First technology presentation

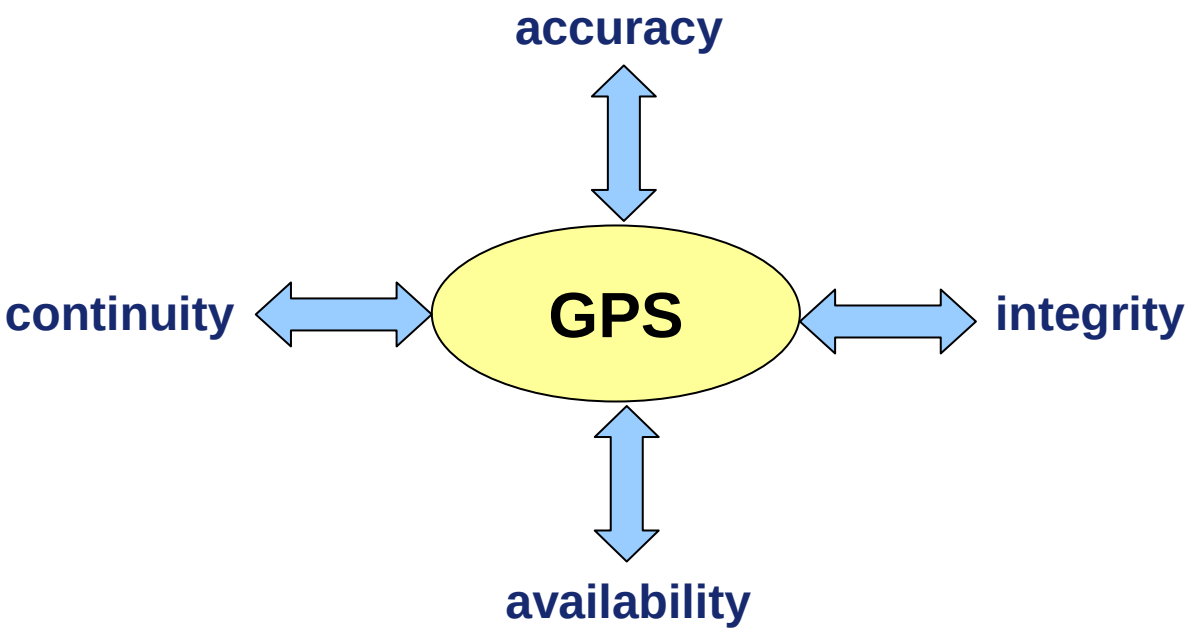
SATELLITE NAVIGATION

Template reference : 100181670S-EN

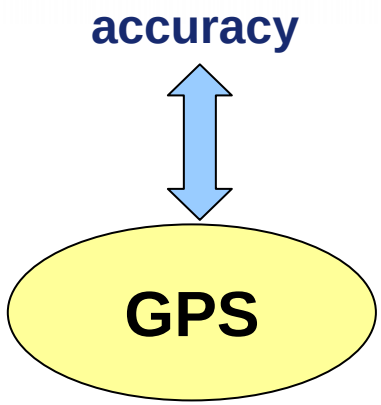
- **Performance properties**
- Examples of use
- Future developments
- Opportunities within SADC
- Open discussion
- EGNOS
- Multi-service
- Terminal presentation

Performance properties 1/7

GPS has limitations, especially for safety-related applications (e.g. aviation) and for high-precision applications.



Performance properties 2/7



<u>Accuracy</u> precision varies according to location and time

- Not good at extreme latitudes
- Not good in building environment and dense areas (city centre, deep forest)
- Failing satellites
- Ionospheric perturbation

Precision ranges from 5 m to 20 m

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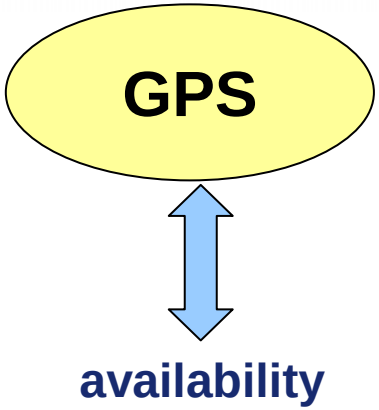
Performance properties 3/7

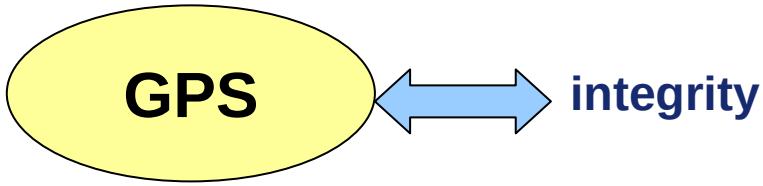


GPS is not <u>available</u> 100% of the time

- No satellite coverage
- Power-up start-up (time to first fix)
- Satellite failures

No guarantee on availability

Performance properties 4/7

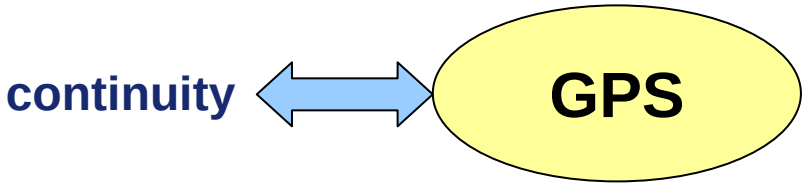


The GPS signal can be wrong and sent anyway

- Satellite failure
- No way to verify the signal reliability

No guarantee on truth of information

Performance properties 5/7



Continuous signal reception cannot be guaranteed for a given period of time

- Linked to availability problems
- Typical example: plane in landing approach phase

What is my risk of losing performance in a future time window

Examples

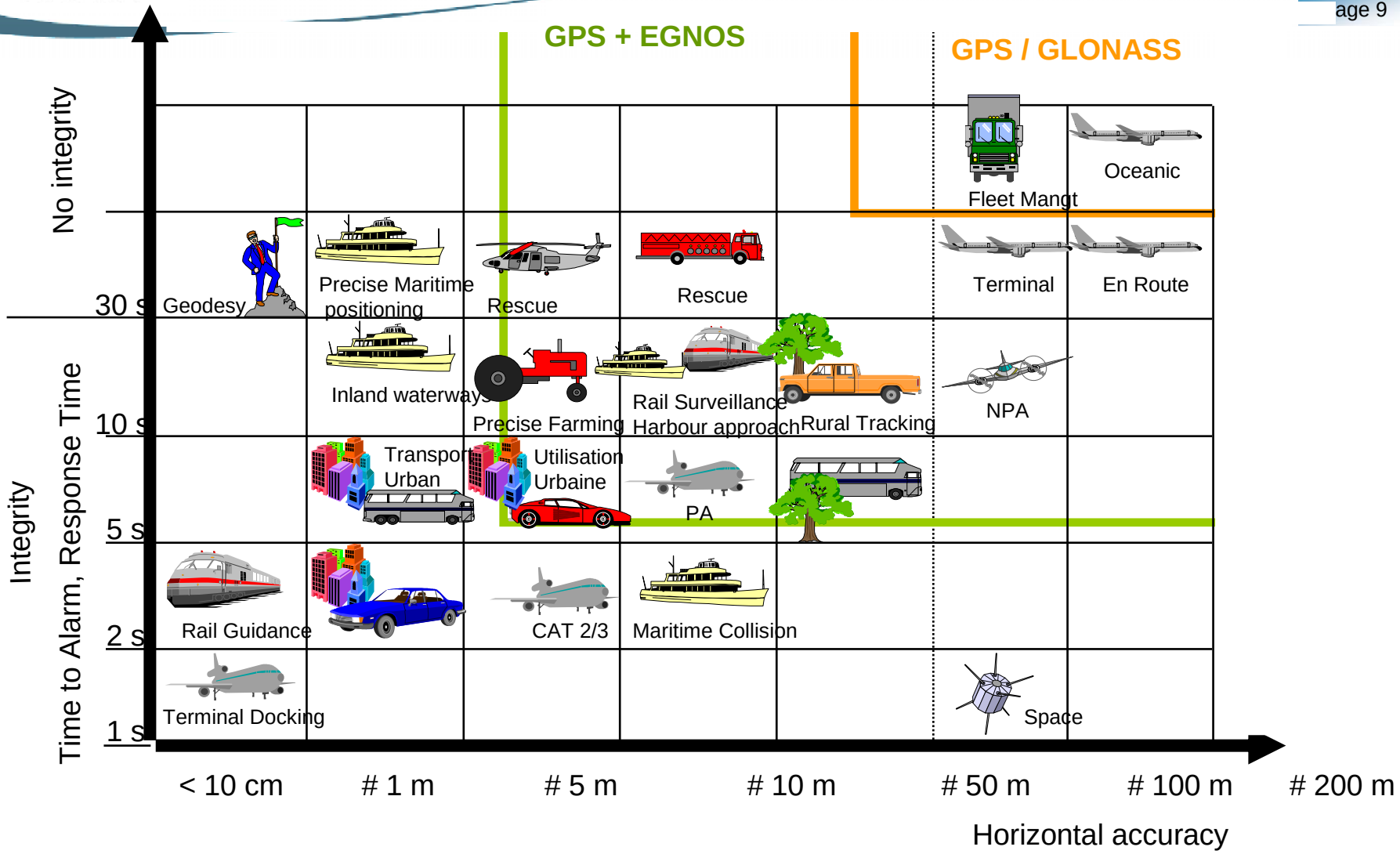
GPS is good but….regularly has problems

- 2 June 2006 18H25 to 22H00
  - Satellite #30 clock event, warning from GPS (NANU)
  - Error from 35m to 20km
- 31 July 2006 20H00 to 24H00
  - Satellite #03 clock event, NO warning from GPS (NANU)
  - Error from 50m
- 25 August 2006 11H00 to 15H00
  - Satellite #29 clock event, warning from GPS (NANU)
  - Error from 10m

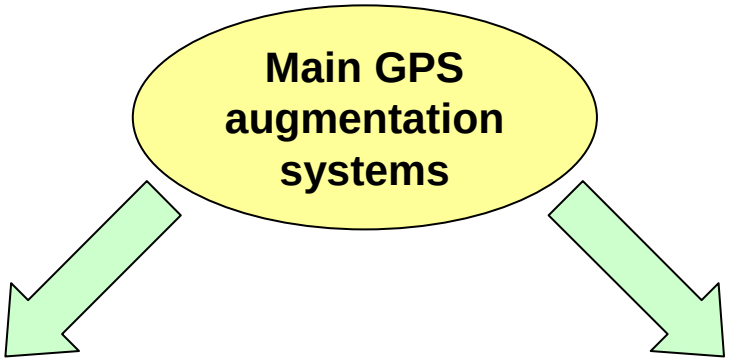
Users were not affected by all these events thanks to EGNOS, the European GPS augmentation system.

Source: French National Space centre (CNES)

EGNOS: more applications possible made



GPS improvement 1/5



Satellite based augmentation system (SBAS)

- WAAS (US)
- CWAAS (Canada)
- MSAS (Japan)
- GAGAN (India)
- EGNOS (Europe)

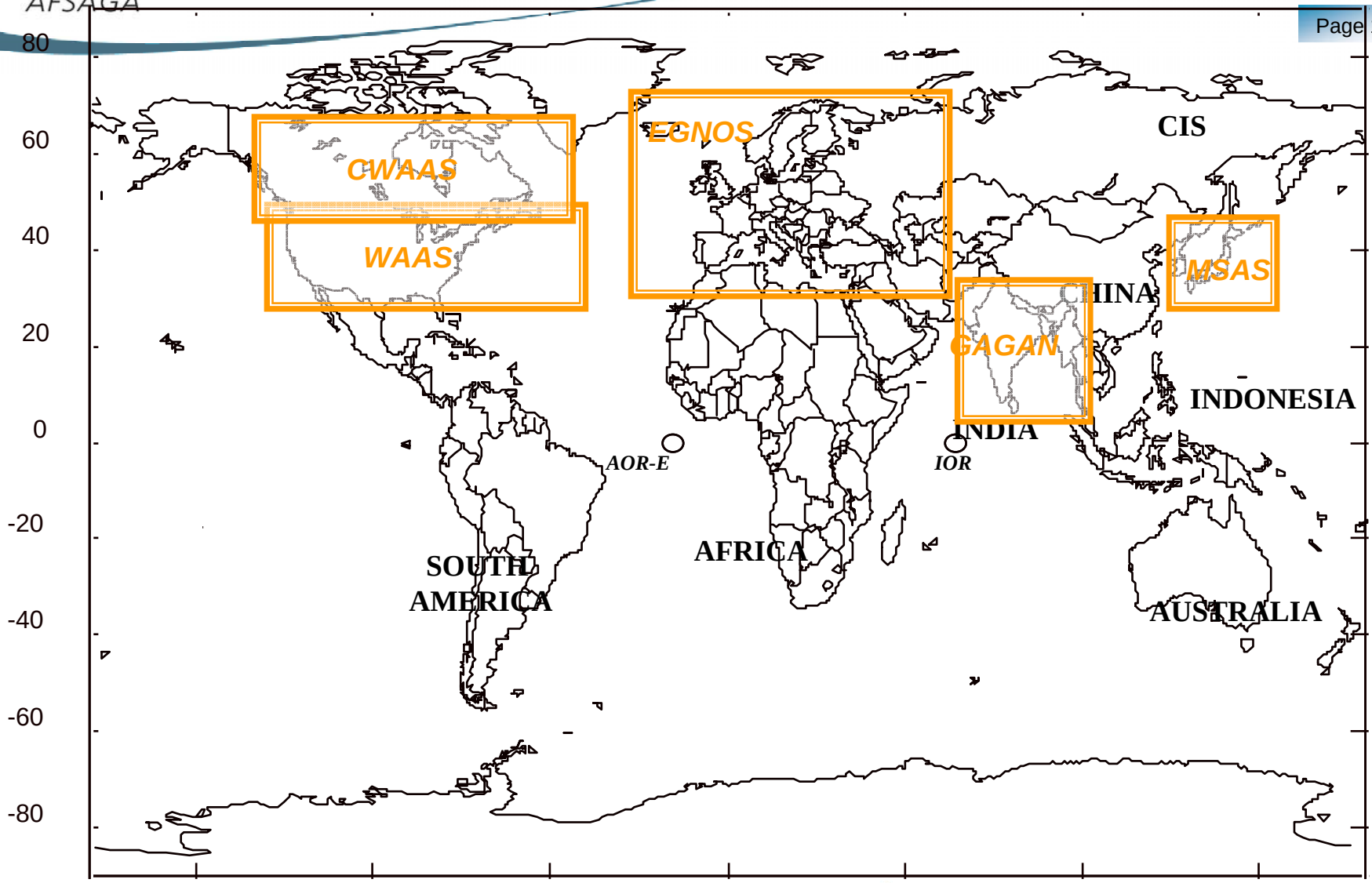
Interoperable

Ground based augmentation system (GBAS)

- Different technology involved
- Higher costs for end users (ground infrastructure)

Note: a third augmentation system exists, the Aircraft Based Augmentation System (ABAS); integrity is monitored through data cross check within the on-board receiver

GPS improvement 2/5



EGNOS

- Early Galileo Navigation Operational Service
- Phase 1 of GNSS (Global Navigation Satellite System), phase 2 being Galileo deployment
- Fully operational since 2006
- Built-in extension capabilities to extend its services to other regions (Africa, Eastern Europe and Russia)
- How does EGNOS work? multi-media presentation

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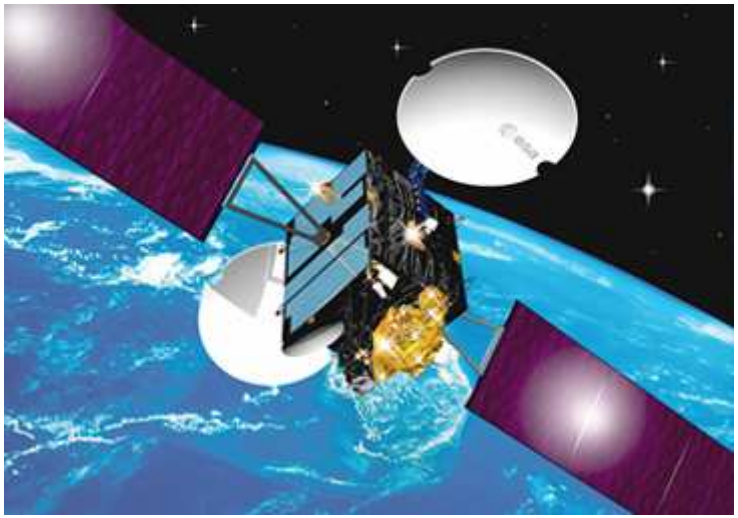


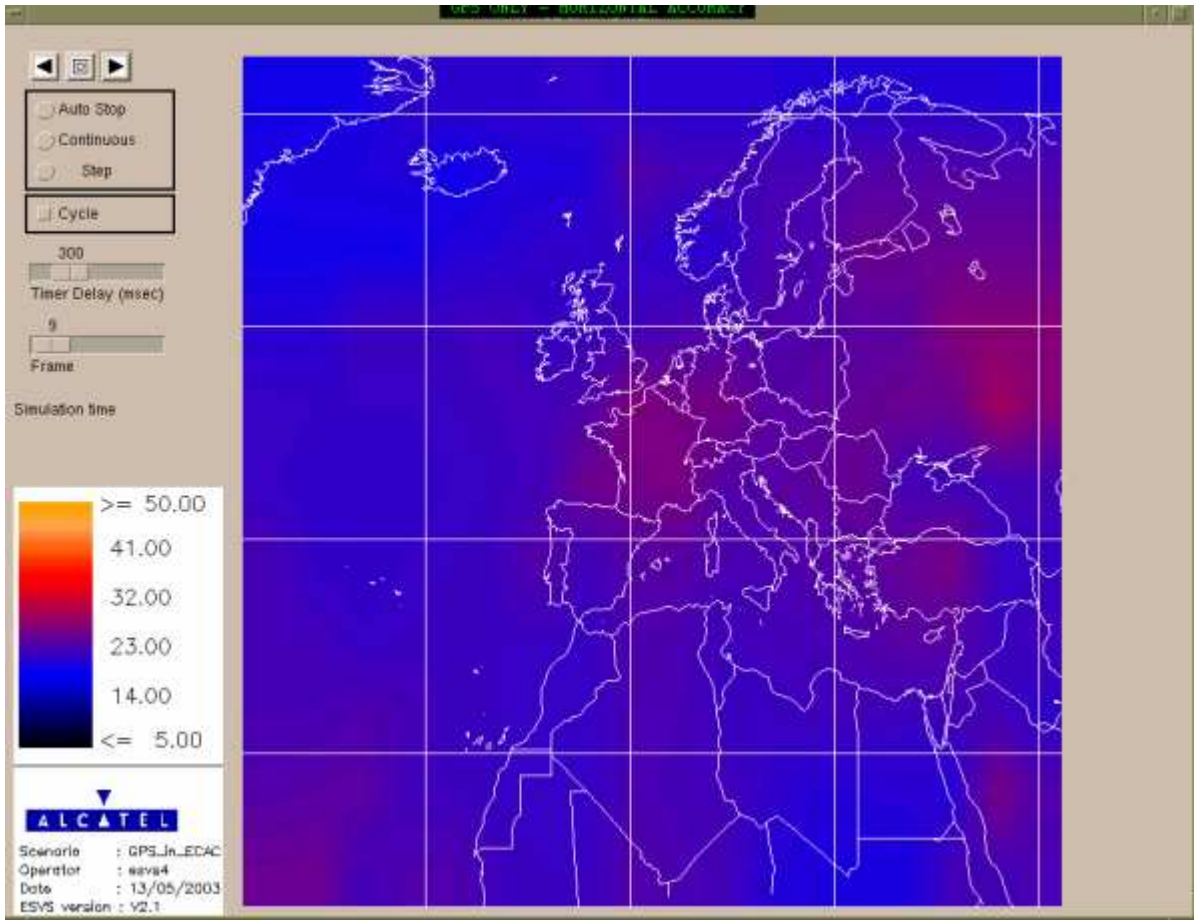
Artemis, one of the three geostationary satellites used for EGNOS

EGNOS: a global standard with access to global markets

GPS improvement 4/5

Horizontal accuracy - GPS only

START ANIMATION



Time compression: x60

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Horizontal accuracy – GPS+EGNOS

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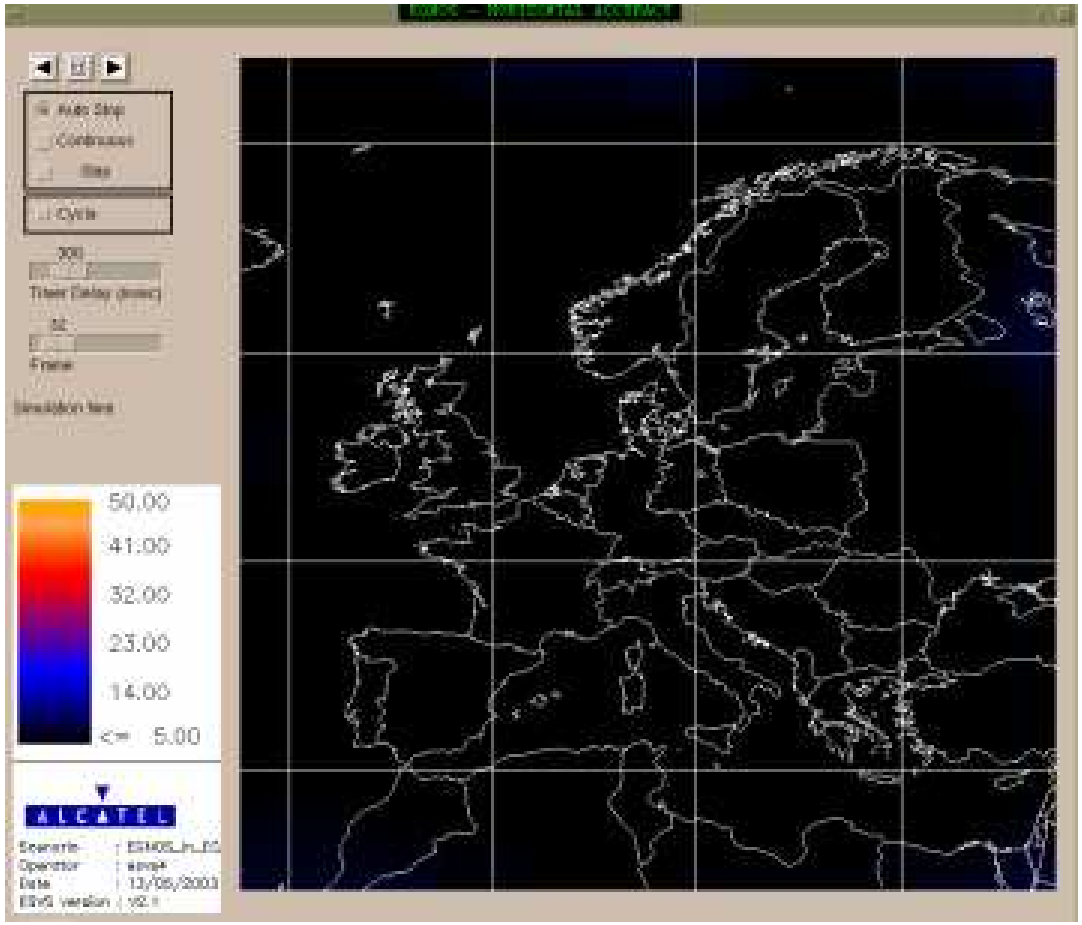


Time compression: x60

Real-life scenarios

- Clear sky view, no obstacle
- Geofencing feature demonstration

START ANIMATION

- Trees along the road
- Partial sky obstruction

START ANIMATION

- Building environment (city centre)
- Limited sky view

START ANIMATION

Test bed

One car fitted with two navigation terminals:

- One GPS
- One GPS/EGNOS

EGNOS signal received via GPRS

- Performance properties
- **Examples of use**
- Future developments
- Opportunities within SADC
- Open discussion
- EGNOS
- Multi-service
- Terminal presentation

World traffic evolution (1994-2005)

Average growth

- Passengers + 5% per year
- Freight + 6.5% per year

A major world-wide business

- Over 1.25 billion passengers in 1994
- Well over a third of the value of the world's manufactured exports

An economic catalyst

- more than 24 million jobs
- US$1.15 billion annual gross output

What is the need?

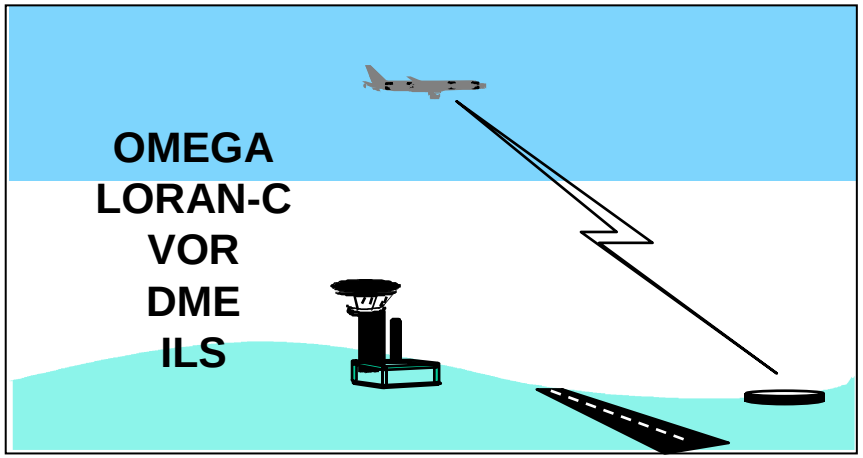
Growth of air traffic causes delays

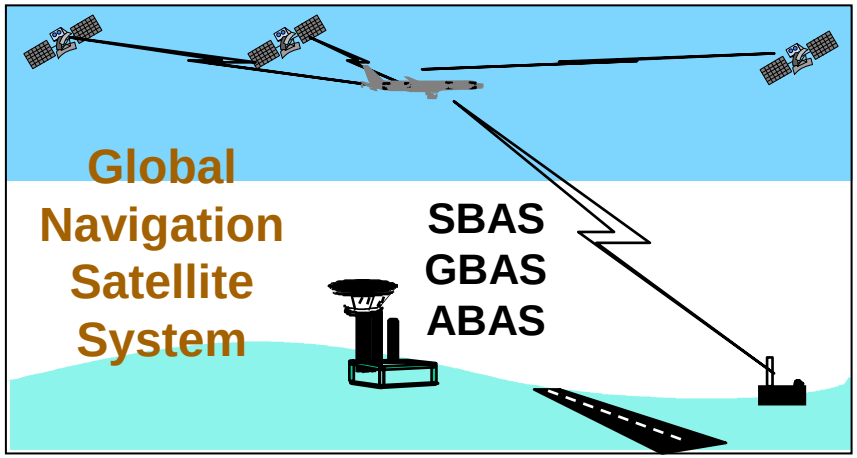
- In Europe
  - In 1996, 15.4% of flights delayed on average by 16.7 min
  - Cost of delays and longer routes estimated to be around 1.6 billion US$ p.a.
- In the USA
  - Average delay for domestic departures in 1995 around 7.2 min
  - This represents the flight time of nearly 250 aircraft in a year

Some regions with limited infrastructure need high investments for ground equipment (particular interest for regional commuting / light aviation)

Need	**Accurate positioning and navigation system safe service, available everywhere** ▪ more direct route for cost reduction for airline ▪ more flexible airspace ▪ reduced separation

Air traffic management 3/3





TODAY ***TOMORROW***

FROM

- **A local implementation**
- **A multi system environment (ILS, VOR, DME, ...)**
- **A lack of ground system in certain areas**

TO

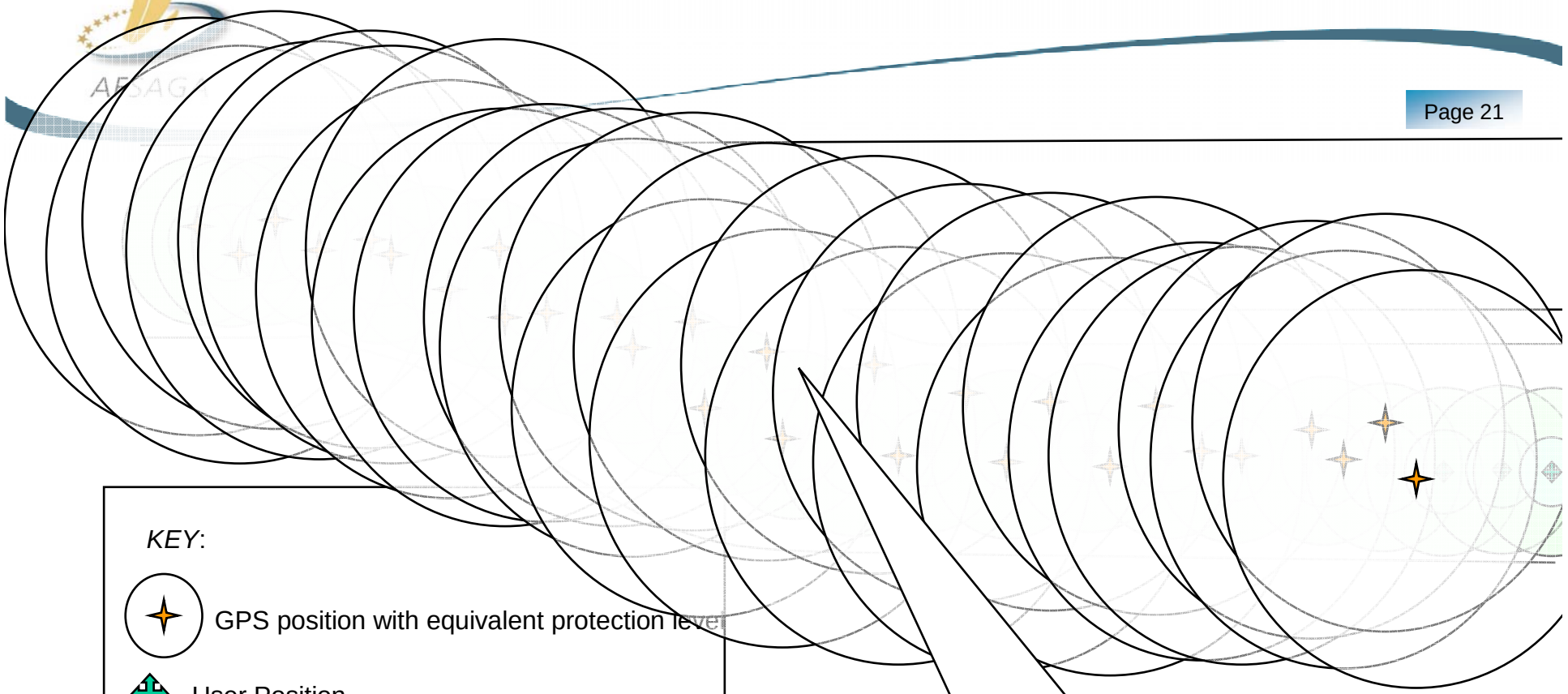
- **A worldwide system**
- **A seamless system**
- **A coherent precision all over the world**

Toll collecting 1/4

- **Some countries have already implemented kilometre-based charging systems relying on GNSS**
- **Urban congestion charging schemes are already in use**
- **New and more advanced methods of user-friendly road charging:**
  - Charge for the use of particular roads at particular times with particular vehicles
  - Charge users travelling in a certain urban zone, according to the distance driven

Only satellite navigation leads to a reliable, seamless and cost effective service

Toll collecting 2/4



KEY:

GPS position with equivalent protection level

User Position

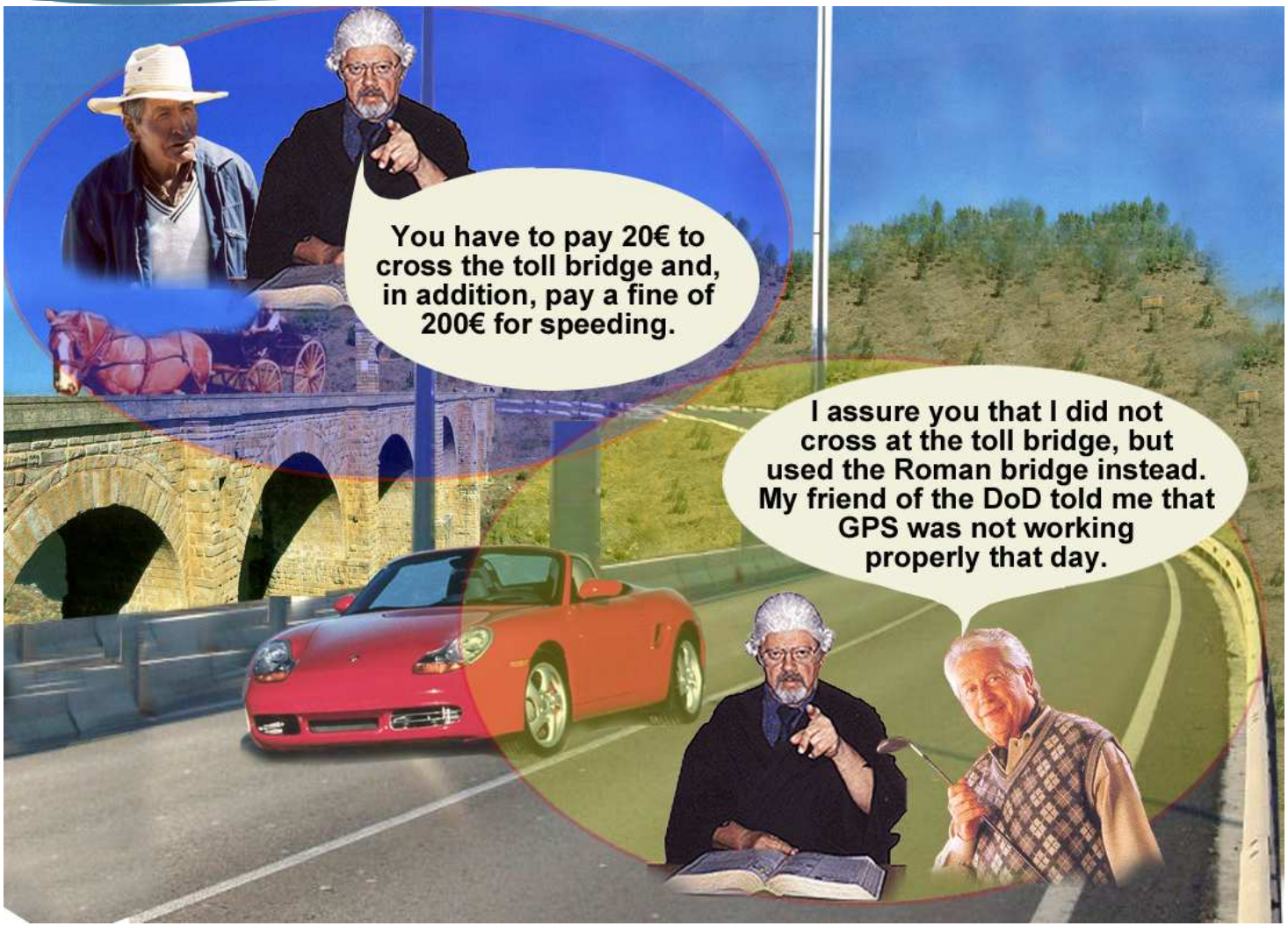
NSE — Navigation System Error

XPL — Horizontal Protection Limit

Did you turn right?

Accuracy, Improved availability & tracking

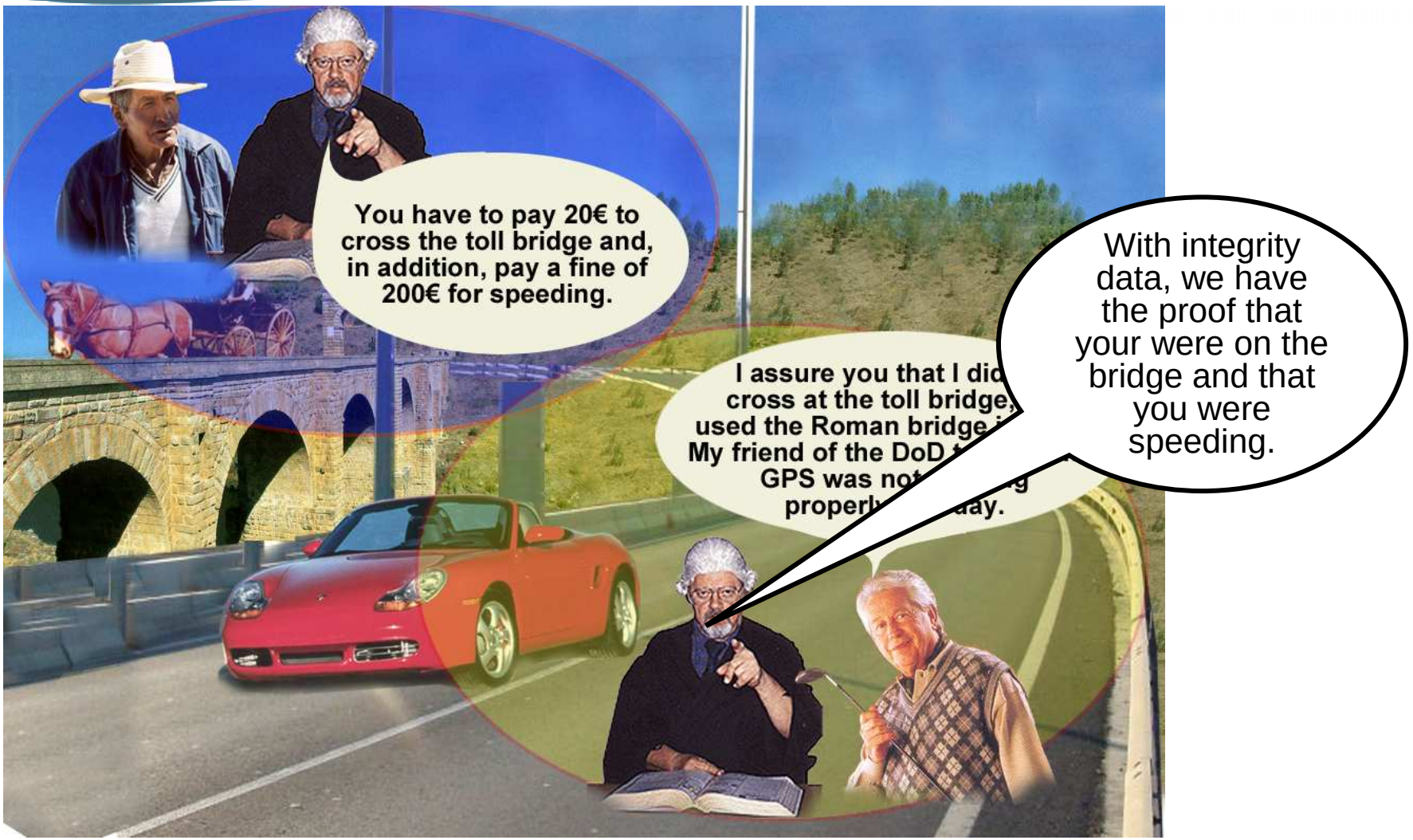
Toll collecting 3/4



THE TOLLING PROBLEMATIC

Without integrity, the business is risky.

Toll collecting 4/4



Agriculture and fisheries 1/2

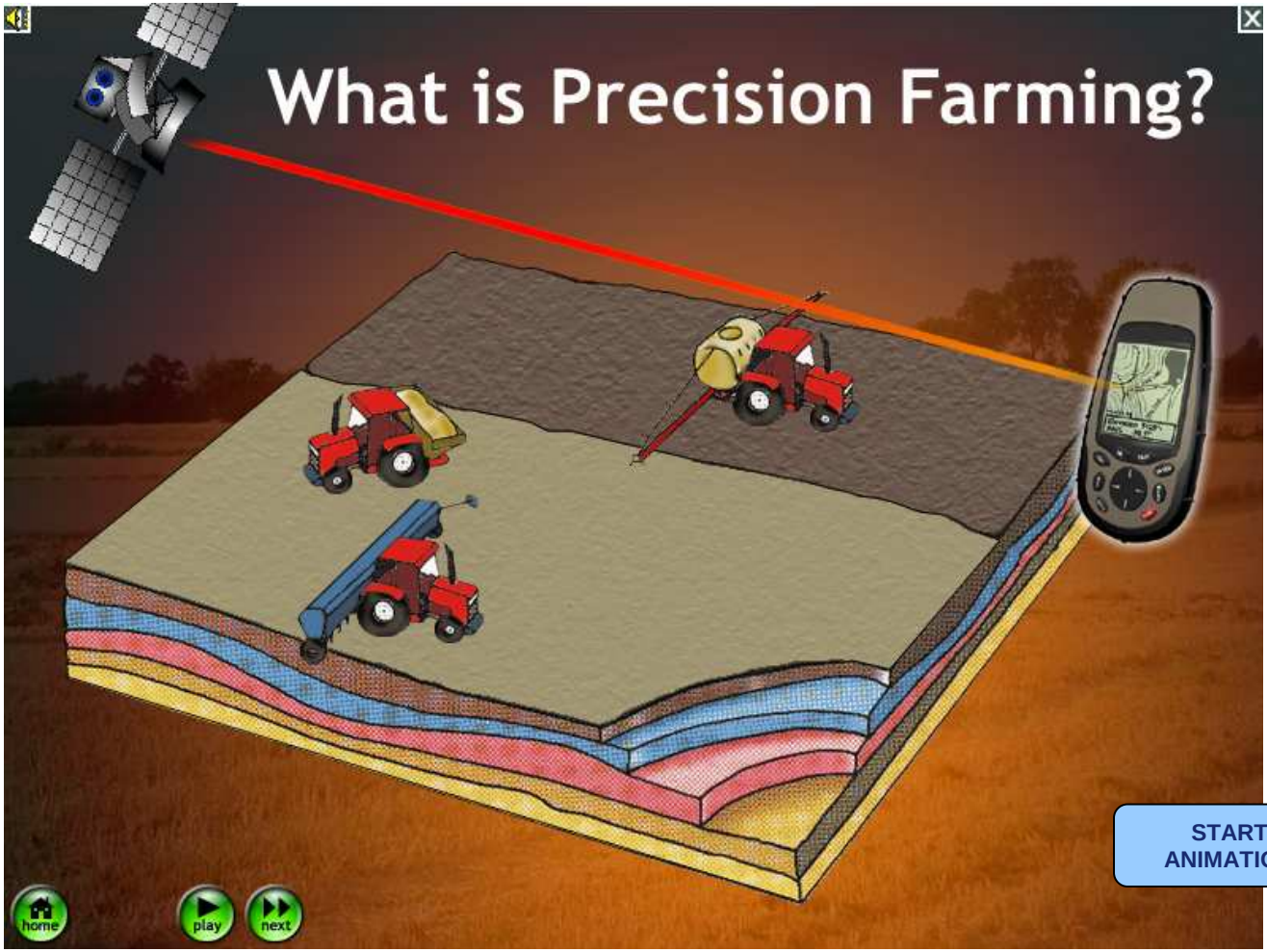
AGRICULTURE

- Improved monitoring of the distribution and dilution of chemicals
- Improved parcel yield from customised treatment
- More efficient property management

FISHERIES

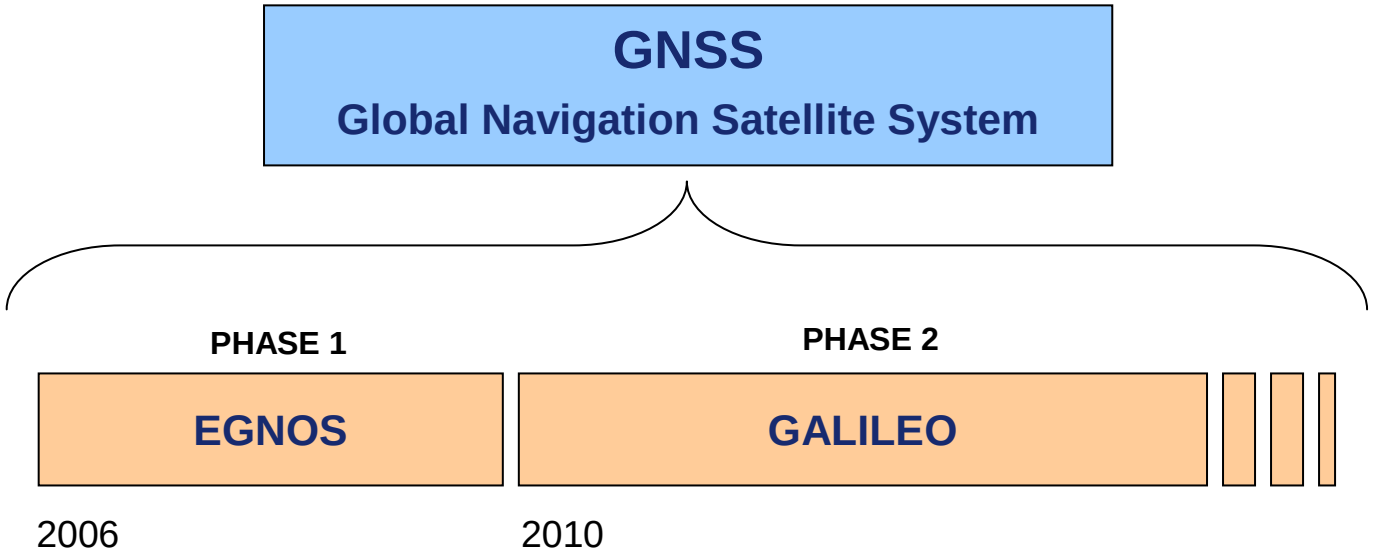
- More effective information exchange between vessels and stations
- Improved fishing capabilities
- Improved navigation aids for fishermen

Agriculture and fisheries 2/2



- Performance properties
- Examples of use
- **Future developments**
- Opportunities within SADC
- Open discussion
- EGNOS
- Multi-service
- Terminal presentation

Europe – Galileo 1/2



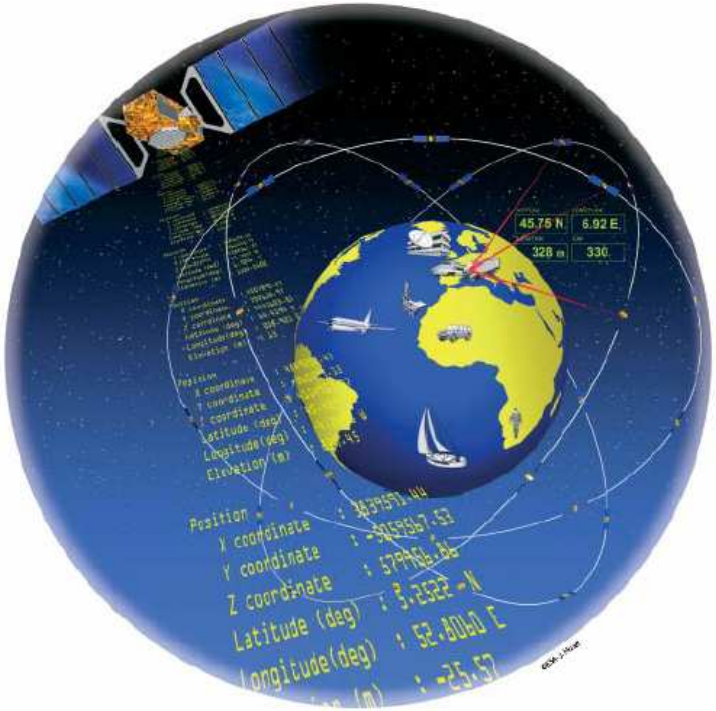
The European Commission chose a two-step approach for the deployment of GNSS

Europe – Galileo 2/2

Galileo:

- 30 satellites
- global coverage
- unrivalled performance
- full interoperability with GPS

START VIDEO



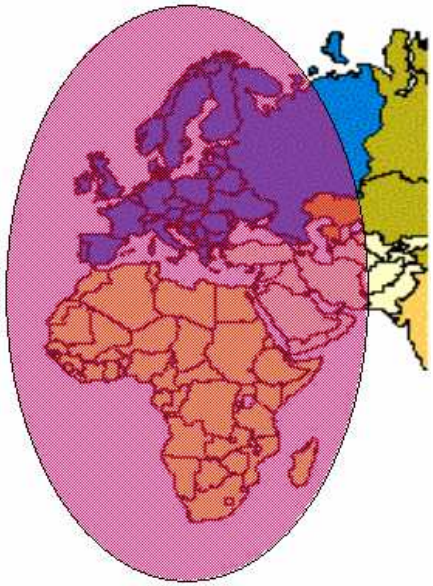
http://ec.europa.eu/dgs/energy_transport/galileo

Galileo: the European programme for global navigation services

Europe – EGNOS evolution

EGNOS coverage to be enlarged to provide multi-modal and safety of life services beyond the ECAC area to include EU Candidates, the Mediterranean and Africa

- The EU Council* concluded “the extension of EGNOS to other parts of the world should be pursued determinedly by the Commission and Member States”
- Expanding EGNOS coverage to the EU Candidate countries and the Mediterranean countries will provide GNSS users with services identical to the core European area
- Expanding EGNOS coverage to the African region will provide GNSS users with a service similar to that in the core European area and identical to current WAAS levels
- Decision by African ICAO group to go for an EGNOS extension



Note: *European Council. *Galileo – Integration of EGNOS*. Provisional Version, 5.VI.2003
Note :

Activities in Africa 1/2

- **South Africa (CSIR) is a longstanding European partner for satellite navigation (station hosted at CSIR SAC Hartebeeshoek)**
- **Thales Alenia Space working with CSIR /ATNS since 1996 (Euridis)**

2004 ATNS staff training in Johannesburg

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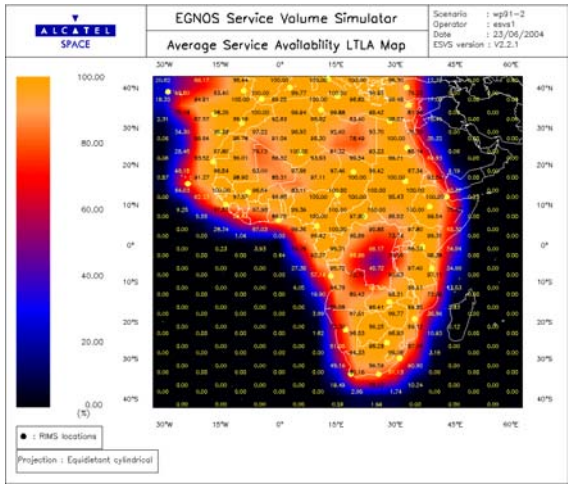
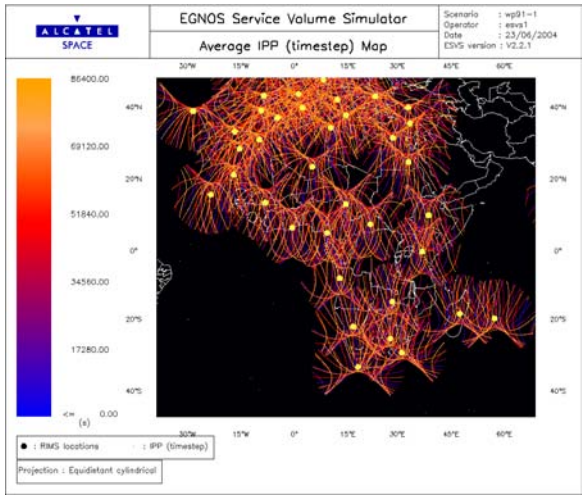
Activities in Africa 2/2

- South Africa was under EGNOS prototype extension coverage
- Africa has decided (International Civil Aviation Organisation forum) to go, for satellite navigation with an EGNOS extension
- EGNOS operational system extension has been designed





START VIDEO

Africa – ASECNA/ESA agreement

ASECNA

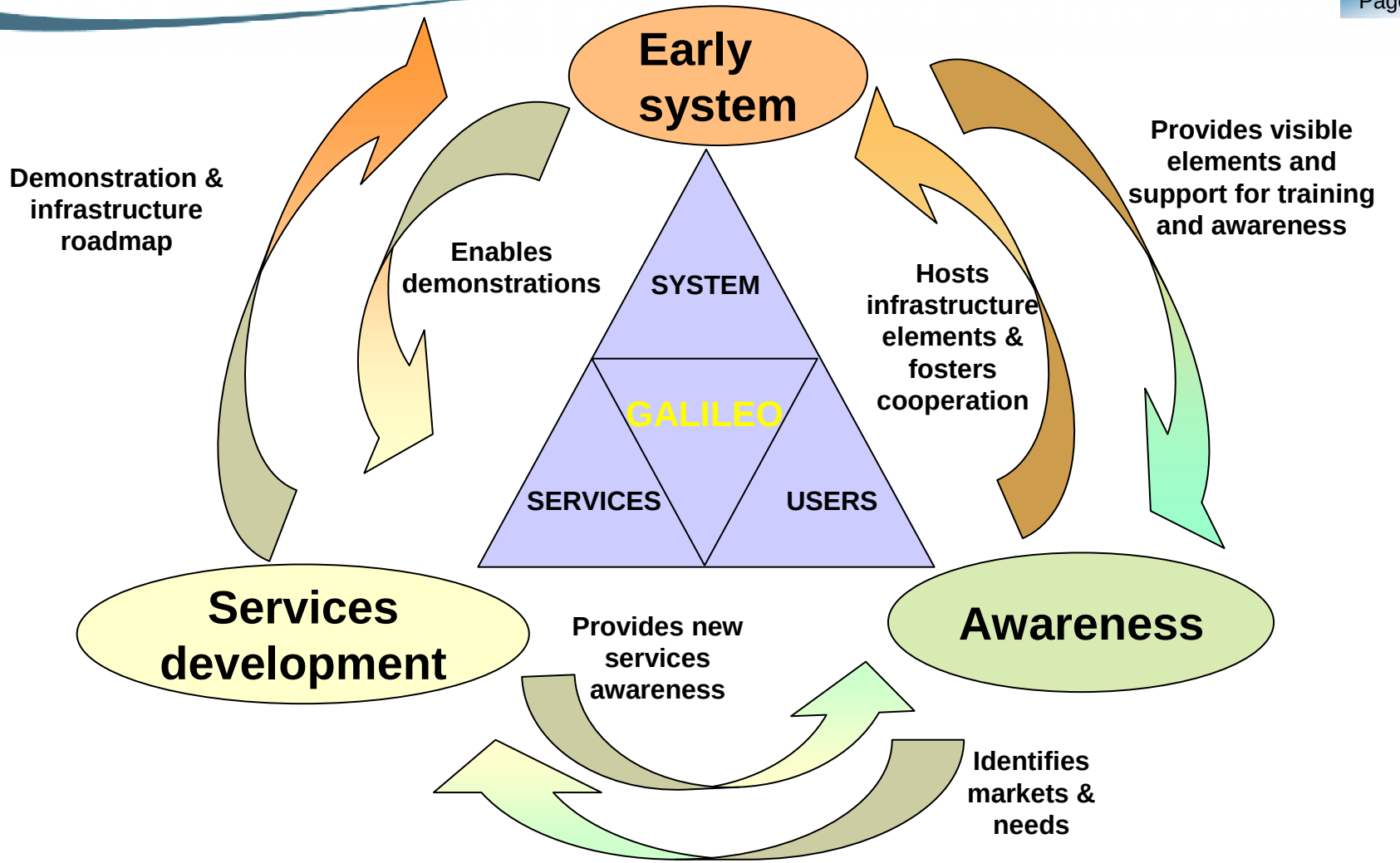
- African Aviation Safety Agency
- Supervises 101 airports (international, national and regional) over 17 countries

Cooperation agreement for satellite navigation in Africa :

- Signed on 28 June 2007 (ESA and ASECNA working since 2003)
- Objective of using satellite navigation to improve air traffic safety over the African continent
- Providing mutual assistance, notably with regard to extending EGNOS operational services more widely in Africa

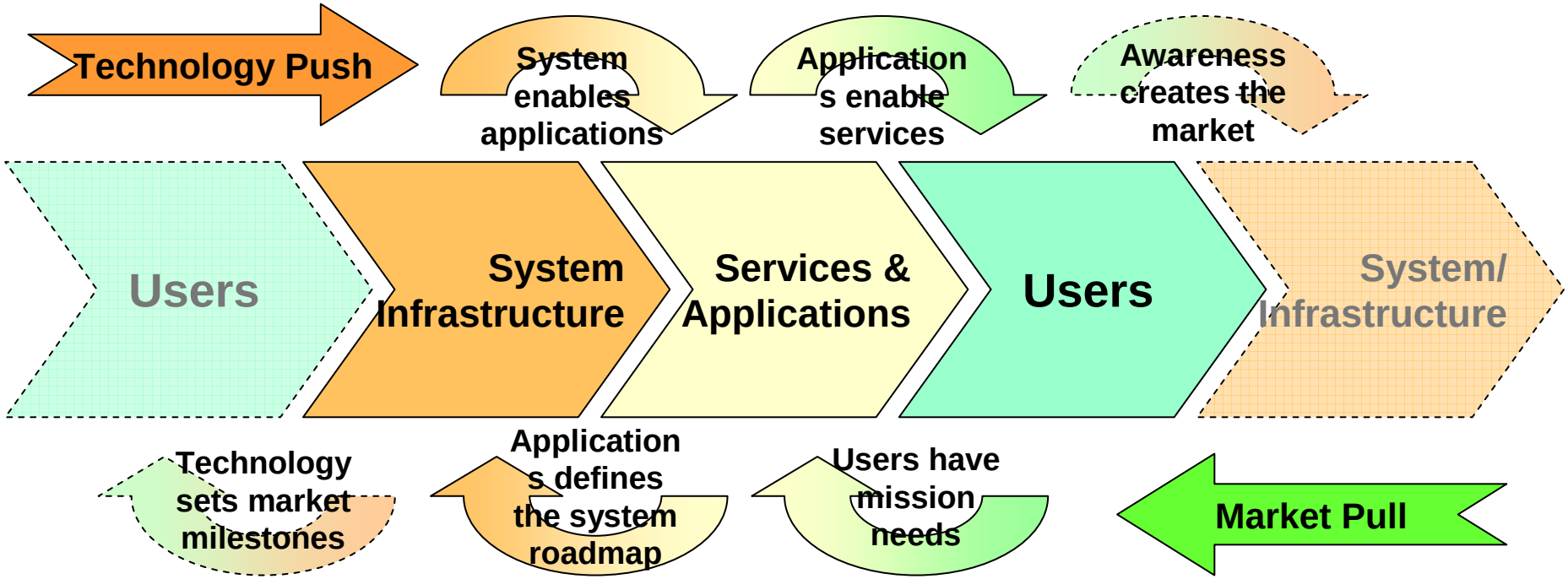
- Performance properties
- Examples of use
- Future developments
- **Opportunities within SADC**
- Open discussion
- EGNOS
- Multi-service
- Terminal presentation

Development of applications



Contributions to operational system 1/2

Galileo successful introduction in region requires a Push-Pull approach between infrastructure and users



- Note: the “needs” chain will in turn also be the revenue chain

Contributions to operational system 2/2

- **All is about navigation signal level of service**
  - Not the same required to land an aircraft as track vehicles

- **Necessity of all application fields to initiate work with first service**
  - Non Safety of life
  - Safety of life
  - Improved service…. (robustness, accuracy…)

It's all about dynamics

- Performance properties
- Examples of use
- Future developments
- Opportunities within SADC
- **Open discussion**
- EGNOS
- Multi-service
- Terminal presentation

Open discussion

Just before the lunch break…

START VIDEO

Lunch break

Back at 13:00

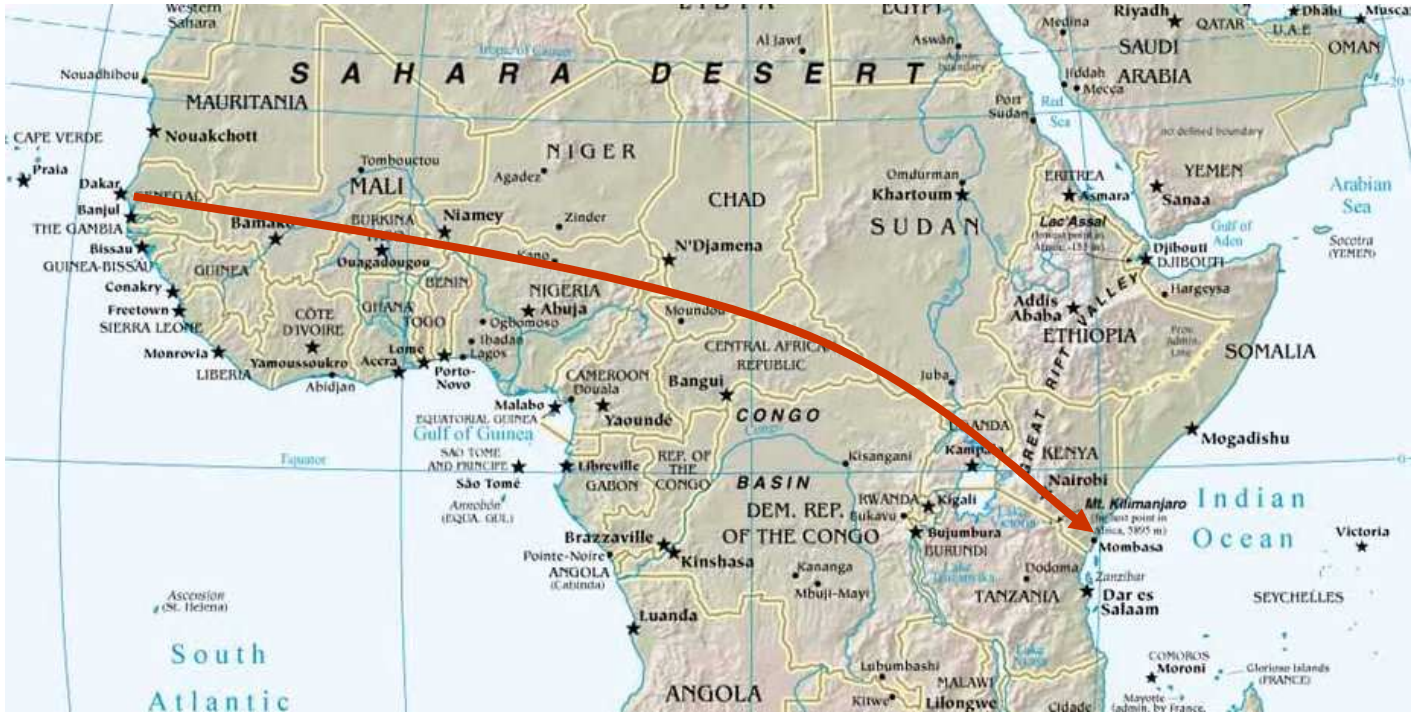
- Performance properties
- Examples of use
- Future developments
- Opportunities within SADC
- Open discussion
- **EGNOS**
- Multi-service
- Terminal presentation

EGNOS: benefits in Africa

Satellite navigation in Africa (TransAfrica, May 2005)

START VIDEO

- Crossing of Africa by plane, from Dakar to Mombasa
- EGNOS used as navigation aid (en-route and landing approach guidance)
- Complete success, validating EGNOS contribution to air navigation



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EGNOS prototype in Africa

- ISA: Interregional Satellite based augmentation system in Africa
- Reference stations installed in Africa (from 2002 to 2006)
- Provides corrections similar to those available in Europe
- Managed from Hönefoss, in Norway

The EGNOS prototype success in Africa has proven feasibility of a fully operational system

EGNOS: results in Europe 1/3

ESA web site for recent applications

- http://www.esa.int/esaNA/egnos.html GO

Helicopter flight trials for EGNOS

18 July 2007

Successful trials have recently been conducted at Lausanne, Switzerland, using the European Geostationary Navigation Overlay Service (EGNOS) to guide a helicopter as it approached and touched down at an emergency medical service landing pad in the city.

Pseudo-satellites allow accurate navigation in Helsinki harbour

29 June 2007

Pseudo-satellites, ground-based substitutes used when signals from ‘real’ satellites are not available, can deliver accurate positioning information in places where conventional solutions fail. This was demonstrated on 27 June in Helsinki harbour as part of a project supported by ESA.

EGNOS: results in Europe 2/3

EGNOS demonstration in South Africa

19 December 2005

A demonstration of the use of the European Geostationary Navigation Overlay Service (EGNOS) for advanced railway traffic management and control recently took place near Johannesburg.

The demonstration made use of EGNOS test signals currently available over Africa and was carried out as part of the Programme for the Development and Demonstration of Applications for Galileo and EGNOS (ProDDAGE), a contract with the Galileo Joint Undertaking. The realisation of the demonstration was a collaboration between ESYS plc, a UK consultancy, and Spoornet, the South African rail freight company.

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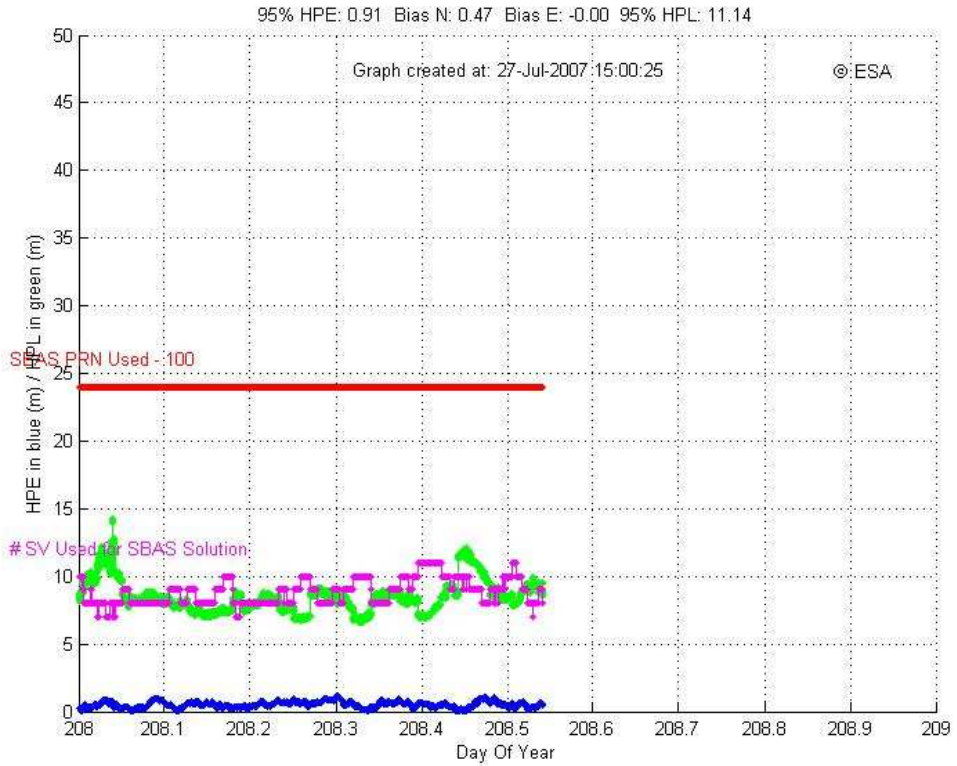
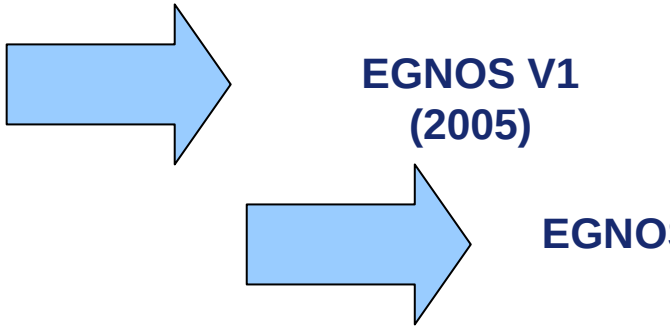
EGNOS: results in Europe 3/3

ESA web site for real-time monitoring

- http://www.egnos-pro.esa.int/IMAGEtech/imagetech_realtime.html GO

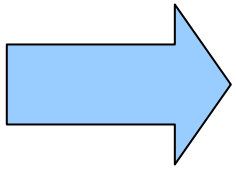


EGNOS perspective



EGNOS V1 (2005)

EGNOS V2 (Ongoing)



Multi-constellation Regional Segment (GPS, Glonass, Galileo)

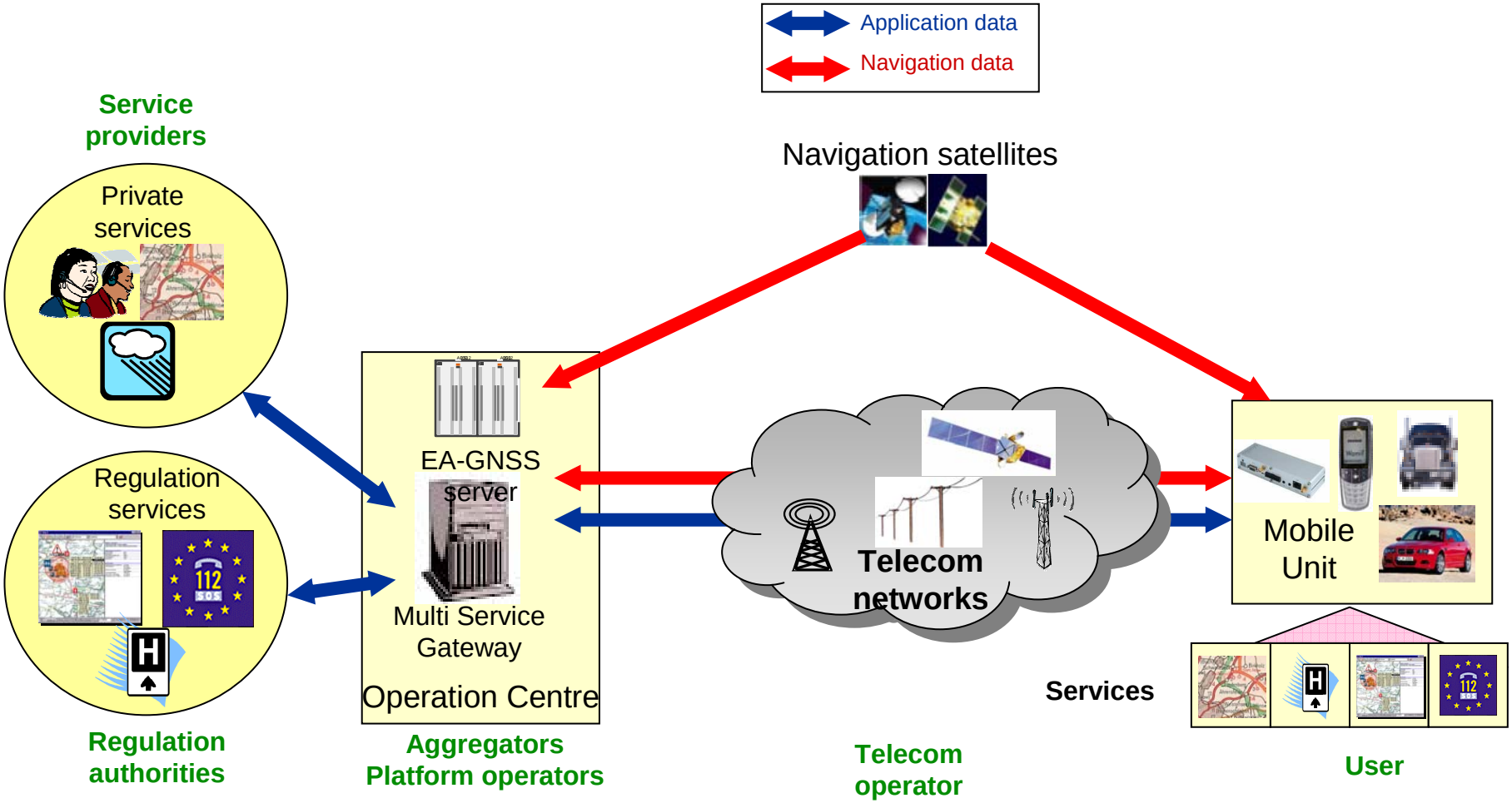
Rebranded

EGNOS: Early Galileo Navigation Operational Service

EGNOS is the first step of the Galileo regional segment

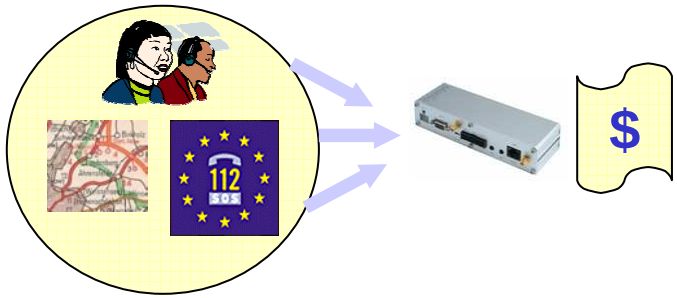
- Performance properties
- Examples of use
- Future developments
- Opportunities within SADC
- Open discussion
- EGNOS
- **Multi-service**
- Terminal presentation

Multi-service concept

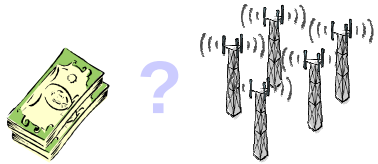


Multi-service technical key drivers

Multi-service architecture**:** one mobile unit - several services - one invoice paradigm



Need for a solution dealing with different components life cycles (weak links): key for **competitiveness** of solution (service, mobile unit, network)



Bundling services is an enabler for market development

- Performance properties
- Examples of use
- Future developments
- Opportunities within SADC
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- EGNOS
- Multi-service
- **Terminal presentation**

- High Tech Corporation (Taiwan)
- Combined GPS/GSM (Tomtom navigator)
- GPRS/EDGE/Wifi/Bluetooth
- Windows Mobile 5, with Direct Push technology
- 2 Megapixel digital camera
- Built-in FM radio
- Price: 600 euros (750 euros with Tomtom)

www.htc.com

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- Actia SA (France)
- OEM Module used by trucks manufacturers
- Multiservice capability
- GPS/ EGNOS / GPRS
- Field proven

Coffee break

Back at 15:00

Next: second technology presentation (satellite communications)

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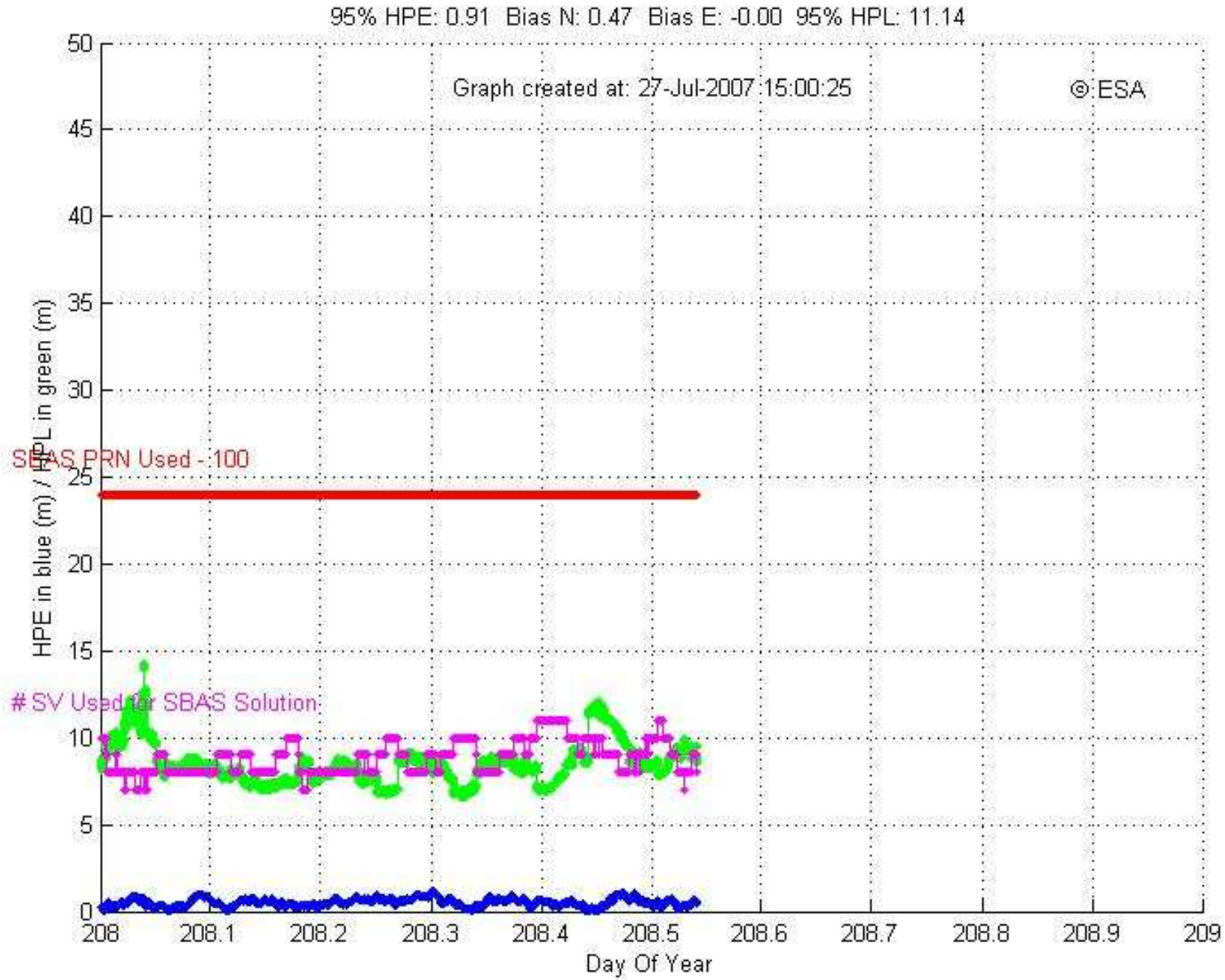
BACKUP SLIDES

SBAS is now part of civil aviation future

SBAS is implemented as per 11th International Civil Aviation Organisation (ICAO) Air Navigation conference :

- Recommendation 6/1: States encouraged to move rapidly towards …..
- Recommendation 6/9 : States to support & participate in preoperational activities...

Backup 2: EGNOS real-time performance


95% HPE: 0.91 Bias N: 0.47 Bias E: -0.00 95% HPL: 11.14
Graph created at: 27-Jul-2007 15:00:25
© ESA
HPE in blue (m) / HPL in green (m)
SBAS PRN Used - 100
SV Used for SBAS Solution
Day Of Year
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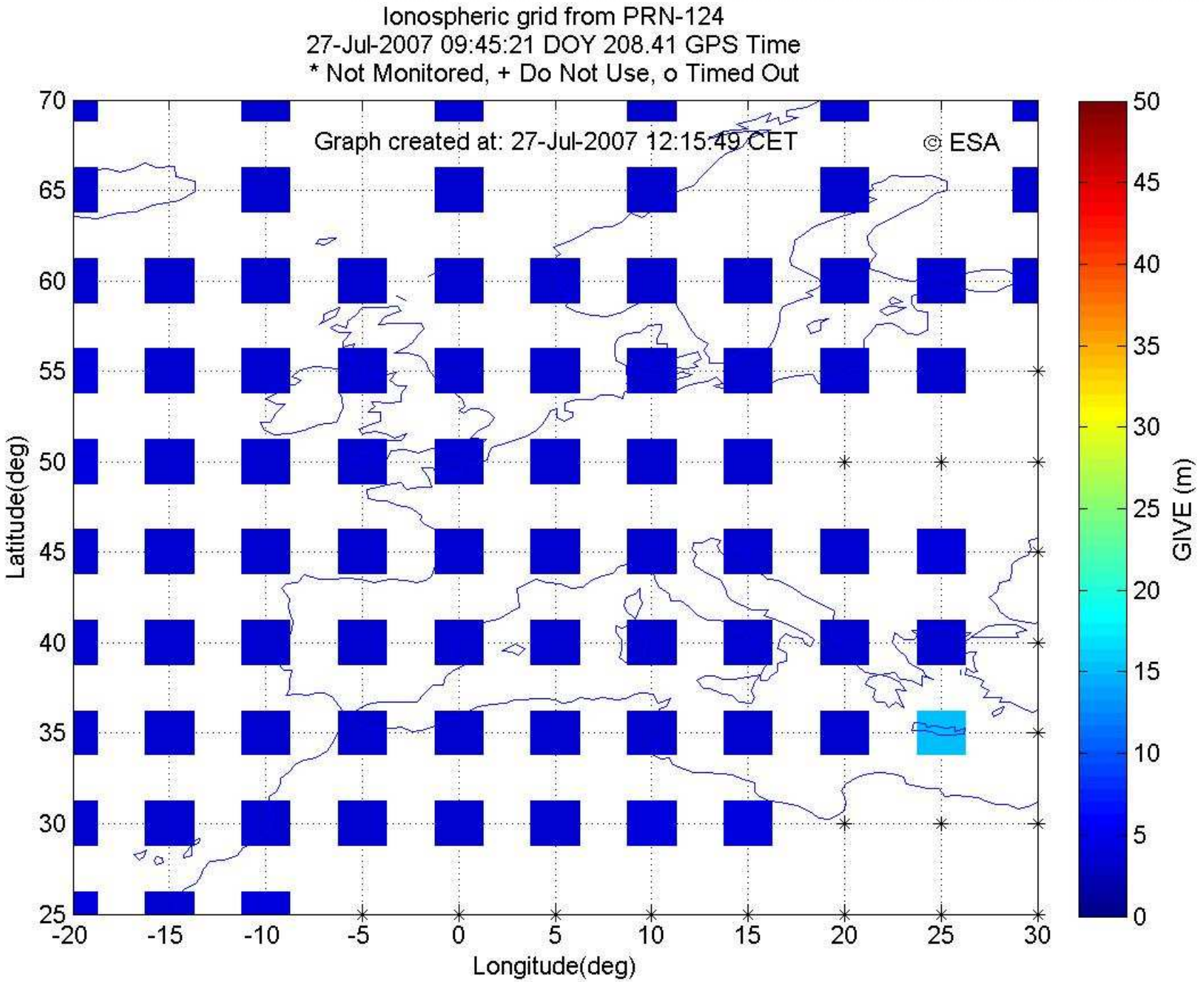
Ionospheric grid from PRN-124
27-Jul-2007 09:45:21 DOY 208.41 GPS Time
* Not Monitored, + Do Not Use, o Timed Out
Graph created at: 27-Jul-2007 12:15:49 CET
© ESA
Latitude(deg)
Longitude(deg)
GIVE (m)
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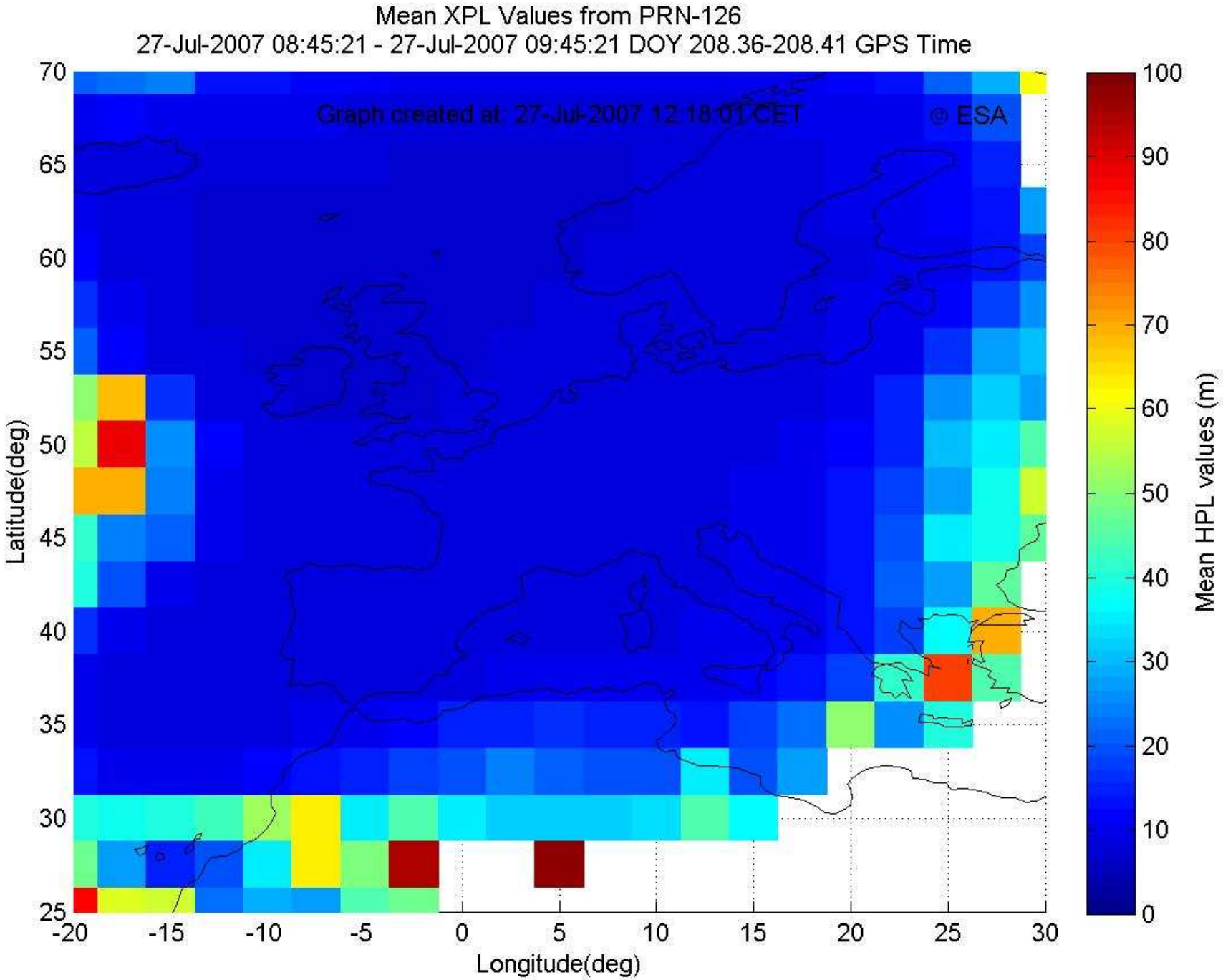
0


Mean XPL Values from PRN-126
27-Jul-2007 08:45:21 - 27-Jul-2007 09:45:21 DOY 208.36-208.41 GPS Time
Graph created at: 27-Jul-2007 12:18:01 CET
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Latitude(deg)
70
65
60
55
50
45
40
35
30
25
Longitude(deg)
-20
-15
-10
-5
0
5
10
15
20
25
30
Mean HPL values (m)
100
90
80
70
60
50
40
30
20
10
0