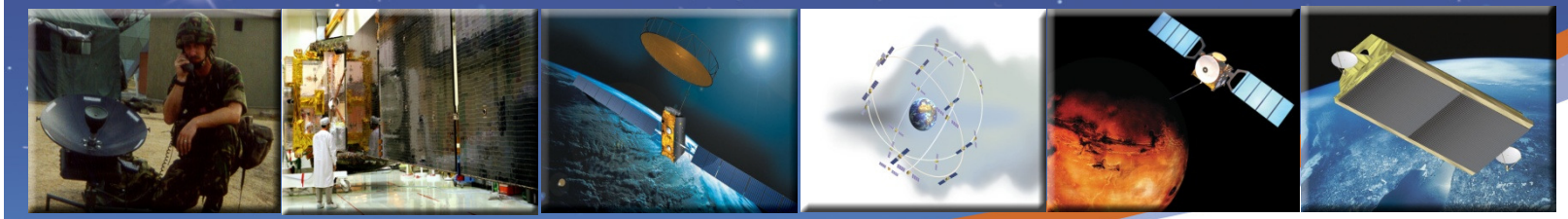
GNSS Pseudolite Signal Augmentation And Applications

GNSS Applications Showcase
Nottingham Geospatial Building, November 11th

Luis Serrano



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Overview

1. **Introduction to EADS Astrium**
2. **EADS Astrium Pseudolite Augmentation: Maritime Example**
3. **Pseudolites Operational Concept, and Signal Specifications (Carrier-Phase Applications)**
4. **Pseudolite Augmentation Simulations Studies**
5. **Conclusions**

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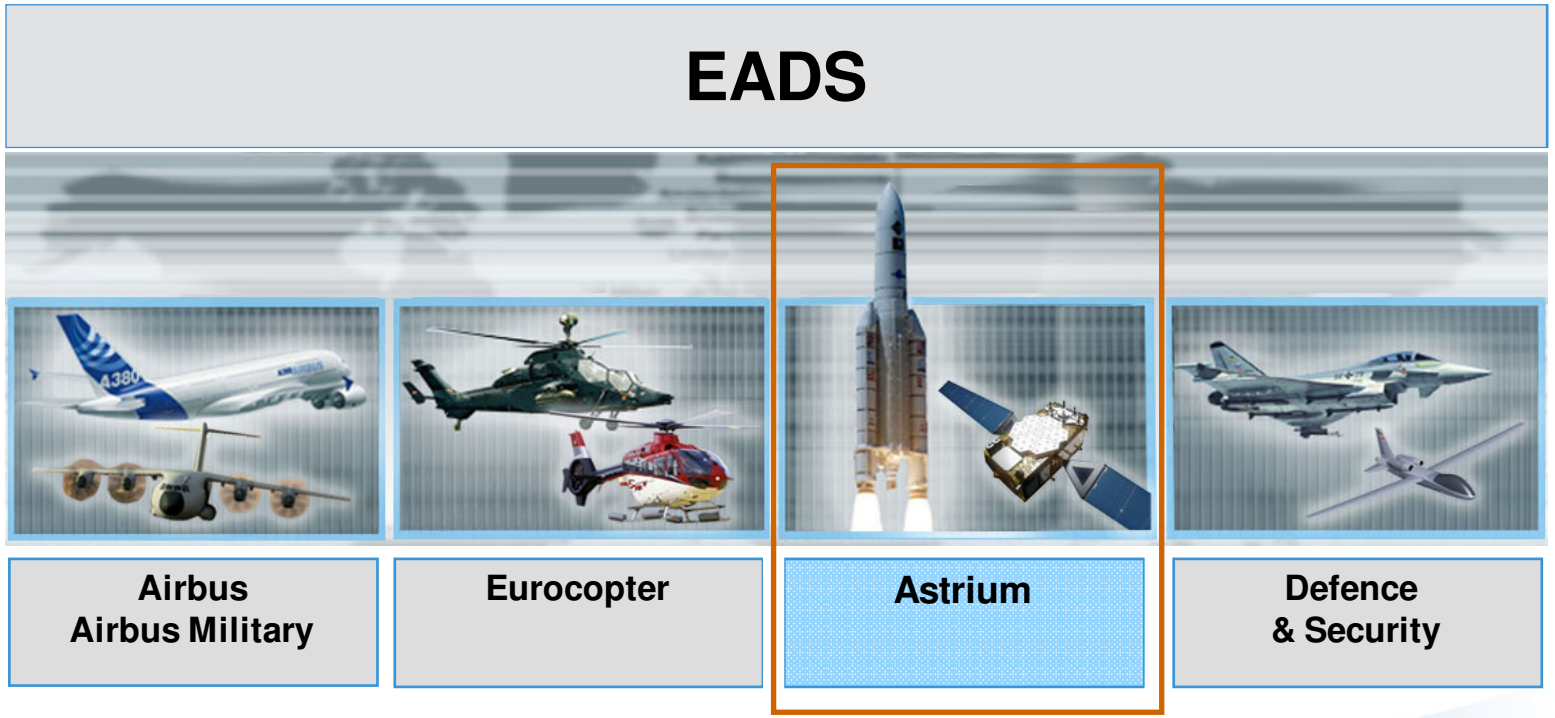

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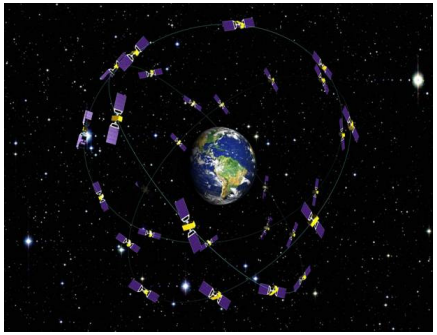
Astrium and Navigation



- Major involvement in Satellite Navigation since its European beginnings in the 1990's
- Leading involvement in Galileo
  - Prime for Galileo Satellites (Germany) & Payloads (UK)
  - Prime for Galileo Ground Control System (UK)
  - Major Contributor to Galileo System Design
  - Build of the system test satellite GIOVE-B and leading ground segment management

- **Growing interests in downstream market of Positioning and Navigation Applications! Looking for strong partnerships in this growing area.**

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MARUSE Project Overview

- GNSS Supervisory Authority Co-Funded FP6 Project
- Partners:

- Focus on GNSS & Maritime User Community
- Technology & Application development, implementation and demonstration where Galileo will bring benefit - typically high-end for improved security, safety & efficiency
- Technology development include:
  - Prototype Galileo receiver (Septentrio) in User Terminal (Kongsberg Seatex)
  - Galileo Pseudolites (EADS Astrium)

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Example End User Requirements

	Navigation Phase		
	Ocean	**Coastal**	**Port**
Accuracy	H: 10 m V: N/A	H: 1 m V: 1 m	H: 0.1 m V: 0.1 m
Availability	99.8%	99.8%	99.8%
Continuity	99.97%	N/A	99.97%
Integrity	Yes	Yes	Yes

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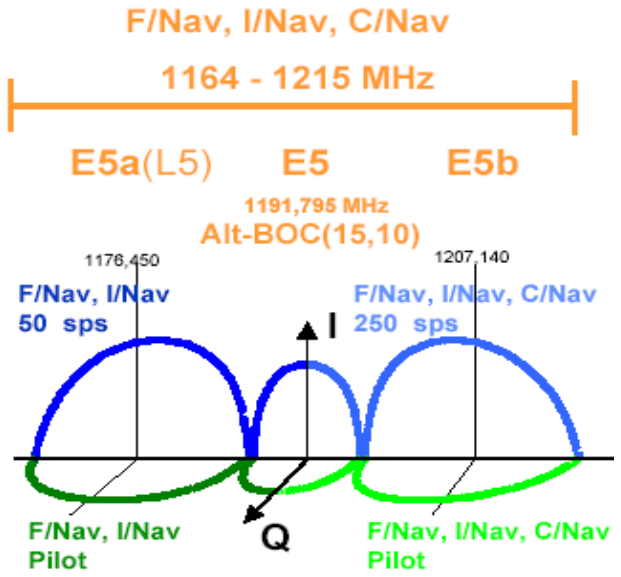
Concept for the Harbour Navigation System

- Positioning with GNSS-like signals
  - "Standard" GNSS User Receiver
  - Adapted S/W in User Terminal to deal with PSL specifics
- Galileo E5 signal selected for demonstrations
  - Operational system could be adapted to use other frequencies
- Physical signals in a realistic environment
- 5 transmit stations installed around demo area
- Core area comprises several km²
- Interoperability: demonstrations include operation with GPS



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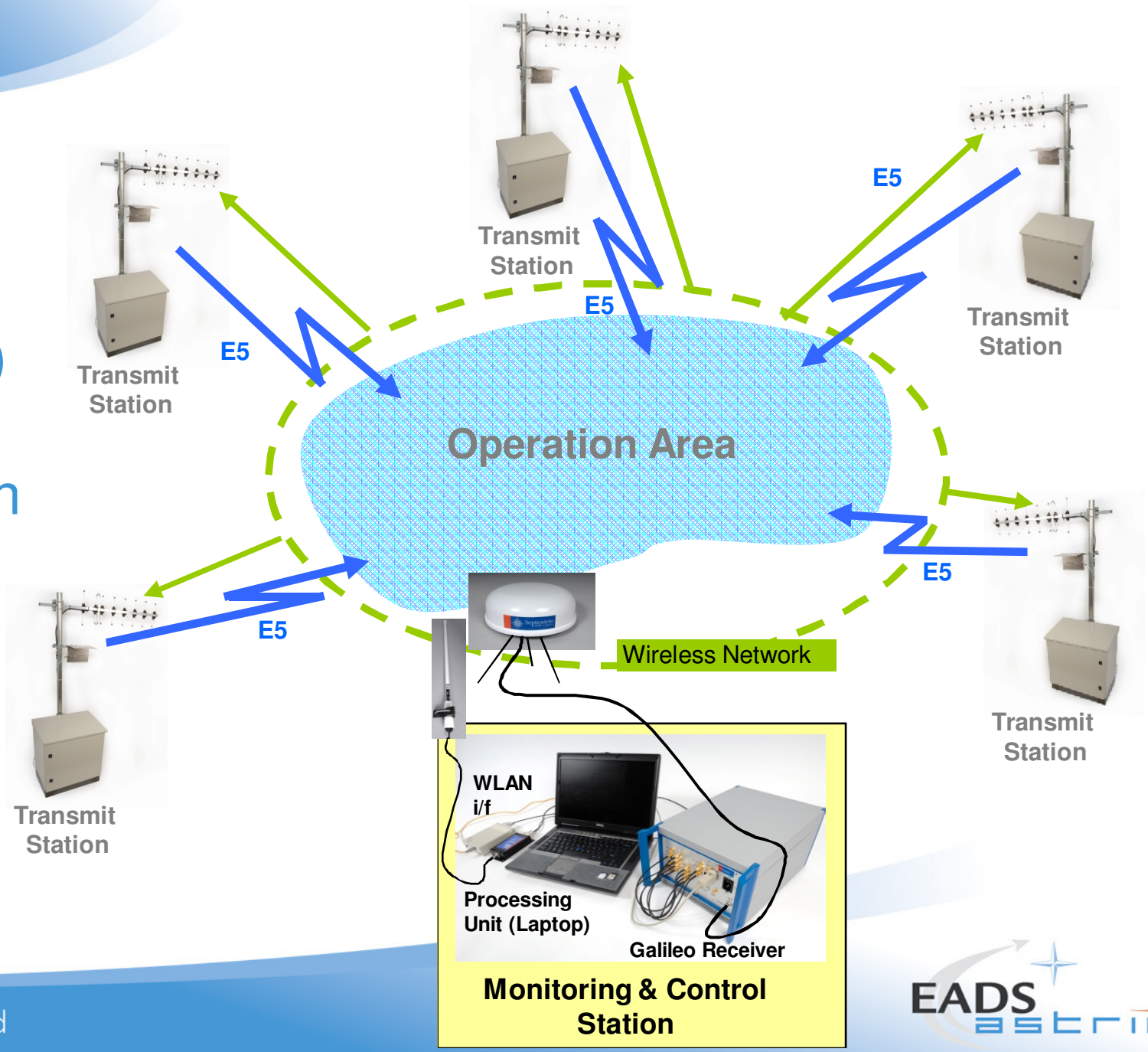
Concept for (demo of) Harbour Navigation System



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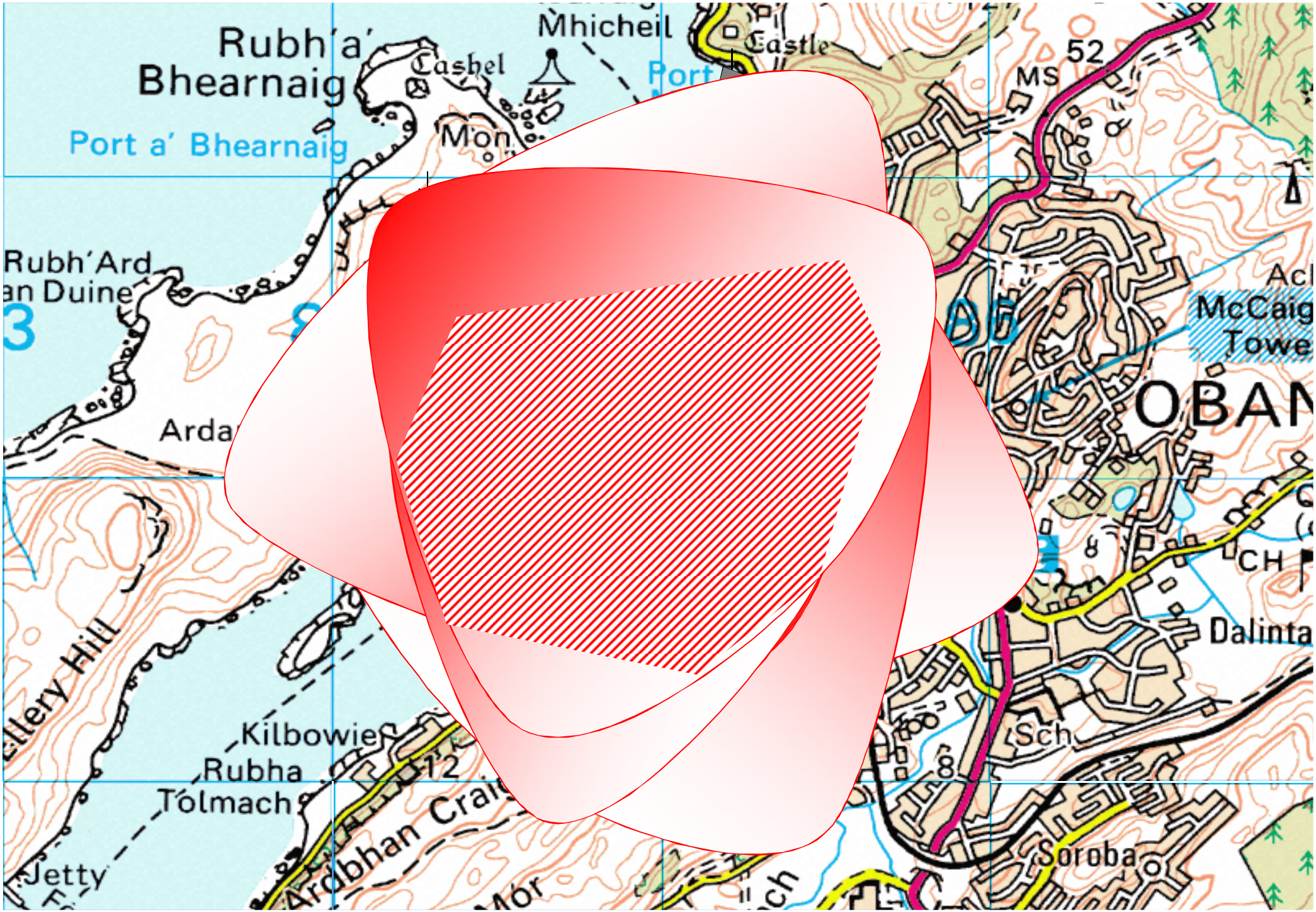
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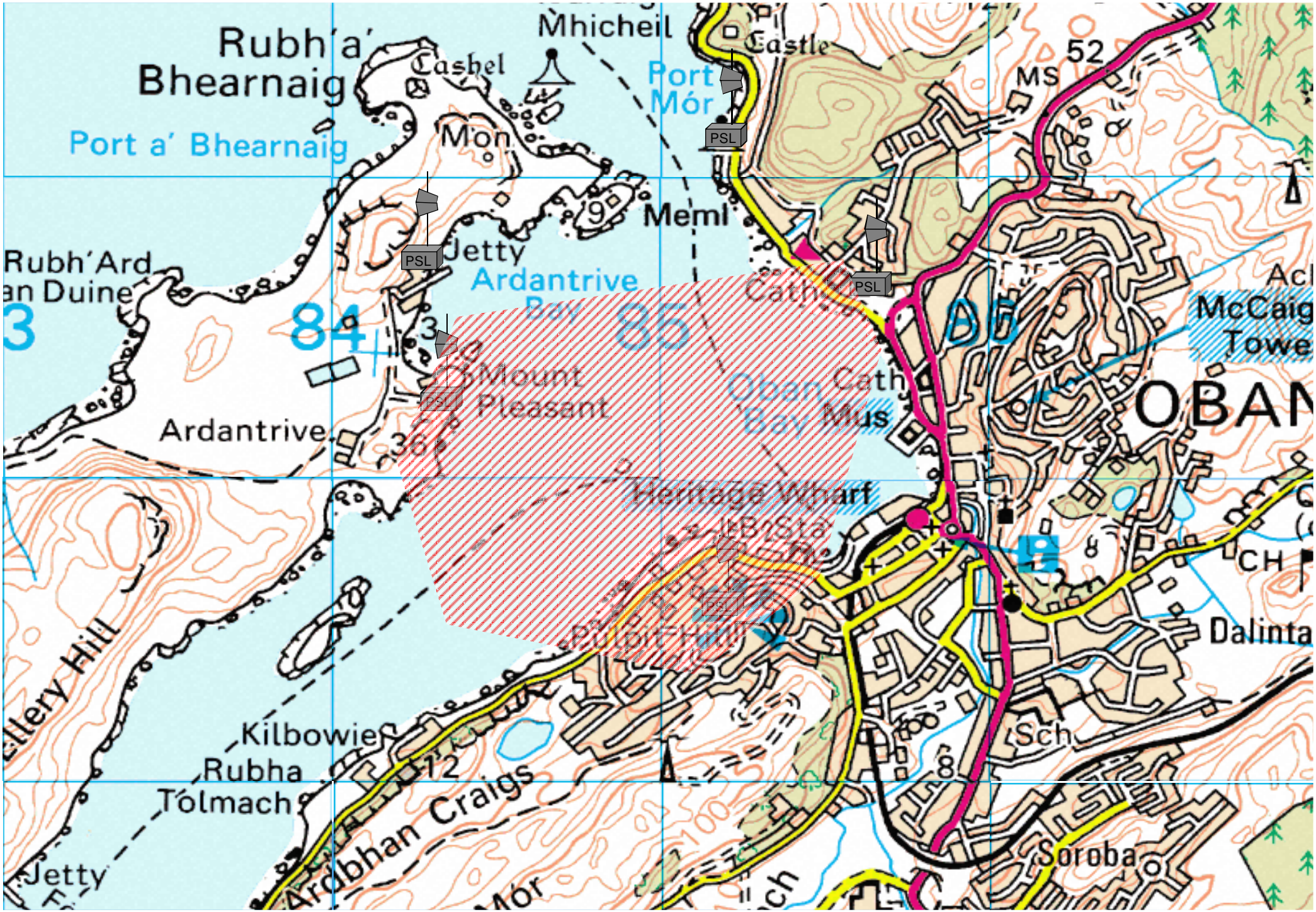
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Ardantrive Bay
Ardantrive
Mount Pleasant
Cath
OBAN
Heritage Wharf
Dalinta
Kilbowie
Rubha Tolmach
Ardbhan Craigs
Soroba
Jetty

Pseudolite Transmit Station

- Broadcast ranging signal & data
  - SIS characteristics based on Galileo (GIOVE B) E5
  - AltBOC combination of E5a (data+pilot) & E5b (data+pilot)
- Commanded from M&C via WLAN Comms
  - Configuration & Functional Commands governing choice of PRN code, and contents of Nav message
  - Frequent updates of Nav data (50s cycle) in order to support synchronisation of multiple PSLs with “cheap” OCXO Clock
- Synchronises to External GNSS device
  - Bespoke Frequency Generation Card
  - Synchronises Stable Local Oscillator (SLO) to external GNSS reference
  - Basis for generation of carrier frequency, PRN code chipping rate and Nav message symbol rate

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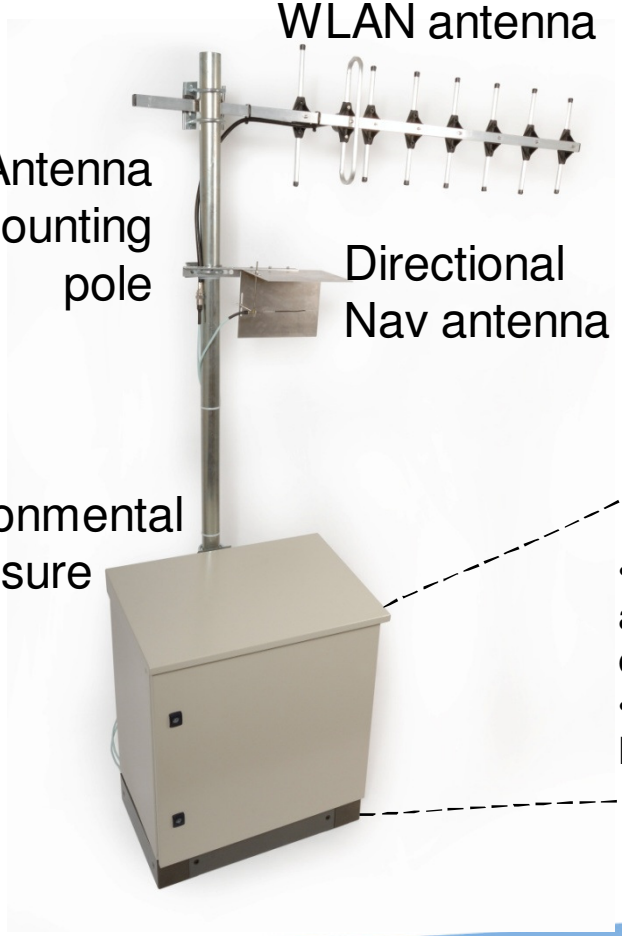
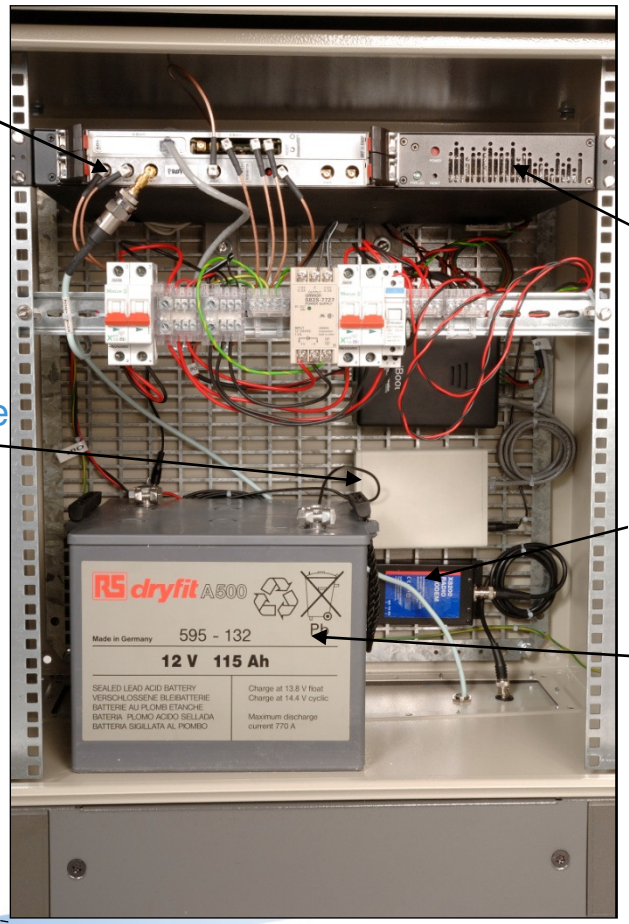
Pseudolite Transmit Station – Physical



- All equipment (except antennas) housed in environmental enclosure
- Rack mounting with cPCI BUS connectivity



Interior

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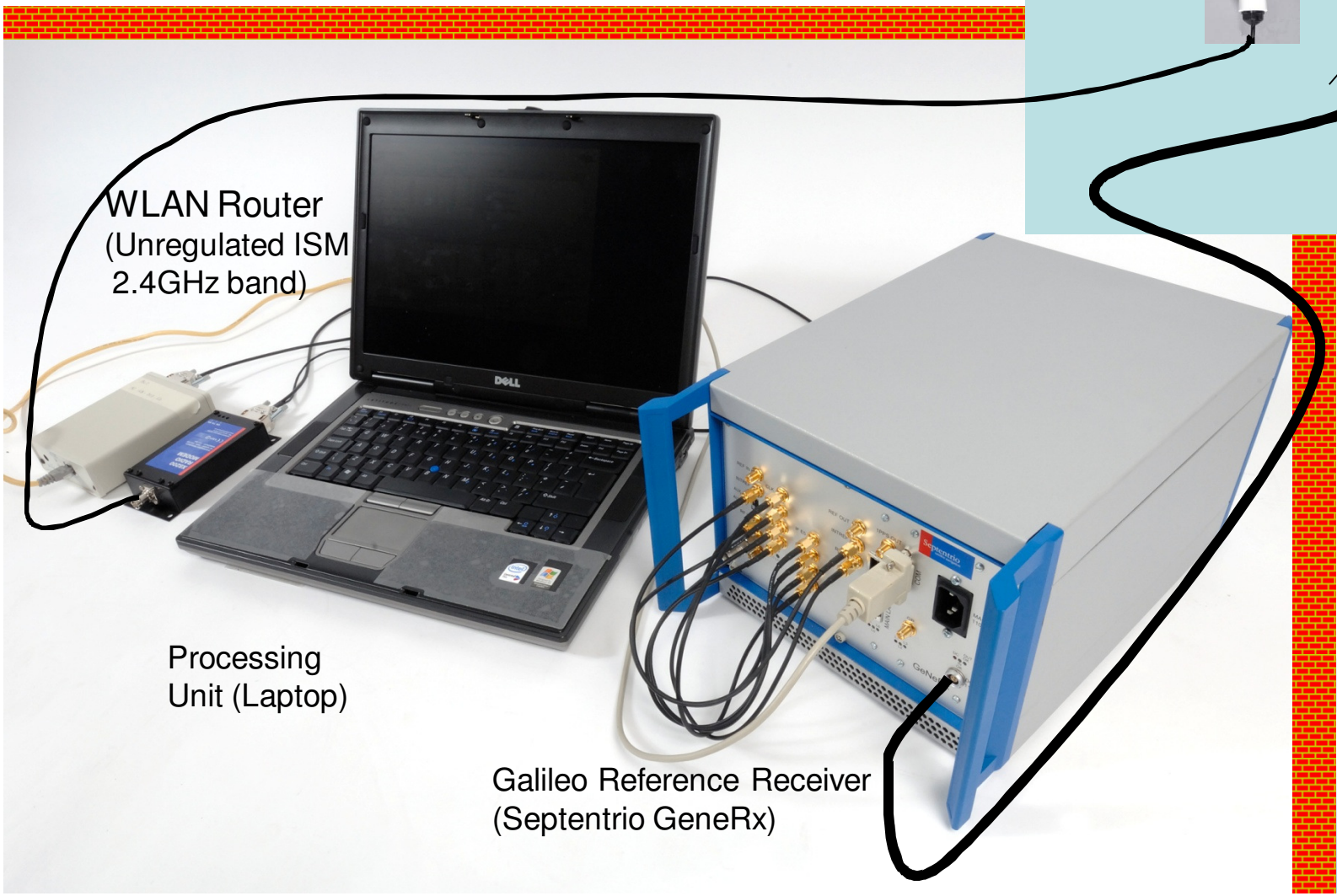
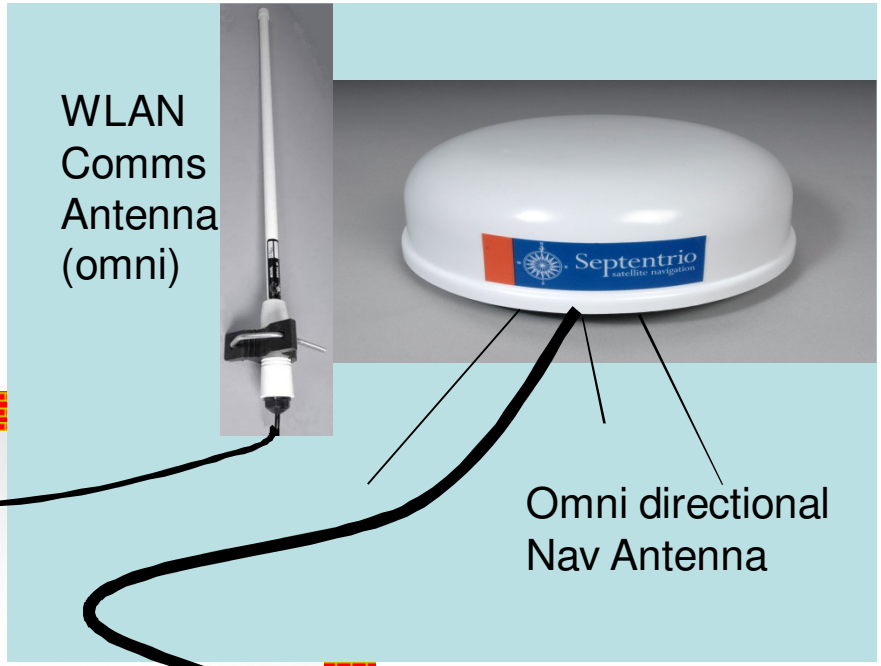
M&C Station – Physical





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EADS Astrium Signal Generator Specs (Next Generation, New Apps)

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Specification

Output signals/frequencies (switchable)

• E5ab	@ 1191.795 MHz
• L1	@ 1575.42 MHz
• E6	@ 1278.75 MHz
• Doppler Range	± 10kHz
	in steps of 1 mHz

(Internal OCXO may also be locked to external 10 MHz frequency standard)

Signal Level

• Nominal	NSG 5100H: -45...0 dBm
	NSG 5100L: -75...-30 dBm
	-122 dBm may be reached by additional attenuator
• Resolution	1 dB
• Pulsing	RTCM, RTCA, user definable

Signal Content

• Ranging Codes	user programmable memory-based
• Primary Code	
• Secondary Code	
• Code Chip Rate	configurable

NSG 5100, GNSS Signal Generator

Features

- Supports Galileo*, GPS, EGNOS and WAAS signals
- Programmable memory based ranging codes
- Configurable message data rates
- User definable transparent messages
- Signal and user dynamics fully configurable
- Standard interface for control

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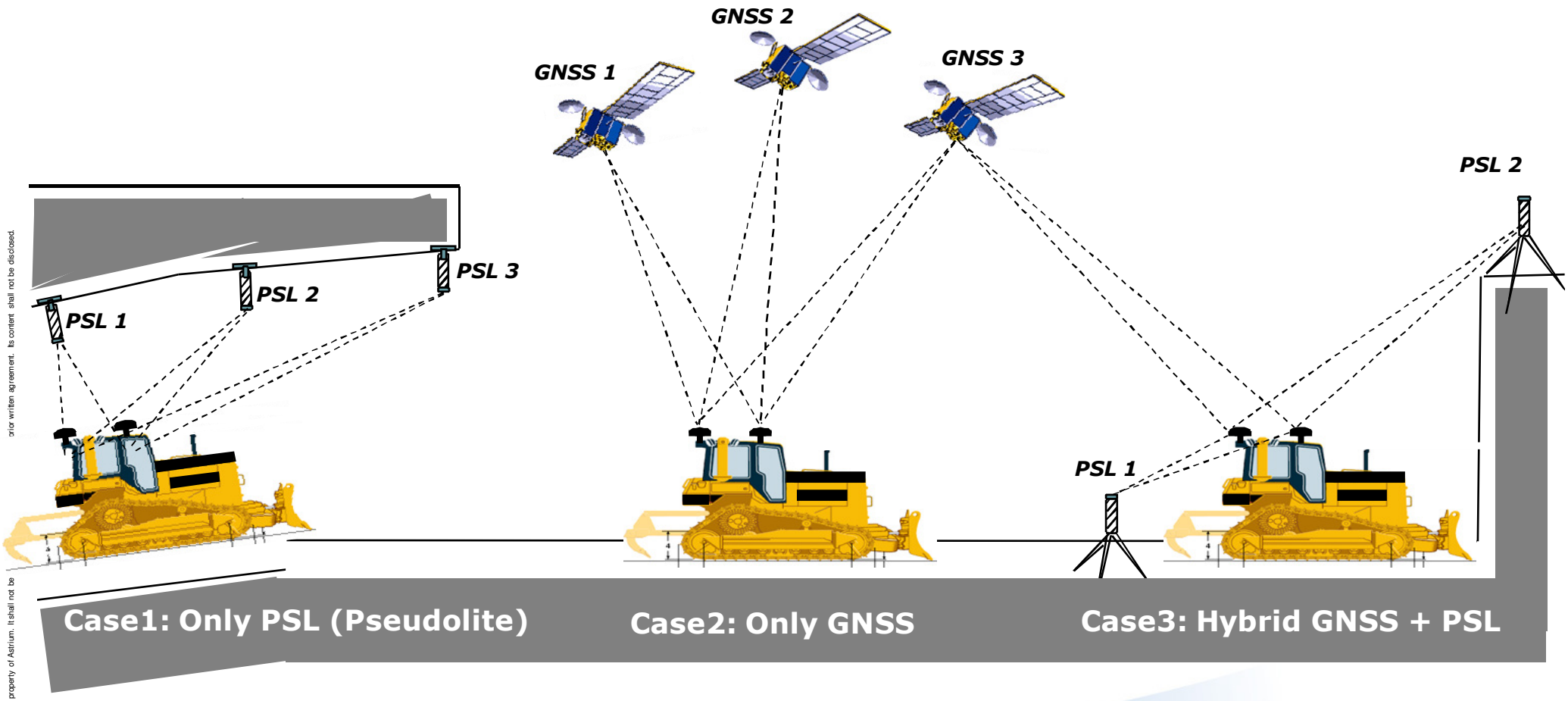
Indoor/Obstructed GNSS-RTK Machine Automation



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Indoor/Obstructed GNSS-RTK Machine Automation

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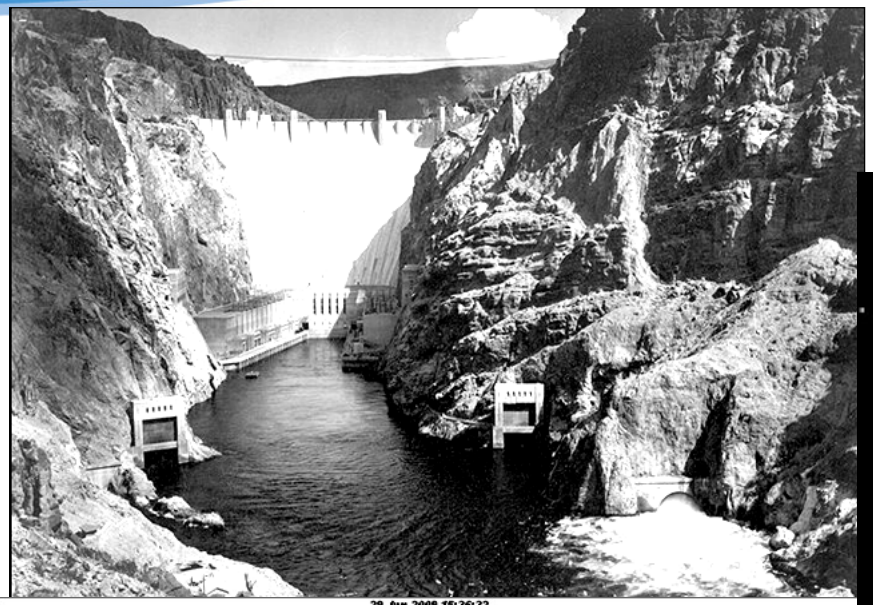
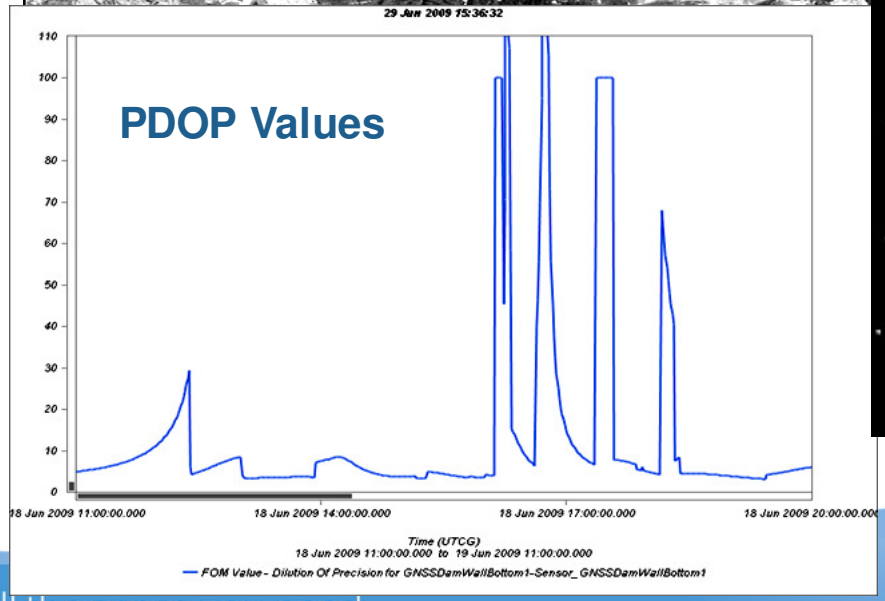
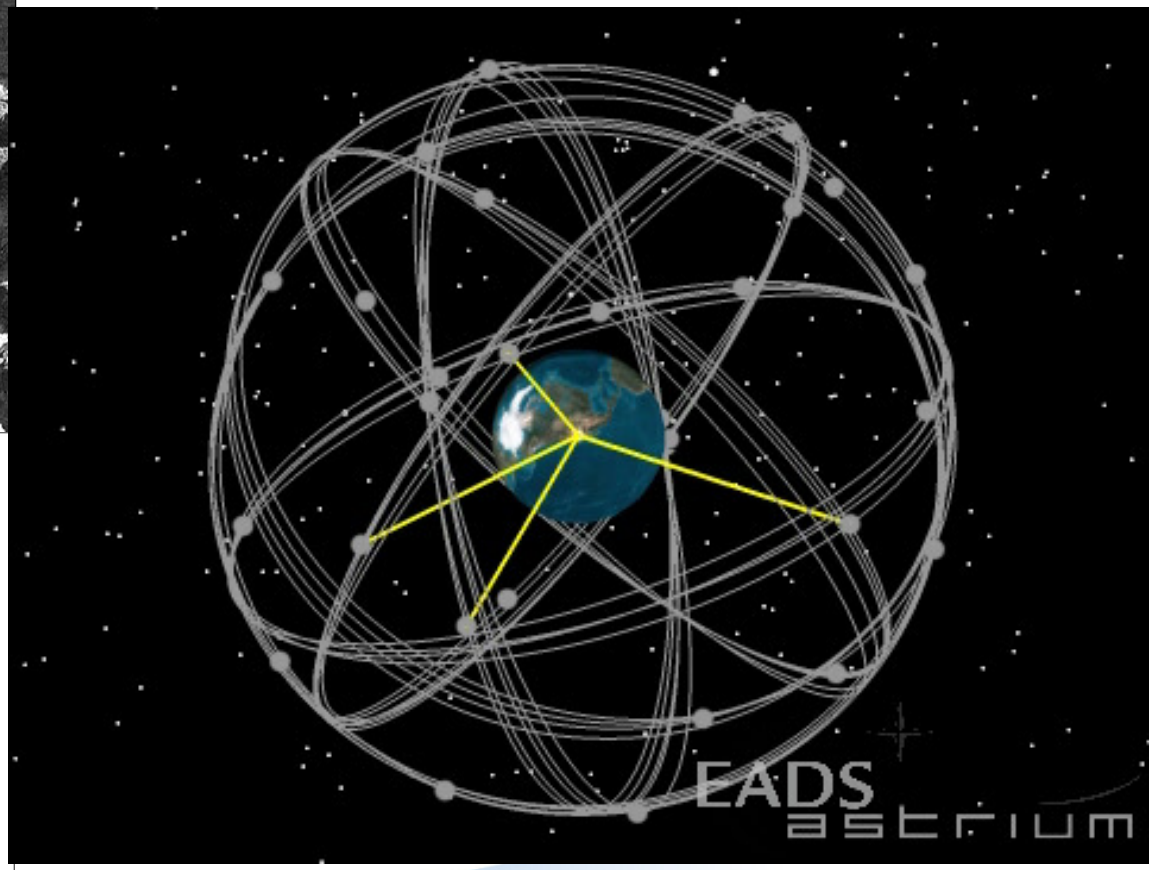
Dam Monitoring Simulation Studies







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Bridge Monitoring Simulation Studies

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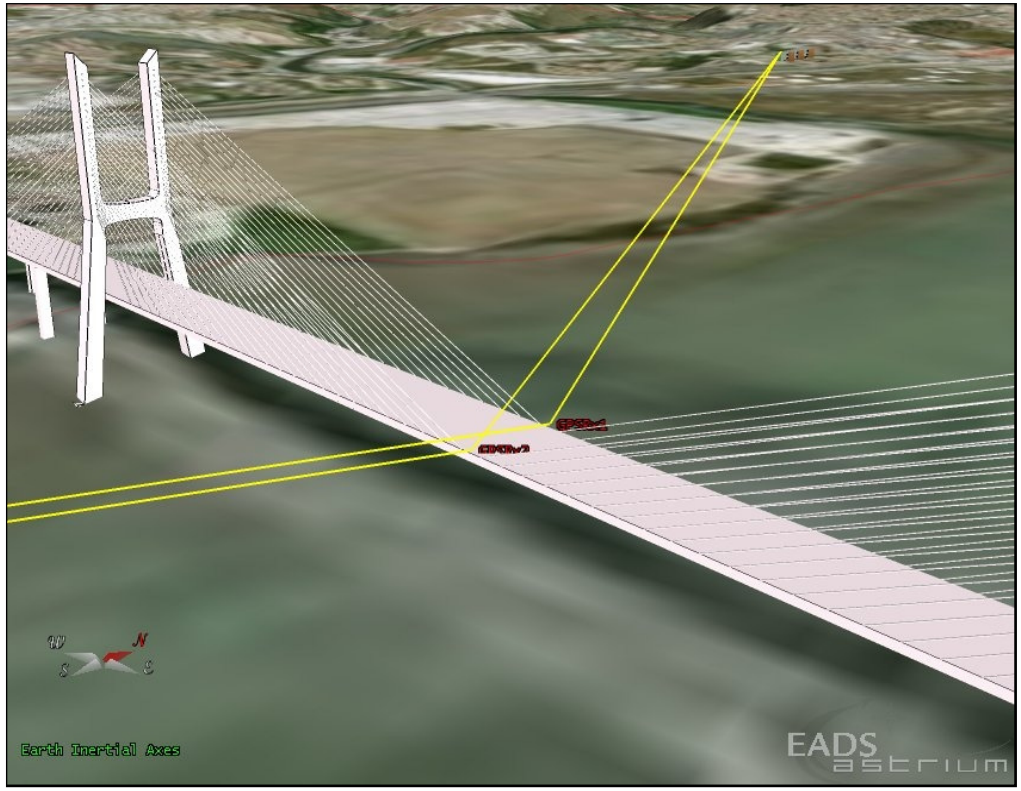
Bridge Monitoring Simulation Studies



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Conclusions

Augmentation of just 2-3 Pseudolites can provide RTK solutions during periods when there are not enough satellites to obtain a valid 3D position

Pseudolite signals, although noisier than satellite signals, provide a dramatic increase in the constellation geometry, thus bringing immediate benefits to the RTK filter quality (precision), and performance (convergence time)

After an initial calibration of Pseudolite static multipath bias, and power-level (dependent on their optimal location assessment), and based on simulations, it is possible to improve the accuracy and continuity of GNSS-based monitoring!

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Thank you for your attention
Any Questions?

Luis Serrano, Dipl.-Ing., PhD Candidate
Senior Navigation Systems Engineer
luis.serrano@astrium.eads.net

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