

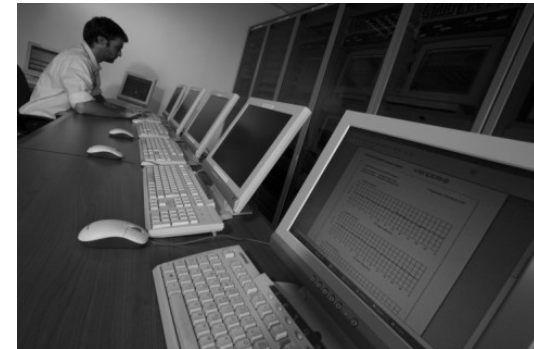


Sensors I

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

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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

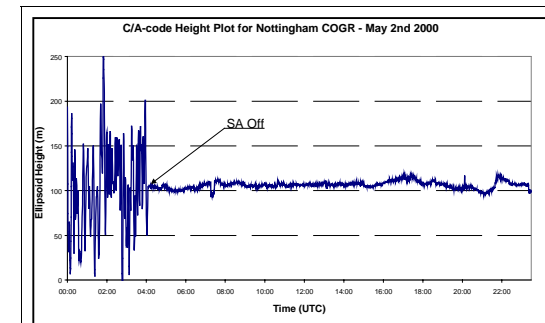


GPS Modernisation Objectives

- ◆ 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

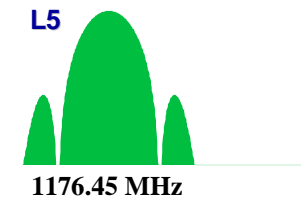
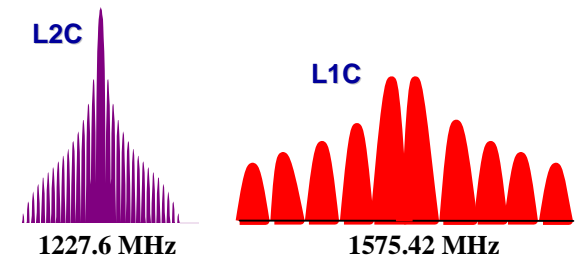


GPS Modernisation

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

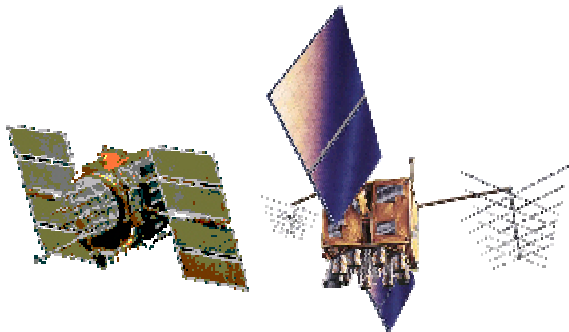
- ◆ New Civil Frequency
 - New L5 frequency at 1176.45MHz
 - Improved signal structure for enhanced performance
 - Signal less vulnerable to radio frequency interference
 - Better ambiguity resolution (TCAR)

- ◆ 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

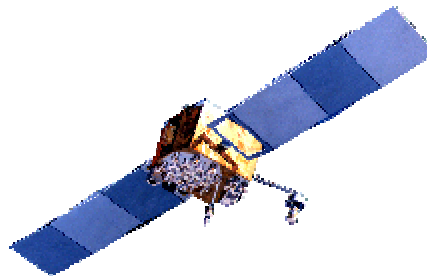
Block IIA/IIR



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



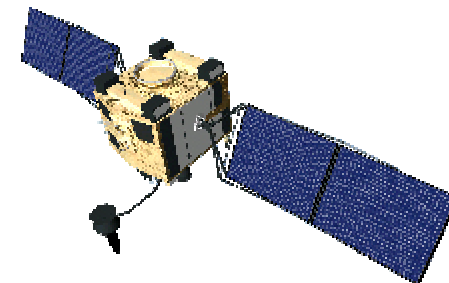
IIR-M: IIA/IIR capabilities &

- 2nd civil signal (L2C)
- **New military code**
- **Flex A/J power (+7dB)**

IIF: IIR-M capability plus

- 3rd civil signal (L5)

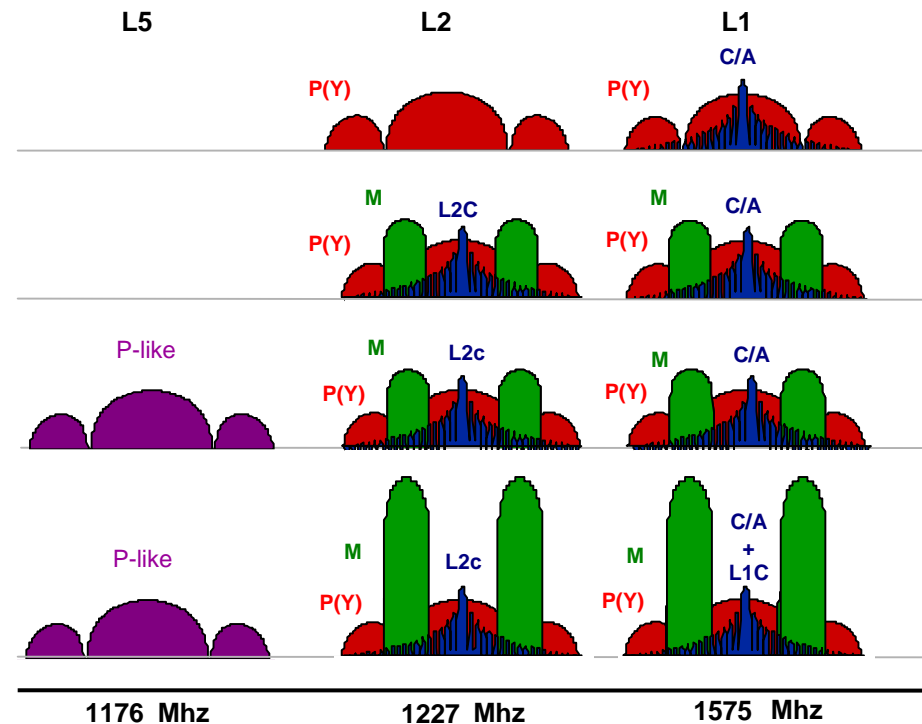
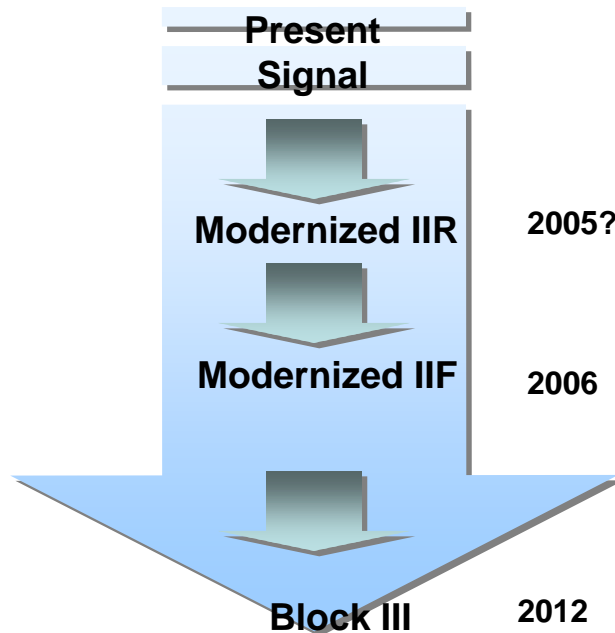
Block III



III: IIF capabilities &

- Improved civil signal (L1C)
- Increased accuracy (4.8-1.2m)
- **Navigation security**
 - **Increased A/J power (+20 dB)**

GPS Signal Evolution

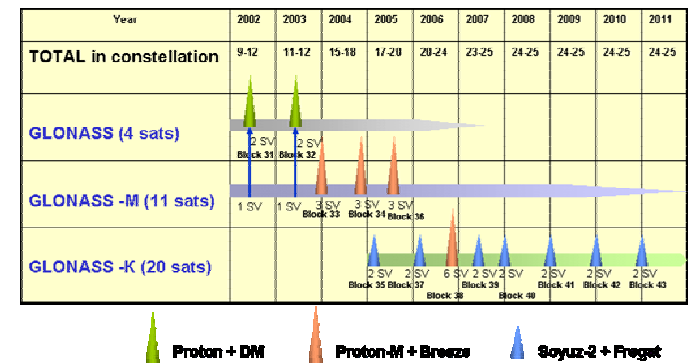


- ◆ C/A: Coarse acquisition
- ◆ P(Y): Precise, encrypted military signal
- ◆ L2: Adding C/A-type code
- ◆ L1 & L2: Adding new military signal (M-Code)
- ◆ L5: Adding civil “safety of life” signal

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

Program of orbital constellation deployment



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

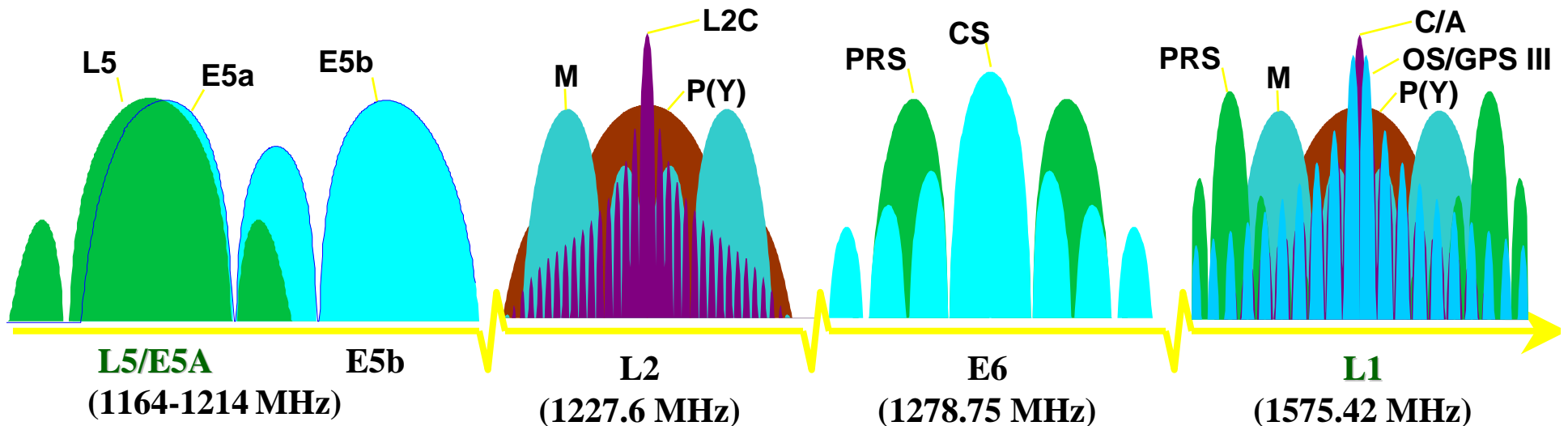
GPS and Galileo Signal Structures

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

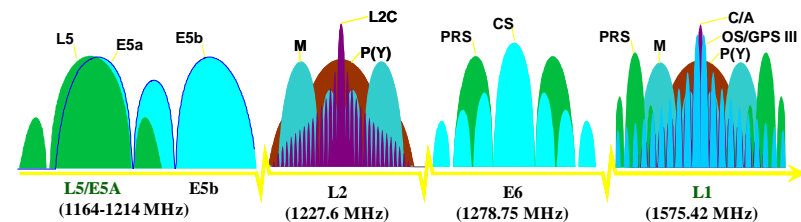
- ◆ Too many signals
 - which are the best combination of signals to use
 - restrictions on receiver power and size depending on application

- ◆ 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
 - geodetic reference frame
 - time systems
 - signal structure



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 be the system of choice for navigation and surveying in the offshore industry

Questions?

