WP7
Integrity Monitoring

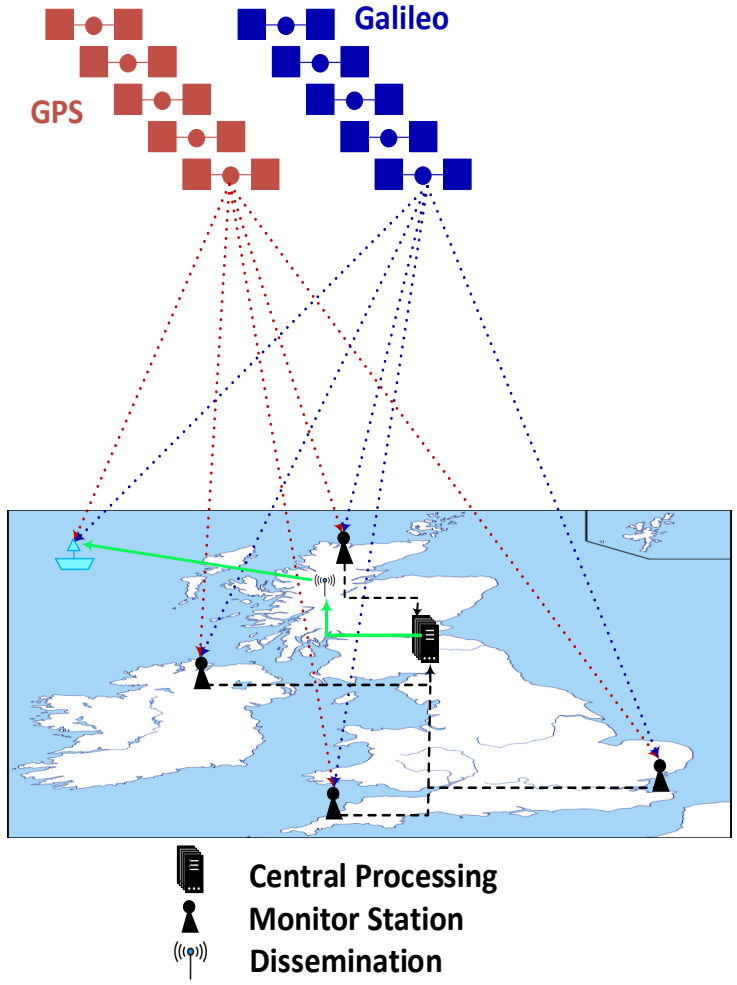
Independent Integrity Assurance for Dual Frequency Multi Constellation Users

The Challenge

- Satellite navigation signals are available from multiple GNSS constellations and at various frequencies
- GNSS position information comes with an accuracy forecast, but without integrity guarantee or instantaneous alert mechanism
- Availability of PNT solution to the mariner will depend on which signals are being exploited, and how they are being combined
- This choice also determines which types of supplementary assurance of the GNSS broadcast information will be available to the mariner

	Integrity Assurance	Availability/Continuity
GPS single frequency	Mariner receiver's RAIM, ARAIM	Constrained in regions of great ionospheric variability
EGNOS V2 Open Service (GPS L1)	No legal guarantee available	Limited ionospheric coverage at sea
Dual frequency multi-constellation (DFMC) GNSS	Mariner receiver's RAIM, ARAIM	Large number of signals, with ionospheric delays eliminated
DFMC GNSS augmented by Integrity Monitoring	Mariner receiver's RAIM, ARAIM supported by integrity guarantee on the information broadcast by GNSS satellites	Large number of signals with ionospheric delays eliminated

The Vision



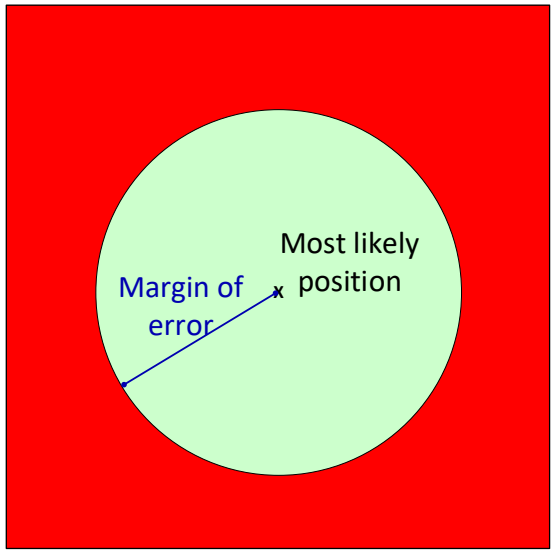
Provide a UK DFMC Integrity Monitoring Service

- Notifying alarms on GNSS satellite status (broadcast position or clock, signal, etc.) within tight time to alarm
- Allowing dual frequency multi-constellation user receivers to pre-select assured GNSS satellites for positioning
- As part of a system of systems approach to integrity

Design of the Service

- Precisely surveyed Monitoring Stations (GNSS Receivers) take GNSS dual frequency measurements across the UK
- Central Processing uses the collected measurements to monitor and mitigate those types of GNSS error which are best detected centrally
- Integrity information is disseminated to mariners via a range of channels and technologies

The DFMC Integrity Monitoring Service



- The precise definition of the significance of alarms from an DFMC Integrity Monitoring Service is critical so that the maritime user (or their receiver algorithms) can be confident information is not misinterpreted.
- The statistical nature of environmental physics and engineering dictate that no position information will ever be absolutely accurate:
  - Each position will be associated with a margin of error reflecting background noise levels
  - Whichever margin is set, there will remain an integrity risk, that is, a residual probability of exceeding the determined margin of error
- Specification of the DFMC Integrity Monitoring Service therefore requires setting accuracy, availability and integrity margins:
  - An alarm for a GNSS satellite shall be generated if and only if the inclusion of the GNSS Satellite in a user position fix may result in the user being misled
  - Underlying definition of margins and probabilities need to reflect operational use and expectations
- The DFMC Integrity Monitoring Service will not monitor or assure the maritime user's timing accuracy.

Study Goals

- Main goals of the study are:
  - To demonstrate that a central DFMC Integrity Monitoring System is able to detect satellite faults
  - To complete the trade-offs between accuracy, availability, continuity and integrity
- The challenge consists in that faults occur extremely rarely; tails of error distributions are not necessarily intuitive; statistically significant numbers of fault conditions will not be found in real data
- On the other hand, real observations must be taken into account so that modelled faults and background noise are representative of real behaviour within a realistic context
- Proof-of-concept testbed:
  - Starting from real, UK based GNSS observations
  - Inject into the data the identified fault conditions against which we expect to protect at system level
- This will quantify the magnitude of satellite fault which is detectable by a UK based DFMC Integrity Monitoring System and illustrate how availability may be reduced by stricter integrity and accuracy requirements