Dynamic Positioning Committee
Marine Technology Society

Sensors I

The Impact of GPS Modernization and Galileo on the DGNSS Service Provider and User

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The Impact of GPS Modernization & Galileo on the DGNSS User and Service Provider

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Overview

- Introduction
- Satellite Navigation Applications
- GPS Modernisation
- GLONASS Modernisation
- Galileo
- Impact on DGNSS User
- Impact on DGNSS Service Provider
- Conclusions

Introduction

- Satellite navigation technology has been used in the marine industry for numerous years

- Over the next decade there will be significant changes in Global Navigation Satellite Systems (GNSS)
  - Modernisation of GPS
  - Modernisation of GLONASS
  - Introduction of Galileo

- GPS History
  - 1967 – USAF Project 621B instigated
  - 1973 – NAVSTAR development begins
  - 1978 – First GPS satellite launched 22nd February
  - 1993 – GPS declared IOC for civil use 8th December
  - 1995 – GPS declared FOC on 27th April

Applications Of Satellite Navigation

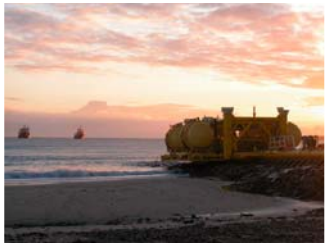
- When GPS was being designed in the 60/70's, the engineers could have never predicted how the technology would be used in the 21st century

- Application areas by receiver types
  - Mass market receiver -- car navigation unit or hand-held for consumer outdoor applications
  - Mass market engine -- for cell phones and other applications requiring urban/indoor use
  - Precision receiver -- for machine control, GIS, survey, or scientific research
  - Safety-of-life transport receiver

- GNSS is essential in today's world
  - embedded in many safety critical systems
  - used for Navigation & Defence…
  - …but also synchronisation of GSM networks, electricity networks, international banking transactions, Intelligent Transportation Systems

DGNSS In The Offshore Oil and Gas Industry

- In offshore operations there are 2 x types of requirement
- Navigation and positioning for survey applications
  - Seismic survey, hydrographic survey, construction and pipe-lay support
  - Positioning of vessels and structures
  - Requires high levels of accuracy and redundancy to ensure high-quality data



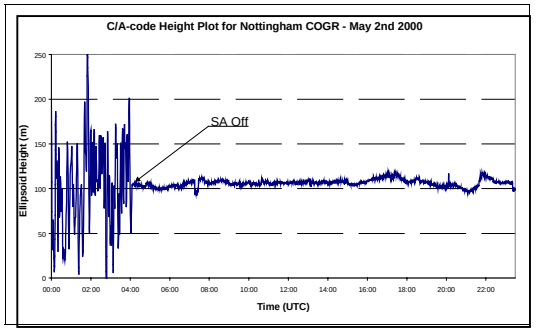
- Navigation and positioning for vessel station-keeping
  - Dynamic positioning / mooring monitoring
  - Stability of position - more important than accuracy
  - Other reference systems such as acoustics, taut-wire – mean less dependence on DGNSS except in deep water where there is likely to be greater dependence on DGNSS
  - Critical to vessel operation

Importance of DGNSS to Offshore Positioning

- Offshore industry was an early adopter of satellite navigation
- Made navigation and positioning more accessible to the wider community plus provided global coverage
- Now-a-days DGNSS is essential to all positioning and navigation offshore
- The offshore industry is a stakeholder in all GNSS systems

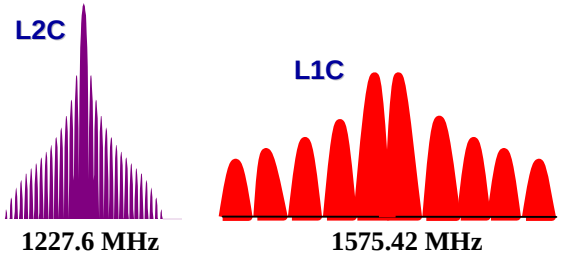
GPS Modernisation Objectives

- Military
  - Protection of service for US/Allied forces
    - Add new signals and increase signal power to improve Navwar capability
    - Develop and field improved anti-jam and security technologies
  - Prevention of adversary exploitation
    - Spectrally separate new military signals from civil signals
- Civil
  - Preservation of civil use while providing enhancements
  - Add new signals to improve accuracy and signal redundancy
- First step was the termination of Selective Availability

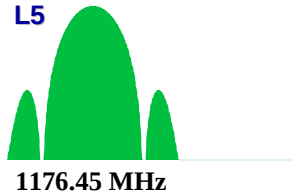


GPS Modernisation

- New Civil Signals
  - Inclusion of L2C on L2 carrier and L1C on the L1 carrier
  - Increased accuracy
  - More redundant signals



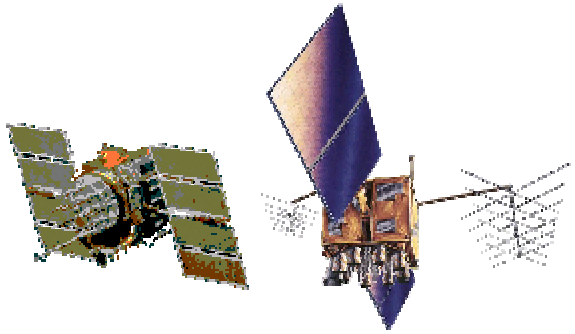
- New Civil Frequency
  - New L5 frequency at 1176.45MHz
  - Improved signal structure for enhanced performance
  - Signal less vulnerable to radio frequency interference
  - Better ambiguity resolution (TCAR)



- Control Segment
  - Upgrade of all monitor stations to track all new signals
  - Inclusion of additional 11 tracking stations
  - Better determination of orbital and clock errors thus increasing the accuracy of the GPS broadcast ephemeris
  - Fully redundant Alternate Master Control Station at Vandenberg, CA

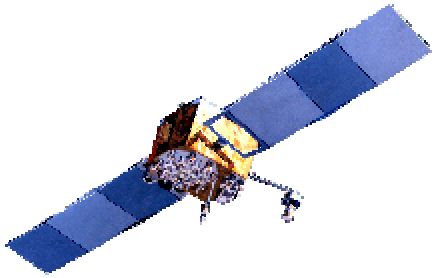
GPS Satellite Evolution

Block IIA/IIR



IIA / IIR: Basic GPS
- C/A civil signal (L1C/A)
- Std Service, 16-24m SEP
- Precise Service, 16m SEP
  - L1 & L2 P(Y) nav

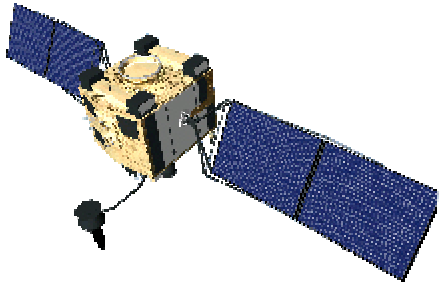
Block IIR-M, IIF



IIR-M: IIA/IIR capabilities &
- 2nd civil signal (L2C)
- New military code
- Flex A/J power (+7dB)

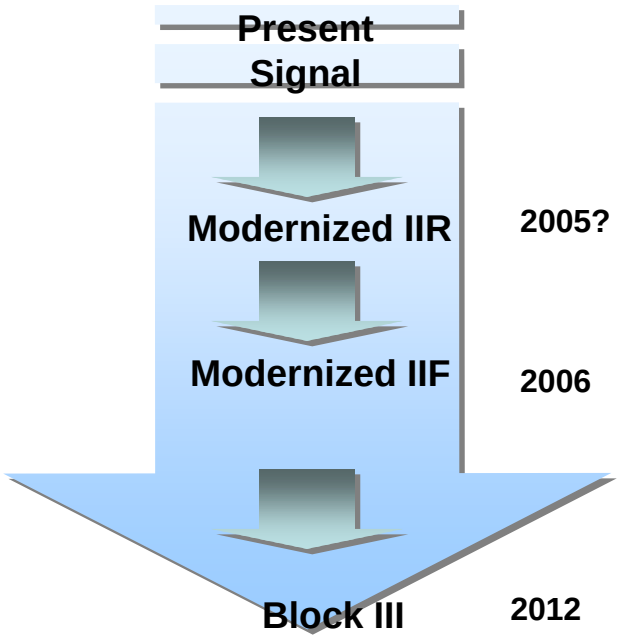
IIF: IIR-M capability plus
- 3rd civil signal (L5)

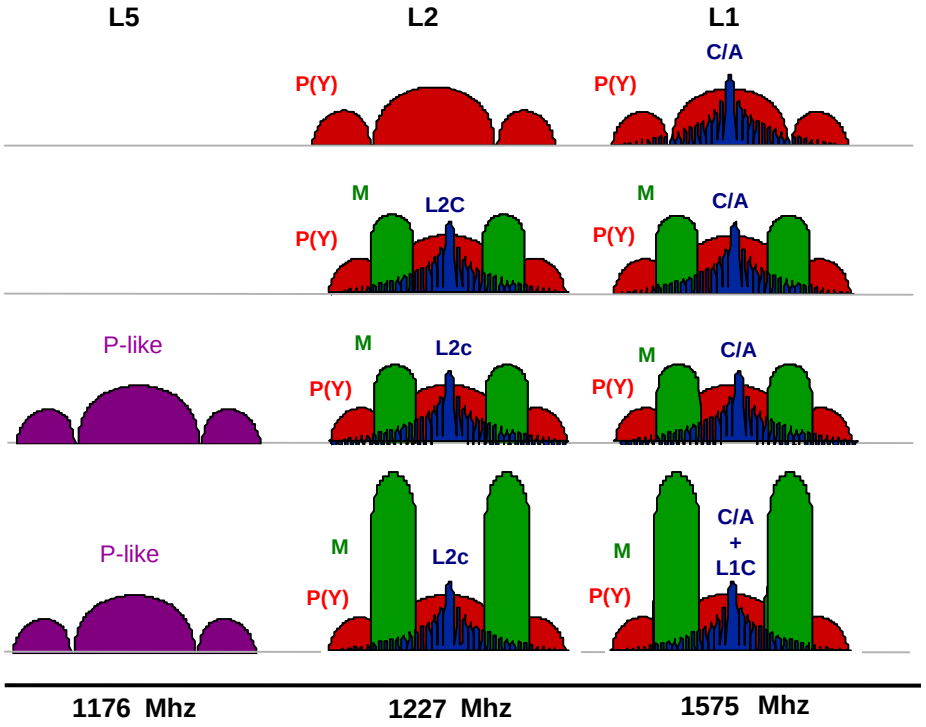
Block III



III: IIF capabilities &
- Improved civil signal (L1C)
- Increased accuracy (4.8-1.2m)
- Navigation security
  - Increased A/J power (+20 dB)

GPS Signal Evolution



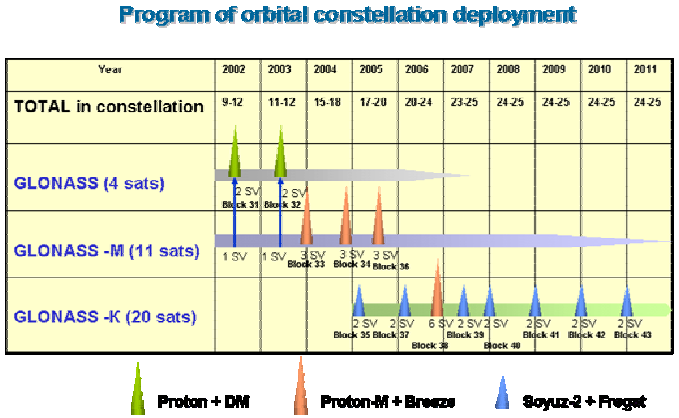


- C/A: Coarse acquisition
- P(Y): Precise, encrypted military signal
- L2: Adding C/A-type code
- L1 & L2: Adding new military signal (M-Code)
- L5: Adding civil “safety of life” signal

GLONASS Modernisation

- GLONASS system is also undergoing a modernisation program

- GLONASS Program 2003-2011
  - Phase 1 - Add to current constellation
    - Maintaining constellation at minimal level
  - Phase 2 - Upgrade to GLONASS-M SV
    - Flight tests M-type in 2003/4
    - Increased lifecycle of 7 years
    - Introduction of a second civil frequency
  - Phase 3 - Further system upgrade to GLONASS-K SV
    - Upgrade of SV active life to 10 years
    - Reducing SV mass to provide launches of 6 to 9 SV at a time
    - Upgrade of the ground control complex
    - Introducing a third frequency



Galileo

- GALILEO : a GNSS designed by Europe
  - Tailored to the civil users
  - Providing worldwide coverage
  - Sovereignty, Independence, Service Guarantee
  - Certifiable for Safety of Life Applications
  - Market share for European Industry
  - Complementary to GPS / GLONASS
- Operated under public control and self financing

Galileo Services

- Open Service (OS)
  - open and free signals providing position and timing performances competitive with other GNSS systems (e.g. GPS)
- Safety of Life Service (SoL)
  - improves the open service performances through the provision of timely warnings to the user when it fails to meet certain margins of accuracy (integrity)
- Commercial Service (CS)
  - provides access to two additional signals, to allow for a higher data rate throughput and to enable users to improve accuracy
- Public Regulated Service (PRS)
  - provides position and timing to specific users requiring a high continuity of service, with controlled access
- Search and Rescue Service (SAR)
  - broadcast globally the alert messages received from distress emitting beacons

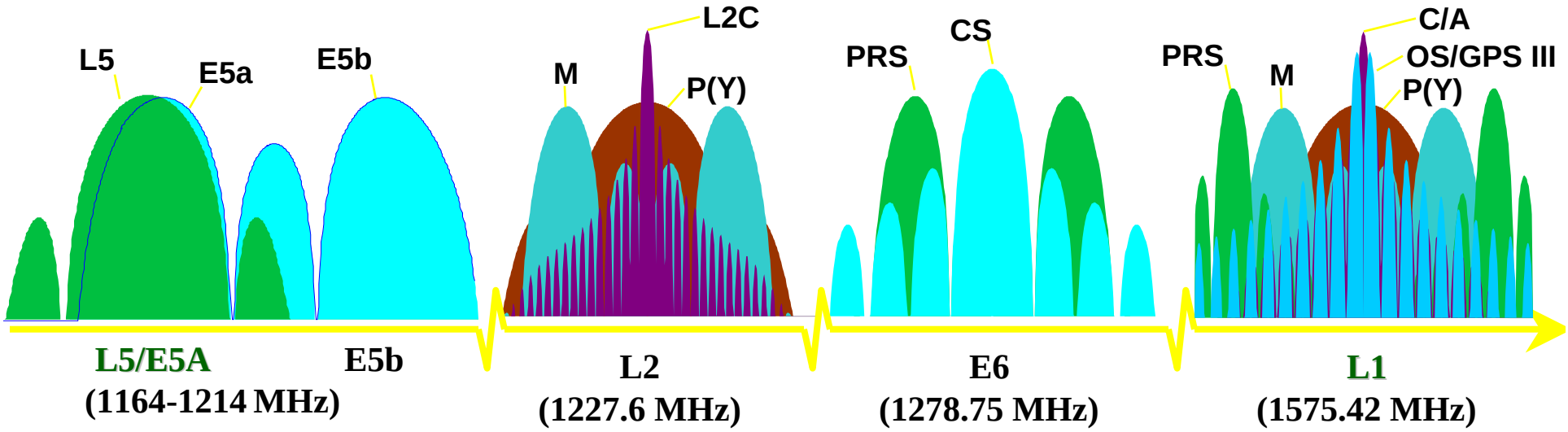
GPS and Galileo Signal Structures

Civil GPS

- **L5** –1176.45 MHz
- **L2** – 1227.6 MHz
- **L1** – 1575.42 MHz

Galileo

- **E5A** – OS & SoL [1176 MHz]
- E5B – OS & SoL & CS [1207 MHz]
- **E6** – CS & PRS [~1279 MHz]
- **E2/L1/E1** – OS & PRS & SoL [1575.42 MHz]



Augmentation Services

- Various regional augmentation services are available to users providing freely available GPS and GLONASS corrections and are aimed at safety critical applications such as aviation

- The main satellite based augmentation services include:
  - WAAS – coverage over North America
  - EGNOS – coverage over Europe
  - MSAS – coverage over Japan

- Accuracies are typically 2 - 4m depending on location within reference station coverage

- Additional augmentation services are also in development such as BEIDOU (China) and GAGAN (India)

Impact on DGNSS User – Advantages

- Combined GPS / GLONASS / Galileo constellations will provide up to 80 satellites
- Availability of new signals
- Greater position accuracy – typical accuracies from combined L1 Galileo OS and GPS C/A code ~2.15m horizontal and ~4.26m vertical
- Greater integrity and availability providing more robust positioning
- Different signal combinations to suit different market requirements
- Development of new positioning techniques (e.g. TCAR/MCAR)
- Service guarantee on some signals and services if using Galileo, important for safety critical operations

Impact on DGNSS User – Potential Disadvantages

- Too many signals
  - which are the best combination of signals to use
  - restrictions on receiver power and size depending on application
- What types of receivers will be available
  - receiver manufacturers favour using common GPS and Galileo signals as it simplifies receiver and antenna design plus keeps costs lower
  - potential radio frequency interference on common signals reducing robustness of position
- Interoperability between GPS / GLONASS / Galileo
  - geodetic reference frame
  - time systems
  - signal structure

Impact On DGNSS Service Provider

- The impact of the modernised and new satellite constellations means significant changes to the service provider network

- Additional signals will impact:
  - data collection – more signals means more information to be collected
  - data transfer from network – increased communication bandwidth required
  - data processing – more information to process
  - message generation – more corrections / service information to generate
  - transfer of service to user – more information means more bandwidth

- Interoperability between GPS / GLONASS / Galileo
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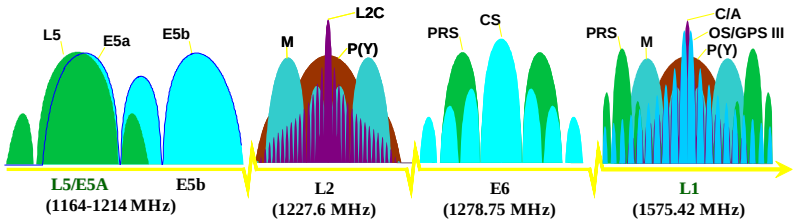

Impact On DGNSS Service Provider

- Will the market want corrections for all available signals?
  - signal choice may trigger a new era of expanding GNSS applications
- What receiver equipment will be available?
  - future reference station receivers will need to be capable of tracking all signals
- Services required by the user will depend on positioning requirements
  - there may be a point in the future when a dual frequency standalone position is more accurate than a single frequency DGPS position
  - there may be no market requirement for differential GNSS services to support single frequency users due to freely available services
  - Technical & operational support will continue to be a major part of the supply scope of the DGNSS provider
- What update rate will be required for corrections?
  - better clock stability on future satellites will reduce this major time varying error source that should allow for a lower frequency of corrections

Conclusions

- DGNSS users will see significant changes in the satellite navigation over the next 10 to 20 years
- This will include the availability of more satellites and also more navigation signals which will provide greater positional accuracy and reliability
- GNSS will have more redundancy because of the multiple constellations and no reliance on one nation
- The actual combination of signals to be used will be determined by the application and will be a trade-off between cost, accuracy and receiver design
- The modernised constellations and Galileo clearly show that satellite navigation will continue to the system of choice for navigation and surveying in the offshore industry

Questions?

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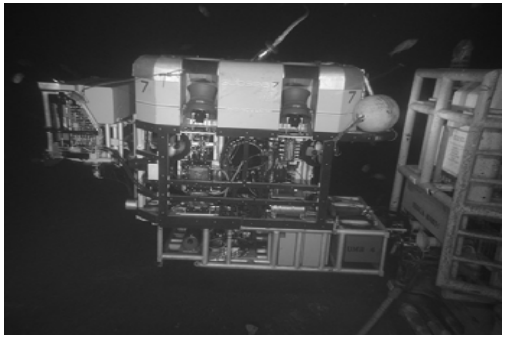
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PWR/SATS