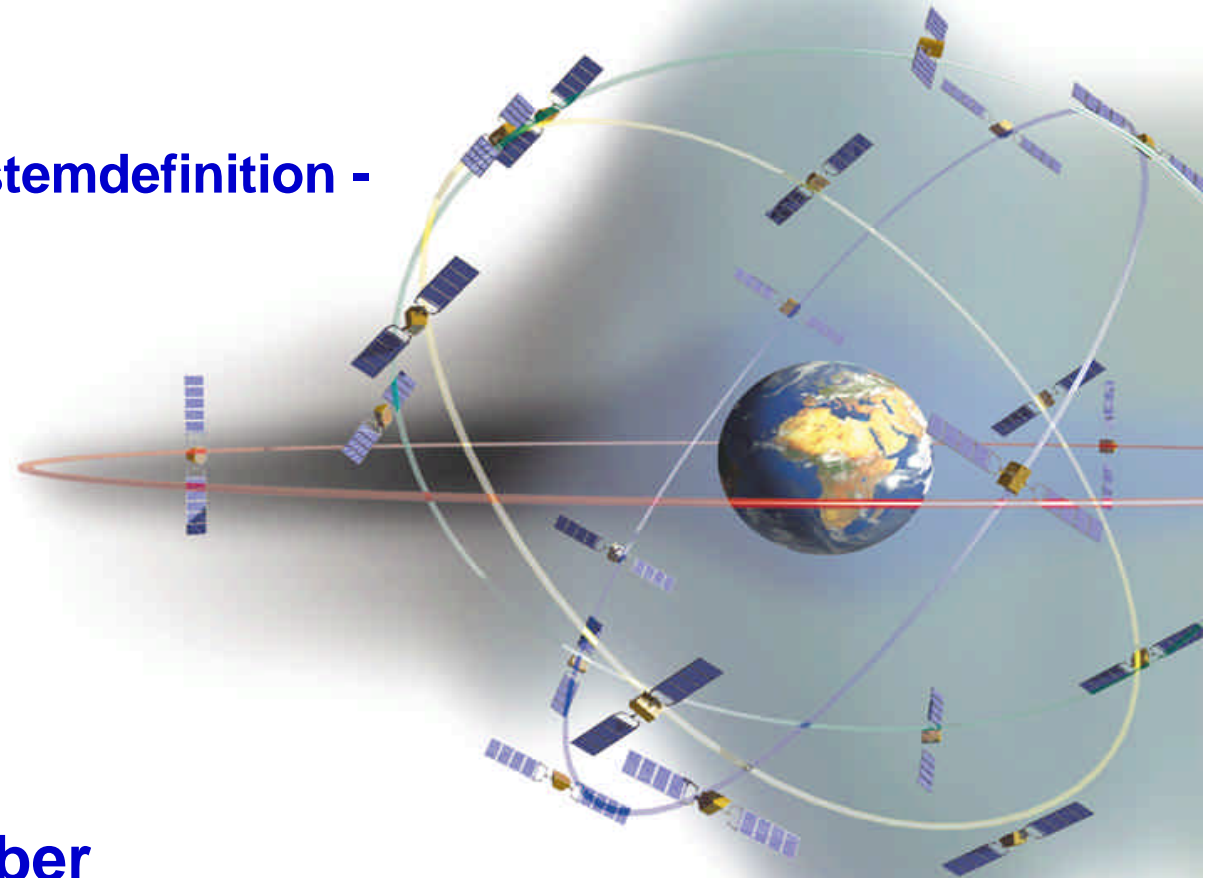


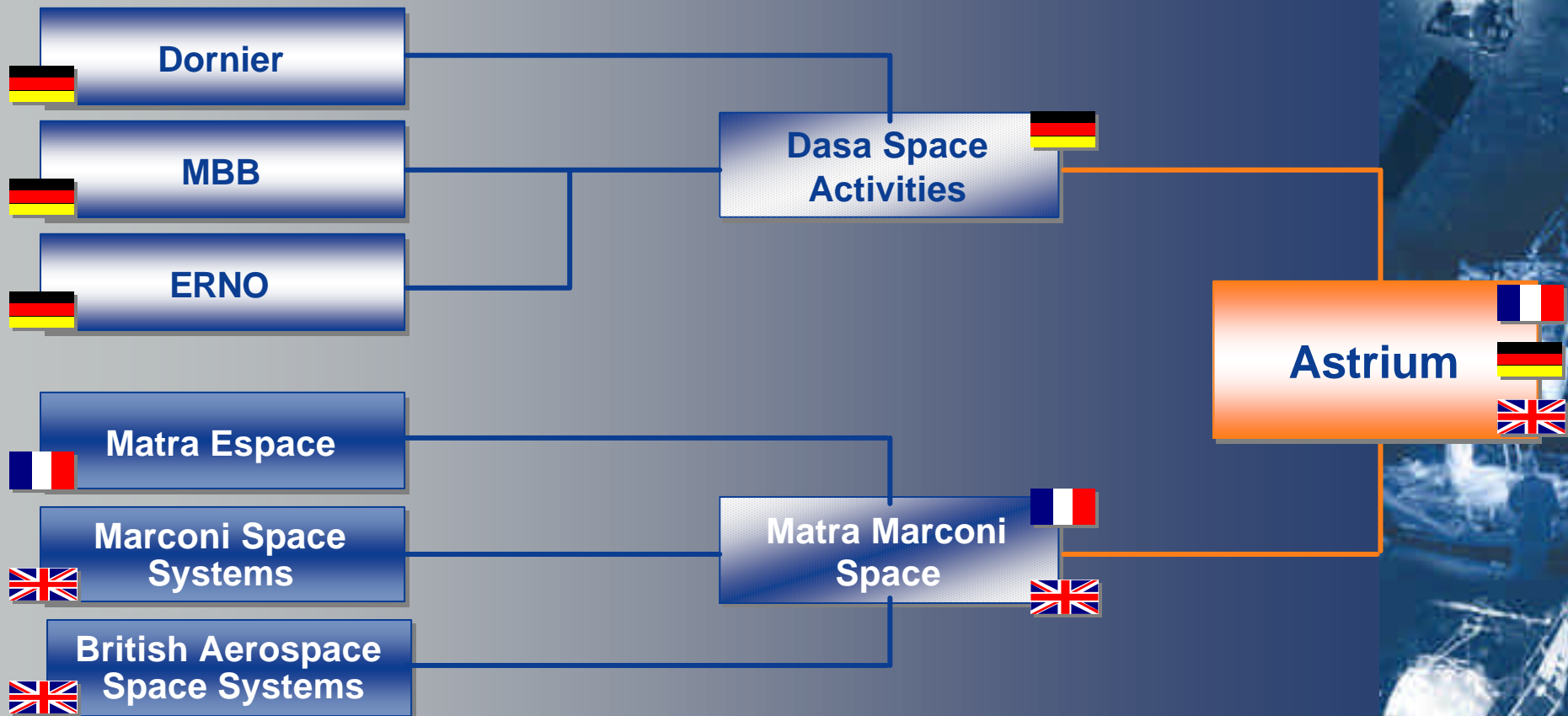
Das europäische Satellitennavigationssystem Galileo

- Konzepte und Stand der Systemdefinition -

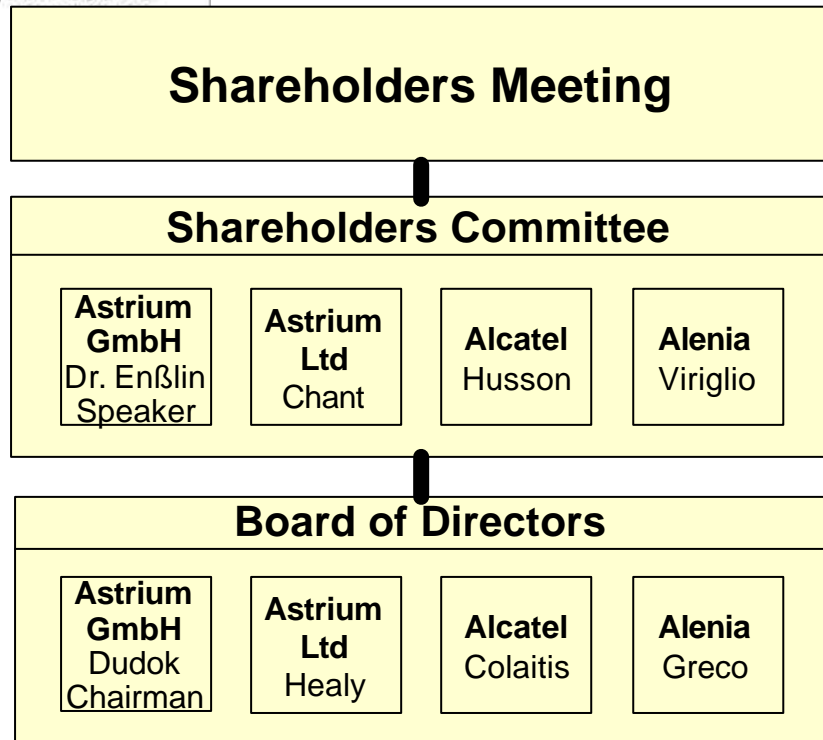


Dr. Thomas Weber
Astrium GmbH, München

Astrium Heritage



Corporate Governance



➔ Meets once a year to pass formal resolutions.

➔ CEOs of the founders, they have to approve all transactions of high importance, quarterly meetings.

➔ Directors represent the company, supported for the daily business by 4 residents in Brussels

➔ **Share of Astrium in Galileo Industries S.A. : 50 %**

Topics

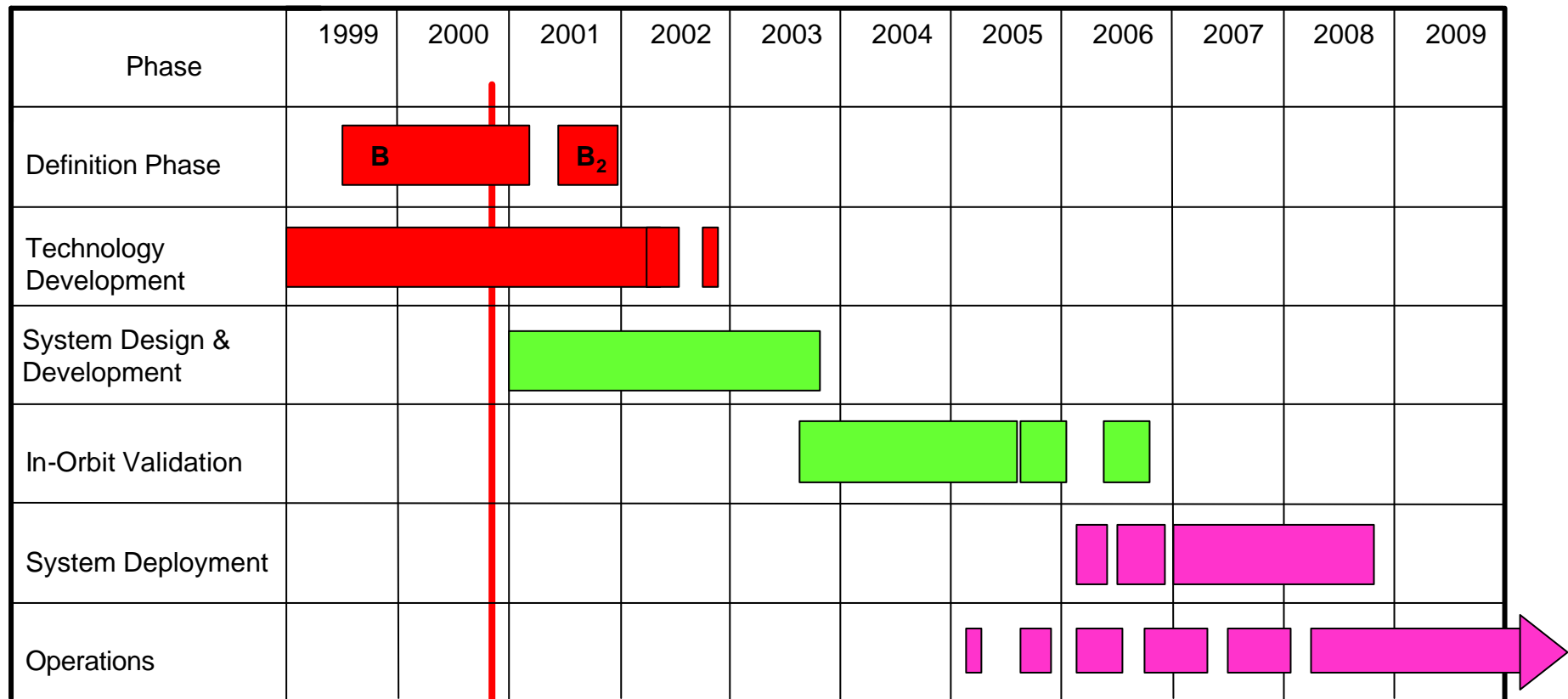


- **Galileo Time Table**

- **User Requirements, Galileo Services and Frequencies**
 - OAS Open Access Service
 - CAS 1 Controlled Access Service
 - CAS 2 SAS Safety Access Service
 - Galileo frequency concepts

- **Galileo Overall Architecture Concept**
 - Galileo overall architecture
 - Galileo satellite constellation
 - Galileo integrity concept
 - EGNOS integration concept
 - SAR

Galileo Timetable



20./21.12.2000 Council of Transport Ministers

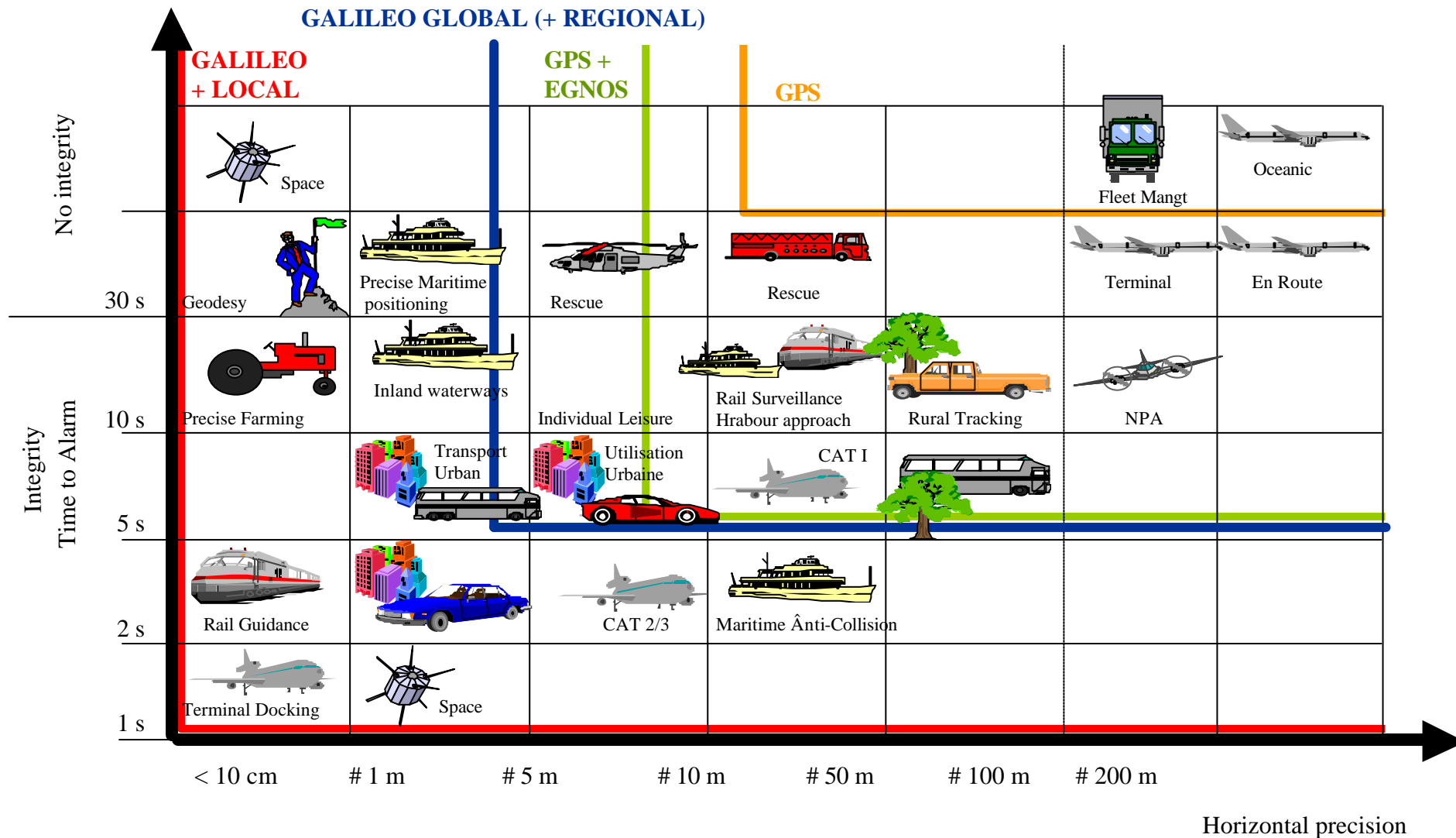
Galileo Programme



- Services definition
 - Architecture definition
 - Space & Ground segment
 - Integration of EGNOS
 - Standardisation
 - Search And Rescue
 - Structural Market Analyse
 - Loran C upgrade
- GEMINUS - EC**
GALA - EC
GalileoSat - ESA
INTEG - EC
SAGA - EC
SARGAL - EC
EC
EC

EC Galileo report at http://www.galileo-pgm.org/ECCommunication221100_en.pdf

Galileo User Requirements



Galileo Services



Open Access Service

free

- ❑ available for free world-wide for mass market use
- ❑ two frequencies, but single frequency use possible
- ❑ integrity via RAIM only
- ❑ comparable to GPS, with better performance than GPS IIF/III

Controlled Access Service 1

commercial

- ❑ professional and scientific applications requiring high precision and integrity
- ❑ two frequencies, three frequencies for TCAR envisaged
- ❑ integrity via RAIM and ground integrity channel

Controlled Access Service 2 Safety of Life Service

public

- ❑ very high level of accuracy and integrity for safety of life critical applications
- ❑ public service with restricted access and increased robustness
- ❑ integrity via RAIM and ground integrity channel with optimised TTA

Controlled Access Service 2 Governmental Access Service

governmental

- ❑ requiring a very high level of accuracy for strategic applications
- ❑ government-restricted access and increased robustness
- ❑ integrity via RAIM and ground integrity channel
- ❑ selective denial possible
- ❑ high robustness and jamming resistance

Galileo Services Performance 1



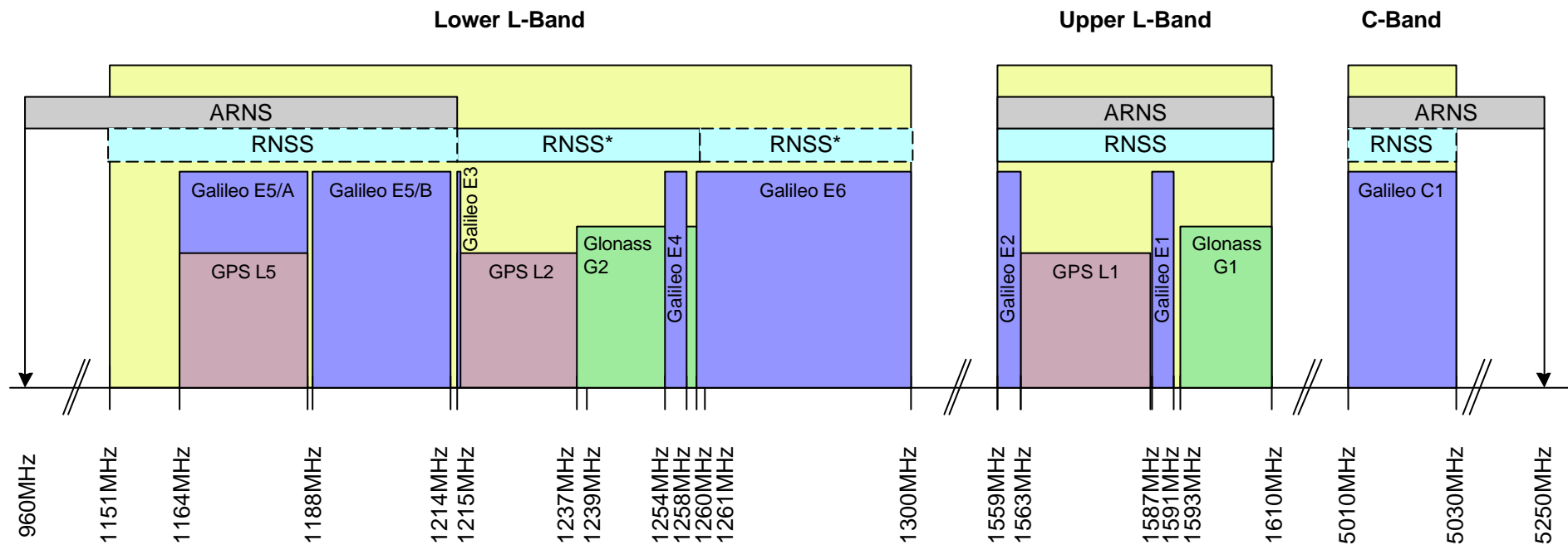
	CAS1-G
Horizontal accuracy	7 m
Vertical accuracy (75°S-75°N)	12 m
Vertical accuracy (90°S-90°N)	15 m
Velocity accuracy	< 0.20 m/s
Timing accuracy	< 100 ns
Maximum planned outage	1 min once per hour
Integrity Risk	$2 \cdot 10^{-7}$ per hour
Integrity TTA	10 s
Horizontal alarm limit	20 m
Vertical alarm limit (75°S-75°N)	35 m
Vertical alarm limit (90°S-90°N)	45 m
Availability	99 %
Masking Angle	10°

Galileo Services Performance 2



	CAS2-SAS
Horizontal accuracy	6 m
Vertical accuracy (75°S-75°N)	8 m
Vertical accuracy (90°S-90°N)	8 m
Velocity accuracy	< 0.20 m/s
Timing accuracy	100 ns
Continuity risk	< 10^{-5} per 150 s
Integrity Risk	< $3,5 \cdot 10^{-7}$ per 150 s
Integrity TTA	6 s
Horizontal alarm limit	11 m
Vertical alarm limit (75°S-75°N)	15 m
Vertical alarm limit (90°S-90°N)	15 m
Availability	99.9 %
Masking Angle	10 °

Galileo Frequency Plan



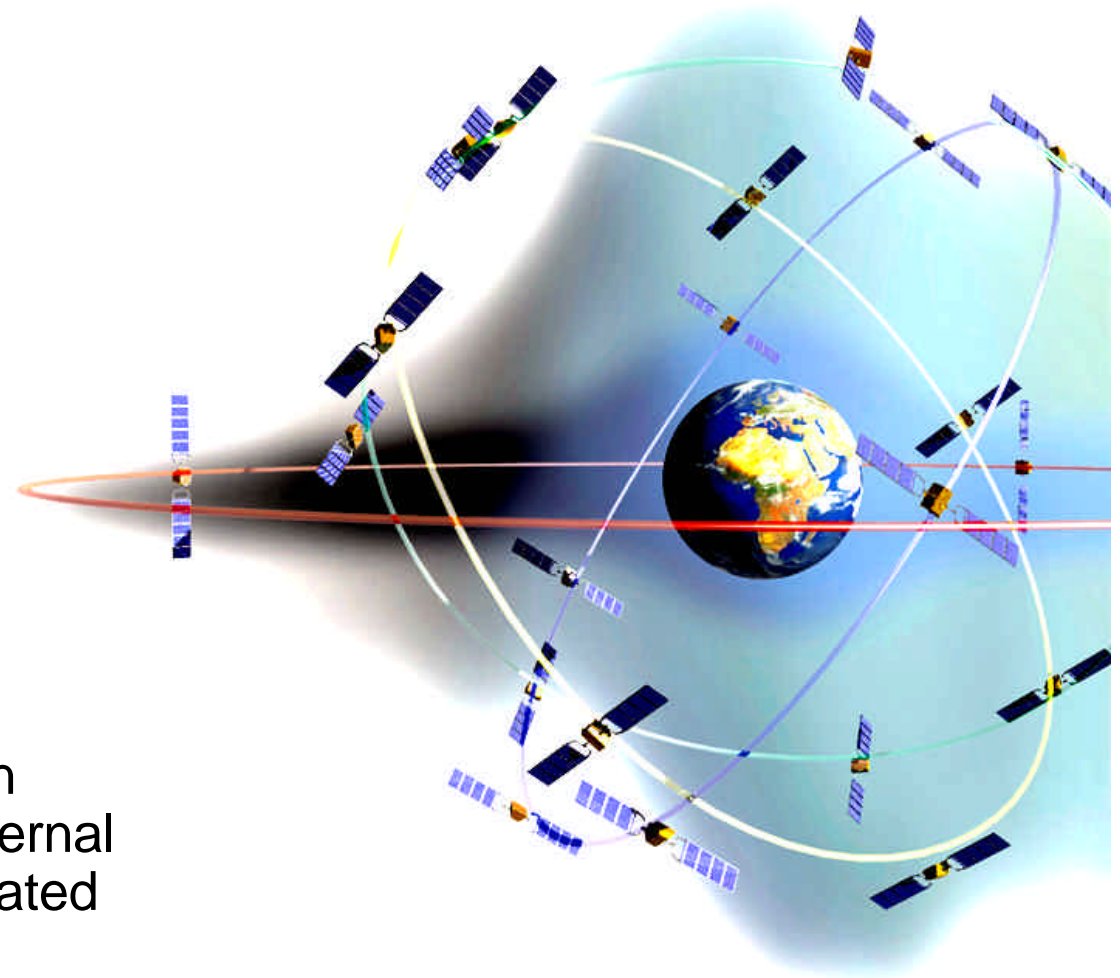
RNSS* shared with other services

Galileo E5/A or E5/B frequency band options

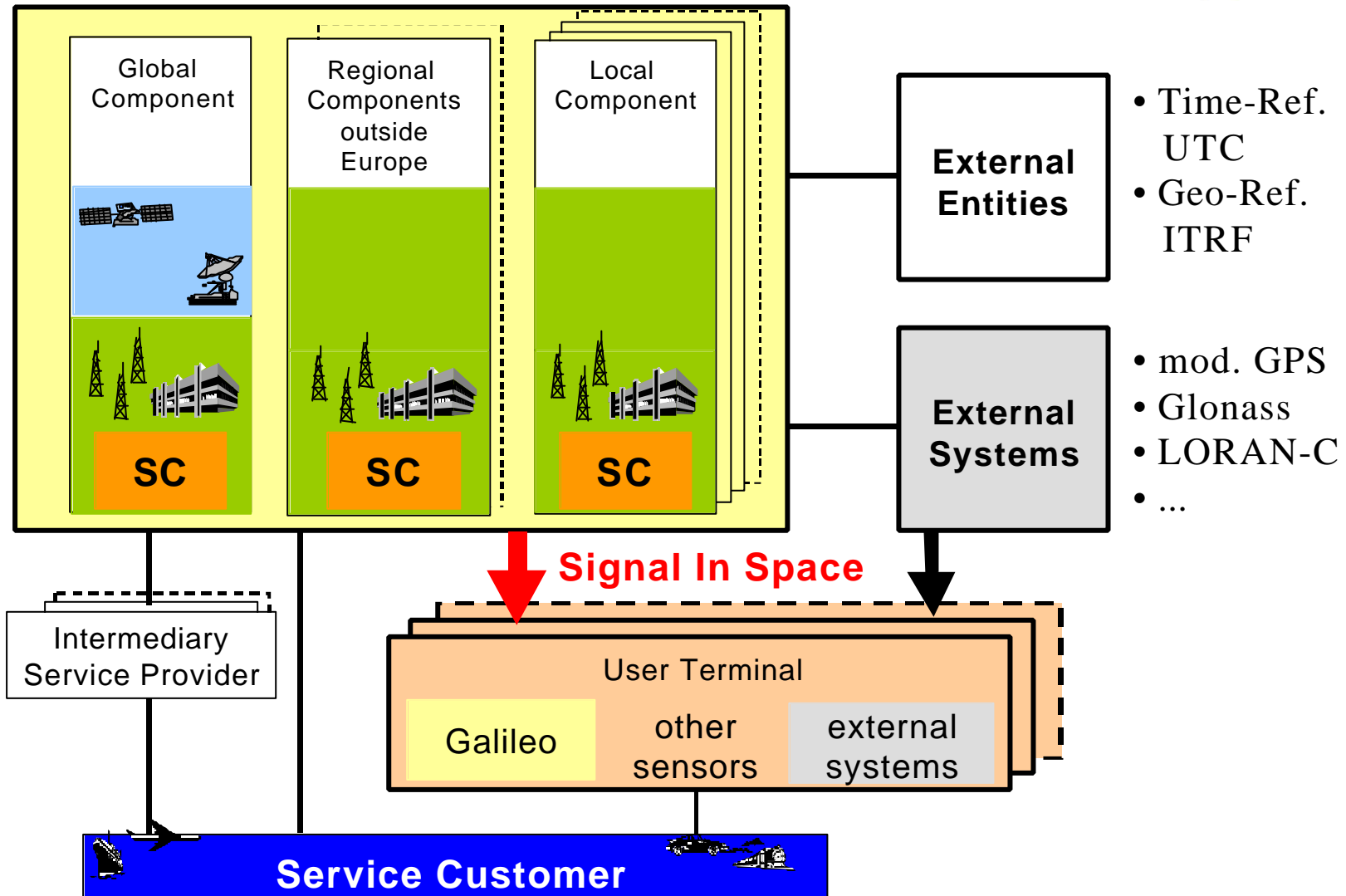
Galileo Constellation



- MEO constellation
 - 30 MEO satellites
 - 3 orbital planes
 - Walker 27/3/1 + 3 hot spares
 - 56° inclination
 - Altitude: 23616 km
- + EGNOS transponders
- optional MEO + GEO constellation with GEO payloads for system-internal communication purposes investigated



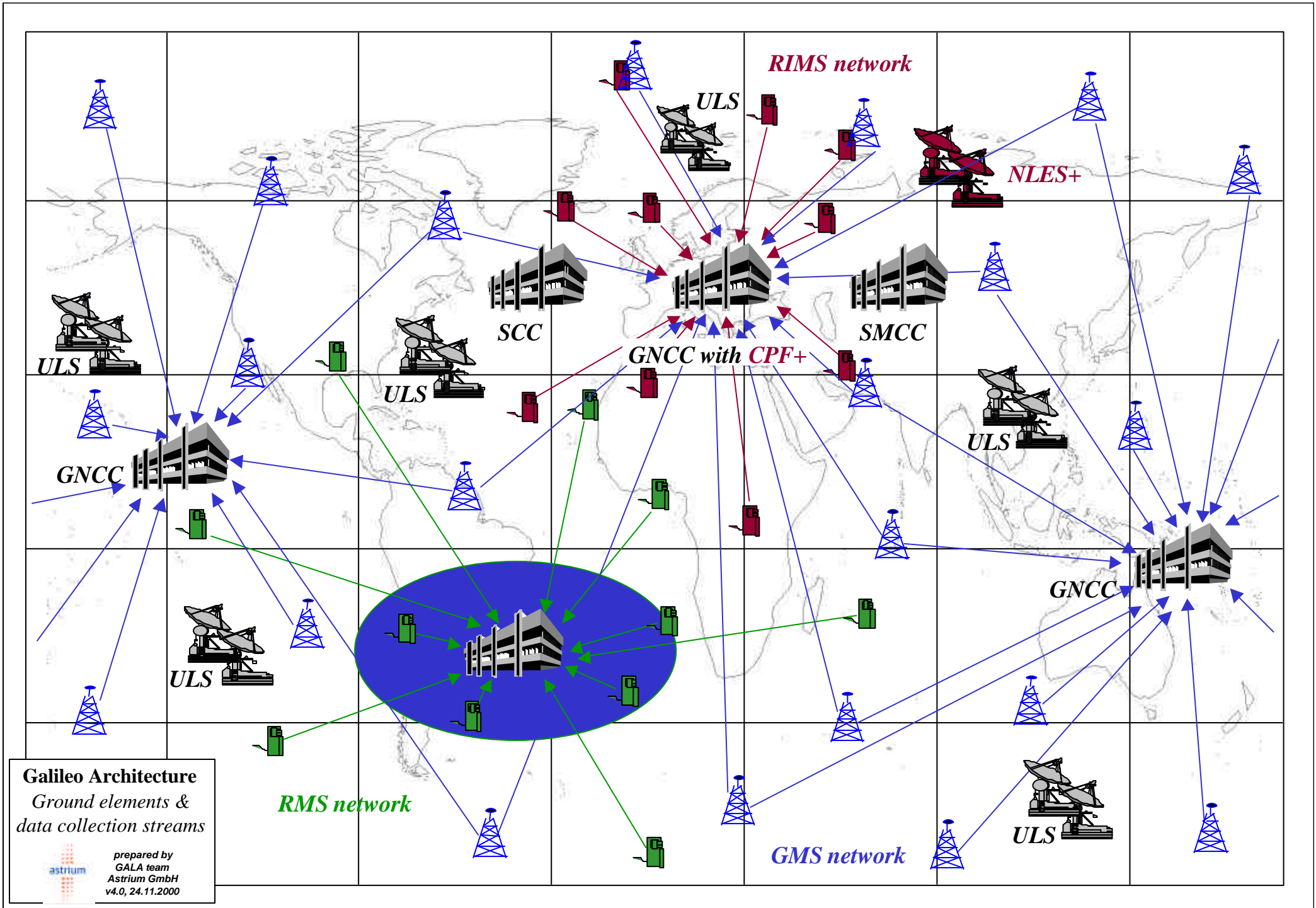
Galileo Overall Architecture



Concept for non-European regions



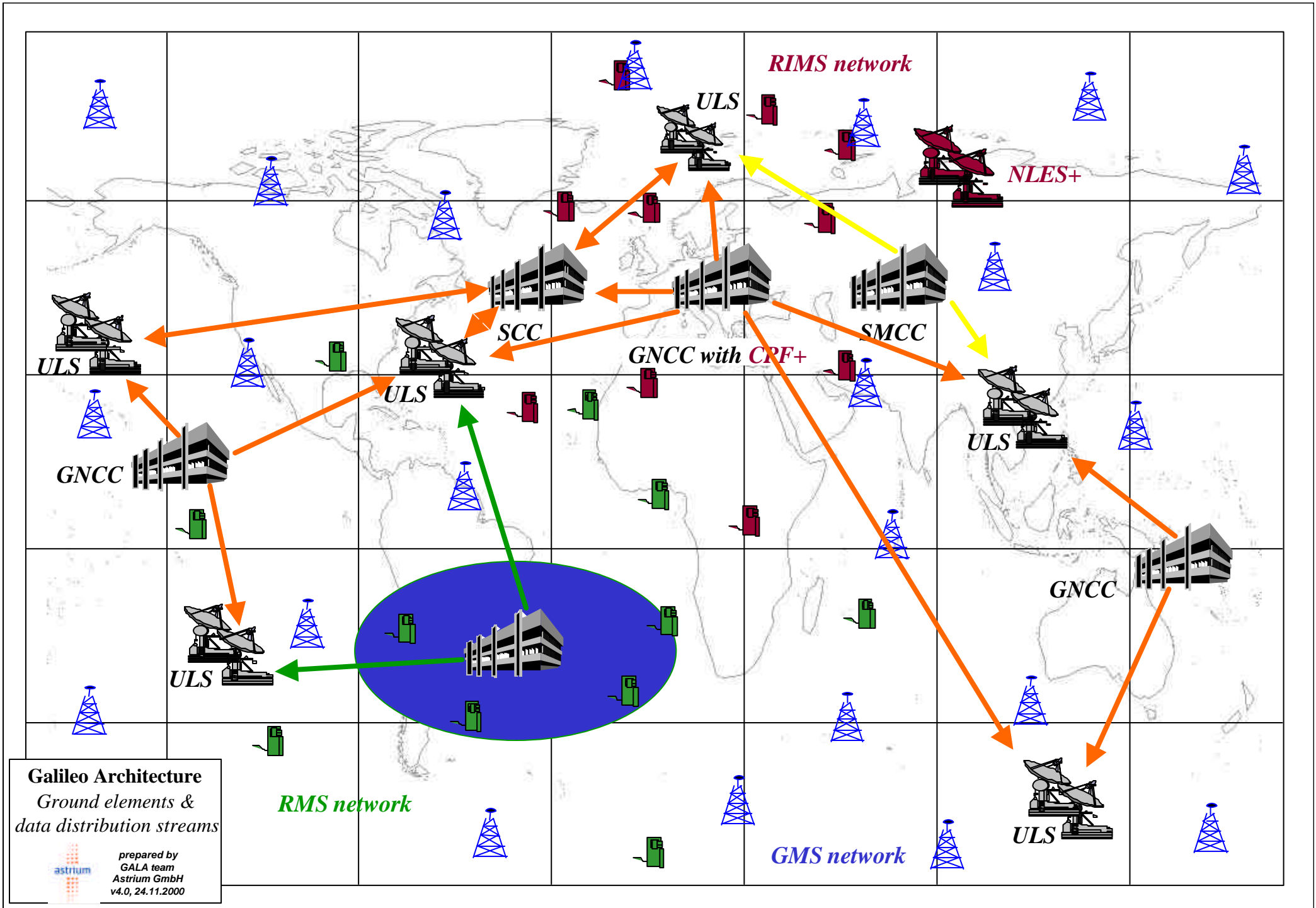
- **Implementation of non-European regions**
 - regions may want to generate their own integrity instead of Galileo global integrity
 - regions install their own integrity monitoring and processing infrastructure
 - flexibility
 - share of responsibility
- **Non-European regional integrity determination**
 - regional monitoring of Galileo signal in space by regional monitoring stations (RMS + shared GMS possible)
 - regional processing and check of integrity data by respective facilities of the regional navigation control centre (RNCC)
- **Uplink of non-European regional integrity data**
 - regional integrity data sent to global uplink stations
 - assembly of navigation message including regional integrity data on ground in the global uplink stations (for connected mode)
 - uplink under European global control



Galileo Architecture
 Ground elements &
 data collection streams



prepared by
 GALA team
 Astrium GmbH
 v4.0, 24.11.2000



RIMS network

NLES+

ULS

SCC

SMCC

GNCC with *CPF+*

ULS

ULS

ULS

GNCC

GNCC

ULS

RMS network

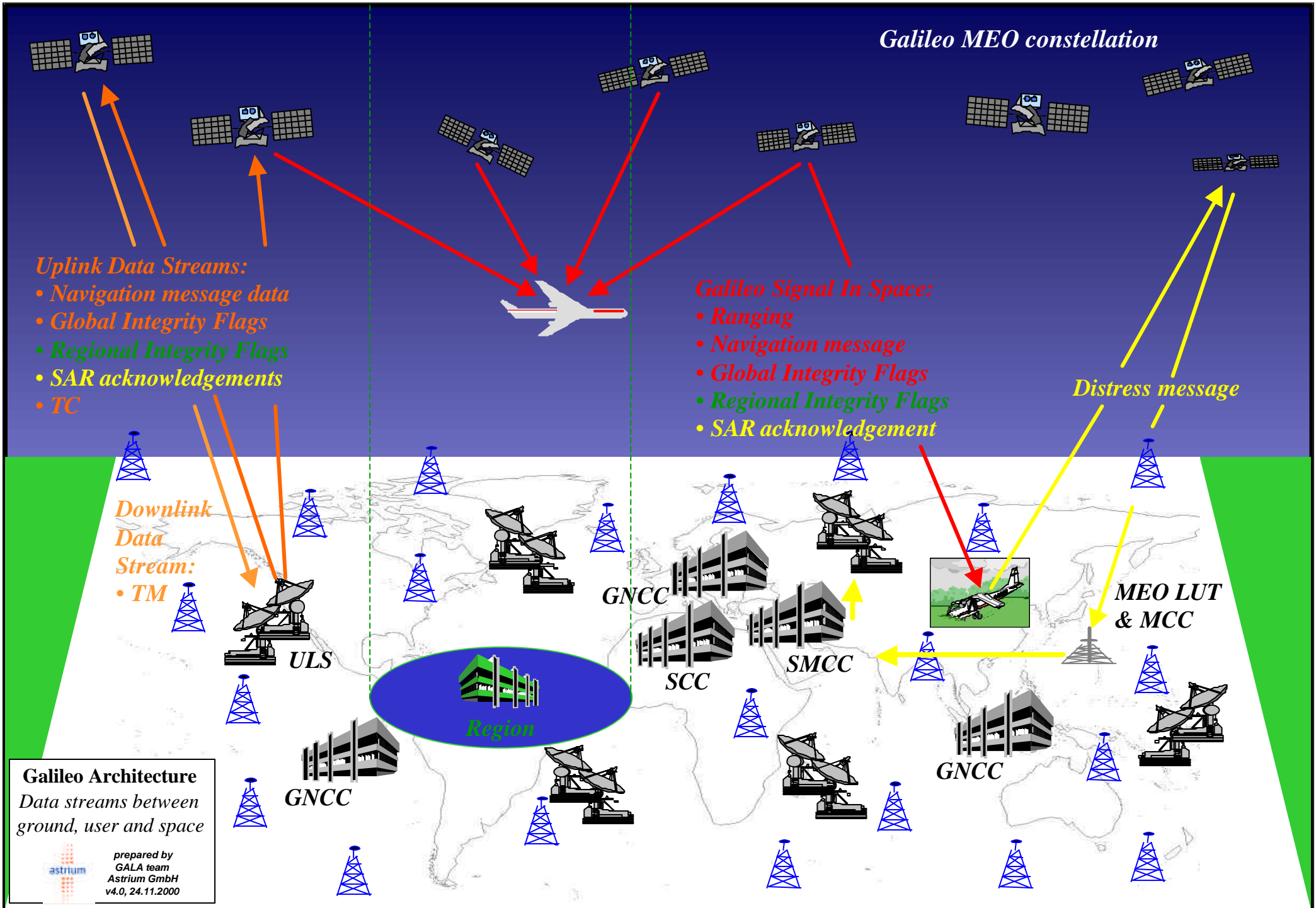
GMS network

ULS

Galileo Architecture
 Ground elements &
 data distribution streams



prepared by
 GALA team
 Astrium GmbH
 v4.0, 24.11.2000



Galileo Architecture
 Data streams between ground, user and space


 prepared by
 GALA team
 Astrium GmbH
 v4.0, 24.11.2000

Galileo Architecture Elements (1)



● Constellation

- ❑ MEO only for ranging
- ❑ 30 in 3 orbital planes, altitude 23616 km, inclination 56°
- ❑ Two main modes:

→ **autonomous** : navigation message assembled on board, from data tables updated by the ground segment each hour approximately. Does not contain real-time data.

→ **connected** : navigation message assembled on ground, and continuously upload to the satellite for immediate broadcast ; used for real-time data dissemination (integrity flags, differential corrections, SAR acknowledgement), connected satellites being used to broadcast the data for the whole constellation.

● Space control centres (SCC)

- ❑ 1 centre located in Europe (without redundancies)
- ❑ Monitoring and control of the space segment and the constellation

Galileo Architecture Elements (2)



- **Up-link stations (ULS)**

- About 8 around the world (without redundancies)
- Interfaces with space segment control, global mission ground segment, regional mission ground segments and SAR system
- Assembly of navigation message for satellites in connected mode

- **Global Monitoring Stations (GMS)**

- About 30 stations around the world (without redundancies)
- Monitoring of Galileo and modernised GPS signals in space

- **Global Navigation Control Centre (GNCC)**

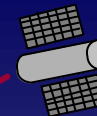
- Centres distributed around the world (decentralised architecture)
- Facilities for

- *orbit-synchronisation,*
- *global integrity determination and check and*
- *global navigation mission segment control*



Galileo MEO constellation

EGNOS transponder on GEO

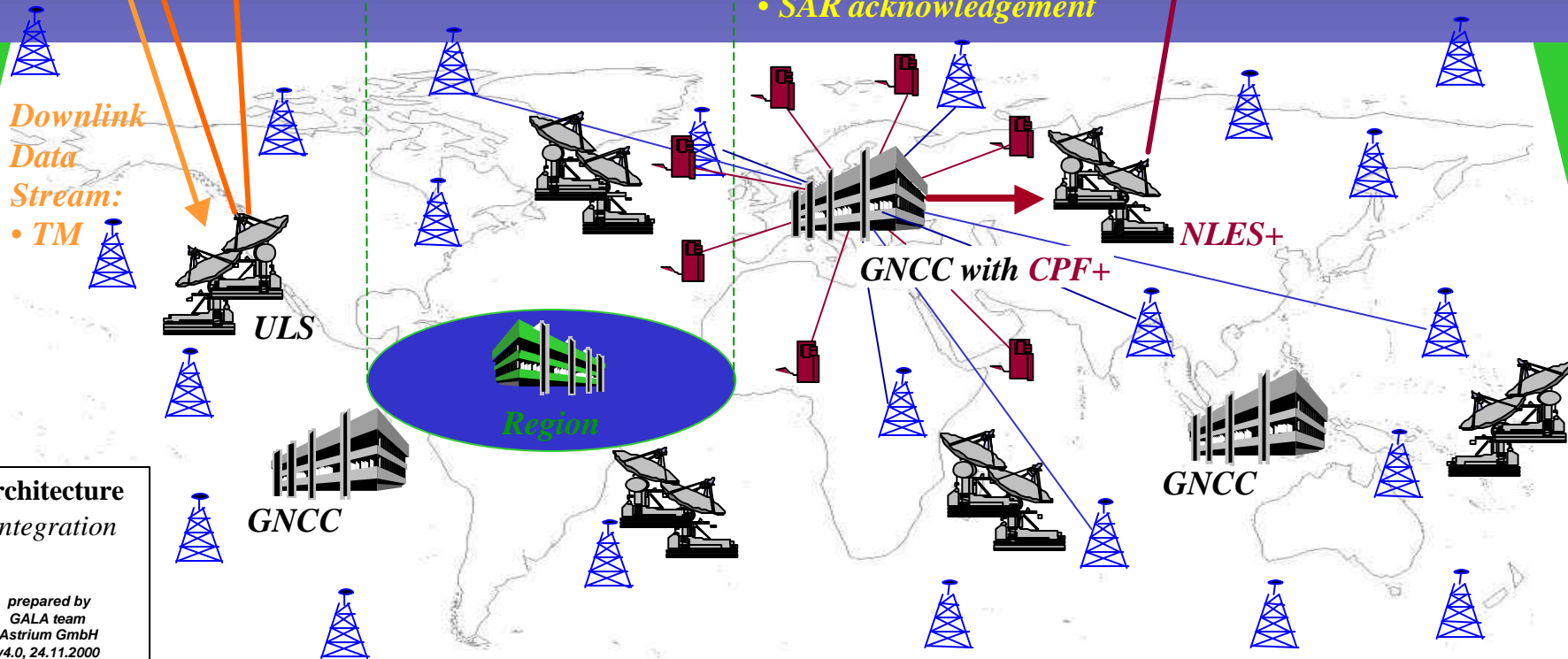


- Uplink Data Streams:**
- Navigation message data
 - Global Integrity Flags
 - Regional Integrity Flags
 - SAR acknowledgements
 - TC

- Galileo Signal In Space:**
- Ranging
 - Navigation message
 - Global Integrity Flags
 - Regional Integrity Flags
 - SAR acknowledgement

- EGNOS+ Signal In Space:**
- iono grids
 - modernised GPS integrity
 - Glonass integrity
 - GEO integrity

- Downlink Data Stream:**
- TM



Galileo Architecture
EGNOS integration



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v4.0, 24.11.2000

Local Component (1)



- **Improvement of basic performance of global (& regional) component with respect to**
 - accuracy
 - integrity
 - availability and
 - continuity
- **Highest performance level in the system**
 - in limited areas of coverage
 - implemented only where needed
- **Implementation highly application specific**

Local Component (2)

