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DYNAMIC POSITIONING CONFERENCE
October 15-16, 2013

SENSORS SESSION II

Improving GNSS Sensor Reliability

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Veripos

Improving GNSS Sensor Reliability

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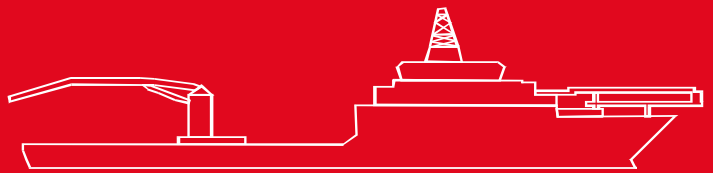
Technology Manager

Presentation Overview



- Introduction
- Satellite Constellations
- Data Delivery
- Antennas
- Preventive Maintenance
- Sensor Integration
- Data Interfacing

Introduction

Ideal surface positioning system should provide a position that is...

I CONSTANT

III STABLE

II ACCURATE

IV REPEATABLE

RESULT = reliable position

However...we don't operate in the ideal world!!

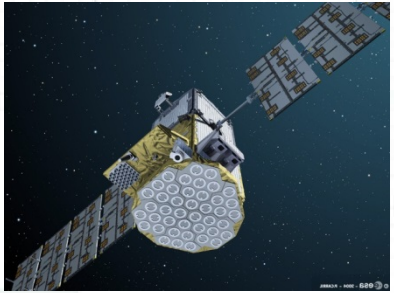
Reliable – consistently good in quality or performance; able to be trusted

GNSS Technology

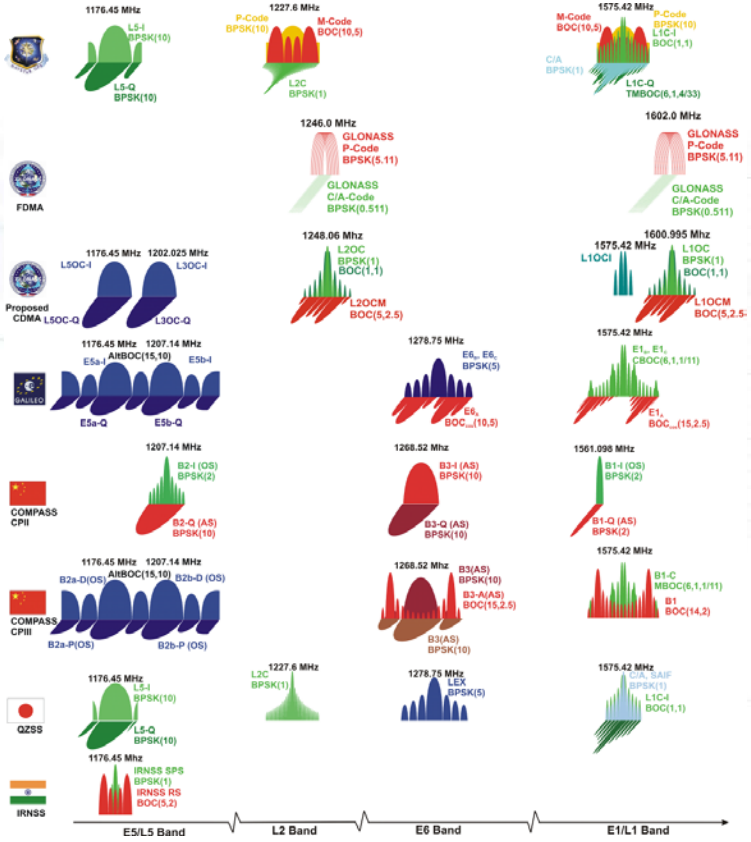
- GNSS satellites
  - Located approx 20,000km above surface of the Earth
  - Transmit power 50W
- Weak signal by time it reaches user antenna
- Signal susceptible to degradation through interference
  - Propagation through the atmosphere
  - Jamming (intentional or un-intentional)
- Require line-of-sight to receive signal
  - Obstructions block the signal

RESULT = unreliable position

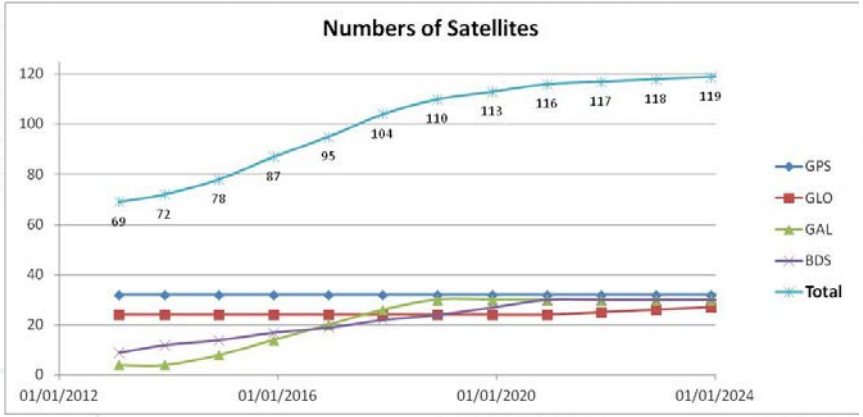
Satellite Constellations



Satellite Availability & Signal Structure



- Additional Satellites, Frequencies & Signals
  - = Higher power signals
  - = Redundancy
  - = Improved signal tracking
  - = Resilience to interference



New & Improved Signals

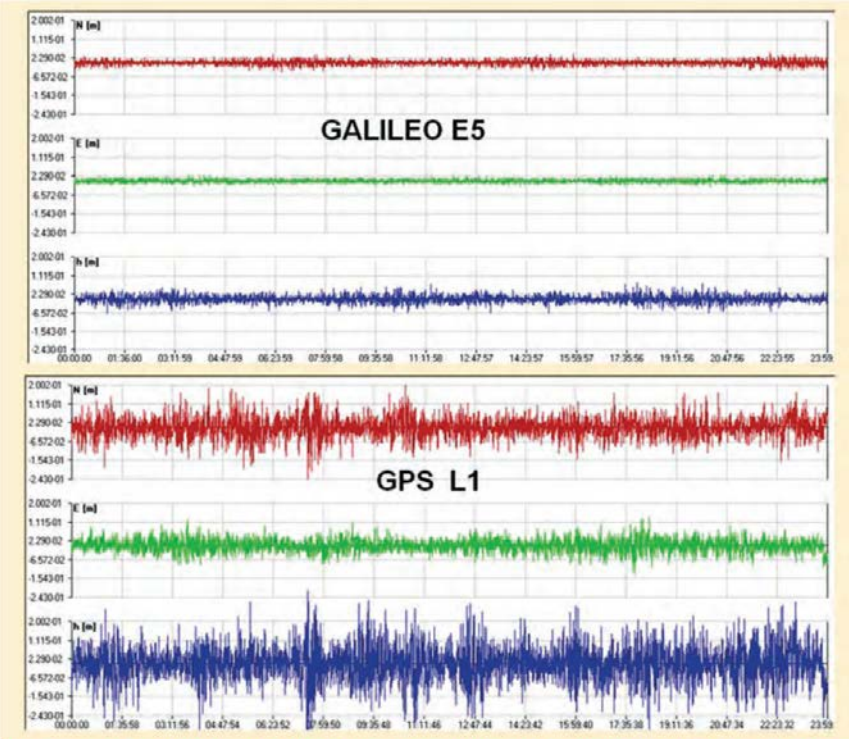


FIGURE 5 Comparison of the time series of the three coordinate components using simulated Galileo E5 (upper plot) and GPS L1 (lower plot) CPC results; 2.290-02 is read 2.290-10-2 meters; GNSS time of day format is hh:mm:ss

Source: *"Exploiting the GALILEO E5 Wideband Signal for Improved Single-Frequency Precise Positioning"*, Inside GNSS, Sep/Oct 2012

- New Signals:

  GPS L1C, L5 and GALILEO signals all have higher power than GPS L1 C/A

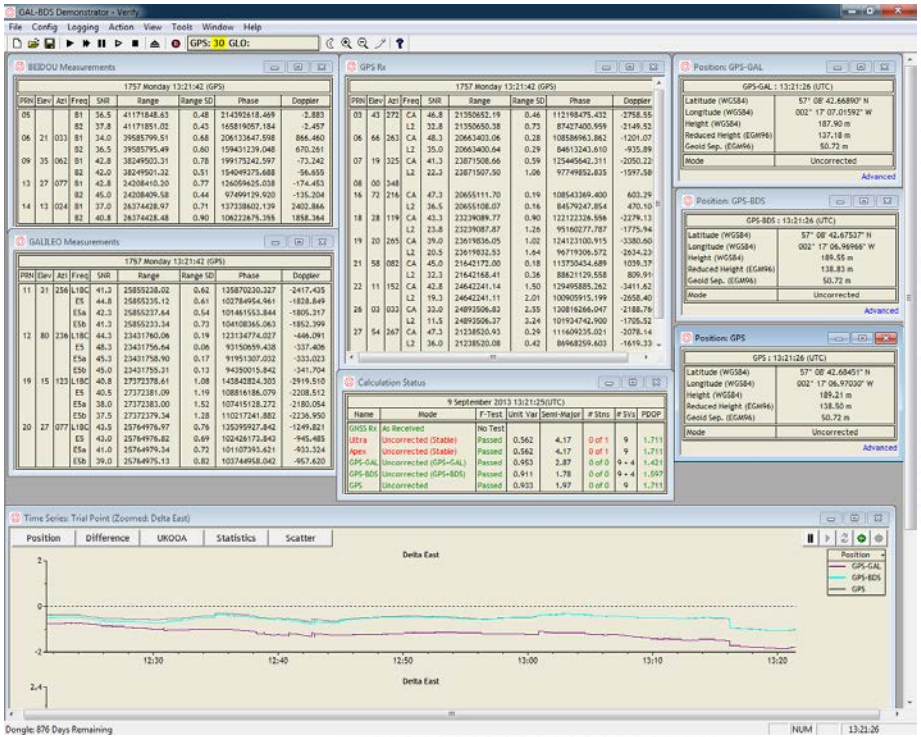
  Longer code sequence » better tracking in difficult environments

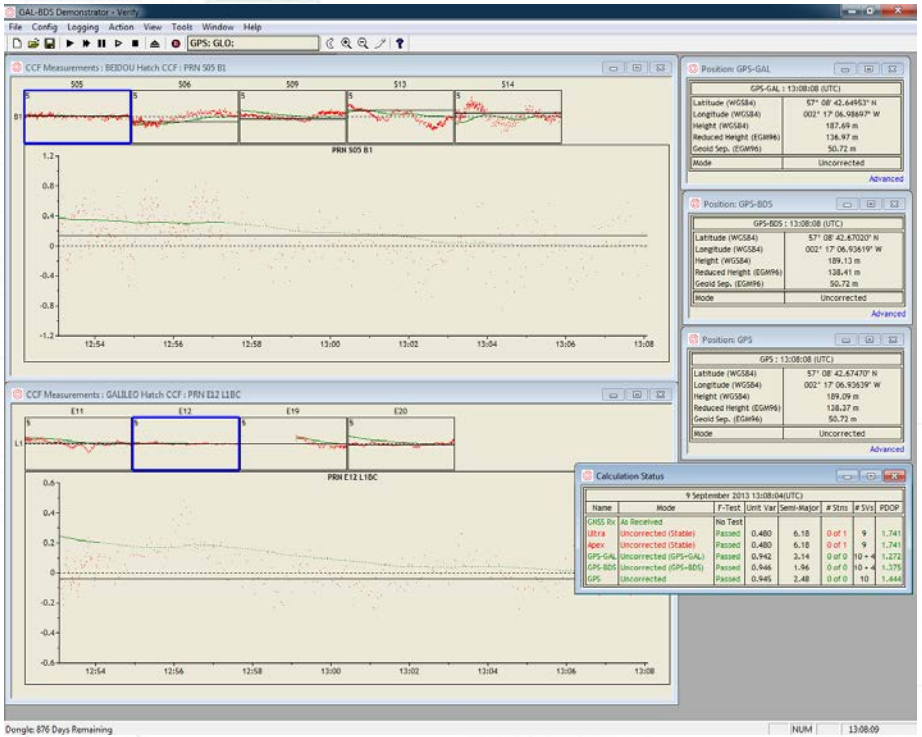
  Pilot signals (GAL E1, E5, E6, and GPS L1c, L2C, L5) » enable weak signal acquisition and tracking

  Wide band signal (E5ab) » is less affected by narrow band interference, less multipath

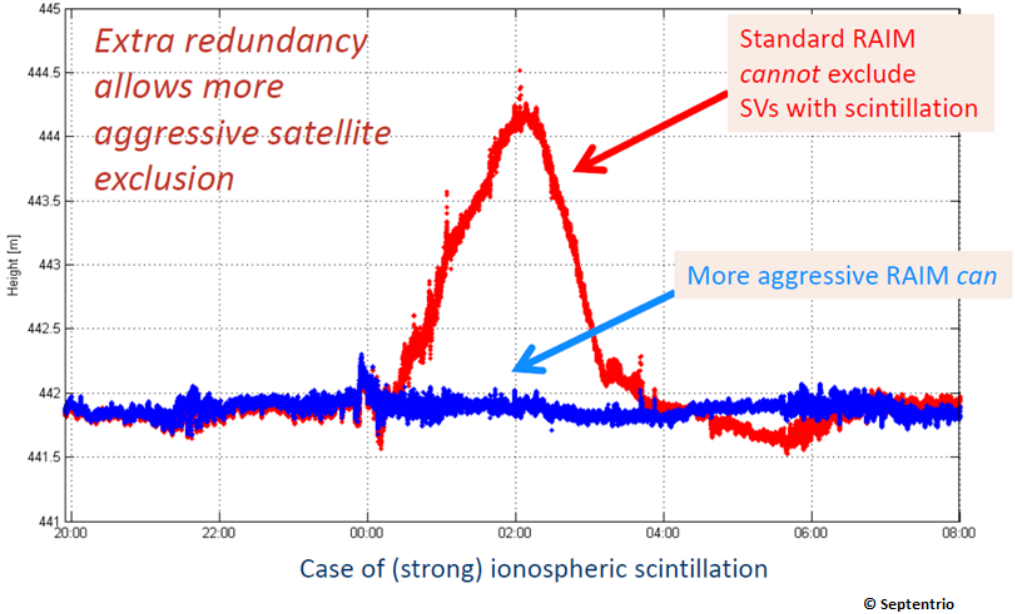
  Faster chipping rates » less noise and more precise code observations

Integration & Evaluation



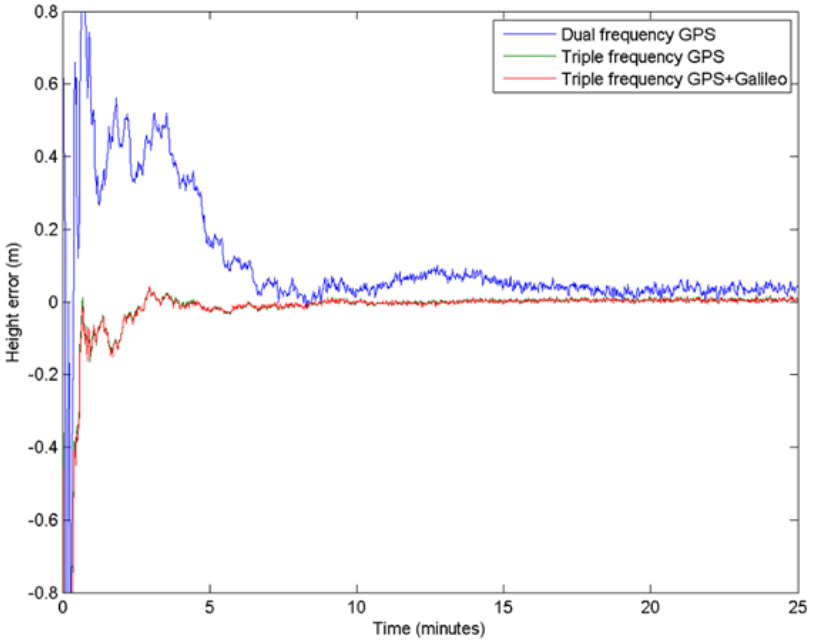


Improvements in Robustness/Accuracy/Convergence



Case of (strong) ionospheric scintillation

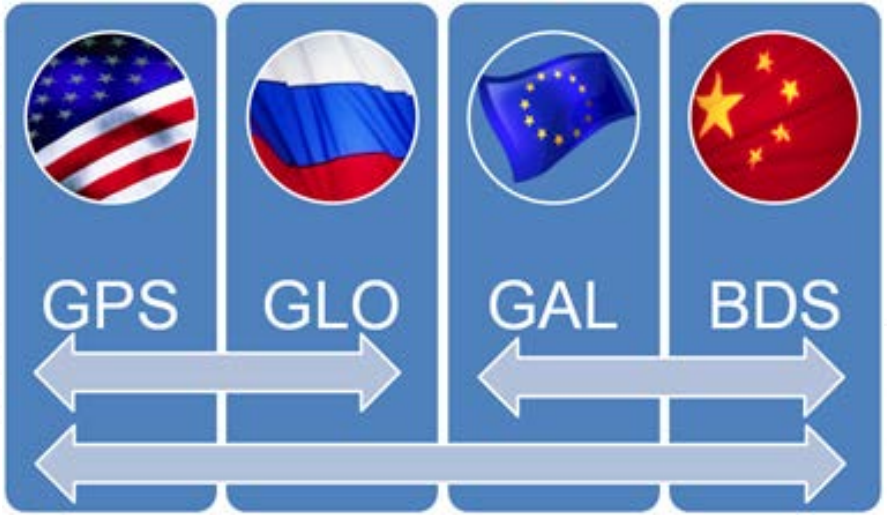
© Septentrio



Source: iNsight project (www.insight-gnss.org)

What Constellation Combination?

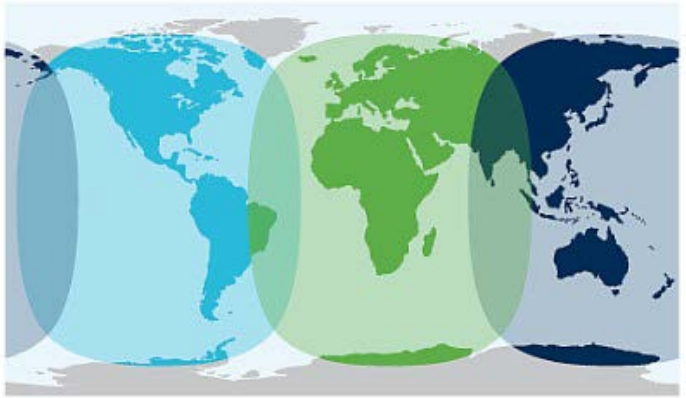
- Any combination is feasible
  - No significant technical barriers
- Accuracy and convergence benefits of using extra satellites drops off beyond 20-25 SVs
- What does the user want
  - all-in-view
  - smart & selective
  - meet client contractual specification
- Regulatory requirements?
- Choice will mainly be driven by Solution Availability vs. Solution Diversity/Independence



Data Delivery

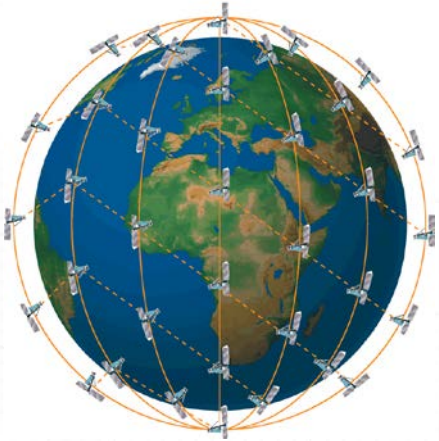
Data Delivery to Users

- L-band
  - Point to Multipoint service
  - Good coverage across the Earth
  - Easy to monitor performance to ensure data delivery
  - Operates up to ~74°N/S
- Internet Delivery
  - Through vessel V-Sat or Iridium system
  - Monitoring of data is a major limitation
  - Data delivery can be delayed due to bandwidth and amount of traffic
- Terrestrial Radio Broadcast
  - Good alternative to satellite delivery
  - Limited range
  - High operating cost (site/power/licence/maintenance)



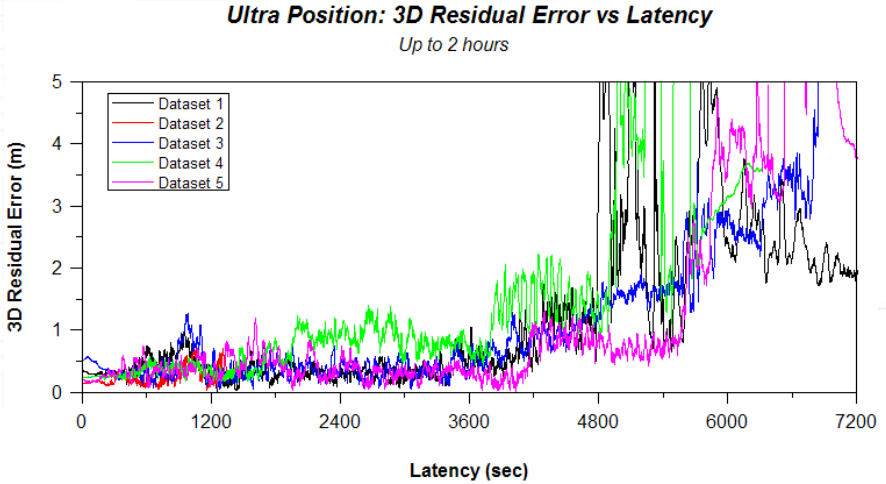
Iridium

- Iridium satellite communication system can provide coverage in the polar regions
- Consists of a network of 66 low Earth orbiting satellites in a polar orbit
- Omnidirectional antenna used
- Iridium Pilot service
  - Broadband internet
- Ideal for maritime operations at high latitudes



Issues with Iridium

- Iridium is a good solution for operations at high latitude
- Based on experience it does have some issues
- Major challenge is the user switching satellites on a regular basis
  - Introduces breaks in data = increased latency
  - This can result it loosing position
  - Solution is to increase age threshold in position algorithms
- Also witnessed issues with buffered data which can cause problems with positioning



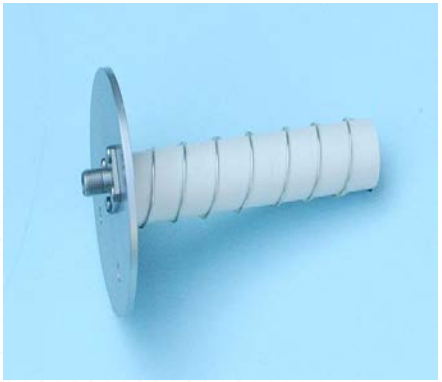
Antennas

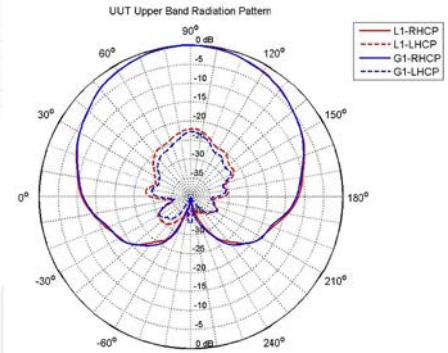
Antenna Installation

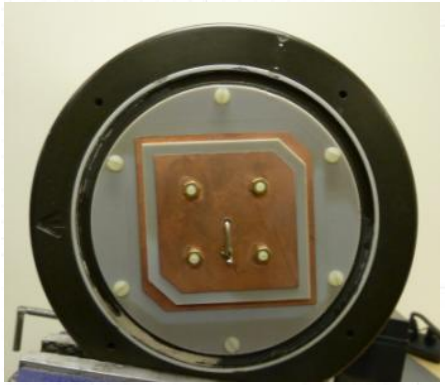
- Badly installed antenna will directly affect system performance
  - Loss of position or poor quality positioning
  - Vessel unable to work
  - Out of operational specification
- Several aspects need to be considered
  - Clear line of site to the sky
  - Minimization of multipath
  - Cables and connectors which will influence signal attenuation
  - Proximity of interference sources
  - RF over fibre for long cable runs

Antenna Selection

- Factors to consider in selection of antenna
  - Frequency coverage
  - Gain pattern
  - Polarization
  - Multipath
  - Interference Suppression
- Many aspects of the antenna are inter-dependent
- Issues with combined GNSS and L-band
  - Trade-off in performance
  - Issue working at high latitudes

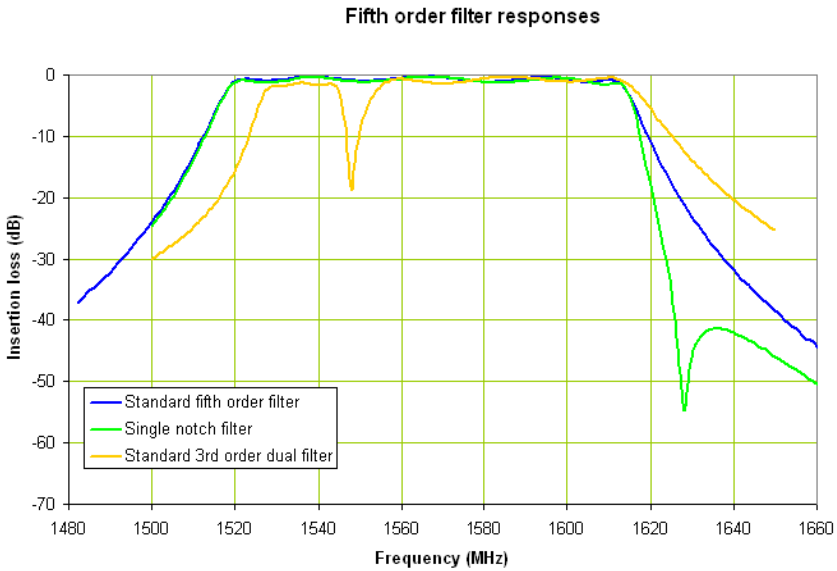






Interference Suppression

- Receiver technology can help combat interference
- Proper antenna design can keep out signals that cause interference
- Use of filters to keep out un-wanted signals
- Inmarsat Sat-C is a system that can affect GNSS systems
  - Incorporate a 5th order filter to reduce impact of Sat-C transmissions



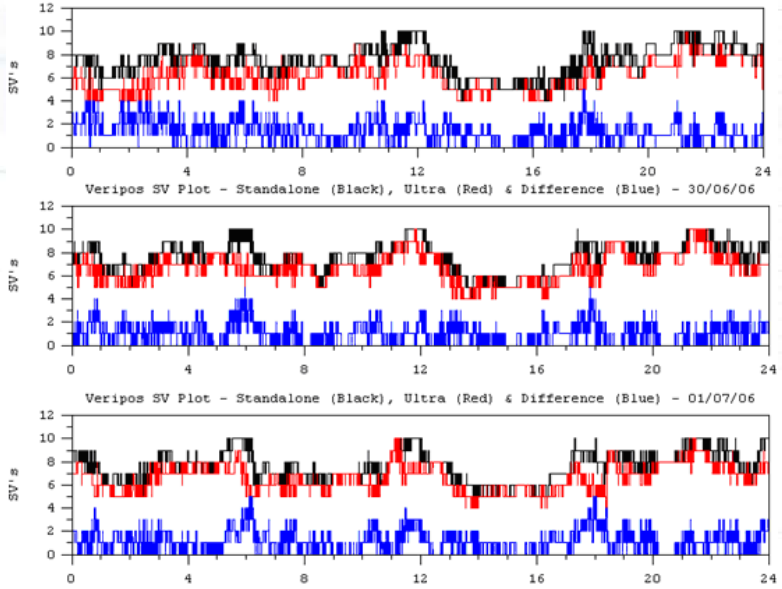
Preventive Maintenance

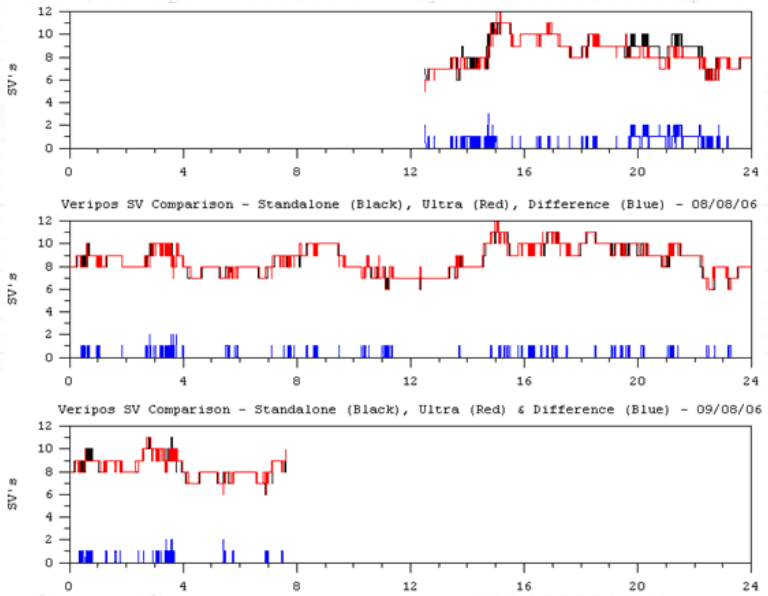
System Maintenance

- All installations will deteriorate over time
  - Irrespective of how good the installation
- Above deck equipment
  - Exposed to the elements
  - Check cabling and connectors
- Below deck equipment
  - Check cabling
  - Upgrade firmware/software
- Planned preventive maintenance
  - What inspection periods?
  - Remedial work completed as soon as practical

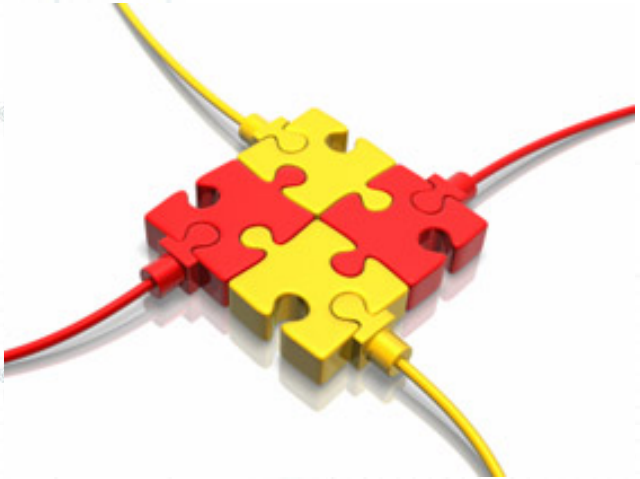
Antenna Cable Issue

- Clear difference in number of SV's used by two solutions (L1/L2 and L1)
- Deterioration of antenna cable caused issues with L2 tracking – cable changed out





Sensor Integration

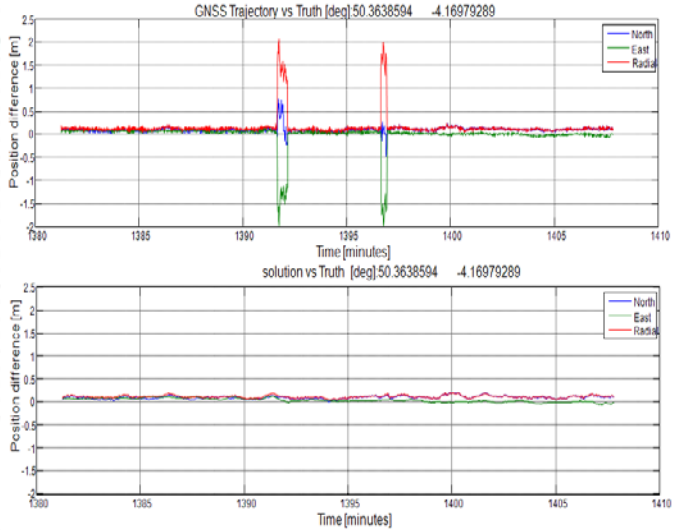


Sensor Integration

- Sensor technology will continue to develop, evolve and become reliable
- However, each sensor will always have some limitations
- Sensors used offshore are complementary
- Integrate and create a fused solution that when combined deliver a position that is:
  - Constant
  - Stable
  - Accurate
  - Repeatable
  - and Reliable

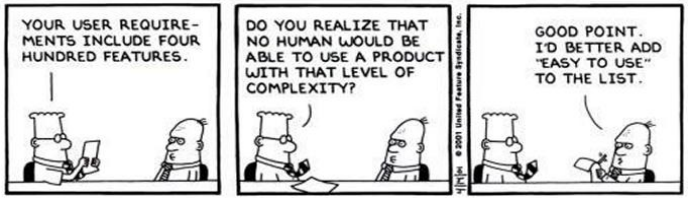
INS – GNSS Integration

- INS and GNSS are complementary sensors
  - GNSS can help constrain the drift of the INS sensors
- Integrated solution exploits
  - Long term accuracy and precision of GNSS positioning
  - Continuous availability and fast update rate of inertial sensors
- System designed to bridge any GNSS disruptions and also to detect position outliers
  - Common mode failures which can otherwise affect vessel GNSS systems simultaneously



Increased Complexity

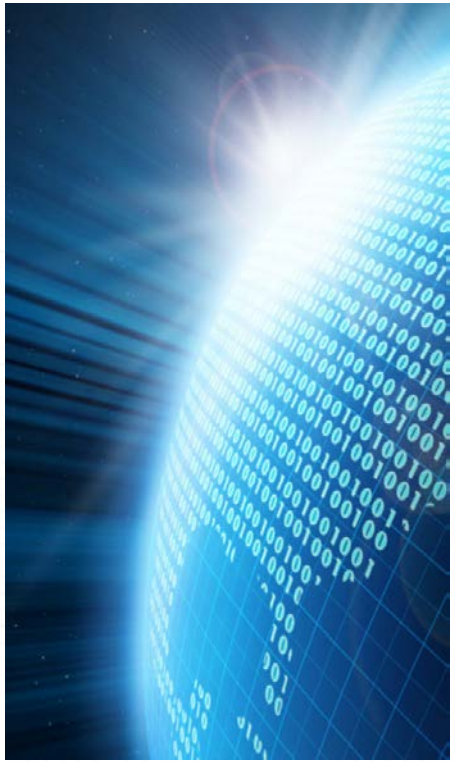
- Increased complexity of different modes of system operation
  - Potential for different combinations of sensors
  - What is the optimal combination
  - How is each system monitored or quality controlled
- A requirement to interpret and understand what is happening with calculated positioning solution
- Additional complexity within individual sensors
  - e.g. GNSS will have potential to use different combination of constellations
- Sensor integration to improve solution robustness and accuracy
  - Loosely or Tightly coupled?



Data Interfacing

Data Interface

- Transport of information from the GNSS sensor or positioning system relies on a data interface
- Most commonly used standard is the NMEA protocol
- No specific provisions for integrated position solution
  - Independence
  - Quality
  - Consistency
- There is a requirement to develop a new interface standard
  - Ensure compatibility between systems
  - Provide the appropriate information to the operator
  - Unlock the full potential of sensors and technology



NMEA

- NMEA standards designed to
  - Facilitate public interest in interconnection & interchange ability of equipment
  - Minimize the misunderstanding & confusion between manufacturers
  - Assist purchasers in selecting compatible equipment
  - Aimed at consumer rather than professional users?
- GPS receiver communication is defined within the specification
  - NMEA 0183 commonly used within DP equipment and sensors that connect to the DP system
  - GGA sentence extensively used

National Marine Electronics Association

Field #	Description
1	UTC of Position
2,3	Latitude, N (North) or S (South)
4,5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
13	Age of Differential GPS Data. Time in seconds since the lastType 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

New Interface Standard

- NMEA sentences are being stretched to accommodate new technology
  - Message structure is inefficient and non-optimal
- Other markets and users are looking to develop a new interface standard to replace GGA
- Proposals have been put in front of RTCM SC-104 committee
  - RTCM believes that this belongs with NMEA
  - Discussions between NMEA and RTCM on how to move this forward
- Proposed message format designed to
  - Provide more comprehensive information than NMEA sentences
  - Allow traceability, validation and downstream processing
  - Unify interface between systems and vendors (hardware/software)
  - New message format aimed at land users

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