

Update on Galileo and Loran-C

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Outline of the Presentation

- Overview of Galileo
- Development schedule
- Signals and services
- Timing infrastructure

- Loran-C background
- Loran-C developments in USA, Europe
- eLoran, Eurofix

Galileo - Overview

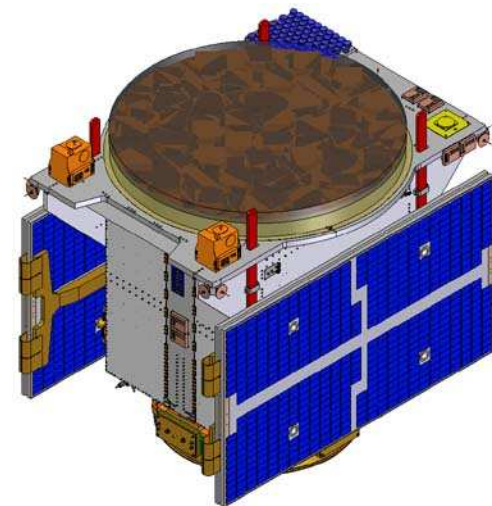
- A European initiative in satellite navigation
 - EC, ESA fund Galileo Joint Undertaking (GJU)
- Superficially similar to GPS but:
 - Focus on civil users, under civilian control
 - International partners
 - Private sector operation and part-funding
 - Will provide additional commercial services
 - Will provide integrity and service guarantees

Galileo – Current Status

- EGNOS broadcasting test signals
 - European Geostationary Navigation Overlay Service
 - GPS augmentation, ranging and integrity signals
 - fully operational by early 2006
 - integration within Galileo
- Galileo Development phase proceeding
 - Core design work completed
 - Creation of an initial ground infrastructure
 - Entering In-Orbit Validation phase

Galileo – In-Orbit Validation

- Galileo demonstration satellites
 - GSTB-V2/A built by Surrey Satellite Technology Ltd (SSTL)
 - GSTB-V2/B built by Galileo Industries (Galn)
 - Carries passive H-maser and 2 Rb standards
- Both satellites now under test
 - First launch expected December 2005



Galileo – Deployment Phase

- Follow with mini-constellation of 4 operational satellites
- Partial ground and space infrastructure will be handed over to “concessionaire”
- Private sector “concessionaire” will
 - oversee completion of the Galileo space and ground segments
 - operate the system for 20 years

Galileo – Concessionaire

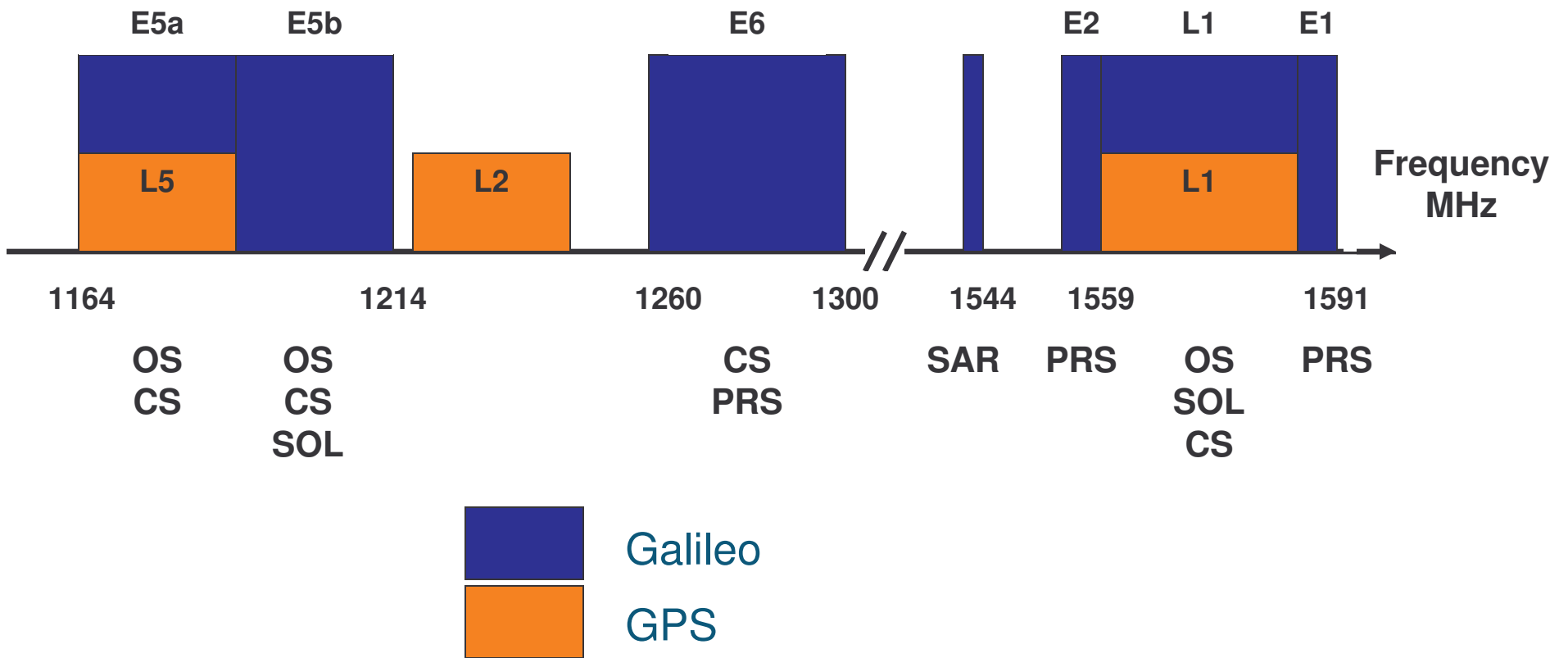
- Two consortia competing for the concession have joined together:
 - iNavSat (Inmarsat, EADS Space, Thales, etc)
 - Eurely (Alcatel, Finmeccanica, Aena, Hispasat, etc)
- GJU negotiating with joint consortium - aims to award 20 year concession contract by end of 2005
- Aim is still to have initial operational capability by 2008

Galileo – Satellite-only services

Five distinct services will be broadcast:

- Open Service (OS)
 - free of charge; similar performance to civil GPS
- Commercial Service (CS)
 - higher data rate, improved accuracy, service guarantee
 - supports integration with wireless communication networks
- Public Regulated Service (PRS)
 - encrypted and robust; restricted to official agencies
- Safety of Life Service (SoL)
- Search and Rescue Service (SAR)

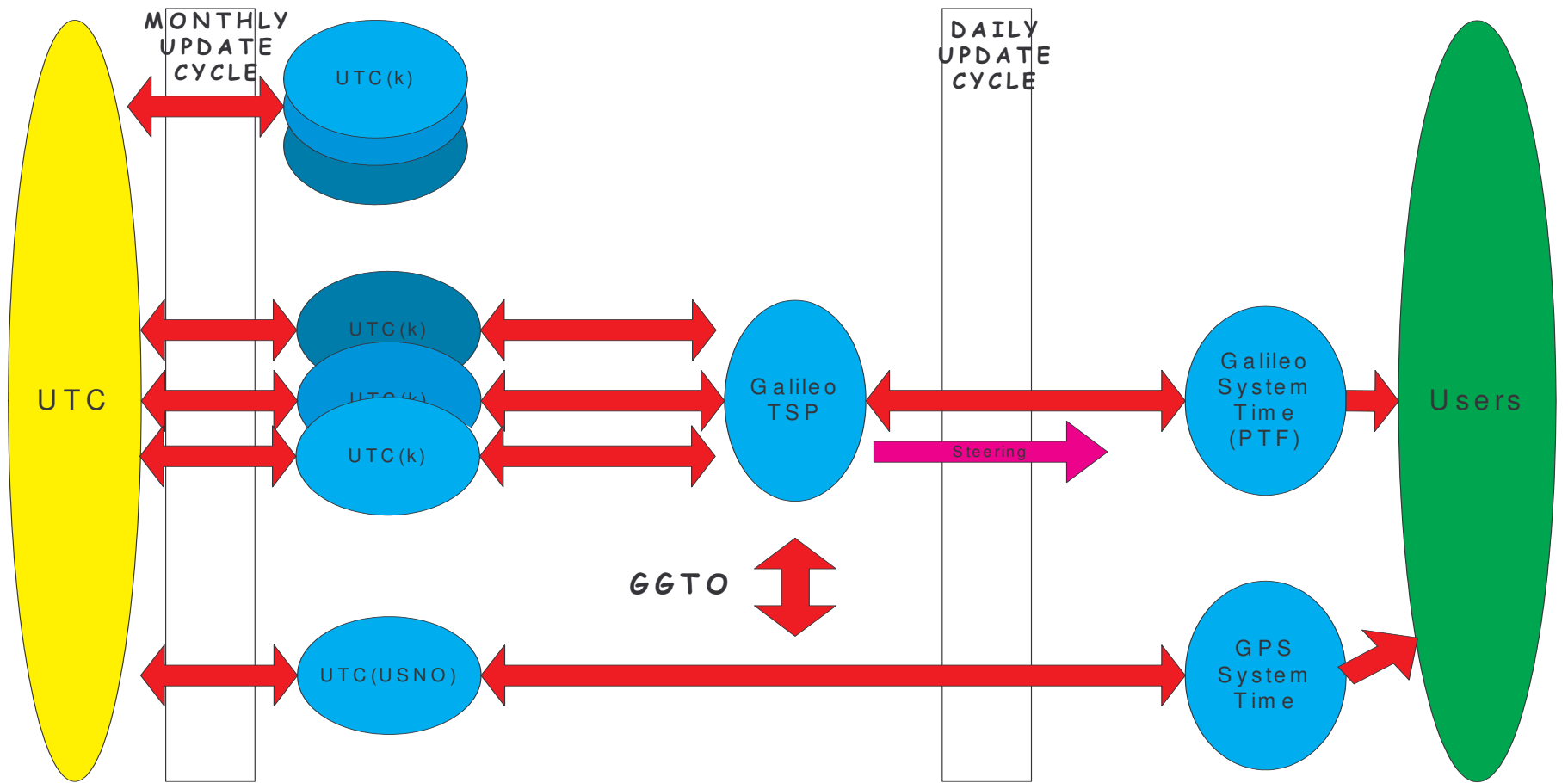
Galileo – Frequency spectrum



Galileo – Timing infrastructure

- Ground Clocks for navigation mission
 - **Precise Time Facility (PTF)** generates Galileo System Time
- Ground Clocks for time service mission
 - **Time Service Provider (TSP)** steers GST to UTC via links to UTC(k) laboratories
 - Contract awarded to Fidelity consortium led by Helios
- Interoperability with GPS
 - proposed broadcast of the Galileo-GPS System Time Offset (GGTO)

Galileo – Generating GST



Galileo – Summary

- Galileo Development phase is proceeding steadily
- Many contract awards for Initial Operational Phase
- 2 test satellites expected to be launched in December
- Galileo operator (“Concessionaire”) contract should be awarded by end 2005
- Likely to be partial constellation operational by 2008

Loran – Background

- Traditional Loran-C is a long-established LF navigation system
- Major enhancements in recent years
 - Interest as complementary, independent backup to GPS (Volpe report)
- Look at developments in:
 - USA
 - Europe
- Enhancements planned or proposed in far-east region
 - Japan, South Korea, China, Russia (similar Chayka system)

Loran – USA

- Loran Recapitalization Plan (LRP)
 - Replacement of elderly infrastructure from 1997
 - All continental US stations modernised
 - Studies into improvements to provide viable backup to GPS
- Requirement for improved timing
 - 3 Cs clocks at each transmitter
 - New Timing & Frequency Equipment combines local clocks
 - Steered to UTC(USNO) using GPS, or flywheels

Loran – eLoran

- Enhanced Loran (eLoran)
 - Addition of new '9th pulse'
 - Carries data stream, including time of day (UTC) and leap seconds
 - Monitor sites determine correction data (differential Loran)
 - Provides significant improvement to position and timing accuracy
 - Tests show <100 ns RMS offset from UTC, $<1 \times 10^{-12}$ freq accuracy (over 24 hrs) to users are easily achieved
 - eLoran timing tests are continuing
 - Commercial receivers already available

Loran – Europe

- NELS (Northwest European Loran-C System)
 - Agreement between France, Norway, Germany, Denmark, Ireland, the Netherlands
 - Took over from USCG in 1995
 - NELS agreement to end on 31 December 2005
- Future uncertain
 - France to continue operation until at least 2015
 - Trial transmission from Rugby, UK, until March 2007
 - Germany interested but favours private funding
 - Norwegian (4), Danish (1), German (1) stations to close in Jan 2006

Loran – Eurofix

- Eurofix developed by NELS
 - Incorporates data stream into the Loran-C signal by pulse time modulation
 - Provides differential GNSS data (corrections, integrity)
 - Can include UTC time code
 - Trial transmissions from European & far east stations

Loran – Summary

- In North America, eLoran will provide a viable stratum 1 PRC
 - Future appears reasonably secure
- In Europe, future of Loran-C is uncertain
 - If funding continues, will provide a sync reference
 - Eurofix would give UTC
- Interest continues in far east region
- New receivers available that take advantage of eLoran and Eurofix