



# il Contributo Europeo alla Navigazione Satellitare: il sistema EGNOS e la prospettiva Galileo



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ESSP (*European Satellite Services Provider*)  
Ordine degli Ingegneri di Napoli  
December 7<sup>th</sup> 2006

# Sommario

- GPS e GNSS
- L'Architettura di EGNOS
- EGNOS oggi
- Il Segmento Utente
  - ▶ L'area di copertura del servizio
  - ▶ I Servizi di EGNOS
  - ▶ Le applicazioni di EGNOS
- L'uso di EGNOS nell'Aviazione Civile
- La prospettiva Galileo

# GPS: caratteristiche

- Sistema sotto il controllo governativo (DoD)
  - ▶ In caso di crisi internazionale, rischio di disattivazione su una larga area di utilizzo
  - ▶ Crisi in Bosnia
  - ▶ Disponibilita' e Continuita' non assicurate
- Servizi
  - ▶ "Standard Positioning Service (SPS)"
    - ◆ singola frequenza, gratis, per uso civile
  - ▶ "Precise positioning service (PPS)"
    - ◆ doppia frequenza, maggiore accuratezza, criptato, per agenzie governative autorizzate
- Evoluzioni (GPS II-R-M)
  - ▶ Seconda frequenza civile
  - ▶ Terza frequenza militare

# GPS: applications and limits

- With the development of GPS, the use of navigation, based on satellites, enlarged to many fields of application
- In 2000 “Selective Availability” switched-off
  - ▶ Boom of use of satellite navigation
- Advantages:
  - ▶ Decrease of transport costs due to optimization of the route
  - ▶ Minimize environmental impact of transport
  - ▶ Cheap and efficient
- Constant monitoring of all satellites not possible
  - ▶ Control Station and Monitoring Stations sited in US
  - ▶ No information about the quality of the position provided
  - ▶ Lack of integrity information
  - ▶ Not reliable for safety-critical application support

# Applications GPS alone

Safety - of - Life market	Mass - Market	Professional market
Aviation	Personal navigation	Oil and gas
Rail	Cars / motorcycle	Mining
Maritime	Truck & buses	Timing
Inland Water	Light commercial vehicle	Environmental
Ambulance	Personal outdoor recreation	Fleet Management
Police brigade		Asset Management
Search and rescue		Land surveying, GIS
Police protection		Precision agriculture
Public surveillance		Emergency services
		Robotics control
		Civil engineering

Error-free  
Standards,  
Regulation,  
Continuity,  
Availability,  
Accuracy

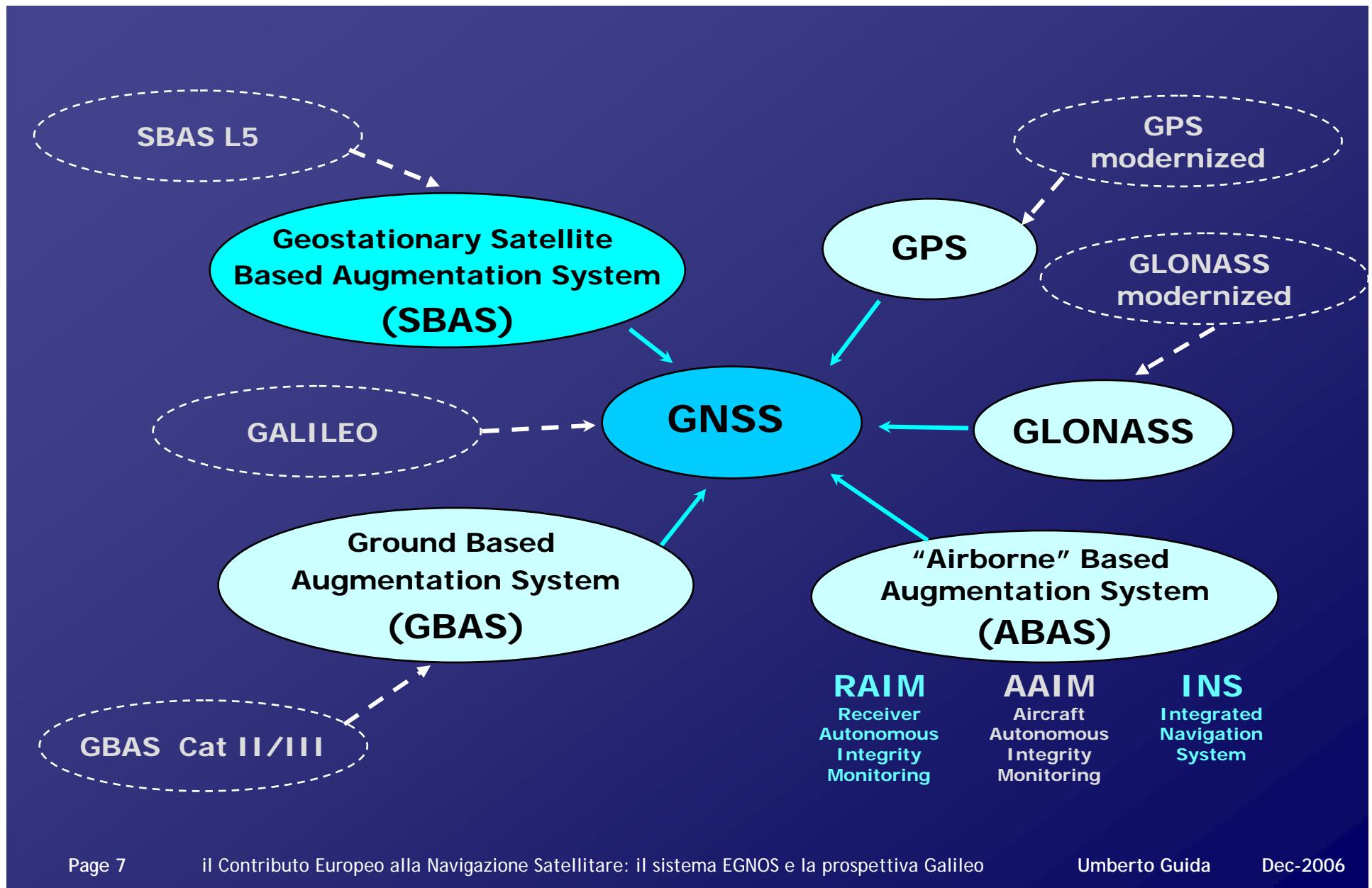
Low costs,  
Low power cons.,  
Small size,  
Friendly use,  
Best perf.  
accordingly

High precision,  
High accuracy,  
High reliability

# GLONASS

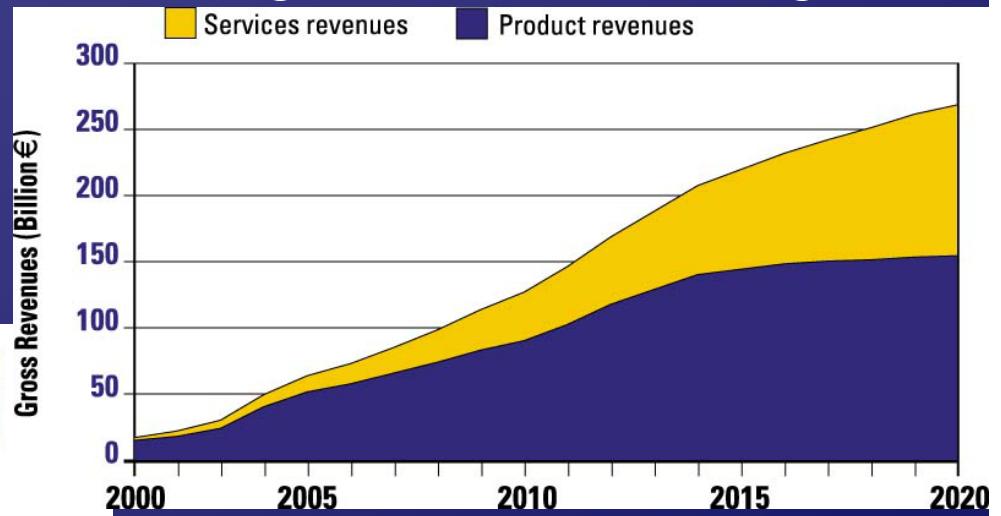
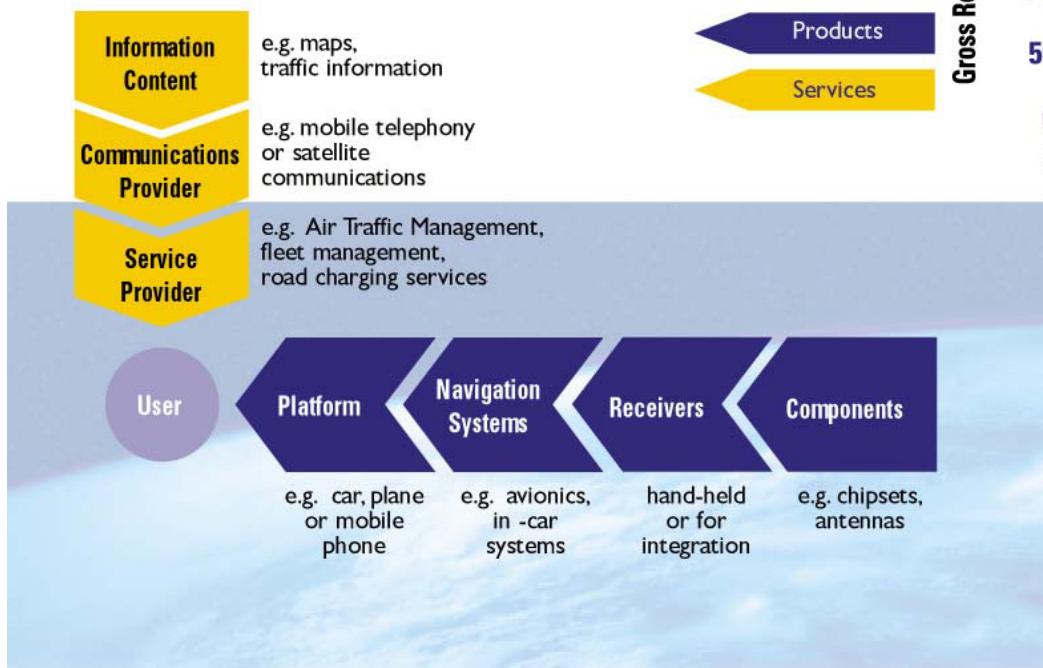
- GLONASS e' controllato dal Governo della Federazione Russa.
- Nominalmente la costellazione GLONASS e' formata da 24 satelliti in 3 piano orbitali.
- L'utilizzo di GLONASS e' molto limitato:
  - ▶ Costellazione incompleta
  - ▶ Scarsa disponibilita' del servizio
  - ▶ Performances datate
- Stessi campi applicativi del GPS, ma penetrazione nel mercato molto inferiore a causa dei limiti
  - ▶ Usato in aree di ex influenza Sovietica

# GNSS Elements



# GNSS Market

- Boom in the use of Satellite Navigation technologies
  - ▶ Real figures up 2005



- In 2020, estimated worldwide GNSS market
  - ▶ €275 - €300 billions
  - ▶ 3 billion receivers

# Applications GNSS-1

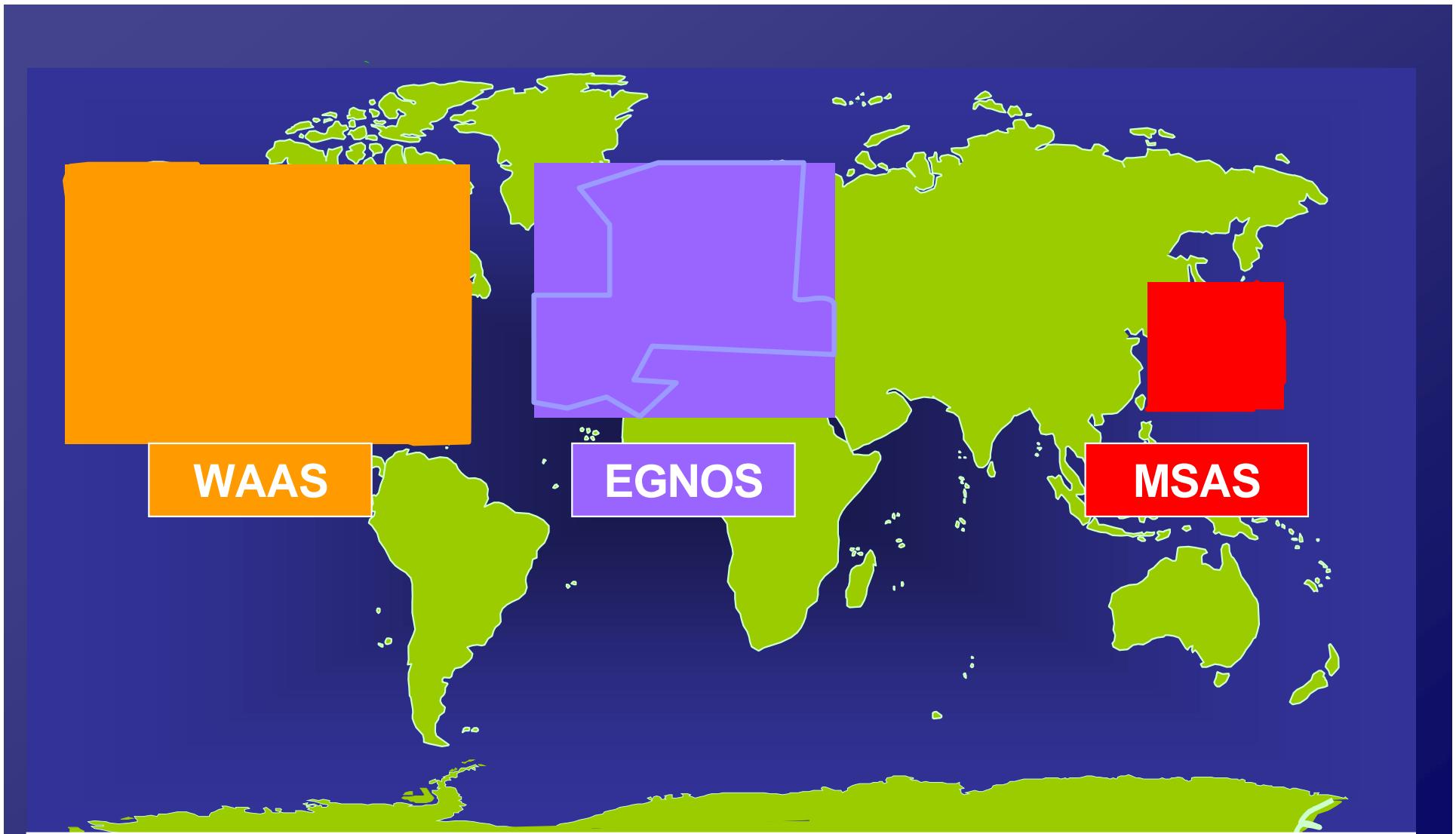
Safety - Reliable market	Mass - Market	Professional market
Aviation	Personal navigation	Oil and gas
Rail	Cars / motorcycle	Mining
Maritime	Truck & buses	Timing
Inland Waterways	Light commercial vehicle	Environmental
Ambulance	Personal outdoor recreation	Fleet Management
Police / fire-brigade		Asset Management
Search and rescue		Land survey / GIS
Personal protection		Precision agriculture
Traffic surveillance		Fisheries
Dangerous good transport		Robotics control
		Civil engineering

**GPS + Augmentations**

The diagram consists of three yellow arrows pointing from left to right, each containing a list of requirements for the respective market segments:

- Error-free**: Standards, Regulation, Continuity, Availability, Accuracy
- Low costs**: Low power cons., Small size, Friendly use, Best perf. accordingly
- High precision**: High accuracy, High reliability

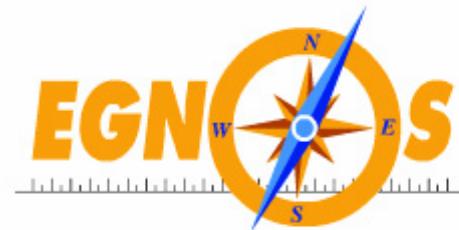
# SBAS today



# EGNOS foundations

**2/3**  
(ETG)  
European Tripartite Group

**1/3**  
(EOIG) Egnos Operators  
and Infrastructure Group



European Geostationary Navigation Overlay Service



# Introducing the ESSP

## EOIG members



CNRS  
Centre National d'Etudes Spatiales



NORWEGIAN MAPPING  
AUTHORITY

**EOIG:** EGNOS Operators and Infrastructure Group. Memorandum of Cooperation between companies supporting and investing in EGNOS

## ESSP members



D S N A



**ESSP:** Company with legal representation and permanent staff



## ESSP members are:

ESA/ARTES9  
programme signatories

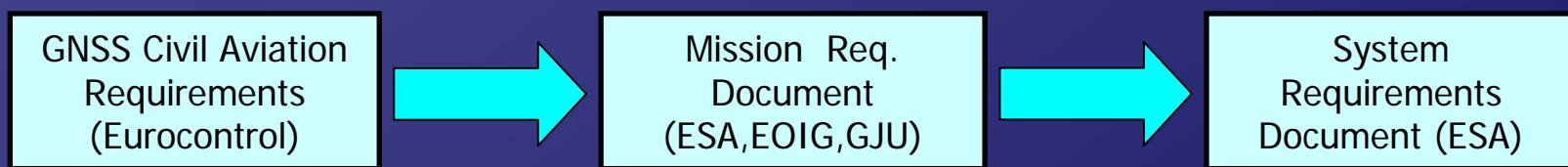
EGNOS Programme investors,  
hosts and operators

# EGNOS key parameters

- Like all navigation signals, EGNOS performances are measured against four different parameters:
  - Accuracy
    - ▶ How precise can a user locate himself, based on the signal?
  - Availability
    - ▶ How rare are failures to provide the service?
  - Continuity
    - ▶ How rare are interruptions in the service?
  - Integrity
    - ▶ How can a user know whether he can rely on his evaluated position or not?

# EGNOS Mission

- EGNOS, like all the SBAS has been designed to overcome a number of deficiencies from GPS in some **aviation-specific operations**.



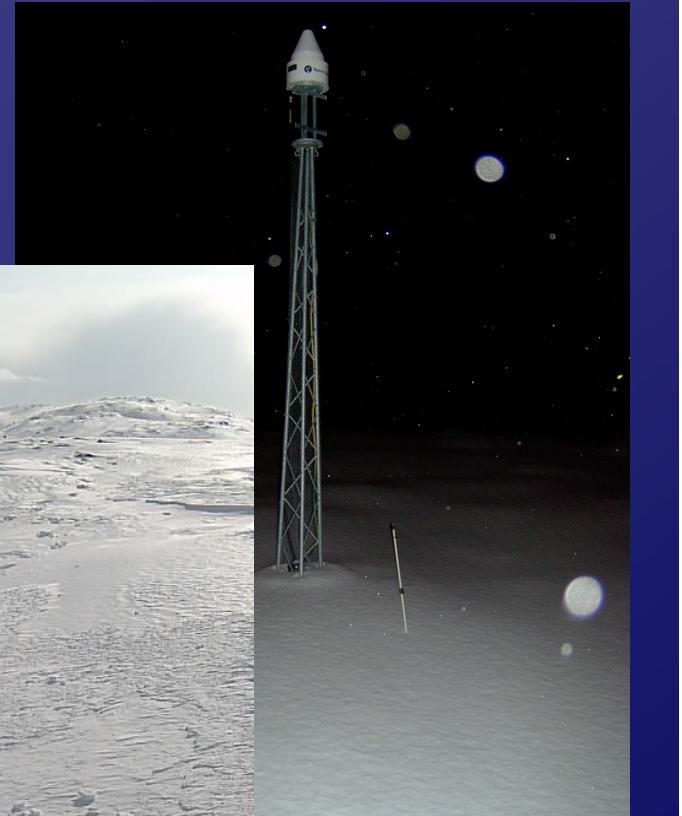
- But EGNOS is a **truly multimodal** system
  - ▶ Key advantages to various navigation markets
  - ▶ Stimulating the creation of new services based on his benefits



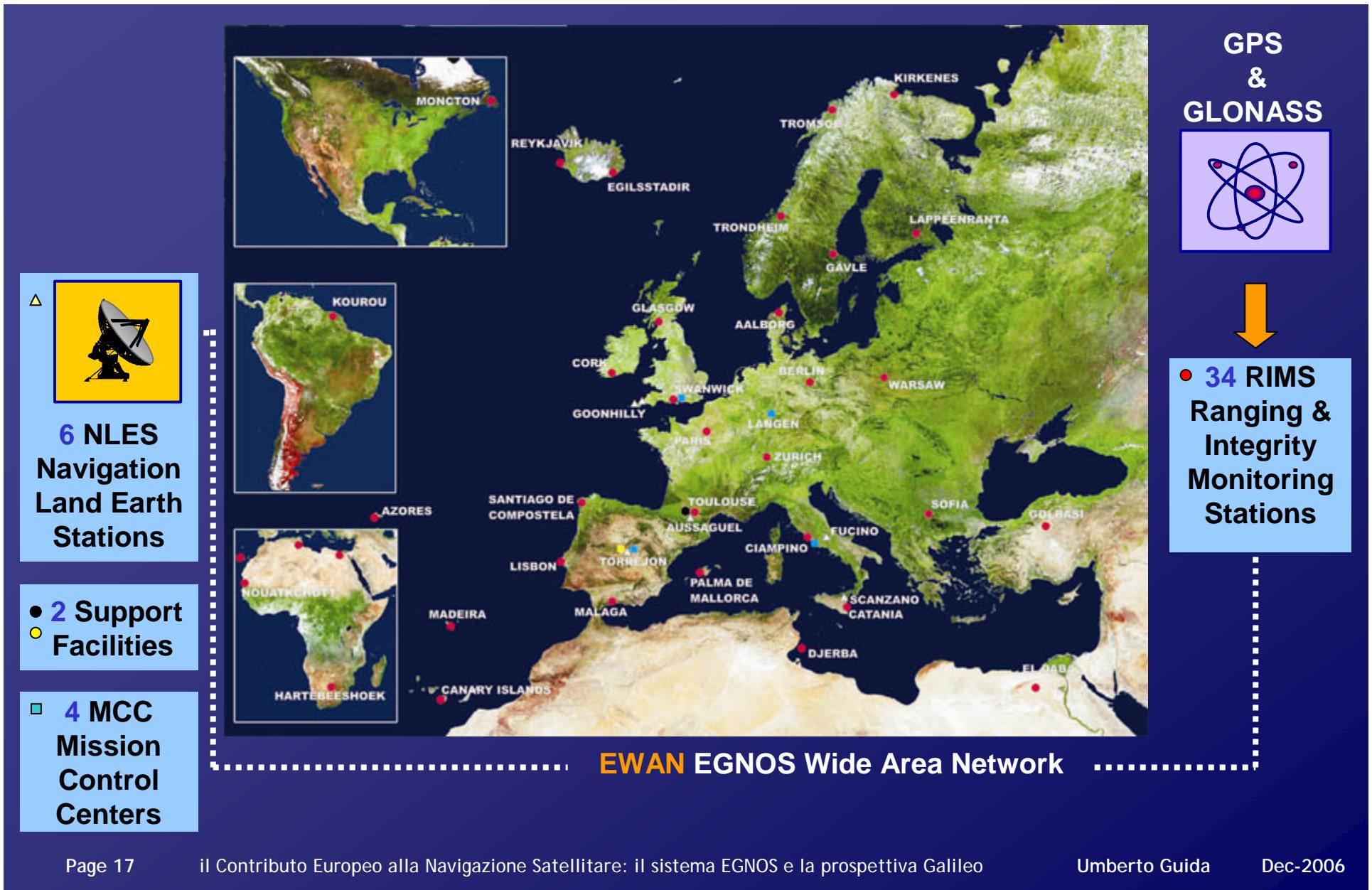
# EGNOS Architecture



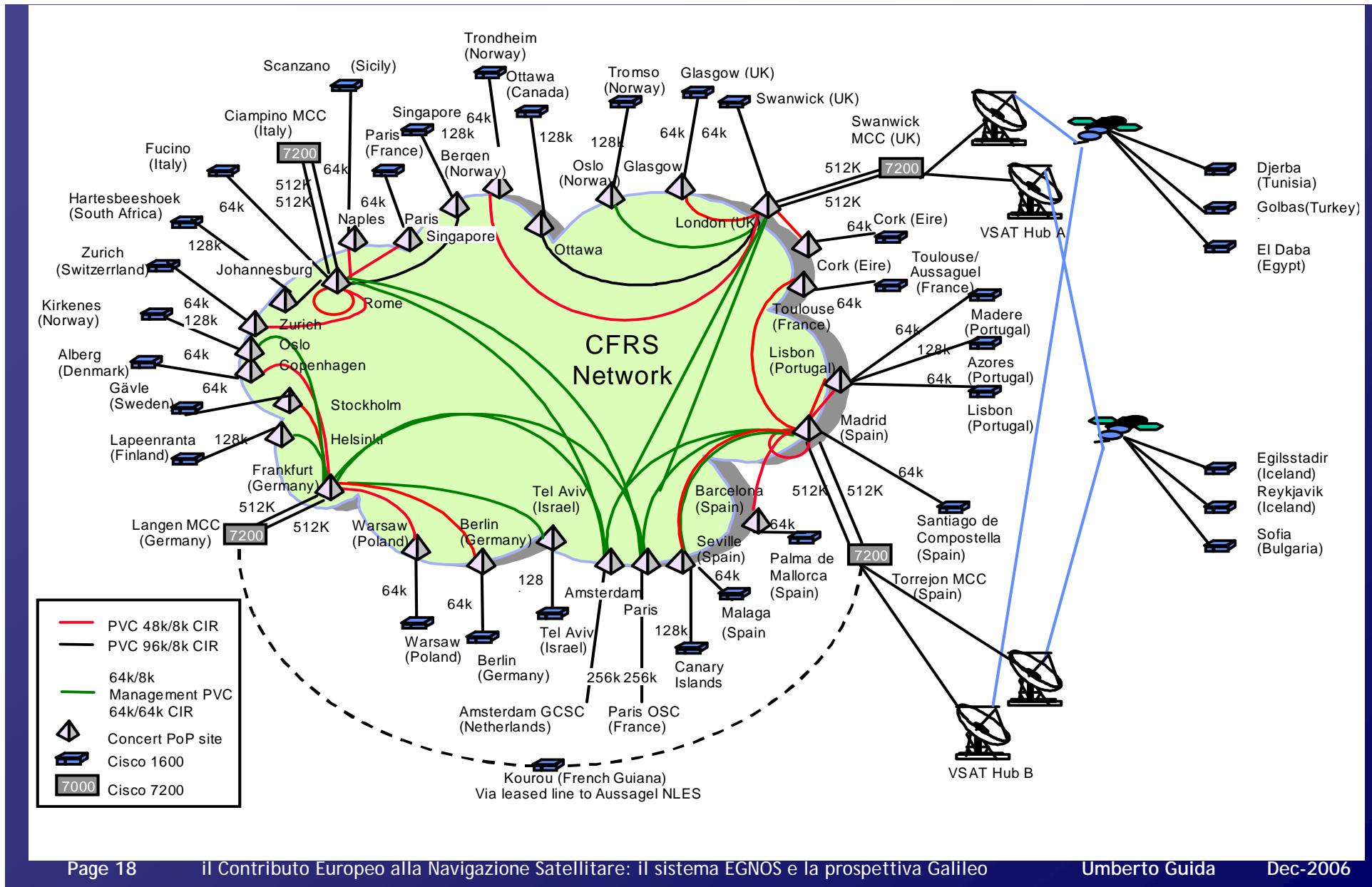
# RIMS Location

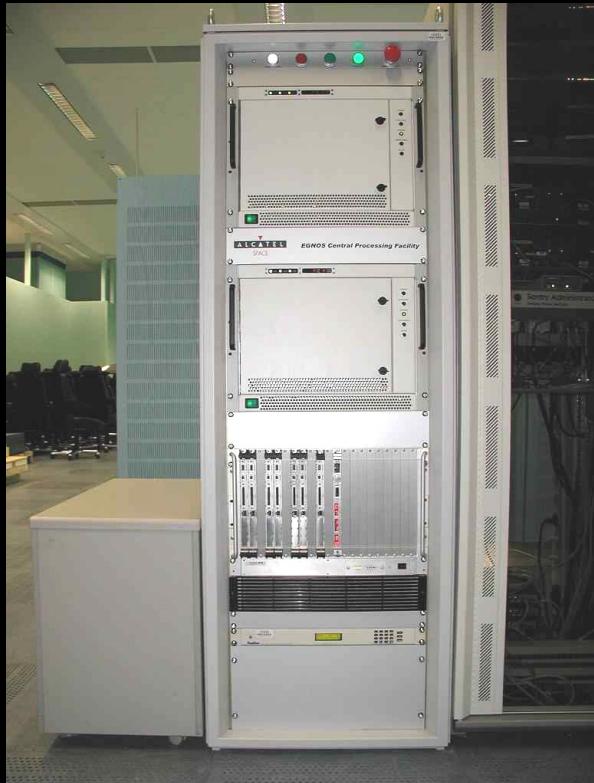


# EGNOS Architecture



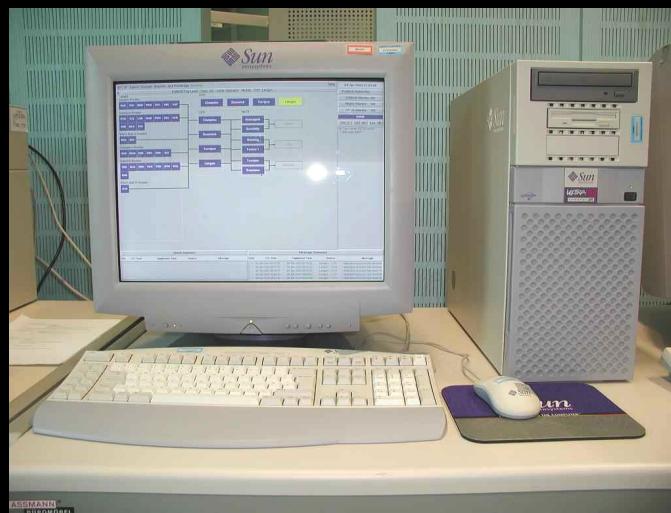
# EGNOS Wide Area Network (EWAN)





CPF

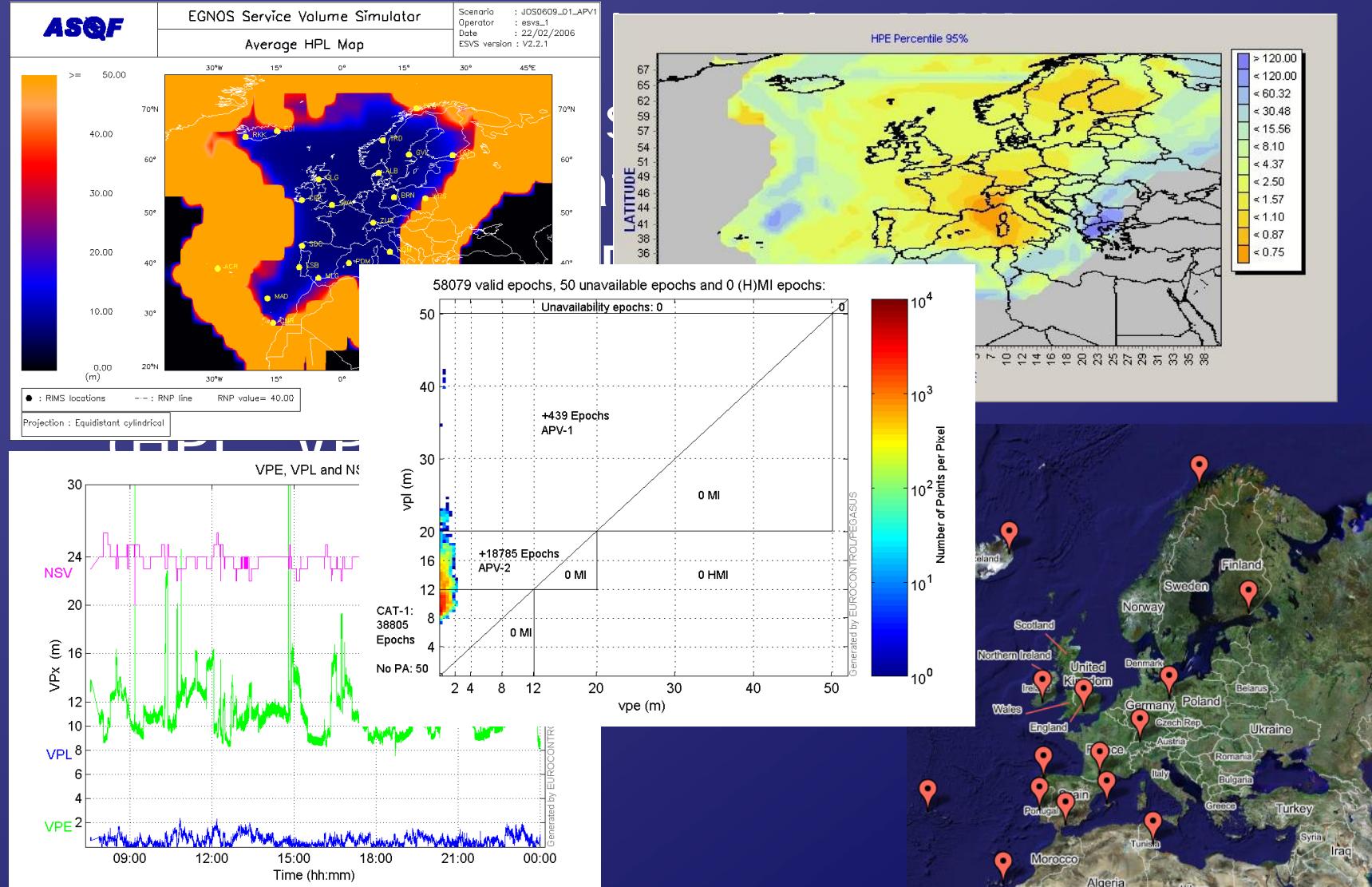
## Mission Control Centre



CCF

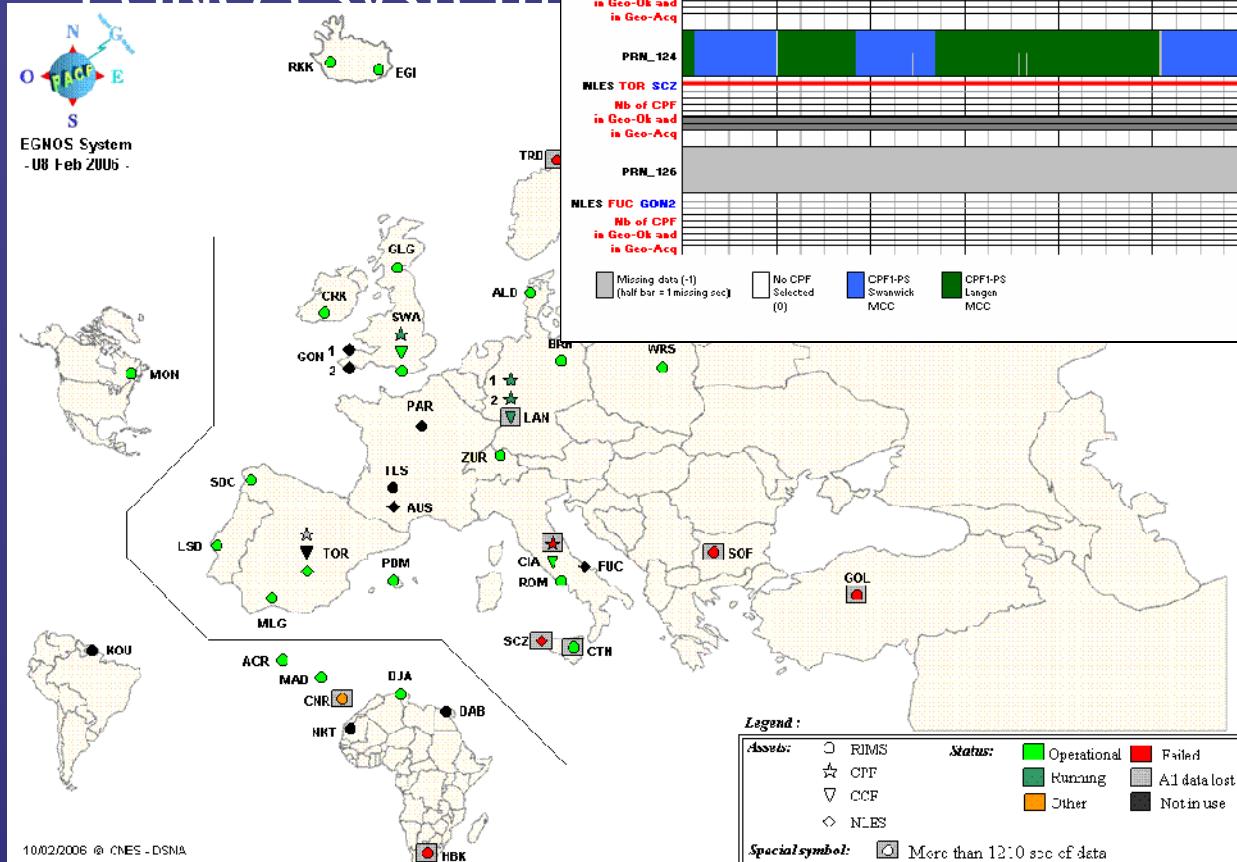


# ASQF: Application Specific Qualification Facility



# PACF: Performance Analysis & Check-out Facility

- located in Toulouse
- Operations and maintenance of EGNOS system

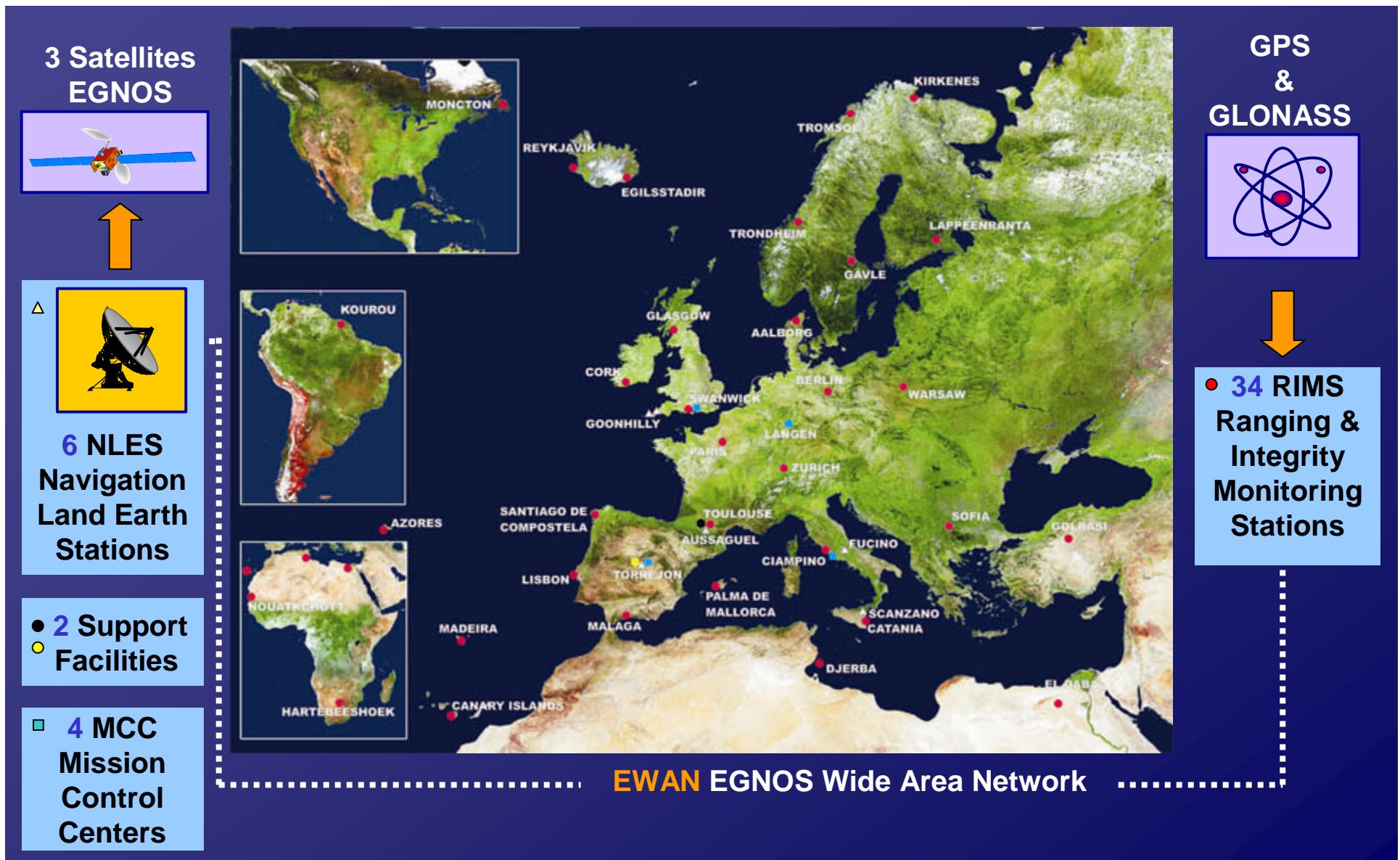


rm), used for  
are items.

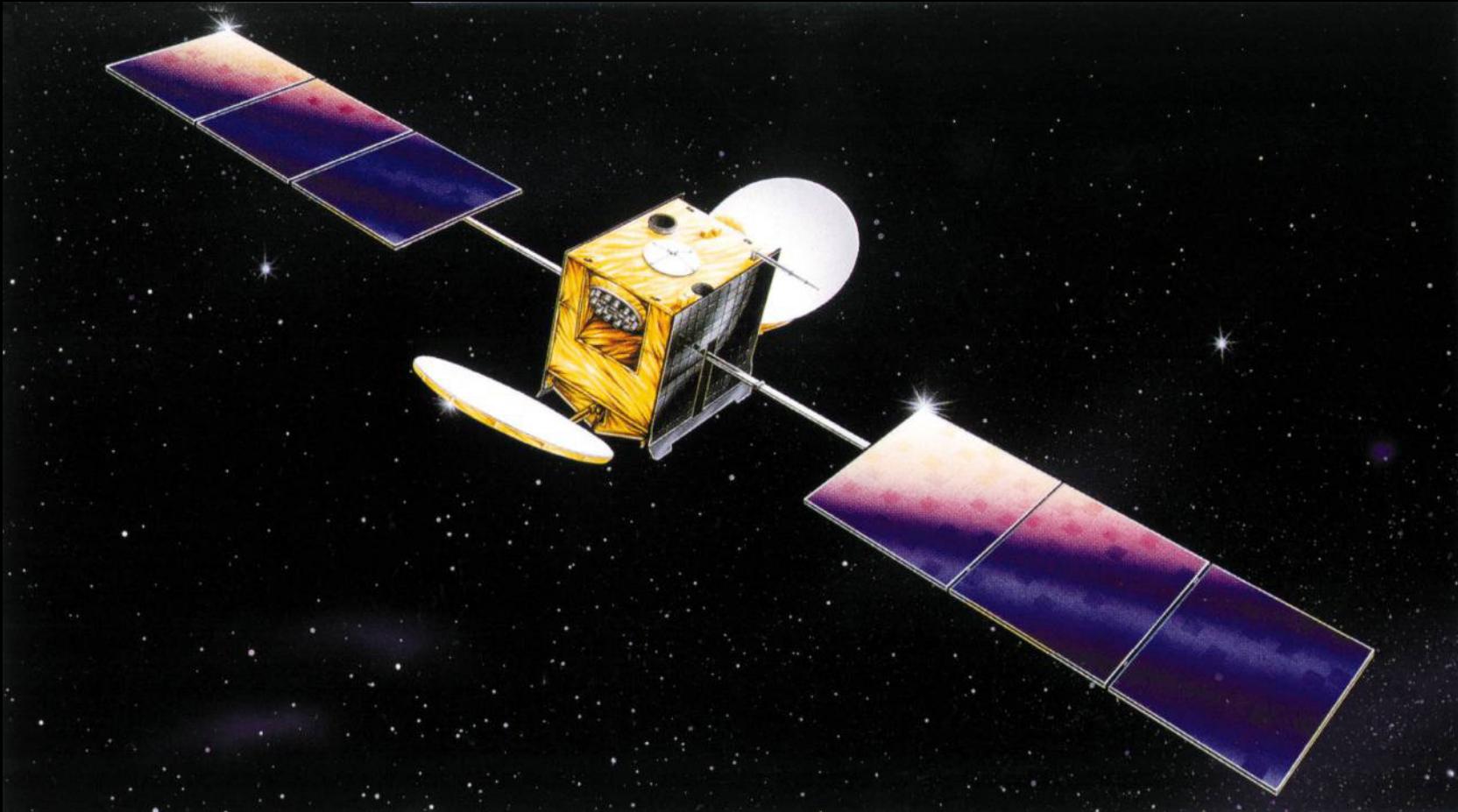
# Navigation Land Earth Station (NLES)



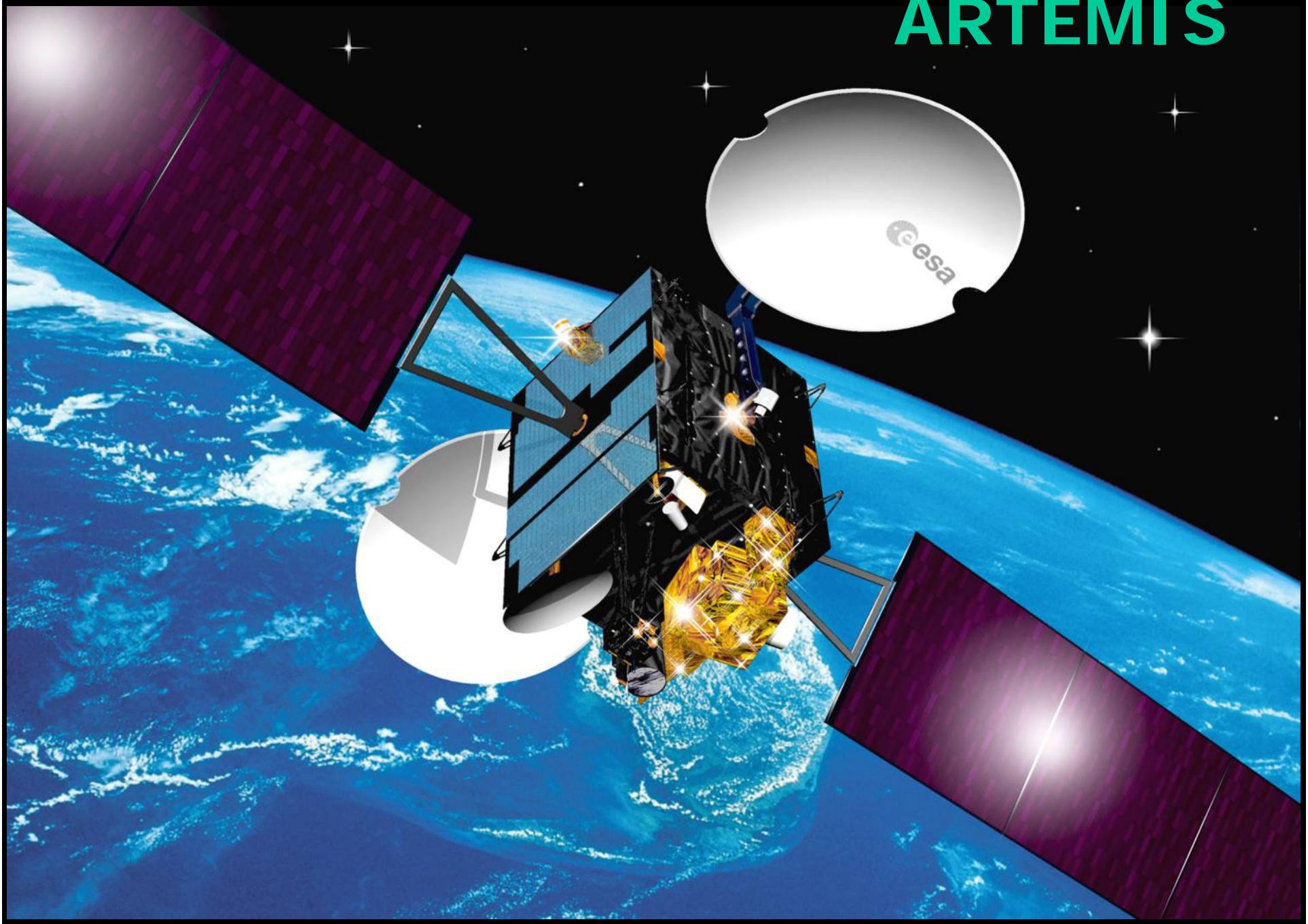
# EGNOS Architecture



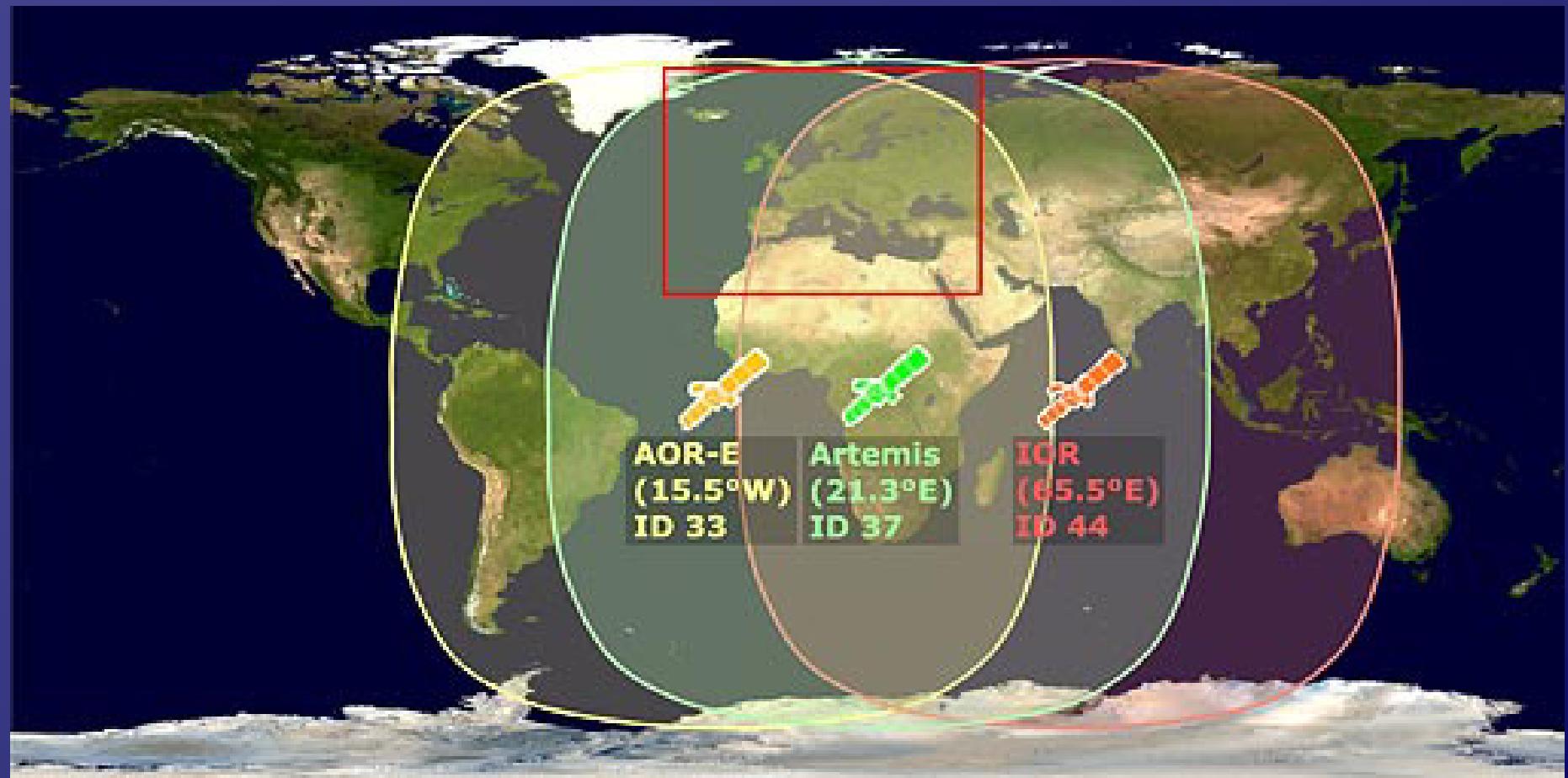
# inmarsat GEO Satellite



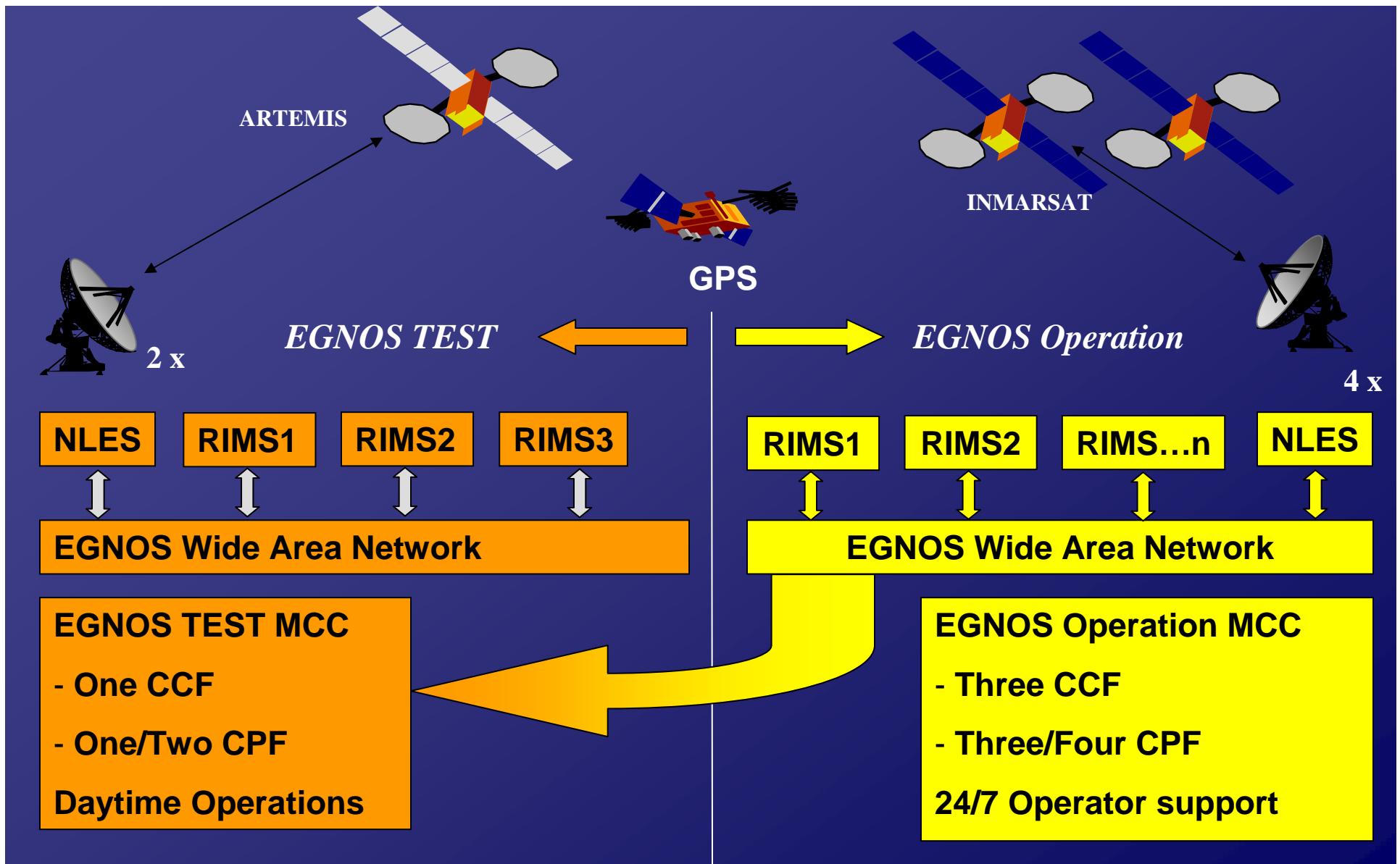
# ARTEMIS



# GEO Coverage Area

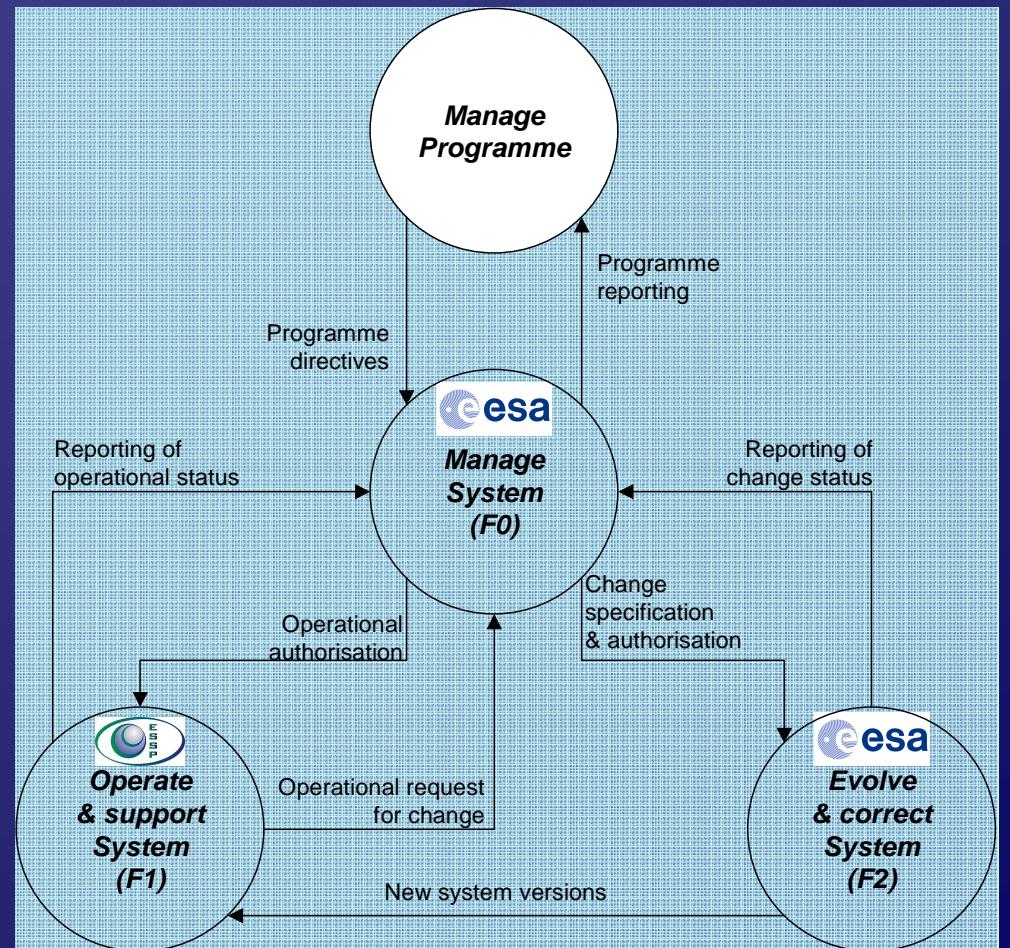


# EGNOS architecture today

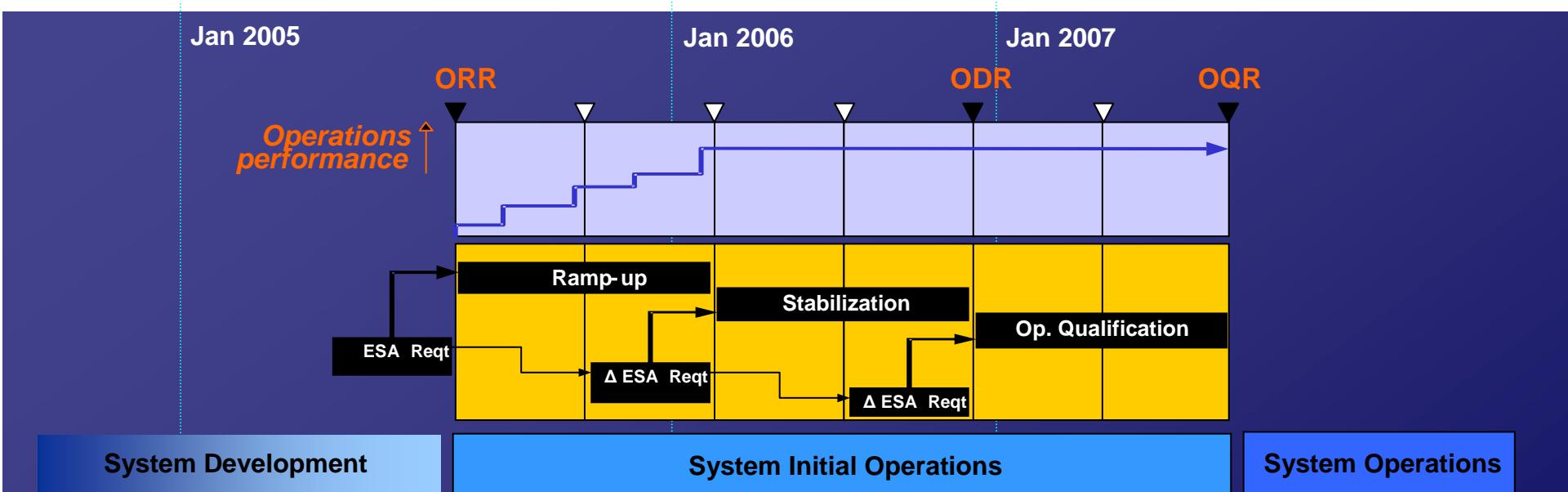


# EGNOS Programme Management today

- ESA EGNOS Project Office is responsible for managing the overall EGNOS programme under the ESA GNSS Support Programme
- Alcatel Alenia Space - France is responsible for system evolutions and corrective maintenance actions
- ESSP is responsible for the Operations and Support of the EGNOS system

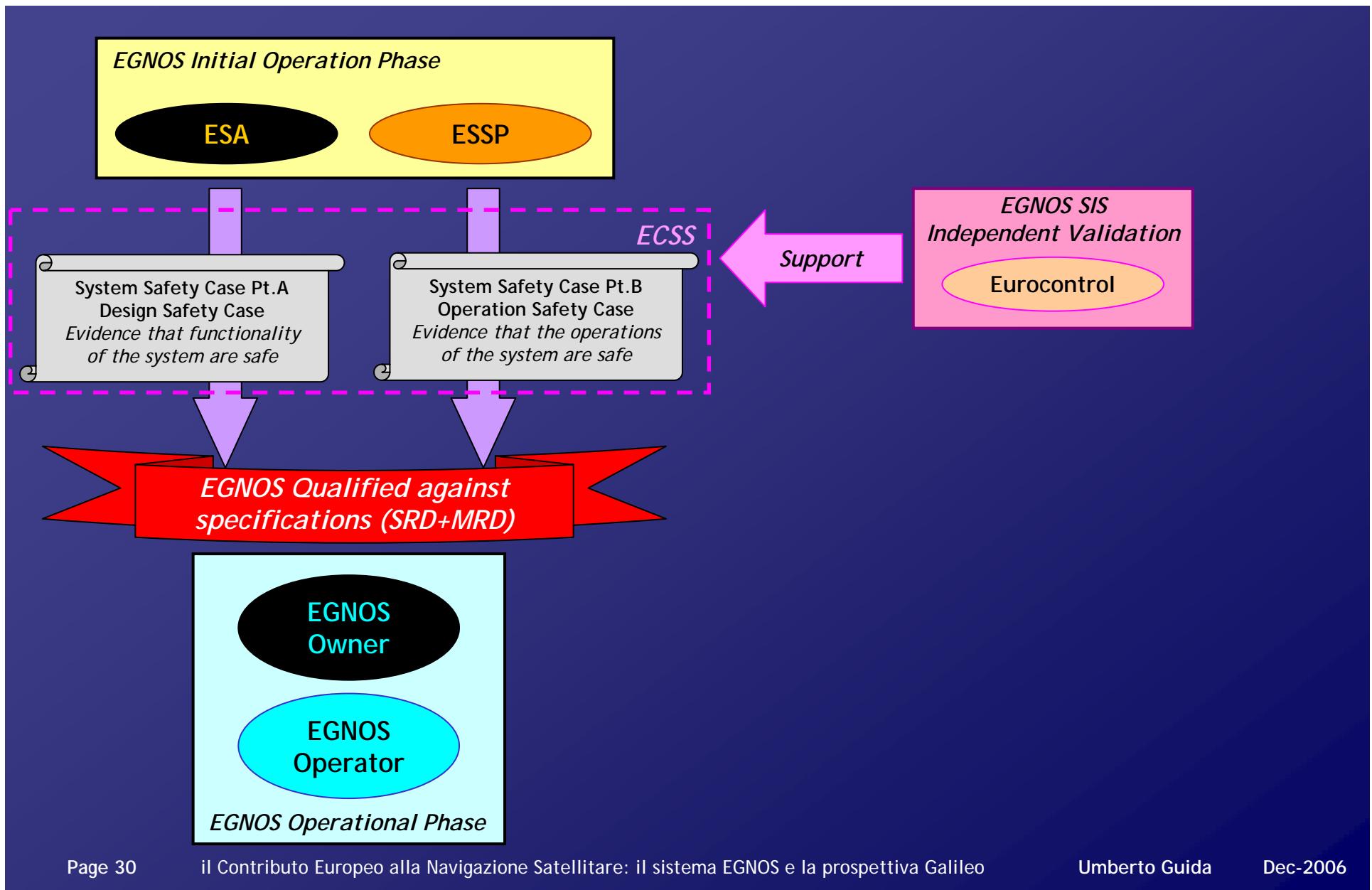


# EGNOS is “Approaching”



- EGNOS is in the Initial Operation Phase
  - ▶ Consortium managed by ESSP
  - ▶ 18 Months contract with ESA split in three phases
    - ◆ Ramp-up, stabilize and qualify the EGNOS Operations respect the nominal operation performances
  - ▶ In the 2007 the EGNOS system and its operations will be qualified
  - ▶ Qualification of EGNOS services for Safety-of-Life will follow

# EGNOS Qualification Process



# Monitoring of Performances

- Eurocontrol's EGNOS SIS Validation Task Force
  - ▶ SIS Independent Monitoring to support SIS certification
  - ▶ Assessment of EGNOS performance achievable with a MOPS Do229C compliant receiver over the ECAC Area.
  - ▶ Support the safety case that EGNOS can be used as a navigation means to provide guidance up to APV-I approach operations as defined in the ICAO GNSS SARPs document (up to amendment 79/05)
- Eurocontrol's EGNOS Data Collection Network and ESA's IMAGE
  - ▶ Academic, ANSP and Research Centres
  - ▶ Awareness objective
- Mediterranean EGNOS Data Collection Network in area MEDA managed by ESSP

# MEDaCoN (Mediterranean EGNOS Data Collection Network)

Network of Data Collection Stations connected to one Data Collection Server for real-time monitoring of EGNOS performances over MEDA



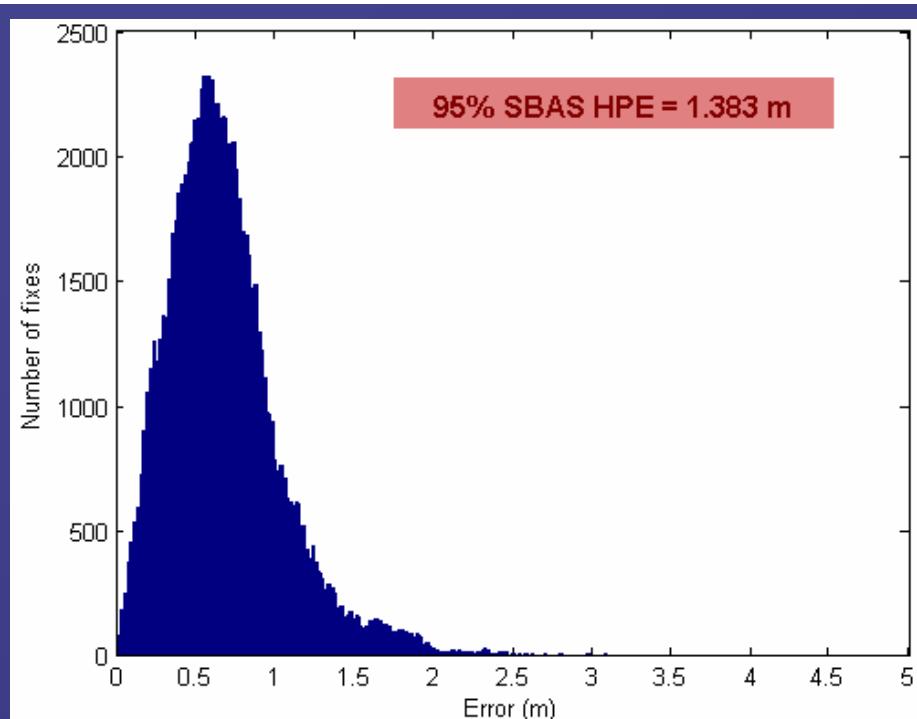
- ▶ Managed by ESSP
- ▶ 9 of 10 Euro-MED Area countries participate
  - > ARCE (Algeria)
  - > NASC (Egypt)
  - > TECHION (Israel)
  - > JUST (Jordan)
  - > ARIJ (Palestine)
  - > AUI (Morocco)
  - > IT.COM (Tunisia)
  - > TURKSAT (Turkey)
  - > University (Lebanon)

## Area monitoring tool to:

- ✓ support academic activities
- ✓ support performance assessments for service / application test

Increase confidence about EGNOS performances vs. application needs

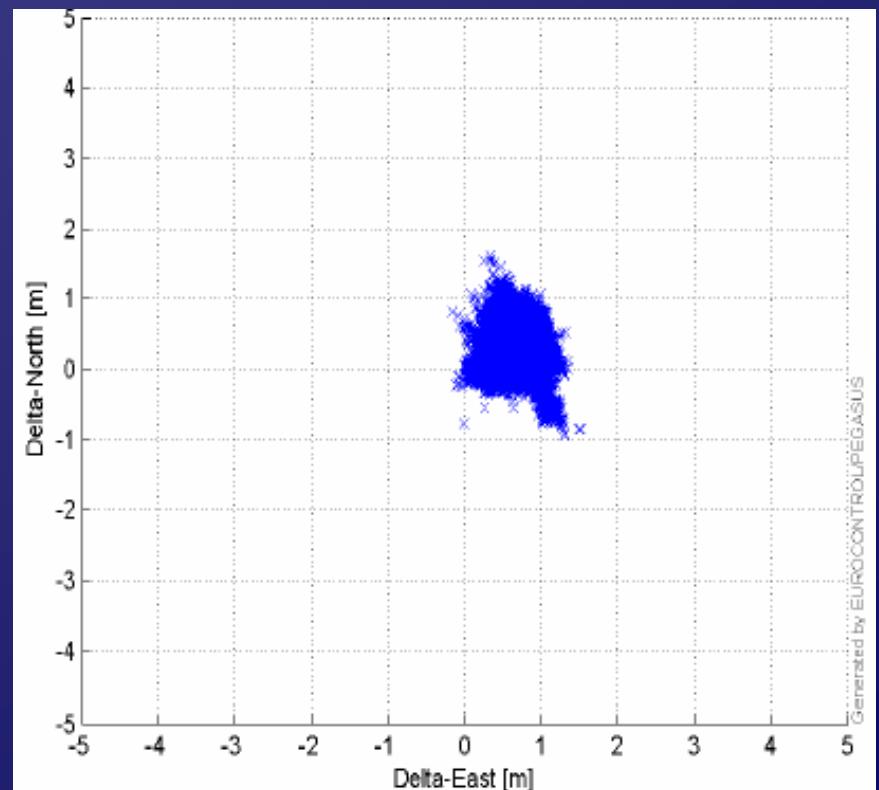
# Accuracy



Position error histogram

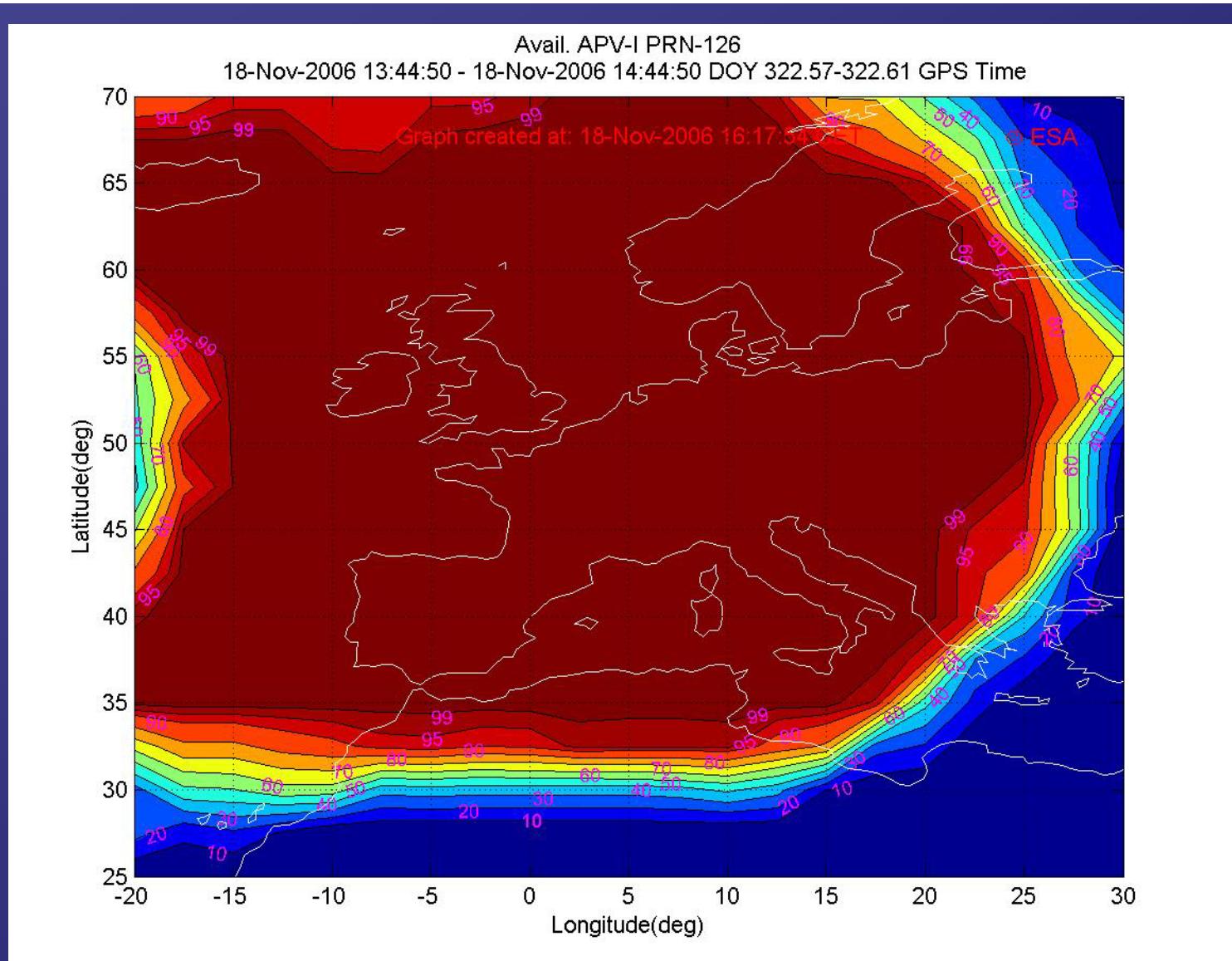
## Initial requirements

Horizontal Accuracy [m]	Vertical Accuracy [m]	Availability of Accuracy	Integrity
2	4	99%	N.A.

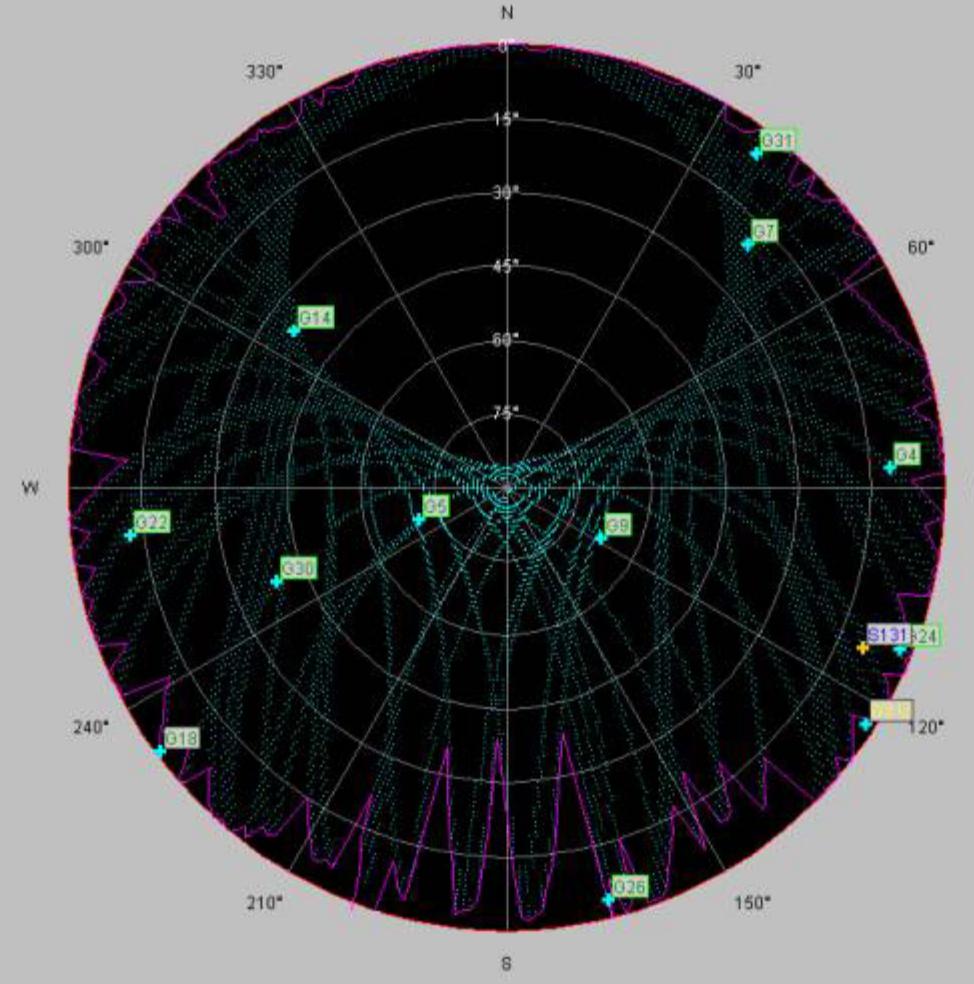


Accuracy deviation from reference

# Availability of service today

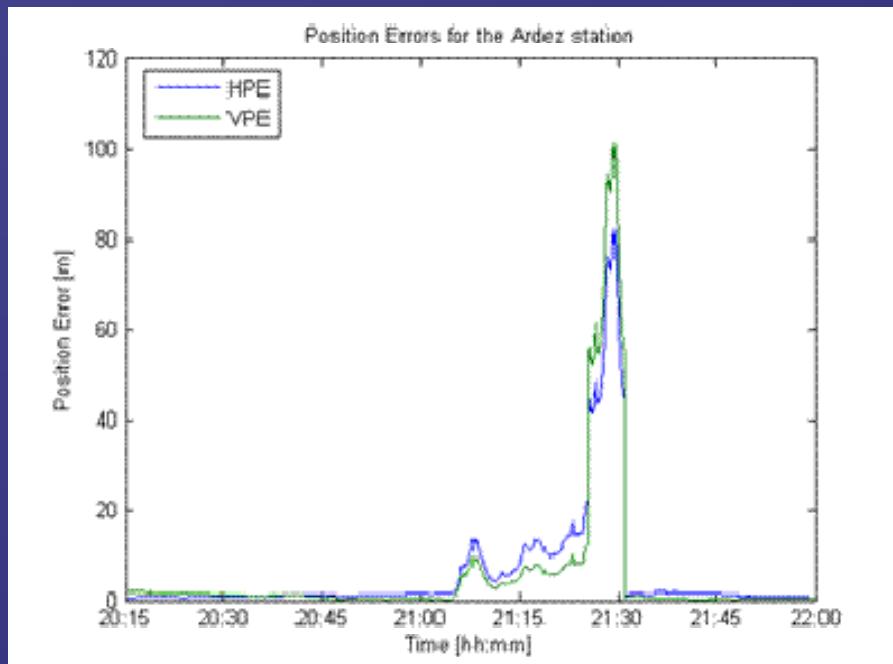


# Local Horizon Mask (at ESSP)

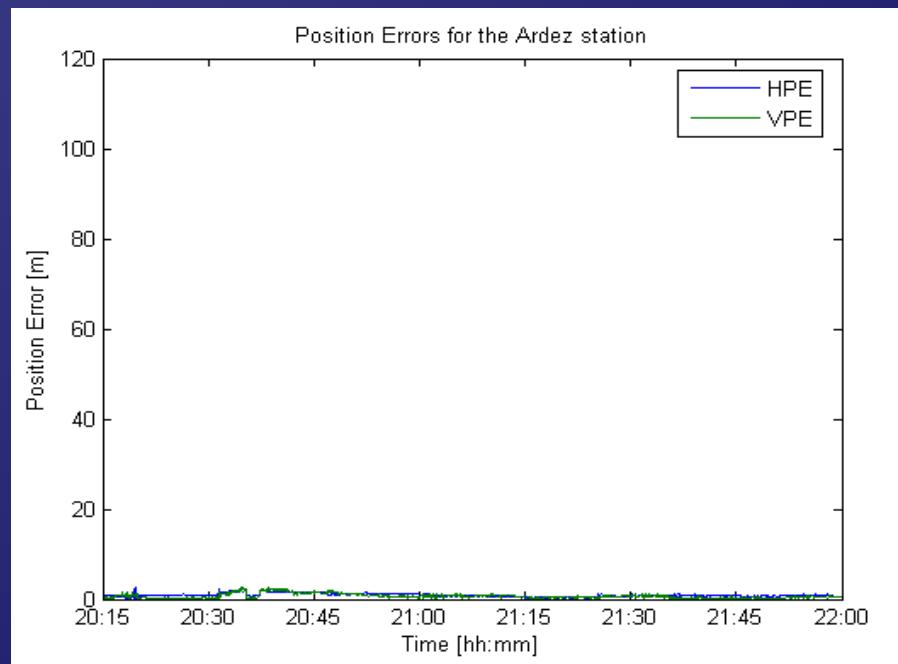


# It works!

- A GPS satellite failure had been reported by the GPS satellite PRN 25 on 25<sup>th</sup> December 2005 at approximately 21:05 UTC.



GPS only receiver



GPS plus EGNOS

*Courtesy of PACF team (who detected the event) and skyguide (who make the analyses)*

# EGNOS User Support Websites

- ESA website “EGNOS for Professional”
  - ▶ Near real-time performances, technical information...
- ESSP website ([www.essp.be](http://www.essp.be)) provides information about services
- Through the ESSP website, access to
  - ▶ The Operations User Support Web Site
    - ◆ Information on EGNOS operations
    - ◆ Projection of performances on a weekly basis (registered users)
    - ◆ SIS-down alerts by e-mail (registered users)...
  - ▶ Helpdesk provides information supporting trials
    - ◆ Request is dispatched to ESA, ESSP, ASOF according to his contents
    - ◆ In the last 6 months, more than 30 demonstrations and trials have been supported by the EGNOS Operation Help-desk

# ESA website

EGNOS for Professionals »

EMS»

SISNetLab»

SISNet»

Real Time

Monthly Reports »

IMAGE»

Contact EGNOS Helpdesk»

Disclaimer »

Search

GO

Advanced Search

Flash Real Time Website »

Today's EGNOS Performance

Position Errors and Protection Levels vs. Time and 2D Histogram:

(Select station from the map)

GEO Satellite Message Broadcast status and contents

(PRN 120 is currently allocated to ESTB):

124

126

[http://ravel.esrin.esa.it/docs/egnos/estb/IMAGETech/imagetech\\_realtime\\_html.htm](http://ravel.esrin.esa.it/docs/egnos/estb/IMAGETech/imagetech_realtime_html.htm)



## safe SATELLITE NAVIGATION CLOSER to you



DSNA

Members of ESSP

HOME COMPANY PROFILE NEWS INFORMATION HELPDESK FAQ CONTACT

About EGNOS

EGNOS in Operations

EGNOS Services

ESSP's Projects

Receiver Technology



AVIATION



TERRESTRIAL



MARITIME



European Geostationary Navigation Overlay Service

EGNOS Operations  
user support website

### NEWS

ION-GNSS 2006 Conference in Fort Worth, Texas USA, on September 26-29, 2006

### ESSP'S MISSION

ESSP has been created in 2001 to operate the EGNOS system and provide Safety of Life services to different user communities. The EGNOS services in Europe are preparing those of the future GALILEO constellation.

EGNOS is a space augmentation to GPS. GPS typically provides 15m to 20m accuracy to the user. EGNOS provides 1m to 2m accuracy and additional performances such as integrity of information meeting aviation, terrestrial and maritime stringent requirements for some of their phases of navigation.

This website provides useful general information about EGNOS, and through its pages will guide the users through specific requirements, performances, trials to show the true benefits of Satellite Based Augmentation Systems.

[Click here to see the EGNOS movie](#)  
[Courtesy of the European Space Agency](#)

### DISCLAIMER

The EGNOS system is currently not qualified. Therefore the signal performances are not guaranteed; ESSP may not be held liable for any damage, direct or indirect consequences linked to the use of the EGNOS signal.

Furthermore, all the data on this website is indicative; ESSP declines all responsibility for erroneous information

### HELPDESK

For any inquiry about EGNOS, its operations and its signal status, please contact our Helpdesk

# Aena EGNOS Operations Website Services

EGNOS OPS  
User Support



ASQF

You are here: [ESSP Home](#) > User Support

## Service Availability

### Today

 **NLES-TOR-FAILURE**  
(from 15:00 to 16:00)  
[Consult historical of alerts](#)

### Next days

Last update: 25/12/2005

[ARTEMIS \(PRN 124\)](#)

PRN124 SIS outage from 00:00 UTC 2005/10/24 (due to NLES-TOR failure; restoration due by 2005/10/24 14:05 UTC (following CPF-CIA re-convergence)...+info

### Mode of signal transmission

> Mode 0



Welcome to



## EGNOS OPERATIONS USER SUPPORT

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's first venture into satellite navigation...+info

You can consult information about...

### EGNOS OPERATIONS:

- > ARTICLES
- > NEWS
- > SBAS RECEIVERS
- > LINKS

### EGNOS SYSTEM:

- > GEO SERVICE AREA
- > CURRENT ARCHITECTURE

### SERVICE PERFORMANCE

This information is only available for registered users.

[Register Now...](#)

## My account

USER

PASSWORD



[Forgot your password?](#)

Not a member yet? [Register Now...](#)

Would you like to acces to more content?...  
Find out the advantages for being a member of the Egnos Ops...+info

## Egnos operations HELPDESK

### FAQ: Frequent asked questions

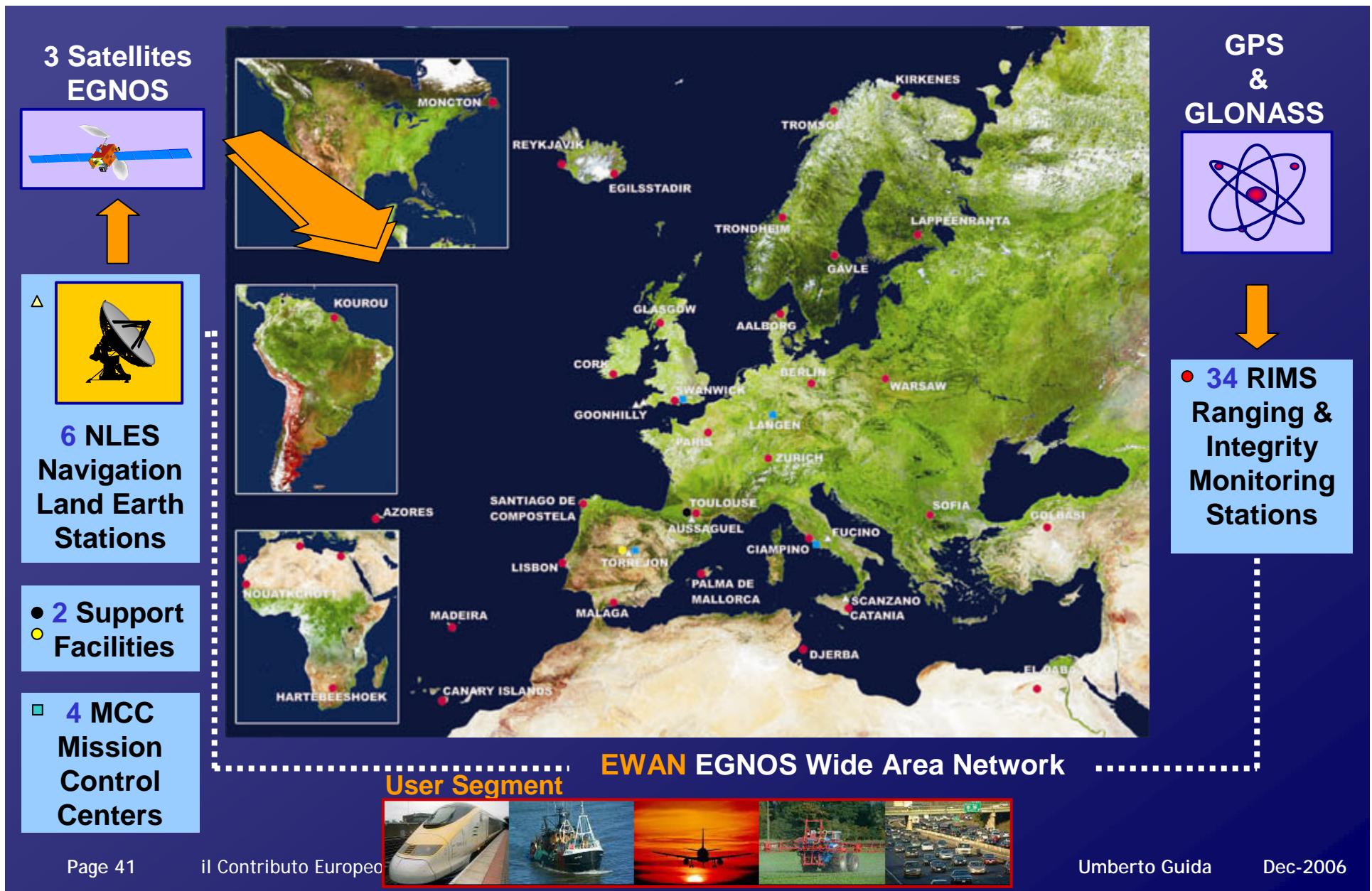
We solve the most frequent asked questions made by ussers of Egnos and doubts about the application...+info

### Questions

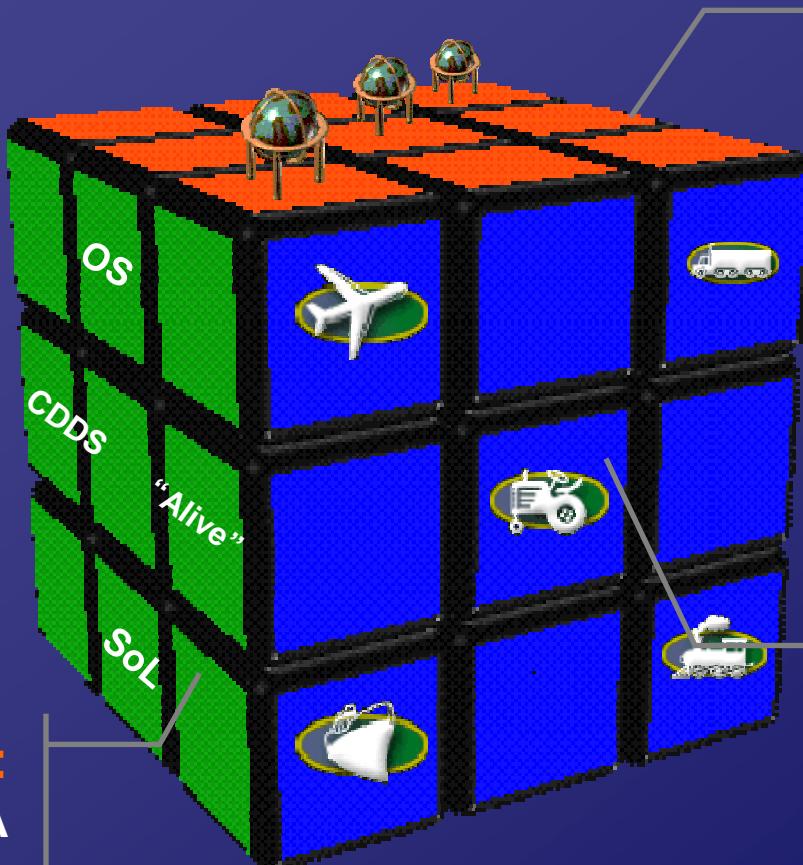
If you want to contact any unit or working department of Egnos consult the contacts list...+info



# EGNOS Architecture



# User Segment



**Services:**  
OA  
SoL  
CDDS

**«Alive» concept**

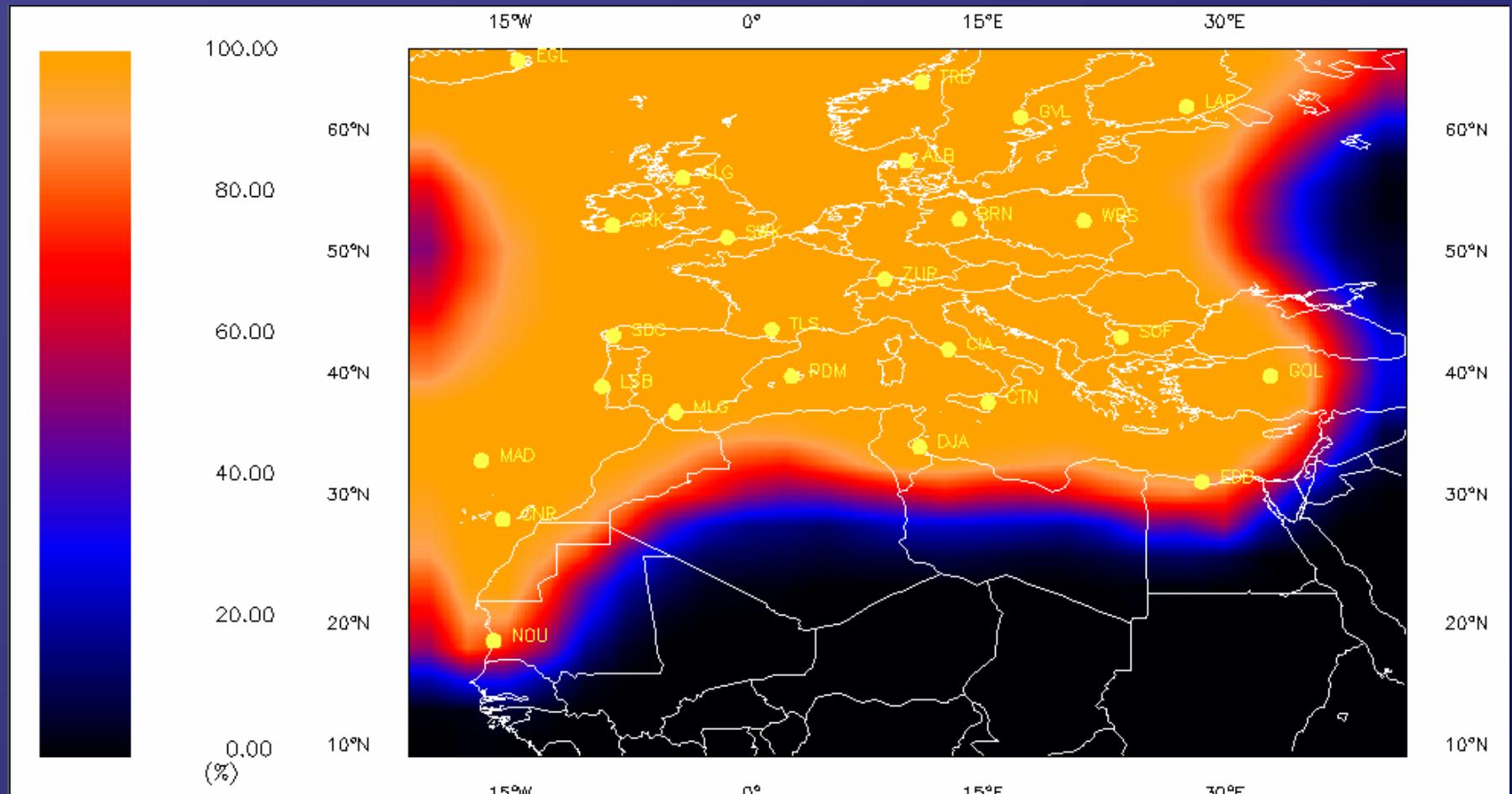
**Service Areas:**  
MEDA Area  
Western Europe  
Eastern Europe  
Middle East  
Africa...

**Application Markets:**  
Aviation,  
Maritime,  
Road and Rail,  
Personal / Consumer

# EGNOS Service Area

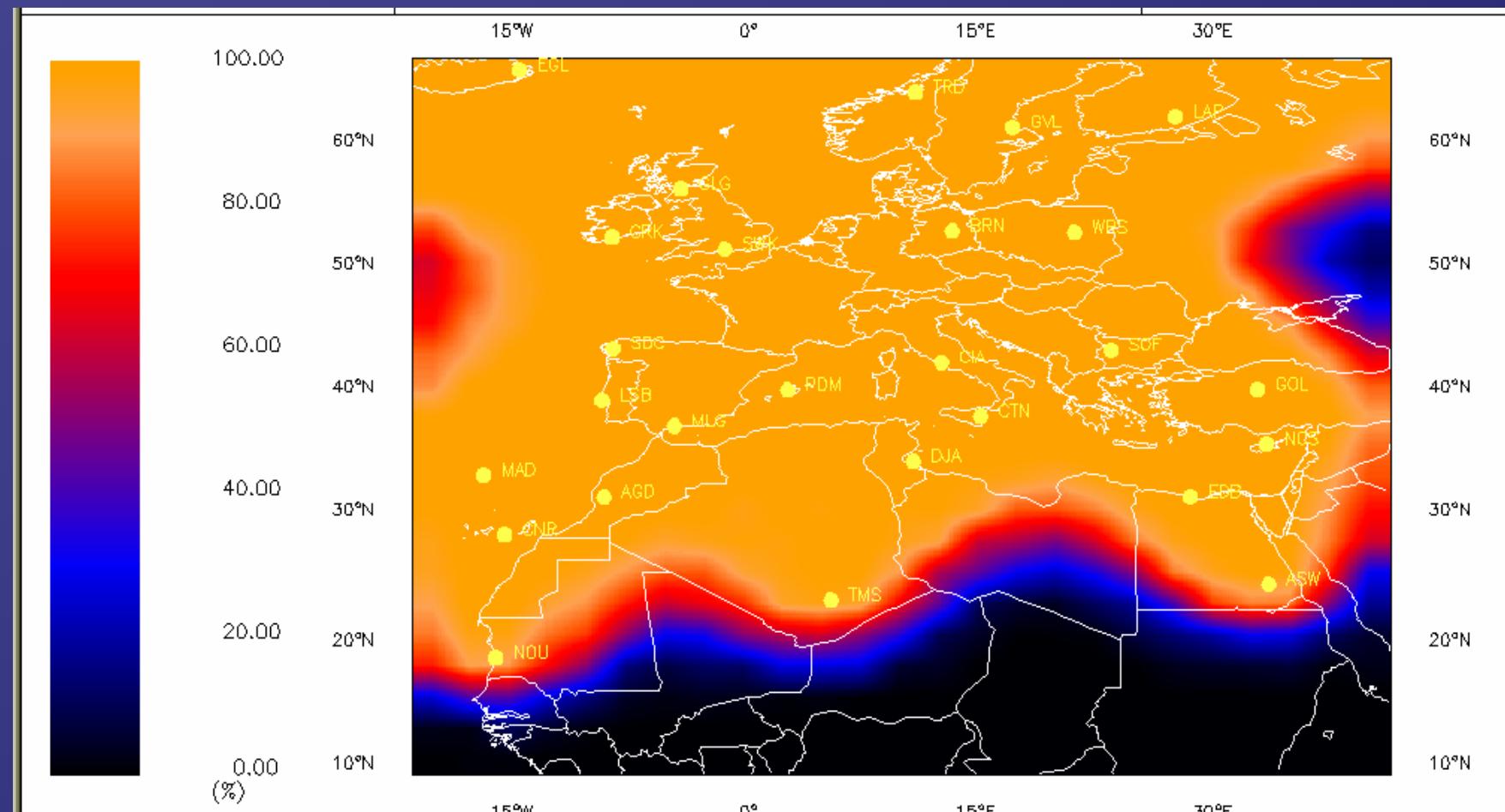
- EGNOS Service Area is ECAC'96
  - ▶ *Austria, Belgium, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey United Kingdom, Cyprus, Malta, Monaco, Hungary, Poland, Bulgaria, Czechoslovakia, Romania, Croatia, Lithuania, Slovenia, Czech Republic, Slovak Republic Latvia and Estonia*
  - ▶ Limited 70 deg. North and 40 deg. East
- New RIMS are going to be added to the existing EGNOS ground network in order to extend the service in:
  - ▶ ECAC Northern latitude
  - ▶ Mediterranean and Middle East Area
- Contacts for other service area extensions have started
  - ▶ Eastern Europe, Africa

# Before MEDA extension



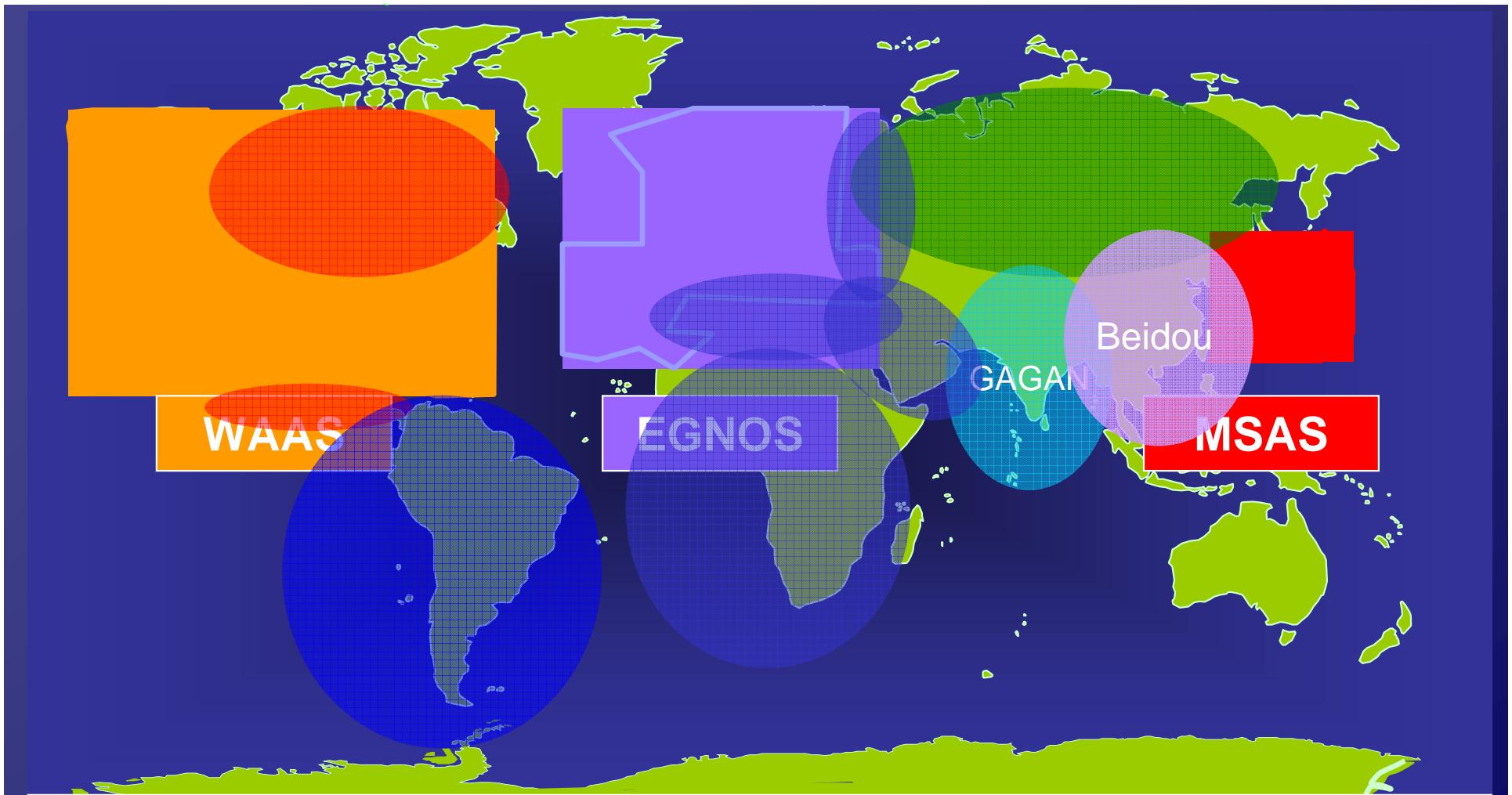
Target Availability of service

# After MEDA extension



Target Availability of service (2007)

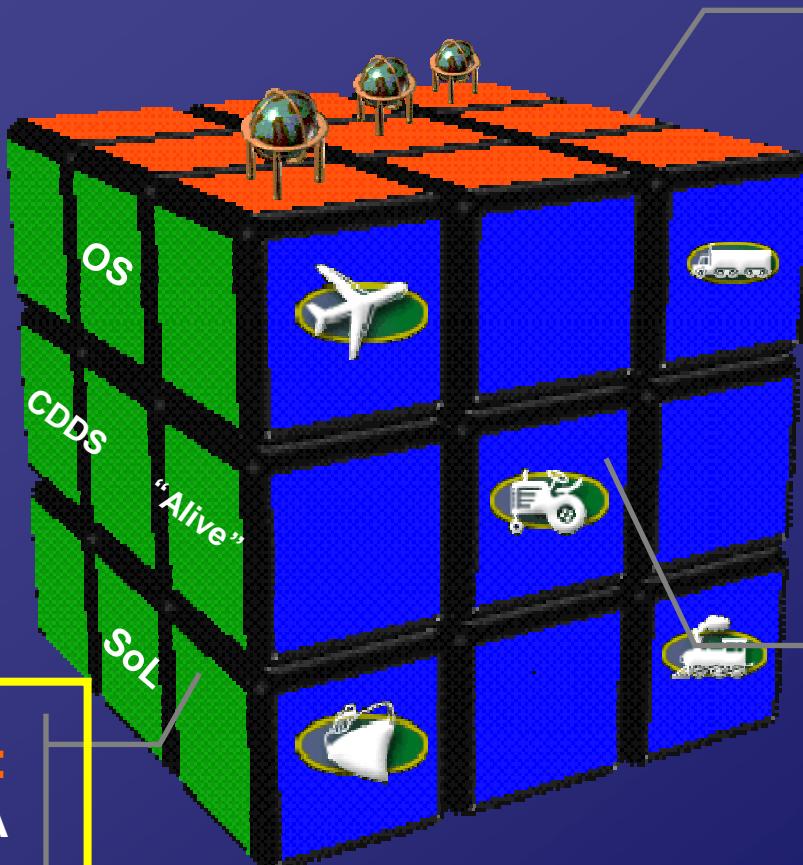
# SBAS future



Provide users with a seamless SBAS service between the different regions



# User Segment



## Service Areas:

MEDA Area  
Western Europe  
Eastern Europe  
Middle East  
Africa...

## Application Markets:

Aviation,  
Maritime,  
Road and Rail,  
Personal / Consumer

## Services:

OA

SoL

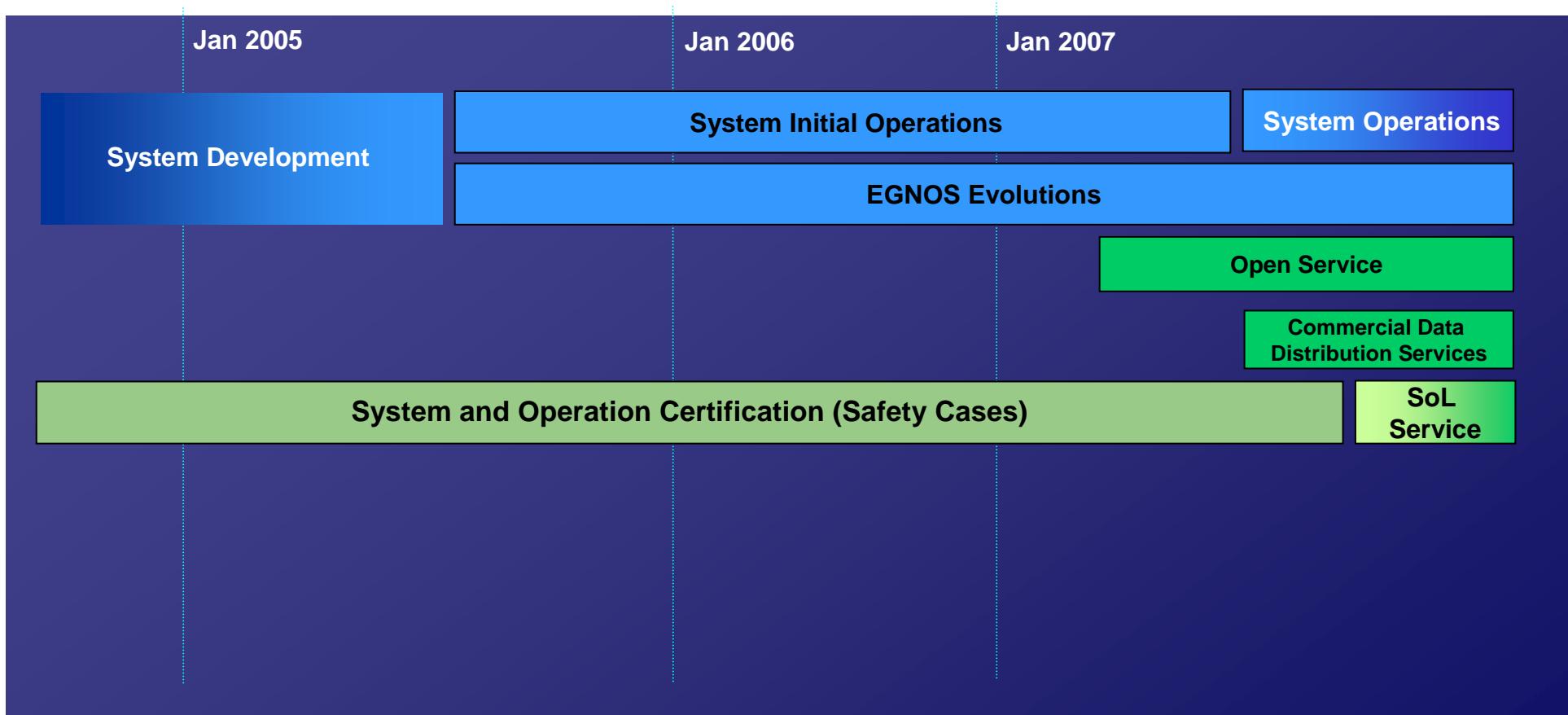
CDDS

**«Alive» concept**

# EGNOS Services

- 1) EGNOS Open Access
  - ▶ Improved accuracy and availability
- 2) EGNOS Safety of Life
  - ▶ Real time integrity through GEO broadcasting
- 3) EGNOS Commercial Data Distribution
  - ▶ Linked to implementation of non-GEO dissemination capability
- 4) Emergency Support: the «Alive» concept
  - ▶ Linked to implementation of emergency broadcasting capability in the EGNOS Message
  - ▶ ESA feasibility study

# EGNOS Services timeline



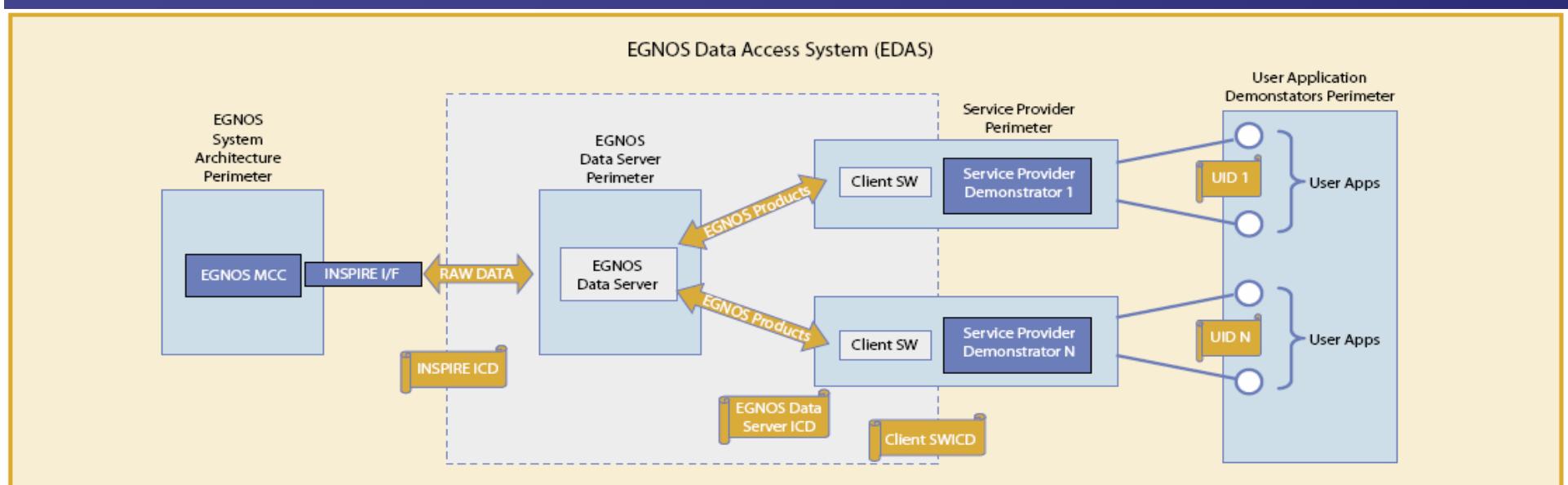
# Open Service

- Freely available to the public over EU 25
- No guarantee of service (liability disclaimer)
- Improved accuracy and availability

Typical performances (recently measured)

Horizontal Accuracy [meters]	Vertical Accuracy [meters]	Availability (Daily)	Integrity
2	4	99%	N.A.

# Commercial Data Distribution Service



- Provision of following EGNOS products via ground controlled access to portal for commercial use:
  - ▶ EGNOS augmentation messages in real time
  - ▶ Raw data from the RIMS stations in real time
- EGNOS data accessible through INSPIRE interface and pre-processed by the EGNOS Data Access Server (EDAS)
  - ▶ Provided on the basis of commercial agreements between the EGNOS Service Provider and its Customer

# Safety of Life Service

- Highest level of performance over ECAC 96
  - ▶ Real time integrity through GEO broadcasting
- Service Level Agreements between the EGNOS Service Provider and the Application Service Providers
  - ▶ Liabilities clause
- Safety of life applications are subjected to regulations
- Require specific authorization issued by relevant authority:
  - ▶ certification of system for the specific user domain / application
  - ▶ certification of provider vs. the required regulations defining the service provision framework in the domain
  - ▶ certification of the on board navigation equipment
  - ▶ specified operational conditions and limitations
  - ▶ existence of published navigation rules

# EGNOS Certification Challenges

- System complexity
  - ▶ Infrastructure distributed in several Countries
- Time/space performance dependence
  - ▶ Wide Service Area
- International acceptability
  - ▶ SBAS interoperability
- Institutional issues
  - ▶ Need for European Certification bodies and regulation

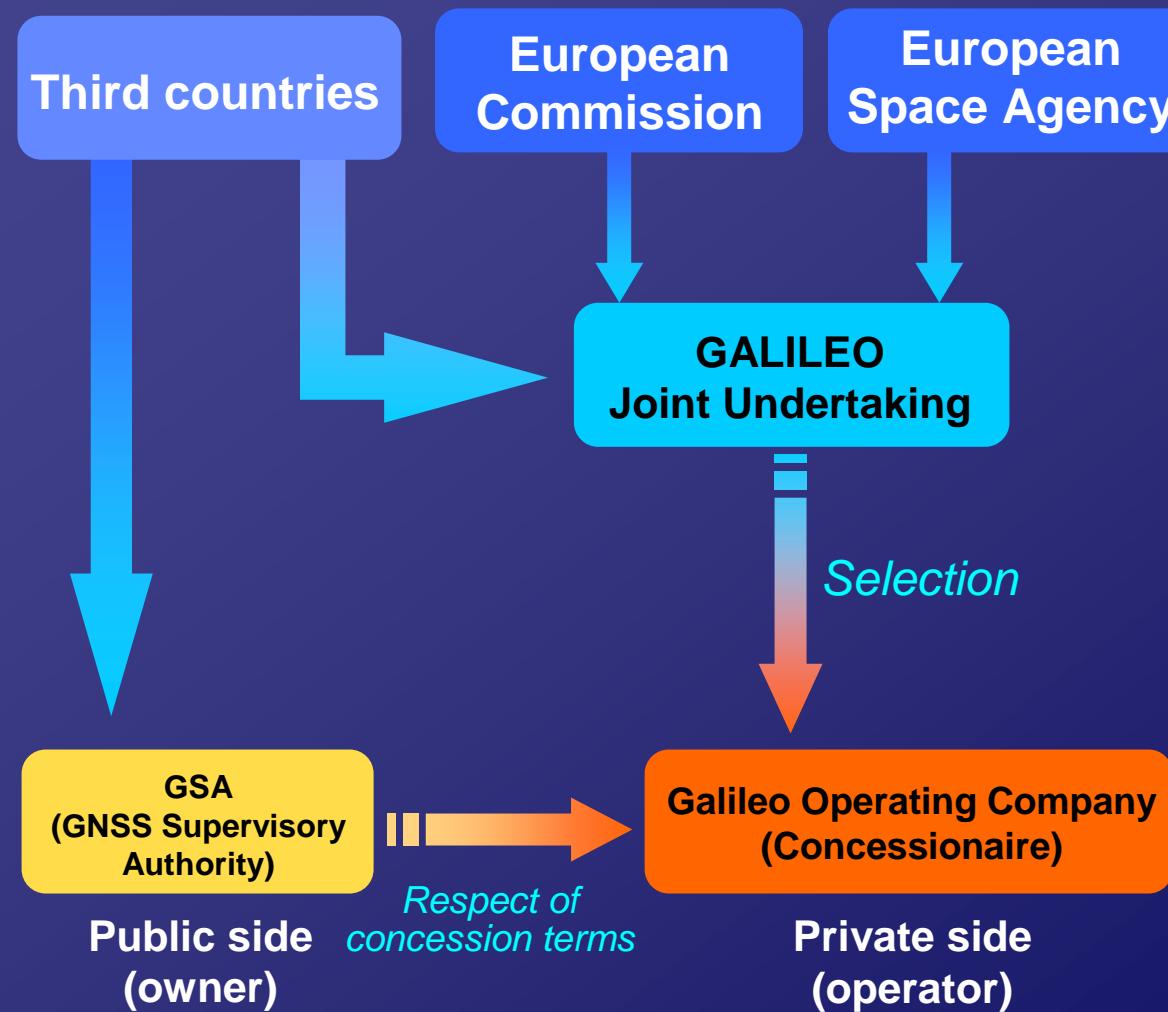
# Institutional Framework

- Currently, the European Space Agency (ESA) and the EGNOS Operators and Infrastructure Group (EOIG) own the EGNOS system.
- The EGNOS system transferred to the GNSS Supervisory Authority (GSA) by 2008
- Integration of EGNOS into Galileo...
  - ▶ The 2515th EU Transport, Telecommunications and Energy Council conclusions on June 5th 2003 have decided for
- ...in the frame of the Galileo Operating Company (the "Galileo Concessionaire")
- EGNOS and GALILEO are foreseen to be administered by the Galileo Concessionaire

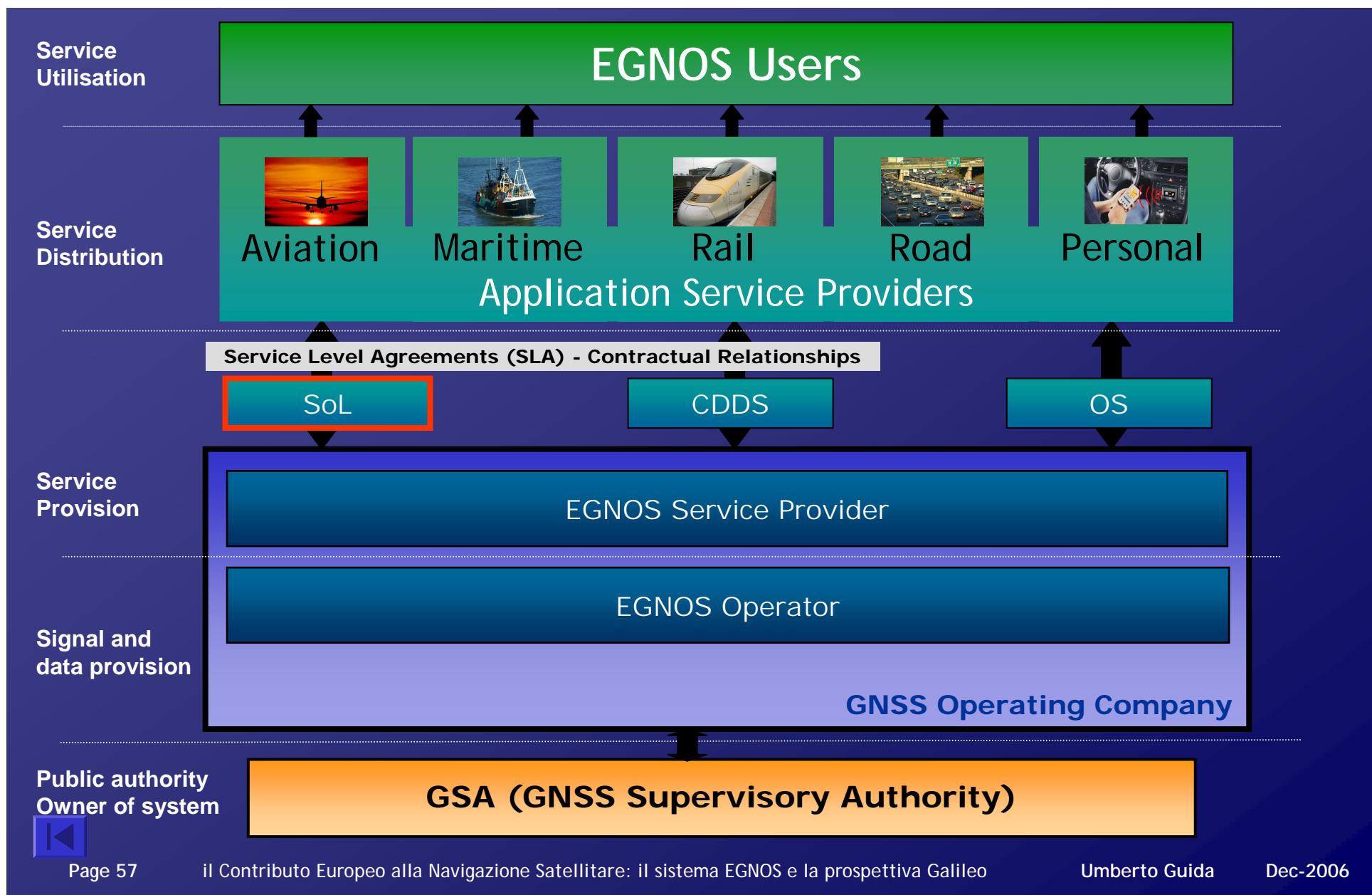
# **ESSP and EGNOS Services**

- EGNOS SoL Service Provision
  - ▶ ESSP has been funded to play a main role in the EGNOS Safety of Life service provision
- ESSP and Galileo Operating Company
  - ▶ Interaction started with the Concessionaire
  - ▶ Negotiation of EGNOS Operations and SoL service provision are going to start officially

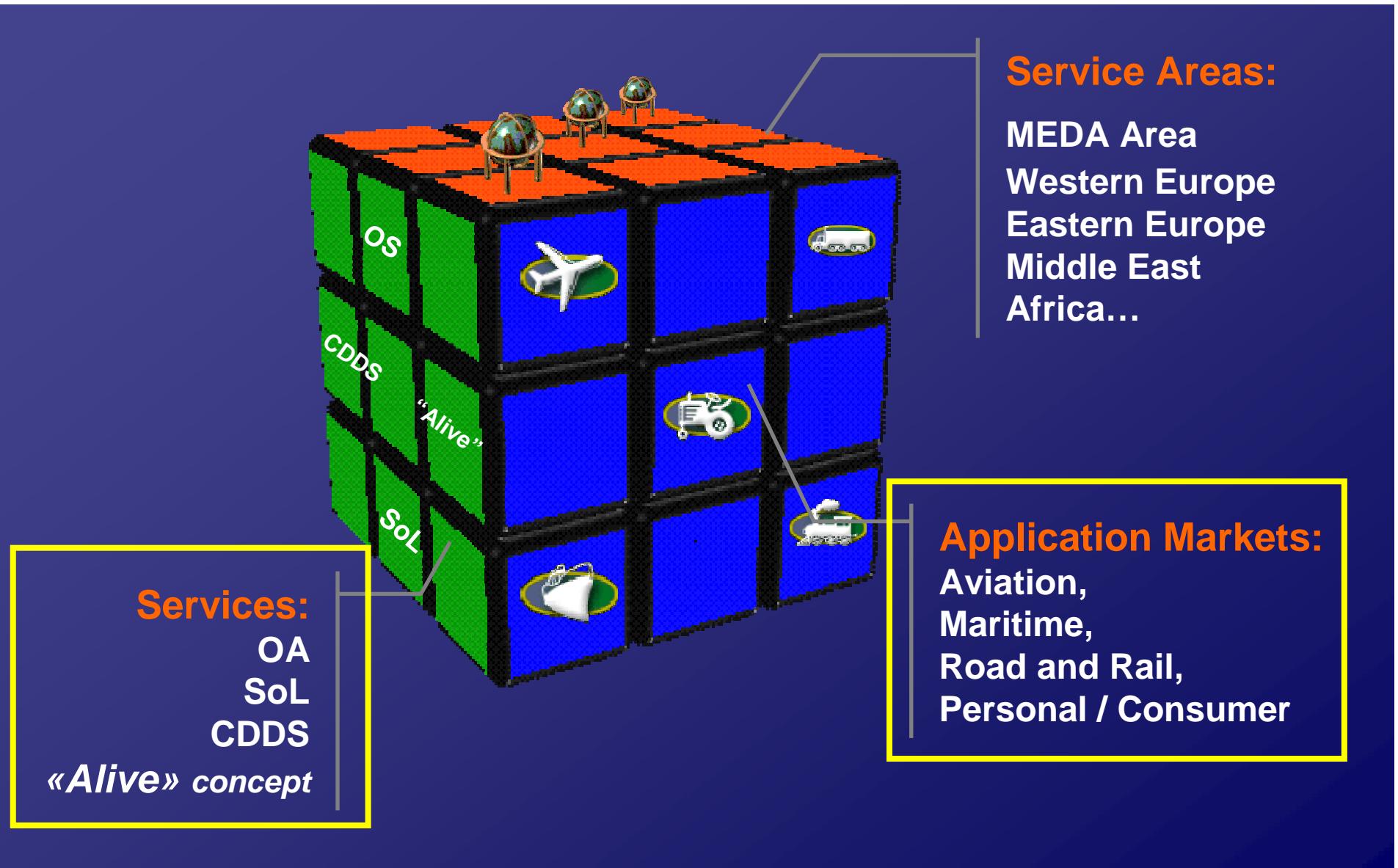
# Galileo framework



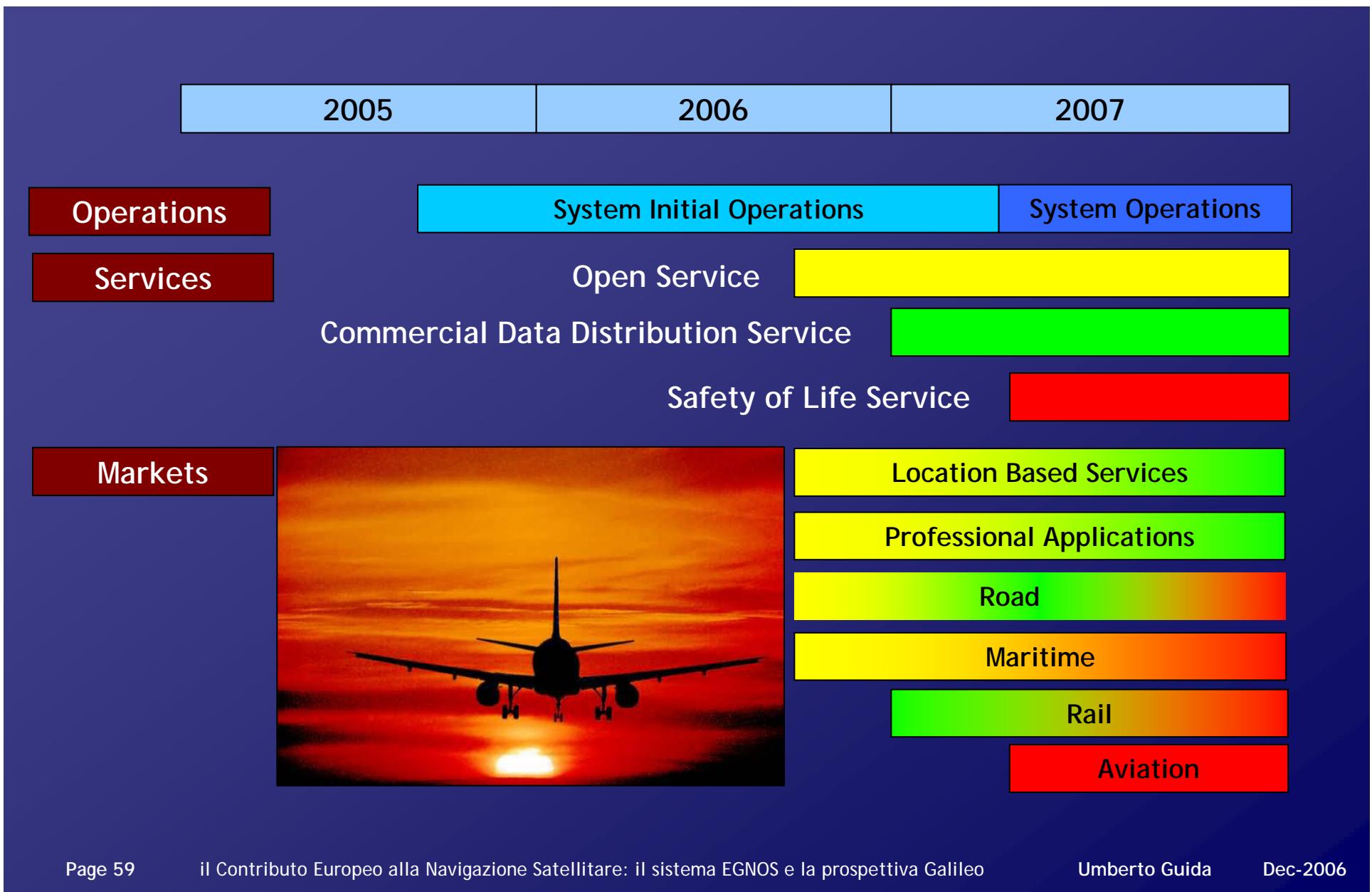
# EGNOS Service Provision Scheme



# User Segment



# Market introduction



# Applications EGNOS

Safety - Reliable market	Mass - Market	Professional market
Aviation	Personal navigation	Oil and gas
Rail	Cars / motorcycle	Mining
Maritime	Truck & buses	Timing
Inland Waterways	Light commercial vehicle	Environmental
Ambulance	Personal outdoor recreation	Fleet Management
Police / Fire-brigade		Asset Management
Search and rescue		Land survey / GIS
Personal protection		Precision agriculture
Traffic surveillance		Fisheries
Dangerous good transport		Robotics control
		Civil engineering

Main  
Applicability  
Integrity  
SoL

Limited  
Applicability  
Better accuracy  
respect GPS alone;  
OS

Reasonable  
Applicability  
Liability critical;  
Accuracy often  
not enough;  
CDDS

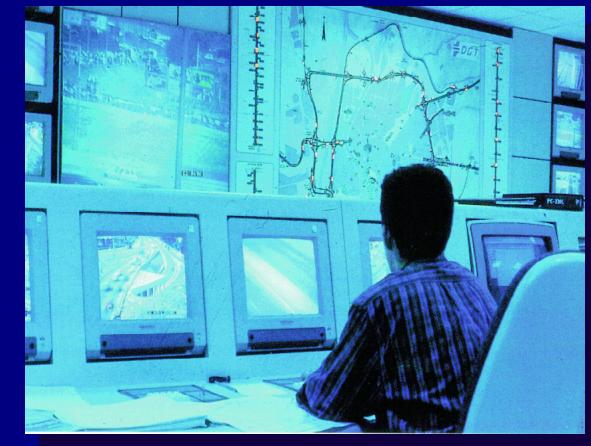
# ESSP and EGNOS Markets

- In the frame of his Business Development activities, ESSP is participating in many projects as Point of Reference for the aspects related to:
  - ▶ EGNOS Signal and Data Provision;
  - ▶ EGNOS Safety of Life Service Provision
- ESSP's participation covers mainly aspects for EGNOS market development:
  - ▶ EGNOS System Introduction
    - ◆ technical & economic aspects, risks analysis
  - ▶ EGNOS Business Aspects
    - ◆ Business Cases, CBA, Business Model, Charging Mechanism
  - ▶ EGNOS Safety of Life Service Provision
    - ◆ value chain, service provision scheme, SLA draft
    - ◆ Relationship between GSA, GOC and Service Providers;
  - ▶ EGNOS SIS contribution to Safety studies
  - ▶ EGNOS Mission Evolution and Requirements Document update
  - ▶ Dissemination and Awareness about EGNOS
    - ◆ Support to Demonstration execution

# ESSP participation to GNSS projects

- Funded by GJU 1<sup>st</sup> call (*closed*):
  - ▶ GEM - Mission implementation
  - ▶ PRODDAGE - Application Market development
  - ▶ ADVANTIS - GNSS liability critical application study
- Funded by GJU 2<sup>nd</sup> call (*running*):
  - ▶ MARUSE - GNSS Introduction in Maritime Sector
  - ▶ GRAIL - GNSS Introduction in Rail Sector
  - ▶ GIANT - GNSS Introduction in Aviation Sector
  - ▶ GIROADS - GNSS Introduction in Road Sector
  - ▶ GARMIS - Reference and Mission evolution
  - ▶ PROGENY - Coordination of R&D activities
- Funded by EuroMED Transport Office
  - ▶ METIS - Introduction of GNSS Service in MEDA Area
- Funded by Eurocontrol / EC:
  - ▶ GNSSNOTAM - requirements, architecture of GNSS NOTAM system
  - ▶ SESAR - ATM Master Plan for 2020+, MEDaCoN, A-SMGCS demo

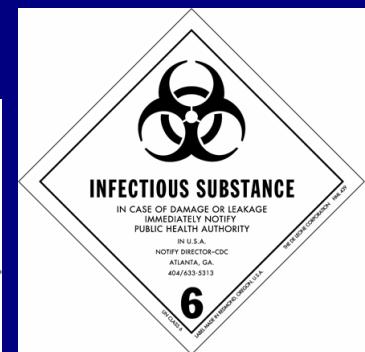
# Road



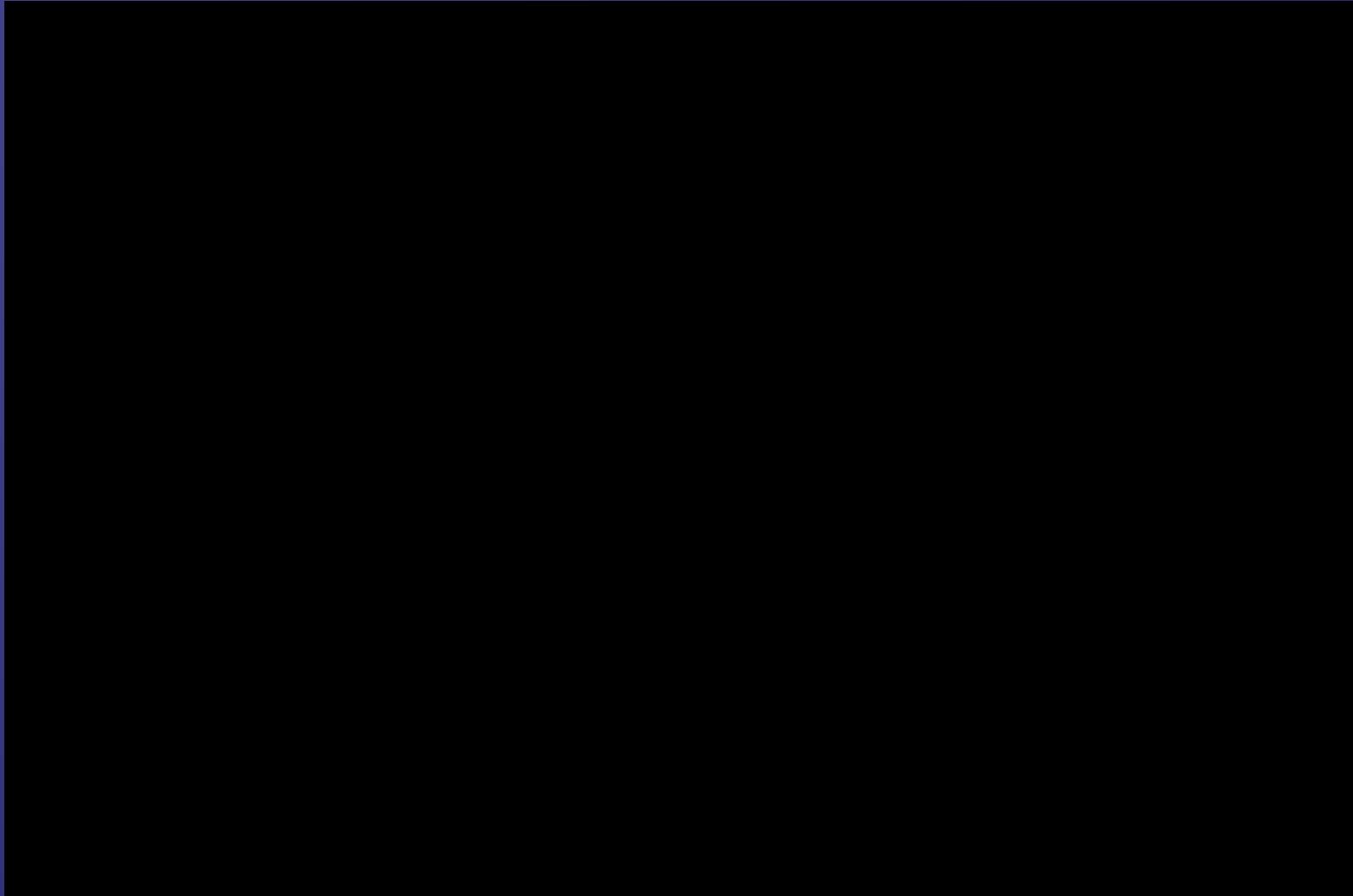
**Liability-critical applications**

- ▶ Public Fleet Management
- ▶ Road Tolling

**Safety & Emergency Services**  
**Dangerous Goods Monitoring**



# World Rally Championship Trial



# Maritime

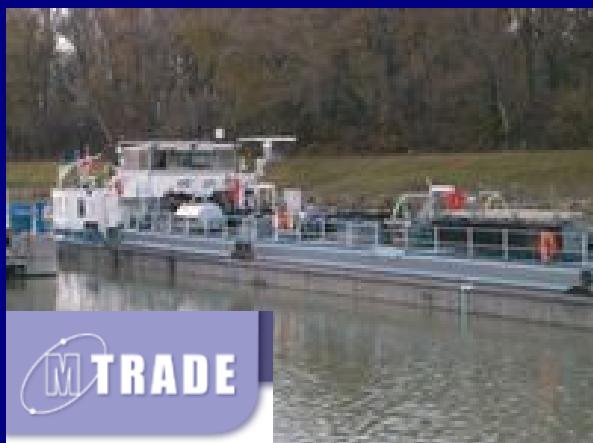


# Maritime Requirements

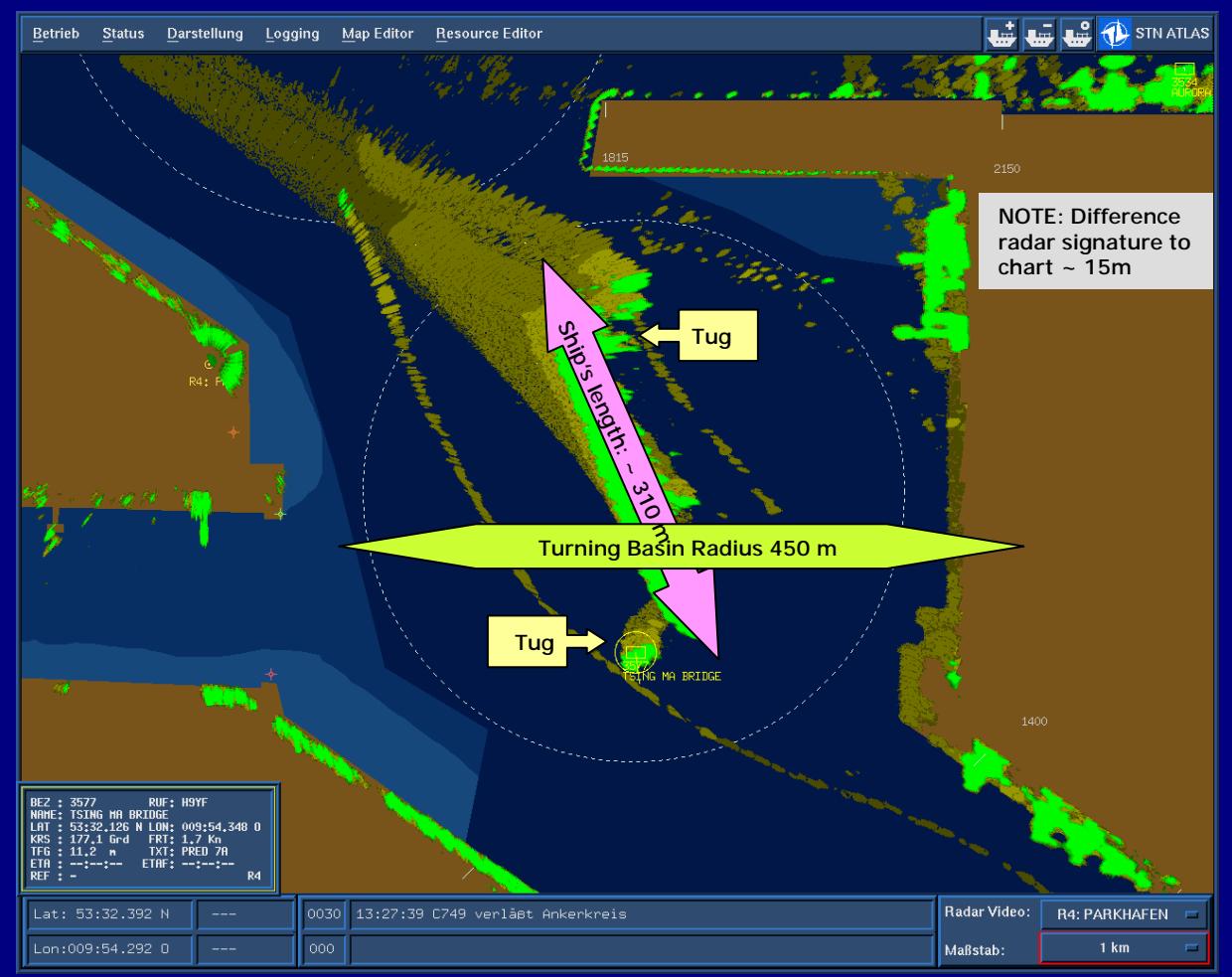
Even if designed according to Civil Aviation requirements, EGNOS fulfil also Maritime user requirements for specific maritime navigation phases

	Absolute Accuracy	Integrity			Availability (% per 30 days)	Continuity (% over 3 hrs)	Coverage
		Horizontal (m)	Alert Limit (m)	Time to Alarm (s)			
Ocean and Coastal Navigation	10	25	10	$10^{-5}$	99.8	N/A	Global
Port Approach and Restricted Waters	10	25	10	$10^{-5}$	99.8	99.97	Regional
Inland Waterways	10	25	10	$10^{-5}$	99.8	99.97	Regional

*International Maritime Organisation (IMO) "Maritime Policy and Requirements for a Future Global Navigation Satellite System (GNSS)", Resolution A.860 (20) of 27th November 1997, updated A.915 (22) of 29th November 2001 (under review)*



M-TRADE project is coordinated by Telespazio



# Rail

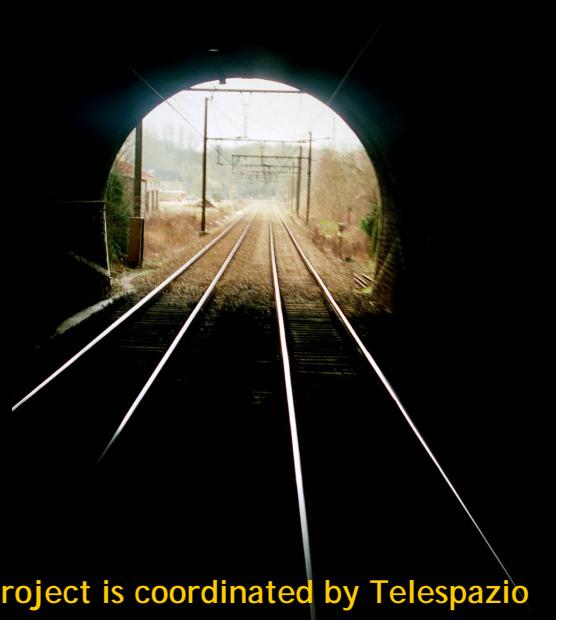




## Rail Transport

- ▶ Traffic Management for low density lines
- ▶ Wagon Fleet Management

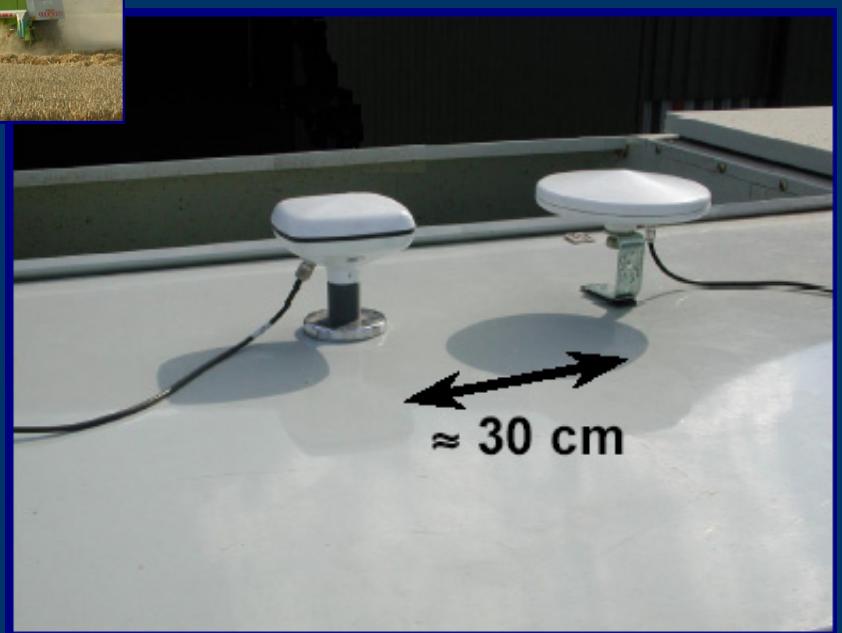
## Dangerous Goods Transport



M-TRADE project is coordinated by Telespazio

# Professional Market





# Personal / Consumer Market

- Limited applicability of the concept of liability of the service
- Higher accuracy respect GPS alone
- Advantages where other means of improvement are not available
  - ▶ Lack of map quality for map-matching
  - ▶ Tourism in not mapped areas
- Lone Worker Protection
- Blind people guidance

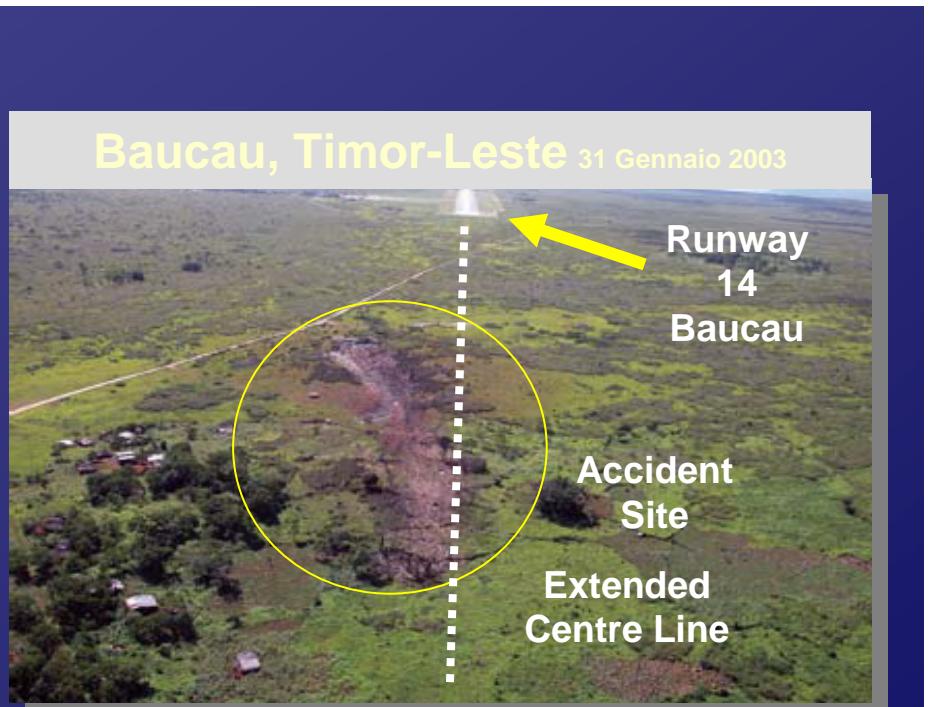
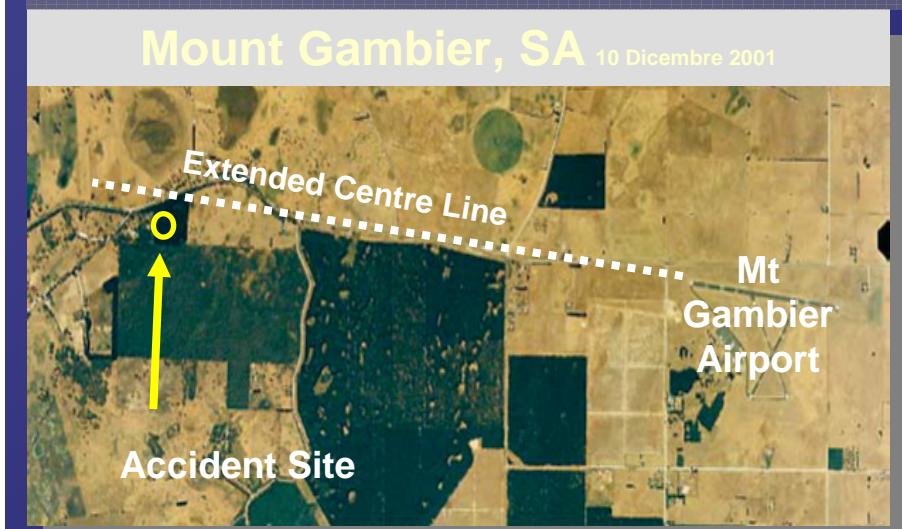
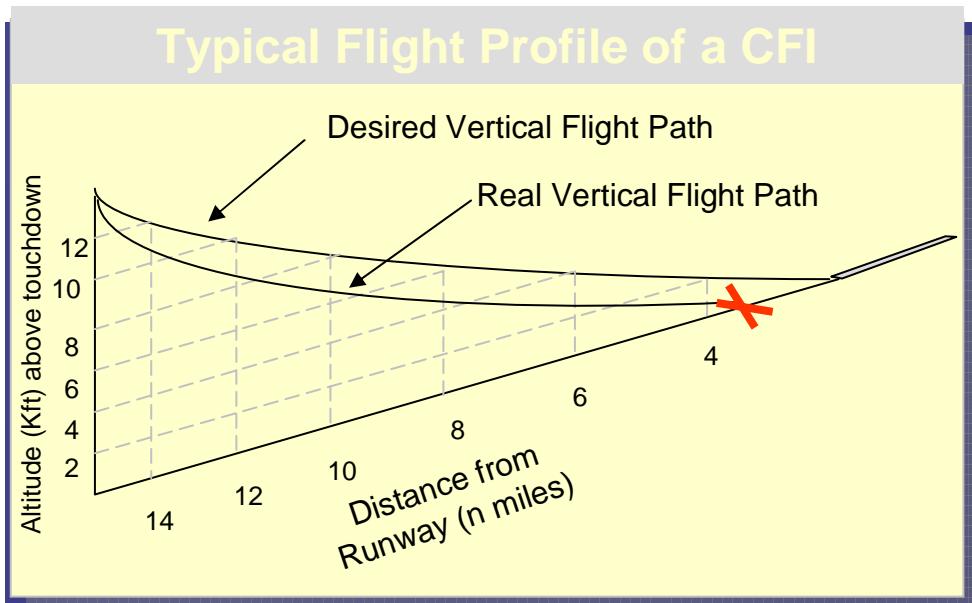


# EGNOS use for Civil Aviation



## LOCAL

# The problem: CFIT



### Statistics

- 30% GA fatal accidents were controlled flight into terrain (CFIT)  
Source: ATSB, Dec 2005
- Every 10 days, a pilot declares an emergency due to weather  
Source: CASA Oct 2005

# Controlled Flight into Terrain

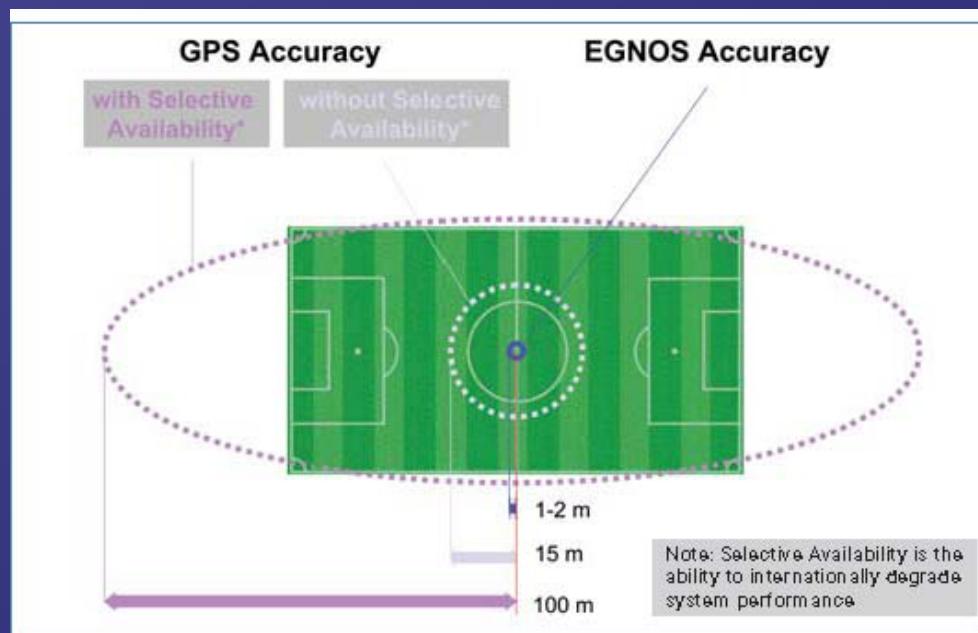


Navigation aids, however also human factors...

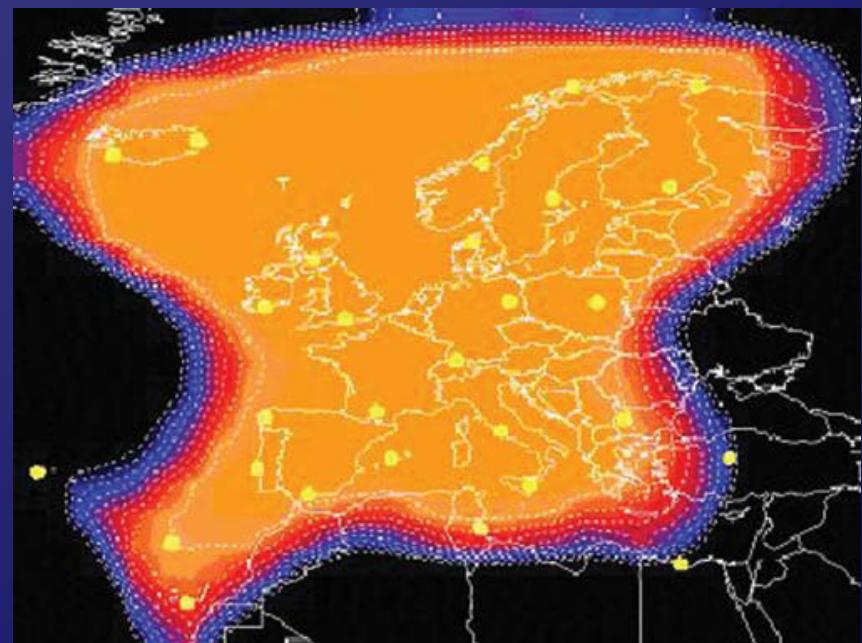
# The solution: Vertical Guidance

- Vertical guidance reduces by 7.7 CFIT probability
- Vertical guidance require an “Augmented” GPS navigation service

Accurate



Available

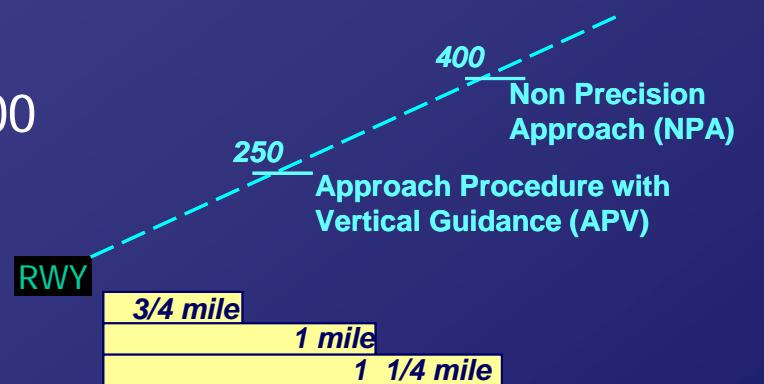


# Approach with Vertical Guidance



# EGNOS benefits for aviation

- Reduce Minimum decision height
  - ▶ NPA (GPS): 300 ft (with barometer) to 400 (only) ft
  - ▶ APV (GPS + EGNOS): 250 ft
  - ▶ PA Cat I: 200 ft



	Accuracy (95%)		Integrity				Availability	Continuity
	Lateral	Vertical	Alert Limit Lateral	Alert Limit Vertical	Integrity Risk	Time to Alert		
APV-I	16 m	20 m	40 m	50 m	1-2x10 <sup>-7</sup> / 150s	10 s	0.99	1-8x10 <sup>-6</sup> / 15 s
APV-II	16 m	8 m	40 m	20 m	1-2x10 <sup>-7</sup> / 150s	6 s	0.99	1-8x10 <sup>-6</sup> / 15 s

Non Precision Approach (**NPA**):

no vertical guidance

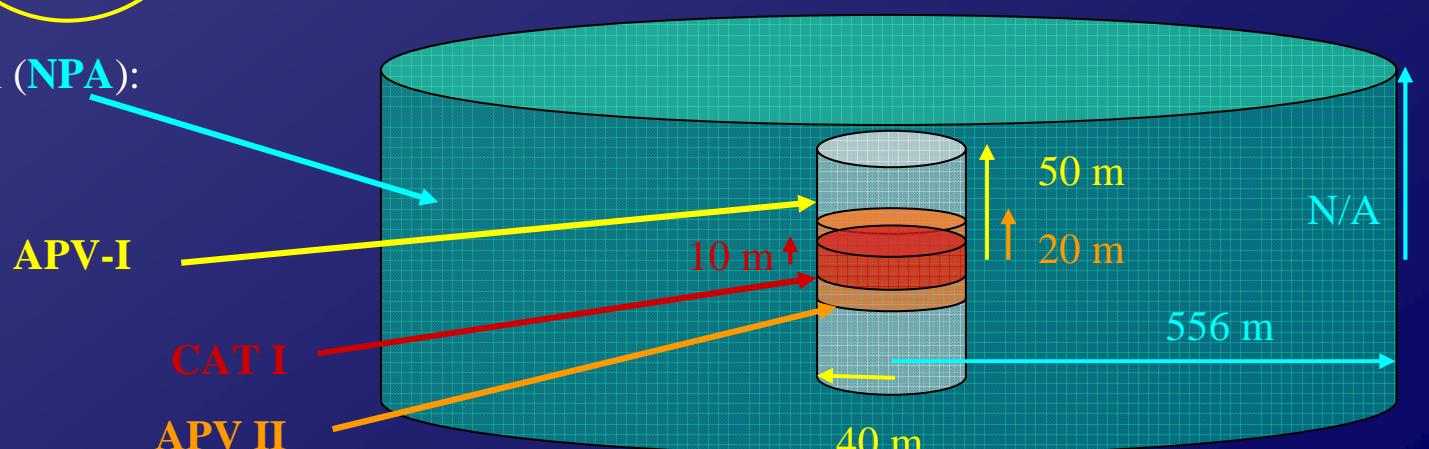
Approach with  
Vertical Guidance (eg  
**APV-I** and **APV II**)

Precision Approach  
with Vertical Guidance  
(eg **CAT I**)

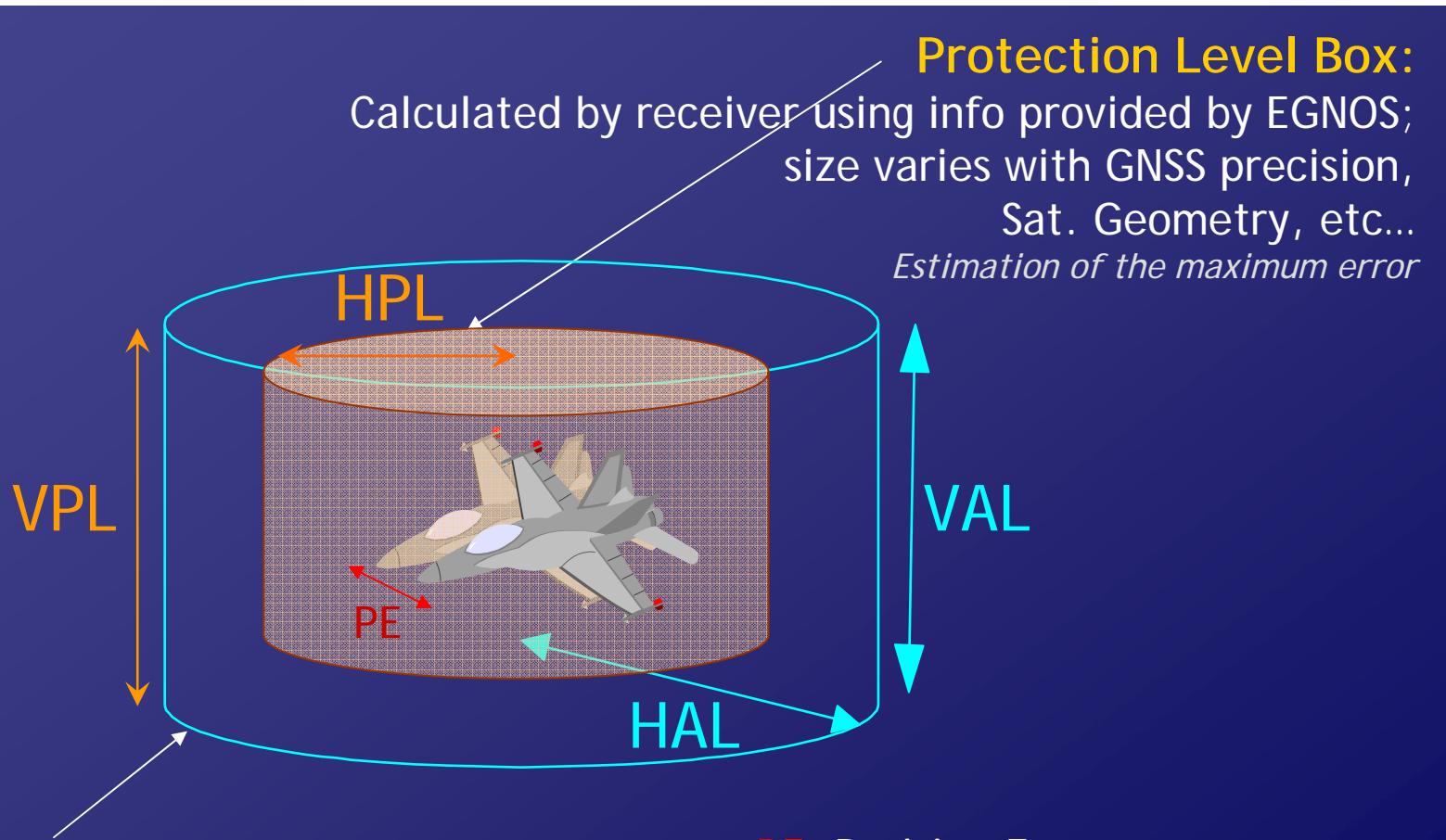
**APV-I**

**CAT I**

**APV II**



# ICAO GNSS Integrity Concept



## Alarm Limit Box:

Fixed Size for a given operation  
*Indicates the max error tolerable for the specific operation*

**PE:** Position Error

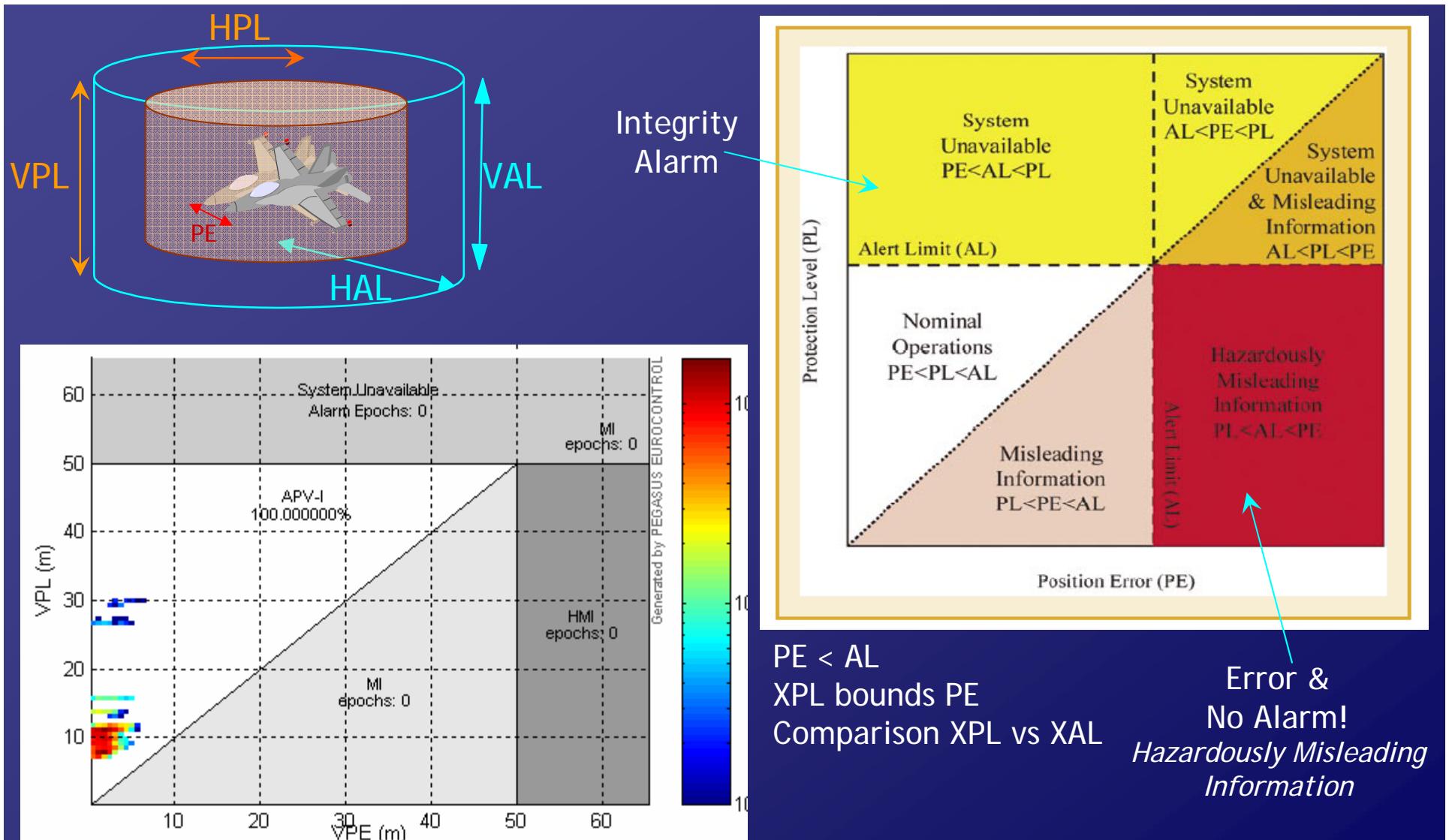
**HPL:** Horizontal Protection Level

**VPL:** Vertical Protection Level

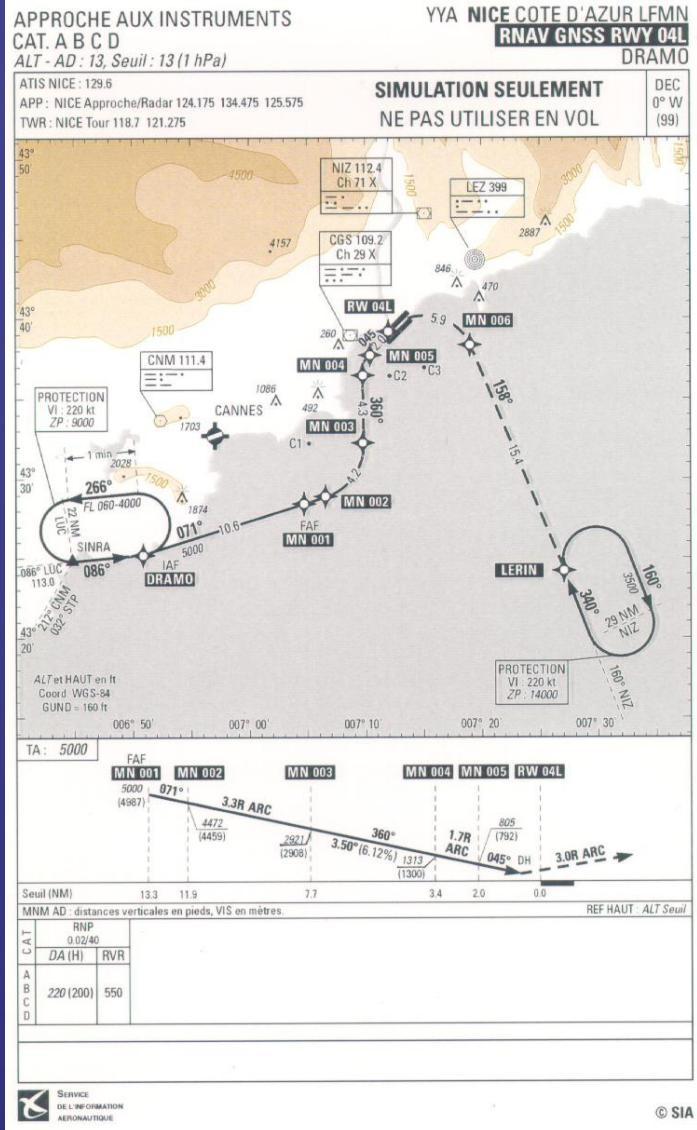
**HAL:** Horizontal Alarm Limit

**VAL:** Vertical Alarm Limit

# Integrity evaluation



# EGNOS benefits for aviation



- Increased runway capacity (landing) with lower visibility
  - ▶ landing possible with lower visibility levels at airports not ILS equipped
  - ▶ reduce delays and diversions to alternative airports & cancelled flights
- Curved/segmented precision approaches (more flexibility in procedure design)
  - ▶ time/fuel savings
  - ▶ environmental benefits from reduced noise impact



# EGNOS Benefits: example



- Aereoporto di San Sebastián (Spagna)
- Impossibile installazione dell'ILS a causa della configurazione dell'aeroporto.
- Restrizioni topografiche
- Zone abitate in prossimità
- Avvicinamento richiede coordinamente con lo spazio aereo francese di Biarritz

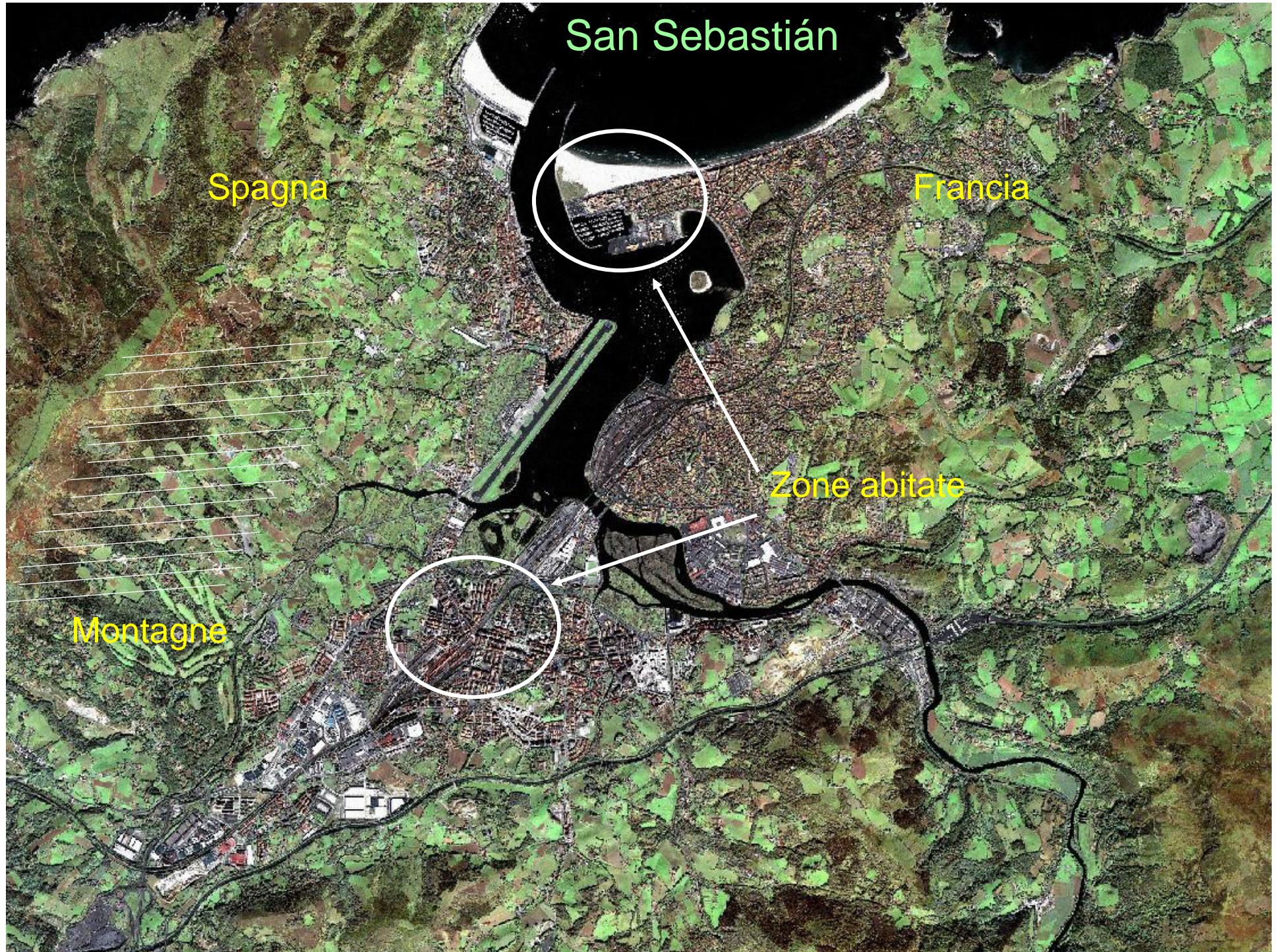
# San Sebastián

Spagna

Francia

Zone abitate

Montagne



# Other aviation applications

- En-route
  - ▶ GPS Monitoring
  - ▶ operations in areas with low conventional navigation aid
- Helicopter Emergency Services
  - ▶ vertical guidance
- General Aviation
  - ▶ safety increase in the use of poorly equipped airfield
- UAV
  - ▶ EGNOS successfully tested as navigation system in a UAV prototype
- Business Jets
  - ▶ 4°slope 3D approach on ILS (to reduce wake vortex separation)
  - ▶ operation in near-PA conditions on any runway for HUD EVS aircraft equipped

# EGNOS+ILS 4D Approaches

Wake Vortex Separation between  
two Large Aircraft : 4 nm

Aircraft categories :

Large : > 255 000 lbs

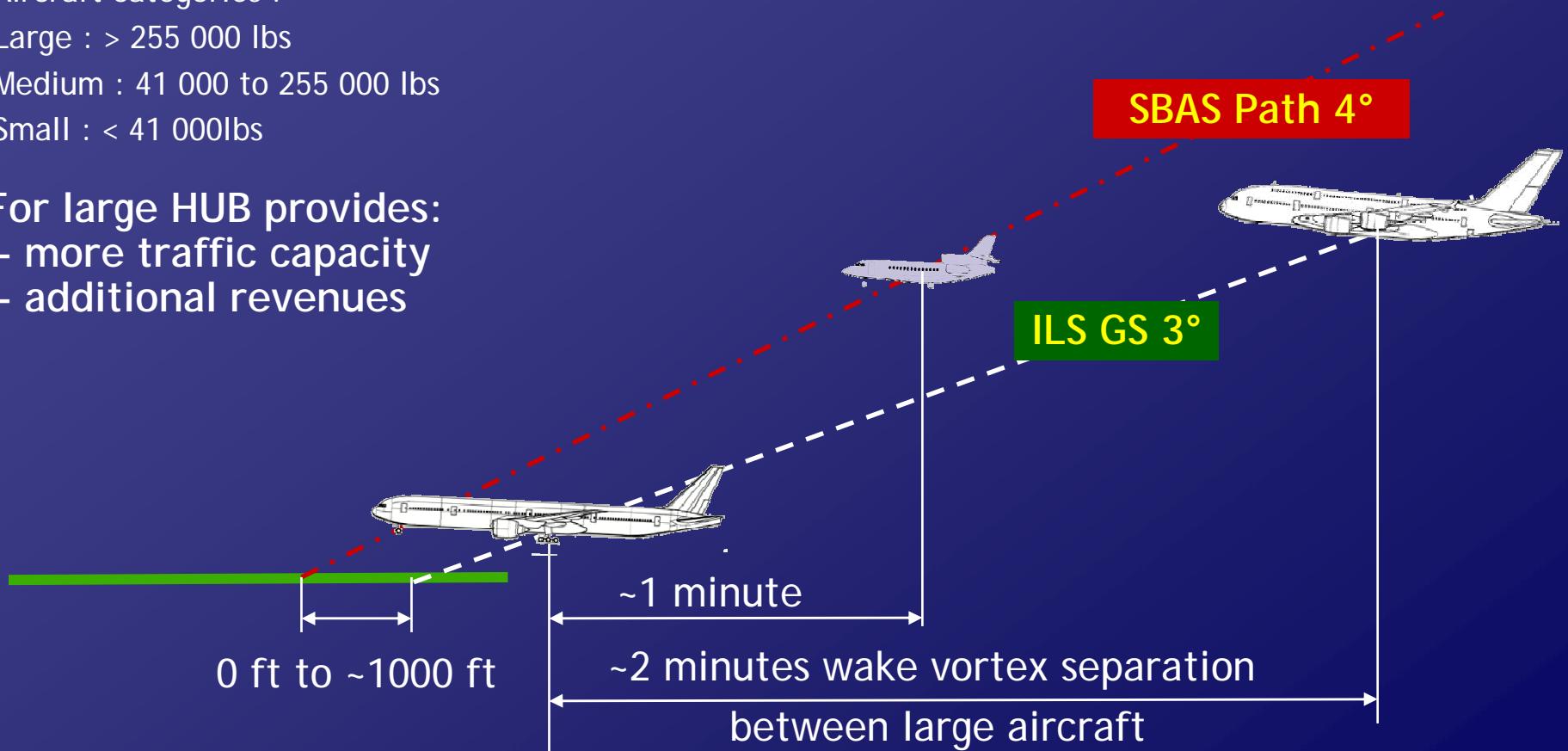
Medium : 41 000 to 255 000 lbs

Small : < 41 000 lbs

For large HUB provides:

- more traffic capacity
- additional revenues

Possibility to insert a Business Jet  
between two large aircraft



# Mobile Surveillance and Control on Airport

## Airport mobiles surveillance and control by means of EGNOS

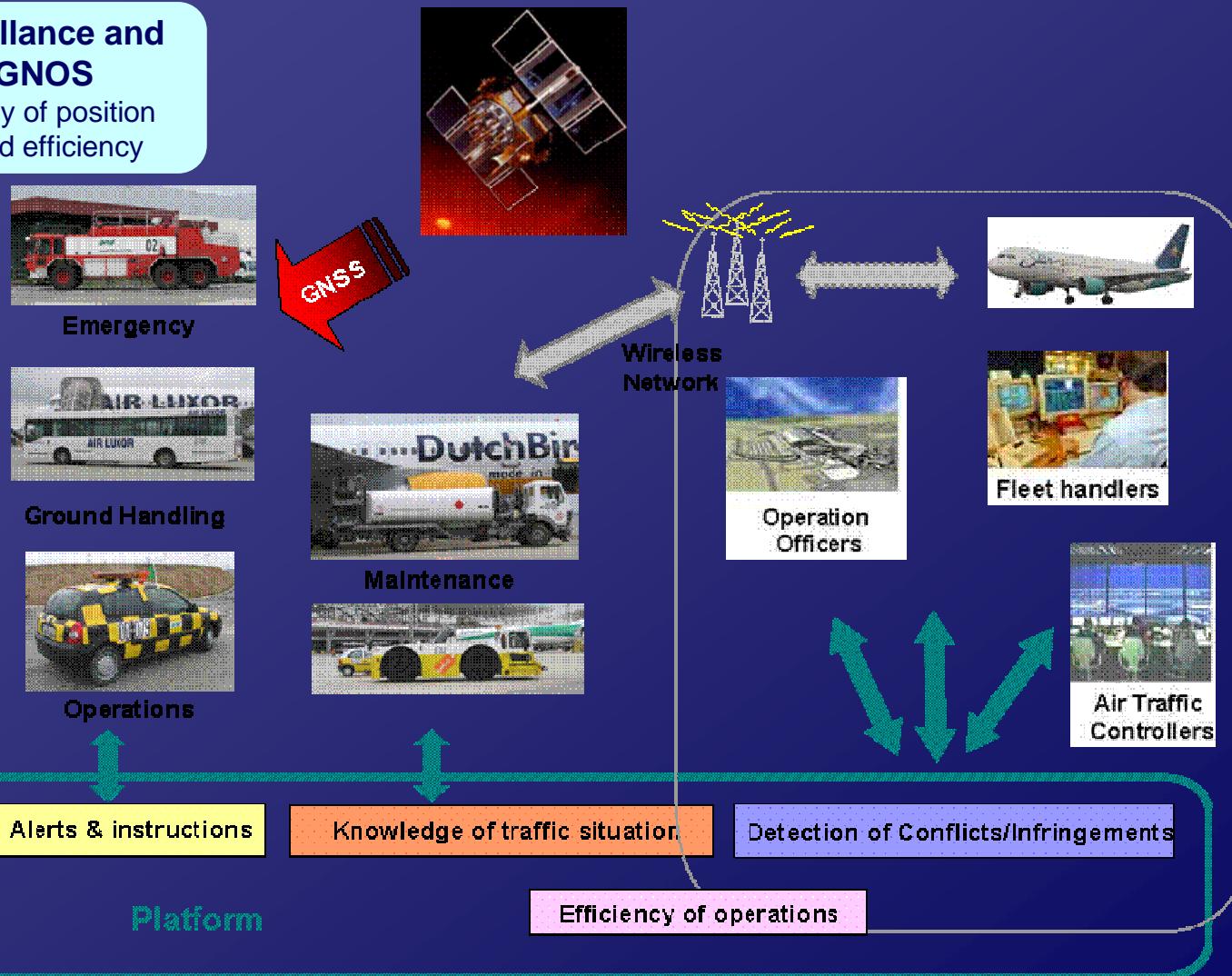
- ✓ high accuracy and integrity of position
- ✓ Improvement of safety and efficiency

### Partners

- > ESSP
- > M3 System (France)
- > SMILE (Morocco)
- > ONDA (Morocco)

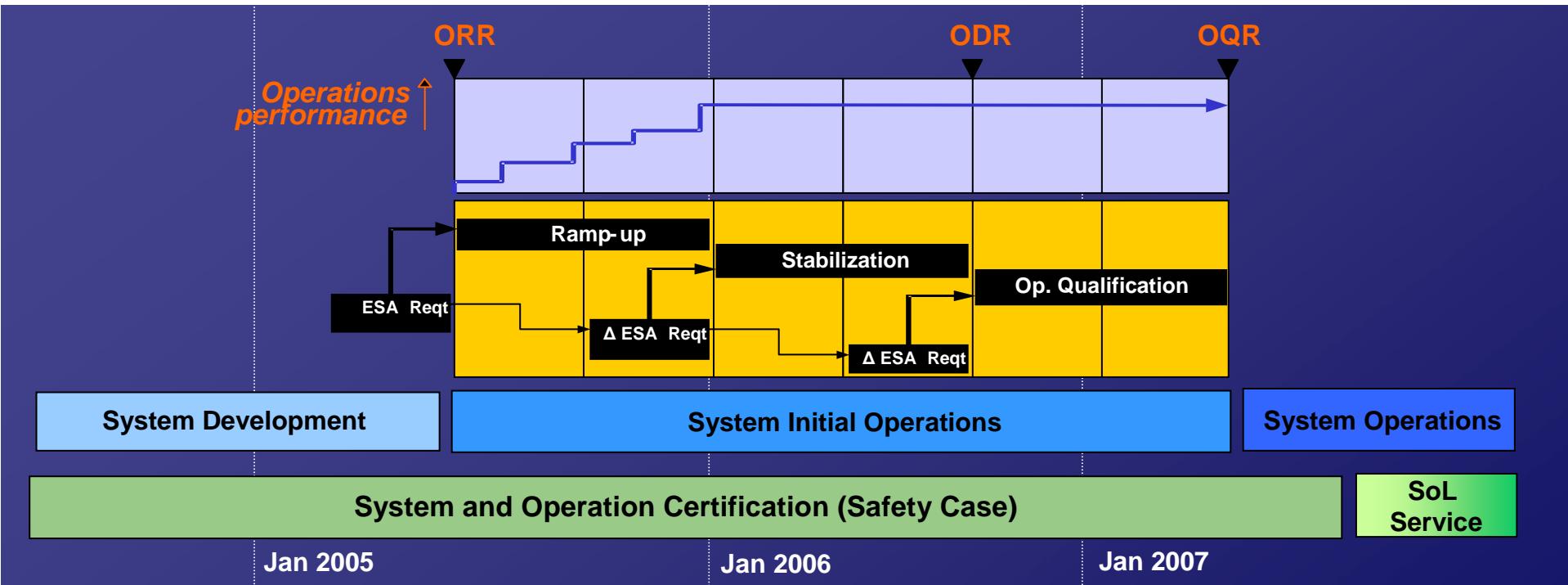
### Location:

“Mohammed V” Airport  
of Casablanca (Morocco)



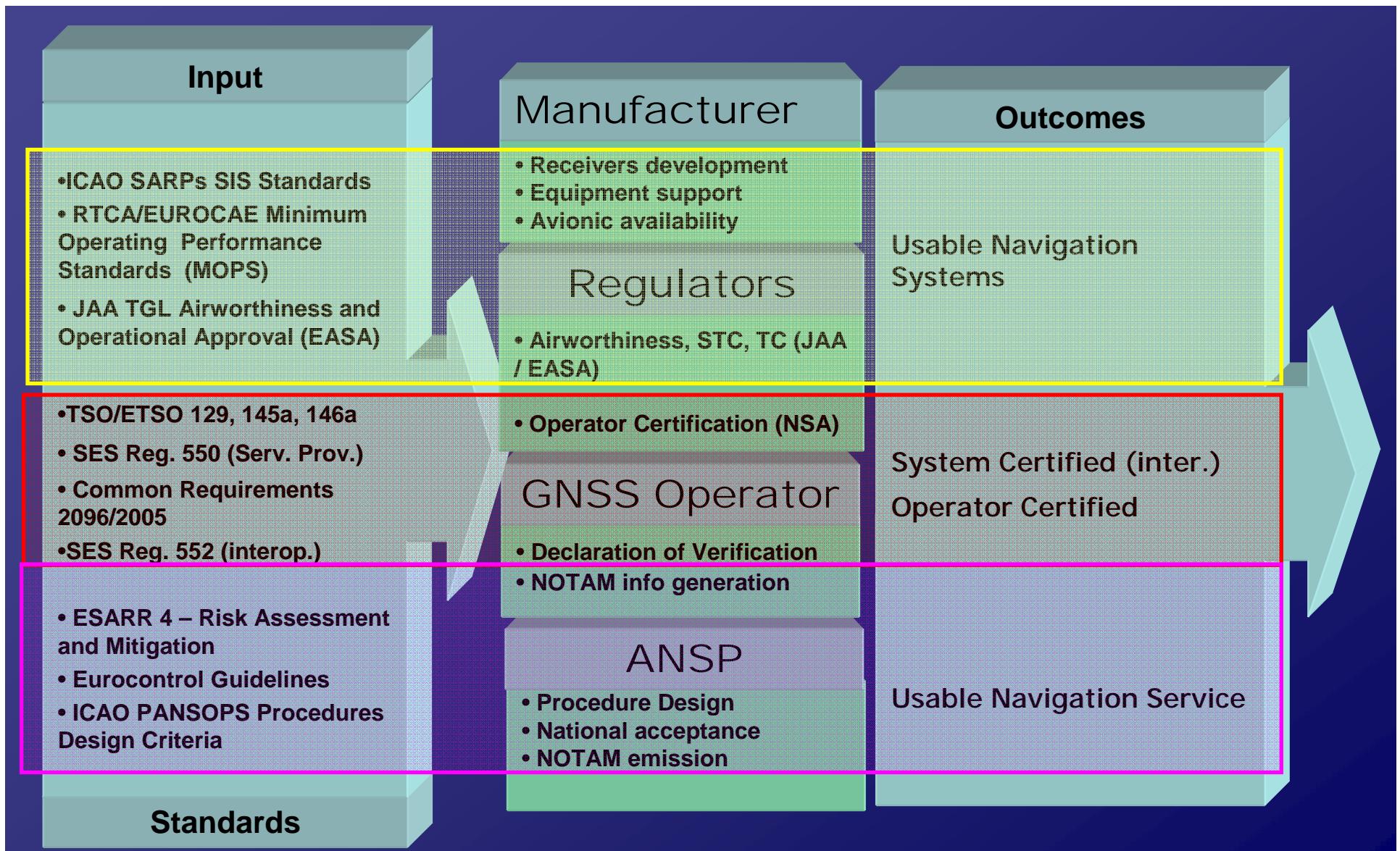


# EGNOS is “Approaching”



- EGNOS is in the Initial Operation Phase
  - Within 2007 the EGNOS system and its operations will be qualified
- Is it enough to use EGNOS for civil aviation?
  - Actions are required to prepare the aviation environment and build an EGNOS service for the civil aviation

# Standards, Actors, Outcomes



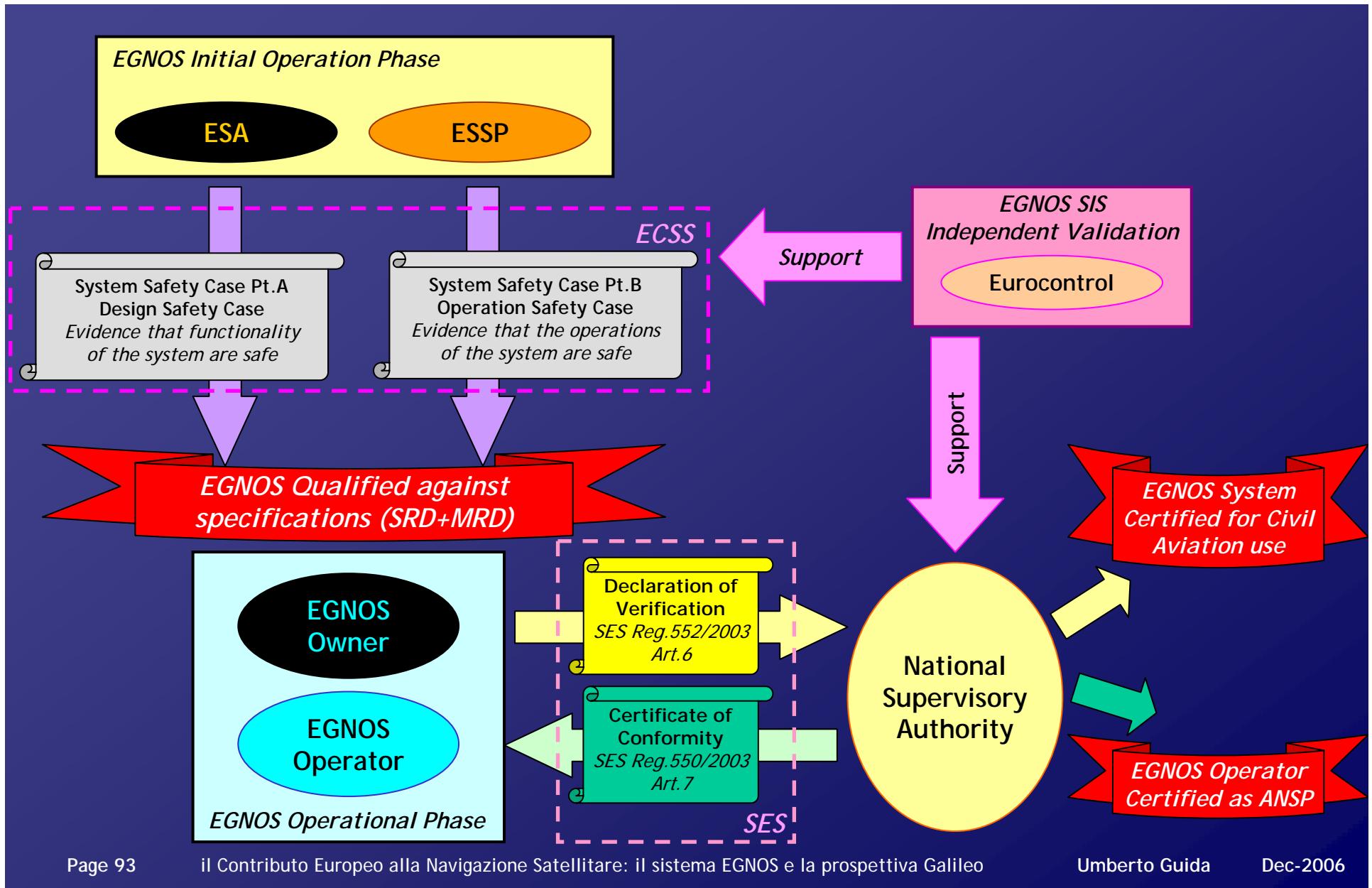
# Aviation Service Provision Challenges

- EGNOS Charging mechanisms
  - ▶ linked to the Operational Benefits
  - ▶ Different Business Cases for different users, operations...
- Pricing schemes based on
  - ▶ Cost allocation (domains) and cost recovery (operations)
  - ▶ Operational Benefits
  - ▶ Competition/alternatives
  - ▶ Number of customers
- Service Level Agreements
  - ▶ Terms and conditions for supply a service
  - ▶ Safety benefits as a criteria for SLA
- Liability scheme design
  - ▶ GNSS Supervisory Authority, Galileo Operating Company, EGNOS Service Provider...
- EGNOS Operator / Service Provider certification
  - ▶ Single European Sky regulation

# EGNOS Certification for aviation

- EGNOS will be certified according to the Single European Sky (SES) regulations by 2008
  - ▶ involvement of European GNSS Supervisory Authority (GSA), the European aviation safety agency (EUROCONTROL)
- SES Reg.552/2004 (Interoperability)
  - ▶ “Declaration of Verification” issued by EGNOS “owner” (GSA)
  - ▶ Declaration of the performances provided in his service area
- SES Reg.550/2004 (Service Provision)
  - ▶ EGNOS Operator to provide application to the NSA where their principal place of business is located
  - ▶ “Certification of conformity” to the Common Requirements (Reg.2096/2005) of the EGNOS Operator issued by NSA
  - ▶ Shows the capability to operate and control the configuration of the system according to the ICAO standards.
- Actors and applicability depend on the final Service Provision scheme adopted

# EGNOS Certification Process



# EGNOS-based Procedures

- Many ANSP have started activities to design EGNOS based APV procedures for candidate airports:
  - ▶ France, Spain for about regional airports
  - ▶ Italy (ENAV) has identified 5 airport for initial development of APV procedures based on EGNOS
  - ▶ Switzerland: Lugano airport, Zurich as ILS back-up, helicopters
- Interest from ANSP of Countries outside the EGNOS initial coverage area
  - ▶ Ukraine, Saudi Arabia, Emirates
- In US are designed around 300 LPV procedures every year (WAAS is operational)

# EGNOS Receivers today

- EGNOS is broadcast on the same civil frequency L1 of GPS
  - ▶ EGNOS capability requires only receiver firmware upgrade to process SBAS data
  - ▶ No antenna upgrade
- EGNOS support receivers compliant to RTCA MOPS Do229C
  - ▶ Many WAAS mass-market receivers usable with EGNOS from early 2007 (like mine...)
  - ▶ WAAS receivers available also for aviation and maritime SoL users

# EGNOS Avionics

- EGNOS capable receivers for different aircraft categories exists
  - ▶ Thales Avionics MMR (big aircraft), TOTEM-3 (military)
  - ▶ Thales Navigation GG12W (GA)
  - ▶ GARMIN GNS480 (US-STC for 700 aircraft) and upgrade of other series to support SBAS
  - ▶ Rockwell Collins GPS-4000S upgrade
    - ◆ GPS-4000A has US-STC for Dassault Falcon Fun-jet, Mystere...
- Database coding of new procedures required
  - ▶ Jeppesen involved in first trials (Valencia, MEDA...)
- Limited technical impact on the FMS
  - ▶ Rockwell Collins dedicated development for CRJ200

# SBAS Avionics Architectures



# Avionics and Aircraft Certification

- Avionic receivers are certified vs. TSO (in US) and ETSO (in Europe)
  - ▶ TSO/ETSO is the approval of the design issued for equipment independent from aircraft, with impact on safety.
  - ▶ In US, TSO 145a/146a are used to certify receivers for SBAS use up to APV capabilities
  - ▶ TSO 145a /146a (WAAS) are currently being transposed to EU standards.
- APV capability is a new operational feature for an aircraft and is considered a major modification of flight capability
  - ▶ it requires the emission of a Supplemental Type Certificate (STC) (Reg. 1702/2003 EASA)
  - ▶ Aircraft Manufacturer, authorized entities (Lufthansa Technik, Officine Aeronavali, LEAT...) can issue an STC

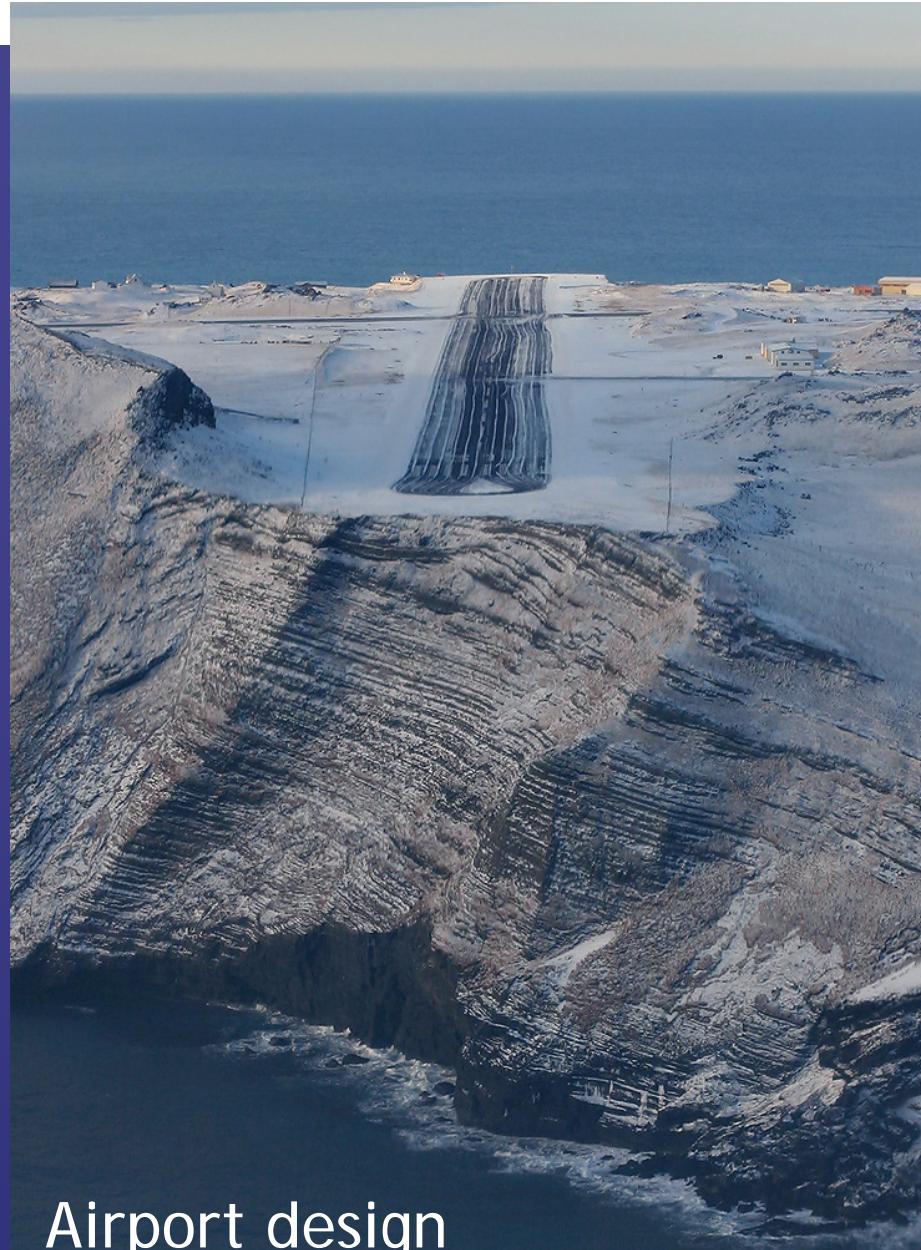
# EGNOS Past Flight Trials

Date	Location	Description
November 2006	Valencia, Spain	Part of the GIANT project (GJU) First flight of a commercial airline (Air Nostrum with a Dash-8)
October 2006	Limoges, France	Managed by DSNA. Flight on an ATR 42 to design the APV flight procedure in Limoges
July 2006	Lisbon, Portugal	Part of HELICITY project (ESA) Enhance navigation capabilities on helicopters using EGNOS.
February 2006 April 2006	Spain	EADS trial on an Unmanned Aerial Vehicle (UAV). EGNOS used as sole navigation means for take-off, en-route and approach.
June 2005	Porto, Portugal	Part of GAMMA project (ESA) Use of EGNOS for airport surface movement navigation and monitoring
May 2005	Nairobi, Kenya	Part of ProDDAGE project (ESA & GJU) Use of EGNOS for Non-Precision Approach with Vertical Guidance APV-I
June 2003	Malabo, Equatorial Guinea and Douala/Yaoundé, Cameroon	EGNOS demonstration for Africa.
April 2003	Kiruna, Sweden	Part of EGNOS TRAN Project. EGNOS used in conjunction with VDL Mode 4 communication to provide navigation data to users in northern latitudes.
March 2003	Marignane, France	Use of EGNOS to support Helicopter Emergency Medical Services, through dedicated receivers and flight routes
February 2003	Dakar, Senegal	Flight trials using EGNOS in Africa

# EGNOS Flight Trials



# Aviation conclusion



Airport design

Photo Copyright © Sigurdur Benediktsson

AIRLINERS.NET

...GNSS use is not the only thing to be considered to improve safety...



Terminal area control

ema EGNOS e la prospettiva Galileo

Umberto Guida

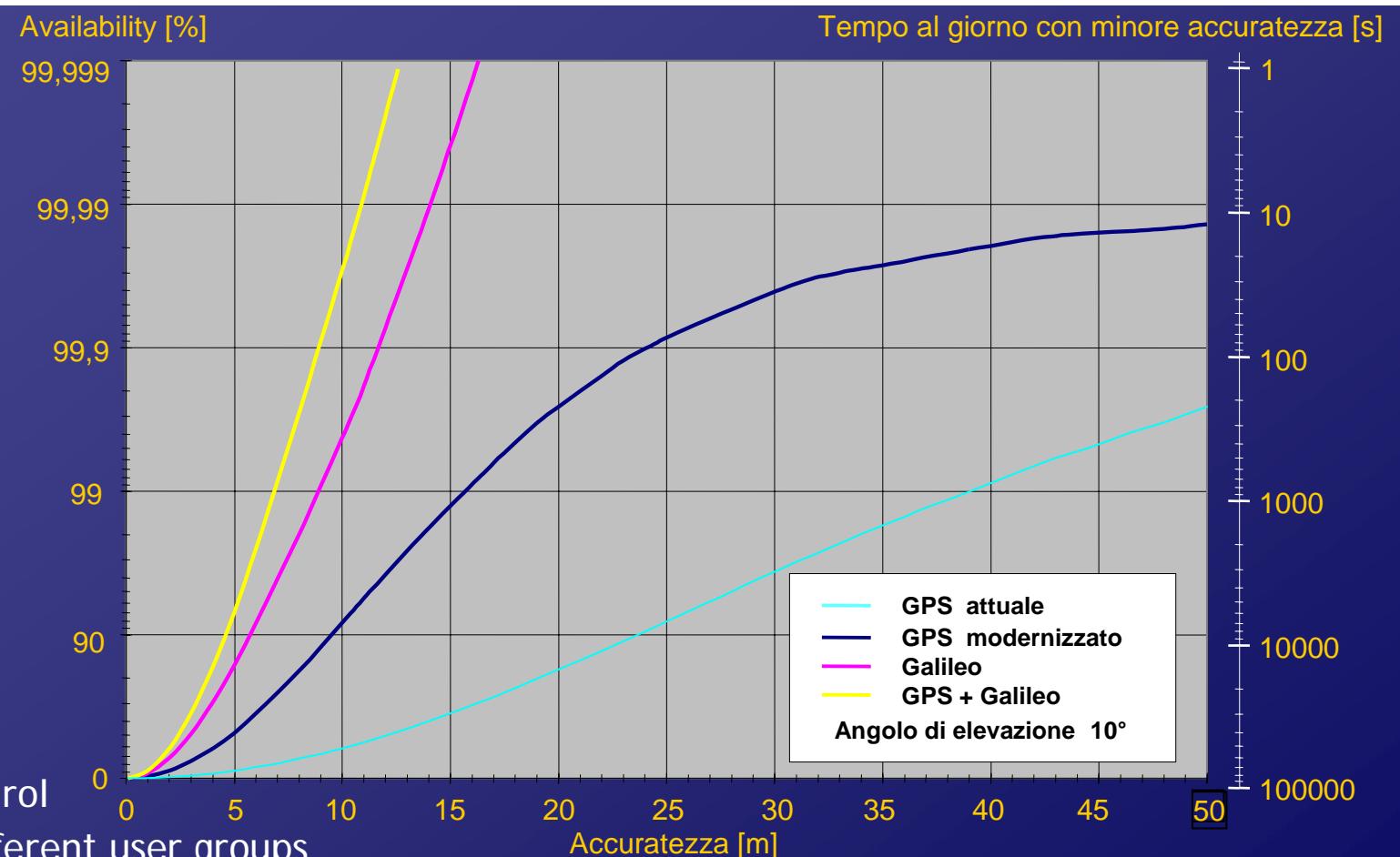
Dec-2006

# EGNOS and the others...

- ABAS evolution
  - ▶ Expected high capabilities from ABAS
  - ▶ Potential synergies to be explored
- Galileo
  - ▶ Integration of EGNOS into Galileo included in the GOC negotiations with the GJU/GSA
  - ▶ GNSS services portfolio
  - ▶ EGNOS integration into Galileo to provide up to CAT-I capabilities
  - ▶ EGNOS for the Regional Integrity of Galileo?
- GPS modernization
  - ▶ Upgrade accordingly
  - ▶ Architecture evolutions identified in the frame of ESA GNSS Support Programme



# Galileo and GPS



- under civil control
- services for different user groups
- high accuracy
- guarantee of service
- integrity and authentication

# Galileo Services

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



# Galileo applications

Safety - Reliable market	Mass - Market	Professional market
Aviation	Personal navigation	Oil and gas
Rail	Cars / motorcycle	Mining
Maritime	Truck & buses	Timing
Inland Waterways	Light commercial vehicle	Environmental
Ambulance	Personal outdoor recreation	Fleet Management
Police / Fire-brigade		Asset Management
Search and rescue		Land survey / GIS
Personal protection		Precision agriculture
Traffic surveillance		Fisheries
Dangerous good transport		Robotics control
		Civil engineering

Error-free  
Standard,  
Regulation,  
Accuracy, Continuity,  
Availability  
SoL

Low costs,  
Low power cons.,  
Small size,  
Best perf.  
accordingly  
OS

High precision,  
High accuracy,  
High reliability  
CS

# Galileo overall schedule



# Galileo: latest development

- First test satellite GIOVE-A launched in December 2005
  - ▶ First Galileo-like signals sent
  - ▶ Frequencies ensured
- In-orbit validation contract started in January 2006
  - ▶ (about 1 billion €)
- Signal definition (ICD) published on 23<sup>rd</sup> May 2006
  - ▶ ( [www.galileoju.com](http://www.galileoju.com) )
- Concession negotiations progressing
  - ▶ signature end 2007
- Management structures defined
  - ▶ transfer from GJU to GSA



ESSP ( European Satellite Services Provider)

<http://www.essp.be>

EC (European Commission)

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

ESA (European Space Agency)

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

GJU (Galileo Joint Undertaking)

<http://www.galileoju.com>

More about EGNOS

# Contacts



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[www.essp.be](http://www.essp.be)

