Providing GNSS Augmentation Data:

A Commercial Service Provider's Perspective

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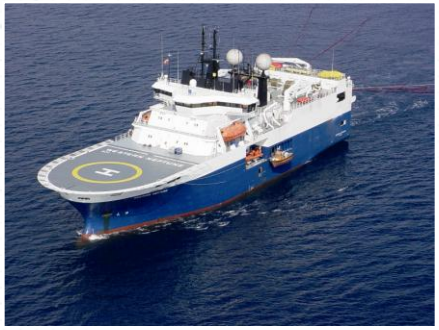
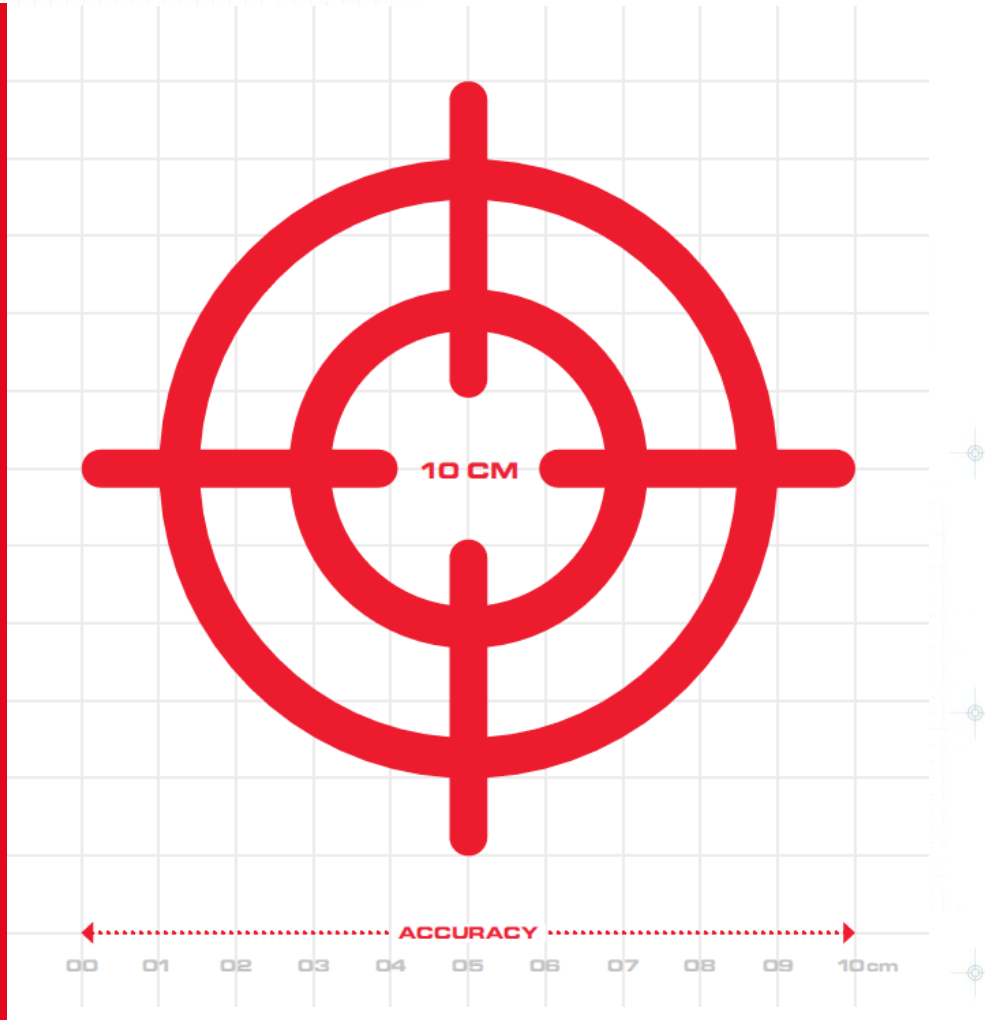
Topics



- Ground Infrastructure
- Augmentation Services
- Message Types
- Service Delivery
- Standards
- Conclusions

Infrastructure

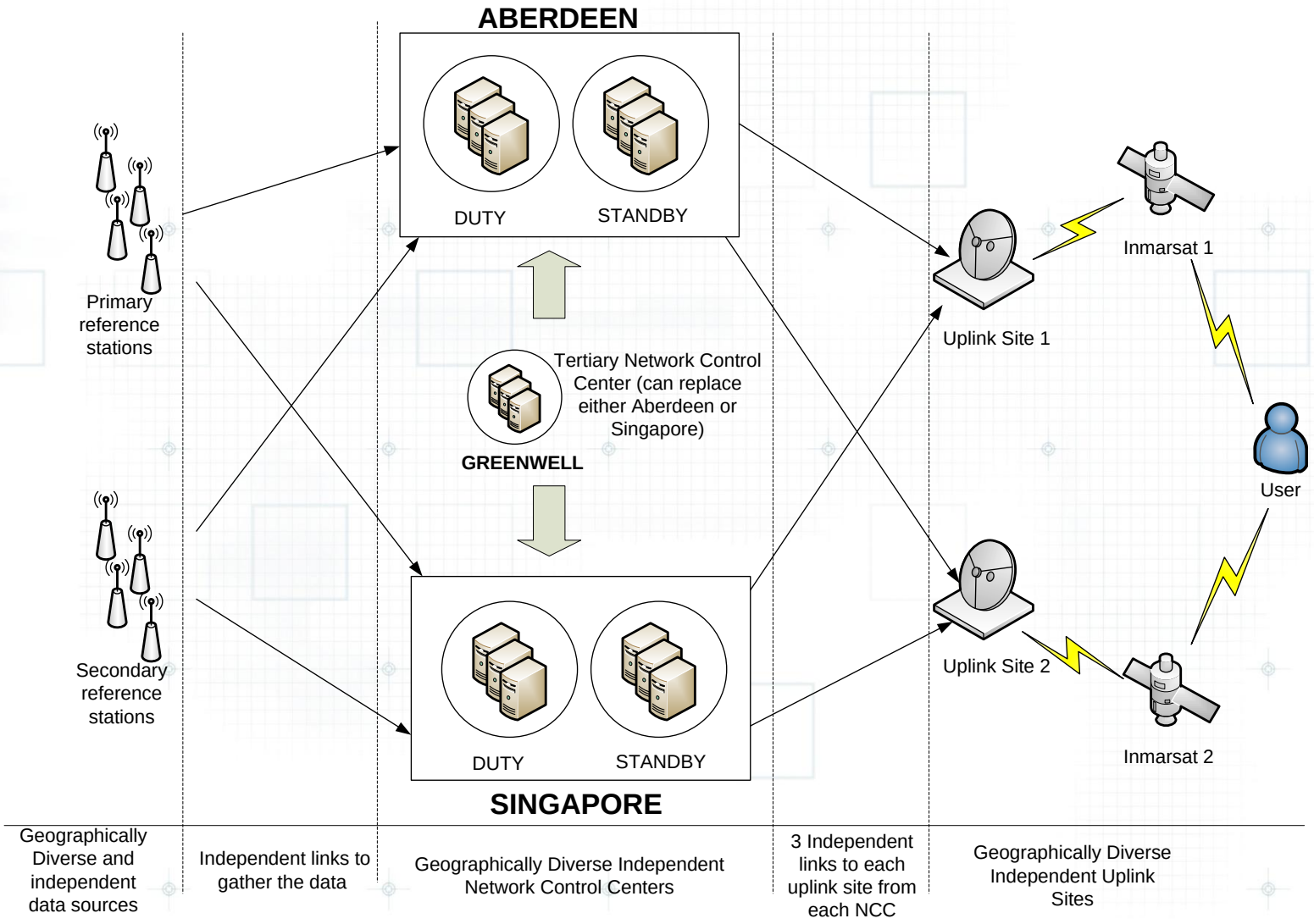
GNSS Stations
Central Processing
Broadcast Channels
Control Centres



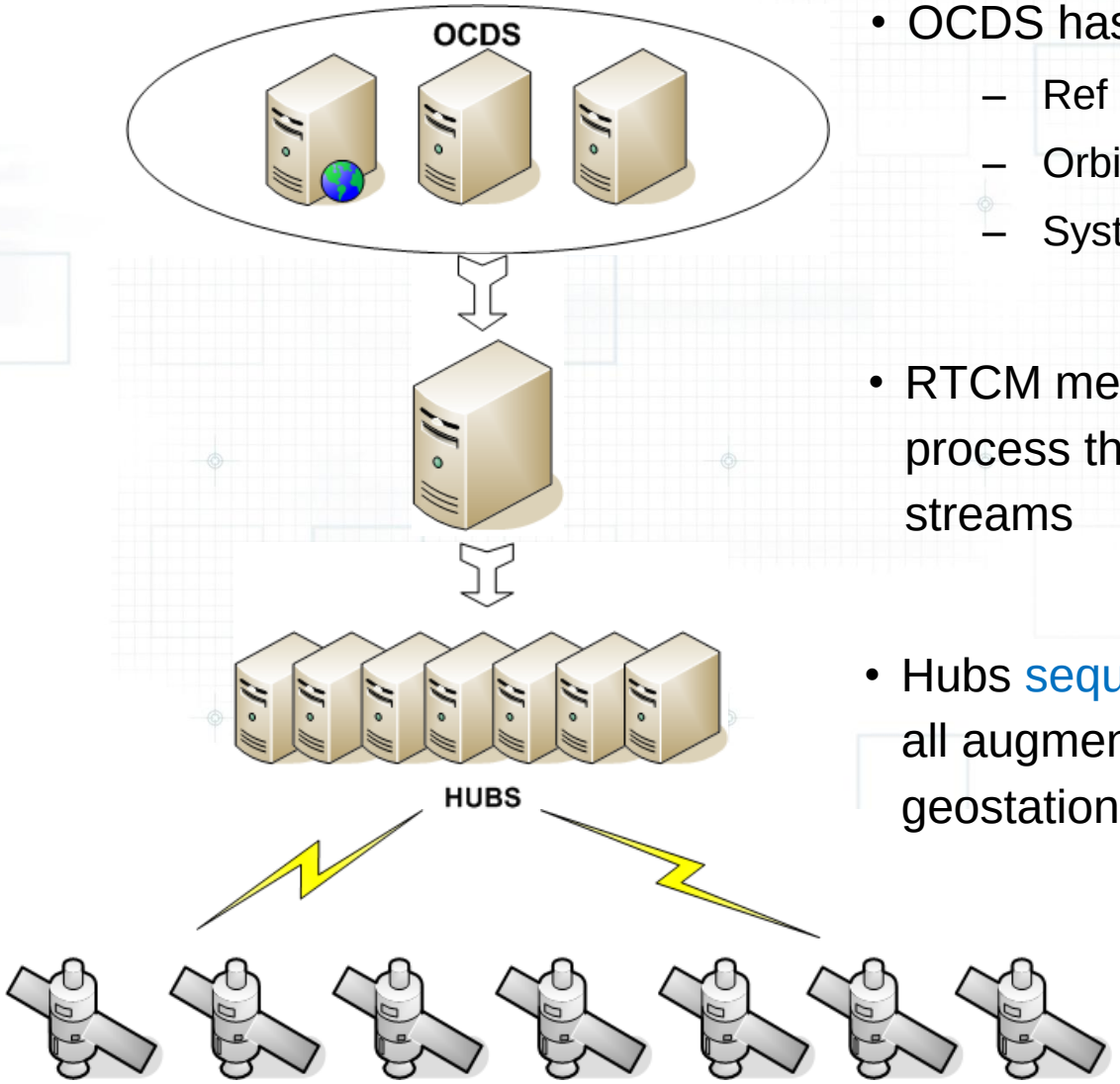
Infrastructure – Station Network

- +/- 75 reference stations
- Each have 2x GNSS Receiver & 2x Antenna and redundant IP connections
- +/- 45 stations track GPS & GLONASS

Infrastructure – Orbit & Clocks

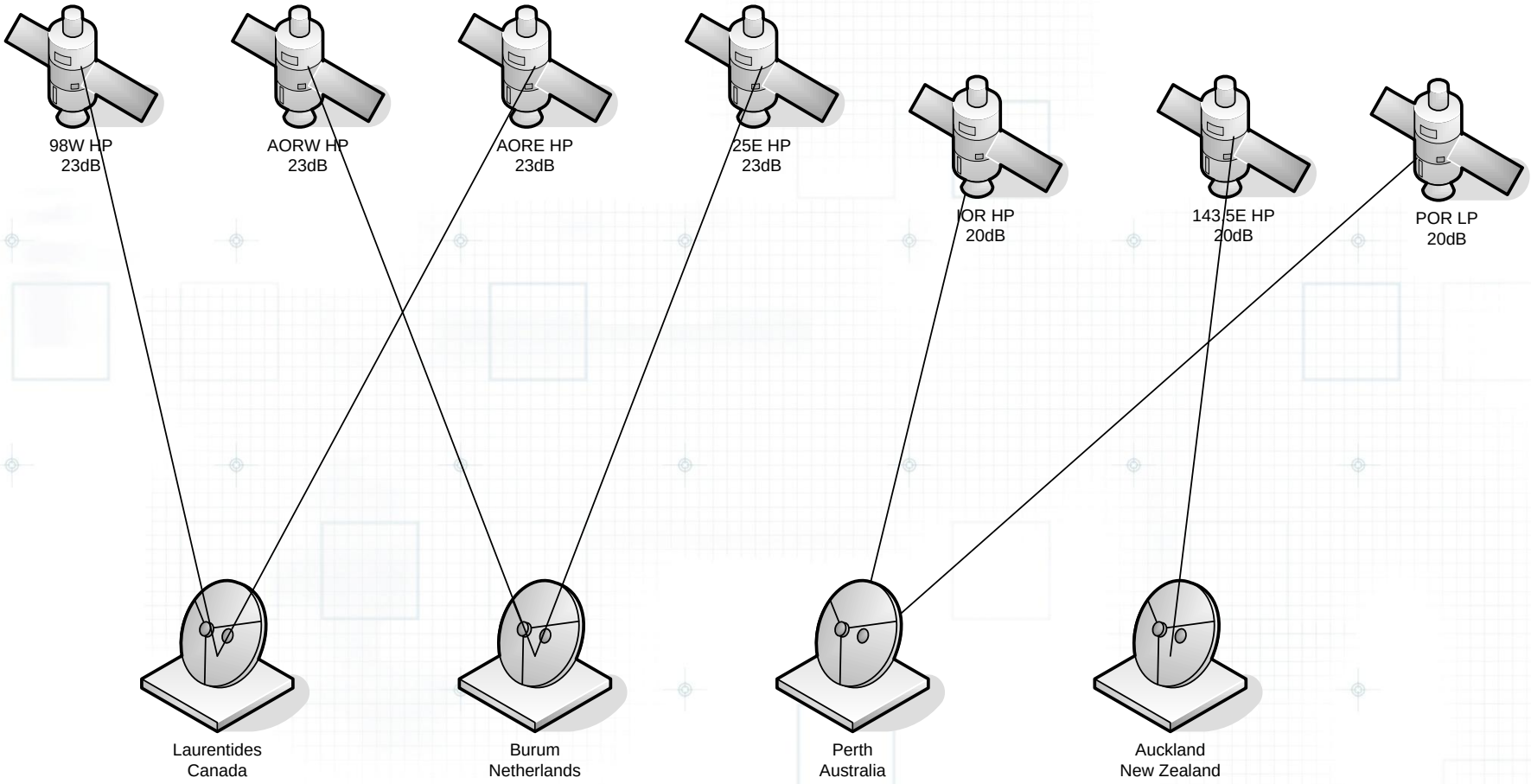


Architecture – Orbit & Clocks



- OCDS has 3 components
  - Ref station raw data management
  - Orbit and Clock determination
  - System Control & Monitoring
- RTCM message formatter required to process the multiple formats and streams
- Hubs sequence the correction data for all augmentation services and send to geostationary satellite uplink sites

Infrastructure – Correction Broadcast

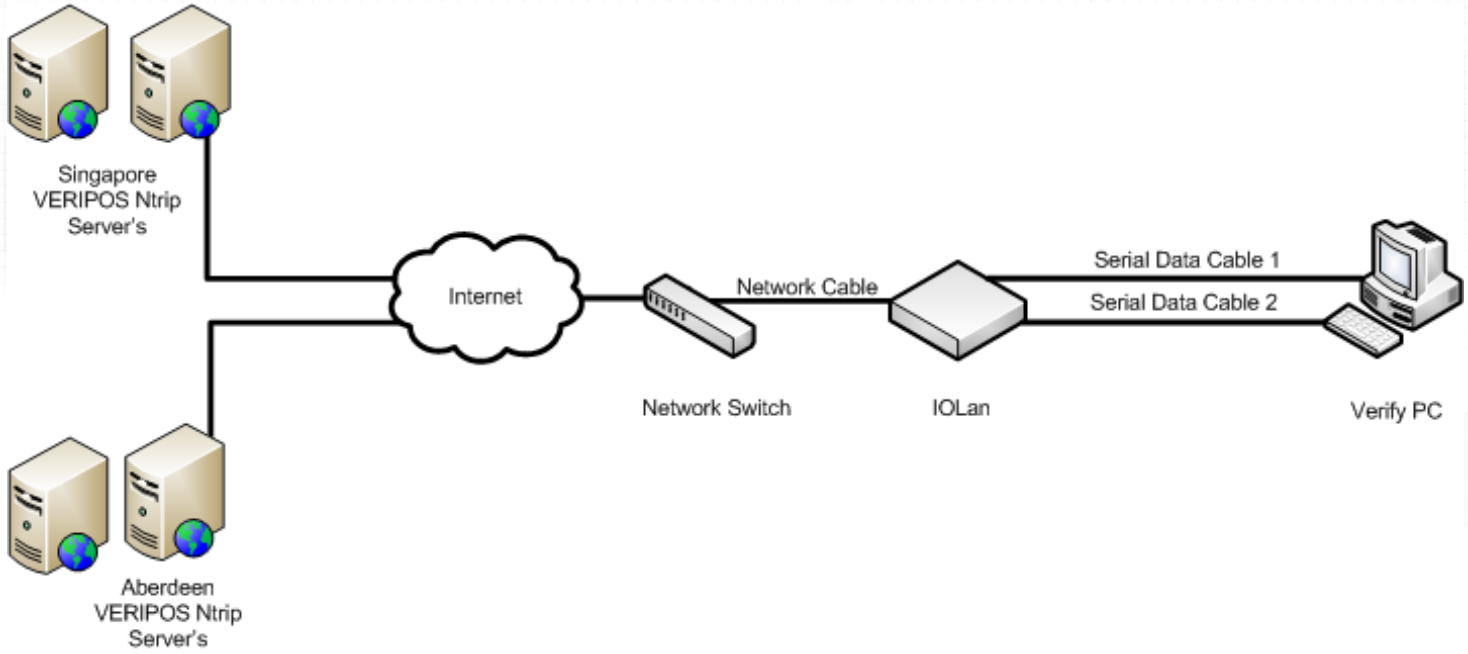


Correction broadcast via:

- 7 Geostationary Communication Satellites
- 4 different Earth Stations

Infrastructure - NTRIP

- Correction data distributed via NTRIP
- Available to existing subscribers as a back-up
- Dual redundant casters in Aberdeen and dual redundant backup casters in Singapore

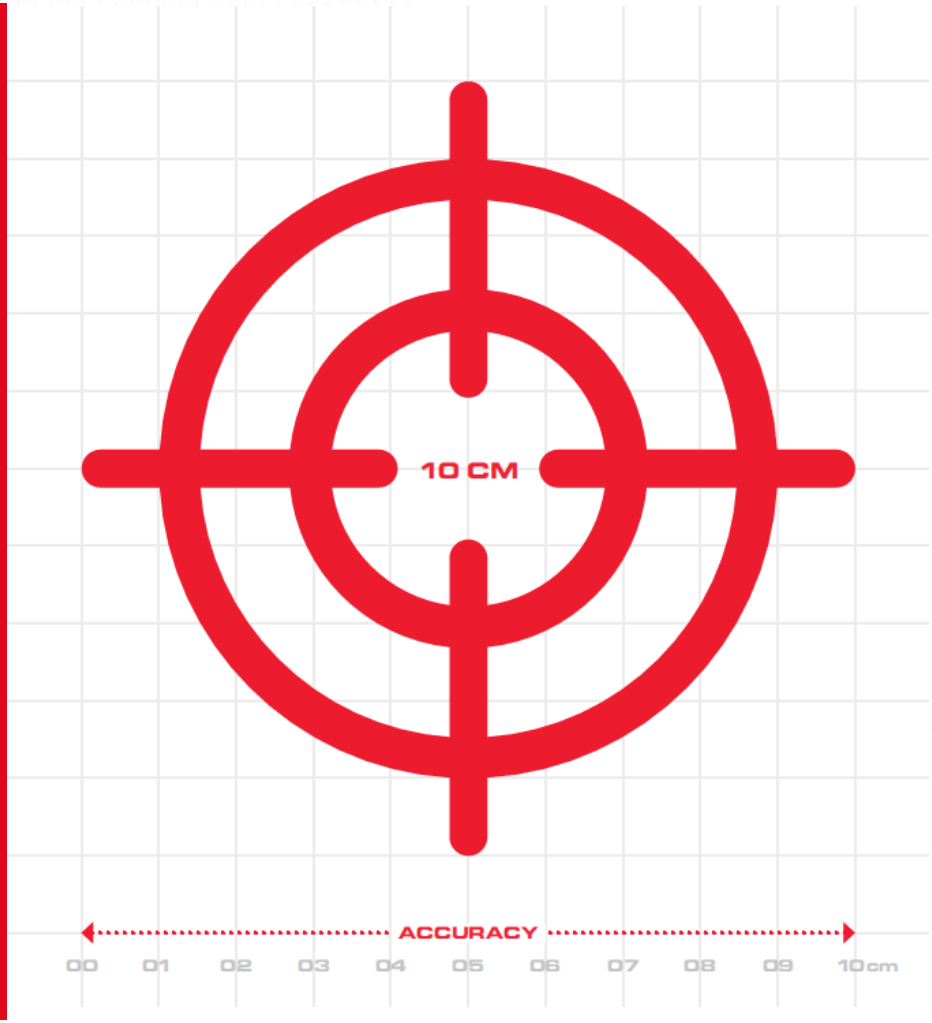


Infrastructure - Network Control Centres

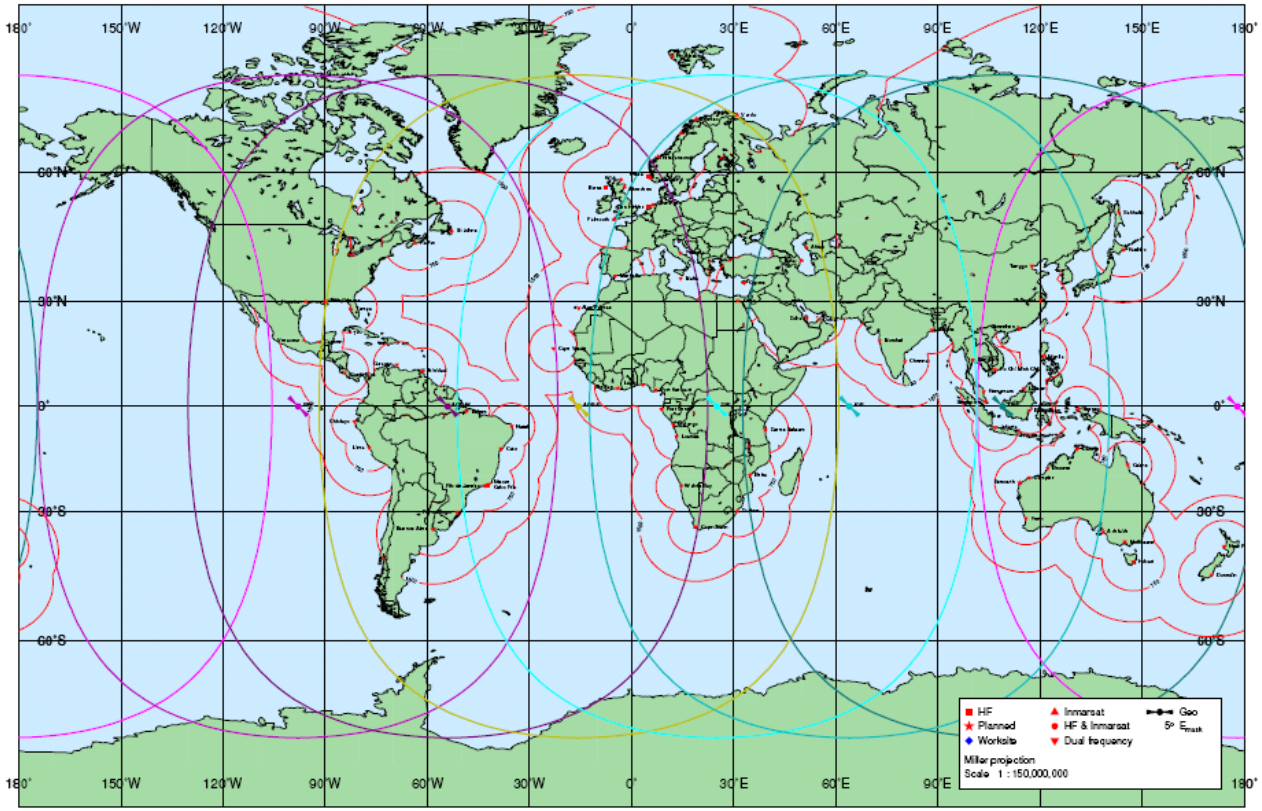
- **Primarily NCC in Aberdeen**
  - Fully redundant equipment
  - 24 Hour manned
  - Redundant communications links
  - Backup Generator power
- **Backup NCC in Singapore**
  - Fully operational
  - Backup Communications links
  - Monitored & Remote Controlled from Aberdeen
- Data switched at Earth Stations should primary NCC fail
- **Tertiary Backup** NCC now active

Augmentation Services

Standard
Standard+
GLONASS
Ultra²
Apex²



Global GNSS Augmentation Services



VERIPOS Standard **1m**

VERIPOS Ultra & Ultra^2 **0.1m**

VERIPOS Apex & Apex^2 **0.1m**

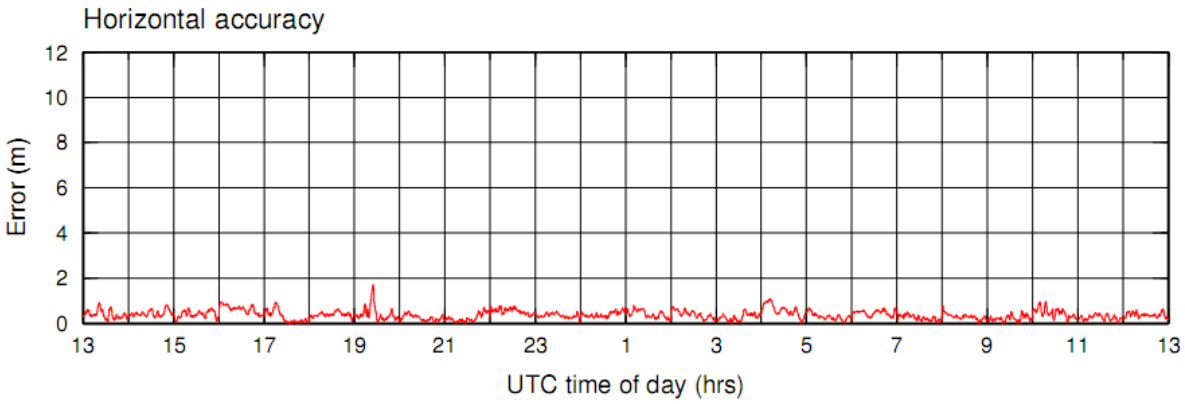
VERIPOS Standard Plus **1m**

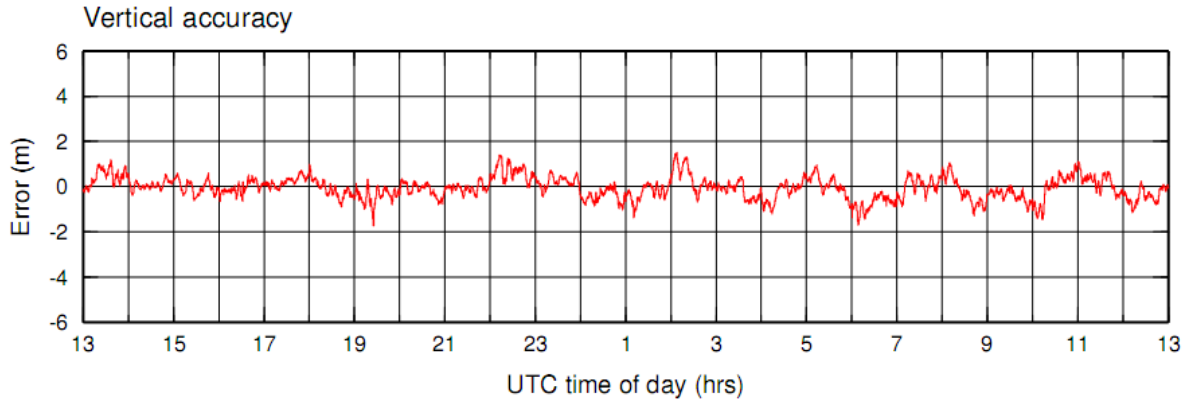
VERIPOS DGLONASS **1m**

VERIPOS Standard HF **1m**

VERIPOS Standard

→ ‘Traditional DGPS’





Multi-Station DGPS solution

Accuracy: Horizontal = 0.40m (2σ) Vertical = 0.97m (2σ)

L1 DGPS

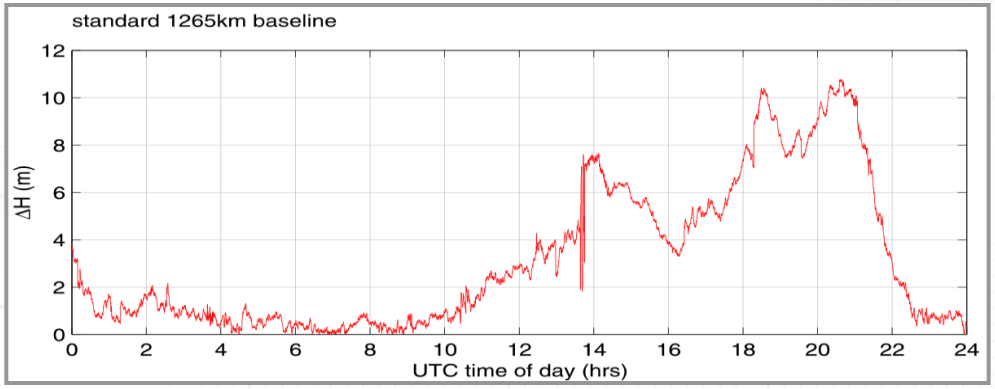
1m Accuracy

Global Coverage

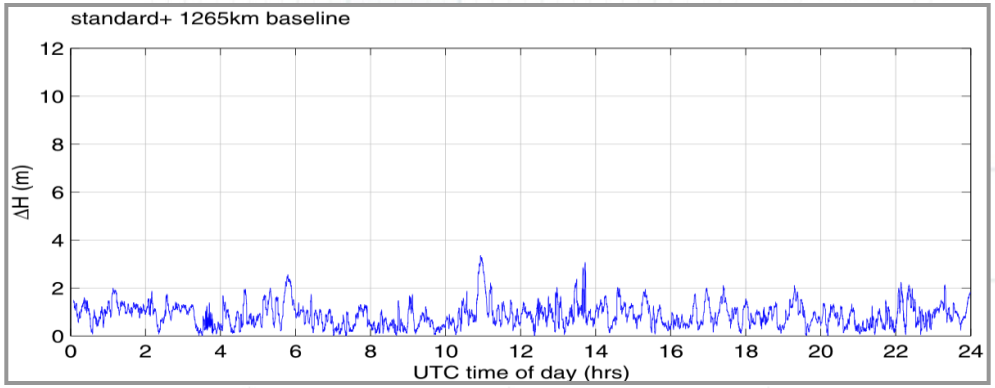
Single / Multi station

VERIPOS Standard Plus

→ Corrects for ionospheric delay



Without Ionospheric Correction



With Ionospheric Correction

L1/L2 DGPS

1m Accuracy

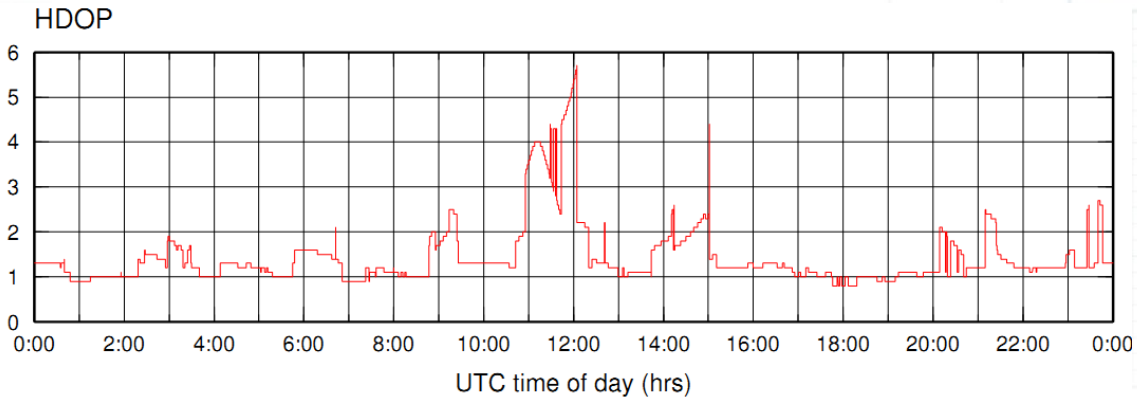
Corrects for Ionosphere

+/-30º around geomagnetic equator

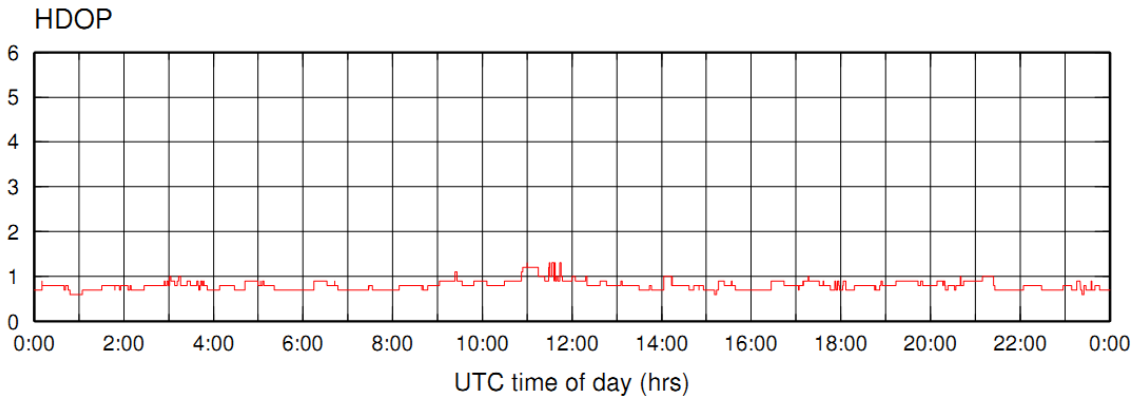
Single / Multi station

VERIPOS Standard GLONASS

- → Increases #SVs and reduces high DOP periods
- → Masking & scintillation environments



DGPS Solution



DGPS+GLO Solution

L1 DGNSS

1m Accuracy

32 GPS + 24 GLO

Regional Coverage

1/3th of stations

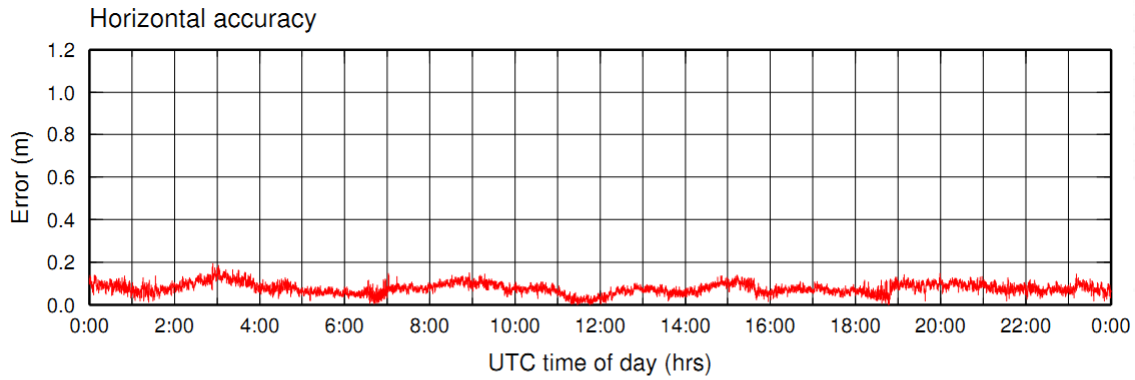
Single / Multi station

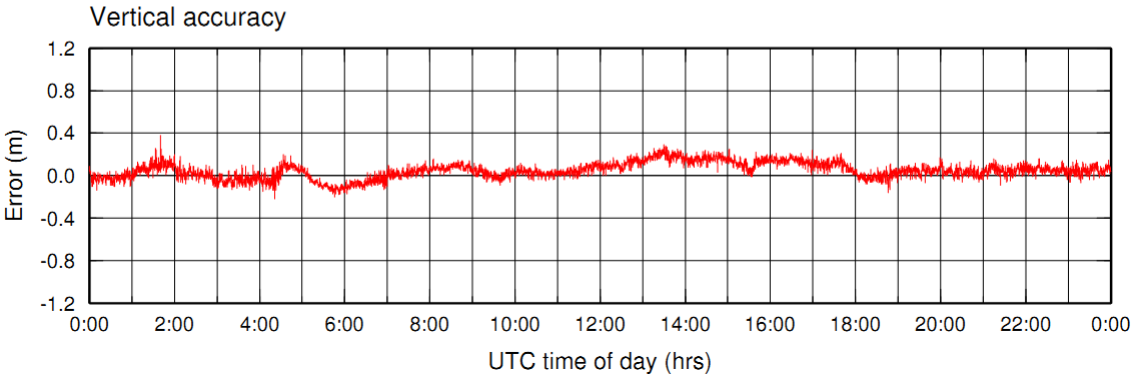
VERIPOS Ultra & Ultra²

→ Orbit & Clock corrections generated by **JPL**

→ GLONASS corrections allow a higher number of satellites to be used:

- improved convergence time
- aids in masking environments





L1/L2 PPP

10cm Accuracy

Global Coverage

Ultra: GPS Only

Ultra²: GPS + GLO

VERIPOS Apex & Apex²

→ Orbit & Clock corrections generated by **VERIPOS**

→ GLONASS corrections allow a higher number of satellites to be used:

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- aids in masking environments

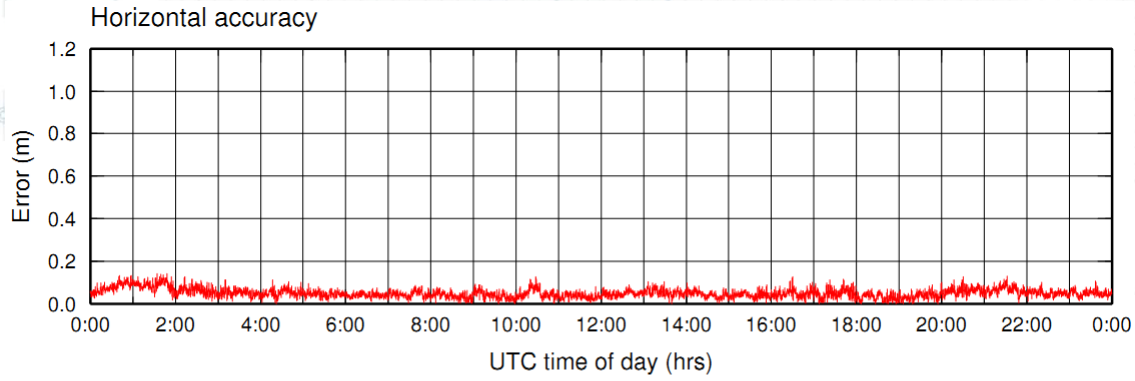
L1/L2 PPP

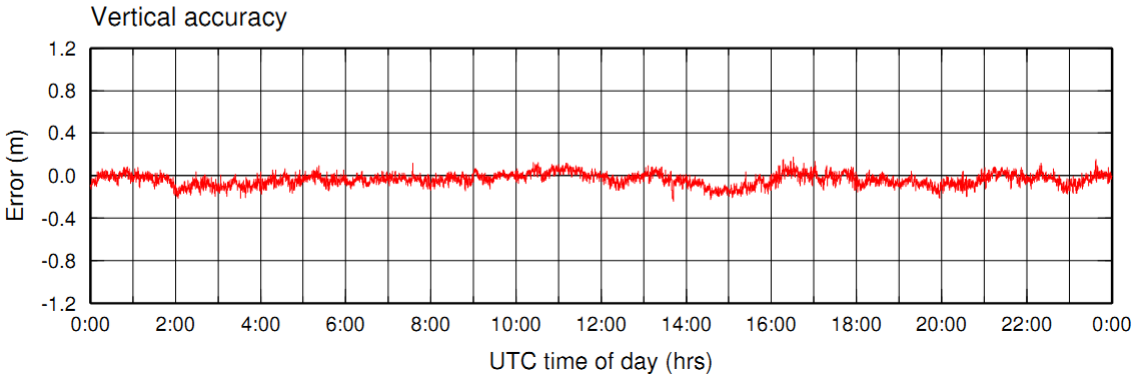
10cm Accuracy

Global Coverage

Apex: GPS Only

Apex²: GPS + GLO





VERIPOS Standard HF

L1 DGPS

1m Accuracy

700Km range from station

Non line of sight

Coverage:

Areas in Europe, Mexico, Brazil

Used in:

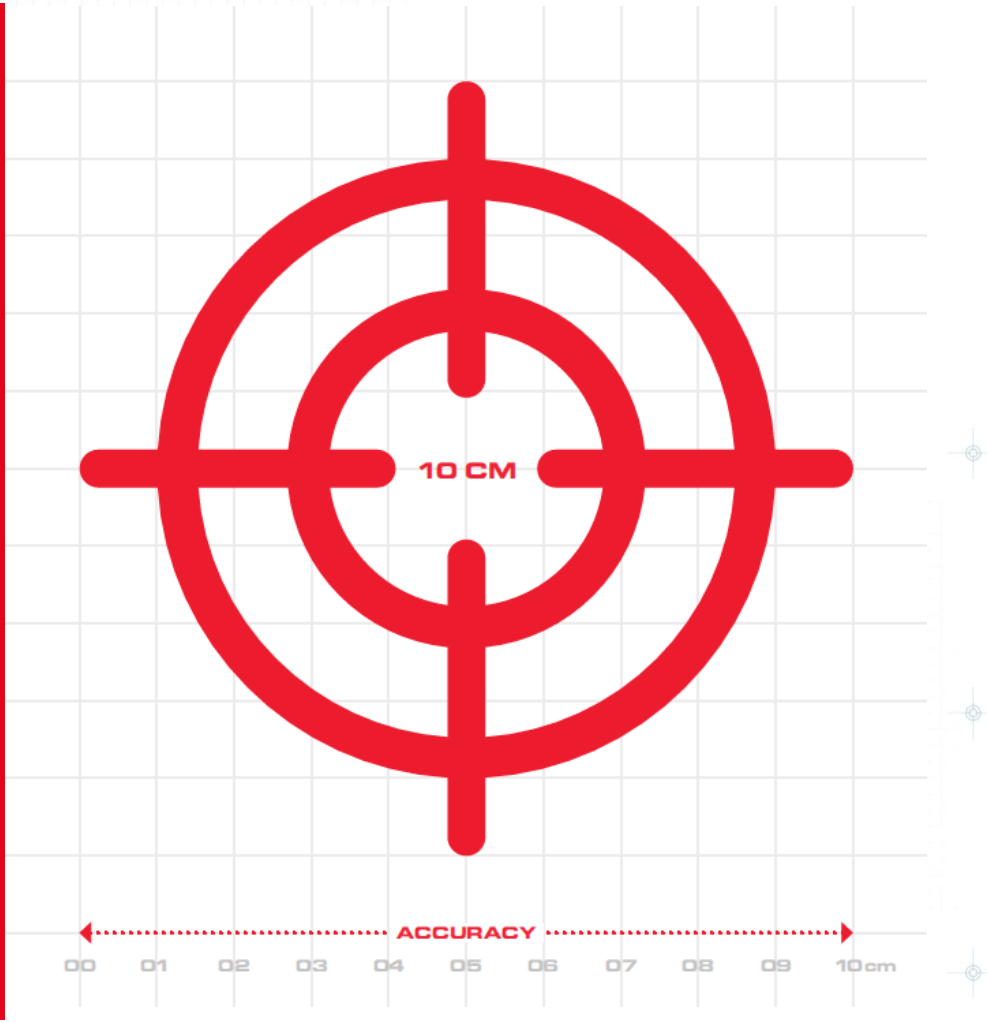
Confined / masked locations

extreme northerly ops

Message Types

&

Service Delivery



Message Types

- Use RTCM v2.2 messages for:
  - ‘Standard’ *Type 1 & 3*
  - ‘Standard Plus’ *Type 15*
  - ‘Standard GLONASS’ *Type 31 & 32*

- Use ‘Undefined’ Message Types for proprietary services:
  - Apex GPS *Type 50 & 51*
  - Apex GLO *Type 38 & 39*
  - Ultra GPS *Type 44*
  - Ultra GLO *Type 48 & 49*

Proprietary Message Types

Why define proprietary messages?

1. No PPP messages were defined in RTCM v2.1-v2.3 when services were developed
2. Minimise bandwidth requirement
   - Send small messages often (e.g. clocks)
3. Optimise the compatibility between ‘server’ and ‘client’
   - Orbit & Clock server handover
   - Keep control over future enhancements
4. Access control: technical restriction on who can use the services
5. Primarily used within VERIPOS products only

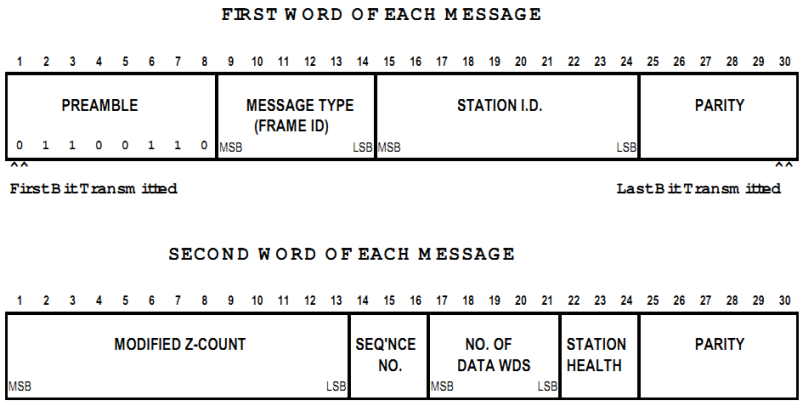
Downsides?

1. 3rd party implementers need to write a dedicated message decoder

   (not been a big issue so far)

Service Delivery - what is important???

- Minimise use of bandwidth:
  - L-Band satellite link supports 1200bps
- Scheduling of data for different services via one channel:
  - We send Type 1, 3, 15, 31, 32, 50, 51, 38, 39, 44, 58, 49
  - Each message type needs to update in an optimum interval
  - Some messages have a fixed broadcast interval (e.g. PPP clocks)
  - Other messages are interweaved
- Update interval per service:
  - Minimise time-to-first-augmented-fix
- User access control:
  - Access to services is controlled on a message-by-message basis



Bandwidth

- Satellite bandwidth is expensive.....
- Offering marine users dual links everywhere means we have 7 links
- Every bit = #$ ☹
- Examples:
  - L1 DGPS station: *+/- 30bps / station*
  - Add GLONASS: *+/- 25bps / station*
  - Add Type 15: *+/- 5bps / station*
  - GPS PPP: *+/- 40bps (global)*
  - Add GLONASS: *+/- 30bps (global)*
- However, this also illustrates how attractive 'global' services are:
  - Can be used globally
  - Very low bandwidth

Open Standards

- Yes, we do use Open Standards (RTCM v2.2)
  - Defined messages
  - Undefined messages
- May not meet everybody's needs
- Server2Client compatibility is important
- Not (always) designed to be bandwidth efficient
  - RTCM messages carry baggage: e.g. parity & header words
- Standards tend to follow when new techniques become widely used
- New standards & message structures focus on:
  - Put no technical constraints on the overall Server2Client system
  - Enable new augmentation techniques for a wide range of applications
  - Anticipate & support innovative augmentation techniques
- Otherwise, organisations will develop their own messages

Concluding Remarks

- VERIPOS have been using Open Standard since 1989
- Code-based augmentation services: Defined RTCM messages
- PPP augmentation services required: Undefined RTCM messages
  - Standards were not available
  - Need to go to market with new service
- New augmentation techniques usually precede standardisation
- However, standardisation can stimulate market potential
- Future standards & message structures need to be:
  - Bandwidth efficient
  - Consider Server2Client compatibility
  - Expandable and allow augmentation services to evolve


veripos
Thank you for your attention