Impact of Next Generation GNSS on Australasian Geodetic Infrastructure

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From GPS to Next Generation GNSS…

2013-20: 4x number of satellites, 6x number of signals!

Profound impact on users, but requiring upgrade of user equipment & reference networks; communications, formats & standards; field techniques, modelling, algorithms, products… including the Geodetic Infrastructure
Impact of Next Generation GNSS…the challenges

- New GNSS & RNSS introduced over the next decade, with particular impact on the Australasian region…
- New GNSS receiver designs…
- Managing the transition to new instrumentation within the global/regional/national geodetic GNSS infrastructure…
- Appropriate “mix” of types & generations of GNSS receivers, and design of future GNSS infrastructure…
- Management/unification(?) of disparate GNSS networks…
- Next generation Geodetic Infrastructure in support of Global Geodesy and satisfying requirements for National Geospatial Frameworks.

From GPS to Next Generation GNSS

Multi-GNSS mean visibility… the “hotspot” in Australasian region
How complex will multi-GNSS receivers be?

If receivers do not track all possible signals, will there be interoperability issues?

Instrumentation Issues...

e.g. Galileo Signals

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<th>E1</th>
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|      | E5a | 1176.45 | I  | FNAV OS | C51 | L51 |
|      |     |         | Q  | no data  | C5Q | L5Q |
|      |     |         | I+Q|       | C5X | L5X |

|      | E5b | 1207.140 | I  | FNAV OS/CS/SeQ | C71 | L71 |
|      |     |         | Q  | no data | C7Q | L7Q |
|      |     |         | I+Q|       | C7X | L7X |

|      | E5 (E5a+E5b) | 1191.795 | I  |       | C81 | L81 |
|      |     |         | Q  |       | C8Q | L8Q |
|      |     |         | I+Q|       | C8X | L8X |

|      | E6 | 1278.75 | A  | PRS | C6A | L6A |
|      |     |         | B  | CNAV CS | C6B | L6B |
|      |     |         | C  | no data | C6C | L6C |
|      |     |         | B+C|       | C6X | L6X |
|      |     |         | A+B+C |       | C6Z | L6Z |

“The IGS in a changing field of developing GNSS”, Urs Hugentobler, EUPOS Symp, Berlin, 1 December 2009
Instrumentation Issues…
e.g. Galileo Signals

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Imagine the complexity with multi-GNSS receiver designs…

- When to upgrade?
- What tracking capabilities?
- Antenna & cabling issues?
- Interoperability of systems, formats, processes, etc.?
- Only L1 & L5 will be interoperable at frequency level…minimum multi-GNSS Rx?

*) depending on receiver configuration
Geodetic GNSS infrastructure consists of CORS...

How to manage the transition in an orderly manner so that the “final” GI is truly multi-GNSS and delivering improved services?
Managing the Transition from GPS CORS to Multi-GNSS Networks…

- The IGS tracking network is a *patchwork* of regional networks…
- There are still gaps in coverage… *Africa, China/Asia*
- Need to coordinate *upgrade* of IGS network, in step with national & other networks
- Need to incorporate new capabilities… *e.g. real-time IGS*
- Need to have liberal data access policies
- Need higher quality geodetic infrastructure… *not just GNSS*
- *Need unprecedented level of coordination & cooperation!*

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From National & Scientific CORS to Global Infrastructure

IGS network upgrade influenced by CORS elements…

*Australasian regional stns & networks are vital components*
But there are many hundreds of additional GNSS reference stations… how will they be incorporated within the Geodetic Infrastructure under multi-GNSS scenarios?

Homogeneity of Geodetic GNSS infrastructure & operations is unlikely...

How to coordinate different tiers, scales & operators of GNSS CORS?

Will there be an optimal “design” of GI?

What are the non-technical challenges?
Multi-Tier GNSS Infrastructure…

GNSS CORS infrastructure could be hierarchical:

(1) Tier 1 being the IGS-class stations… possibly equipped with "system of system" (SoS) multi-GNSS receivers, perhaps software-configurable, with best monumentation, collocated with other geodetic instrumentation, and so on.

(2) Tier 2 the primary national geodetic CORS network… COTS multi-GNSS receivers, with best instrumentation, providing foundation for datum and NPI.

(3) Tier 3 the state (or secondary) and private CORS networks… less than SoS (unclear by how much) Rxs, supporting many RT-PP users, as well as other GNSS applications.

Coping with Multi-GNSS Complexity

- The minimum specifications of Tier 1, 2 and 3 CORS receivers… this is of course a "moving target" as tracking capability will necessarily change with time as we progress from the current GPS+Glonass, to GPS(modernised) +Glonass, GPS+Glonass+Galileo, G+G+G+Compass, and so on, over the next decade.

- Ratio of Tier 1 to Tier 2 to Tier 3 CORS, and their geometric pattern of deployment across a country, or city or region… the so-called spatial deployment strategy.

- Timeline for the deployment of the multiple generations of GNSS CORS over the coming decade… the so-called temporal deployment strategy.
Specify System
- Target Density, Coverage
- Reliability and Availability
- Site Quality
- Equipment Quality
- Geodetic Reference Frame
- Data Services Produced
- Data Access Policy

Stations
- Own Stations
- Network the Data
- Process Network
- Deliver Service

Process
- Network the Data
- Data Comms from Network Stations
- Control Centre
- Data Archive
- Copy of Network
- Data Processing (for RTK)
- Production of Data Streams
- Distribution of Data Streams
- Data Wholesaling
- Retailer Support

Deliver Service
- Retail Sale of Data Products
- Marketing
- Rover Equipment support
- End User Support
- Liaison with User Comms Providers

Governance - Joint Ventures overseen by ICSM?

Different Organisational Roles in a Multi-Tier, Multi-GNSS Geodetic Infrastructure

AuScope's Geospatial Committee for Science Issues

Geoscience Australia's ARGN Stations

State/Territory Government Non-AuScope Stations

Non-Government Stations

Commercial Partners merge non-Government stations with unified Government network to create value-added services

Value Added Services

User Needs Input from User Groups

Precise by federal, state and territory governments responsible for geodesy (via ICSM)

Governance - Joint Ventures overseen by ICSM?

CRC SI Annual Conference 2008, Matt Higgins
Concluding Remarks…

- The future of multi-GNSS is an exciting one
- Increased complexity of GNSS signals will impact on Rx design, with new classes of receivers developed for different user markets… *top-of-the-line receiver may only be embraced by the geodesy and scientific users*
- Significant impact on all tiers of *Geodetic GNSS Infrastructure*
- Issues such as type of receiver, design of the CORS networks, and deployment strategies will need to be addressed
- Multi-tier model of CORS will evolve, with different Rxs & networks, and different operators, to service different markets
- Challenge is to organise patchwork of different GNSS networks, over the next decade as new GNSS signals are broadcast, into a single *National Positioning Infrastructure*