GALILEO
Enlarging Satellite Navigation

Tokyo
18 November 2004

Pascal CAMPAGNE
FDC - OREGIN

Presentation content

Galileo Overview

- Galileo Infrastructure
- Services and Performances
- Applications
- Market

Galileo programme status

- Programme phases
- Planning
- Concession process

International Dimension

- Partners and contacts
- Early Opportunities

European Industry

- OREGIN
- Galileo Services

GALILEO OVERVIEW

a User Driven Approach

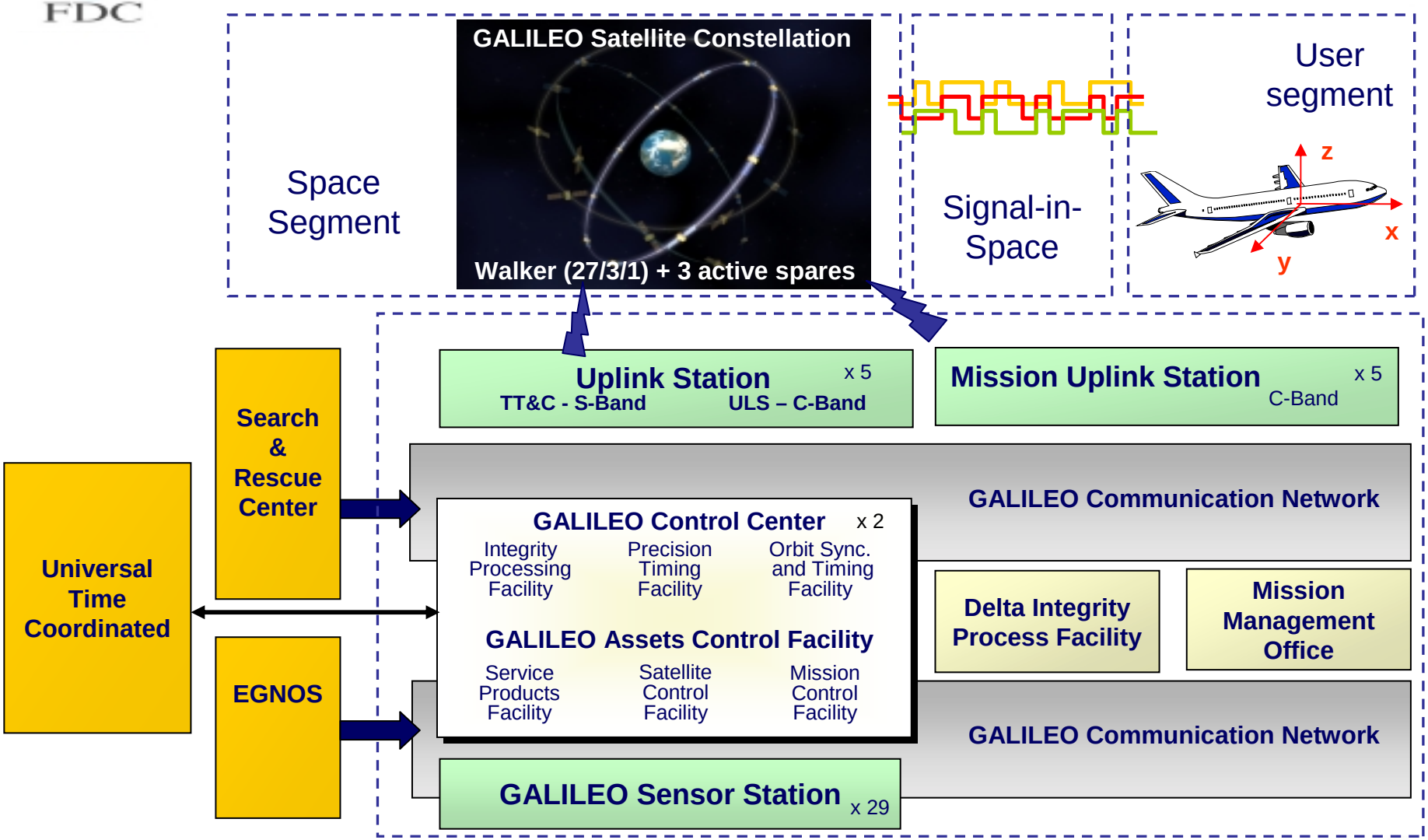
The European Approach

- Galileo
  - Global Navigation Satellite System
  - Under Civil Control
  - Independent but compatible and interoperable with GPS and GLONASS, and most probably with QZSS
  - With service guarantees
  - Initial service provision by 2008
  - Open for cooperation

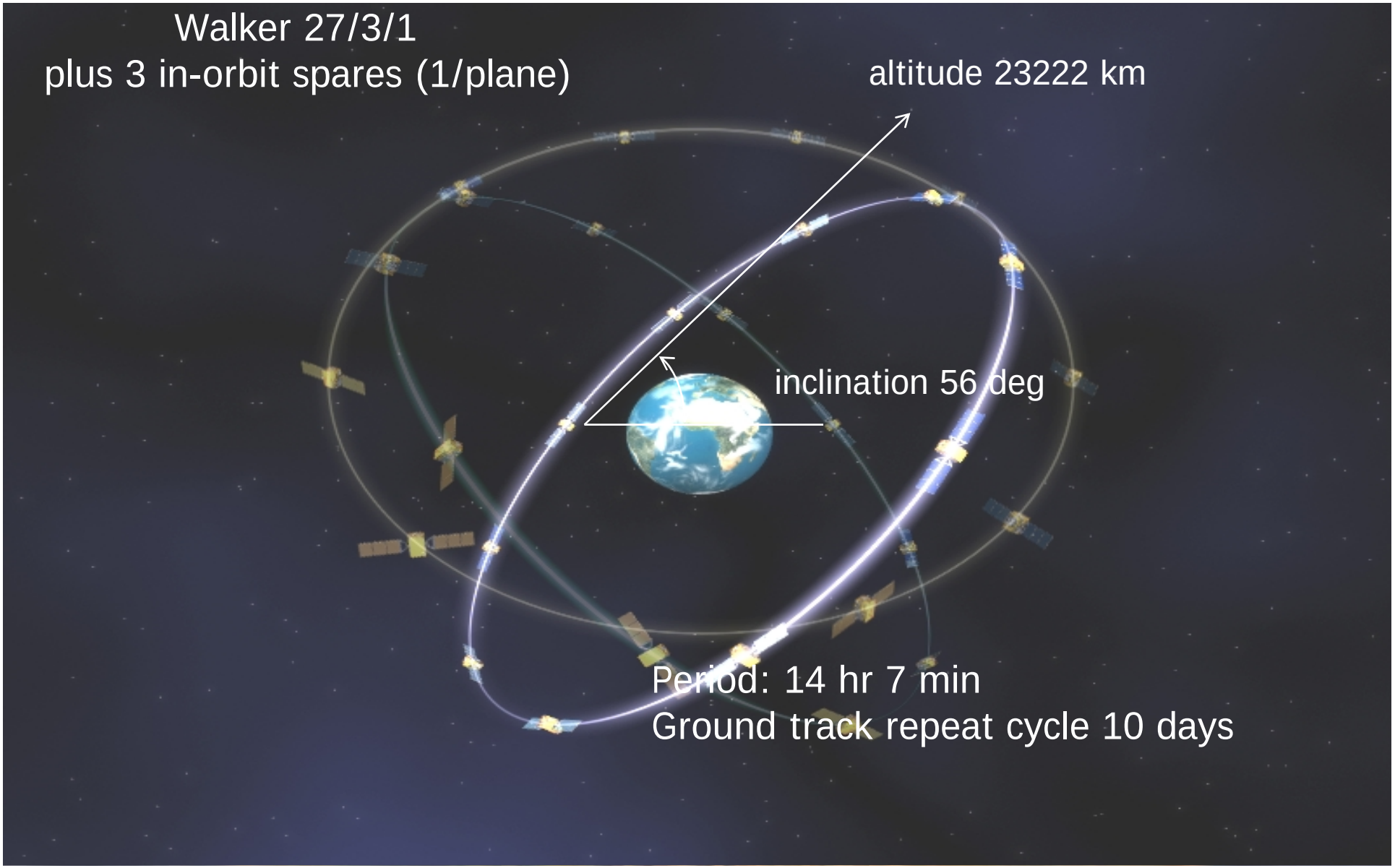
Galileo Programme Key Features

- Market driven, commercially oriented
- Global Positioning, Timing and Search and Rescue services
- Worldwide coverage (including Northern & Southern latitudes)
- Built-in Global System Integrity
- Provision for additional Regional Integrity Components
- Satellite-only services Services
  - OS: Open Service
  - CS: Commercial Service
  - SoL: Safety of life
  - PRS: Public Regulated Service
  - SAR: Search and Rescue
    (extension of COSPAS-SARSAT features)

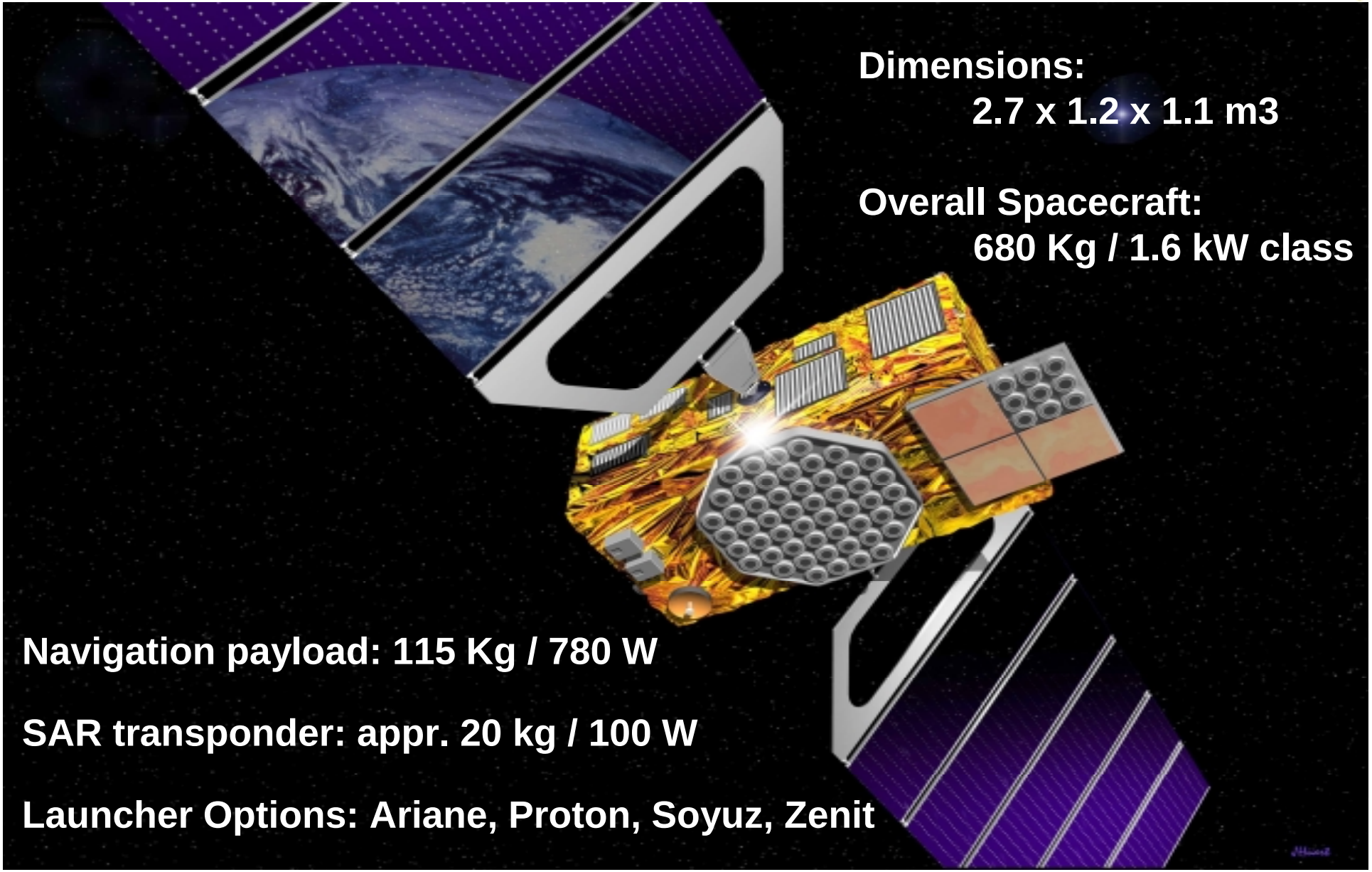
Galileo Architecture



Space Segment



Galileo Satellite



Dimensions:
2.7 x 1.2 x 1.1 m3

Overall Spacecraft:
680 Kg / 1.6 kW class

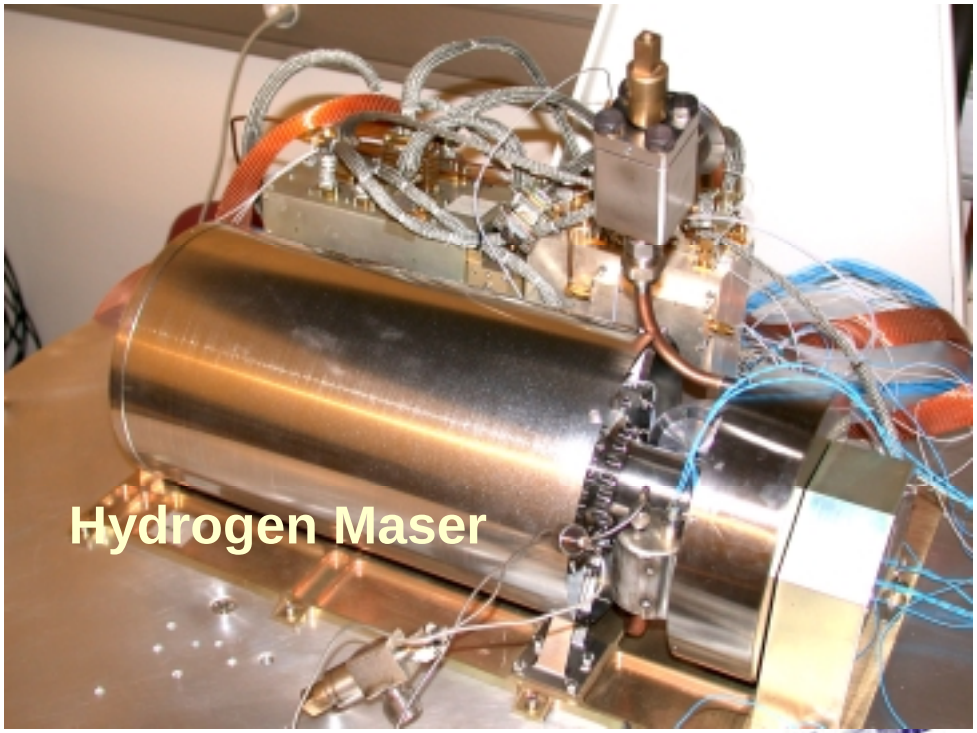
Navigation payload: 115 Kg / 780 W

SAR transponder: appr. 20 kg / 100 W

Launcher Options: Ariane, Proton, Soyuz, Zenit

On-board Atomic Clocks

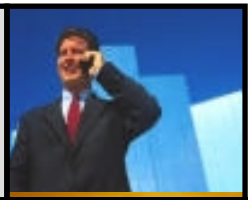
Rubidium Standard



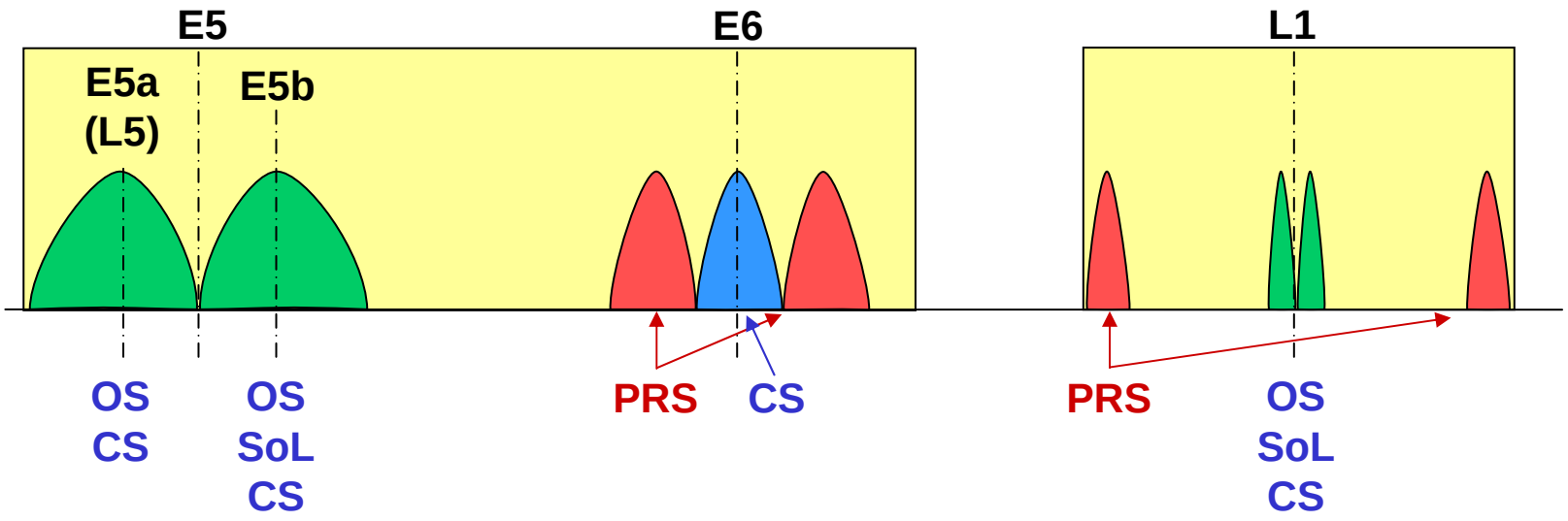
Hydrogen Maser

Baseline is 2+2 on-board clocks

Galileo services

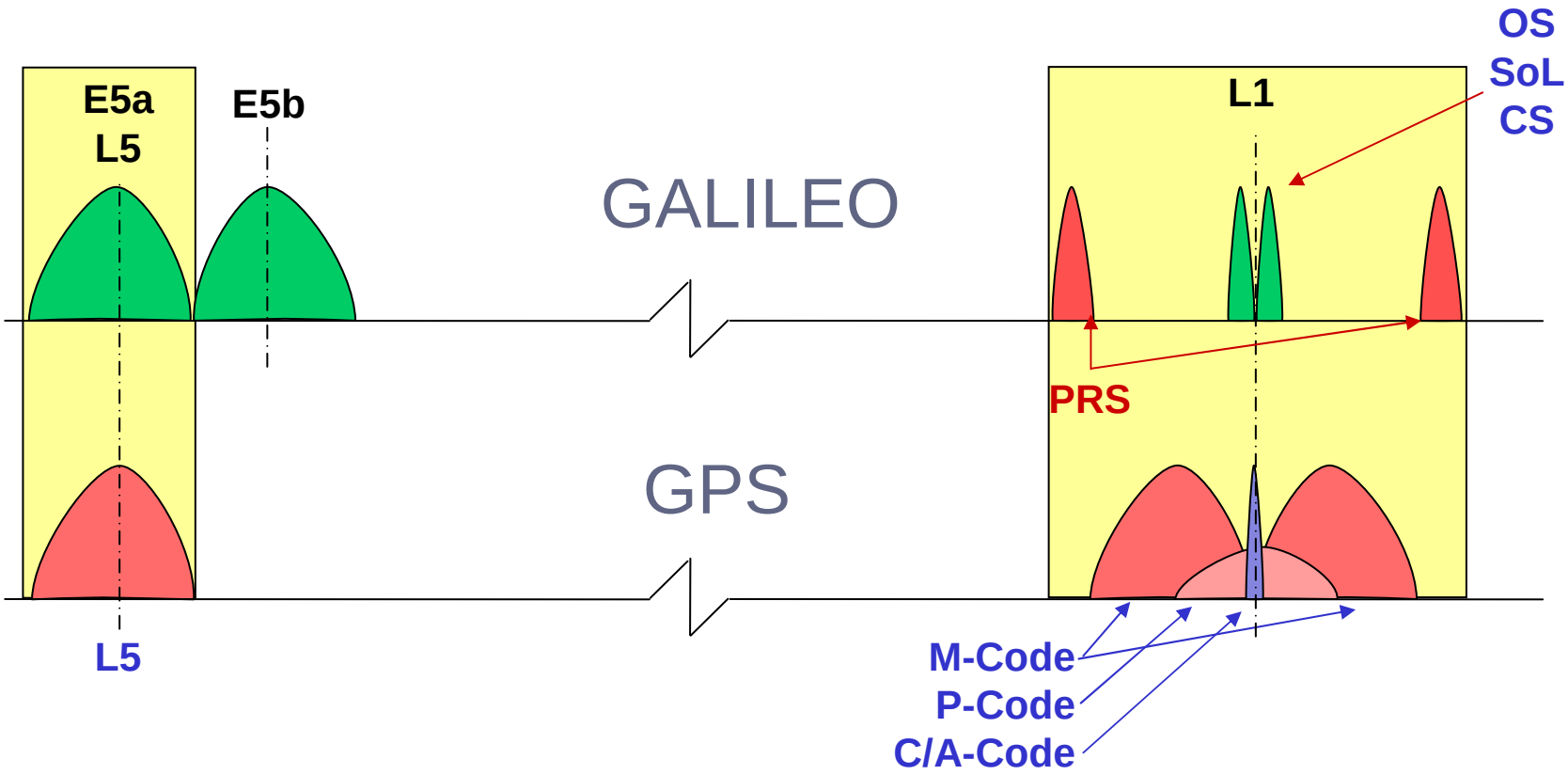
Navigation	Open Access	Free to air - Mass market Simple positioning and timing	
Navigation	Commercial	Encrypted - High accuracy Guaranteed service	
Navigation	Safety of Life	Open Service + Integrity and signal Authentication	
Navigation	Public Regulated	Encrypted - Integrity Continuous availability	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

GALILEO Frequency Plan



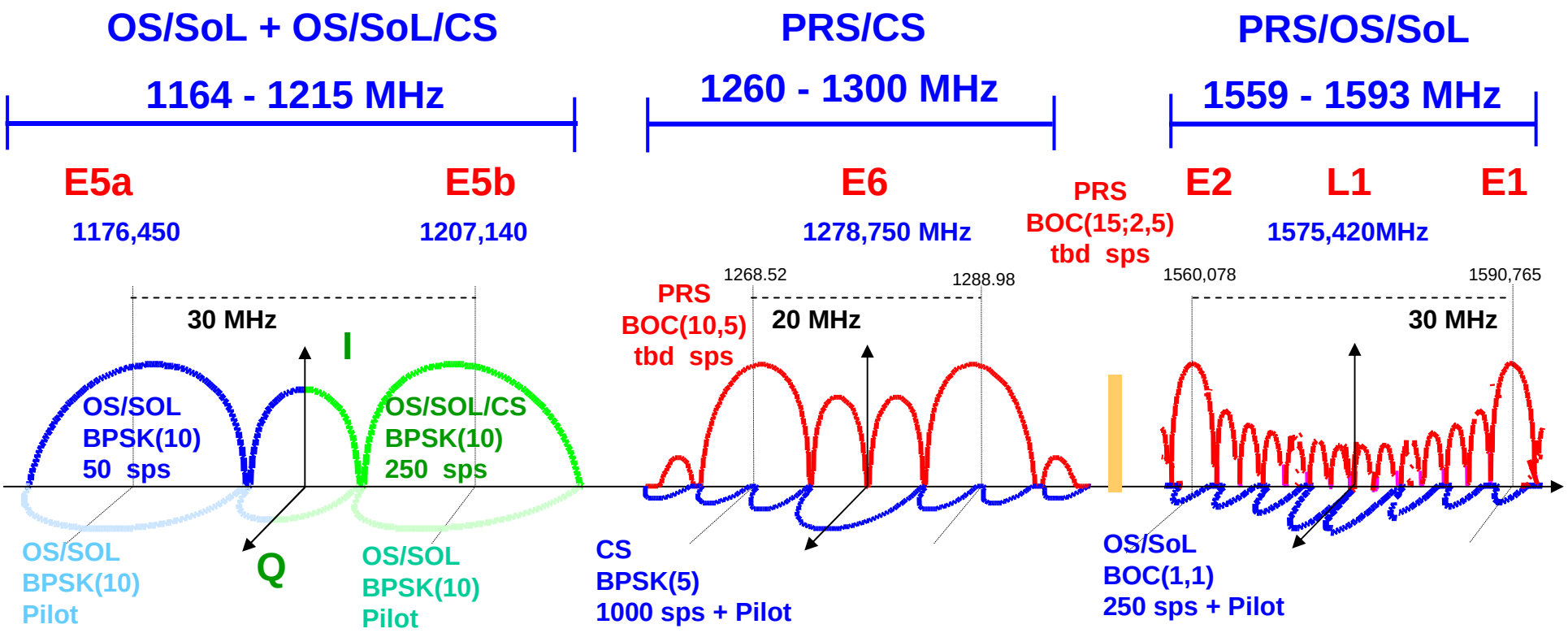
Not to scale

GPS and Galileo Frequency Sharing



A US-EU agreement to share the L1 band between GPS and Galileo has been successfully negotiated and signed on 26 June 2004

Galileo Signal in Space

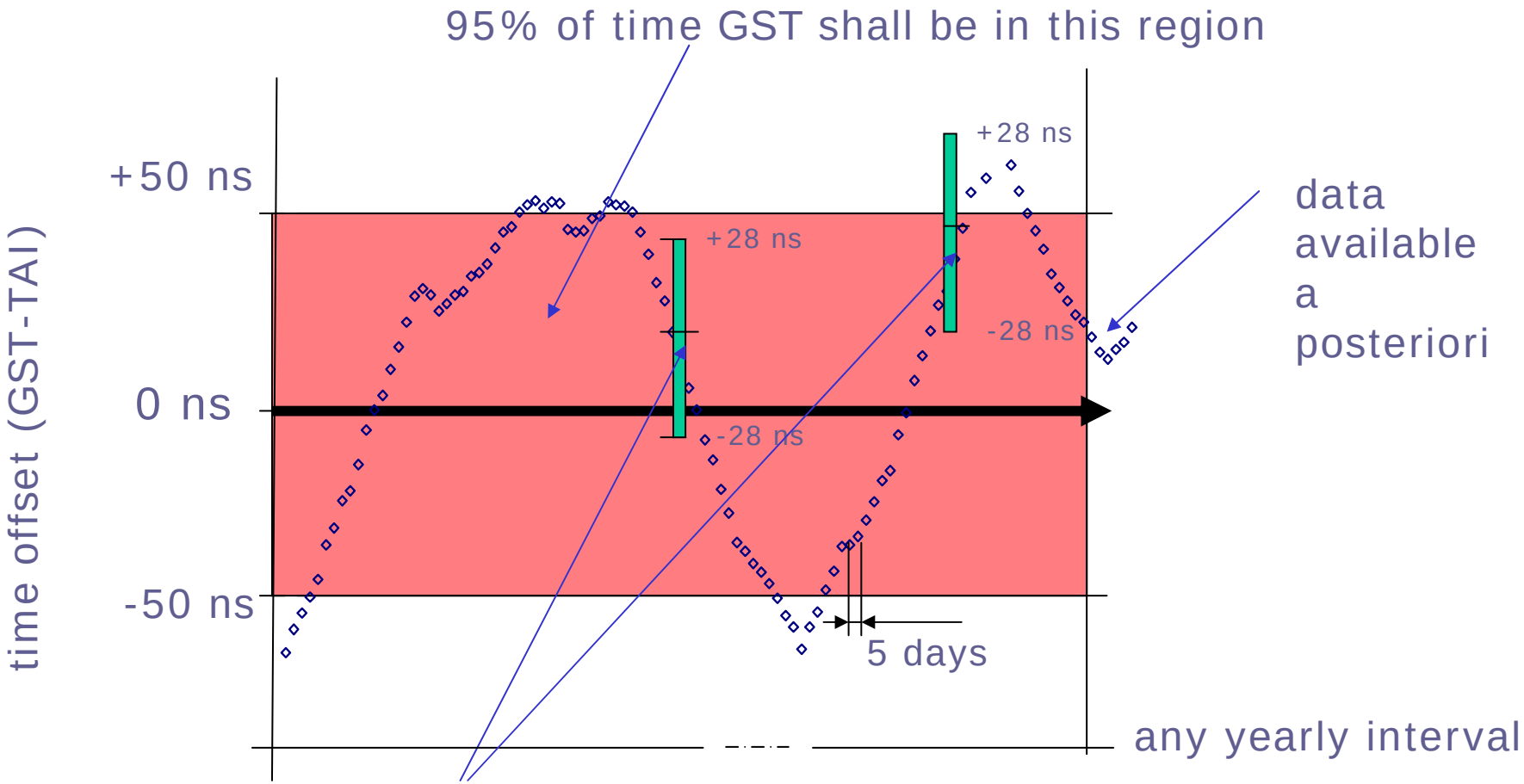


- Three Navigation bands (E5; E6; L1) and Two SAR bands (406MHz, L6)
- Same Center Frequencies than GPS on E5a (L5) and E2-L1-E1 (L1):
  ⇨Maximum interoperability, security aspects in L1 negotiated with US

Performance: Position Accuracy

Carriers		Single Frequency (L1)	Dual Frequency (L1 + E5)
Ionospheric correction		Based on simple model	Based on dual-frequency measurements
Coverage		Global	
Accuracy (95%)		H: 15 m V: 35 m	H: 4 m V: 8m
Integrity	Alarm Limit	Not Applicable	
	Time-To-Alarm		
	Integrity risk		
Availability		99.5 %	

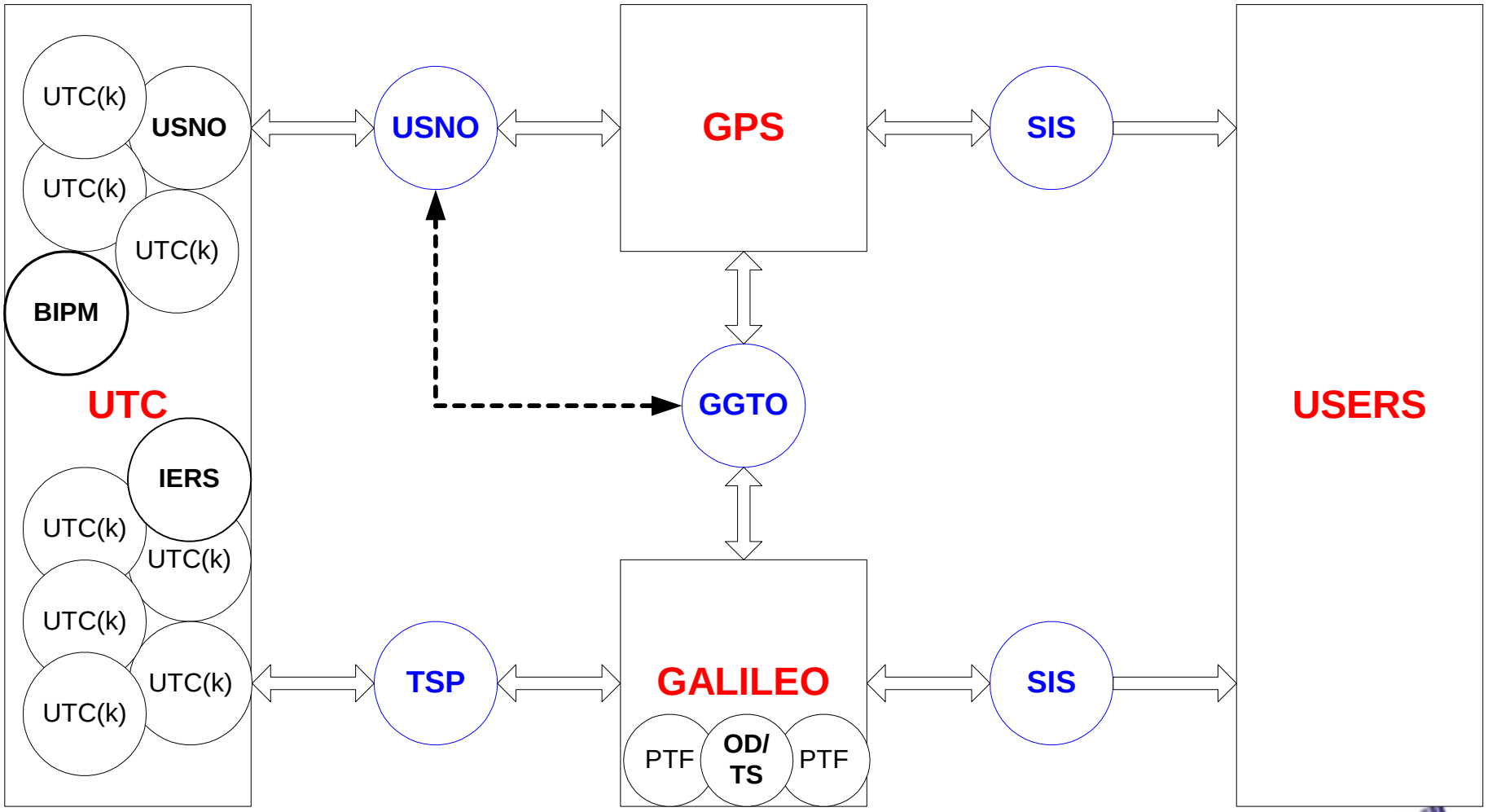
Performance: Time Accuracy



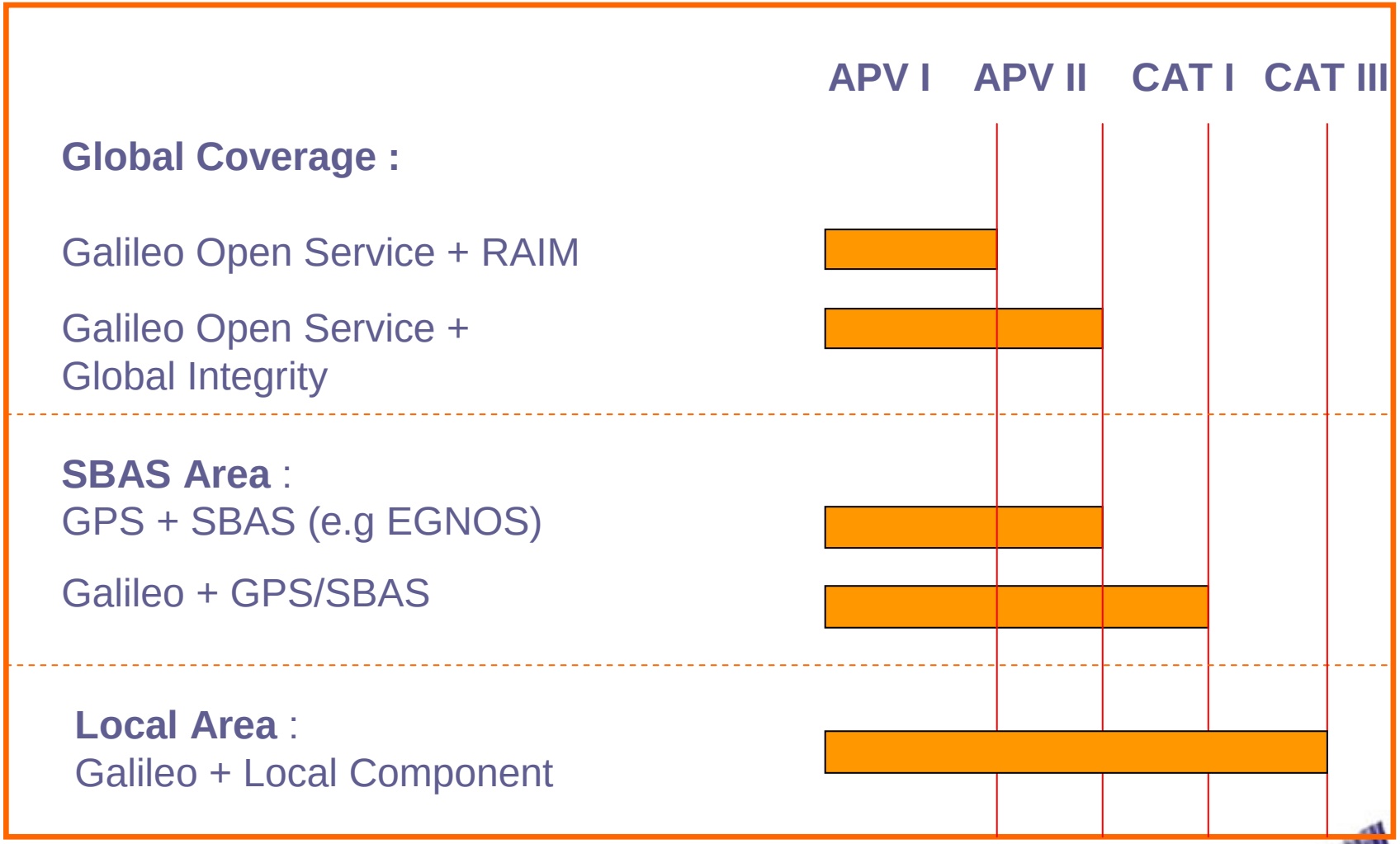
predicted offset shall be in this region, 2s, due to delay in UTC estimation (1.5 months)

not to scale

Galileo timing system and interfaces

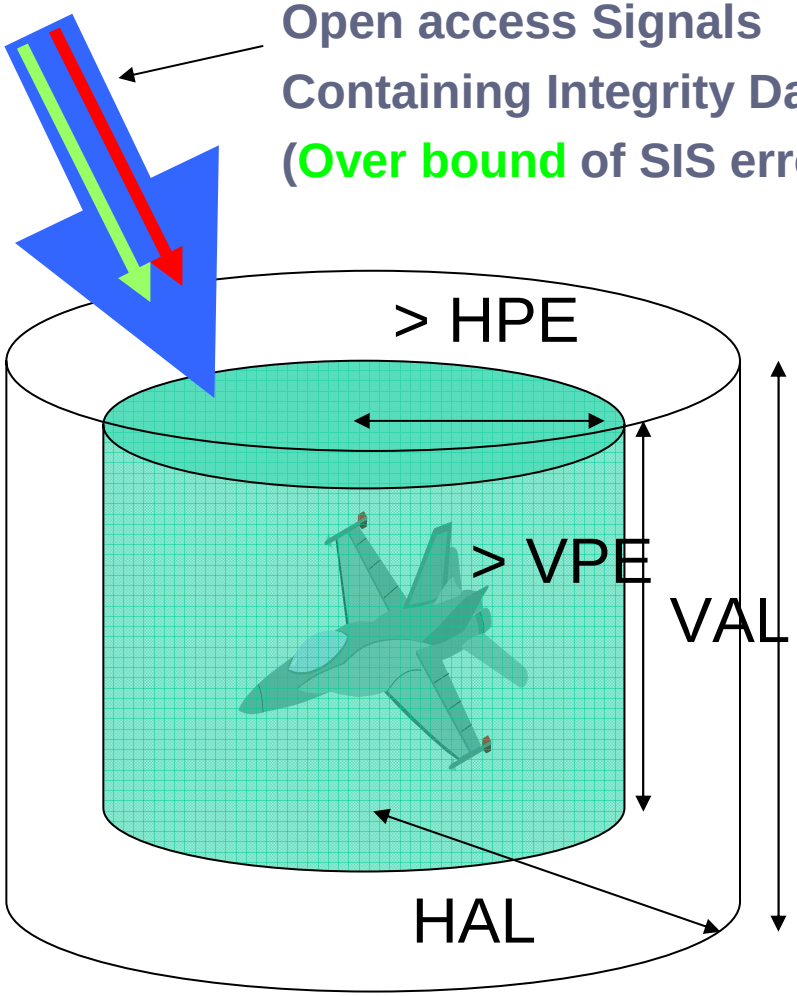


Combined GPS/Galileo performances



Performance: Integrity

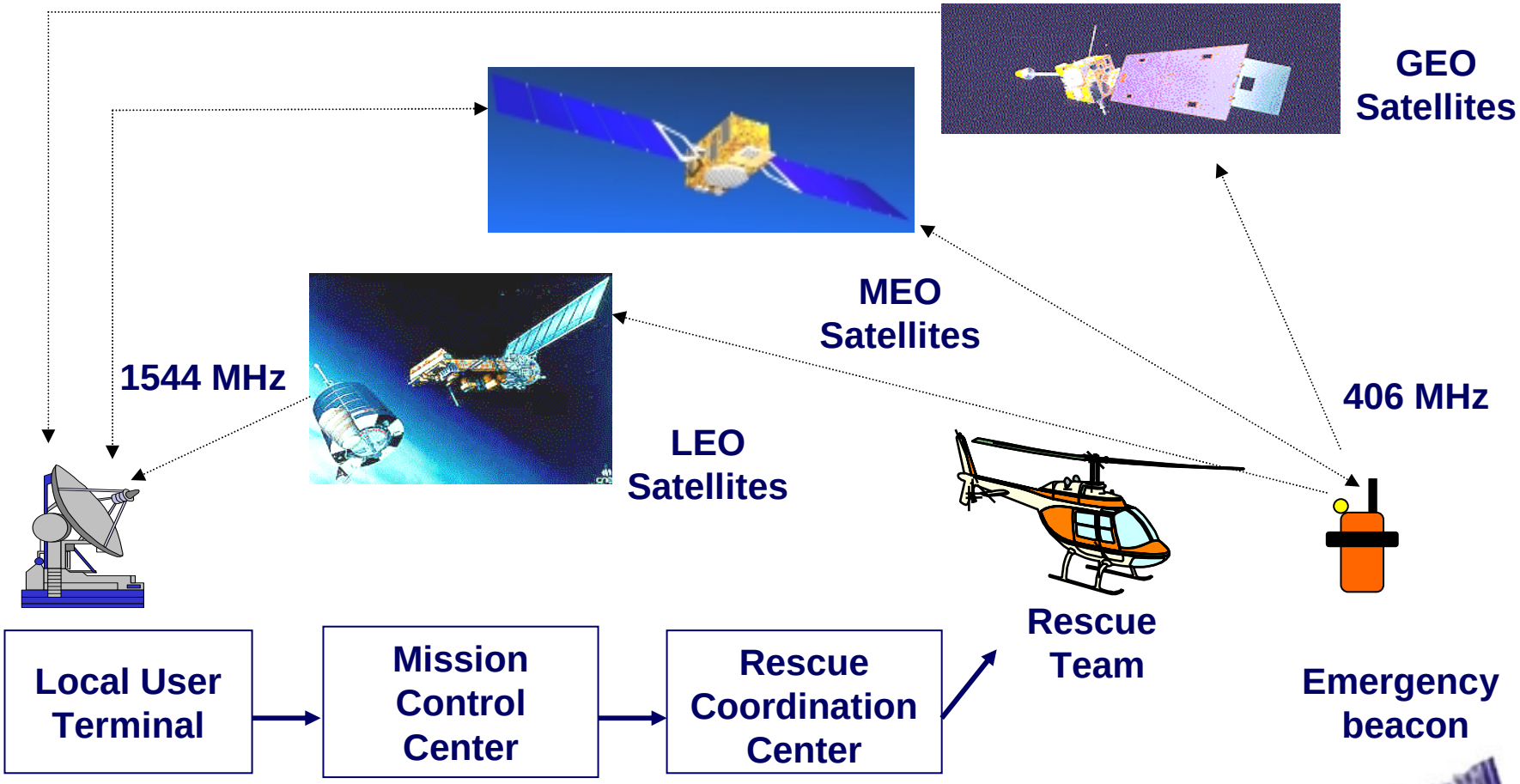
Open access Signals
Containing Integrity Data
(Over bound of SIS error+ IF)



Coverage		GLOBAL
Service		SoL
Signal		E5b + L1
Integrity	Alarm Limit	H: 40 m V: 20 m
	Time-To-Alarm	6 seconds
	Integrity risk	$2x10^{-7}$ / 150 s
Continuity Risk		1 - ($8x10^{-5}$) over 15 s
Availability		99.5%

SAR/Galileo Description

Integration of the MEOSAR Component in the International SAR Satellite System



Transport

Road Applications

- Route Guidance (including real-time traffic information)
- Emergency and Breakdown Assistance Services
- Automatic Driver Assistance
- Fleet Management
- Stolen Vehicle Recovery
- Traffic Information in Public Transport

At least 4 to 6 satellites permanently in view worldwide in addition to GPS satellites, SBAS, GLONASS…

…Urban canyon is no more an issue

Transport

Aeronautical Applications

- Aircraft Navigation for all phases of flight
- Surveillance Applications (ADS-B and SMGCS)
- UAV guidance
- Free flight

Certification and Service Guarantee…

…GNSS meet Safety concerns of Transport applications

Transport

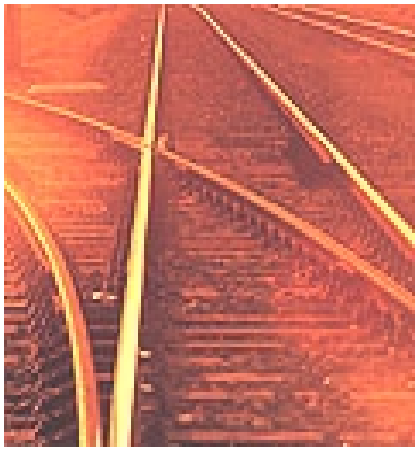
Maritime Applications

- Maritime Navigation
- Fishing
- Precision harbour approach and docking
- Survey and inspection
- Dredging and cable laying
- Marine construction
- Emergency and rescue operations
- Positioning of navigation buoys
- Inland waterways navigation

Transport

Rail Applications

- Signalling and train control: Infrastructure data collection, End of movement authority, Supervision to buffer stops, …
- Passenger information: Pre-trip information, On-trip information
- Management information systems: Fleet management, Cargo monitoring, Rolling stock maintenance



Professional Applications

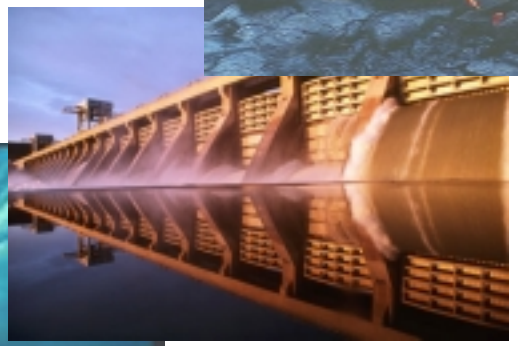
- Agriculture, precision farming
- Fisheries
- Forestry
- Civil Engineering, Mining, Oil
- Static Applications, Public Works
- Surveying and Mapping
- Timing and synchronization
  - Banking
  - Electricity network
  - Communication network

Reliability, redundancy and a service dedicated for Commercial application…

…Professional applications can rely on GNSS

Scientific Applications

- Surveying
- Geodesy
- Geology
- Meteorology
- Vulcanology
- Monitoring dam deformations



Performances are never good enough…

…new possibilities are offered for scientific applications (e.g. new carriers)

Location Based Services Applications

- Local Information
- Navigation Assistance
- Emergency Services (E 112)
- Commerce
- Mobile Call routing/billing
- Personnal Assistance
- Gaming

LBS is a promising market…

…specific attention is paid to overcome technical limitations of existing systems (e.g. Indoor)

Leisure

- Leisure boat
- Hiking
- Rally raid

Leisure applications have each their specific needs…

…even low cost equipment will benefit from Galileo service qualities

Security Applications

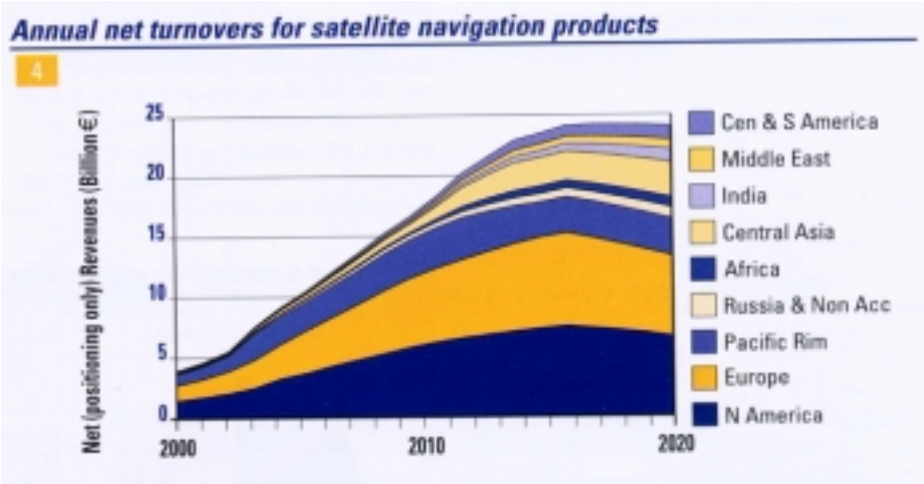
- Crisis management
- Civil Security
- Emergency services
- Police
- Search and Rescue
- Anti-fraud (custom)
- Transport of dangerous goods
- Earthquake monitoring

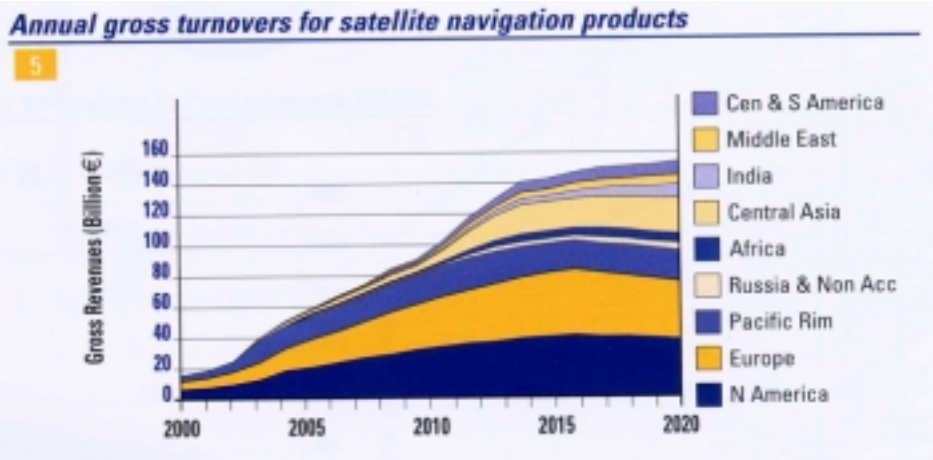
Continuity, robustness and a Controlled Access service…

…Public service mission, including SAR is carefully addressed in a GNSS system design

Satellite Navigation Market

- **Market forecast for 2020:**
  - 1 billion mass market chipset sold (e.g. mobile phones)
  - 50 million car units sold
  - 25 billion € net revenues



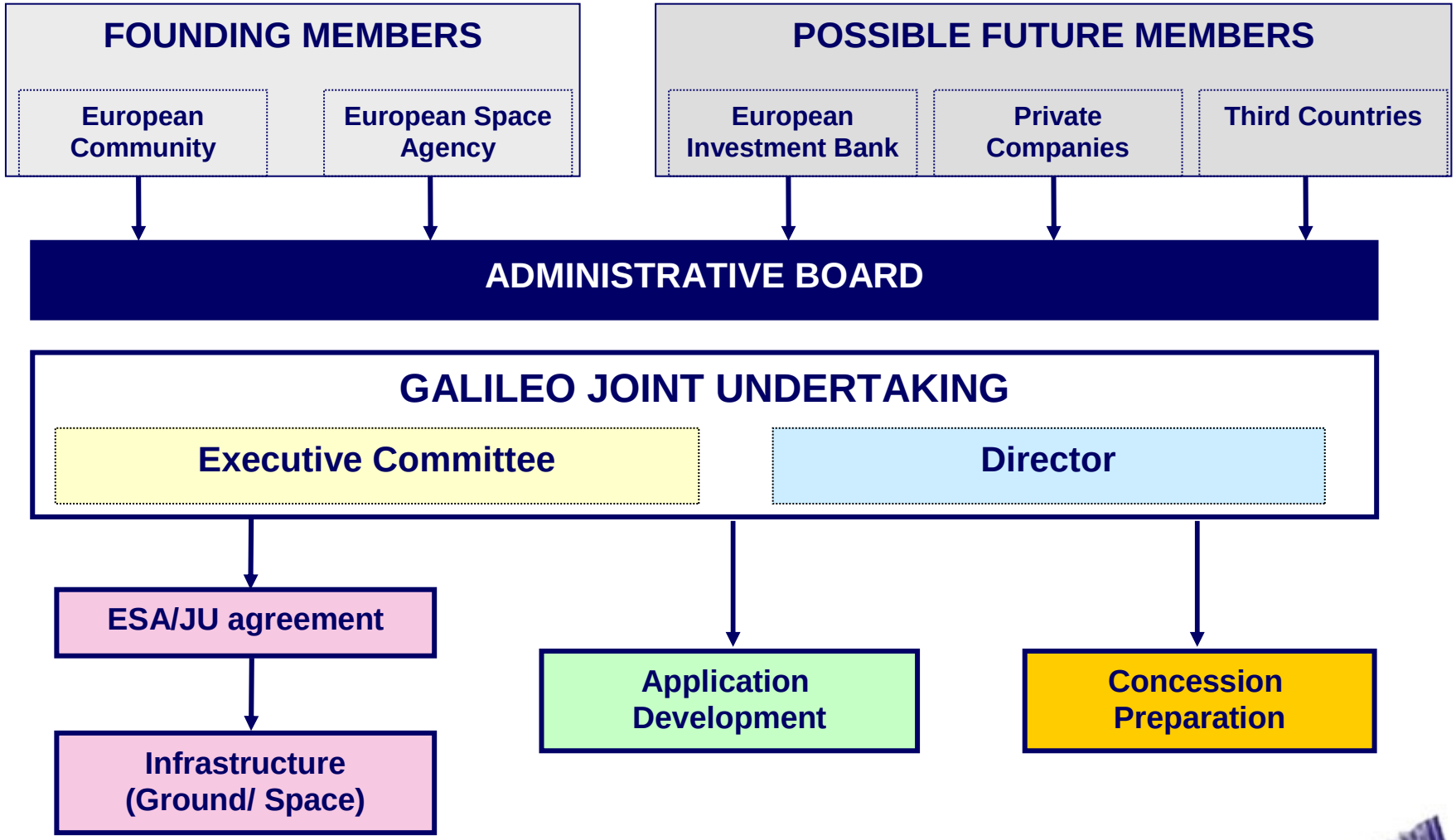


- **3 billion terminal in use in 2020**

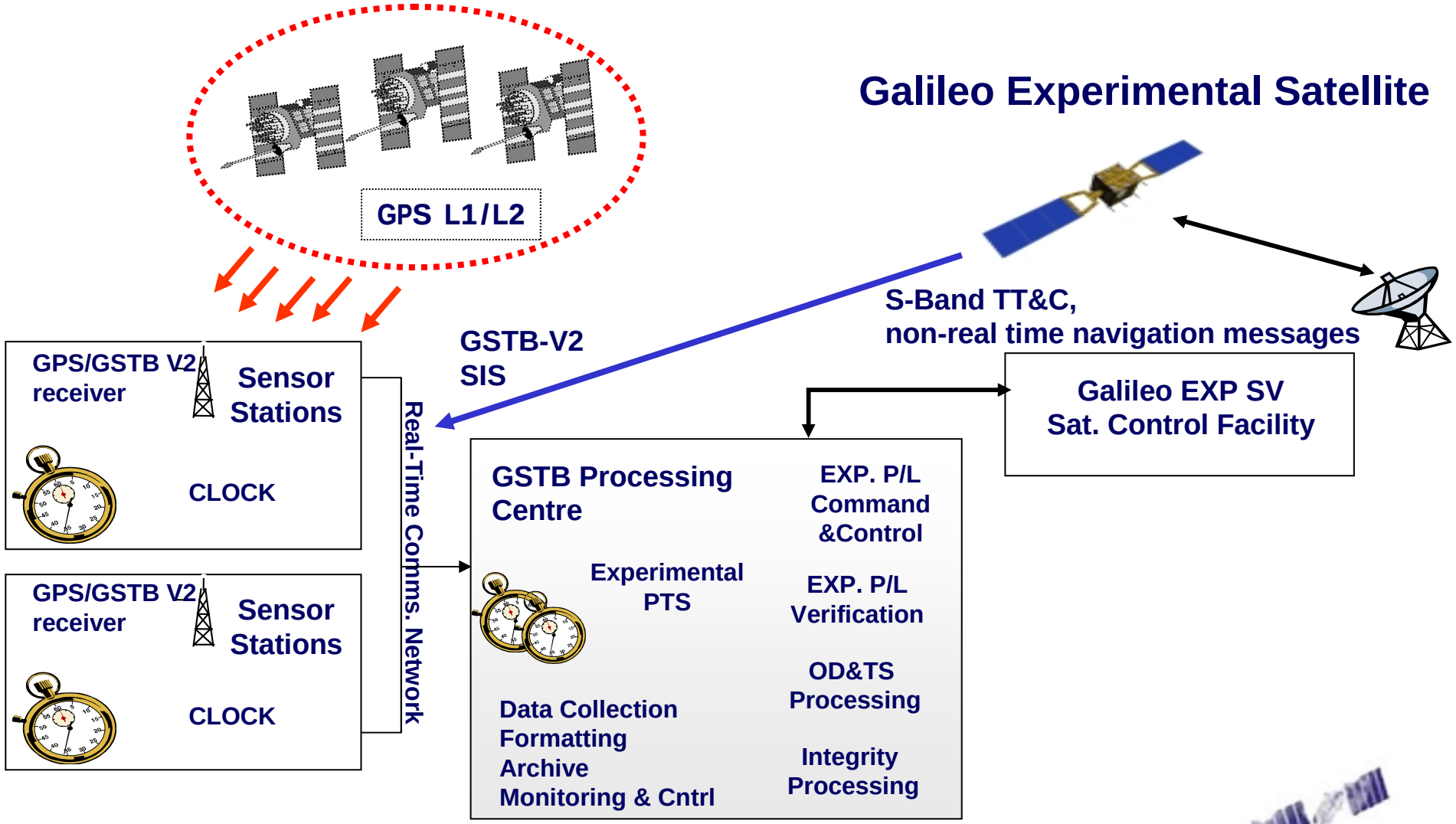
GALILEO PROGRAMME STATUS

On the right tracks

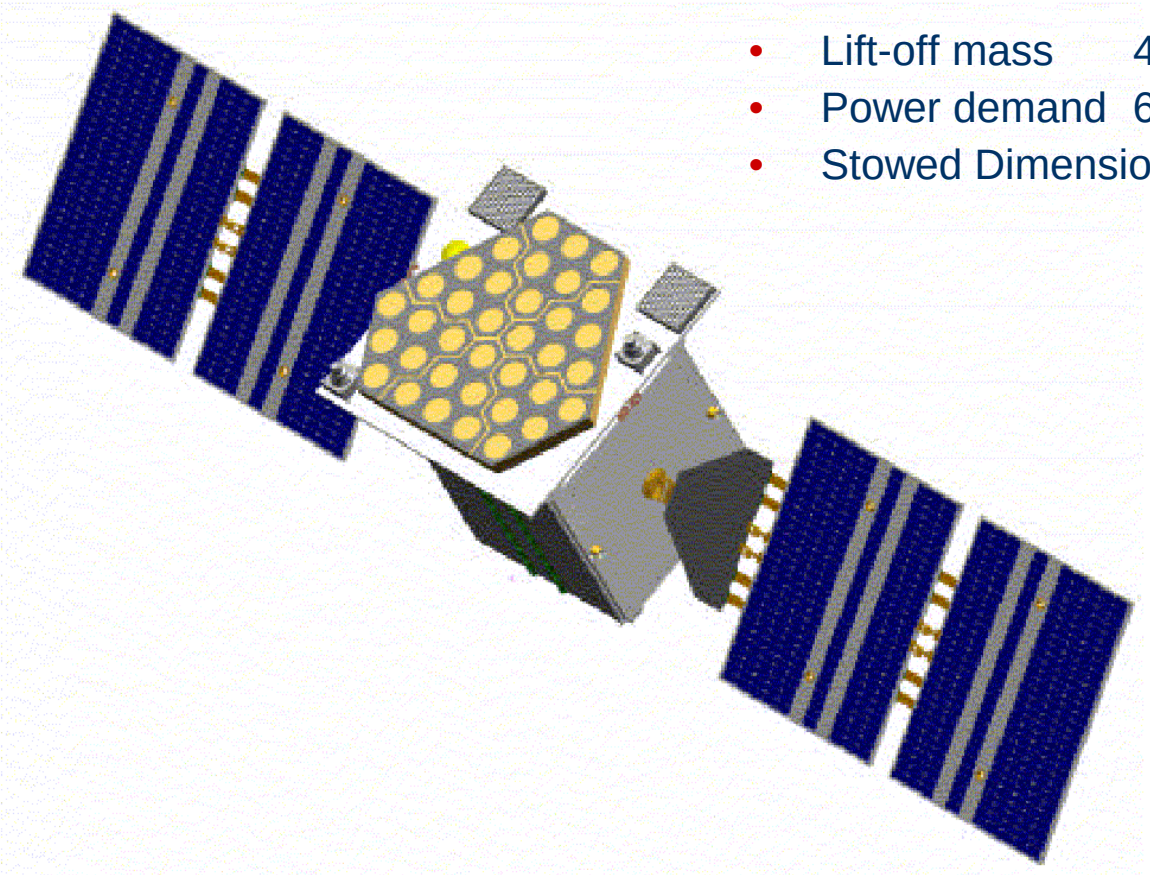
Galileo Joint Undertaking



GSTB V2 Architecture

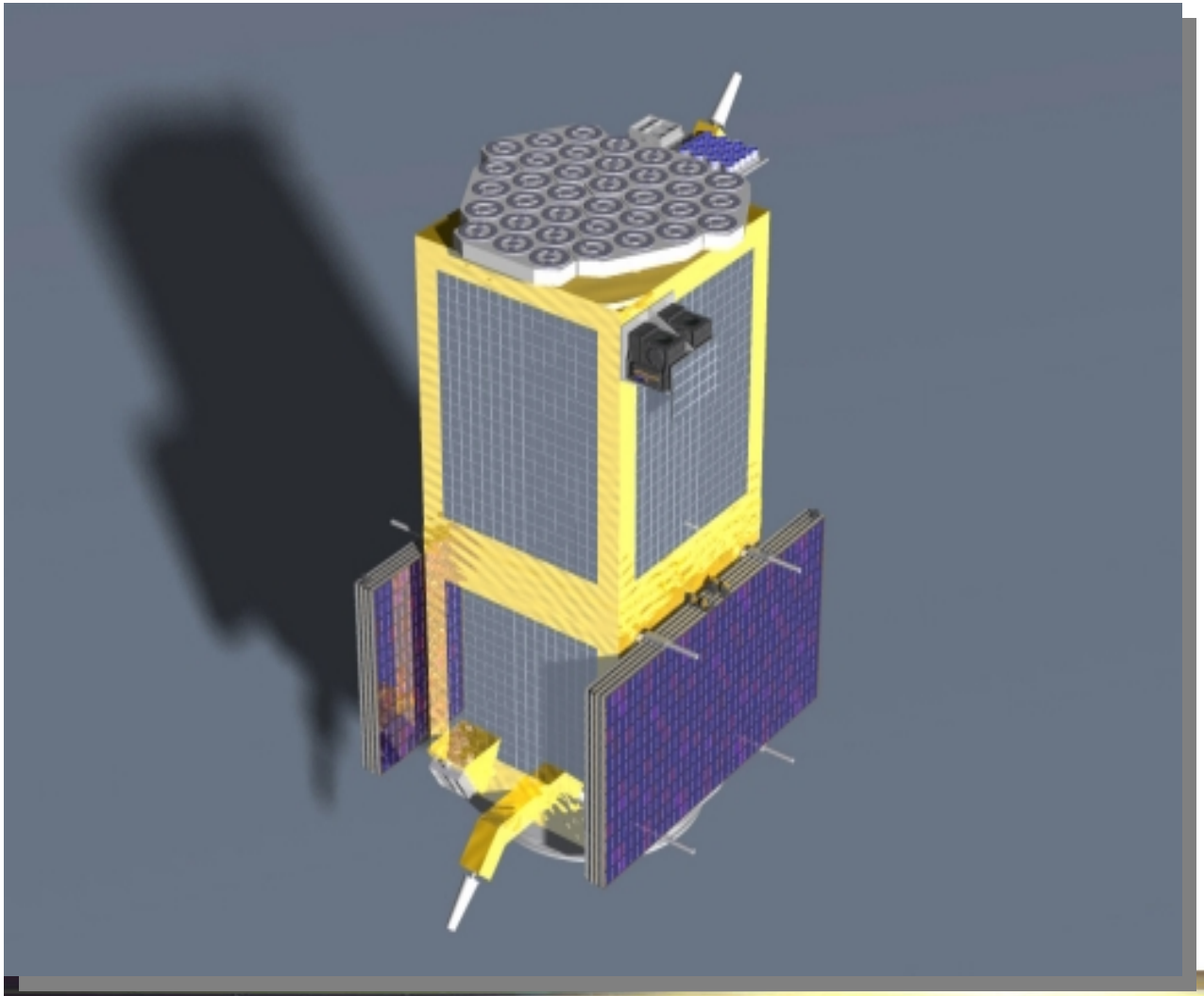


GSTB-v2 A Satellite
(Surrey Satellite Technology Ltd)



- Lift-off mass 450 kg
- Power demand 660 W
- Stowed Dimensions 1.3 m x 1.74 m x 1.4 m

GSTB-v2 B Satellite (Galileo Industries)



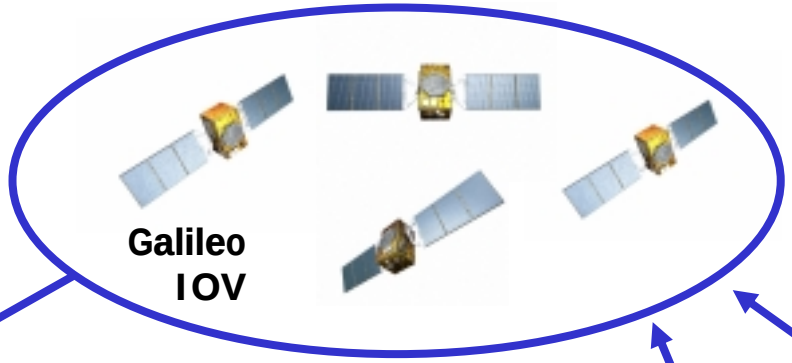
- Lift-off mass 523 kg
- Power demand 943 W
- Stowed Dimensions: 0.955 m x 0.955 m x 2.4 m

IOV Phase

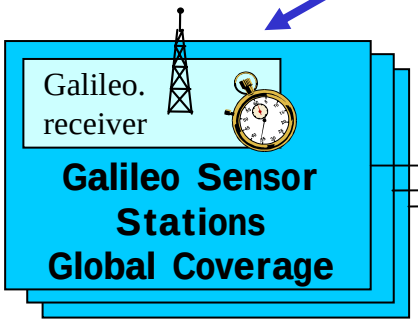
- Verification of all space, ground and user components, including their interfaces, prior to full system deployment
- Analysis of system performance with the view to refine the FOC system prior to full system deployment
- Verification of the adequacy of the sitting requirements.
- Verification of Navigation Processing
- Verification of Integrity Processing
- UERE budget characterisation
- Deployment risk reduction
- Verification of operational procedures

IOV System Configuration

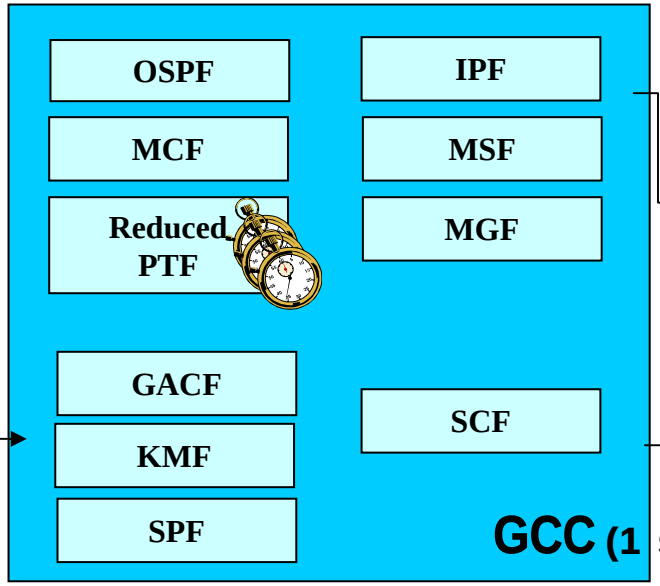
Legend:
OSPF – ODTS Processing Facility
IPF – Integrity Processing Facility
MCF – Mission Control Facility
MSF – Mission Support Facility
MGF – Message Generation Facility
PTF – Precision Timing Facility
GACF – Ground Asset Control Facility
KMF – Key Management Facility
SPF – Service Product Facility
SCF – Satellite Control Facility

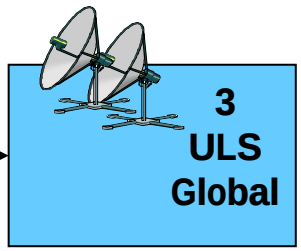


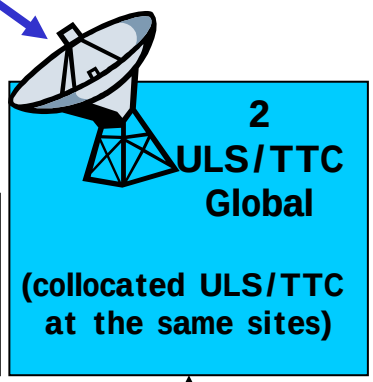
4 SV's



18 to 20 Galileo Sensor Stations (worldwide):
- 1 Hz sampling
- 8 equipped with RT
- data transfer (TTA 6 s)







Concession

- After IOV, the concessionaire takes over for the deployment and commercial operating phases;

- Cost of operations shall be progressively offset by market revenues. This requires:
  - Consolidation of business plan
  - Definition of risks allocation

- Concession duration is 20 years

- Replenishment of the system is foreseen within the Concession duration

Overall Schedule:

48 months	24 months	20 years
Development and Validation	**Deployment**	**Operations and Maintenance**
1.2 Billion €	**2.1 Billion €**	**220 Million € per year**
1 Test Satellite & 4 Operational Satellites Ground Infrastructure	26 Satellites Ground Infrastructure	Routine Operations and Replenishment

EC/ESA → Joint Undertaking → GALILEO Concessionaire
European GNSS Supervisory Authority

Concession Bidding process

iNavsat Consortium

Eurely Consortium

iNavsat consortium

Core Members	EADS Space Services, Paris Inmarsat Ventures Plc, London Thales S.A., Paris

Associat. Partners	SES Global Lockheed Martin China Aerospace Science & Techno. ERTICO Navtech, Vitrociset, SciSys, Vega

Point of Contact: Patrick McDougal

Inmarsat ventures

Patrick_McDougal@inmarsat.com

Eurely Consortium

Core Members	Alcatel Participations SA, Paris Finmeccanica, Roma

Subcontractors	International Space Brokers, Paris GMV SA, Madrid Vinci Concessions SA, Paris

Point of Contact: Jean-Claude Dardelet

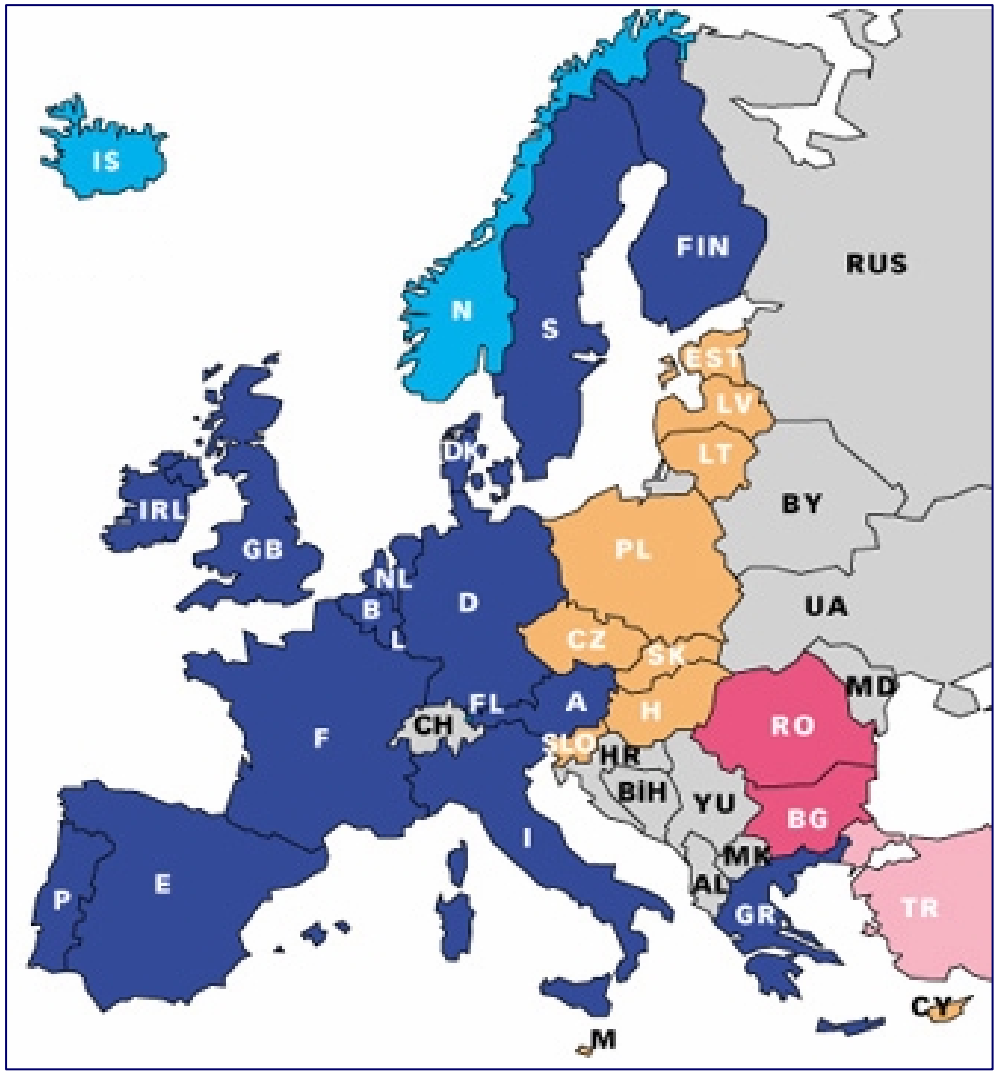
Alcatel Space

jean-claude.dardelet@space.alcatel.fr

INTERNATIONAL DIMENSION OF GALILEO

A Global system

EU Members



European Union 15 members

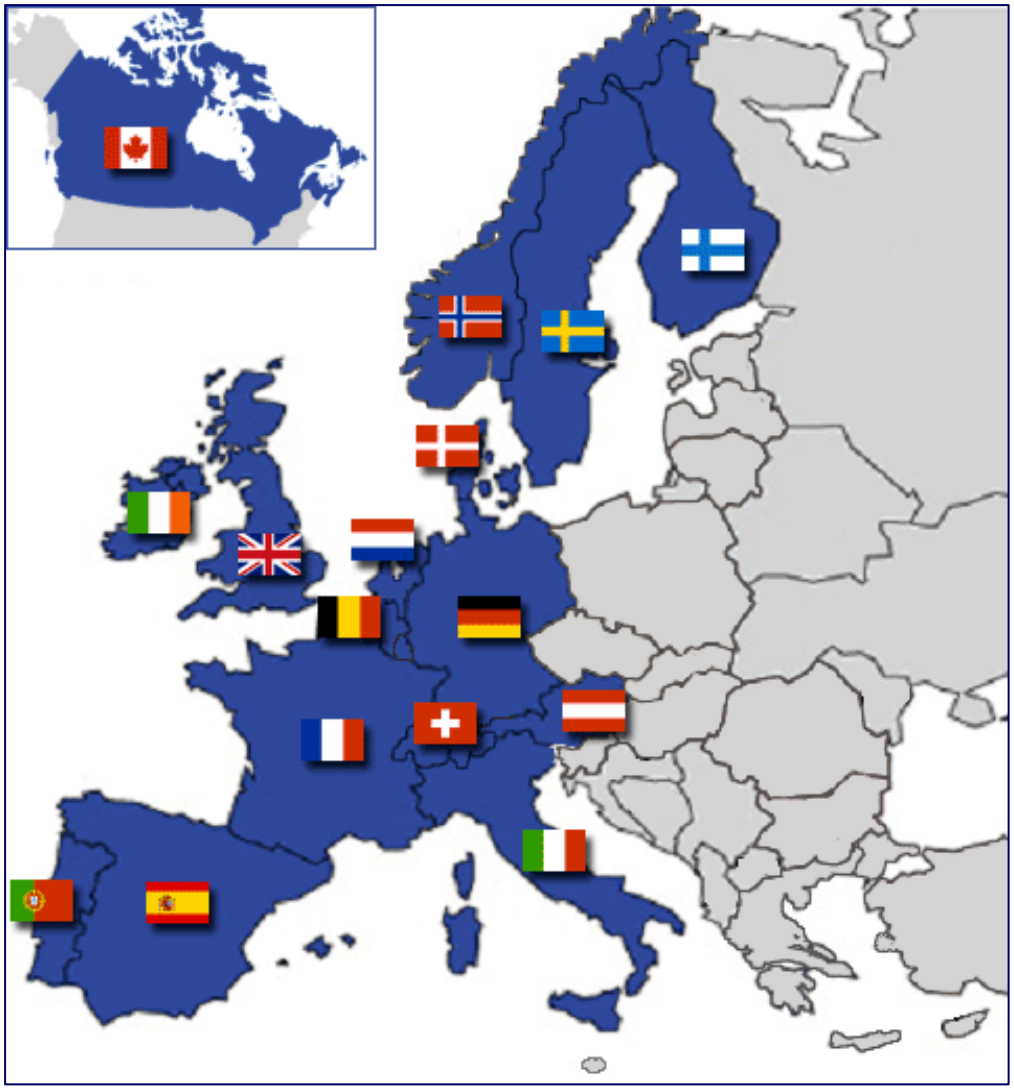
Joined the EU in 2004

Will join the EU in 2007

Candidates to join the EU

EEA

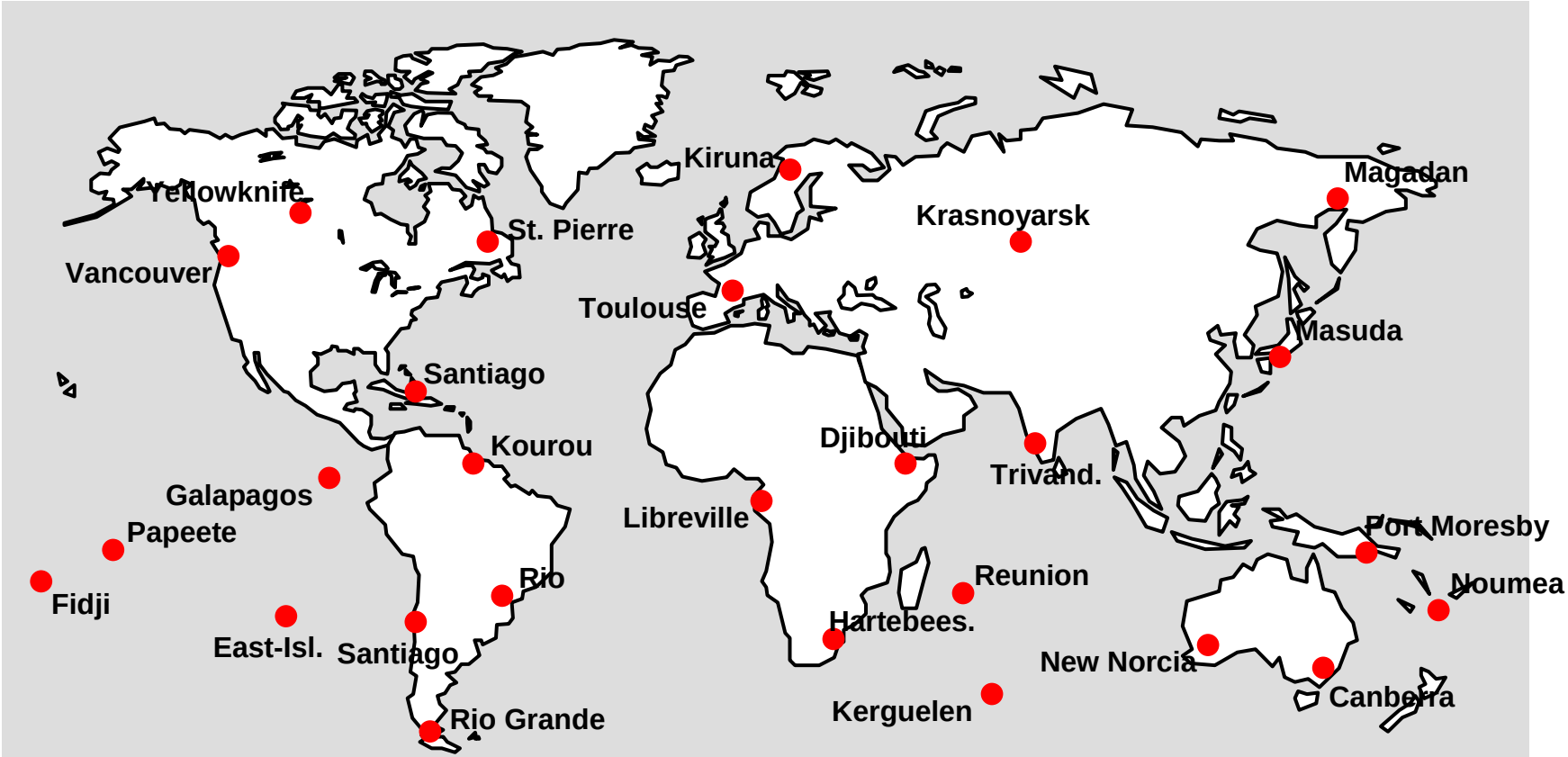
ESA Members



Members of ESA programs:

- 15 Member States: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom
- Canada

Ground Sensors Stations Network



Note.: Utilization of the locations is matter of ongoing assessment

International Dimension

- Signed Agreements
  - US
  - China
  - Israel

- Further Mandates for Negotiations (EC)
  - Russia
  - Ukraine
  - India

- Further Contacts
  - Morocco, South Korea, Australia, Mexico, Brazil, Chile, Canada

Opportunities in the Galileo Concession

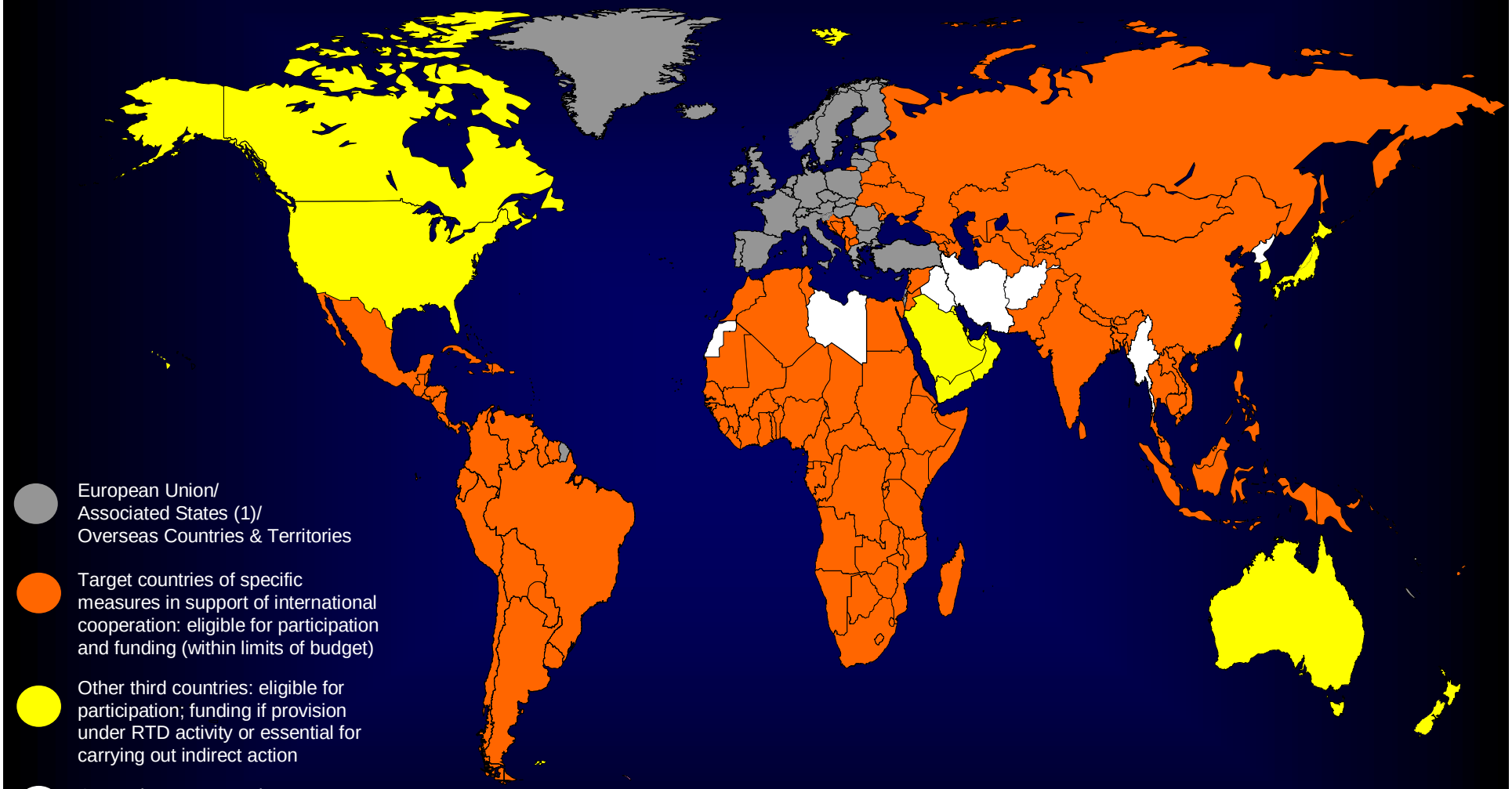
Companies in Third Countries may have interest to cooperate with the current Concession Bidders in order to prepare the ground for their relations with the Galileo future Concessionaire

Opportunities in different areas, some examples:

- Licensing for the Galileo market exploitation
- Implementation of the Galileo Service provision end-to-end downstream chain (local actors, end-customer interface)
- Service agreements for specific market sectors at local, regional level
- Optimisation of Galileo “Service Centres” and their interface with the Galileo Core System
- Dedicated Galileo/EGNOS Market analysis focused on specific regional/national priorities involving the current and future investors and users
- Setting-up group of interests for the different market sectors

SIXTH FRAMEWORK PROGRAMME 2002-2006

Participation by legal entities from third countries



- European Union/ Associated States (1)/ Overseas Countries & Territories
- Target countries of specific measures in support of international cooperation: eligible for participation and funding (within limits of budget)
- Other third countries: eligible for participation; funding if provision under RTD activity or essential for carrying out indirect action
- Currently no cooperation

FP6 GJU 1st Call Projects

Activities	Project Title	Budget (M€)	Leader	Comments
User Receiver Prelim. Development	-	3.8	LABEN	Core technologies Basis for the 2 nd call
Galileo Local Component Develop.	-	3.8	Thales ATM UK	Buildings blocks Input for 2 nd call
Introduction of Galileo Services using EGNOS	-	4.7	-	Close to the market Service implementation
Integrity and service guarantee in non- aviation application	ADVANTIS	1.3	Alcatel S.I	
E- 112	SCORE	1.1	GMV	
Road Tolling	VERT	0.9	Sinelec	
Maritime: Harbor Docking and Inland Waterways	MARGAL	1.4	Kongsberg Seatex	
Application Market Development	PRODDAGE	1.7	ESYS	Service type contract
Mission Implementation	GEM	4.9	FDC	Service contract on key technical fields: Standard / frequency …

FP6 GJU 2nd Call Activities

Activities	Budget (M€)	Number of Contracts
Area 1 : User Segment		
1A User Community		
LBS Sector	3.2	1
Road Sector	3.2	1
Rail Sector	3.2	1
Maritime Sector	3.2	1
Aviation Sector	2.2	1
Special User Communities	1.25	4
1B Technological Development		
Mass Market Rx Develop.	2.5	3
Professional Rx Develop.	2.6	2
Safety of Life Rx Develop.	3.5	1
Interference Detection, Mitig., Isolat.	1.8	1

FP6 GJU 2nd Call Activities

Activities	Budget (M€)	Number of Contracts
Area 2 : Mission Definition Implementation		
Galileo Reference Mission	3.8	1
Galileo Advanced Concepts	2.8	1
Impl. Galileo Time SP Prototype	2.8	1
Impl. Galileo Geodesy SP Prototype	1.8	1
Impl. SAR Interfaces	4.3	1
Area 3: Innovation and International Activities		
Coordination Galileo R & D Activities	4.9	1
Innovation SMEs Subcontracts	0.3	10

EUROPEAN INDUSTRY

Ready for cooperation

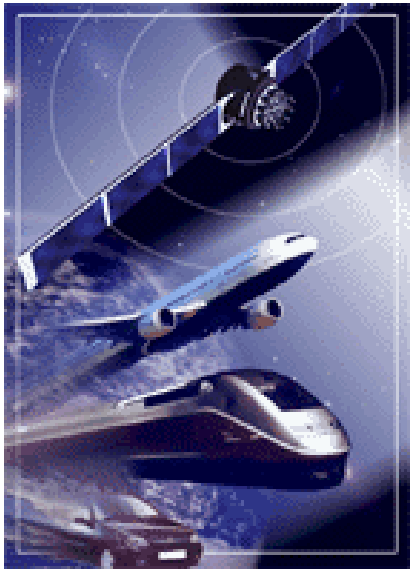
EUROPEAN INDUSTRY

- EU Industry is leading the world in many areas of technology

- EU Industry, through its active participation, is well aware of latest Galileo's infrastructure (signal and services) development

- It is capable of the complete range, from chipset design to manufacture, integration and certification of major systems and provision of innovative services

The ORganization of European Gnss INdustry of equipment and services has been created in Feb 1999 for:



- information exchange
- cross-fertilisation of expertise
- point of contact/industry voice for the European Institutions
- publicity and lobbying
- fostering co-operation with non-European industries

Members

- More than 140 members
  including international industry organisations and national groups
  (close to 250 industrialists represented)
- Industries from 15 European countries
- From SMEs to biggest groups
- Associating Universities
  Research labs since 2003

Members profile (1/2)

- Chip producers, Equipment manufacturers, Software developers, Service providers, Integrators, Telecom and Car manufacturers, …

Source: OREGIN Members websites

Members profile (2/2)

- Experienced in all kinds of applications:
  - Safety of Life, Governmental, Professional, Mass markets
  - Air, Maritime, Rail, Road, Intermodal, Pedestrian, Leisure, Geodesy, Scientific, Agriculture, Space, …

Source: OREGIN Members websites

Members list (1/4)

- **ACSA** (FRANCE)
- **ADVANCED AVIATION TECHNOLOGY** (UK)
- **ADVETO AB** (SWEDEN)
- **AERODATA F.** (GERMANY)
- **AGROCOM** (GERMANY)
- **ALCATEL/SEL** (GERMANY)
- **ALENIA** (ITALY)
- **ALGONET** (GREECE)
- **ALGOSYSTEMS** (GREECE)
- **ALL COMM** (FRANCE)
- **ASTRIUM** (UK)
- **BMW-AG** (GERMANY)
- **BOMBARDIER TRANSPORTATION** (GERMANY)
- **CAA** (GERMANY)
- **CAP GEMINY ERNST & YOUNG** (FRANCE)
- **CARLO GAVAZZI SPACE** (ITALY)
- **CLARITI Technologies** (FRANCE)
- **COM DEV Europe** (UNITED KINGDOM)
- **CRYPTOLOG INTERNATIONAL** (FRANCE)
- **CS Communication & Systèmes** (FRANCE)
- **DAIMLER CHRYSLER GROUP** (GERMANY)
- **DIGINEXT** (FRANCE)
- **DIGIUTOPIKA** (PORTUGAL)
- **DORNIER CONSULTING** (GERMANY)
- **EADS** (FRANCE)
- **EADS** (GERMANY)
- **EDISOFT** (PORTUGAL)
- **EGERY** (FRANCE)
- **ELNA** (GERMANY)
- **ERICSSON TELECOMUNICAZIONI** (ITALY)
- **ERTICO** (INTERNATIONAL)
- **EURO-TELEMATIK** (GERMANY)
- **EUTELSAT** (INTERNATIONAL)
- **FASTRAX** (FINLAND)
- **FAUCON ROBOTIQUE** (FRANCE)
- **FDC** (FRANCE)
- **FIAT** (ITALY)
- **FINMEK SPACE** (ITALY)
- **FUTURASPACE SARL** (FRANCE)
- **GEO STRATEGIES Ltd** (UK and ROMANIA)
- **GEOTOPOS SA** (GREECE)
- **GPV TECHNOLOGICAL INOVATIONS** (GREECE)
- **Grupo GMV SA** (SPAIN)
- **HELIOS TECHNOLOGY** (UK)
- **HELLENIC AEROSPACE INDUSTRY** (GREECE)
- **HIGH TECHNOLOGY ASSOCIATES** (UK)
- **HÖGEL & PARTNER** (GERMANY)
- **IDOM** (Spain)
- **IFEN** (GERMANY)

Members list (2/4)

- **IGUASSU Software Systems Ltd** (CZECH REPUBLIC)
- **IMEC** (BELGIUM)
- **INDRA ESPACIO** (SPAIN)
- **INECO** (SPAIN)
- **INFORMATION TECHNOLOGY SERVICE** (ITALY)
- **INSYST** (FRANCE)
- **INTECS SISTEMI** (ITALY)
- **I-SPACE** (FRANCE)
- **KONGSBERG** (NORWAY)
- **LABEN** (ITALY)
- **LEICA GEOSYSTEMS** (SWITZERLAND)
- **LNR GLOBALCOM** (THE NETHERLANDS)
- **LOGICA** (UNITED KINGDOM)
- **LOPOS TECHNOLOGIES** (GERMANY)
- **M3 SYSTEMS** (FRANCE)
- **MAN TECHNOLOGIE** (GERMANY)
- **MANNESMANN VDO** (GERMANY)
- **MARCOSOFT** (ITALY)
- **MLR Electronique** (FRANCE)
- **MORS** (FRANCE)
- **MUNICH ORIENTATION CONVENTION** (GERMANY)
- **N2C** (FRANCE)
- **NATIONAL PHYSICAL LABORATORY** (UK)
- **NATS** (UK)
- **NAVIGATION TECHNOLOGIES** (BELGIUM)
- **NAVIONICS** (ITALY)
- **NAVOCAP** (FRANCE)
- **NEMERIX** (SWITZERLAND)
- **Neos Iann** (ITALY)
- **NEXANS** (BELGIUM)
- **NEXT** (ITALY)
- **NOKIA** (FINLAND)
- **NORDNAV TECHNOLOGIES** (SWEDEN)
- **OMNISTAR BV** (THE NETHERLANDS)
- **ORMSTON** (UK)
- **PIONEER TECHNOLOGY** (BELGIUM)
- **POLE STAR** (FRANCE)
- **PRAXIS CRITICAL SYSTEM** (UK)
- **Q-SYSTEMS** S.A.
- **RAYTHEON** (UK)
- **ROBERT BOSCH** (GERMANY)
- **ROKE MANOR RESEARCH** (UK)
- **SAGEM** (FRANCE)
- **SATCON** (GERMANY)
- **SATPLAN** (FRANCE)

Members list (3/4)

- SCHLUMBERGER SEMA (SPAIN)
- SENA GPS (SPAIN)
- SENER (SPAIN)
- SEPTENTRIO (BELGIUM)
- SGIC (Suède)
- SKEYE (GERMANY)
- SKYSOFT (PORTUGAL)
- SPACECHAKER (BELGIUM)
- SPACE SYSTEM FINLAND (FINLAND)
- SPIRENT COMMUNICATIONS (UK)
- ST MICROELECTRNICS (UK)
- STA (ITALY)
- SURREY SATELLITE TECHNOLOGY (UK)
- TECHNIUM (FRANCE)
- TECHNOMAR (GERMANY)
- TEKELEC Systèmes (FRANCE)
- TELE ATLAS (BELGIUM)
- TELECONSULT (AUSTRIA)
- TELECONSULT (GERMANY)
- TELEMATICA (GERMANY)
- TELESPAZIO (ITALY)
- TELIT (ITALY)
- TERRAFIX (UK)
- THALES (FRANCE)
- THALES AIBORNE SYSTEMS (FRANCE)
- THALES AIR DEFENCE (FRANCE)
- THALES ATM (GERMANY)
- THALES ATM (UNITED KINGDOM)
- THALES AVIONICS (FRANCE)
- THALES AVIONICS (UNITED KINGDOM)
- THALES COMMUNICATIONS (FRANCE)
- THALES NAVIGATION (FRANCE)
- THALES RESEARCH (UNITED KINGDOM)
- THALES TRACKS (UNITED KINGDOM)
- TI-WMC (The Netherlands)
- TTTC Ltd (HUNGARY)
- TWENTE INSTITUTE FOR WIRELESS AND MOBILE COMMUNICATIONS (NETHERLANDS)
- VITROCISET (ITALY)
- ZENITEL (BELGIUM)

Members list (4/4)

NATIONAL GNSS INDUSTRY ORGANIZATIONS

· **ASA - Austrian Space Agency** (Austrian Industry)
· **Navigate Consortium** (Italian Industry)
· **SGIC - Scandinavian GNSS Industry Council** (Scandinavian Industry)
· **GSS - Galileo Sistemas y Servicios** (Spanish Industry)
· **Space Research Centre of Polish Academy of Sciences**

EUROPEAN UNIVERSITY RESEARCH CENTER

·**Centre for Communication Systems Research**, University of Surrey (UK)
·**GIS Research Centre**, University of Glamorgan (UK)
·**Institute of Engineering Surveying and Space Geodesy**, University of Nottingham (UK)
·**Lulea University of Technology** (Sweden)

Galileo Services

- Galileo Services is a non-profit association set-up to support the development of the downstream business
- Its Members are selected on grounds of the expertise and motivation in the future Galileo services
- Galileo Services is a unique blend from SMEs to large industrial groups from a large number of European countries and covering all positioning market sectors
- GS Members are working on a non exclusive basis, promoting cooperation on common interest actions
- GS Members may choose to compete or collaborate on business related actions

Galileo Services Members 1/2

The founding members are :

- Eutelsat
- FDC
- Hispasat
- Indra
- Kongsberg Seatex
- Septentrio
- Telespazio
- Thales

Galileo Services Members 2/2

New 2003 members:

- Ericsson
- LogicaCMG
- Kayser-Threde
- Ineco

New 2004 members:

- Sogei
- Terma
- Skysoft
- Mapflow

Useful Internet links (1/2)

Galileo website:

http://europa.eu.int/comm/dgs/energy_transport/galileo

Navigation page on ESA website:

http:// www.esa.int/export/esaSA/navigation.html

Useful Internet links (2/2)

Contact: info@oregin.net

Website: www.oregin.net

Contact: info@galileo-services.org

Website: www.galileo-services.org

Contact: info@galilean-network.org

Website: www.galilean-network.org

Conclusions

- Galileo will provide Worldwide services with high performances and reliability.
- At least 4 to 6 satellites will be in view from Japan, in addition to GPS and QZSS satellites.
- Free services with better performances than current GPS will be available to any Japanese user.
- Japanese industry will be able to develop Galileo equipment and services.
- Considering
  - the limitations of other systems,
  - Galileo added value (availability, reliability and redundancy, performances…),
  - Japanese market and industry strengths in Road and Mobile Telephony,

Japan will most probably be the first important market of Galileo.