EFTF-FCS Opening Day

Tuesday, MAY 29

Common Sessions with ENC-GNSS 2007

09:00-10:45 PLENARY I - TimeNav'07 OPENING CEREMONY

Introduction	René Dändliker, Honorary TimeNav'07 Chair
Welcome Address	Bernardo Jaduszliwer, TimeNav'07 co-Chair
Welcome Address	Alain Geiger, President, ION-CH
Welcome Address	Arthur Ballato, IEEE-UFFC Society President
Welcome Address	Rein Van Gooswilligen, Chair, EUGIN Council
Welcome Address	Pierre-François Unger, Minister, Canton of Geneva
Welcome Address	Rudolf Dieterle, Director, Swiss Federal Roads Authority
Keynote Speaker	Sylvain Loddo, GALILEO System, Ground Segment and Operations Manager, ESA Keynote Address: "Galileo Status and Perspective"
Programme Information	Edward Byrne, Local Organising Committee, FSRM

11:30-13:00 PLENARY II - NAVIGATION SYSTEMS STATUS

Chair:	Prof. Brad Parkinson, Stanford University, USA
GPS	Mr. Ray Clore, Senior Advisor for GPS-Galileo Issues, U.S. Department of State
Galileo	Dr. Hermann Ebner, Head of Technical Department, European GNSS Supervisory Authority (GSA)
The International GNSS Service (IGS) in Support of Geoscience and Society	Dr. Gerhard Beutler, Director, Astronomisches Institut, Universität Bern
Downstream Industry: Concerns and Expectations for Galileo	Mr. Gard Ueland, Chairman of Galileo Services

14:30-16:00 PLENARY III - PANEL DISCUSSION

Title: Timing and Navigation Communities: Cohabitation or Full Partnership?

Chair: Prof. Vidal Ashkenazi, Chief Executive Nottingham Scientific Ltd.

Panellists:
Mr. Jean-François Bou (THALES), Interim CEO of the Galileo Concessionnaire
Mr. Pascal Rochat, CEO of Temex Neuchâtel Time SA
Prof. Christoph Günther, Director Communications & Navigation, D.L.R.
Dr. Lute Maleki, Senior Research Scientist, JPL, and co-Founder of OEwaves
Mr. Gian-Gherardo Calini, Head of the Market Development Dept, GSA

16:30 - 18:30 EFTF-FCS Poster Session

Galileo Status and Perspective

Sylvain LODDO

Galileo Project Office – System, Ground Segment & Operations Manager

European Space Agency

TIME NAV'07

Geneva 29 May 2007

Keynote Address

- **GALILEO is a strategic venture essential for Europe: for reaching its autonomy in satellite navigation and fostering related economic/ societal benefits**
- **GALILEO has the characteristics to make it the reference Global Satellite Navigation System**
- **Significant and concrete achievements have been completed (EGNOS, GIOVE), which confirm that the European strategy is progressively implemented**

But

- **Important delays and overcosts have been accumulated, mainly linked to programme management/ industrial organisation problems**

- **Major redefinition of the programme approach is currently under way (EC communication, decision expected in June 2007) that will stabilize its implementation in the long run**

Part 1 - GALILEO Characteristics

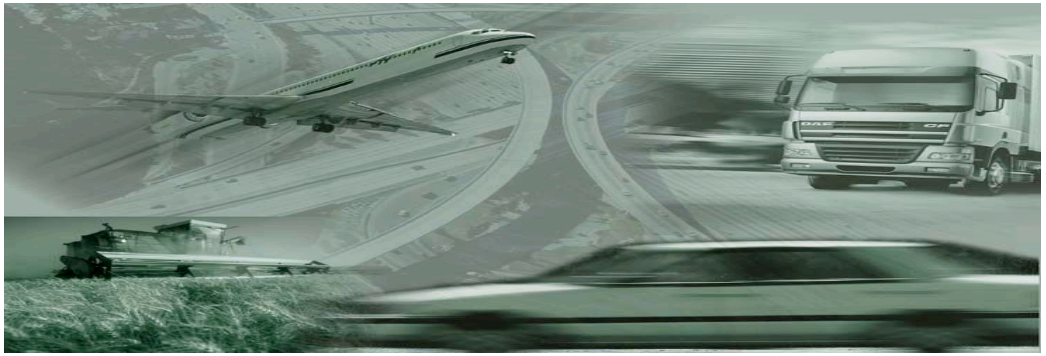
GALILEO System Main Drivers

- No single State and civil control
- Modern system, increased number of signals and bandwidth, new modulations and spreading codes, improved performance, robustness against interference
- Civilian and Government applications with access control capabilities
- Built-in Integrity, Safety and Security
- Built-in Regional and Local components
- Service guaranteed
- Fully interoperable with other GNSS components
- Open for international co-operation

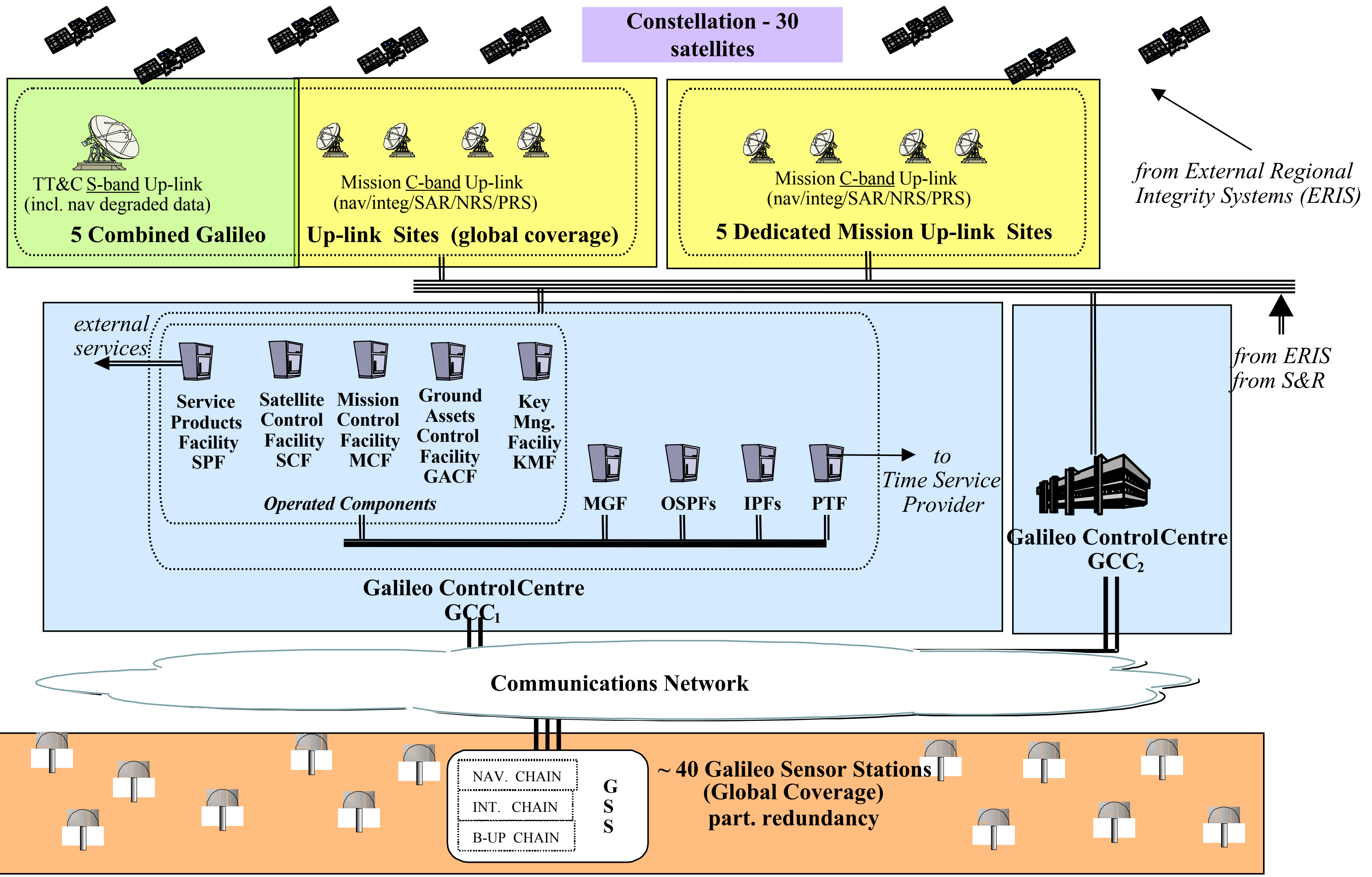
GALILEO Services Definition

- Open Service
- Commercial Service
- Safety-Of-Life Service
- Public Regulated Service

- Support to Search-and-Rescue Service



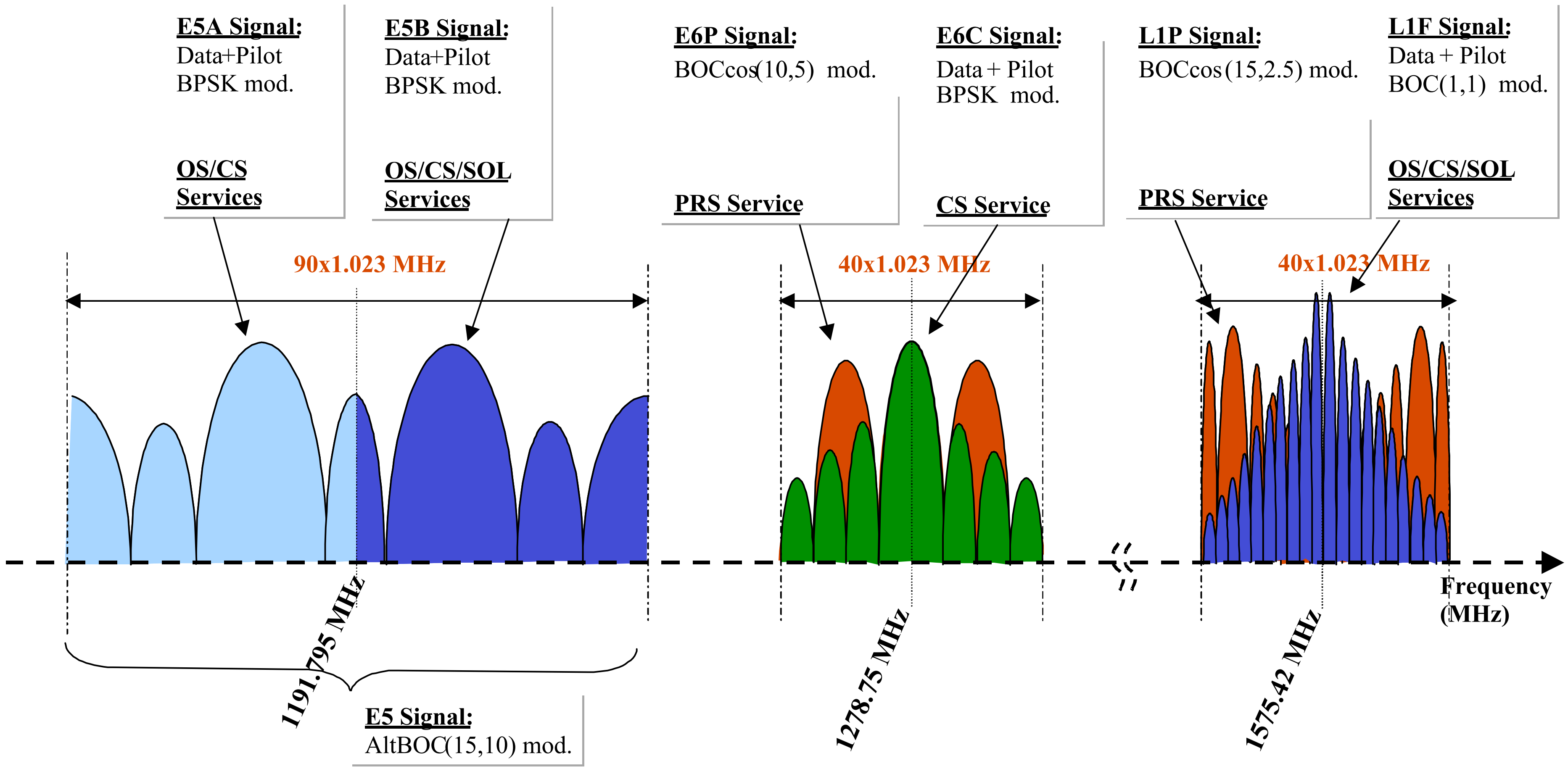
GALILEO FOC System Architecture



Services Performances

GALILEO Global Services	Open Service	Commercial Services	Safety of Life Services
Coverage	Global	Global	Global
Positioning Accuracy	15 m H - 35 m V (single frequency) 4 m H - 8 m V (dual frequency)		4 m H - 8 m V (dual frequency)
Timing Accuracy	30 nsec		30 nsec
Availability	99.5%	99.5%	99.5%
Integrity	None	None	Required
Alert Limit			12 m H - 20 m V
Time to Alert			6 seconds
Integrity Risk			3.5×10^{-7} / 150 seconds
Continuity Risk			1.0×10^{-5} / 15 seconds
Access Control	Free Open Access	Controlled Access of Ranging Code and Nav Data Message	Authentication
Certification and Service Guarantees	None	Guarantee of Service Possible	Build for Certification and Guarantee of Service

GALILEO Signals Overview



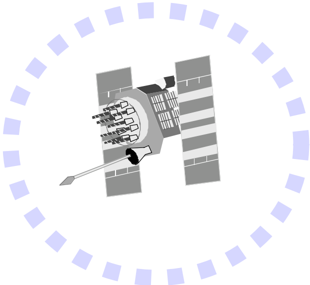
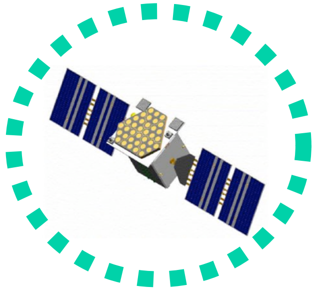
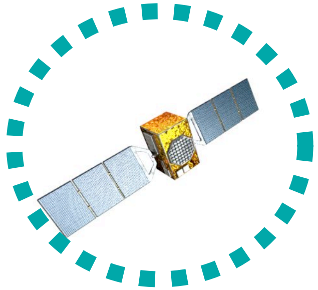
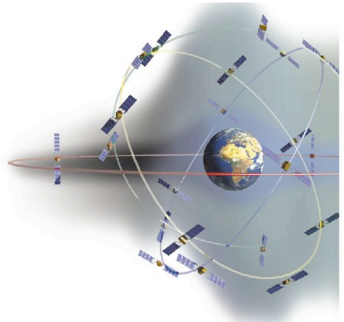
Part 2 – GALILEO at the Crossroads

EC Communication

- **The initial concept of the concession process could not be implemented**
- **The success of the programme as well as the protection and continuity of the past investments should rely on a public procurement of the overall Infrastructure, with a PPP approach focused on Services**
- **EGNOS operational introduction has to be secured in 2008**
- **ESA role should be reinforced to overall GALILEO design authority and procurement agent under an ESA/EC cooperation scheme**
- **Future funding of EGNOS and GALILEO should be based on EU funds, the requested funding exceeding the current earmarked budget (1 B€) over 2007-2013**

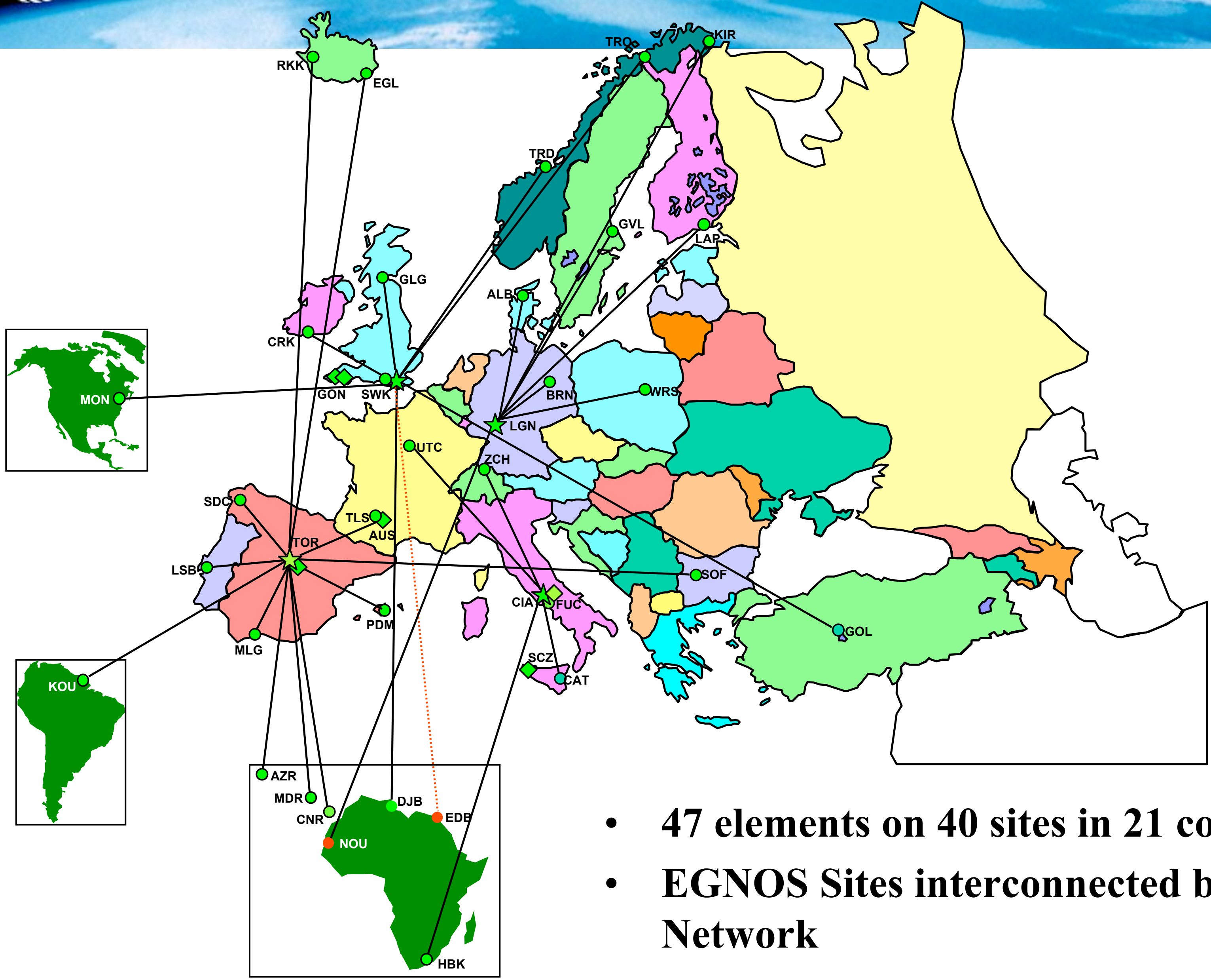
- **The EC proposes a set of decisions to the EU Transport Council scheduled on June 7th 2007**

GALILEO Updated Development Logic

2003	2005-2007	2009	2010-2012
			
GPS Constellation	Galileo Exp. SV (*2)	Galileo In Orbit Validation Const. (*4)	Galileo Full Operation Const. (30)
GSTB V1	GSTB V2	IOV Phase	FOC Phase
Step 1	Step 2	Step 3	Step 4

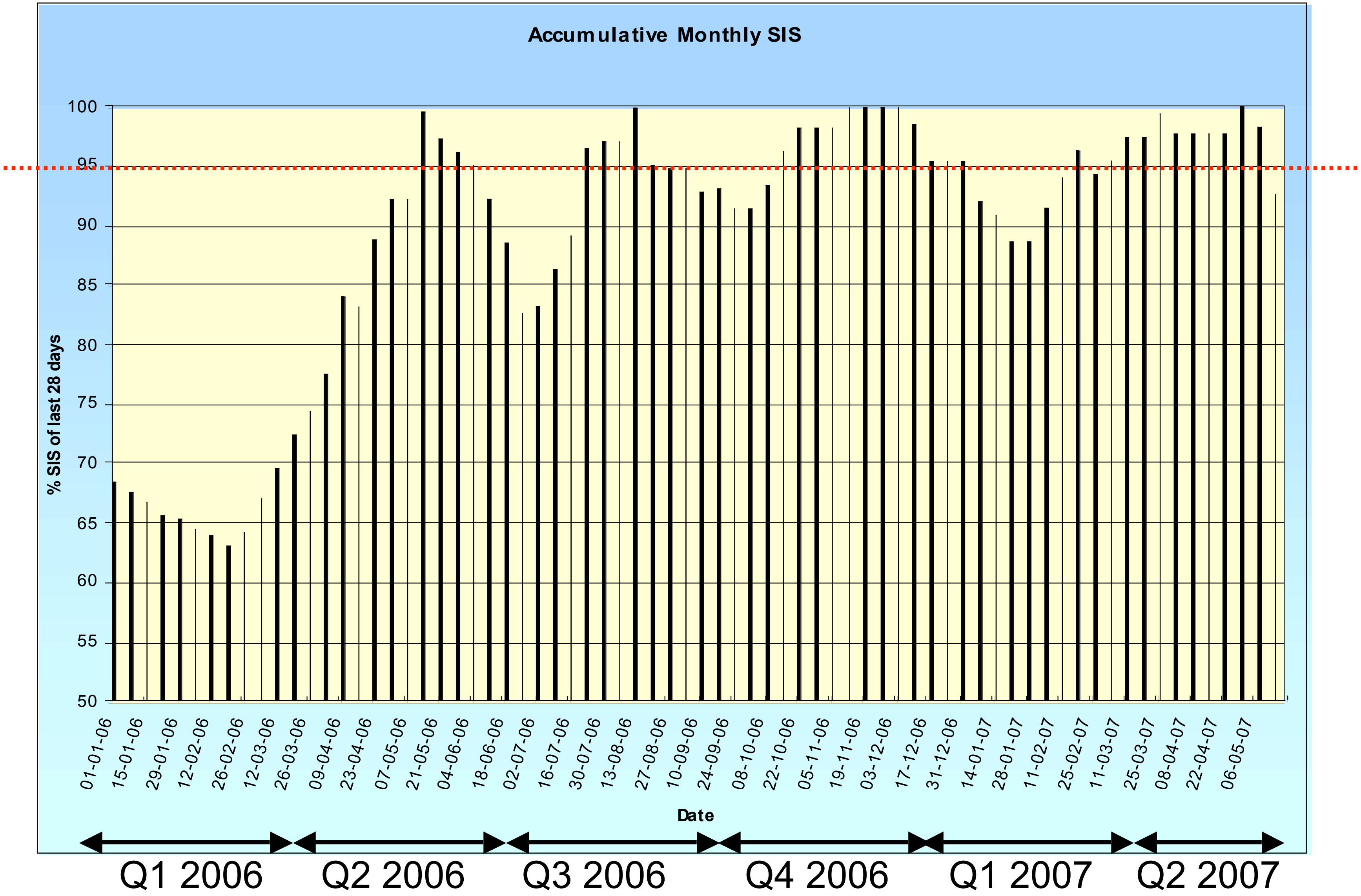
Part 3 – EGNOS Achievements

EGNOS Sites

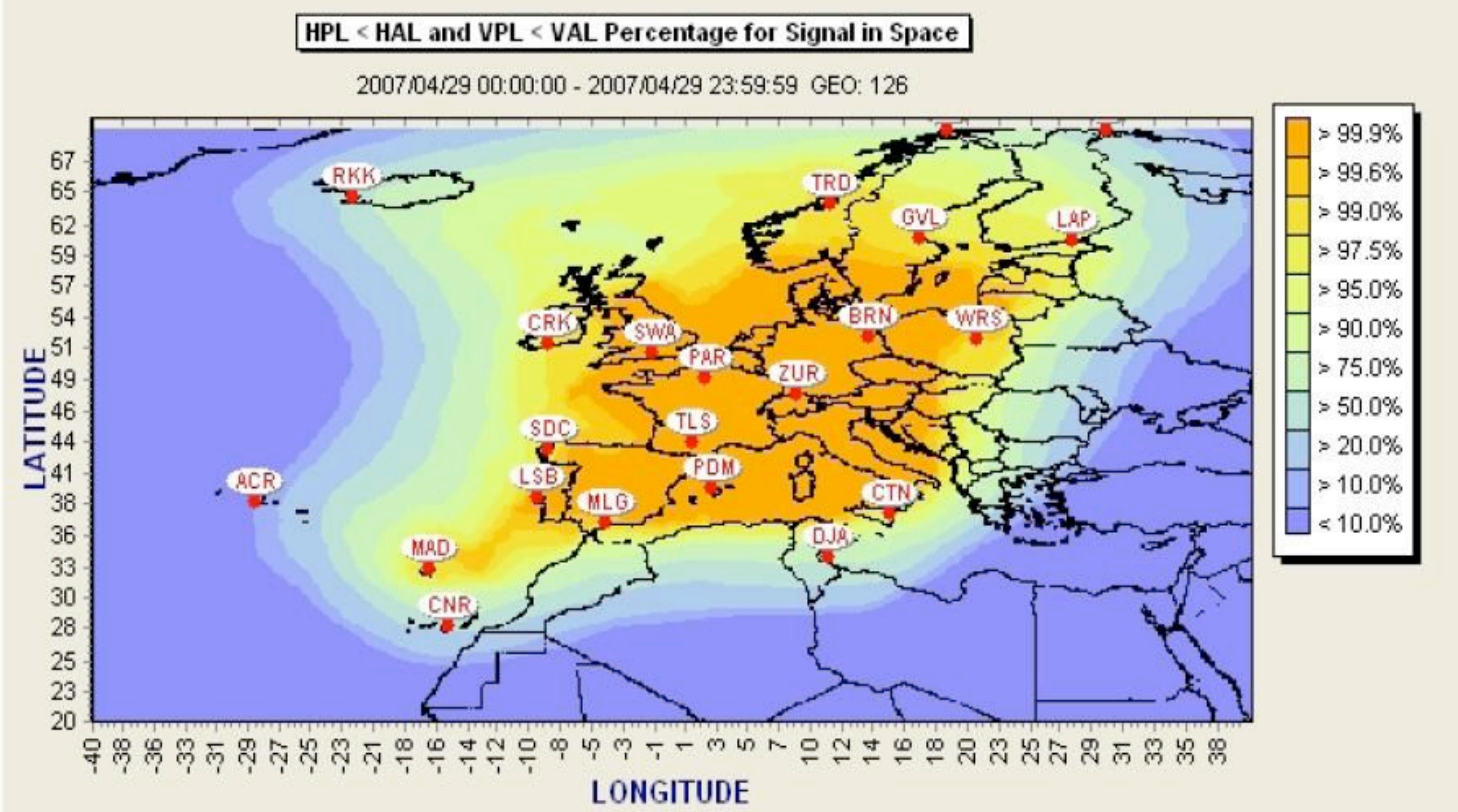


- **47 elements on 40 sites in 21 countries**
- **EGNOS Sites interconnected by Digital Network**

Towards an Operational EGNOS (1/2)



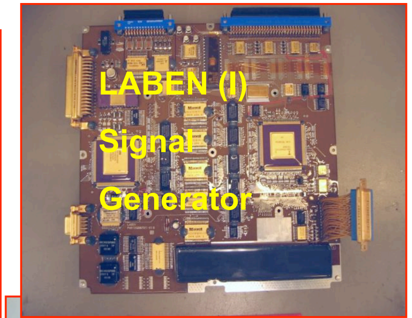
Towards an Operational EGNOS (2/2)

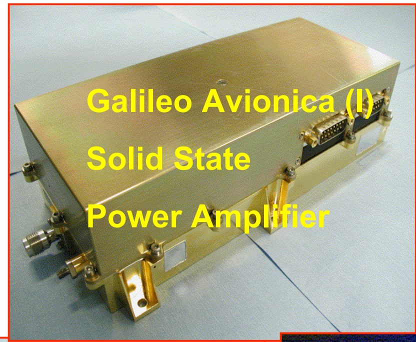


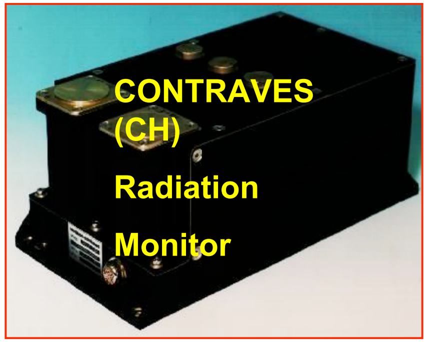
29/04/07:APV1 service area, PRN126

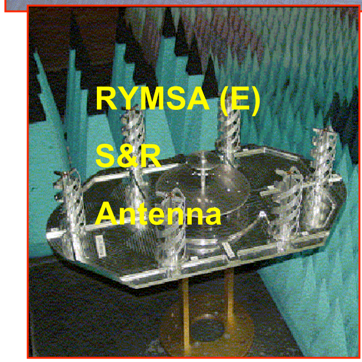
Part 4 – GIOVE Satellites

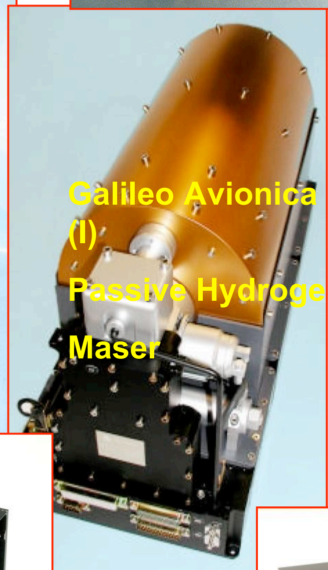
Pre-Developments for Experimental Satellites

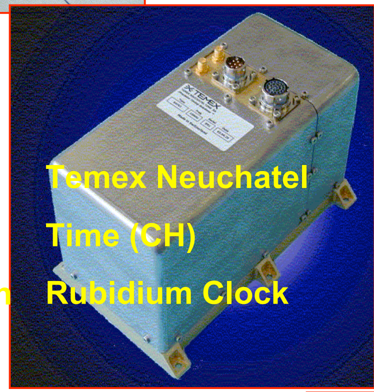


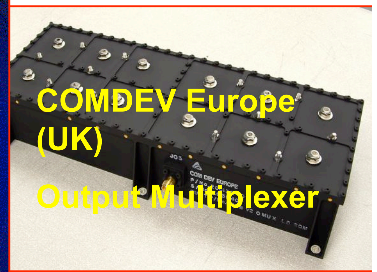


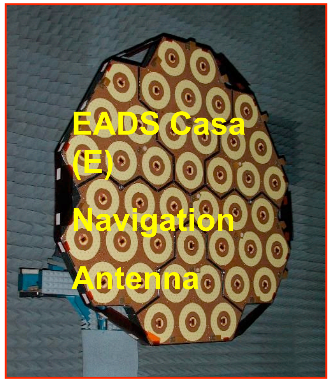


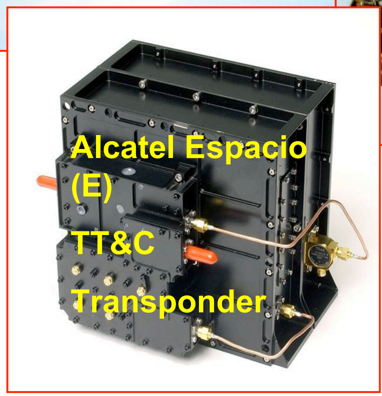










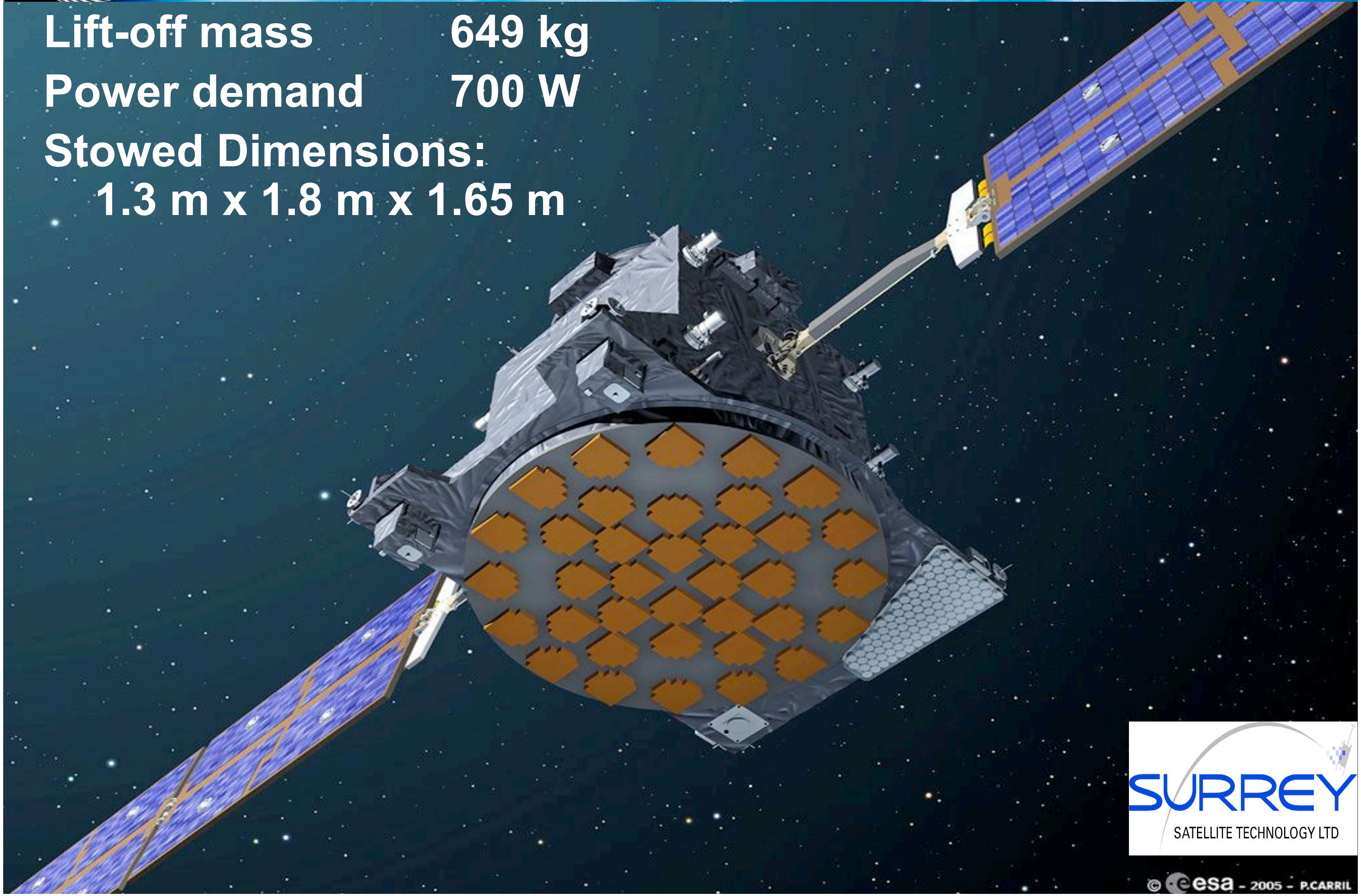


GIOVE-A Satellite

Lift-off mass 649 kg

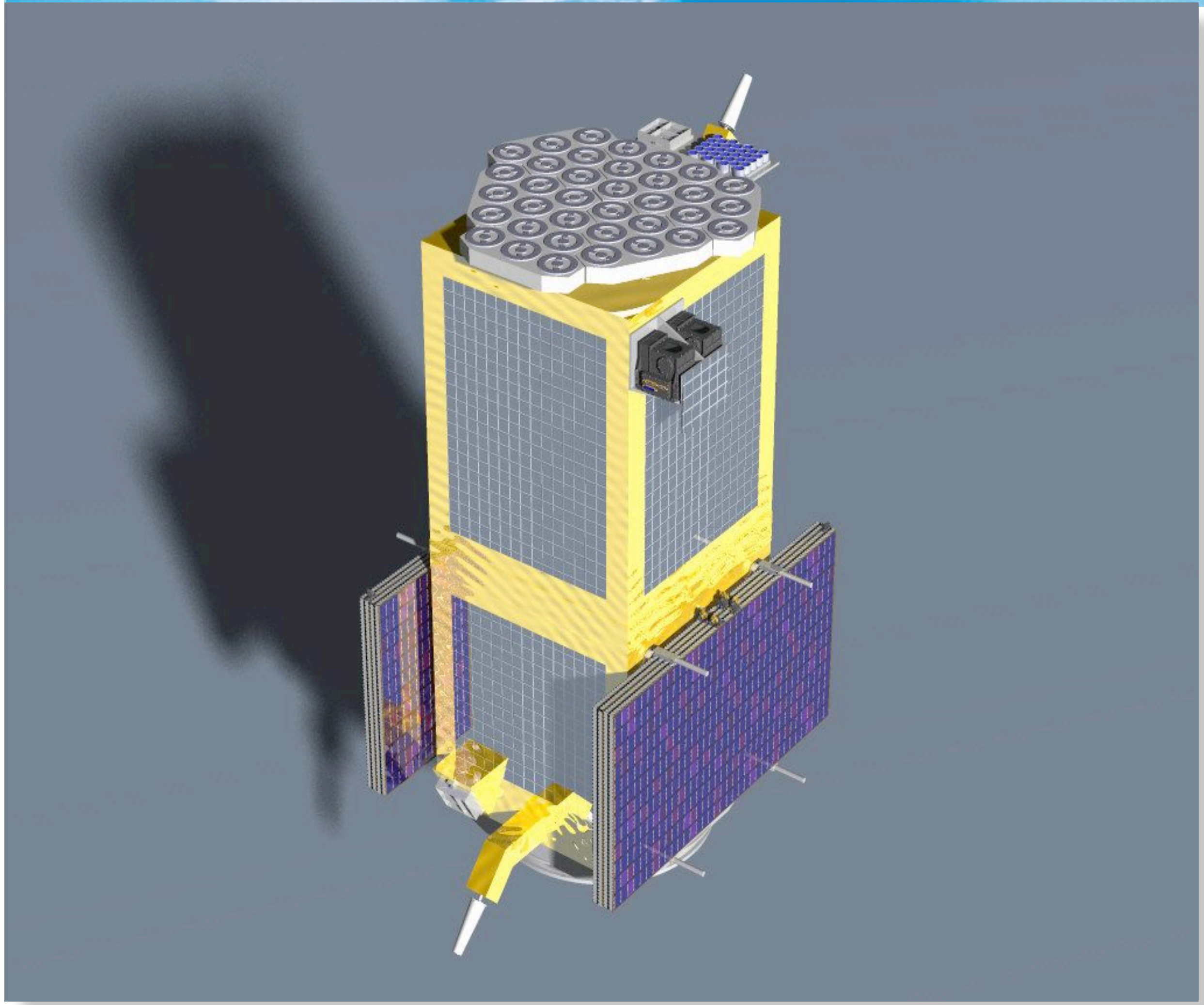
Power demand 700 W

Stowed Dimensions:
1.3 m x 1.8 m x 1.65 m



SURREY SATELLITE TECHNOLOGY LTD

GIOVE-B Satellite



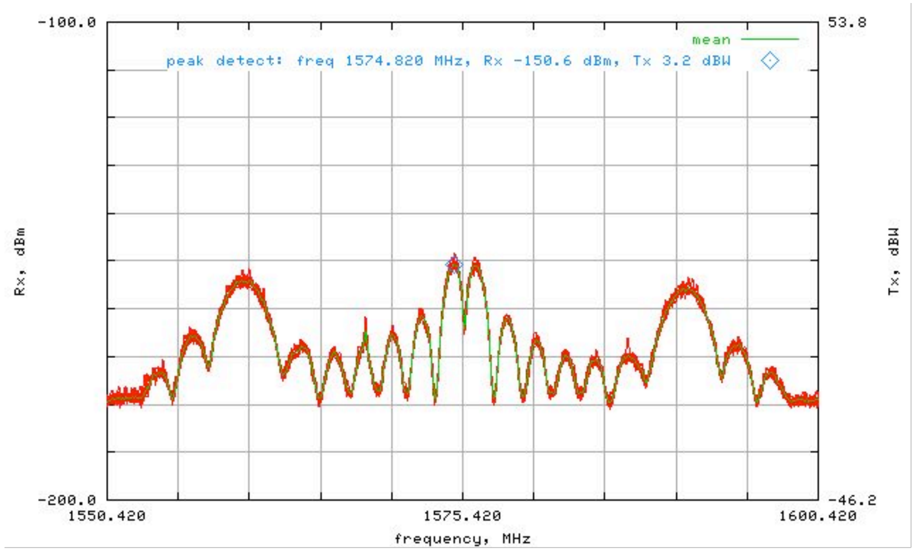
- Lift-off mass 523 kg
- Power demand 943 W
- Stowed Dimensions:

0.955 m x 0.955 m x 2.4 m

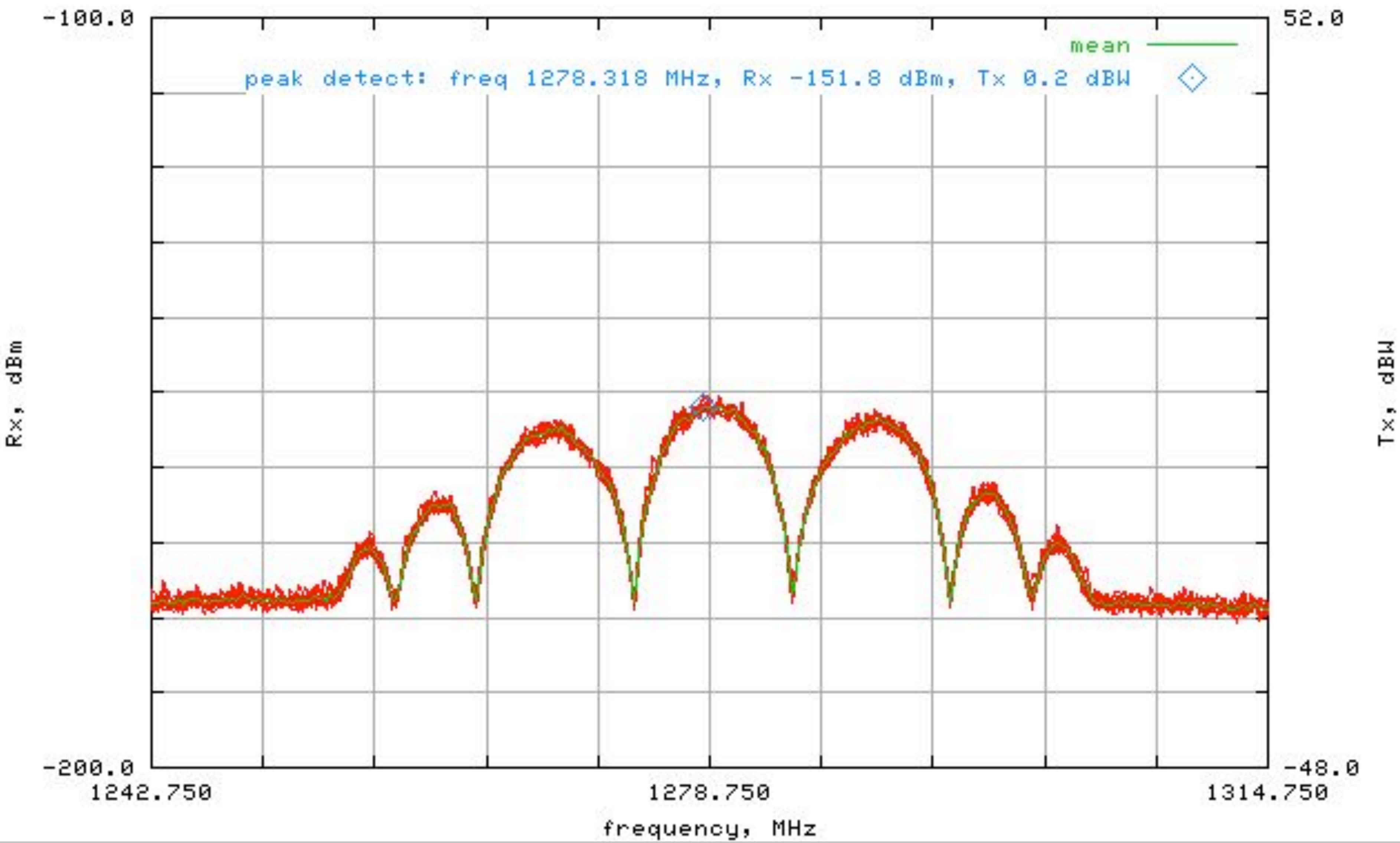
. Launch: December 2007

GIOVE-A Launch

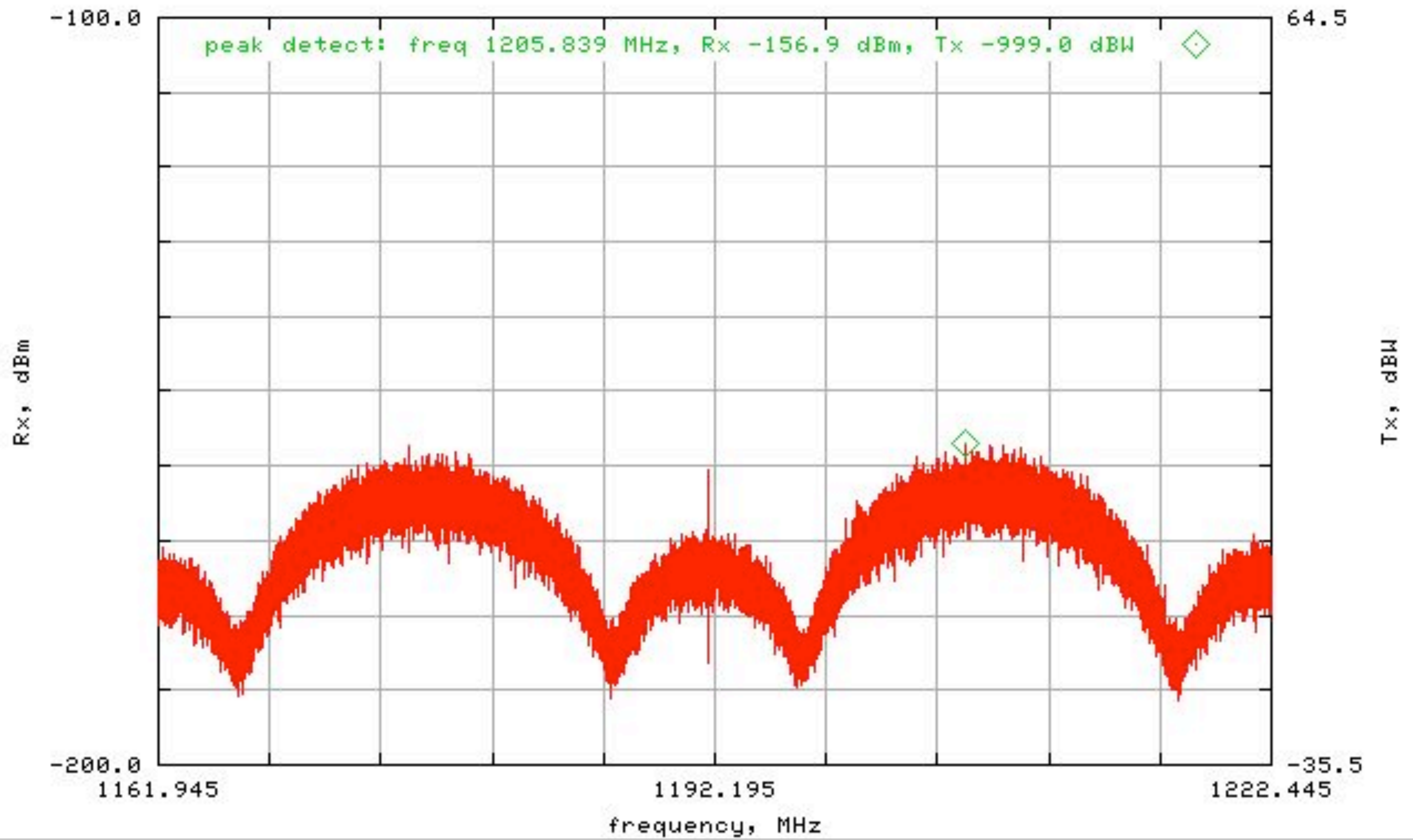
- Soyuz launch on 26th December 2005 from Baikonur
- SIS broadcast from 12th January 2006
- Frequencies brought into use on 3rd March 2006



E6 Interplex Spectrum



E5 AltBOC Spectrum



Part 5 – GIOVE Experimentation

GIOVE Experimentation Objectives

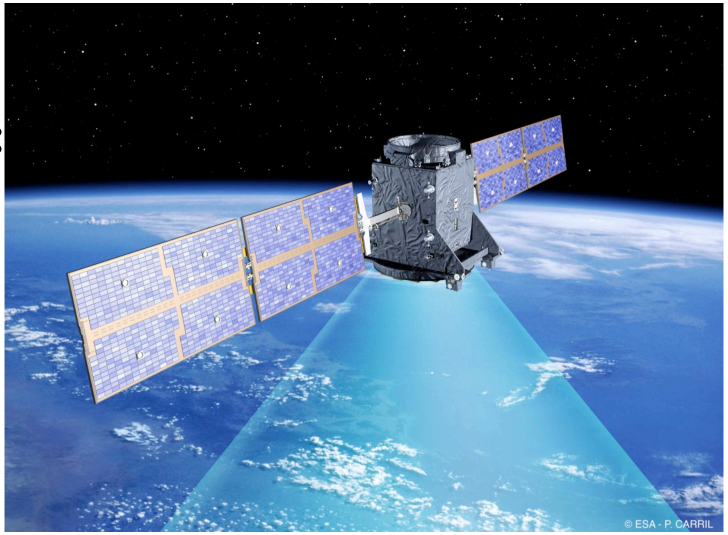
Support field experiments using GIOVE-A (and GIOVE-B) Satellite for:

- **Validating Signal In Space performance in representative environment (RFI and Multipath) conditions**
- **Characterising the On-Board Clock (RAFS and PHM) technology in space**
- **Characterising the Radiation Environment for the Galileo Medium Earth Orbit**
- **Collecting lessons learned on Ground Mission Segment development, deployment and validation especially as far as Galileo Sensor Station are concerned**
- **Collecting lessons learned on Space Segment on-board units pre-development and in-orbit operations**

GIOVE Experimentation (1/2)

A real Galileo system prototype is now in place:

- Satellite on Medium Earth Orbit
- Satellite Control Centre in Guilford, UK
- Mission Control Centre at ESTEC, NL
- 13 Sensor Stations worldwide
- Ground Receivers



Payload performance in orbit very similar to reference ground based tests

Operational 86% time

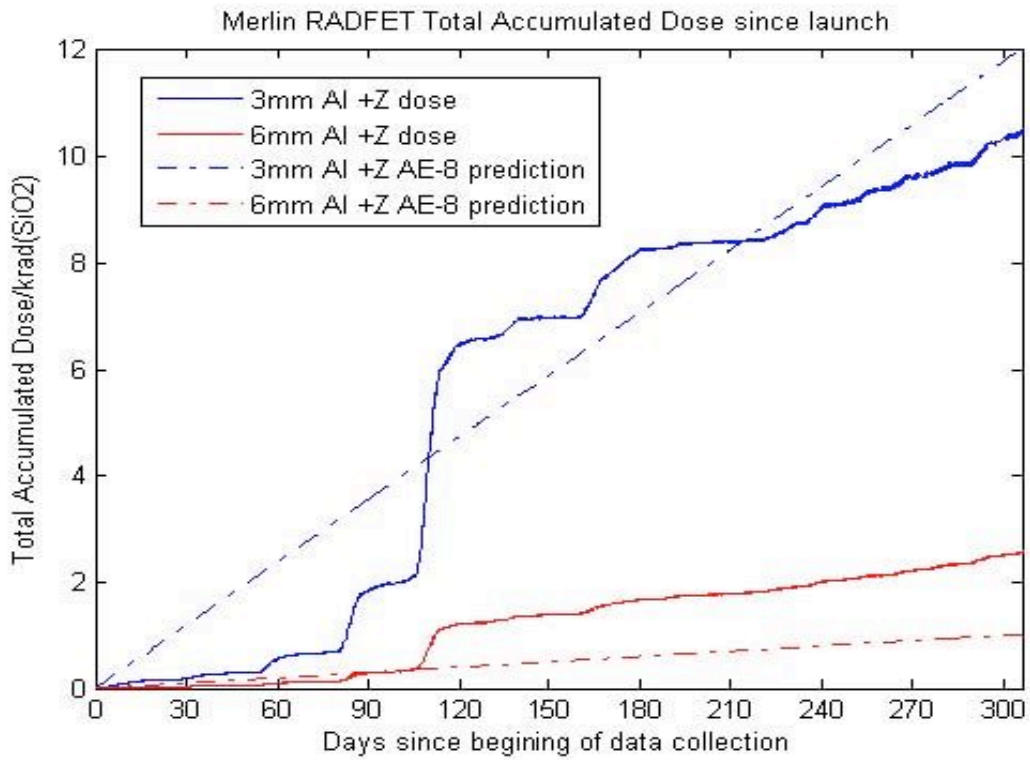
Results largely in line with specifications

GIOVE Experimentation (2/2)

- Galileo Signal In Space design is confirmed by measurements on the field
- On board clock performance specification appears feasible and with margin (in nominal conditions)
- Sensor station tracking error specification for Galileo Sensor Stations is confirmed
- Corresponding models extracted from GIOVE data have been provided to Ground Mission Segment for Raw Data Generator validation
- System Performance Budget File will be updated accordingly
- One-year operation in orbit has allowed full characterisation of the RF chain
- GIOVE-A Signal-In-Space is fully representative of GALILEO SIS (GIOVE-A code, navigation message for demonstration)
- SIS ICD and technical information is now publicly available from:

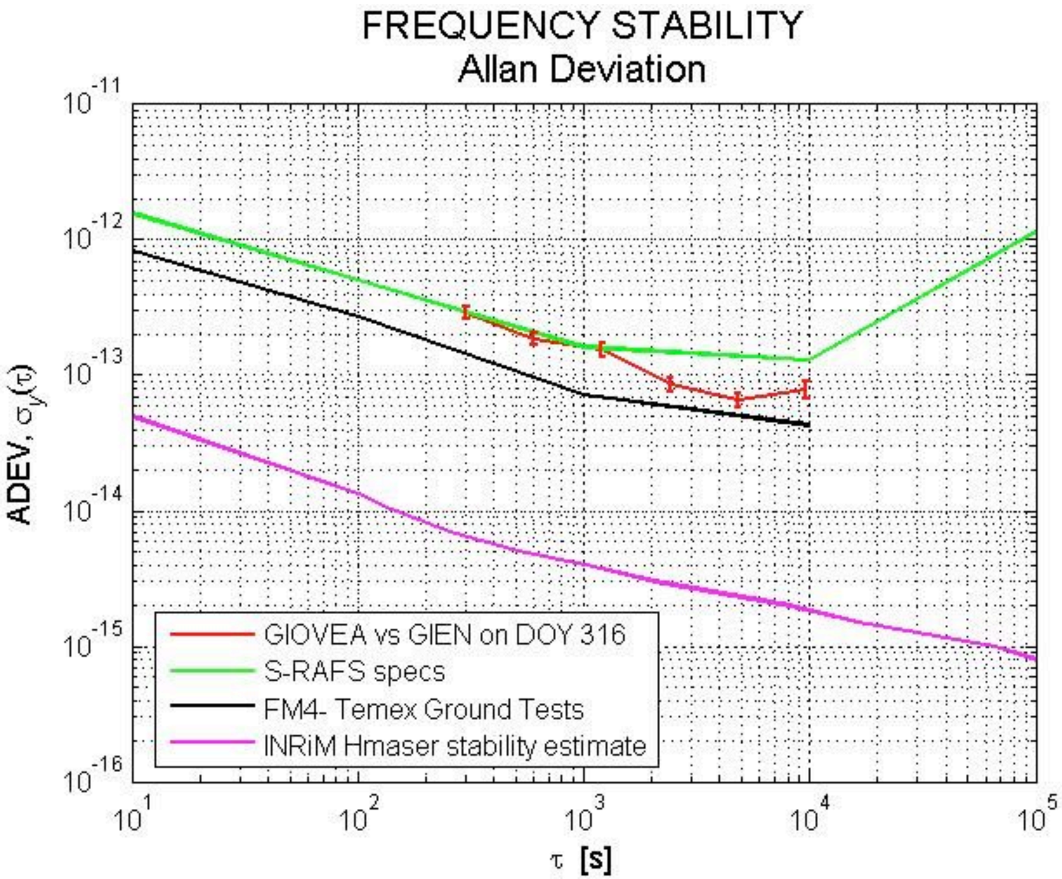
www.giove.esa.int

MEO Environment



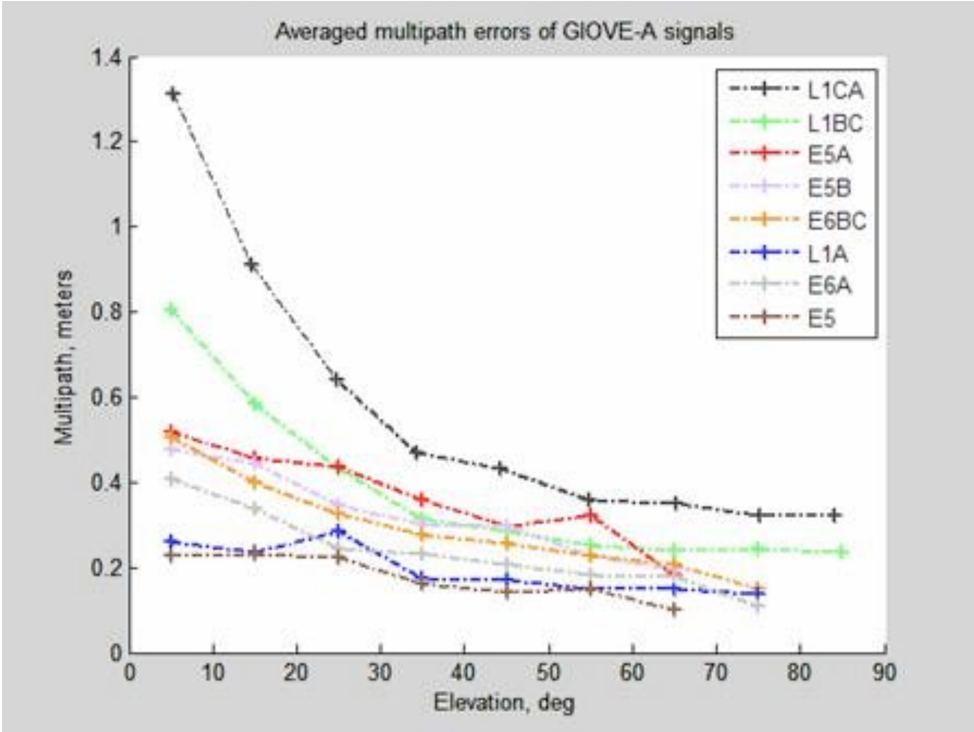
- **3mm-shielded RADFET shows good correlation with AE8 model**
- **6mm-shielded RADFET measurements above model predictions, however data set limited (full 11 year cycle required).**
- **Results still in line with Giove-B/IOV requirements**

Apparent Clock Analysis



- **Apparent Clock is within specification for "quiet" periods**

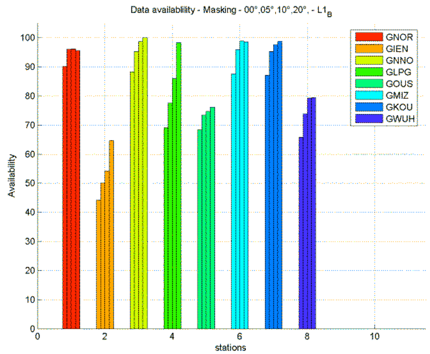
Receivers Code Multipath

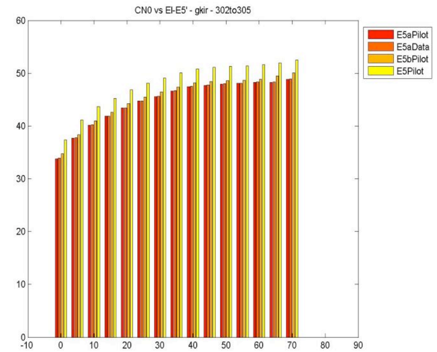


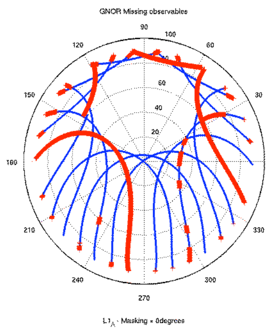
- **All Galileo signals perform significantly better than GPS-CA;**
- **Except at low elevation, no significant differences between BOC(1,1), BPSK(5) and BPSK(10).**
- **AltBOC clearly best signal, as expected.**

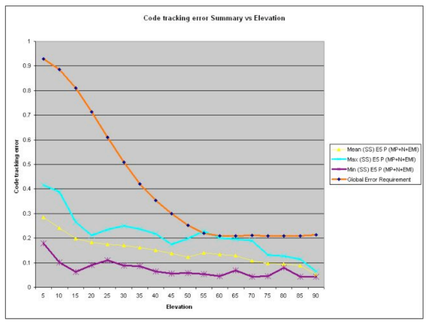
Sensor Stations Characterisation

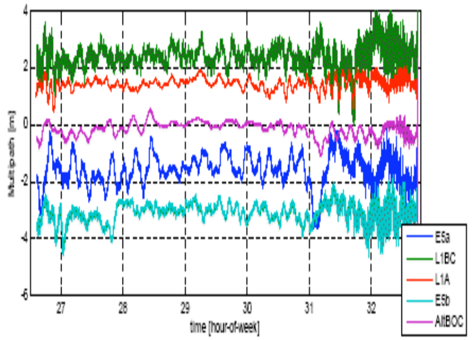
• **A wide range of analyses has been carried out to reach a satisfactory level for the characterisation of sensor stations**

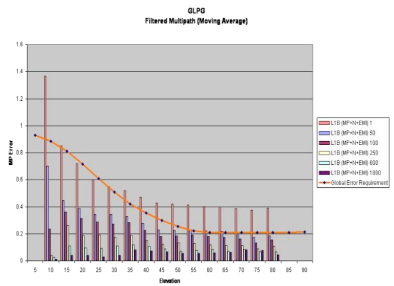


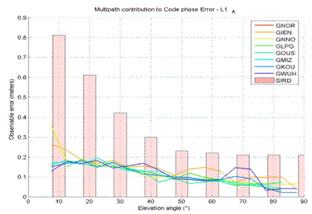


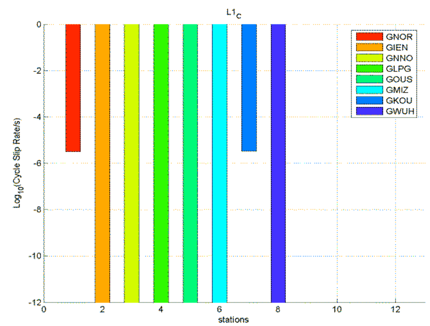












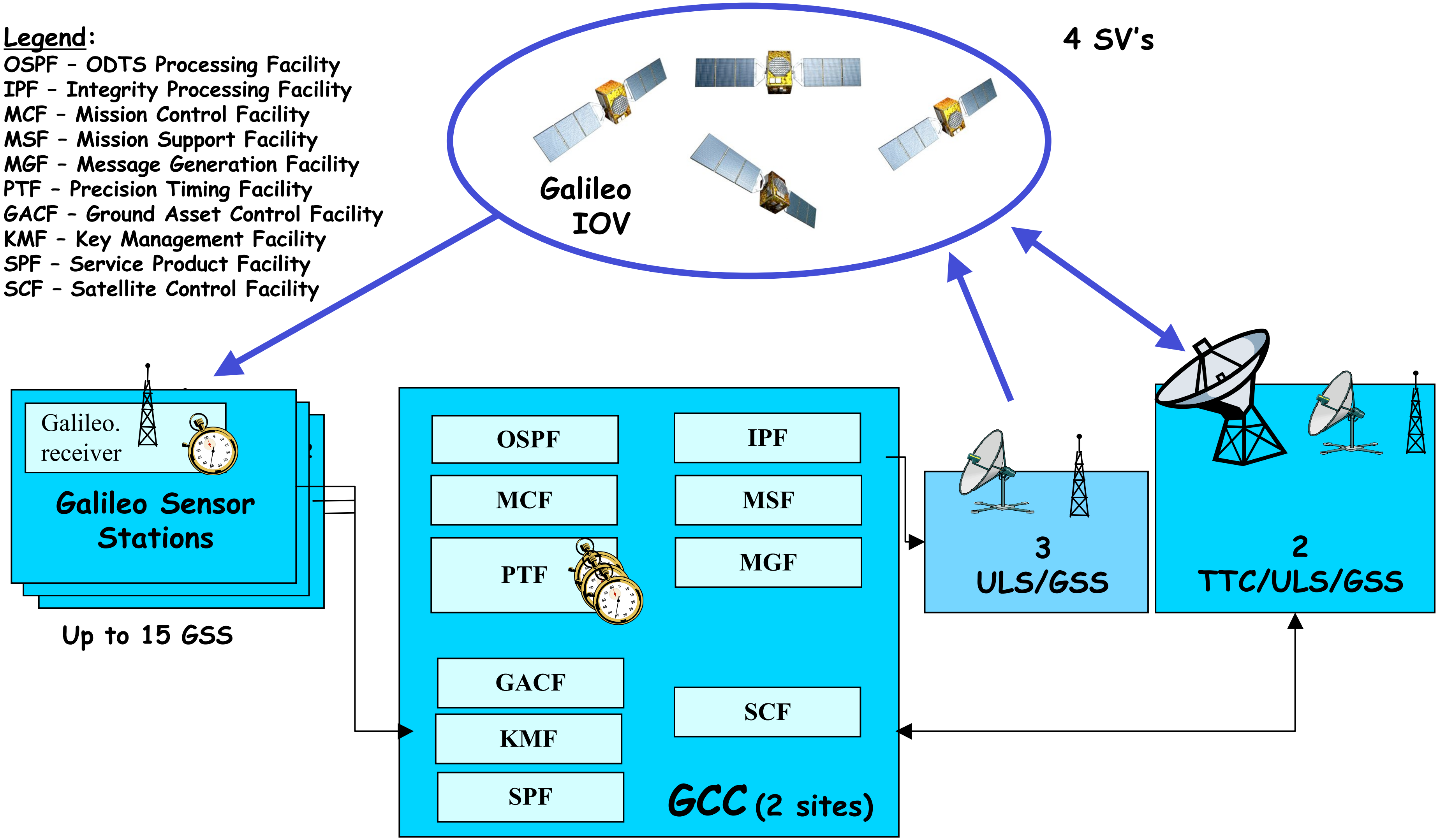
Part 6 – IOV Achievements

GALILEO IOV Phase Objectives

- Verification of all space, ground and user components, including their interfaces, prior to full system deployment
- Assessment of system performance with the view to refine the FOC system prior to full system deployment
- Verification of the adequacy of the site environment requirements.
- Verification of Navigation Processing and of Integrity Processing
- User Equivalent Range Error budget characterisation
- Deployment risk reduction
- Verification of operational procedures

GALILEO 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

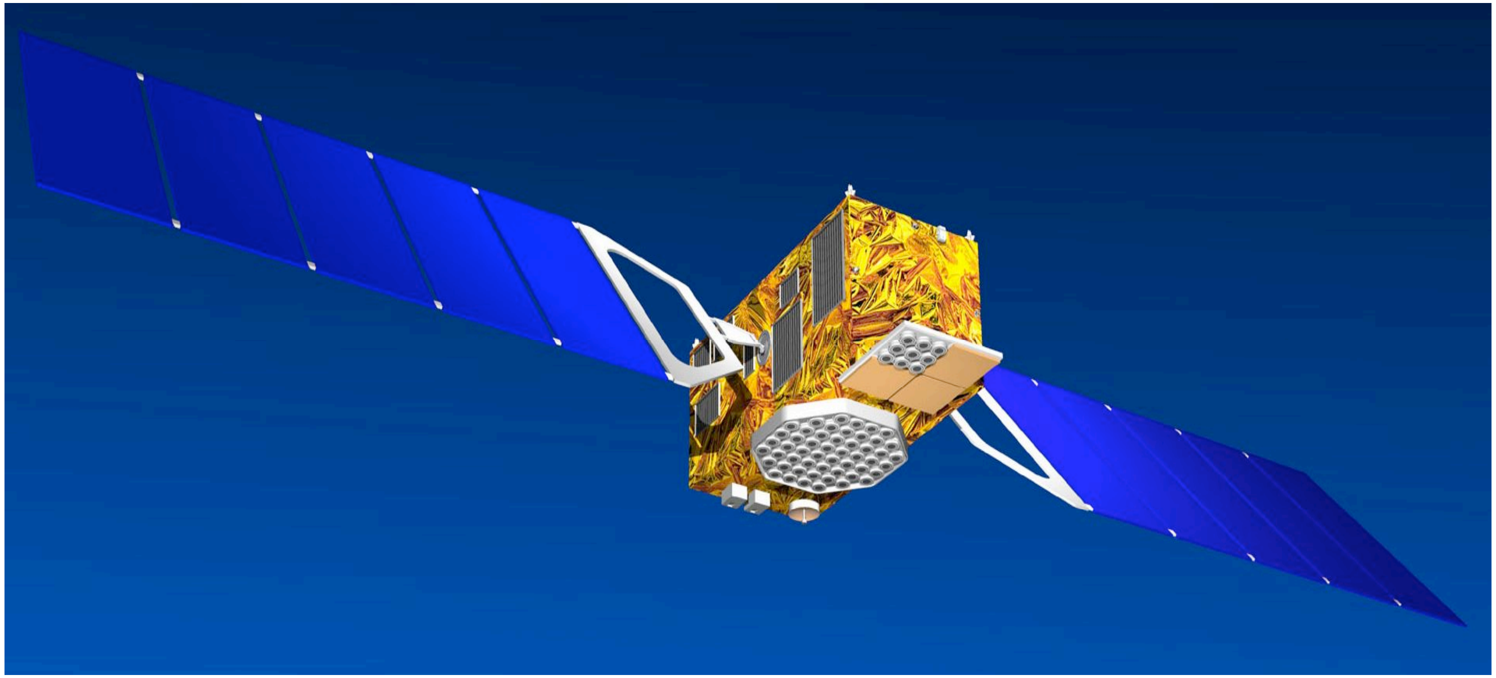


GALILEO IOV Spacecraft

- **Overall Spacecraft: 680 Kg / 1.6 kW class**
- **Launcher Options: Ariane, Proton, Soyuz, Zenit**

- **Navigation payload: 115 Kg / 780 W**
- **SAR transponder: appr. 20 kg / 100 W**

- **Dimensions: 2.7 x 1.2 x 1.1 m3**



GALILEO IOV Phase Status

- Some figures:
  - Phase CDE1 started in December 2004, scheduled to be completed by mid 2009
  - More than 1000 persons actively working on the programme all over Europe
  - More than 400 subcontracts implemented
- Technical baseline fully consolidated from System down to element/ equipment level (security, internal and external interfaces)
- Selection of sites hosting IOV Galileo remote stations (TTC, ULS, GSS) well under way
- Implementation of the Galileo Control Centre on 2 sites (on final FOC locations)
- Advancement status is between PDR and CDR at element/ equipment level
- Deployment of Ground Segment items will be carried out in 2008 as well as the integration of payload equipment and satellite sub-systems, leading to the first launch of IOV satellites end 2008

Part 7 – Way Forward

Continuity is ensured

GIOVE-B planned for launch end of 2007

- **Frequency Filing continuation**
- **Passive Hydrogen Maser Validation In-Orbit**
- **Radiation Environment Monitoring complement**
- **Additional space H/W predevelopment validation**
- **GIOVE B now part of IOV contract**

GIOVE-A2 initiated for guaranteeing European presence in space and maintaining the GIOVE demonstration mission

Future Implementation is Secured

IOV Phase is on-going:

- **Development of GALILEO system on-going**
- **Technical baseline frozen**
- **Optimisation of management**

Transition to FOC infrastructure implementation is being redefined in order to secure its effective and efficient implementation and overall programme management organisation is being reshuffled

ESA has initiated the GNSS Evolution Programme:

- **To maintain European scientific and industrial know how at the best international level and sustain competitiveness and innovation capabilities in the field of Positioning, Navigation and Timing**
- **To pave the way for the gradual evolution of EGNOS and GALILEO, exploring new technologies and new system concepts**

Conclusion

Europe has demonstrated its technical capability to develop operational Navigation systems:

- EGNOS is ready to enter into operations
- GALILEO is moving ahead steadily
- The future is prepared

Europe is now to show its ability to overcome the management and organisational challenges by supporting an appropriate way of developing/ deploying GALILEO infrastructure

Some Good News and Some not so Good News

Professor Bradford Parkinson
Stanford University

GNSS Status

- Good News
  - 50 to 100 ***Million*** users
  - World-wide infrastructure dependence
- Less Good News---
  - So far…World is dependent on
    one, relatively frail (GPS L1 C/A) signal

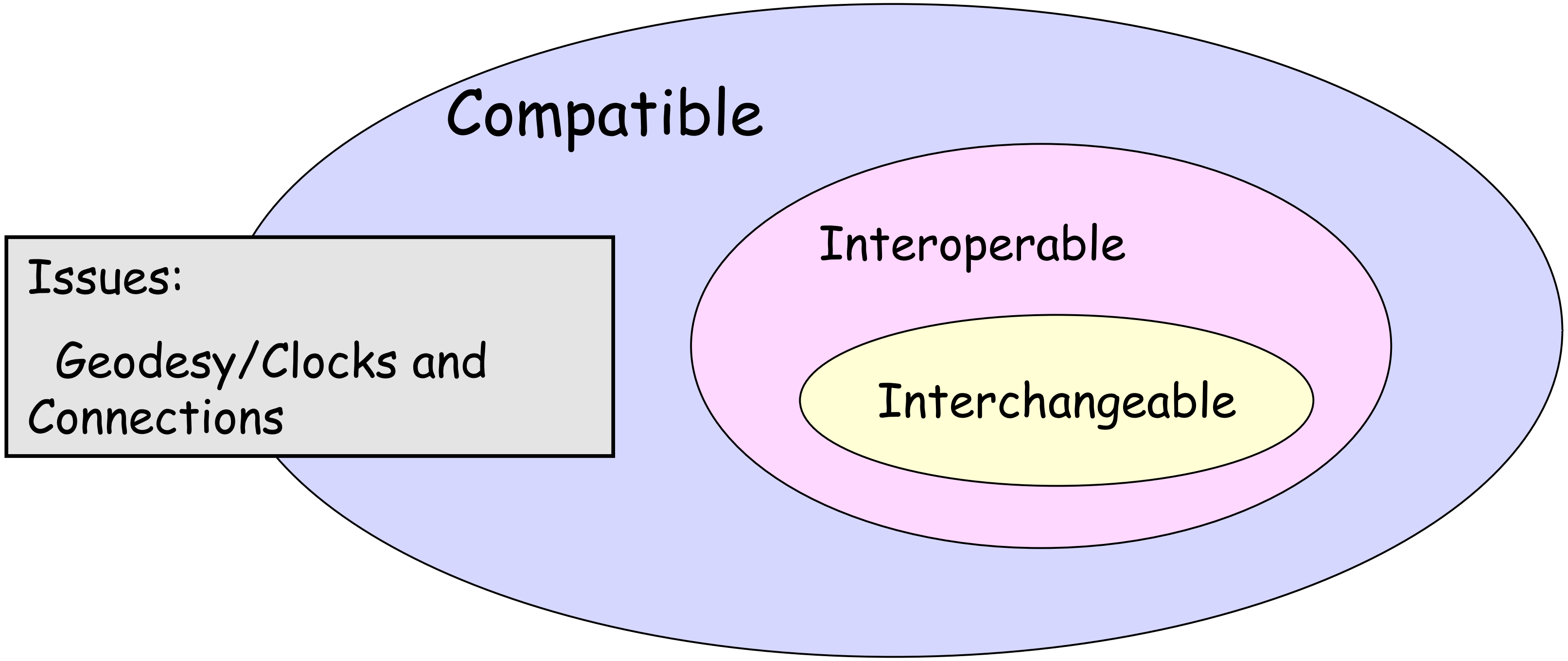
As Providers, Our Commitment must be:

Insure a Robust GNSS (GPtS) Service

What Must We Do?

1. Add Signals and Frequencies
   - ***Interchangeable***

     GPS/GLONASS/Galileo/GZSS



What Must we Do?

- Make Receivers More Robust
  - Inertial Integration
  - New Signals and more Power
  - Antennas
- Provide Out-of-Band Augmentations
  - eLORAN?
  - DME/DME?

URGENCY

GPS Constellation Update

TimeNav'07

Navigation Systems Status

Geneva , Switzerland

29 May-01 June 2007

Ray Clore

Senior Advisor for GPS-Galileo Issues

U.S. Department of State

Overview

- **U.S. Government GPS Policy**
- **System Improvements & Modernization**
  - GPS Constellation Status
  - Next Steps for Space and Control Segments
- **Interoperability & International Collaboration**
- **Summary**

The Global Positioning System

- **Baseline 24 satellite constellation in medium earth orbit**
- **Global coverage, 24 hours a day, all weather conditions**
- **Satellites broadcast precise time and orbit information on L-band radio frequencies**
- **Two types of signals:**
  - Standard (free of direct user fees)
  - Precise (U.S. and Allied military)
- **Three segments:**
  - Space
  - Ground control
  - User equipment

GPS: Global Public Service

- **Like the Internet, GPS has become a critical component of the global information infrastructure**
  – Scalable applications enabling broad new capabilities
  – Facilitating innovations in efficiency, safety, environmental, public security, and science
- **Over the past decade, GPS has grown into a global utility providing space-based positioning, navigation and timing (PNT)**
  – Consistent, predictable, dependable policy and performance
  – Augmentations improve performance even further

GPS: Global Public Service

- **Global GPS civil service performance commitment continuously met/exceeded since 1993**
- **Access to civilian GPS service is free of direct user charges**
  - As well as USG augmentation services
- **Public domain documentation**
  - Free and equal availability to all users and industry
  - Equal opportunity to develop user equipment and compete on the world market
- **Owned and operated by the U.S. Government**
  - Managed at national level as multi-use asset
  - Acquired and operated by U.S. Air Force on behalf of USG

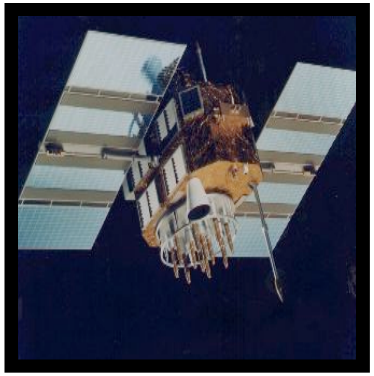
Overview

- **U.S. Government GPS Policy**
- **System Improvements & Modernization**
  - GPS Constellation Status
  - Next Steps for Space and Control Segments
- **Interoperability & International Collaboration**
- **Summary**

Current Constellation

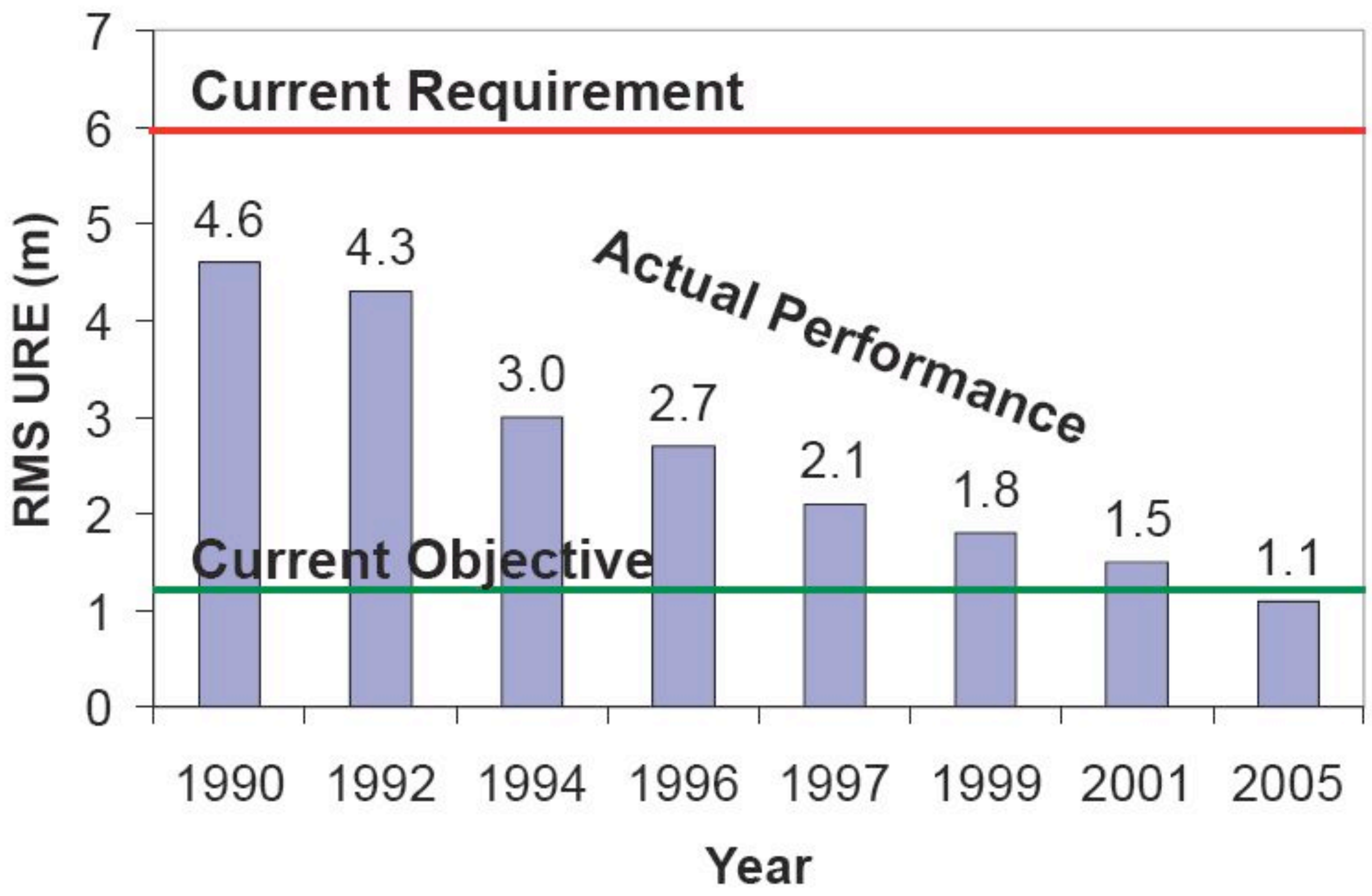
30 Operational Satellites
(Baseline Constellation: 24)

- **15 Block IIA satellites operational**
- **12 Block IIR satellites operational**
  - 5 remaining Block IIR satellites are modernized
- **3 Block IIR-M satellites operational**
  - Transmitting new civil signal (L2C)
- **U.S. Government continuously assessing constellation health to determine launch need**
  - New IIR-M satellites launched
    - » Sep 05, Sep 06, Nov 06
  - Next launch: **Aug/Sep 07**
- **Global GPS civil service performance commitment met continuously since Dec 2003**



IIR-15(M) Launch & ISS View
25 September 2006

GPS constellation – Delivering excellent performance



Overview

- **U.S. Government GPS Policy**
- **System Improvements & Modernization**
  – GPS Constellation Status
  – Next Steps for Space and Control Segments
- **Interoperability & International Collaboration**
- **Summary**

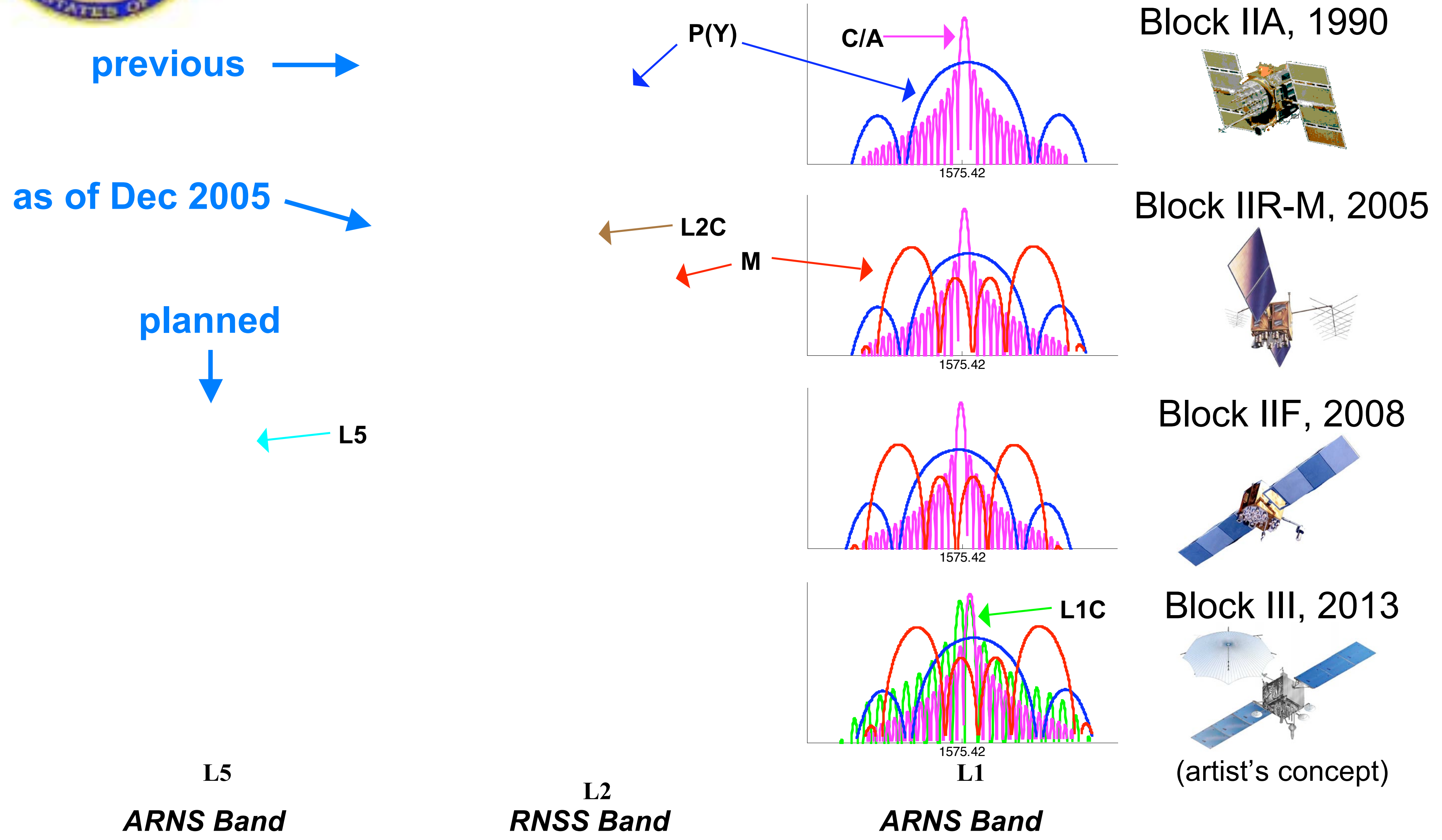
Modernized GPS – Civil Signals

- **Second civil signal (“L2C”)**
  - Designed to meet commercial needs
    - » Higher accuracy through ionospheric correction
    - » Higher effective power and improved data structure reduce interference, speed up signal acquisition, enable miniaturization of receivers, may enable indoor use
  - Began with GPS Block IIR-M in Sep 2005; 24 satellites: ~2014

- **Third civil signal (“L5”)**
  - Designed to meet demanding requirements for transportation safety (safety-of-life)
    - » Uses highly protected Aeronautical Radio Navigation Service (ARNS) band
  - Begins with GPS Block IIF
  - First launch: ~2008; 24 satellites: ~2016

- **Fourth civil signal (“L1C”)**
  - Designed with international partners to enable GNSS interoperability
  - Begins with GPS Block III
  - First launch: ~2013; 24 satellites: ~2021

GPS Modernization – Spectrum



GPS Evolutionary "System-of-Systems" Programs

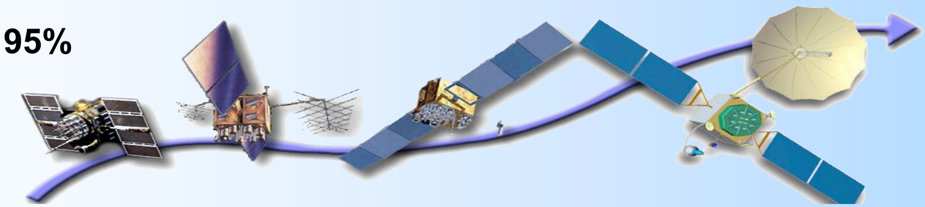
Space Segment

Legacy (Block IIA/IIR)
- Std Service (≤ 6 meters RMS SIS SPS URE)
  - Single frequency (L1)
  - Coarse acquisition (C/A) code navigation
- Precise Service (≤ 2.6 m 95% URE PPS at Zero AOD)
  - Y-Code (L1Y & L2Y)
  - Y-Code navigation

Modernized (Block IIR-M)
- 2nd civil signal (L2C)
- M-Code signals (L1M, L2M)
- Anti-jam flex power

Modernized (Block IIF)
- 3rd civil signal (L5)

GPS III (Block III)
- Increased accuracy
- Increased A/J power
- Signal integrity
- Search and Rescue
- L1C civil signal common w/Galileo, QZSS, & possibly GLONASS



Ground Segment

Legacy
- TT&C
- L1 & L2 monitoring

Upgraded (AEP)
- IIR-M IIF TT&C
- WAGE, AII, LADO
- NMCS/AMCS

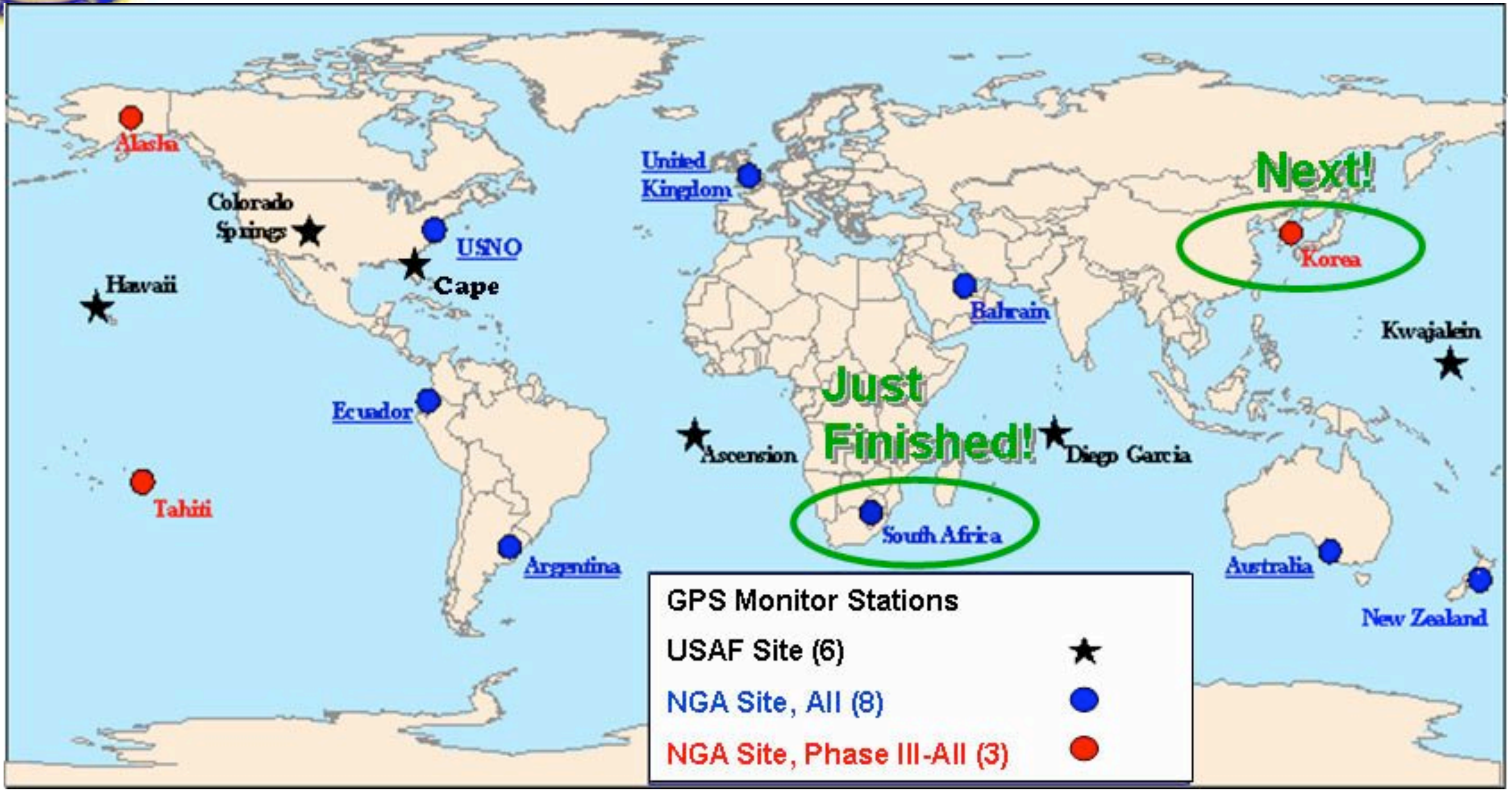
Modernized (OCX V1)
- New Architecture
- Signal Monitoring

GPS III (OCX V2)
- GPS III TT&C
- Real-Time C2

GPS OCS Modernization Status

- **Transitioning from old to new ground segment Summer 2007**
- **OCS Modernization impacts every element of OCS architecture**
- **Architecture Evolution Plan (AEP) migrates OCS from mainframe to distributed architecture -- makes OCS easier to operate/maintain**
  - Legacy control segment over 20 years old; cumbersome operations
  - Two new control stations:
    - New Module at Schriever AFB
    - New Alternate MCS (AMCS) at VAFB
- **AEP provides flexibility to incorporate future requirements**
  - Command and Control for IIF (1st launch scheduled for 2008)

Modernizing the operational control segment (OCS): Legacy Accuracy Improvement Initiative (L-AII)



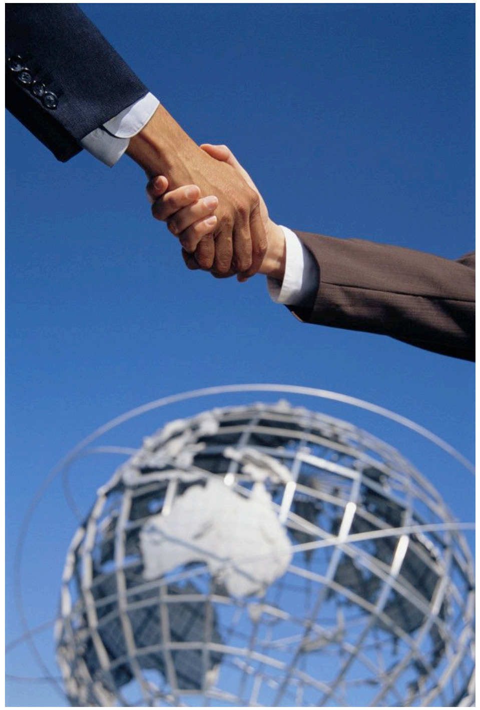
- **Each SV tracked by three or more monitor stations over 99% of time**

Overview

- **U.S. Government GPS Policy**
- **System Improvements & Modernization**
  - GPS Constellation Status
  - Next Steps for Space and Control Segments
- → **Interoperability & International Collaboration**
- **Summary**

International Cooperation

- **Positive results of a decade of diplomatic efforts are beginning to be seen**
  - New satellite constellations and regional augmentations systems, while independently owned and operated, are being designed to be compatible and interoperable
  - Coordination mechanisms are being created to promote interoperability, promote GNSS use, and ensure a level playing field in the global marketplace



GPS-Galileo Cooperation

- **In 2004, United States and European Community signed landmark agreement on GPS-Galileo cooperation**
  - Recognizes importance of compatibility/interoperability for all parties
  - Agreed to spectrally separate signals for military and civilian services
  - Agreed to implement a common, open, civil signal on both Galileo and GPS III
- **Working Groups established to continue dialogue:**
  - Compatibility & Interoperability
  - Trade & Civil Applications
  - Next-Generation GNSS
  - Security Issues
- **Joint Handout on "GPS and Galileo. Progress Through Partnership" distributed at Munich Summit**

June 26, 2004, press conference at U.S.-EU Summit in Ireland (U.S. Sec. of State Colin Powell, Irish Foreign Minister Brian Cowen, EU Vice-President Loyola De Palacio)

GPS-GLONASS Cooperation

- **Discussions on US-Russia agreement on satellite navigation cooperation have been underway since late 2005**
  - Next meeting is planned for second half of 2007
- **Working groups are pursuing GPS-GLONASS interoperability**
  - Enhanced PNT availability through common open service civil signals
  - Cooperative search and rescue capabilities

Other International Cooperation

- **U.S.-Japan: Policy consultations and technical meetings on GPS cooperation since 1996**
  – QZSS fully compatible and interoperable with GPS
- **U.S.-India: Policy and technical consultations on GPS cooperation since 2005**
  – Research into ionospheric distortion/solutions
  – Joint Statement on GNSS Cooperation issued in February 2007 in Washington
- **U.S.-Australia: Joint Delegation Statement on Civil GPS cooperation signed April 2007**
  – Developing enhanced mechanisms for notification of GPS satellite operational changes

International Committee on GNSS (ICG)

- **Emerged from 3rd UNISPACE Conference held in 1999**
- **Promote GNSS use, particularly in developing countries**
- **Encourage compatibility and interoperability among global and regional systems**
- **Unique mix of GNSS providers (US, EU, Russia, Japan, China, India) and international user groups**
  – Focal point for international information exchange
- **First meeting held in Vienna in November 2006**
  – Agreed on terms of reference, work plan, and concept of "GNSS Providers Forum" to address common issues
- **Next meeting in September 2007 in Bangalore, India**

Summary

- **U.S. Space-Based PNT Policy continues to provide stability and transparency for users and industry**
- **Continuing success in GPS sustainment & modernization**
  – New capabilities delivering enhanced performance
  – Developments on track to enhance space and ground control segments
- **International Collaboration**
  – Excellent cooperation with civil service providers
  – Improving RNSS interoperability/compatibility for best GNSS

Contact Information

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This presentation and other GPS information available:
www.pnt.gov and www.gps.gov

Galileo Status

TIME NAV'07

29 May 2007 - Geneva, Switzerland

Dr. Hermann Ebner

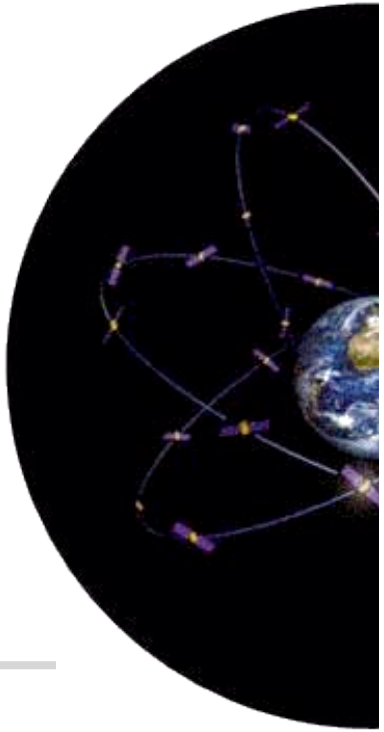
Head of Technical Department

European GNSS Supervisory Authority

Introducing the European GNSS Supervisory Authority (GSA)

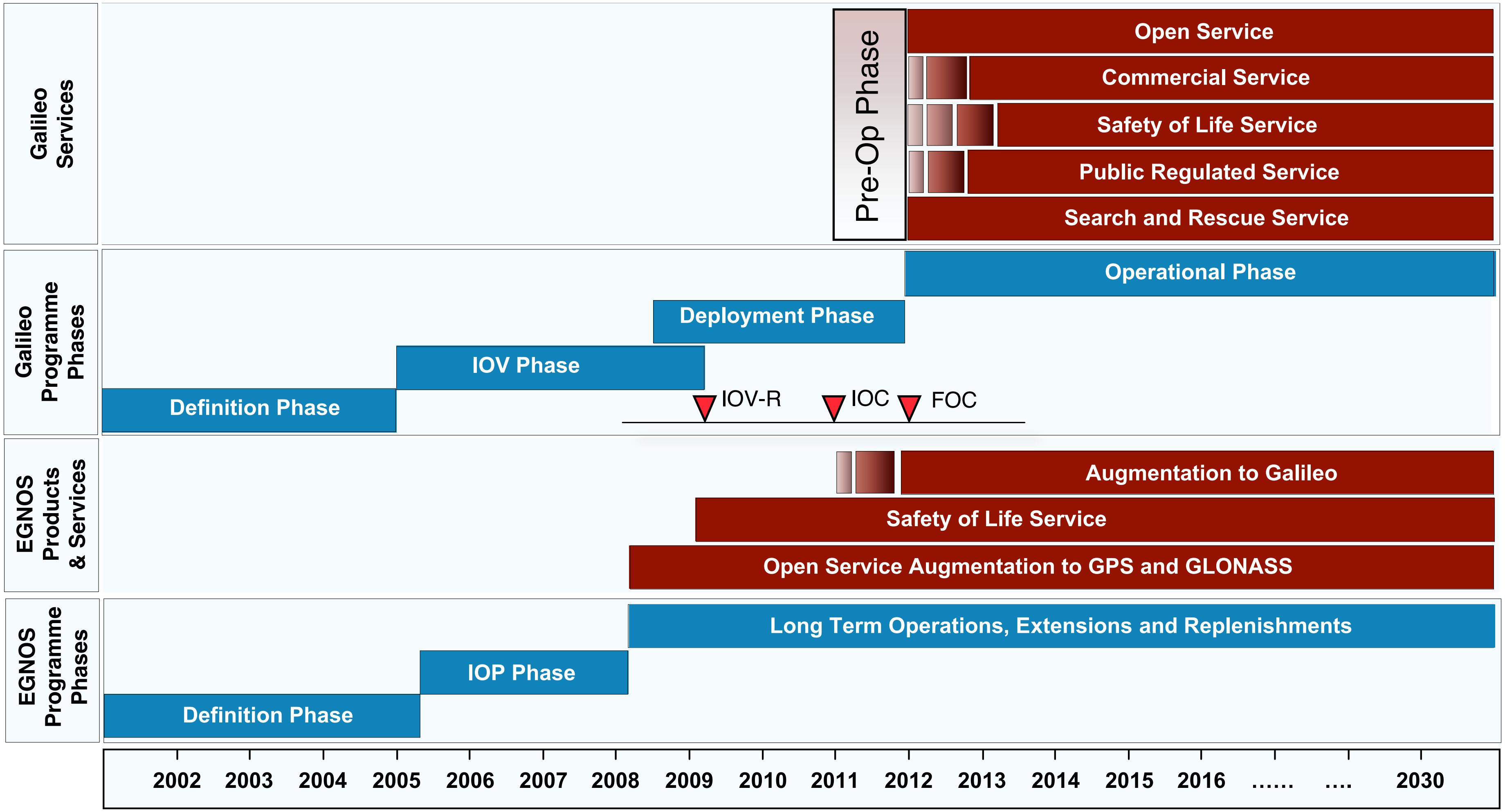
The core mission of the GSA

- To manage the public interests related to and to be the regulatory authority for the European GNSS programmes EGNOS & GALILEO
- Be the licensing authority vis-à-vis the future concession holder responsible for managing the Galileo deployment phase and the Galileo and EGNOS operation phase
- Be responsible for matters related to the right to use the frequencies necessary for the operation of the systems, the certification of their components, and their safety and security
- To carry out all research of benefit to the development and promotion of the European GNSS programmes (6th and 7th Framework Programmes)
- Be the owner of all tangible and intangible assets created or developed under the Galileo and EGNOS programmes



European GNSS Implementation Plan

The Phasing of the EGNOS & Galileo Programme



RNSS Compatibility and Interoperability

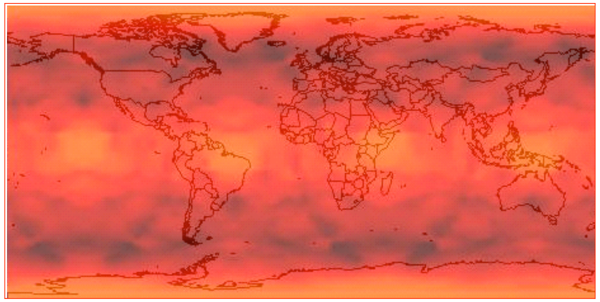
Status of bilateral RNSS discussions

	Compatibility	Interoperability
GPS	Agreement signed in 2004: ✓ No harmful interference ✓ Protection of PRS & M codes ✓ Consultation process	✓ Common OS L1 signals (+ MBOC) ✓ Interoperable timing and geodetic standards ✓ Broadcast of GPS/Galileo time offset
GLONASS	Set up of compatibility Working Group planned	Under discussion: Frequency sharing Joint broadcasting of Time offsets Geodetic parameters
QZSS	TT&C compatibility	QZSS broadcast of Galileo corrections
COMPASS	Discussions started in 2007	

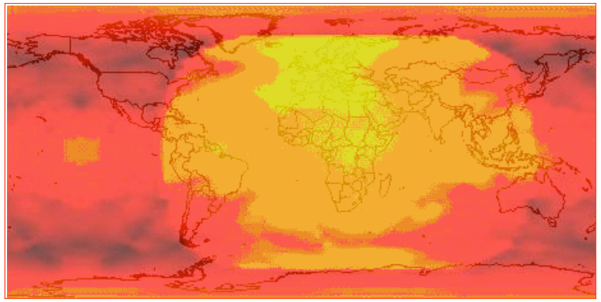
Example:
Global Improvement Horizontal Accuracy

Combined use of GNSS systems will enhance performance

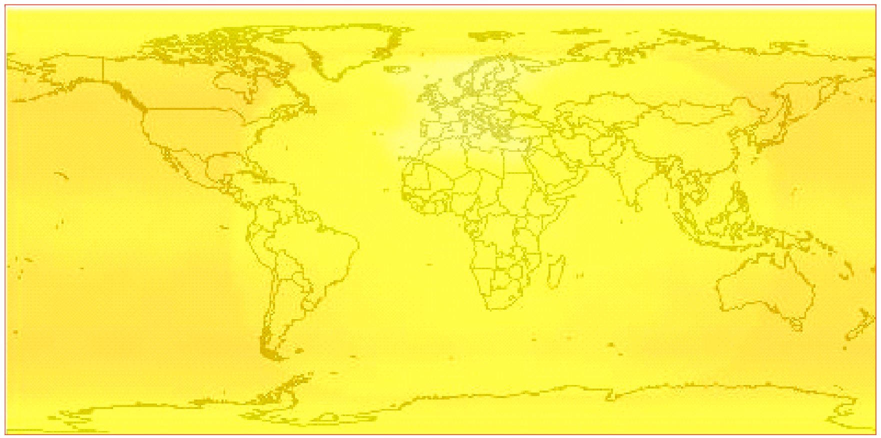
GPS

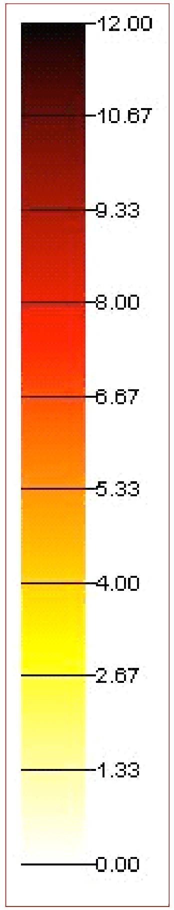


GPS + EGNOS



GPS + EGNOS + GALILEO





Note: single frequency user, error in meters.

International Activities

International co-operation is fundamental to Galileo

Perspectives

- New worldwide infrastructure
- Regional & Local components
- Research & technology
- Industrial cooperation
- Market development and Trade
- Global Standards and certification

Galileo Centres

- China
- Egypt (Mediterranean Region)
- Latin America

Agreement EU-MS and..	Signed / Initialed	In Progress
U.S.A.	✓	
China	✓	
Israel	✓	
India	✓	
Morocco	✓	
Ukraine	✓	
Russia		✓
Argentina		✓
South Korea		✓
Canada		✓
Brazil		✓
UAE, Malaysia, Australia, Japan,South Africa, Chile, Mexico		Exploratory Talks

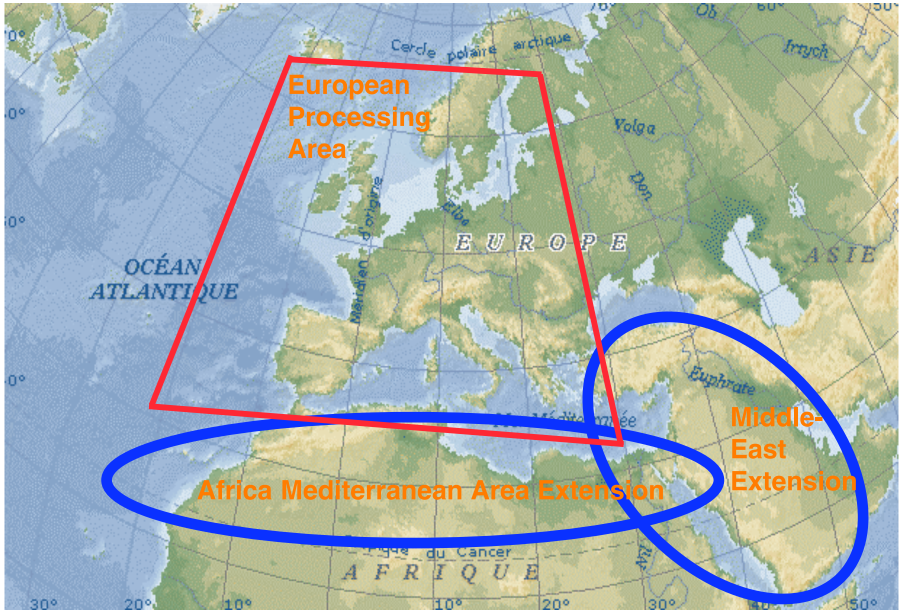
Galileo International Board

Formal Agreement between EU Member States and third countries

European Commission has been authorised by Council to start nego tiations

EGNOS Extensions

Making tangible outcomes from international cooperation on GNSS



Extension of EGNOS
to Africa Mediterranean Area (MEDA)

✓ Implementation of EGNOS network extension is on-going (2007-2008)

Extension of EGNOS to Middle East (ACA)

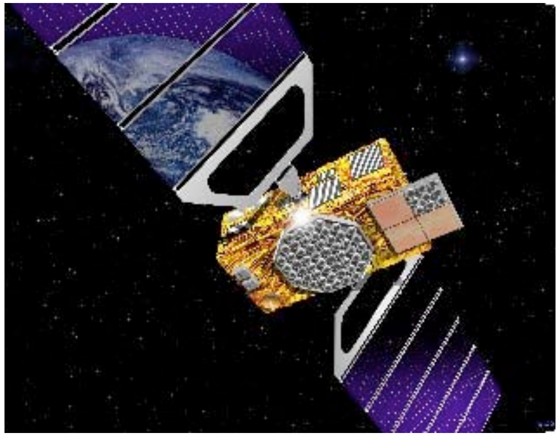
✓ Preliminary definition phase launched early 2007

Galileo Research and Development

GSA’s mission in support for the system and its utilisation

Generic European Research Objectives

- Support implementation of European policies
- Development of **safer**, **greener** and **smarter** pan-EU transport systems
- Strengthen research co-ordination at European level
- Facilitate international Science and Technology co-operation
- Reinforce the role of SMEs



Specific GNSS Research Objectives

- Complement the development of the Galileo infrastructure
- Setting the conditions for the widespread utilisation of GNSS
- Ensuring users in different sectors ready for the use of Galileo and EGNOS
- Make the European GNSS industry competitive in the worldwide scenario

The 6th Framework Programme

Setting the foundations for the future use of GNSS

- Addressing all user sectors
- Developing technology in mass-market and professional terminals
- Demonstrating technical feasibility with the early use of EGNOS services
- Supporting all enabling factors
- Consolidating the Galileo mission and interfaces

SIXTH FRAMEWORK PROGRAMME

€ 110 millions of co-funding, for an overall budget of around € 170 millions

77 projects are run under the management of the GSA

More than 300 companies are participating to the projects

Involvement of space industry, research centres, universities & SMEs

Covering equipment manufacturing, service provision, and utilisation of GNSS

The 7th Framework Programme

The key enabler for securing the competitiveness of Galileo

- Capitalize the precedent research programmes in order to fill gaps towards the strategic objectives
- Pursue creation of value for stakeholders.
- Correctly position the research activities in the innovation chain
- Preparation of system evolution / modernization
- Support to the development of applications of wide public interest
- Getting the market ready for service exploitation
- Indicative budget: 350 MEuro (2007-2013)
  ~ 50 MEuro / year
- 1st Call for 7FP will be launched by 3Q/07.

SEVENTH FRAMEWORK PROGRAMME

Concession

Structural problems encountered during negotiations

From Concession Perspective…

Design Risk Transfer

- How to evolve from the reduced architecture at In-Orbit-Validation (IOV) to the complete constellation at Final Operation Capability (FOC)

Market Risk Transfer

- In absence of historical data and with market projections far into the future (2020-2025)

In some cases, the political dimension prevailed over the commercial one (« *Airbus syndrome* », press March 2007)

The June 2007 EU Transport Council

Re-profiling the Galileo Programme ?

- **March 2007 EU Transport Council**
- **EC/ESA/GSA assessed the ongoing negotiation process**
- **Analysed the margin of successful completion**
- **Evaluated possible alternate scenario 's**
- **Including also those that assume a more substantial involvement of the Public Sector in the deployment of the system**

- **June 2007 EU Transport Council**
- **Expected to take appropriate decisions with respect to the project.**

Conclusion

The Galileo perimeter, challenges and opportunities

- Galileo is representative of the Political ambition of Europe
  - Independence and sovereignty
  - 27 EU Member States supporting the Programme
  - Safety and Security
  - Economic & Social perspectives
- The success of Galileo will largely depend on the market penetration in a wide range of GNSS applications and services.
- The 7th FP will provide an excellent opportunity to explore new domains of applications.
- The GSA will
  - ensure the enablers for the system adoption, i.e. certification, standardization and licensing of IPRs,
  - foster the international dimension of the Galileo programme,
  - Aim at an early introduction of EGNOS operations as an important precursor function to Galileo

thank you

further information can be found at:

http://gsa.europa.eu/

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The International GNSS Service *(IGS)* in Support of Geoscience and Society

G. Beutler

Astronomical Institute, University of Bern

President IAG

The European Navigation Conference

ENC-GNSS 07

Plenary-2: Navigation Systems Status

Geneva International Conference Center

Contents

- **International Association of Geodesy (IAG) and its Services**
- **The International GNSS Service (IGS)**
  - **History and Development**
  - **Scope and Products**
  - **IGS: *I GPS Service* → *I GNSS Service***
- **The impact of the IGS on science and society**
- **Imbedding the IGS in GGOS (Global Geodetic Observing System)**

The Three Pillars of Geodesy

Modern geodesy is based on and provides information for

- ***geometry and kinematics,***
- ***Earth orientation and rotation*, and**
- ***gravity field and its variability.***

Positions and trajectories on and near the Earth‘s surface have to be referred to one and the same reference frame

- **a unique terrestrial reference frame has to be defined, realized and maintained.**

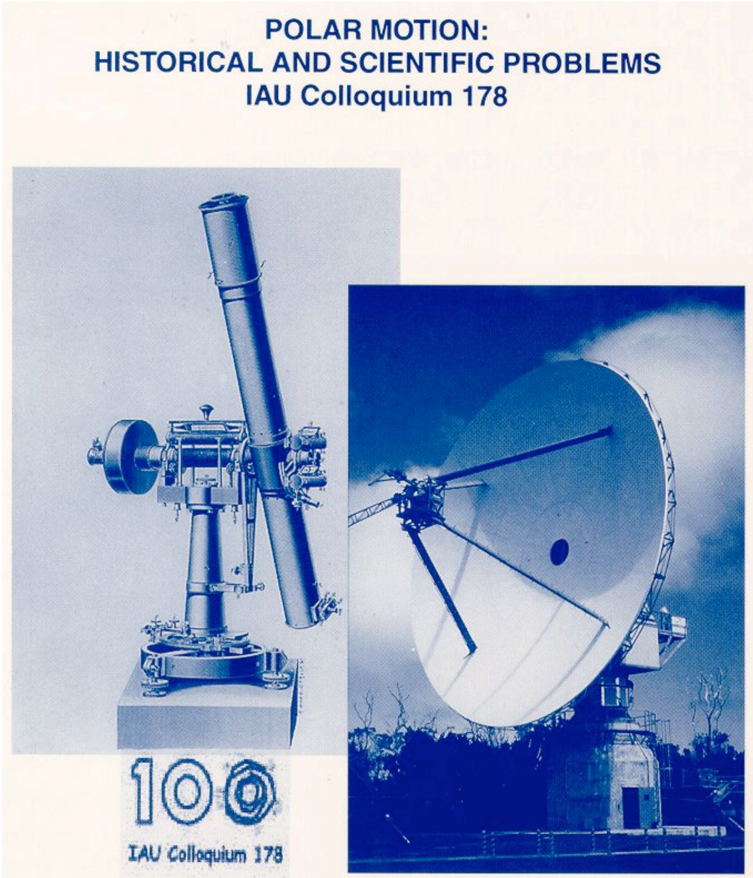
The motion of the Earth as a body of finite size has to be described in a unique celestial reference frame,

- **which has to be defined and realized.**

The Earth rotation parameters (ERPs) provide the transforma-tion between the terrestrial and the celestial system,

- **The ERPs have to be monitored with high accuracy (mas) and (at least) daily resolution.**

IAG and its Services

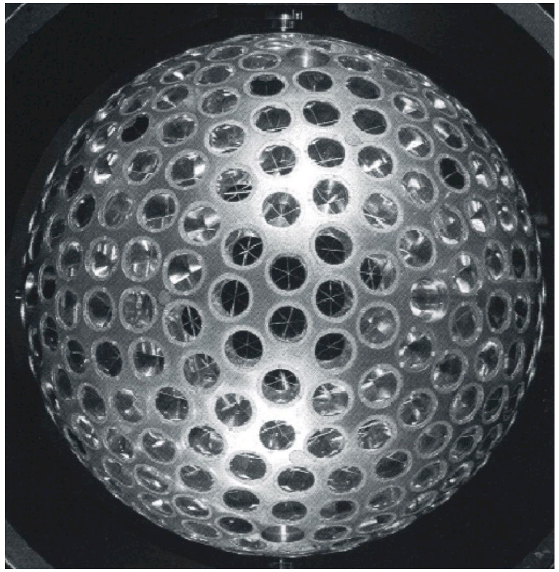


The book cover documenting the IAU Colloquium 178 symbolizes the radical change of instrumentation used for geodetic monitoring (thus also for polar motion) between 1899 and today.

Astrometric (angle) measurements have been replaced by distance measurements using radio interferometry (VLBI), laser ranging to satellites (SLR/LLR), and Global Navigation Satellite Systems (GNSS).

Distances are derived from the propagation times of signals.

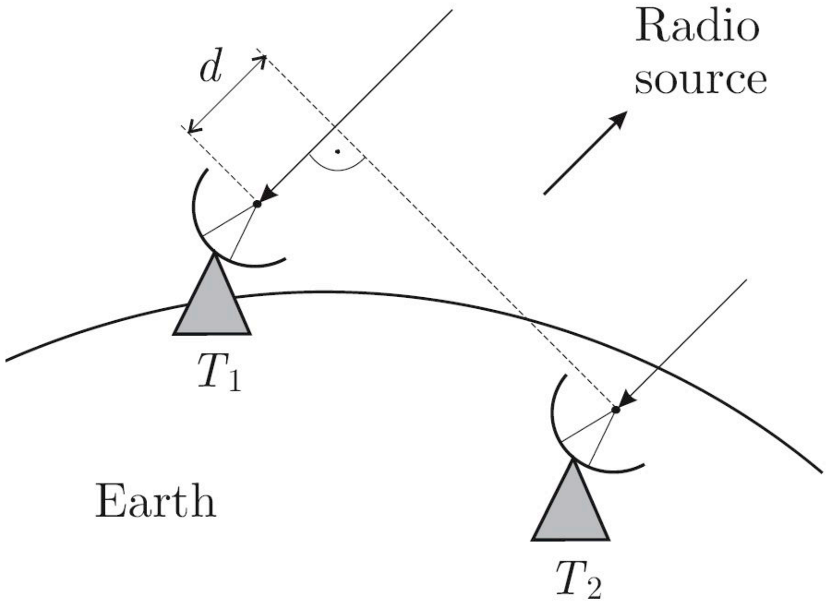
Space Geodesy: Laser Ranging



... SLR provides the origin of the terrestrial system, it contributes to the scale, Earth rotation, calibrates/validates GNSS orbits.

The ILRS (International Laser Ranging Service) provides measurements and products

Space Geodesy: VLBI



Celestial reference frame is established by VLBI.

VLBI provides in addition precession, nutation *and UT1,* and contributes to scale of the terrestrial network.

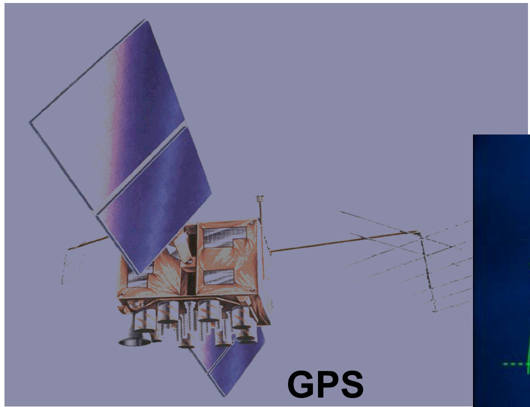
Space Geodesy: GNSS

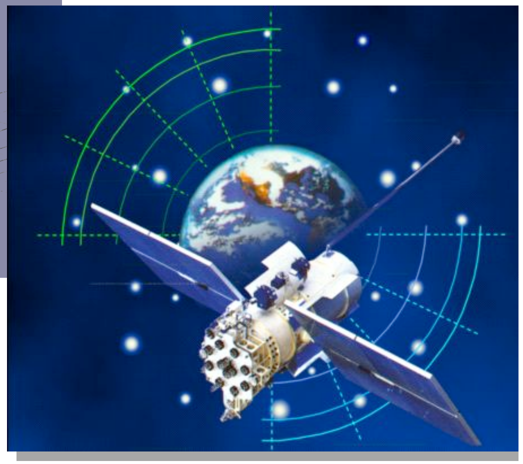
GPS: USA , about 30 satellites in 6 planes
GLONASS: about 12 satellites in 3 planes

GALILEO: one test satellite in 2007

Densification of and easy access to ITRF through GNSS

All satellites *should be* equipped with reflectors ...





GLONASS

GALILEO

IGS: History and Development

Ivan Mueller (OSU)

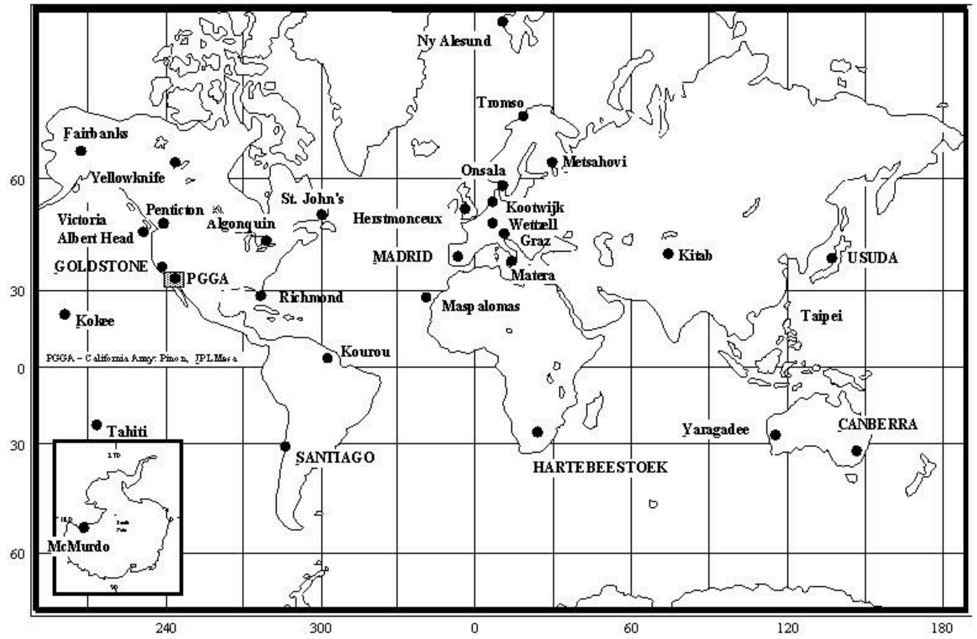
Development started in 1991 with an insult:

„The primary motivation in planning the IGS was the recognition in 1989 that the most demanding users of the GPS satellites, the geophysical community, were purchasing receivers in exceedingly large numbers and using them as more or less black boxes, using software packages which they did not completely understand, mainly for relative positioning".

The other (real) motivation was the generation of precise ephemerides for the satellites with by-products such as Earth Rotation parameters and GPS clock information.

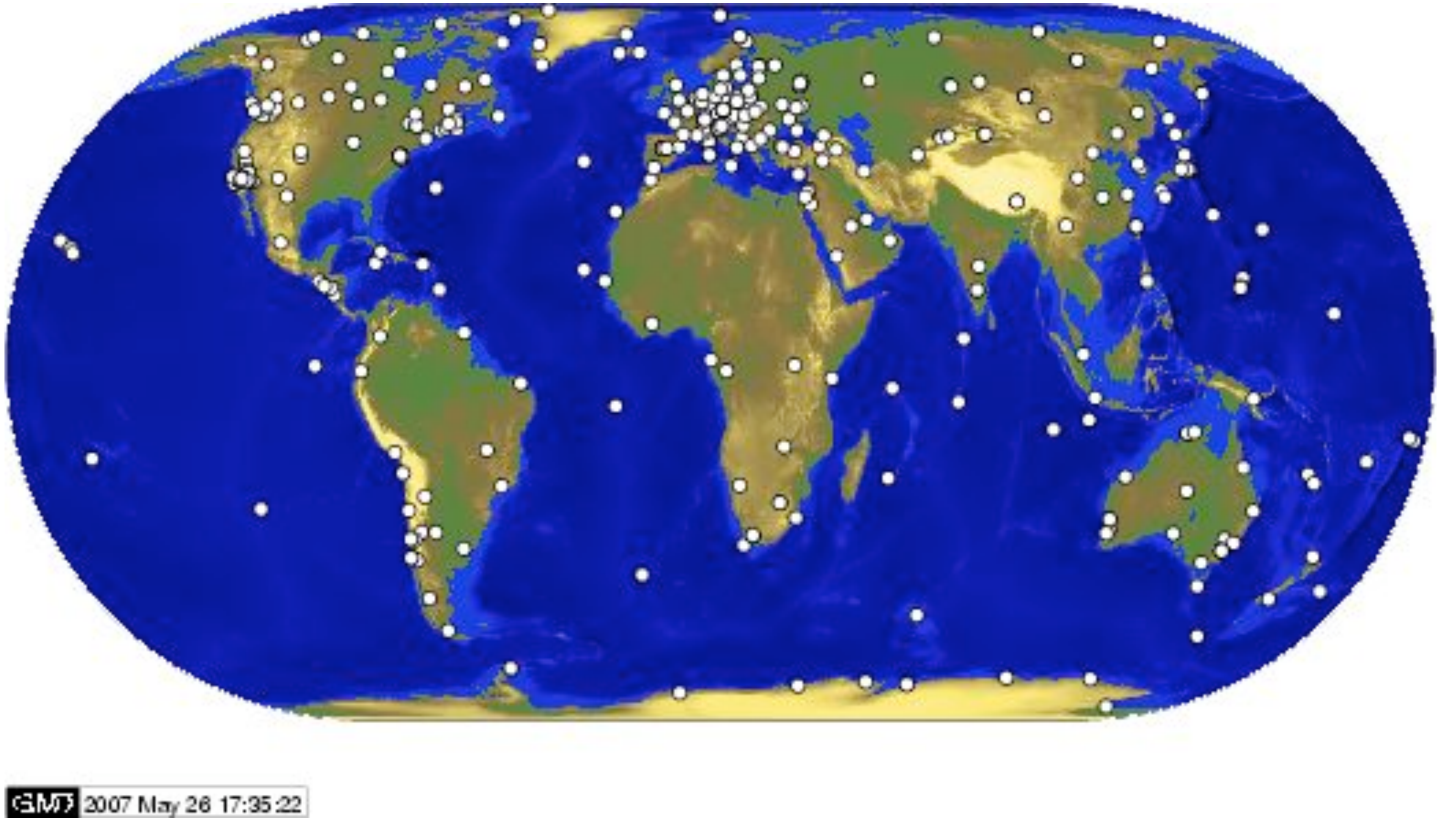
IGS: History and Development

Station Locations for the IGS Pilot Campaign, 1992



In 1992 the IGS was based on about 20 geodetic receivers (mainly ROGUE); the data were analyzed by the scientific community.

IGS: History and Development



The IGS Network in 2007 consists of 400+ sites

IGS: History and Development

In 1992 the IGS started off as an orbit determination service (dm accuracy) for about 20 GPS satellites.

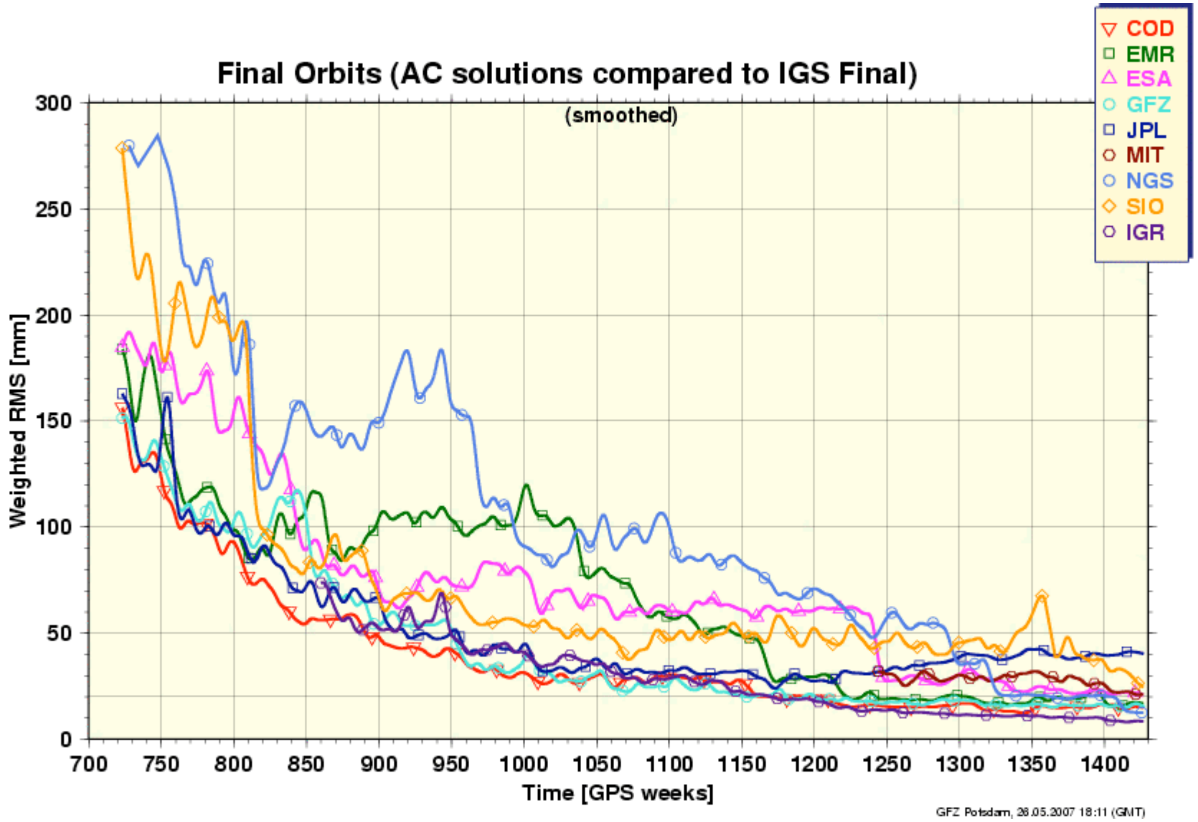
Today, the IGS provides ephemerides (accuracy of 2-4 cm) for about 30 GPS satellites and for about 12 GLONASS satellites, i.e., for all GNSS satellites.

In addition the IGS generates and makes available

- Satellite and receiver clock corrections (sub-ns accuracy)
- Polar motion (PM) and length of day (lod) (cm accuracy)
- Coordinates and velocities for 200+ sites (cm / mm/y accuracy)
- Atmosphere information

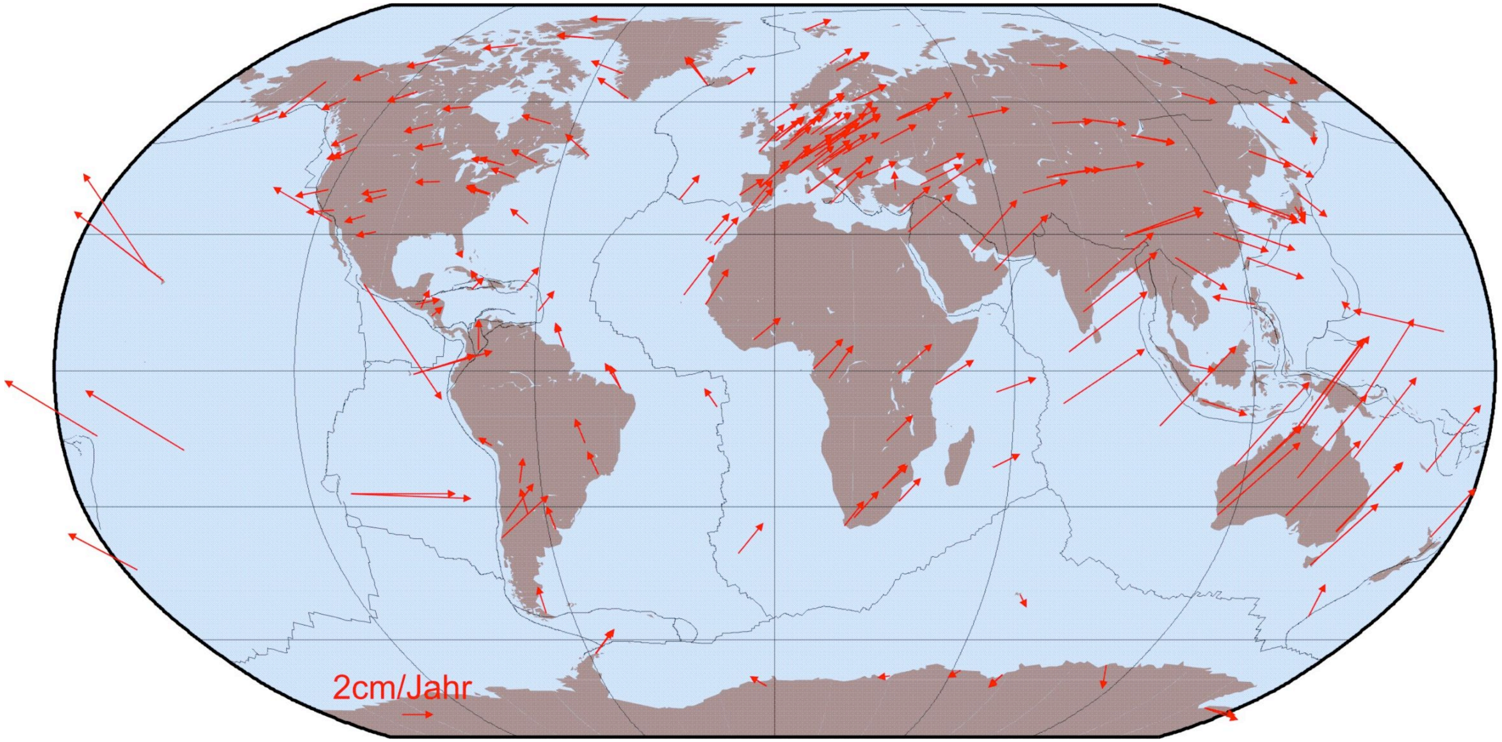
IGS products are accurate, reliable and robust, available in a timely manner (1 week delay → real time).

The IGS as an Official Service



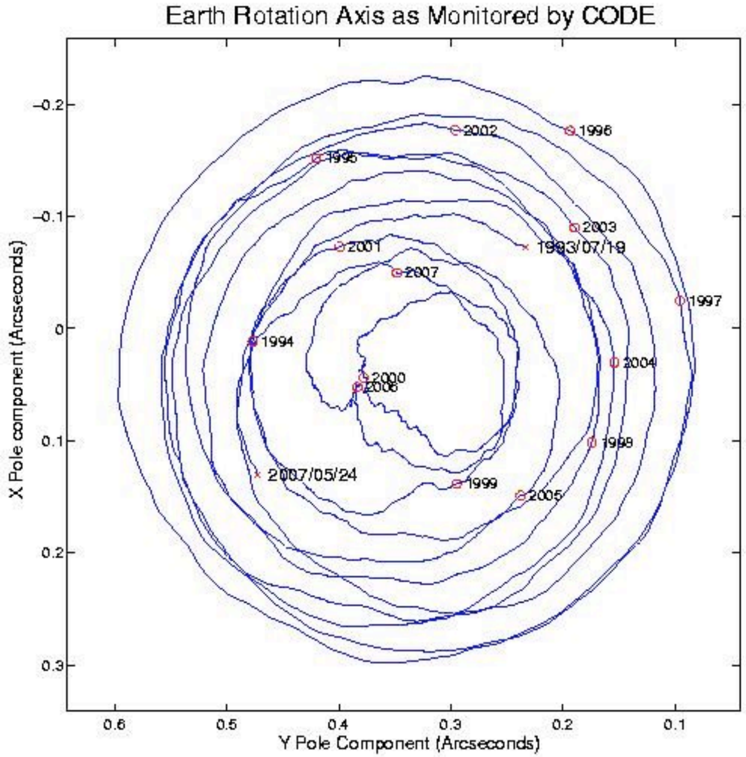
Orbit consistency between 1994 and 2007 (im mm per coordinate) of individual AC solutions w.r.t. combined product reaches 2cm level.

Monitor the Terrestrial Reference Frame



By combining the IGS results with those of the other space geodetic techniques, the IERS generated the unique terrestrial reference frame, to which all national first order surveys refer today.

Monitoring Polar Motion



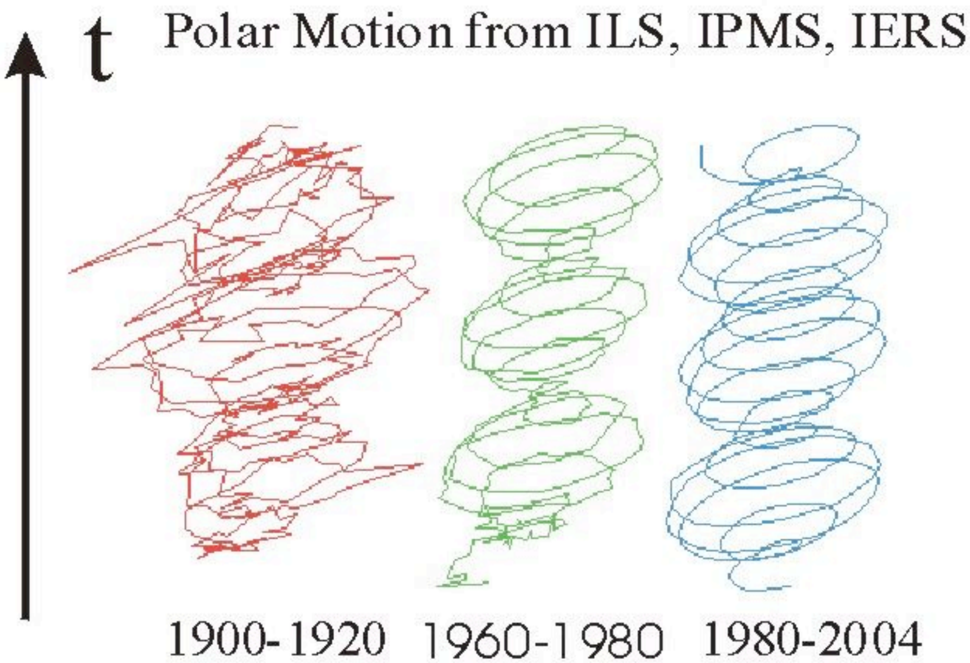
Polar motion monitored by the IGS between 1993 and 2007.

Diameter of figure about 7m, accuracy of daily estimates < 1cm!

Changing diameter of PM due to beat period (of 6 years) of Chandler and annual period

The Earth‘s pole moves „in bad circles of slowly varying radius“ around the Earth‘s figure axis (once in 430 days=Chandler period).

ILS, IPMS, IERS: A Case Study

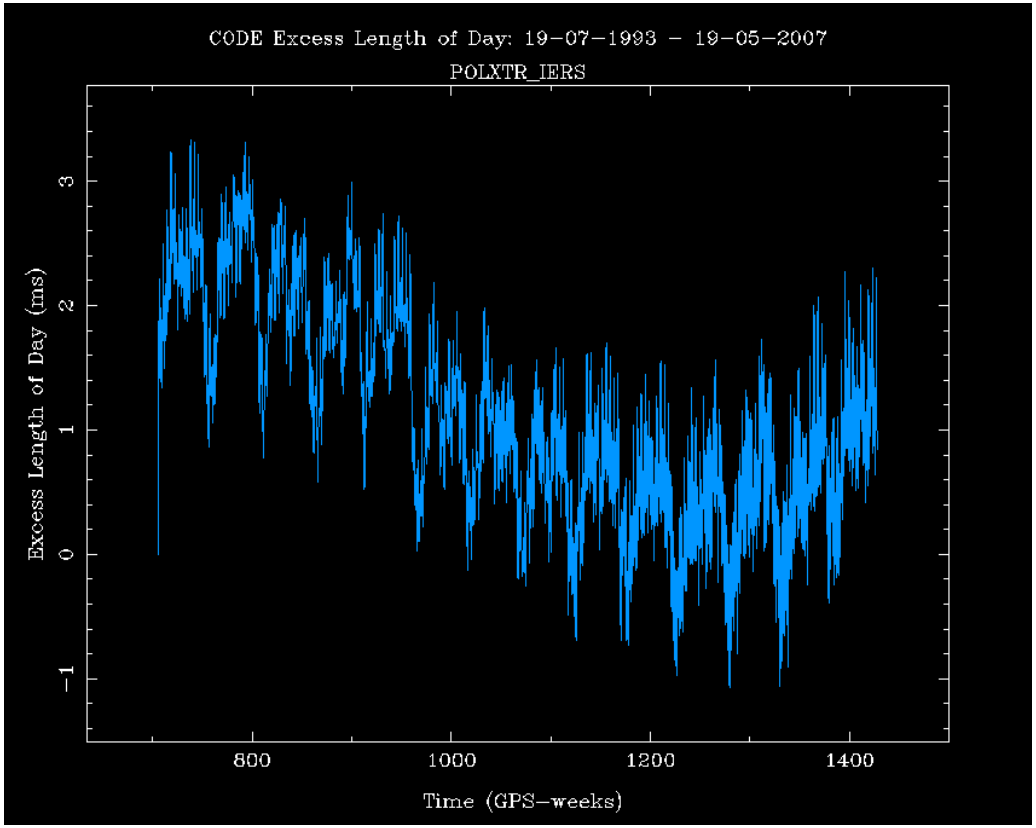


The *ILS (left)*, created 1899, was capable of monitoring PM with about 100 milliarc-seconds (mas) using astro-metry.

The *IPMS (center)* did the same (using astrometry) with an accuracy of a few 10mas.

The *IERS (right)* monitors PM using space geodetic techni-ques with a quality < 0.1 mas.

Monitoring Length of Day



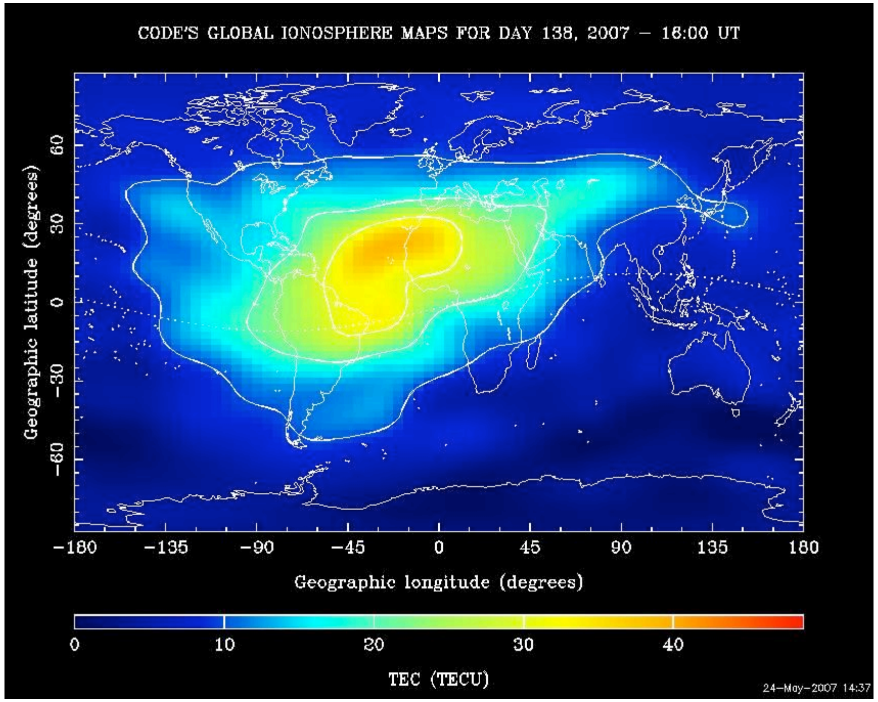
LoD decreased between 1993 and 2005, increases since.

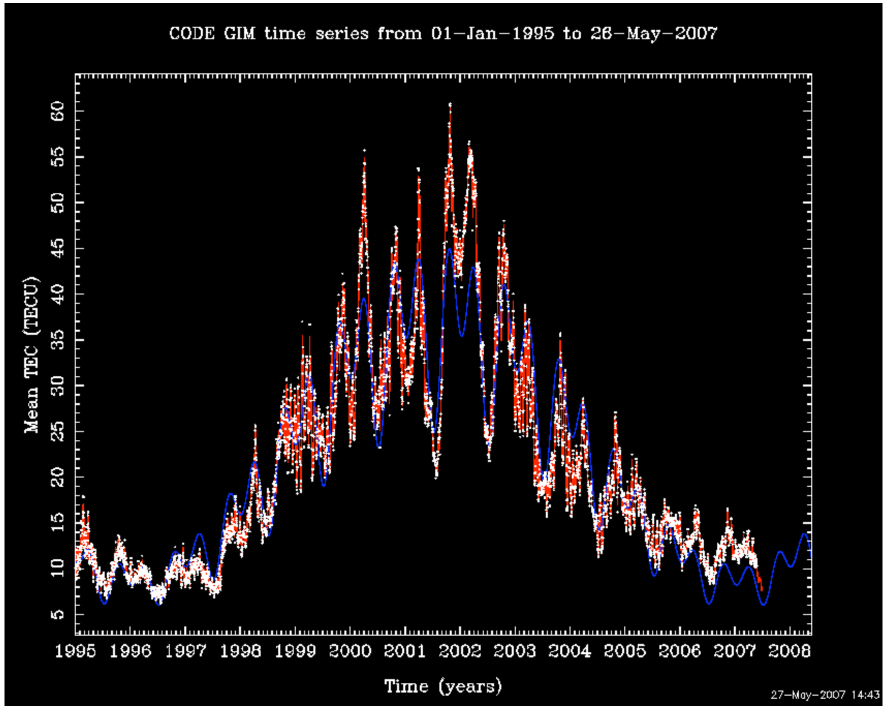
LoD should increase on the average by 2 ms per century.

Large varaitions due to complex (inner) structure of the Earth.

Length of day variation between 1993 and 2007 (daily estimates by IGS with few microseconds accuracy)

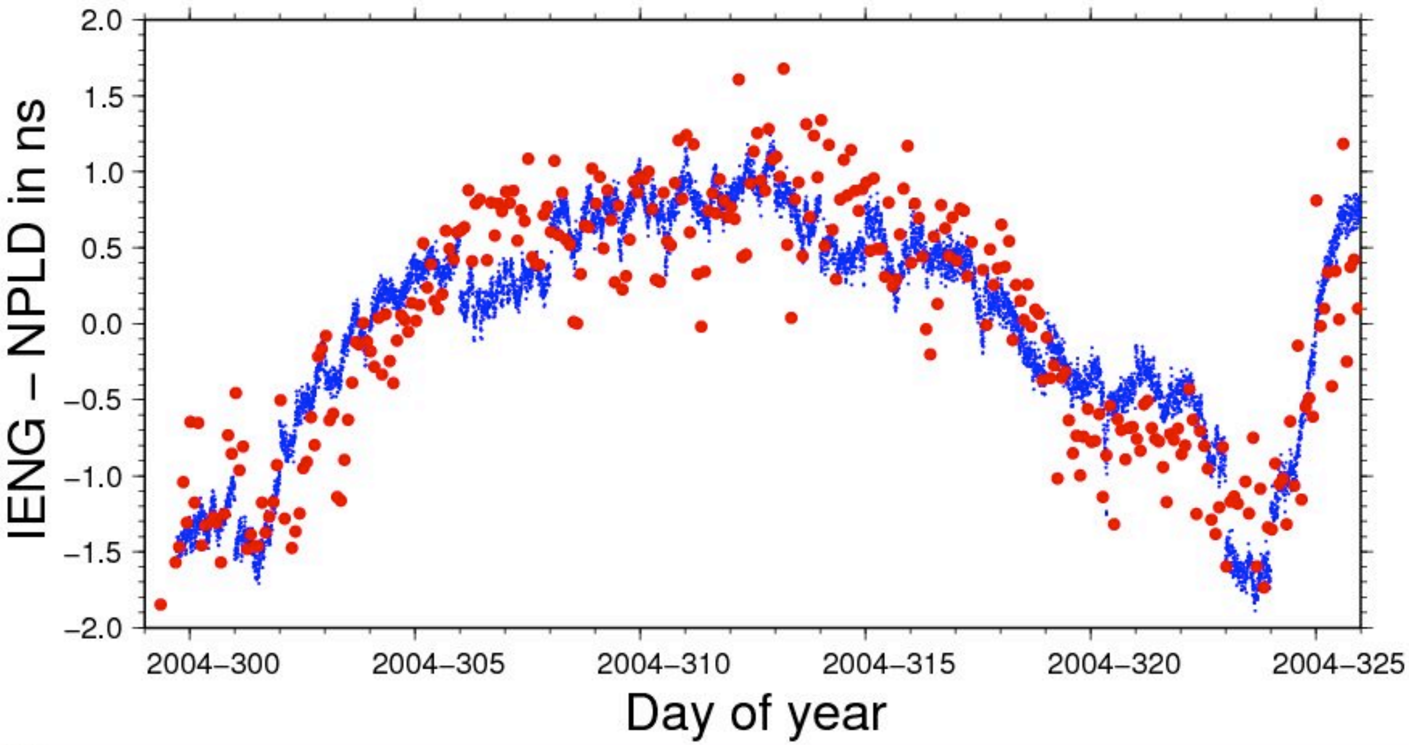
Monitoring the Earth's Ionosphere





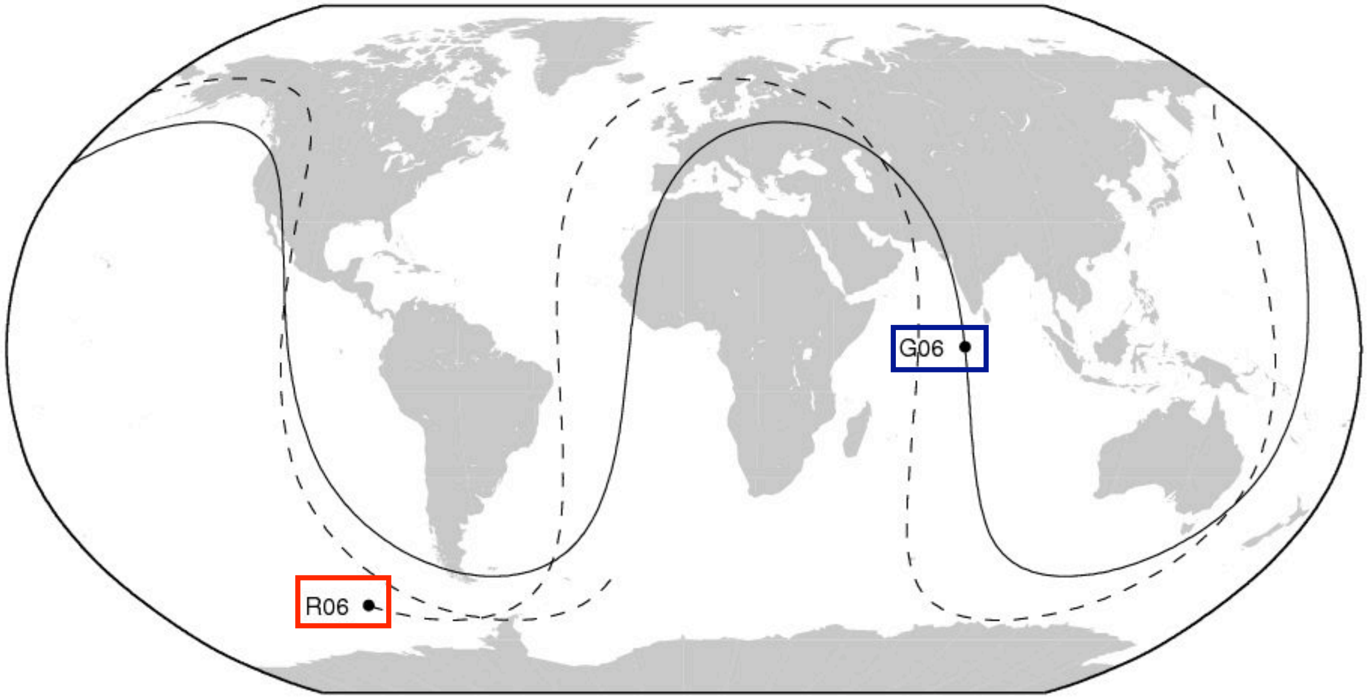
Mean total electron content (TEC) of the ionosphere may be extracted using the two (or more) carriers of the GNSS signals (left). Global maps of the mean TEC available every two hours since 1995, daily mean TEC is extracted since 1995 (right).

IGS and time synchronization



Comparison between clock-differences using only the GPS carrier phases (small blue dots) and TWSTFT measurements (red dots) for the clocks in Torino, Italy and Teddington, U.K., during a four weeks comparison campaign in 2004. (Bauch et 1l., 2006)

The IGS as a GNSS Service



July 7, 2006: **sub-satellite tracks of:**

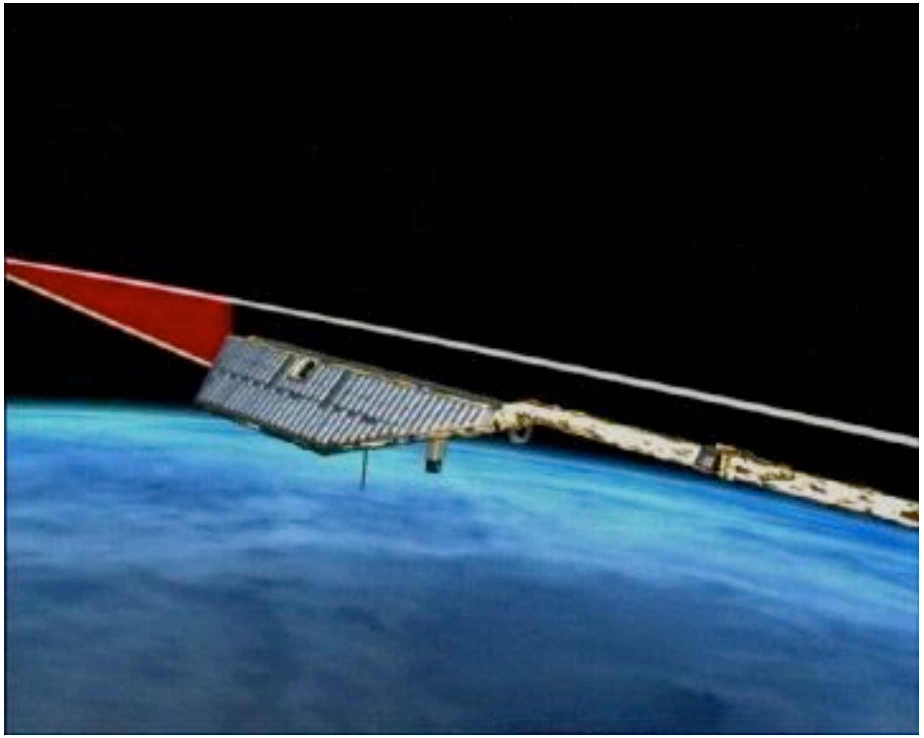
PRN 6, (GPS) repeating each day) and

GLONASS R06 (repeating after 8 days).

The IGS is dedicated to track all GNSS systems, to make available orbits / clocks for active GNSS satellites, and to base its products (ERP, coord, etc.) on the observations of all systems.

Different systems improve the geometry, help to avoid systematics.

IGS enabling great science



CHAMP in Orbit

The IGS enables great science.

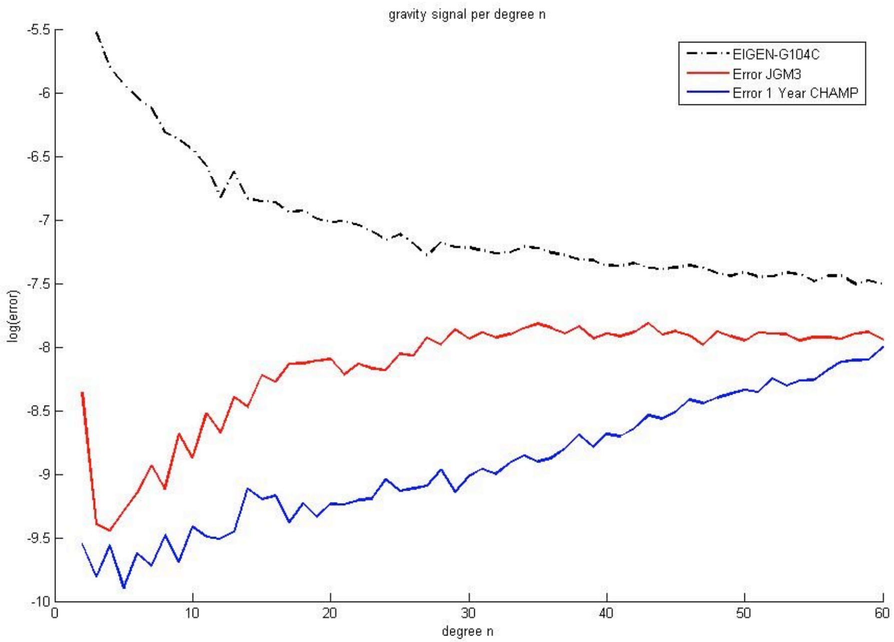
Example:

Gravity field determination is performed with satellites and constellations of satellites

- **at low altitudes and high inclinations (LEOs)**
- **equipped with accelerometers (or sets of them)**

The IGS products are used to establish the kinematic LEO orbits (orbit differences) with cm to mm precision, which in turn allow an easy estimation of the Earth's gravity field.

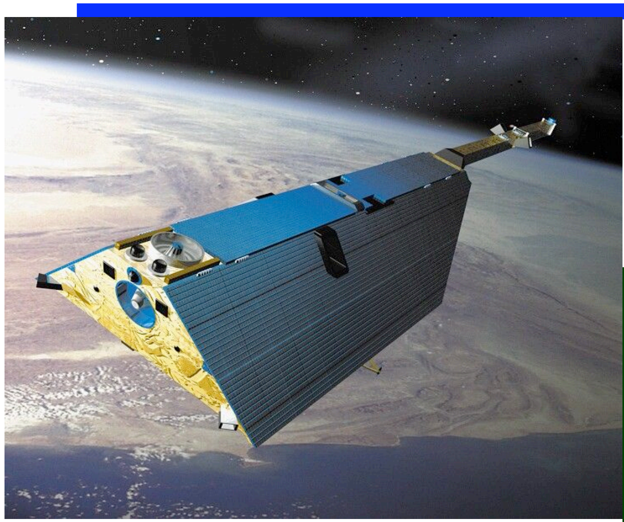
IGS enabling great science

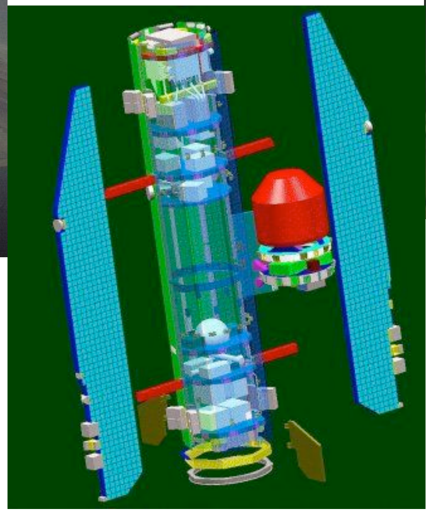


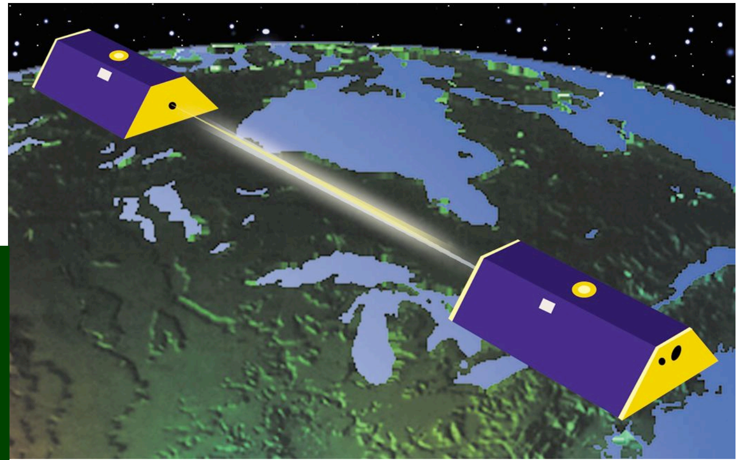
The „error“ (log scale) of the gravity field as determined in the years 1960-1999 (by SLR, astrometry) and with one year of CHAMP data relative to (one of the best known) gravity fields known today.

The CHAMP-derived field was established using the IGS products.

IGS enabling great science


CHAMP

GOCE



GRACE A and B

GNSS/IGS-derived positions contribute to gravity field estimation! (lower degree & order harmonics)

The new age of gravity field determination was initiated with the launch of CHAMP in July 2000. GRACE, launched in 2002, explores the use of inter-satellite measurements (1-d-gradiometer) to study the time variability of the gravity field, GOCE will make use (starting 2007) of the 3-d-gradiometer to derive the „best possible stationary gravity field.

IGS contibute to science and society

The **IGS supports Earth science & society** by providing accurate

- ➢ **satellite orbits** for all GNSS
- ➢ satellite and (selected) receiver **clock corrections** for all GNSS

The IGS contributes and gives (will give) easy acces to

- ➢ the **International Terrestrial Reference Frame** (ITRF)

The IGS **relates** system-specific **systems like WGS-84, PZ-90** and **will relate** the corresponding **GNSS system times** on the sub-nanosecond level.

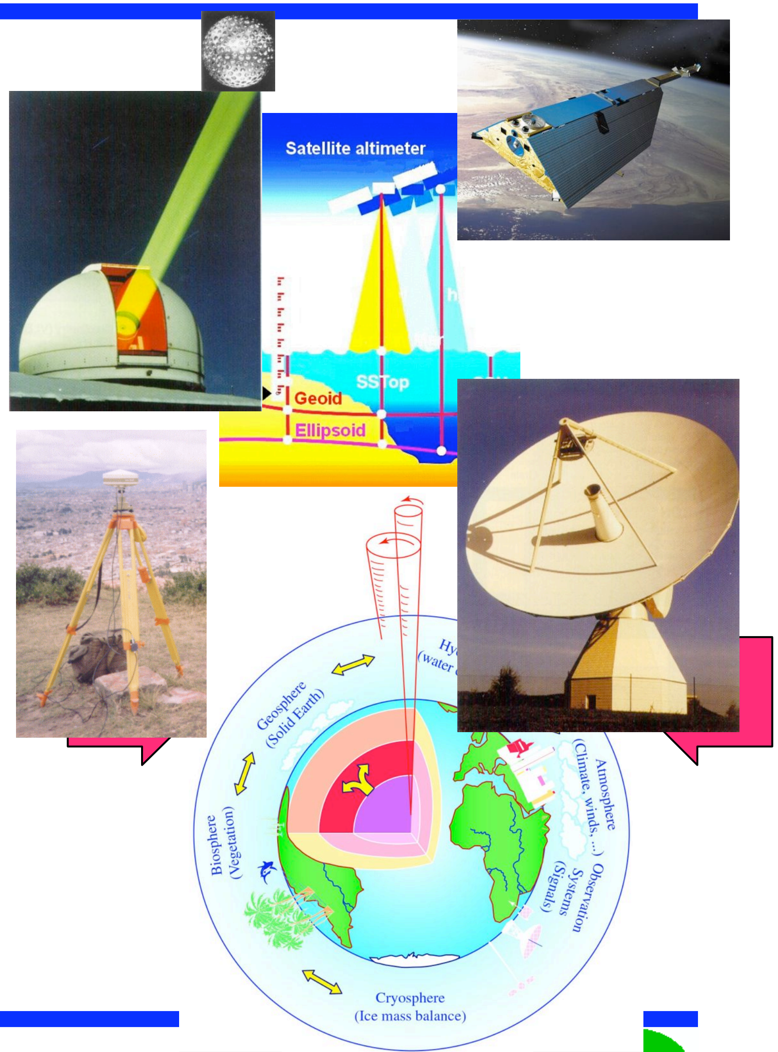
The IGS **monitors Earth orientation and -rotation** with daily reso-lution.

The IGS **monitors the Earth‘s ionosphere** with two-hours time resolution.

The IGS **helps enabling modern gravity field determination & monitoring**.

The Global Geodetic Observing System (GGOS)

GGOS integrates different geodetic techniques, different models, different approaches in order to achieve the required long-term consistency, reliability and understanding of geodetic, geodynamic and global change processes.



GGOS provides the scientific & infrastructural basis for all global change research in Eart sciences.

The IGS is an important part!

“Downstream Industry: Concerns and Expectations for Galileo”

TimeNav’07, Geneva

Galileo Services Overview

- Non-profit Making Association aiming at developing, promoting and maximizing the potential of the applications' market
- Voice the industry concerns & expectations toward the institutions
- Share market experience and knowledge of user needs
- Leverage member's competitiveness and business perspectives
- Contribute to the success of Galileo from a user and industry viewpoint (i.e. Galileo socio-economic challenge)

Galileo Services Members

- Represent all GNSS applications and services
- Initially restricted to EU countries, now opened to non EU
- SMEs represent more than 40%
- Close link with OREGIN network to bridge with more than 150 other companies (mainly SMEs from 19 European countries)
- Recently joined: NOVATEL (CA), JAVAD (US), ARGOSS (NE), EDISOFT (PO), SEIKO-EPSON (J),D-MEDIA (TAIWAN)

Galileo Services Members

Galileo services

- ARGOSS
- dmedia
- EADS astrium
- EDISOFT
- EPSON EXCEED YOUR VISION
- eutelsat communications via satellite
- FDC
- funkwerk EuroTelematik
- gmv INNOVATING SOLUTIONS
- hispasat acercando culturas
- Indra
- INECO TIFSA
- JAVAD NAVIGATION SYSTEMS
- KAYSER-THREDE
- KONGSBERG
- logicaCMG
- mapflow
- NAVTEQ
- NovAtel
- OHB TECHNOLOGY
- Septentrio satellite navigation
- SKYSOFT PORTUGAL
- SOGEI
- Tele Atlas
- TELESPAZIO A Finmeccanica / Alcatel Company
- TERMA
- THALES
- TNO

Sample of Current Galileo Services Activities

- Working Groups on:
  - Standardization,
  - International Cooperation,
  - IPRs
- Position Papers circulated to Key Decision Makers and Press releases (IPRs, R&D contracting rules, programme delays…)
- Meetings with
  - ESA, EC, GJU/GSA
  - EU MS Representatives (COREPER)
  - Professional and User organisations
  - Key GNSS Industries from Asia, North and Central America
- EUGIN honorary member
- Sponsoring and actively involved in navigation conferences
  - ENC-GNSS for several years
  - Gold Sponsor of ENC-GNSS TimeNav’07
  - GS Booth at the ION GNSS 2005, 2006 and in 2007

Galileo Services – an Active Actor of the Programme

- Promotion of EGNOS/Galileo
  - Common approach and common messages enhancing the Galileo image worldwide
  - Highlight the real added value of EGNOS/Galileo from the applications perspectives
- Support GNSS R&D
  - Building on former work in new R&D activities (GSA FP7, ESA, National activities, etc.)
  - Active role in R&D Programmes Definition
- Standardisation/Certification
  - Promote European Institutions' positions on Galileo
  - Support Galileo penetration in end-user applications
- International Cooperation
  - Sharing Industry experiences on the Regions
  - Recommending technical domains for cooperation
  - Assess the impacts on Industry (positive, risks)

Galileo Programme at a Turning Point

- Huge revenues are expected from the applications and services
- Downstream industry has invested in R&D since the start of the programme
- Application & Services development and business plans have been elaborated from Galileo Programme published schedules
- Accumulated delays and programmatic problems can jeopardize the success of Galileo
  - Early R&D investment may be lost
    (risk of obsolescence of technology, signal definition must be frozen, services must be available for demonstrations)
  - Competing GNSS might considerably decrease the user interest in Galileo for some applications (e.g. mass market) if an operational Galileo is late
- EC Communication of the 16th May 2007 is warmly welcomed and is seen as a chance to give the programme the required new impulse

Galileo Services strongly believes

- Galileo is necessary to Europe independence and sovereignty
- Galileo is one of the key projects to reach the Lisbon objective
- Galileo respond to actual User Needs
- Galileo is a chance to boost industry competitiveness
- Galileo is affordable (1€ per citizen/year)
- Existing mechanism will allow Member States to recover investment (taxes, social charges, VAT on sales,..)

EC communication proposes several scenarios to put Galileo on track again.

Galileo Services strongly appeals to the relevant public authorities to secure a rapid and complete deployment of Galileo

Conclusion

Europe needs Galileo

Let's not leave the job half done, but rapidly deploy the Full System

ENC-GNSS 07 General Programme

Tuesday, MAY 29

Common Sessions with EFTF-FCS 2007

09:00-10:45 PLENARY I - TimeNav'07 OPENING CEREMONY

Introduction	René Dändliker, Honorary TimeNav'07 Chair
Welcome Address	Bernardo Jaduszliwer, TimeNav'07 co-Chair
Welcome Address	Alain Geiger, President, ION-CH
Welcome Address	Arthur Ballato, IEEE-UFFC Society President
Welcome Address	Rein Van Gooswilligen, Chair, EUGIN Council
Welcome Address	Pierre-François Unger, Minister, Canton of Geneva
Welcome Address	Rudolf Dieterle, Director, Swiss Federal Roads Authority
Keynote Speaker	Sylvain Loddo, GALILEO System, Ground Segment and Operations Manager, ESA Keynote Address: "Galileo Status and Perspective"
Programme Information	Edward Byrne, Local Organising Committee, FSRM

11:30-13:00 PLENARY II - NAVIGATION SYSTEMS STATUS

Chair:	Prof. Brad Parkinson, Stanford University, USA
GPS	Mr. Ray Clore, Senior Advisor for GPS-Galileo Issues, U.S. Department of State
Galileo	Dr. Hermann Ebner, Head of Technical Department, European GNSS Supervisory Authority (GSA)
The International GNSS Service (IGS) in Support of Geoscience and Society	Dr. Gerhard Beutler, Director, Astronomisches Institut, Universität Bern
Downstream Industry: Concerns and Expectations for Galileo	Mr. Gard Ueland, Chairman of Galileo Services

14:30-16:00 PLENARY III - PANEL DISCUSSION

Title: Timing and Navigation Communities: Cohabitation or Full Partnership?

Chair: Prof. Vidal Ashkenazi, Chief Executive Nottingham Scientific Ltd.

Panellists:
Mr. Jean-François Bou (THALES), Interim CEO of the Galileo Concessionnaire
Mr. Pascal Rochat, CEO of Temex Neuchâtel Time SA
Prof. Christoph Günther, Director Communications & Navigation, D.L.R.
Dr. Lute Maleki, Senior Research Scientist, JPL, and co-Founder of OEwaves
Mr. Gian-Gherardo Calini, Head of the Market Development Dept, GSA

16:00-18:00 ENC POSTER SESSION

Wednesday, MAY 30

8:30-10:15 **Parallel Session 1**

A1-GALILEO GIOVE-A Chair: Jörg Hahn, ESA	**B1-Geodesy & Geodynamics** Chair: Elisabeth Klaffenböck, OVN	**C1-Air Navigation I** Chair: Maurizio Scaramuzza, Skyguide; ION-CH

10:45-12:15 **Parallel Session 2**

A2-Signal & Interference I Chair: Alain Geiger, Geodesy and Geodynamics Lab, ETH; ION-CH	**B2-Integrated Navigation I** Chair: Ismael Colomina, Institut de Geomatica	**C2-Applications for Road & Rail** Chair: François Peyret, Laboratoire Central des Ponts et Chaussées - FR

13:45-15:15 **Parallel Session 3**

A3 -Signal & Timing Chair: Pierre-André Farine, Université de Neuchâtel, Institute of microtechnology (IMT)	**B3 -Integrated Navigation II** Chair: Alvaro Urech, INECO; Galileo Services	**C3 -Indoor Positioning I** Chair: Bertrand Merminod, Laboratory of Geodetic Engineering, EPFL; ION-CH

15:45-17:30 **Parallel Session 4**

A4-GNSS System development Chair: Urs Wild, swisstopo	**B4-Space & Safety Applications** Chair: Urs Frei, Swiss Space Office	**C4-Maritime Navigation I** Chair : Rafael da Silva

Thursday, MAY 31

8:30-10:30 **Parallel Session 5**

A5-Local & Regional Augmentation Systems Chair: Stig Erik Christiansen, Kongsberg Seatex AS	**B5-Signal & Interference II** Chair: Rein van Gooswilligen, Chair of EUGIN Council	**C5-Air Navigation II** Chair: Norman Bonnor, Royal Institute of Navigation

11:00-12:30 **Parallel Session 6**

A6-Signal & Interference III Chair: Stuart Martin, LogicaCMG	**B6-Integrated Navigation III** Chair: Arne Jungstand	**C6-Maritime Navigation II** Chair: Andrzej Felski, Gdynia Maritime Academy; PNF

14:00-15:30 **Parallel Session 7**

A7-Network-based Navigation Chair: Norbert Suard, Centre National d'Etudes spatiales (CNES)	**B7-Receiver & Antenna** Chair: Bruno Blachier, Institut Français de Navigation	**C7 - Indoor Positioning II** Chair: Börje Forsell, Nordic Institute of Navigation

16:00-17:30 **ENC-GNSS 07 CLOSING SESSION**
Chair: Alain Geiger, Geodesy and Geodynamics Lab, ETH; ION-CH

ENC-GNSS 07 Recapitulation David Broughton, RIN

AWARDS	**presented by**
1. ION-CH Student Paper Competition	Bertrand Merminod, ION-CH; EPFL
2. EUGIN Best Paper Award	Rein van Gooswilligen; EUGIN
3. ION-CH Best Poster Award	Bertrand Merminod, ION-CH; EPFL

ENC-GNSS 2008 Presentations

Georges Estibal, Vice-President of Grand Toulouse
Bruno Blachier, IFN
Frédéric Cornet, CNES

ENC-GNSS 07 Closing — Rein van Gooswilligen; EUGIN