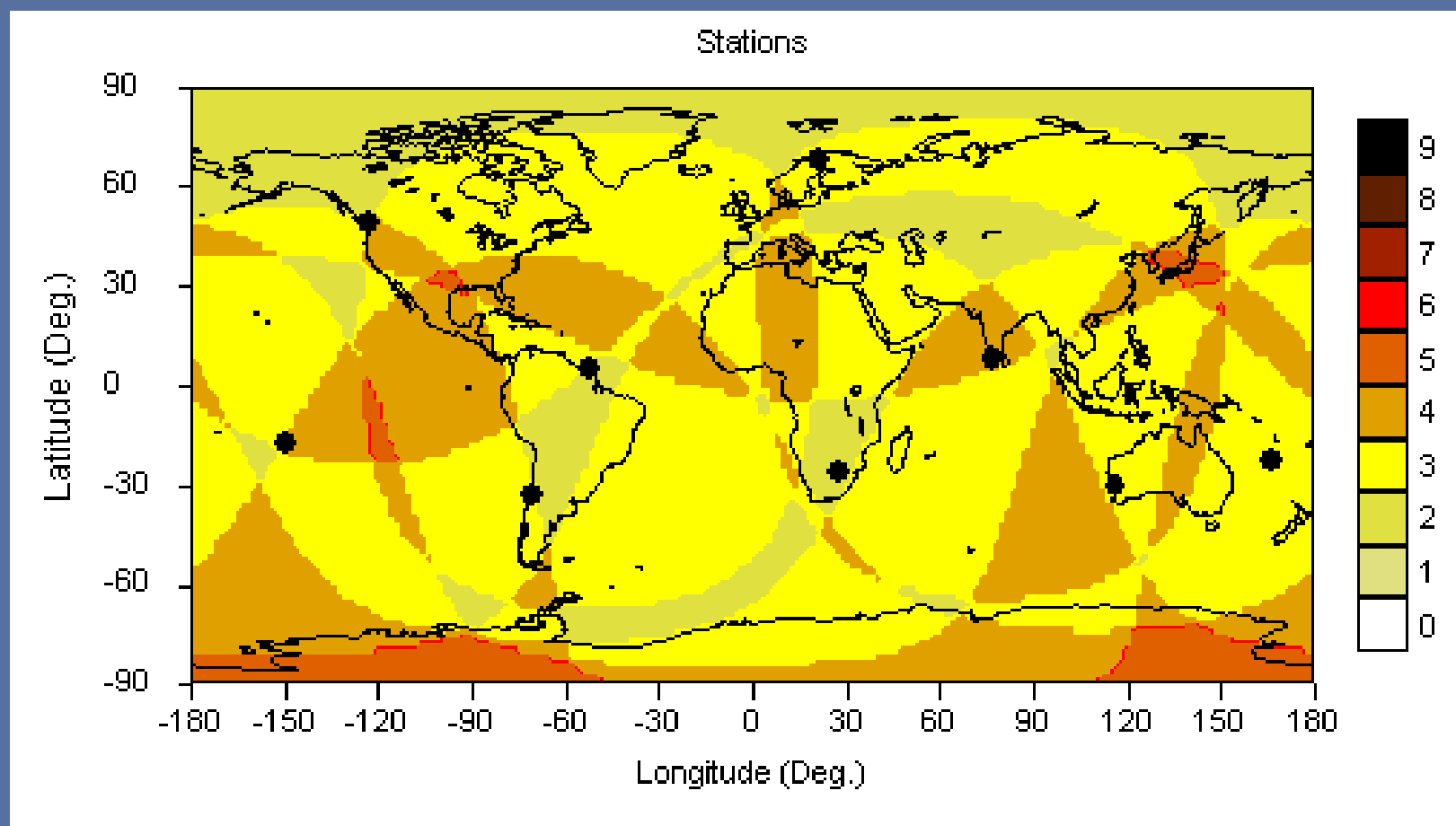
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## Coverage of Up-link Stations





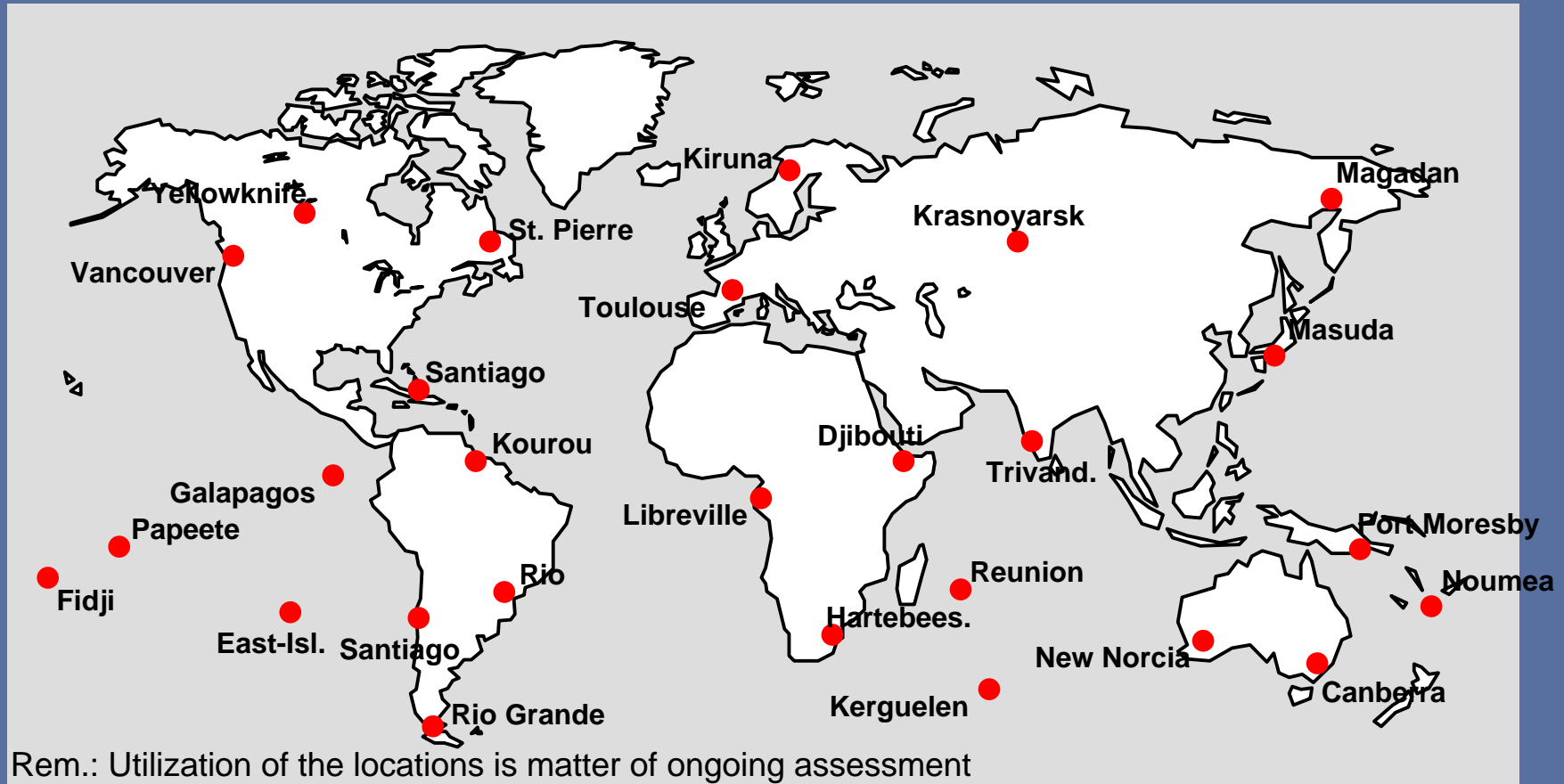
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## Proposed GALILEO Sensor Stations





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## The Security Policy of the GALILEO System



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# The GALILEO Security

- **GALILEO is a strategic program with strong economic implications; the system requires adequate protection**
- **A GALILEO Security Board has been set-up by the European Commission to deal with the security issues of GALILEO**
- **Members of the GALILEO Security Board (GSB) are:**
  - **The security representatives of all 15 EU countries**
  - **One security representative of the European Commission**
  - **One security expert of the European Space Agency as observer**
  - **One representative of those Countries, which are member of ESA, but which are not members of the EU, as observer**
- **The members of the GSB are high level security officers from the governmental organizations**





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## The GALILEO Master Schedule



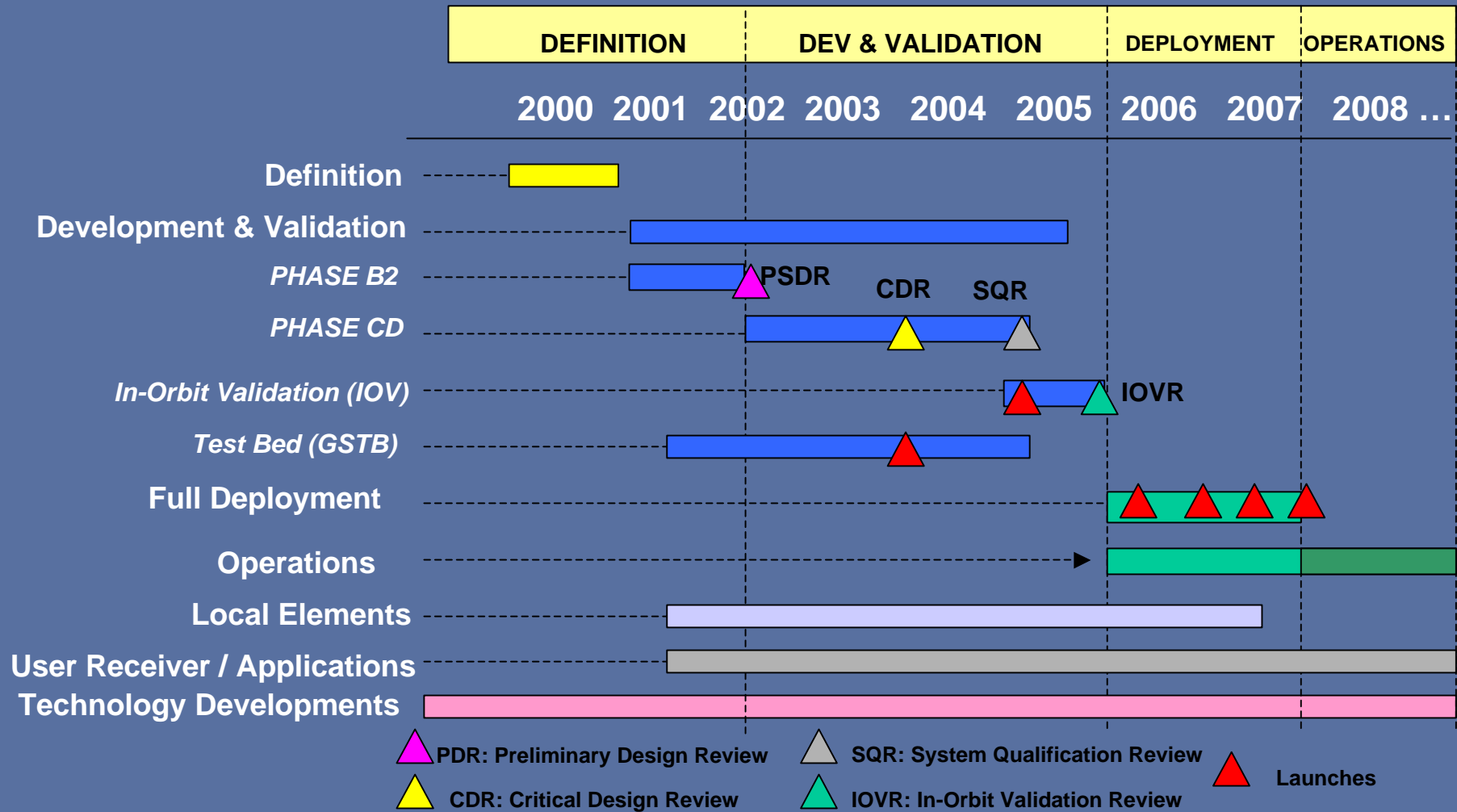
# GALILEO INTERIM SUPPORT STRUCTURE



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## The GALILEO Master Schedule





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## Information and Communication



## GALILEO INTERIM SUPPORT STRUCTURE

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# The GALILEO Communication



### Web:

[http://europa.eu.int/comm/dgs/energy\\_transport/galileo](http://europa.eu.int/comm/dgs/energy_transport/galileo)

<http://www.esa.int/navigation>

### E-Mail:

Contact: [tren-galileo@cec.eu.int](mailto:tren-galileo@cec.eu.int)