

Directorate-General
for Energy
and Transport

European GNSS Programmes Galileo and EGNOS

3rd Meeting of the International Committee on GNSS
Pasadena, California, USA
December 8 -12, 2008

Paul Verhoef
European Commission



EUROPEAN
COMMISSION



Outline

- Galileo and EGNOS Description
- Galileo and EGNOS Services
- Compatibility and Interoperability

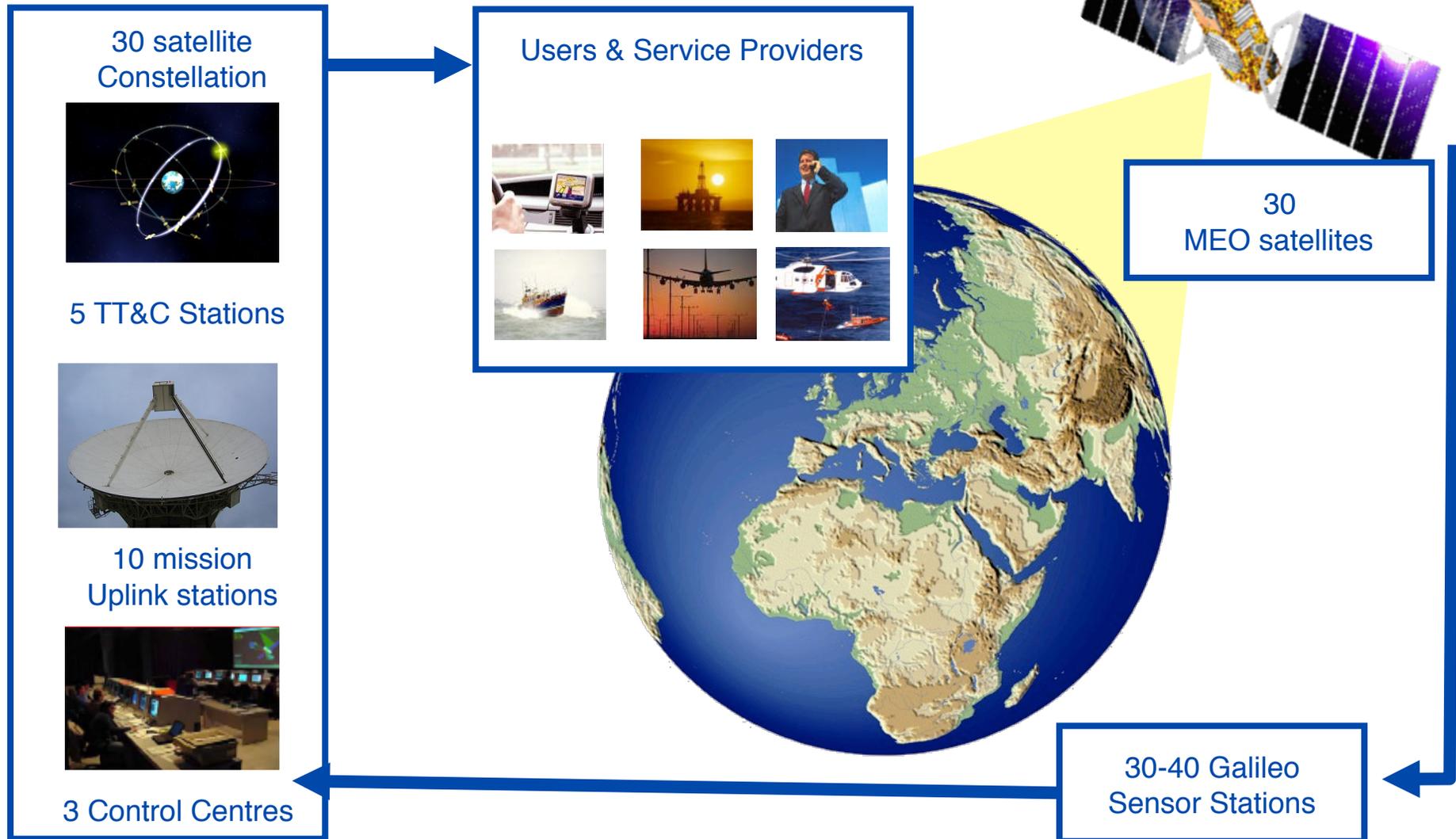




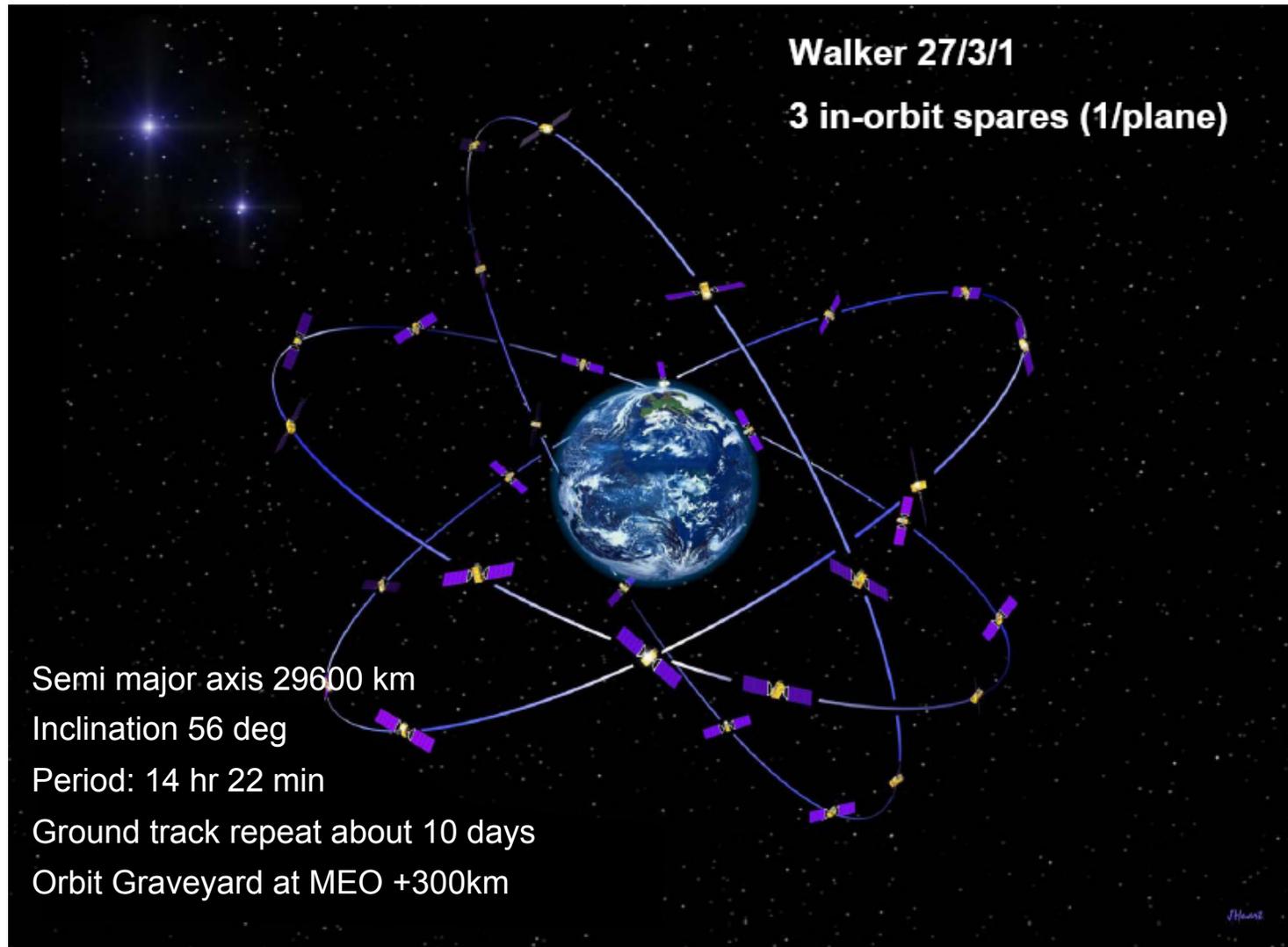
Galileo Description



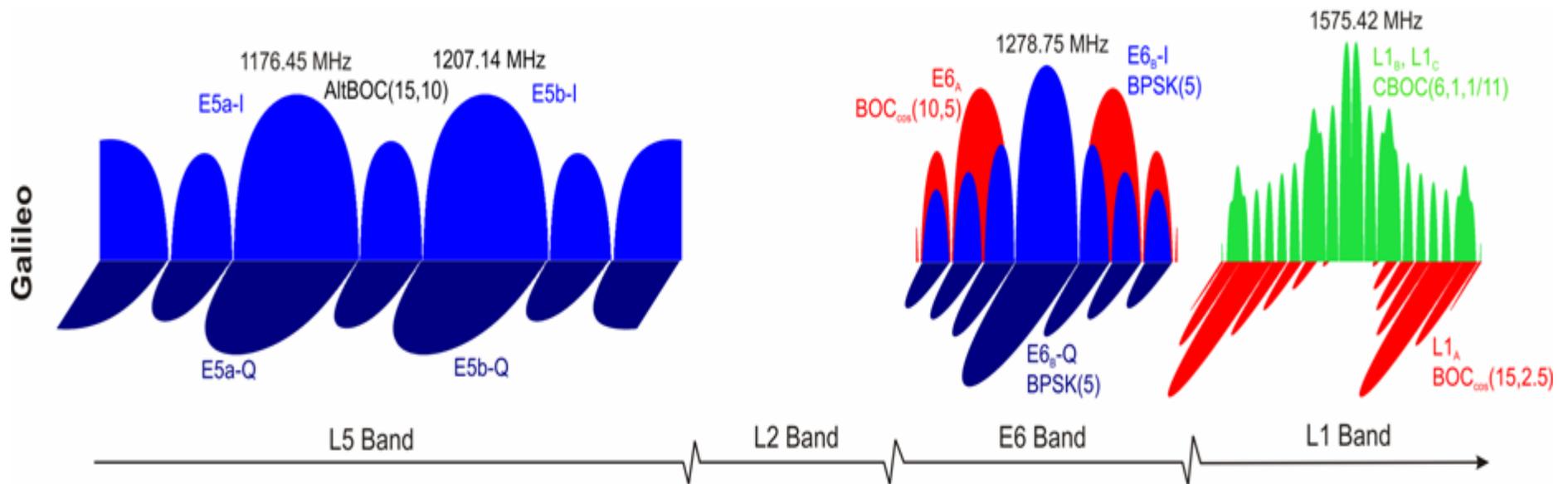
Galileo – An Infrastructure



Galileo – Space Segment



Galileo: Current Signals



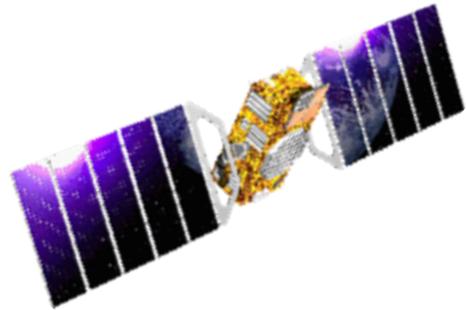
Galileo : System Time and Geodetic Reference Frame Standards

- Galileo System Time:
 - » Steered to TAI (International Atomic Time)
 - » The difference between GST and TAI and between Universal Time Coordinated (UTC) and TAI broadcasted to the users via the SIS
 - » GPS-Galileo Time Offset broadcasted
- Galileo Terrestrial Reference System (GTRS)
 - » Realisation (GTRF) within < 3 cm (2 sigma) wrt. ITRF (International Terrestrial Reference Frame)

Galileo : Performance Standards

Galileo Service	Horizontal Accuracy (95%) (incl. system margins)	Vertical Acc. (95%) (incl. system margins)	Availability (WUL)	Integrity
Open Service	4 m	8 m	> 99.5%	NO
Safety of Life	4 m	8 m	> 99.5%	YES – LPV200
Commercial Service	Detailed performance requirements under elaboration			
Public Regulated Service	4 m	8 m	> 99.5%	YES

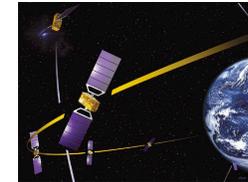
Galileo Implementation Plan



Full Operational Capability
27 (+3) Galileo Satellites
2013



In-Orbit Validation
4 satellites plus
ground segment
2010



Galileo System Testbed v2
Initial Test Satellites

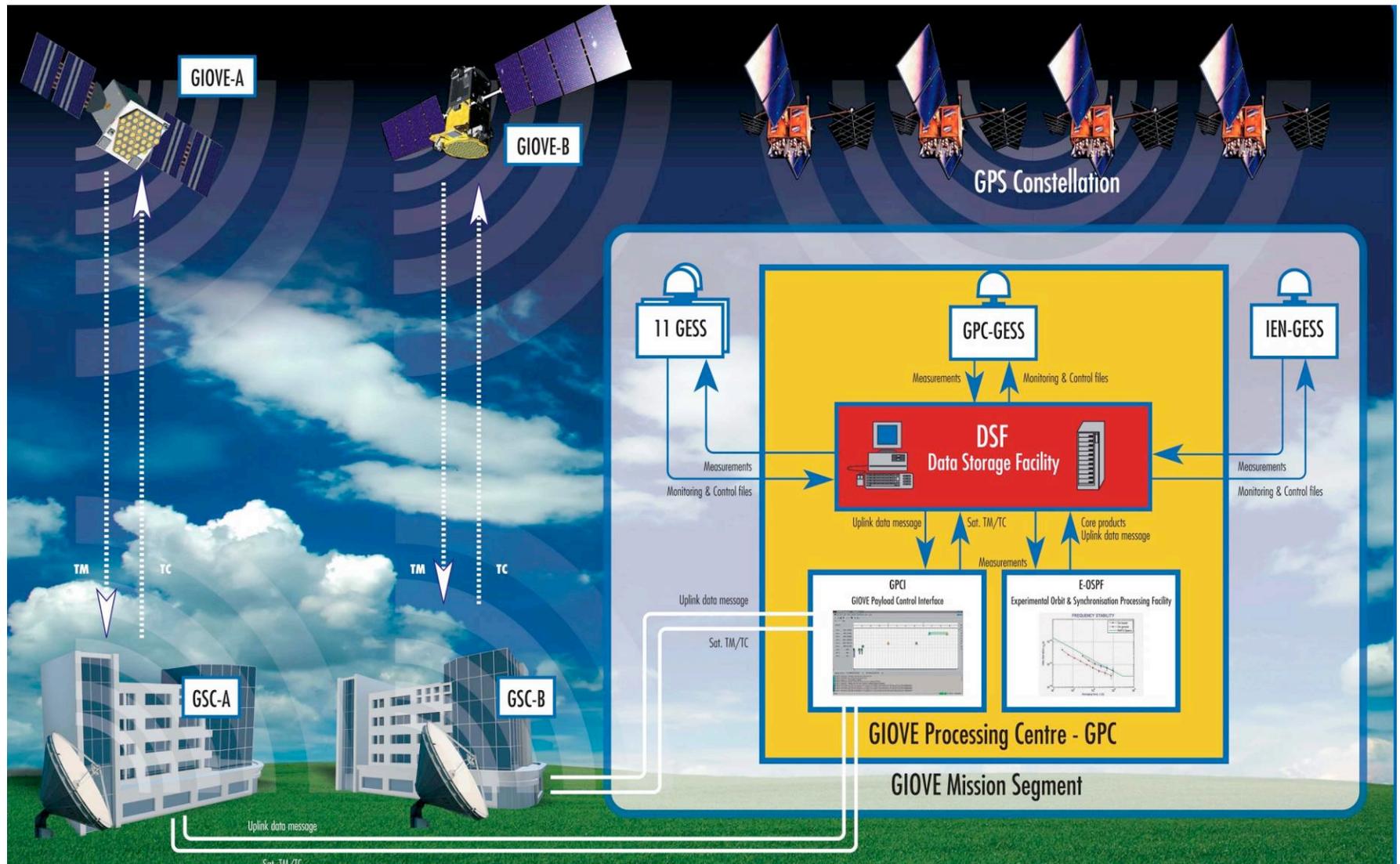
2005



Galileo System Testbed v1
Validate critical algorithms
2003



GIOVE Mission Architecture

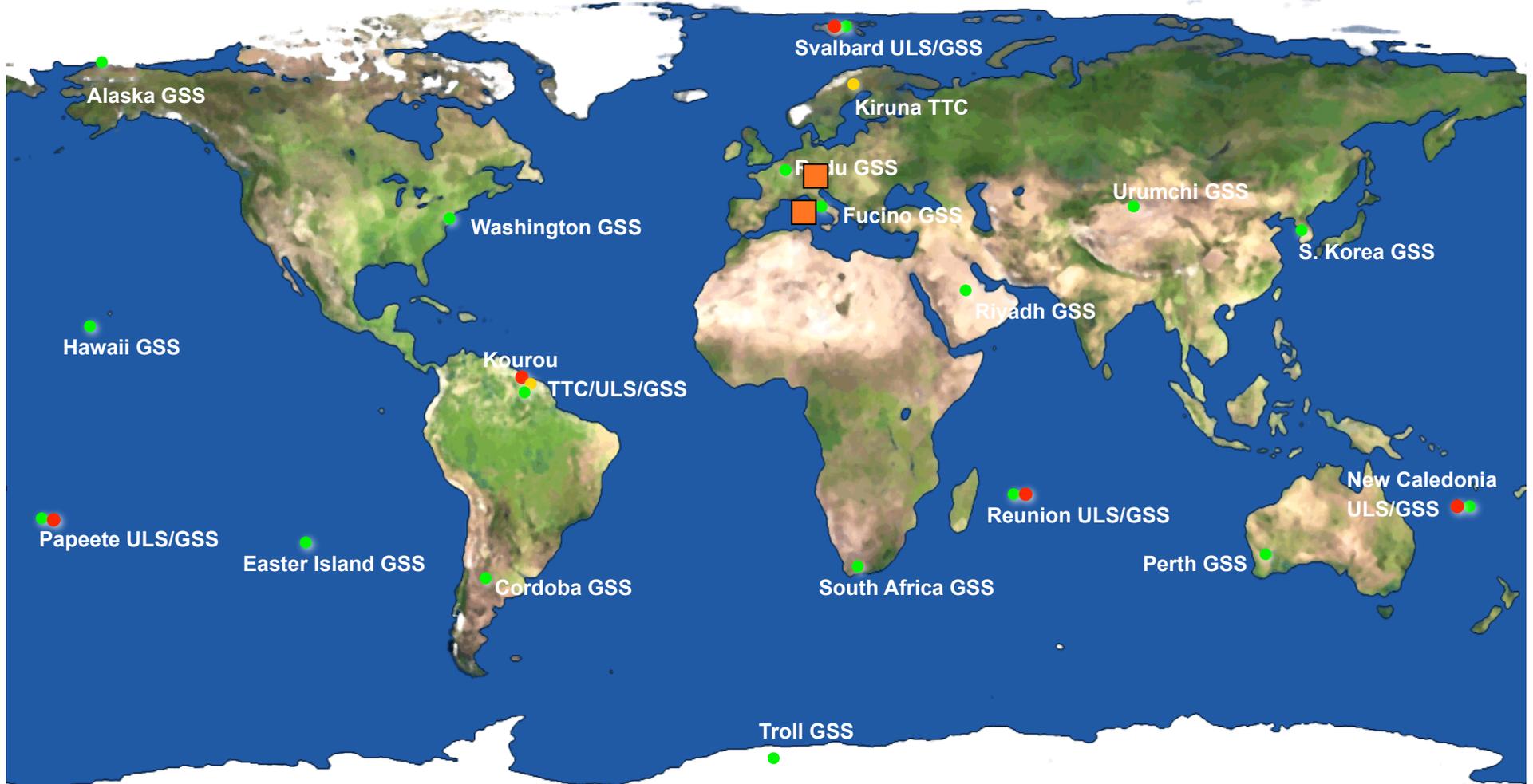


Galileo Test Satellites

- **Giove-A** still operating since Jan. 2006
- **Giove-B** launched on 27 April 2008
 - » Works as expected
 - » First maser atomic clock ever flown
 - » MBOC (CBOC) signal première



Ground Segment Sites (IOV status)



- Sensor Stations
- Up-Link stations
- TT&C stations
- Control Centres



Galileo – IOV vs FOC

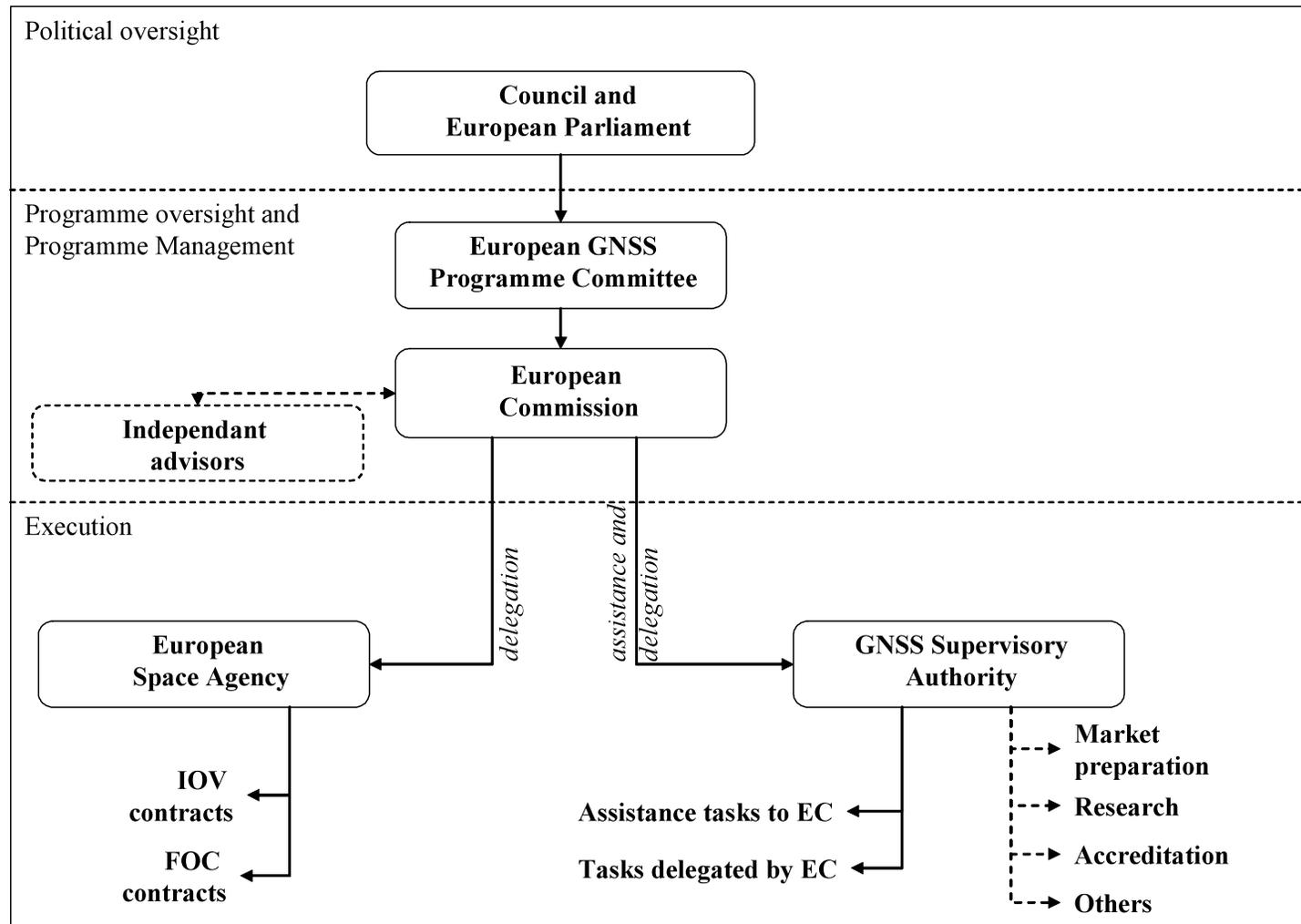
	Component	IOV Phase	FOC Phase
	Satellites	4	27(+3)
	Control Centres	1	2
	Mission Uplinks	5	10
	TT&C	2	5
	Sensor Stations	20	30-40



GALILEO Re-Structuring in 2007

- PPP: private sector limitations
 - Was not ready to bear market and technical risks at early stage (IOV)
 - No (or expensive) money
- Implementation funding secured: 3.4 billion € (some 4.7 billion \$)
- European Commission
 - Fully in charge
 - Owner

Updated Governance



GALILEO FOC Procurement

- Contract notice: 1 July 2008
- EC procurement rules (subject to WTO agreements on government procurement)
- Infrastructure in 6 work-packages
- Enter the « Competitive Dialogue » phase
- Full Operational Capability in 2013



FOC Procurement: Selected Candidates

- 1. System Support
 - » ThalesAleniaSpace (IT)
 - » Logica (NL)
- 2. Ground Mission System
 - » ThalesAleniaSpace (FR)
 - » Logica (UK)
- 3. Ground Control System
 - » Astrium (UK)
 - » G-Nav grouping represented by Lockheed Martin IS&S (UK)
- 4. Space segment
 - » Astrium (DE)
 - » OHB System DE
- 5. Launch Services
 - » Arianespace (FR)
- 6. Operations
 - » Nav-up grouping represented by Inmarsat (UK)
 - » DLR (DE) and Telespazio (IT)



Fucino (Italia) Control Centre



Building A:
Administrative Area

Building B:
Operational Area



Kiruna Galileo Site Completed (Nov'07)



Svalbard Galileo Site Completed (May'08)



Oberpfaffenhofen (Germany) Control Centre



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CSG- Kourou Galileo TTC/ULS/GSS



TTCF Building construction (Jul'08)



Site Technical Building finished (Jul'08)

Troll GSS Site Completed (Apr'08) and ready for Site Acceptance (Feb'09)



Galileo Troll Site
at Site Survey (Feb'08)



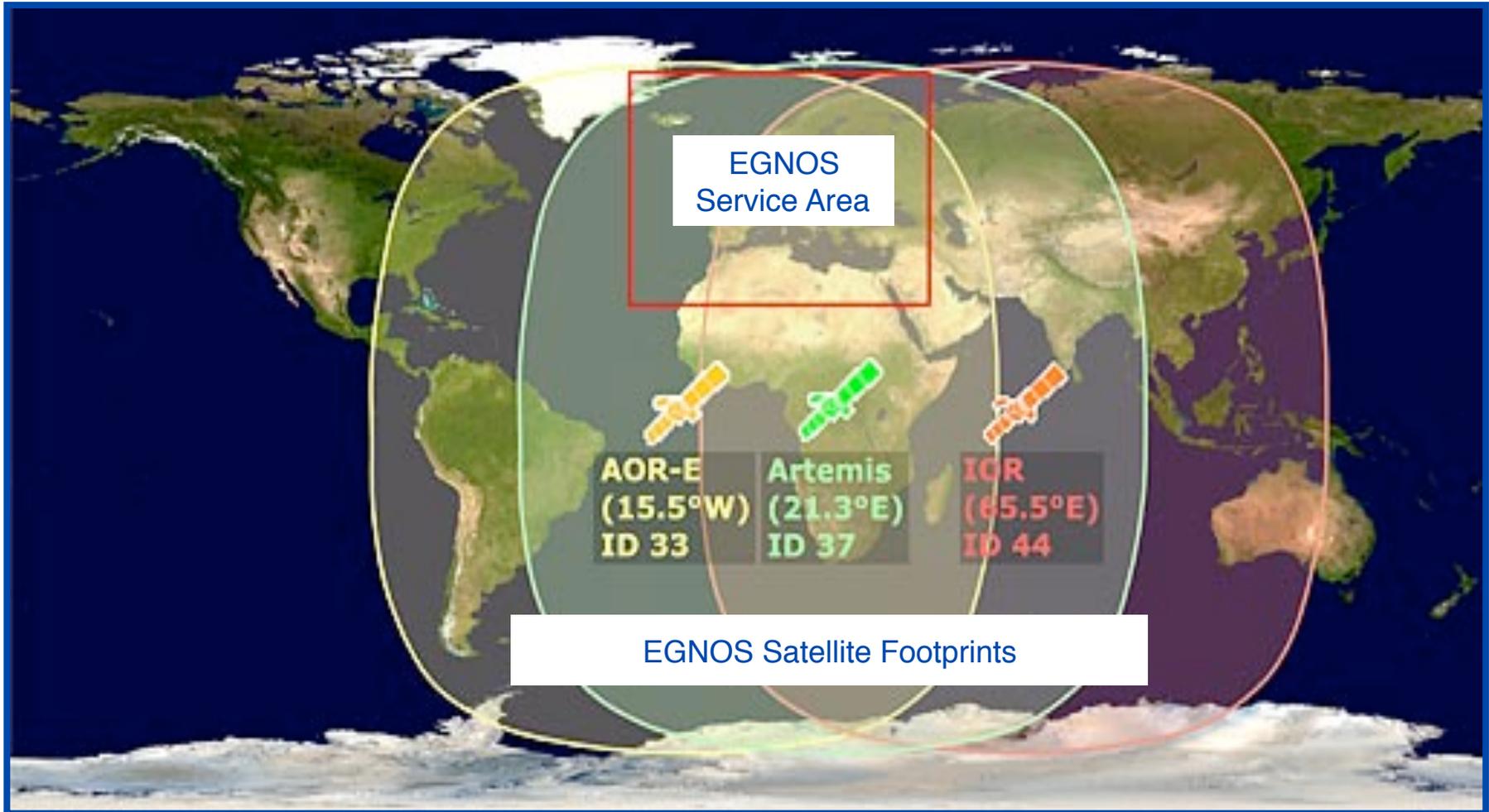
GSS Troll
Artic Building finished (Mar'08)



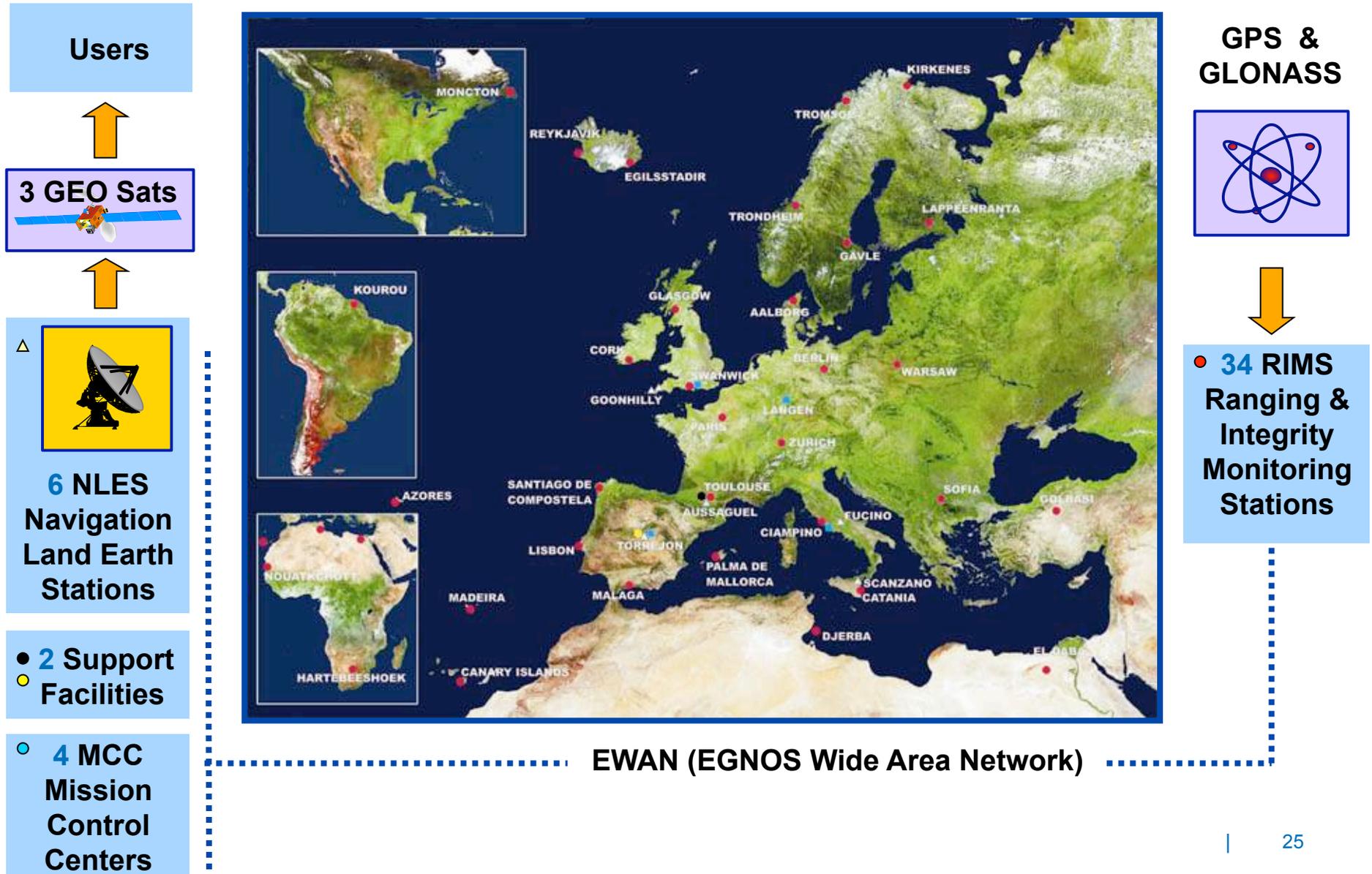
EGNOS Description



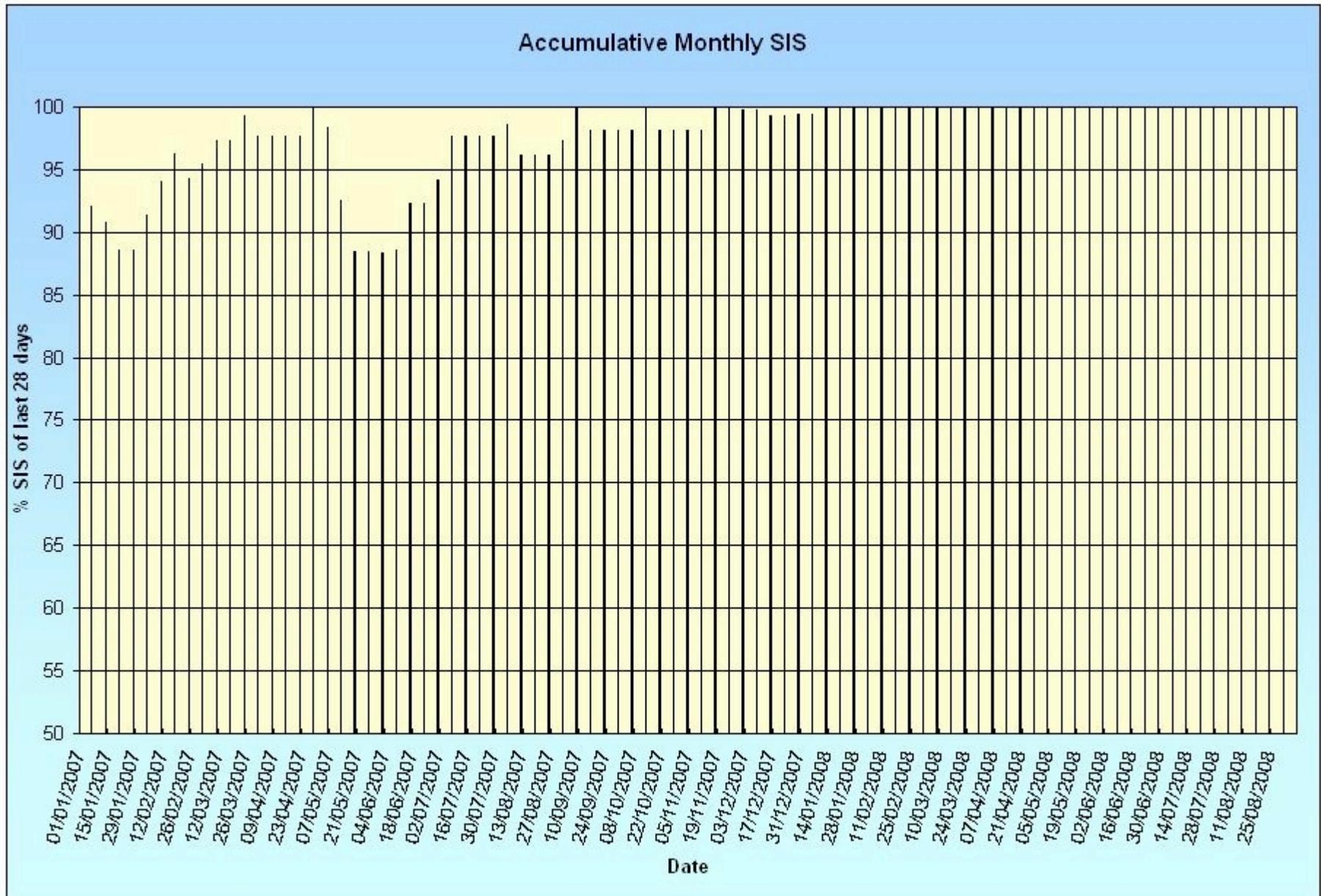
EGNOS Becoming Operational



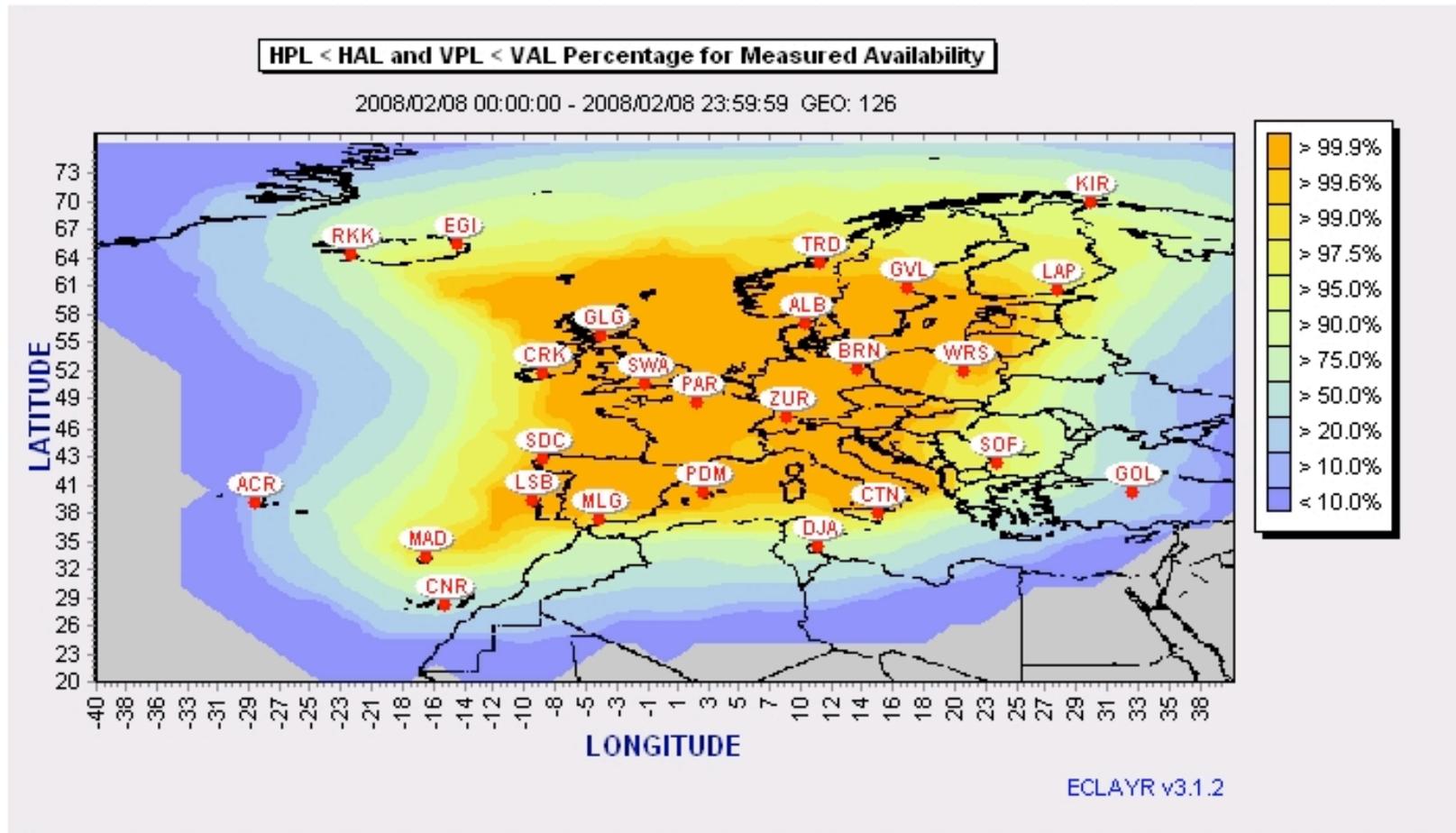
EGNOS System Architecture



EGNOS Performance 01/2007-08/2008



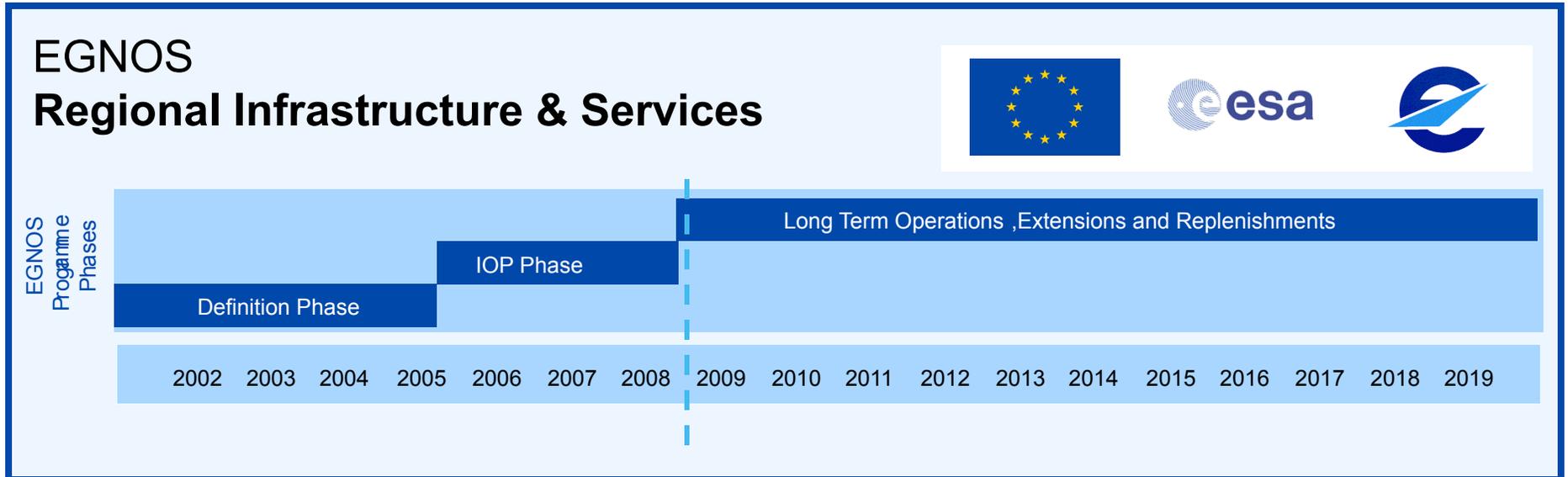
EGNOS Performance (Feb. 2008)



The deployment of 7 additional RIMS in Southern Europe and Northern Africa, and 1 additional in Northern Europe will increase the coverage area.



EGNOS Timeline



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EGNOS : 2008 Programme Status

- Assets transfer from the European Space Agency to the European Community
- EC will contract an operator
- Although already broadcasting excellent signals quality, enters formally into operations Spring 2009
- Certification by end 2009
- Service geographical service extension under study
- EC is finalising the procurement and lease of an EGNOS transponder to replace Artemis as of 2011





Galileo and EGNOS Services



Galileo – 5 Services

Open Access	Free to air; Mass market; Simple positioning	
Commercial	Encrypted; High accuracy; Guaranteed service	
Safety of Life	Open Service + Integrity and Authentication of signal	
Public Regulated	Encrypted; Integrity; Continuous availability	
Search and Rescue	Near real-time; Precise; Return link feasible	

Description of Galileo Services

Service			Receiver	Benefits	Target user groups	Availability
Open Service	OS		Single frequency	<ul style="list-style-type: none"> • Additional satellites for better multi-system coverage (e.g., deep urban) • Coding and modulation advances for increased sensitivity and multi-path mitigation • Pilot signal for fast acquisition 	• Low end mass market (e.g., LBS, outdoor)	Open
			Double frequency	<ul style="list-style-type: none"> • As above + increased accuracy with 2nd frequency 	• High end mass market (e.g., car navigation, maritime)	Open
Commercial Service	CS		Double frequency	<ul style="list-style-type: none"> • Increased accuracy using additional frequencies and signals • Additional features under investigation (e.g., data rate capacity) 	• Professional markets (e.g., surveying, precision agriculture)	Commercial basis
Safety of Life Service	SoL		Single frequency (Level B)	<ul style="list-style-type: none"> • As OS + • Integrity and authentication of signal • Continuity and service guaranty 	• Aviation (en route)	Certified receivers
			Double frequency (Level A and C)	<ul style="list-style-type: none"> • As above at higher performance levels suitable for stringent dynamic conditions 	<ul style="list-style-type: none"> • Aviation (A) • Maritime (C) • Road, Train (A) 	Certified receivers
Public Regulated Service	PRS		Dual frequency	<ul style="list-style-type: none"> • As OS + • High Continuity (in times of crisis) • Improved Robustness (vs jamming, spoofing) 	<ul style="list-style-type: none"> • Law enforcement • Strategic infrastructure 	Regulated
Search and rescue	SAR		Single frequency	<ul style="list-style-type: none"> • Almost instantaneous reception of emergency calls • Exact positioning of emergency beacon 	• Emergencies	Certified & registered beacons



EGNOS Services

	Open Service	Safety Of Life
Transmission means	RF signal (L1 frequency)	RF signal (L1 frequency)
Reference	EGNOS MRD	EGNOS MRD
Guarantee of Service	None	Guarantee of compliance to ICAO standards (certification)
Definition of the Service	SIS only (free-to-air)	SIS + Guarantee of compliance to ICAO standards (certification)
Typical user communities	Pedestrian, in-car navigation	Aviation, Maritime, railway, road (tolling), emergency services

Added-Value Data
Ground network
EGNOS MRD
Guarantee of compliance to SLA
EGNOS data + Guarantee of compliance to SLA
Pedestrian, in-car navigation, research (e.g. atmospheric, tectonics), high-precision GNSS

EGNOS Service Evolutions Under Study

- Coverage Evolution
 - » Enlargement (Eastern Europe, MEDA)
 - » Extensions (Africa, Middle East)
 - » Regional extension module
- Potential Standard Evolution
 - » New frequencies
- Potential Infrastructure Evolution
 - » Augmentation of new GNSS
- Additional services
 - » EGNOS Time Service
 - » Critical Communication message (ALIVE concept)



Compatibility and Interoperability



ICG Providers Forum

- Galileo complies with ICG Providers Forum's definitions of Compatibility and Interoperability of Sep. 2007, Bangalore
 - » Bi-lateral and multi-lateral coordination meetings

EU Objectives in Bi-lateral and Multi-lateral Coordination with other GNSS (1/2)

- Ensure compatibility at a minimum: ability of space-based PNT services to be used separately or together without interfering with each individual service or signal, and without adversely affecting national security
 - Radio frequency compatibility (ITU provides a framework)
 - Spectral separation between PRS and other signals

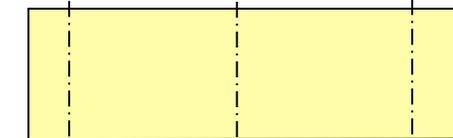
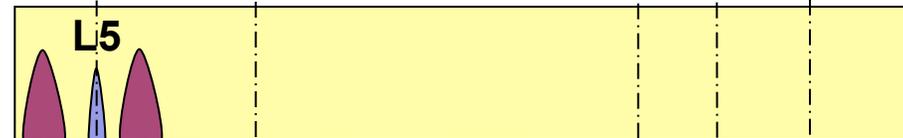
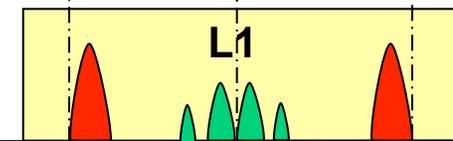
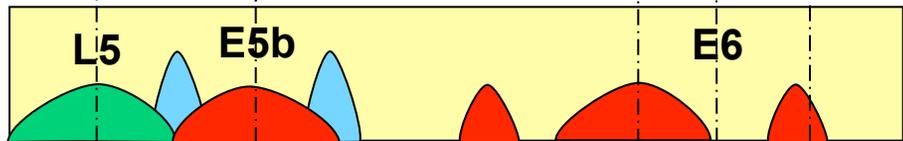
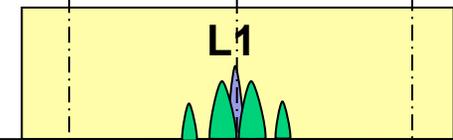
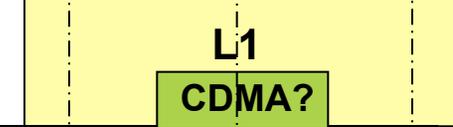
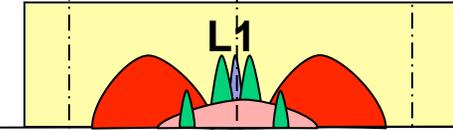
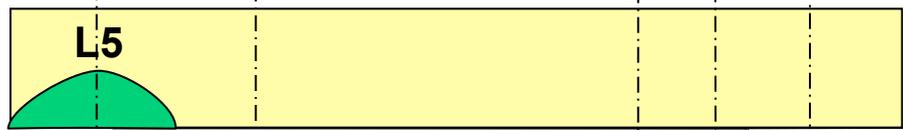
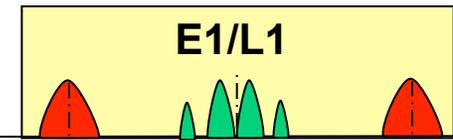
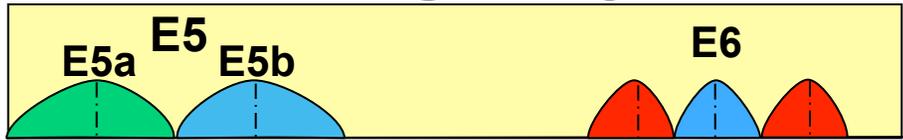
EU Objectives in Bi-lateral and Multi-lateral Coordination with other GNSS (2/2)

- Achieve interoperability between Galileo open signals (OS, SoL and CS) and other space-based PNT signals when desired for the benefits of users
 - » Focus on E1 CBOC, AltBOC E5b (+ E5a & E5b) and E6 BPSK(5) CS signals

Outstanding Issues on Interoperability

- Definition of interoperability?
 - » **Technical:** same center frequency, same modulation, commonly agreed maximum power level, geodetic reference frames realization and system time reference
 - » **Non-technical:** transparency and availability of open information on signals (e.g. SIS ICD), availability of open information on performance standards and actual performance
- ICG should work on the definition of consolidated “boundary conditions” to achieve interoperability

Planned GNSS Signals as of ICG Expert's Meeting, July 2008

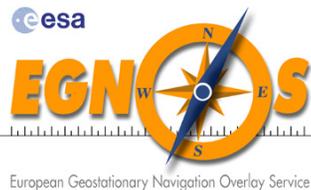


Conclusions



EGNOS is in its Operational Validation Phase

- Initial Commercial Services starting in 2007
- Open Service in 2008
- Safety of Life Service in 2009



Galileo is in its Development Phase

- Major EU initiative
- GIOVE-A, GIOVE-B missions on-going
- Initial 4 satellites around 2010
- Full Operational Capability around 2013



International Coordination is an important feature:

- Ensure compatibility at a minimum and achieve interoperability when desired

