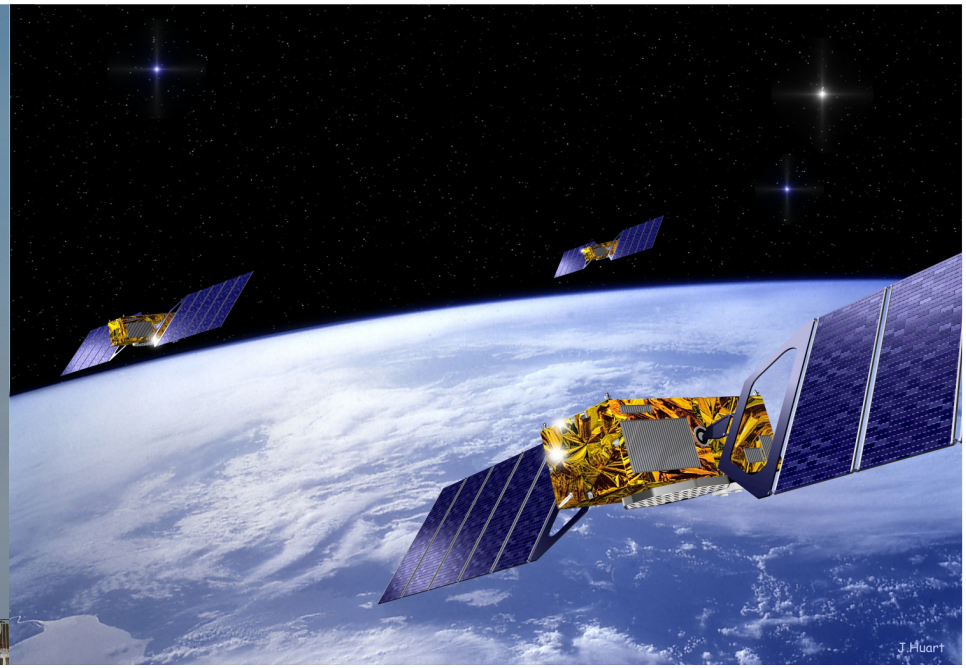

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EUROPEAN COMMISSION

Galileo Perspectives on Compatibility and Interoperability Issues

3rd Meeting of the International Committee on GNSS
Pasadena, California, USA
December 10, 2008

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European Commission

GALILEO

Objectives in Bi-lateral and Multi-lateral Coordination with other GNSS (1/2)

- Ensure compatibility at a minimum: ability of space-based PNT services to be used separately or together without creating harmful interference with each individual service or signal
  - » Radio frequency compatibility (ITU provides a framework)
  - » Spectral separation between PRS and other signals

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Objectives in Bi-lateral and Multi-lateral Coordination with other GNSS (2/2)

- Achieve interoperability between Galileo open signals (OS, SoL and CS) and other space-based PNT signals when desired for the benefits of users
  - Focus on E1 CBOC, AltBOC E5 (+ E5a & E5b) and E6 CS signals

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Galileo Signals

- E1/L1 band
  - OS/SoL CBOC – interoperable with GPS L1C TMBOC
  - PRS $BOC_c(15,2.5)$ – spectral separation with GPS, QZSS, GLONASS and other Galileo signals
- E5 band
  - Very wideband AltBOC(10,5) signal for significantly improved performance
  - Standalone OS E5a signal – interoperable with GPS L5
  - Standalone OS/SoL E5b signals – high performance and improves frequency diversity in E5 so better robustness to interference
- E6 band
  - CS BPSK(5) – 4th frequency band and interoperable with QZSS LEX
  - PRS BOC(10,5) – spectral separation with QZSS and other Galileo signals
- Latest Galileo signals specification published in April 2008 (www.gsa.europa.eu/go/galileo/os-sis-icd)

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Galileo E1 - Opportunities

- Galileo E1 modulation CBOC
  - Wideband signal for improved performance (e.g. multipath noise)
  - Same spectrum (called MBOC) than GPS L1C TMBOC following the EU/US 2004 Agreement on GNSS
- Galileo E1 supports both the OS and SoL services
  - Transmission of both navigation and integrity data
- Possibility to develop interoperable signals in E1 that could support a global integrity scheme compatible with Galileo's scheme

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Galileo E5 - Opportunities

- Galileo E5 modulation AltBOC(15,10)
  - Can be processed as single wideband (~50 MHz) signal: significantly improved performance (e.g. multipath noise)
  - Or as 2 standalone separate signals: E5a and E5b
    - *The user makes its own choice*
- E5a @ 1176 MHz supports OS
  - High performance, QPSK(10)-type spectrum like GPS L5
- E5b @ 1207 MHz supports OS and SoL
  - High performance, QPSK(10)-type spectrum
  - Improves frequency diversity in E5 so better robustness to interference
- Possibility to develop interoperable signals in E5b or E5 band such as AltBOC
  - Option: such interoperable signal could provide a global integrity scheme compatible with Galileo's scheme

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Galileo E6 - Opportunities

- Galileo E6 modulation is BPSK(5)
  - Brings additional frequency diversity (4th Galileo frequency band) so better robustness to interference
- Galileo E6 supports the Commercial Service (CS)
  - Transmission of added-value data to improve performance (e.g. accuracy), exact content under consolidation
- Possibility to develop synergies between Galileo CS and other system's added-value services transmitted by interoperable signals in E6

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Outstanding Issues on Interoperability

- Consensus reached at ICG in Sep. 2007 on the Interoperability concept definition
  - However, how does it translate for signals and systems characteristics?
- Definition of interoperable signals and systems?
  - **Technical** - ex: same center frequency, same modulation, limit maximum power level to avoid harmful interference jeopardizing interoperability benefit, Geodetic reference frames realization and system time reference
  - **Non-Technical** - ex: availability of open information on system architecture, performance standards and actual performance, availability of open information on signals (e.g. SIS ICD)
- ICG should work on a consolidated definition of interoperability for signals and systems

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Overview of Coordination Processes (1/2)

- Galileo – GPS: regular political and technical meetings since the EU-US Agreement was signed in 2004
  - » Agreement on common interoperable MBOC modulation in July 2007
  - » Further discussions aiming at maintaining the compatibility with the modernized systems
  - » Wide topics of cooperation in the field of GNSS
- Galileo – GLONASS: regular technical meetings since 2004
  - » Discussion on the compatibility and the interoperability of modernized GLONASS signals (FDMA and CDMA)
  - » Further discussion on way to improve interoperability at user level

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Overview of Coordination Processes (2/2)

- Galileo – COMPASS: regular technical meetings since 2007
  - » On-going discussions focusing on resolving compatibility and interoperability issues
- Galileo – QZSS: regular technical meetings since 2004
  - » Successful discussions focusing on compatibility (L-band and TT&C) and interoperability, including further interoperability of the Galileo Commercial Service and QZSS LEX
- Galileo – IRNSS: 1st technical meeting in 2007 and regular technical exchanges
  - » Compatibility analysis and potential interoperability in L- and S-bands

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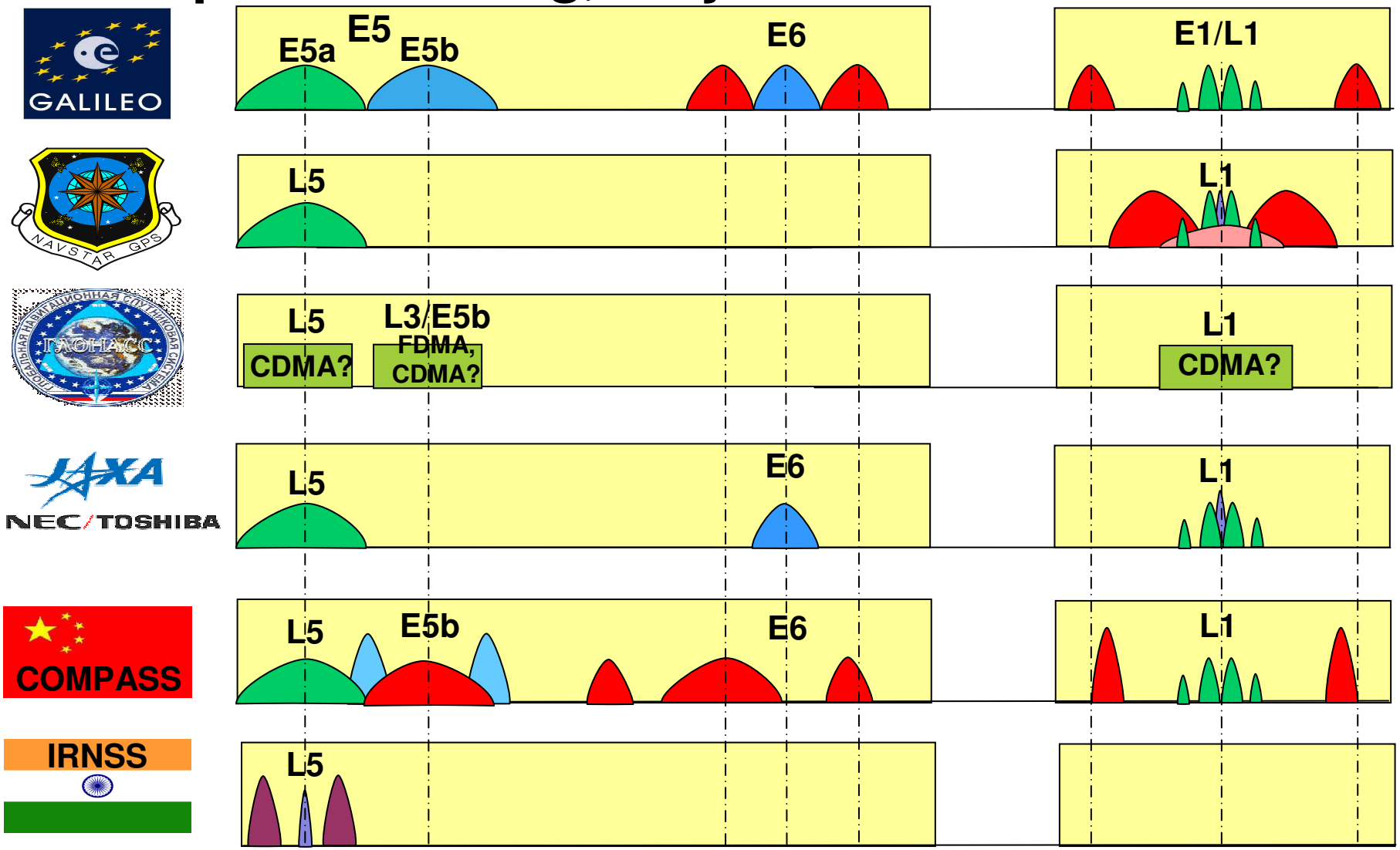
Planned GNSS Signals as of ICG Expert's Meeting, July 2008



Conclusions

- Galileo is actively involved in bi-lateral and multi-lateral coordination processes in order to ensure Compatibility, at a minimum, and Interoperability, when desired, with Galileo
- Currently, there are opportunities and challenges for Galileo and other GNSS in some frequency bands
  - Galileo welcomes potential interoperability with other systems, once compatibility is achieved
- Galileo will continue working with other GNSS to provide, at the end, better benefits to users

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