The Transition from ESTB to EGNOS: Managing User Expectation

Dr Sally Basker, Helios Technology Ltd

Mr Giorgio Solari, ESA GISS, Belgium

Dr Javier Ventura-Traveset, ESA EGNOS PO, France

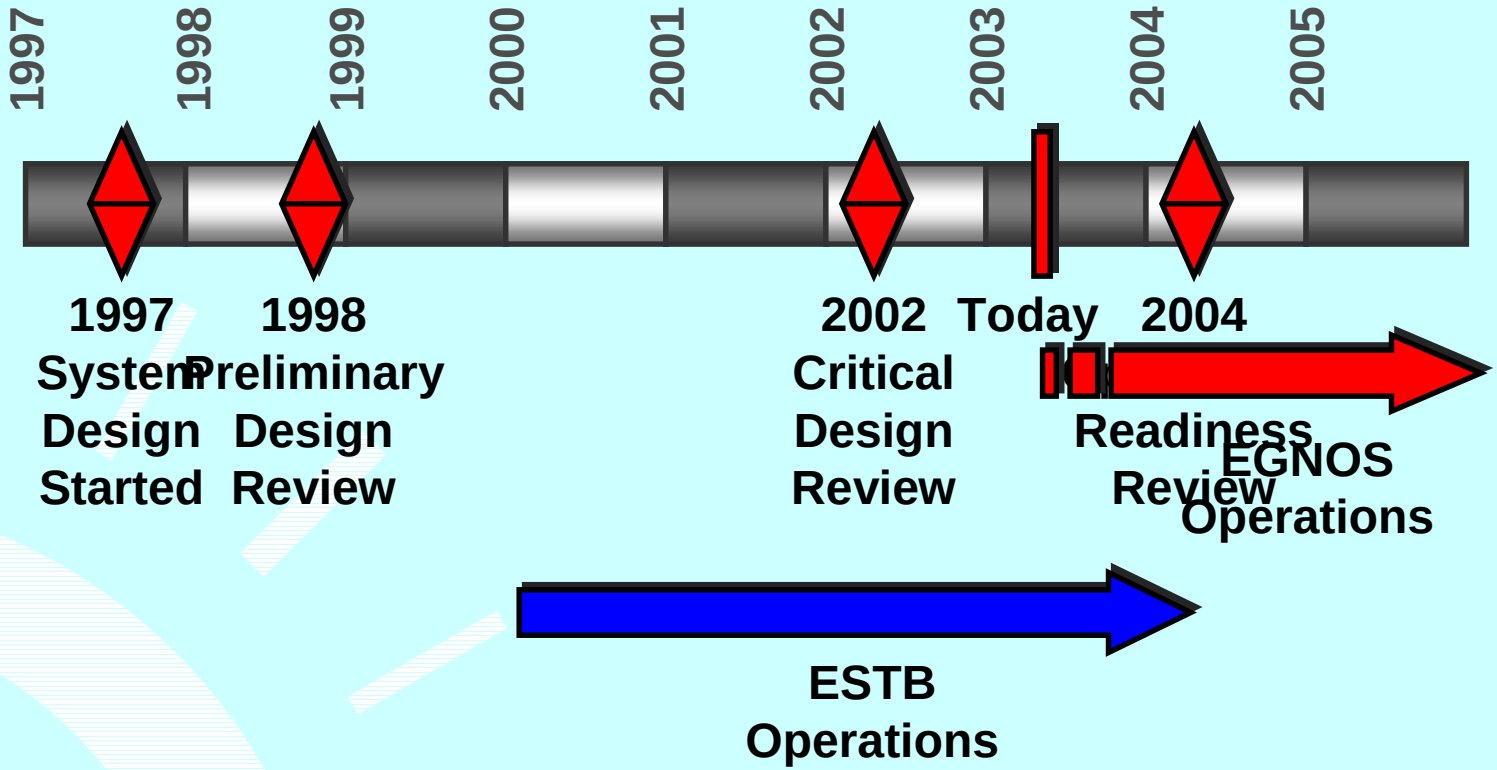
Mr Cristoforo Montefusco, ESA EGNOS PO, France

Contents

- Introduction
- EGNOS and ESTB
- The Transition to EGNOS
- The User Experience

Introduction

EGNOS is nearing completion after six years of intense effort



ESTB has been developed in parallel as an EGNOS prototype providing pre-operational signals from February 2000

2003 is going to be a year of change and we need to ensure a smooth transition from ESTB to EGNOS

- We need to ensure that user perception meets user expectation in terms of performance
- User perception is driven by
  - signal broadcast by the geostationary (GEO) satellites
  - the wide area differential corrections (WAD) & integrity data
- The limiting factor here is the number of GEOs available for both systems
- We need to manage this transition so that users understand which GEO is being used by which system (ESTB or EGNOS) and the level of performance provided

EGNOS and ESTB

- EGNOS
- ESTB

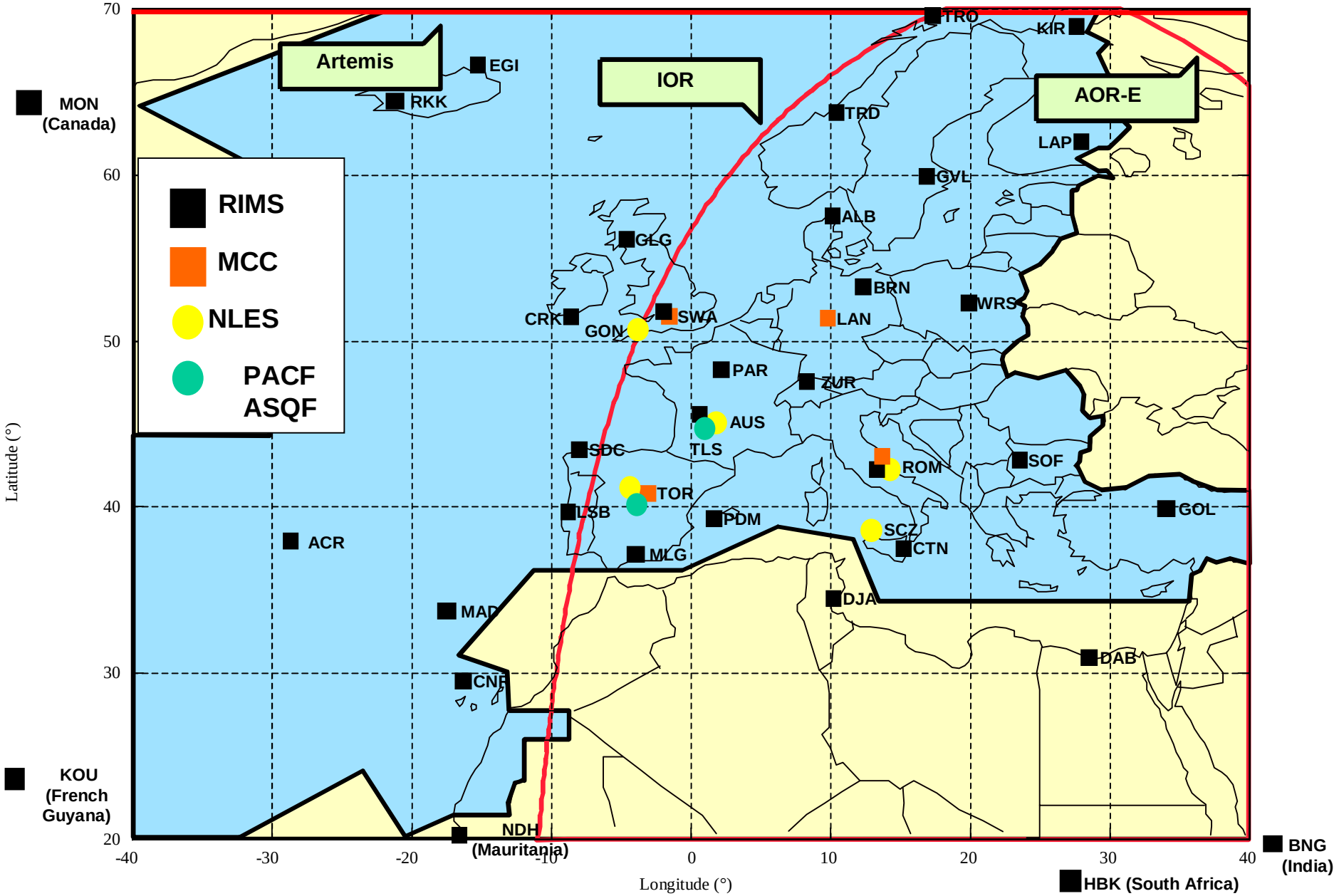
EGNOS – the European Geostationary Navigation Overlay Service - does what it says on the box!

- **European** coverage, standardised, and quality assured
- Broadcasts GPS look-alike signals from three **GEO** satellites to augment GPS for **navigation**
  - 5m vertical, 1m horizontal
  - 6 second integrity time to alarm
- Highly compatible **overlay** to GPS so a single receiver and antenna can process GPS and EGNOS
- **Services** the needs of mission/safety critical users

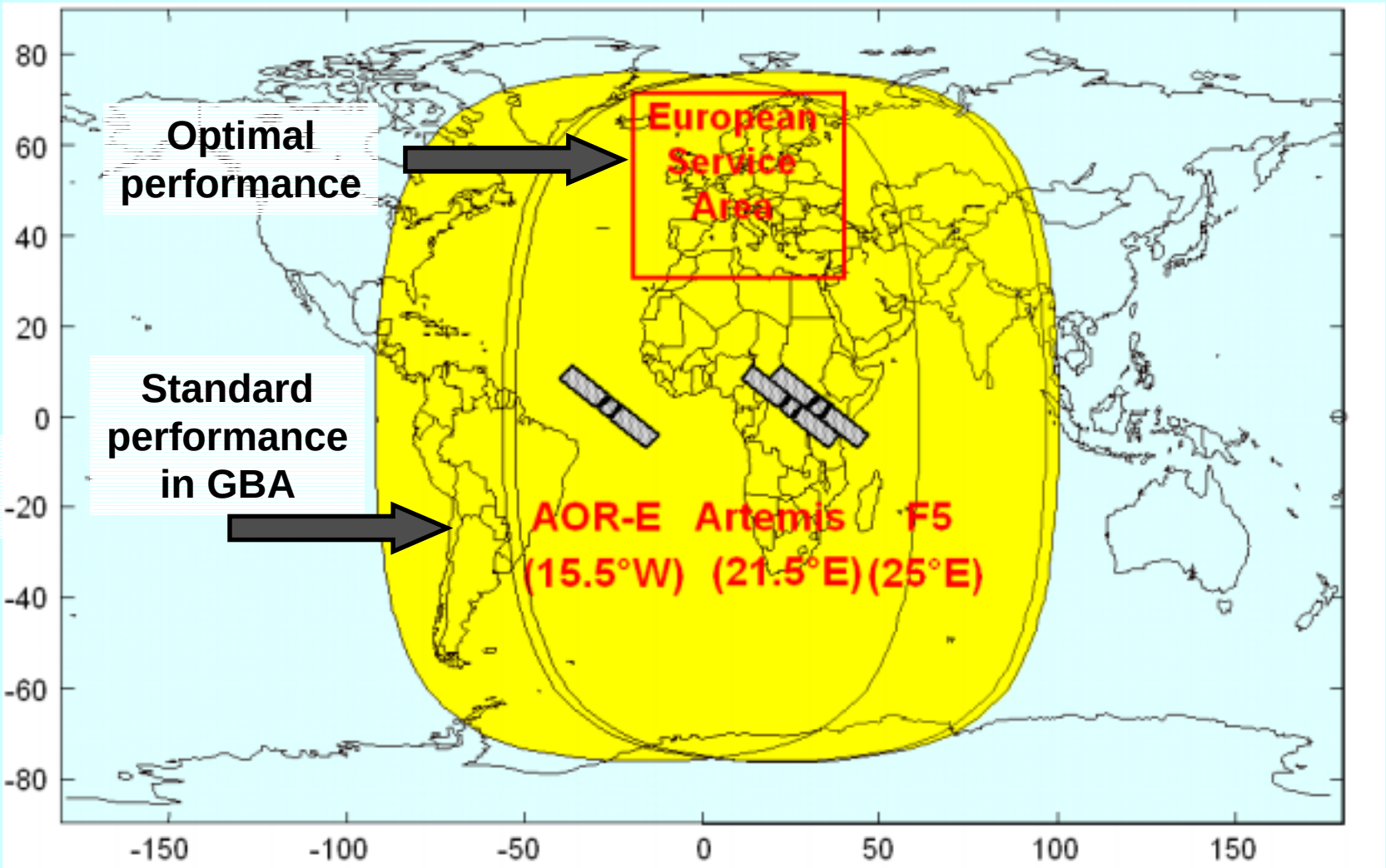
Users will benefit from improved performance, removing the need for local-area differential in many cases

The EGNOS architecture is highly redundant

- 34 RIMS – reference & integrity monitoring stations
  - each satellite has to be monitored by multiple RIMS before corrections and integrity messages are generated
- 4 MCCs - mission control centres
  - one active and three hot spares
- 6 NLES – navigation land earth stations
  - one active and one hot spare per GEO
- Supporting infrastructure includes
  - PACF – performance assessment check-out facility
  - ASQF – application specific qualification facility


Artemis
IOR
AOR-E
RIMS
MCC
NLES
PACF
ASQF
MON (Canada)
KOU (French Guyana)
BNG (India)
HBK (South Africa)
NDH (Mauritania)
TRO
KIR
EGI
RKK
TRD
LAP
GVL
ALB
GLG
BRN
WRS
CRK
GON
SWA
LAN
PAR
ZUR
AUS
TLS
SDC
ROM
SOF
TOR
LSB
PDM
GOL
SCZ
CTN
ACR
MLG
DJA
MAD
DAB
CNR
70
60
50
40
30
20
-40
-30
-20
-10
0
10
20
30
40
Latitude (°)
Longitude (°)

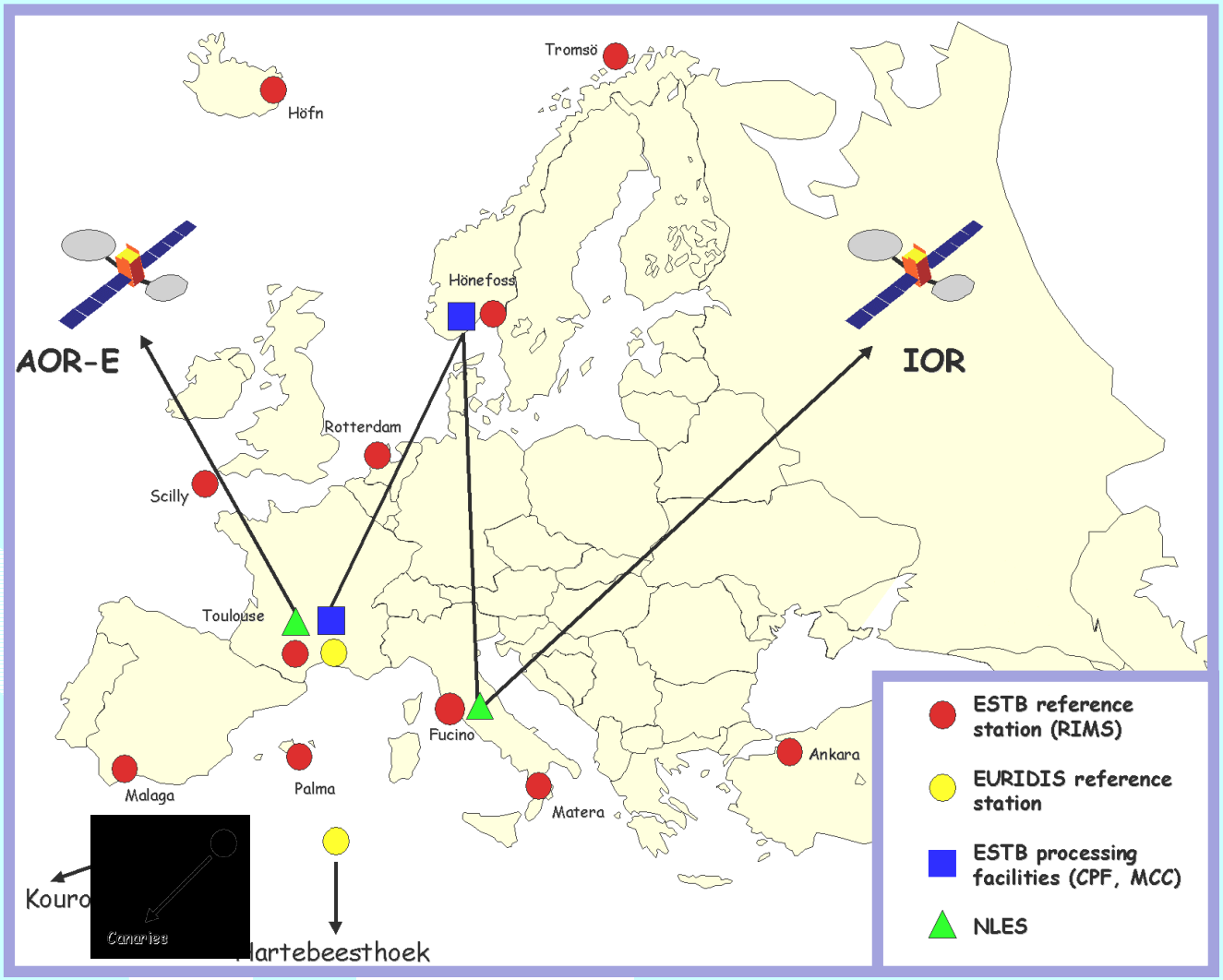
The three GEOs provide triple coverage over Europe, the Mediterranean and Africa



EGNOS and ESTB

- EGNOS
- ESTB

The ESTB provides a pre-operational service and allows us to prepare both for EGNOS from 2004 and for Galileo later this decade



The differences between ESTB and EGNOS for the same coverage area emphasise the pre-operational nature of the ESTB

Parameter	ESTB	EGNOS
Number MCS	1	4
Number RIMS	12	34
Number NLES	2	6
Accuracy	1m 95% limited by RIMS density	1m 95% throughout coverage area
Integrity	No	Yes
Service Guarantee	No	Yes

The Transition to EGNOS

- Overview
- Signal Structure
- Using the GEO satellites
- RIMS Deployment
- SISNET

We need to consider both the user and system needs during the transition period

- User *expectation* is performance specific while user *perception* is driven by the quality of the WAD and integrity data received from the GEO satellites
- The WAD and integrity data quality are dependent on the distribution and density of the RIMS network
- ESA aims to ensure continuity of the ESTB service at least until EGNOS is declared operational, but at the same time it needs to deploy and test EGNOS
- The limiting factor is the number of GEOs available

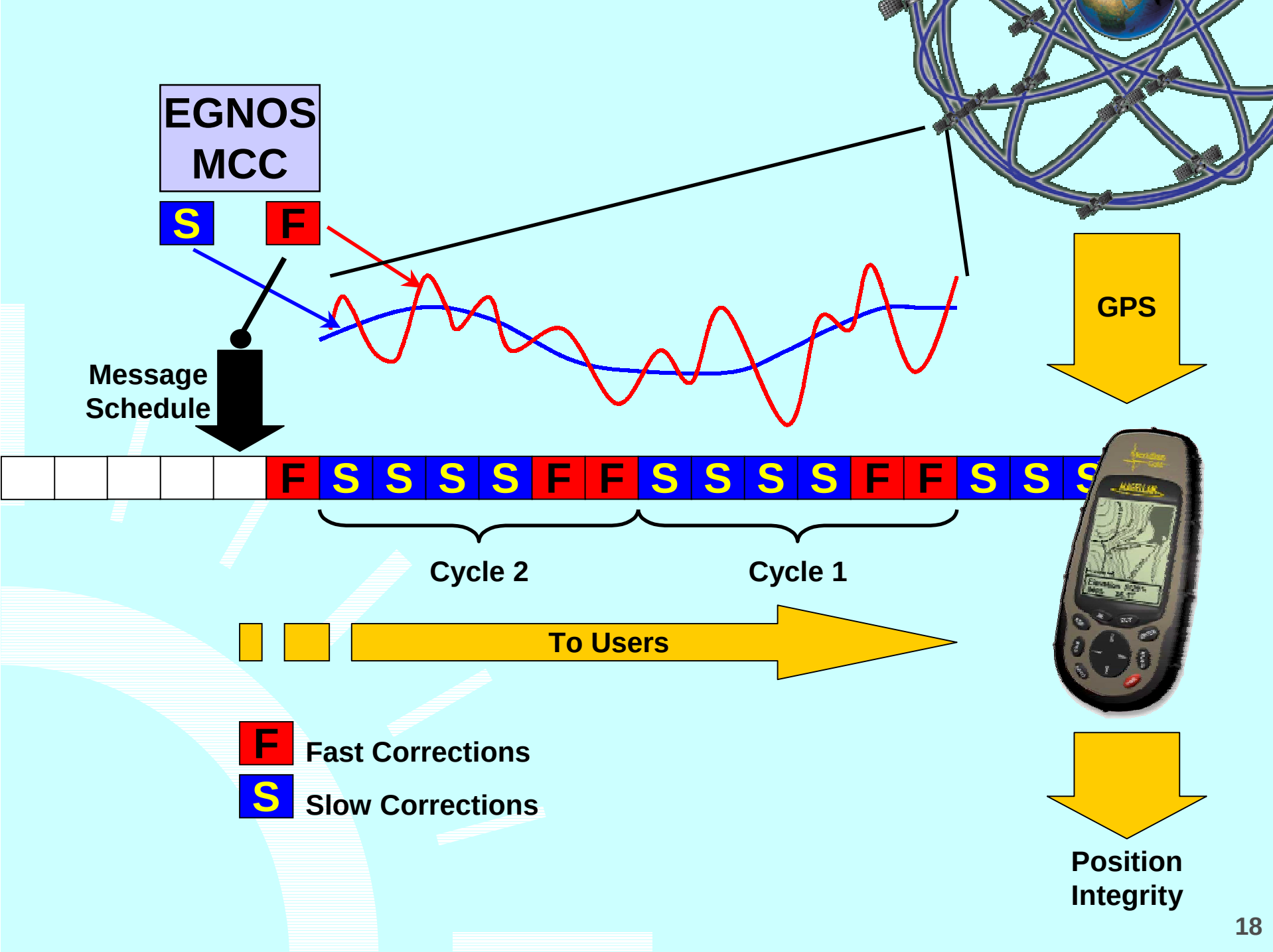
It is crucial that users understand which GEO is being used by which system and the performance provided

The Transition to EGNOS

- Overview
- Signal Structure
- Using the GEO satellites
- RIMS Deployment
- SISNET

The EGNOS signal is similar to GPS and only slight modifications are required for a GPS receiver to track EGNOS

- Similar signal to GPS
  - Same frequency (1575.42 MHz) and ranging codes
  - Different data format (250 bps)
- Integrity
  - Coarse use / don't use for all satellites (inc GEOs)
  - σ^2_{UDRE} and σ^2_{UIVE} that are estimates of the errors remaining after the WAD corrections used to compute error bounds
- WAD corrections
  - Separate terms for orbits, clocks and ionosphere
  - Fast and slow corrections for temporal de-correlation


EGNOS
MCC
S
F
GPS
Message
Schedule
F S S S S F F S S S S F F S S S
Cycle 2
Cycle 1
To Users
F Fast Corrections
S Slow Corrections
Position
Integrity

The EGNOS signal has three key benefits

- Compliant with international standards and interoperable with similar systems
- Design based on GPS
  - EGNOS range measurements enhance availability
  - EGNOS corrections can be used without purchasing an additional receiver
- Provides enhanced accuracy and integrity

Recent changes to the ESTB signal improve interoperability with other systems and allow all SBAS receivers to process ESTB

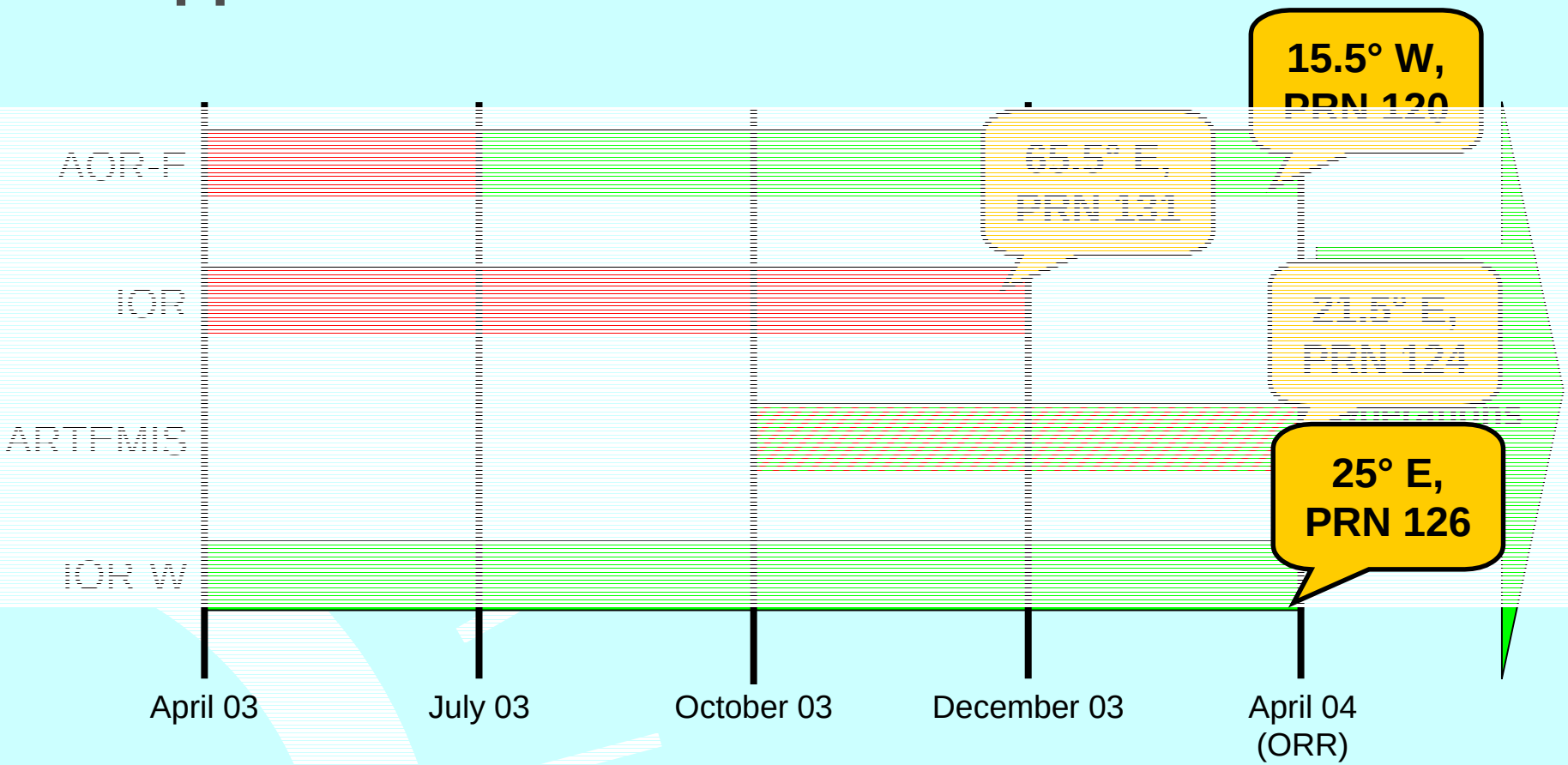
- SBAS Interoperability Working Group has developed SARPS[1] for system developers and MOPS[2] for receiver manufacturers
- Some initial confusion from test-messages
  - ESTB used Message Type 0 with all 0s
  - WAAS used MT2 data in MT 0
- Both approaches are allowed in the MOPS
- At 7:30 UTC on 1 April 2003 ESTB moved to the second format allowing all users equipped with GPS/SBAS receivers to benefit from ESTB & WAAS

1. **Standards And Recommended Practices**
2. **Minimum Operational Performance Standards**

The Transition to EGNOS

- Overview
- Signal Structure
- Using the GEO satellites
- RIMS Deployment
- SISNET

There are four GEOs currently available to support the transition from ESTB to EGNOS



The Transition to EGNOS

- Overview
- Signal Structure
- Using the GEO satellites
- RIMS Deployment

RIMS deployment has been designed to deliver incremental improvements

- SIS 0 (Today) – end to end tests, message compliance, no performance objective
  - 6 RIMS, 1MCC, 1NLES
- SIS 1 (Q3 2003) – Level 2 performance (NPA/APV1)
  - 10-15 RIMS, 1MCC, 1NLES
- SIS 2 (Q4 2003) – Level 3 performance (APV2)
  - >25 RIMS, 2MCCs, 2NLES

HEALTH WARNING: all dates are preliminary and indicative, signals are subject to testing, do not use for operations until after ORR

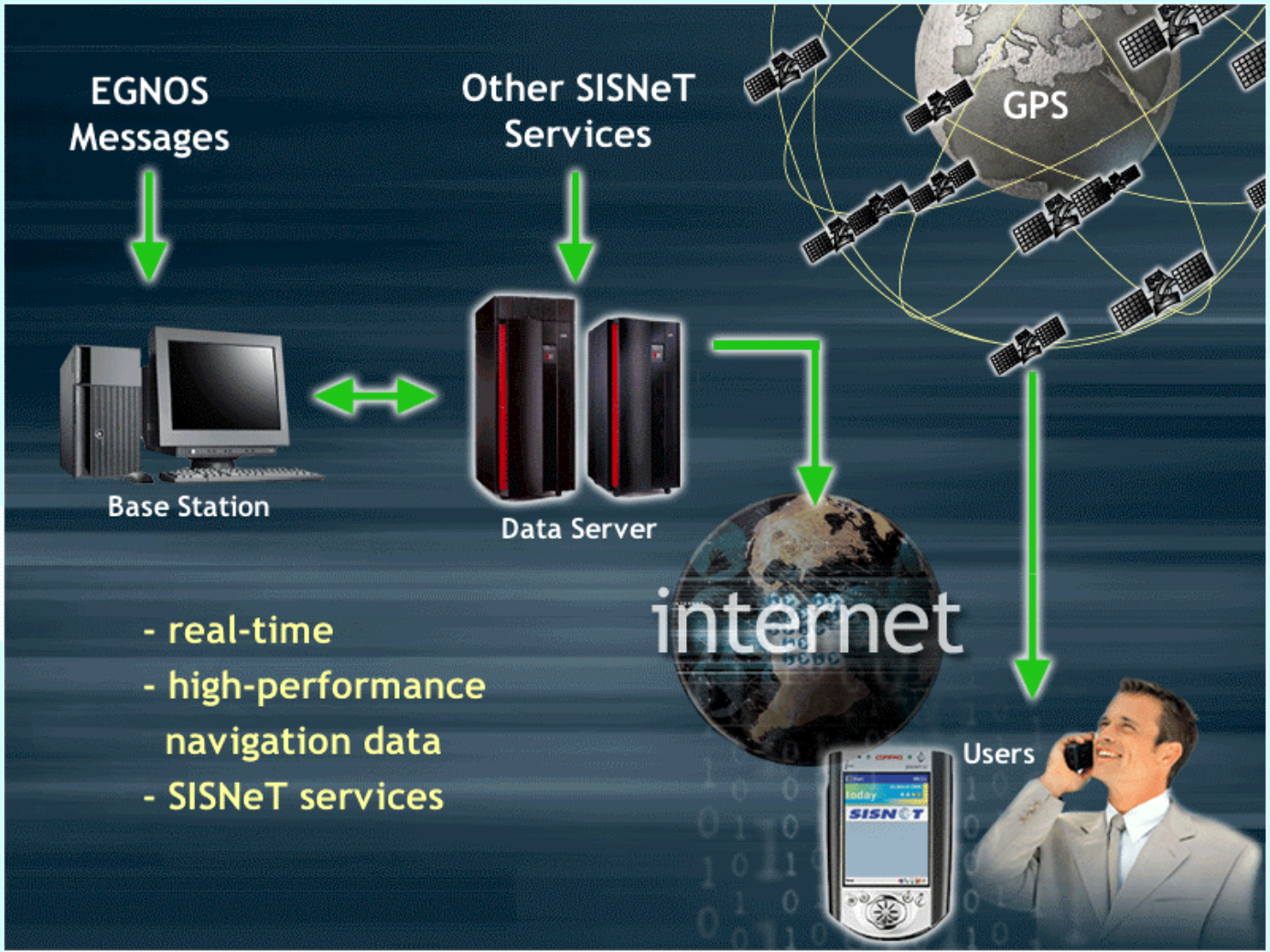
The Transition to EGNOS

- Overview
- Signal Structure
- Using the GEO satellites
- RIMS Deployment
- SISNET

SISNeT solves EGNOS delivery problems in urban and other challenging environments

- Aviation and maritime users generally find it easy to maintain contact with the EGNOS GEOs to receive the WAD and integrity data
- It is far harder for land-mobile users because urban canyons block the GEO signals
- Critically, this is where EGNOS can bring real benefits to GPS
  - WAD corrections can deliver 10m (95%) with high availability

SISNeT allows users to access EGNOS in real-time over the internet



It brings real benefits to users and can be accessed using mass market technology

- The EGNOS signal is available even if GEOs are not visible
- The data rate (< 1kbps) is ideal for GSM/GPRS
- An EGNOS receiver is not needed, only a link to the Internet
- Pedestrian or land mobile-users benefit from improved performance at higher mask angles

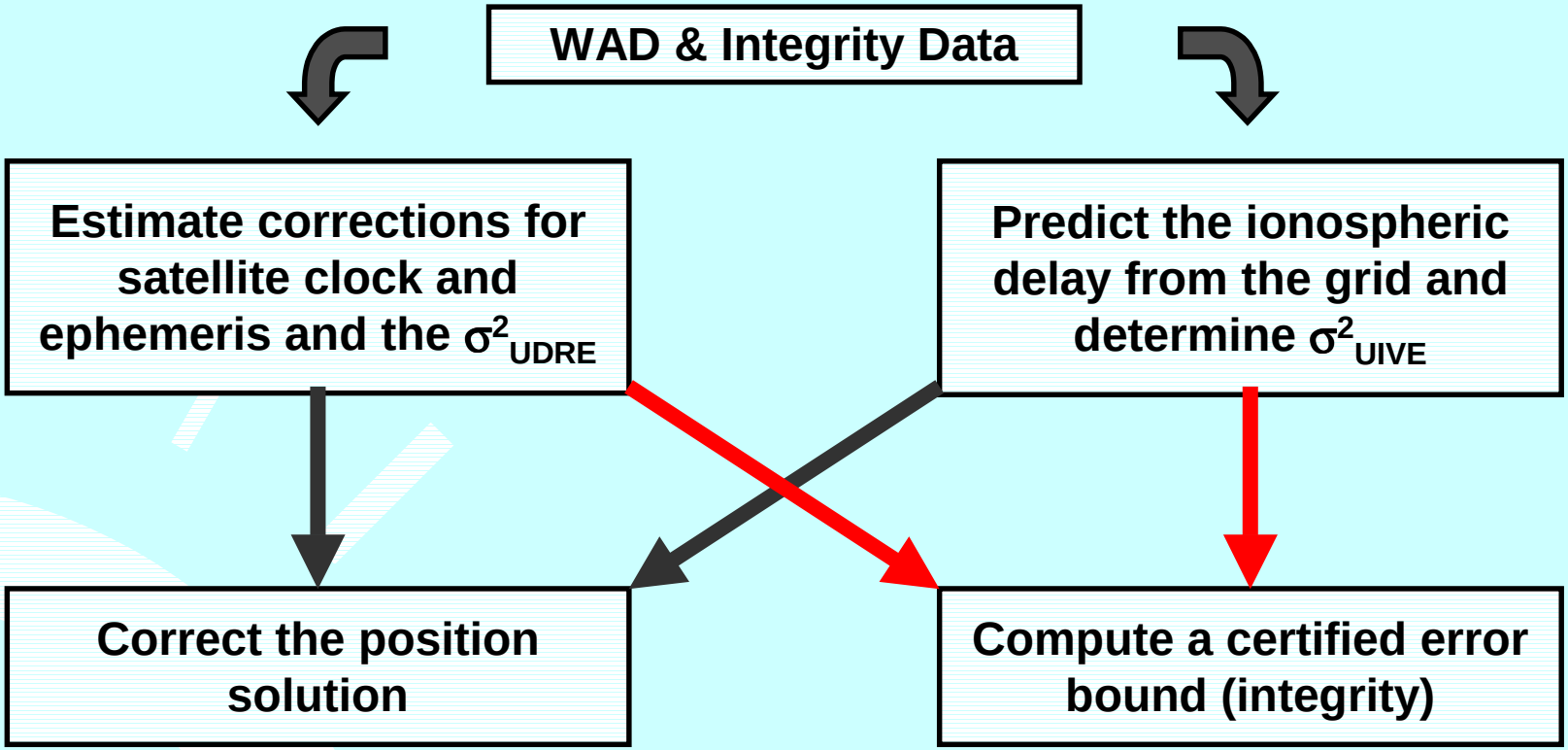
The User Experience

- Receivers
- Expected performance
- Finding the latest information

There are more than 120 receivers and 90 chipsets available – critically they must be compatible with the GPS/SBAS MOPS

- Receivers should be compatible with the GPS/SBAS MOPS (DO-229C)
- A WAAS receiver that is DO229-C will track EGNOS
- If you are in the EGNOS coverage area
  - Your receiver will track signals from other SBAS GEOs
  - Range measurements are valid if monitored by EGNOS
  - Only EGNOS WAD and integrity is valid
- Otherwise the receiver works normally
  - As an SBAS receiver if in SBAS coverage
  - As a GPS-only receiver elsewhere

SBAS data processing is more complex than GPS

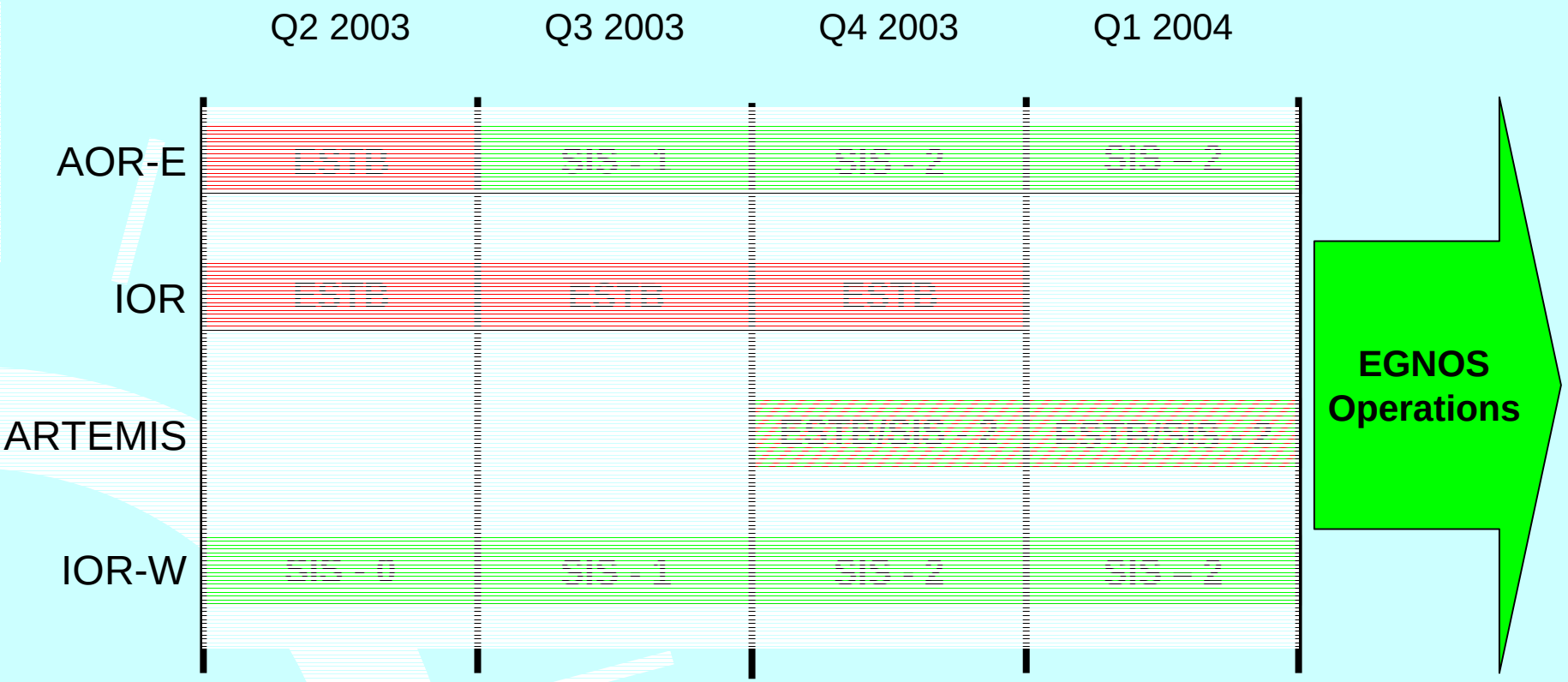


Prudent users with commercial or safety critical applications will value the added confidence from EGNOS guaranteed services

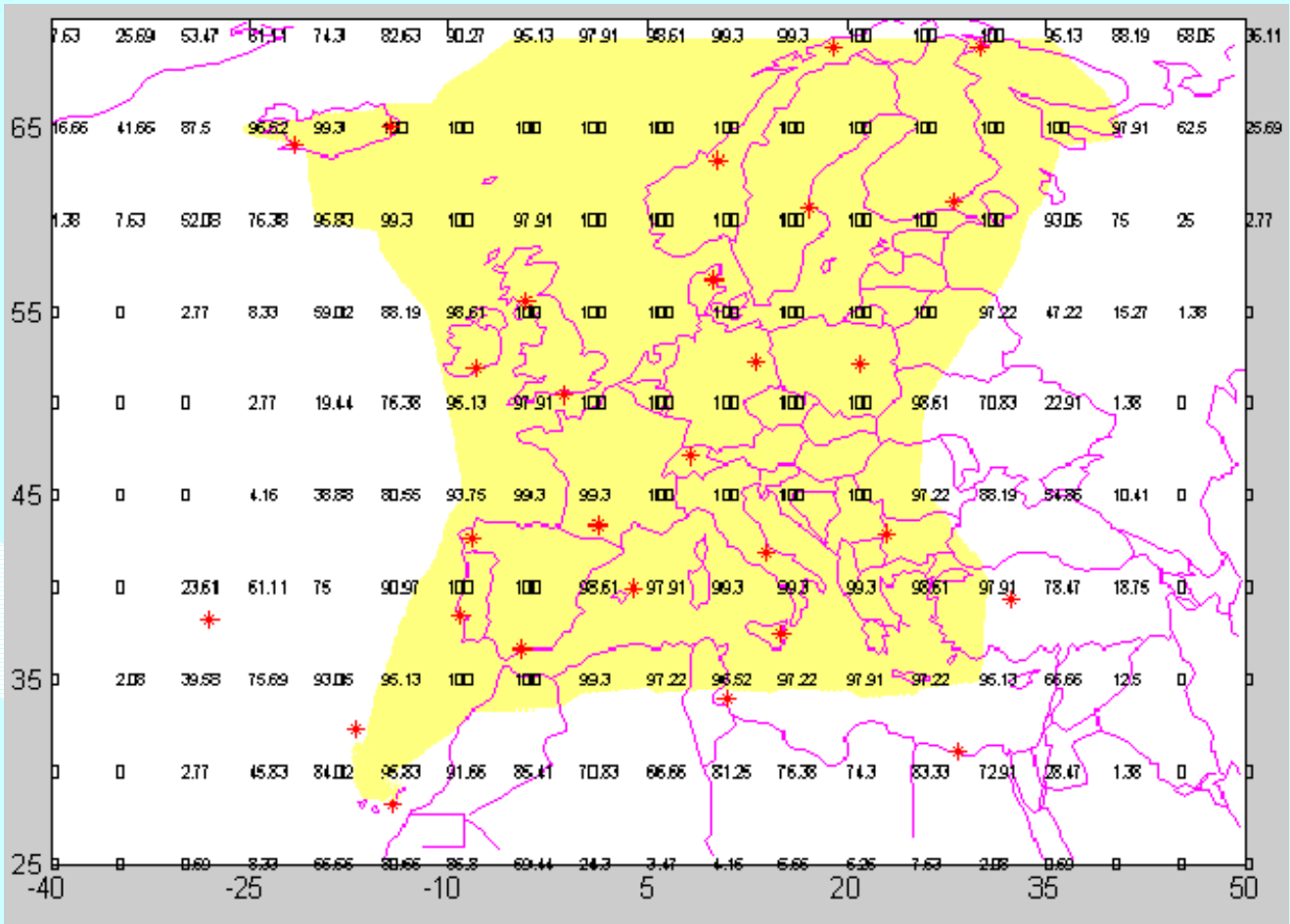
The User Experience

- Receivers
- Expected performance
- Finding the latest information

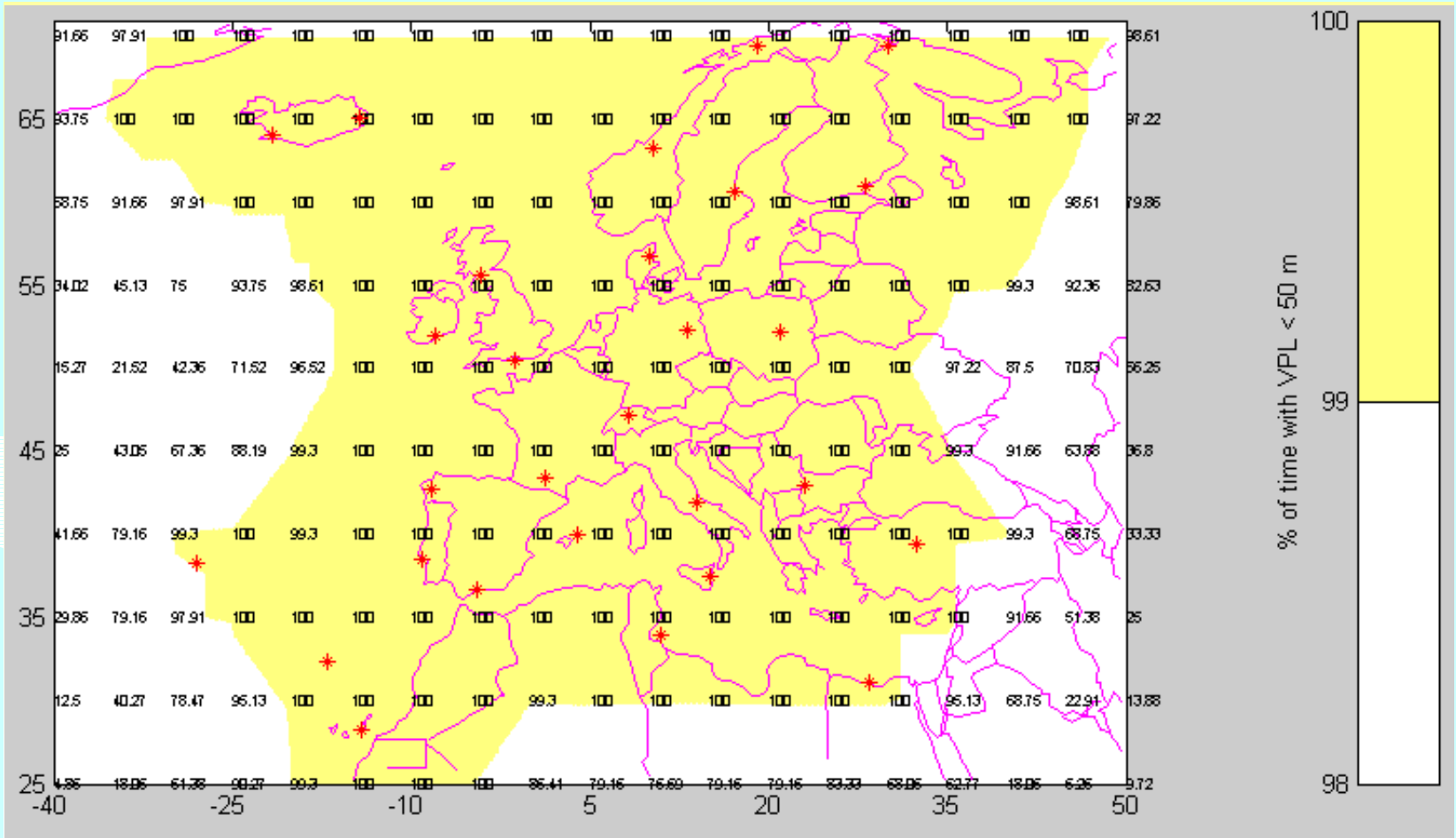
The expected performance achievable from a specific GEO is dependent on the RIMS deployment and satellite/system selected



Expected EGNOS coverage for a high accuracy service (1m – 3m horizontal)



Expected coverage for an APV service (equivalent to the current WAAS)



The User Experience

- Receivers
- Expected performance
- Finding the latest information

There are four ways for users to receive reliable and timely information

- ESA Helpdesk
  - Accessed through email
- ESA's ESTB web pages
  - Links to EGNOS, ESTB, Galileo …
- EGNOS News
  - Hard copy, email circulation, download from web
- EGNOS CD ROM
  - Available here and from ESA

Useful EGNOS-related links

ESA Navigation Web Page	www.esa.int/navigation
ESA EGNOS Web Page	www.esa.int/EGNOS
ESA ESTB Web Page	www.esa.int/ESTB
ESA SISNET Web Page	www.esa.int/SISNET
ESA ESTB Helpdesk	ESTB@esa.int
EGNOS News	ESTB-News@esa.int