Impact of Next Generation GNSS on Australasian Geodetic Infrastructure

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FIG Congress Sydney, 11-16 April 2010 , Session TS10C "GNSS Modernisation & Trends"

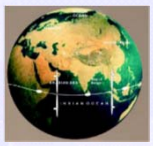
From GPS to Next Generation GNSS…



COMPASS

QZSS

+



IRNSS

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.***

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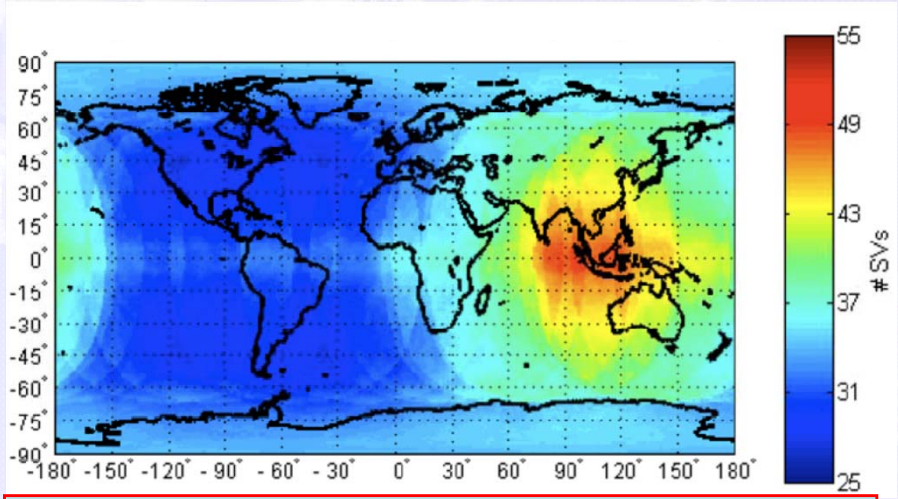
From GPS to Next Generation GNSS

Multi-GNSS mean visibility… *the "hotspot" in Australasian region*



Constellations: GPS, Galileo, Glonass, Compass, QZSS, WAAS, EGNOS, MSAS, GAGAN, IRNSS

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

Galileo	E1	1575.42	A PRS	C1A	L1A
			B I/NAV OS/CS/SoL	C1B	L1B
			C no data	C1C	L1C
			B+C	C1X	L1X
			A+B+C	C1Z	L1Z
	E5a	1176.45	I F/NAV OS	C5I	L5I
			Q no data	C5Q	L5Q
			I+Q	C5X	L5X
	E5b	1207.140	I I/NAV OS/CS/SoL	C7I	L7I
			Q no data	C7Q	L7Q
			I+Q	C7X	L7X
	E5 (E5a+E5b)	1191.795	I	C8I	L8I
			Q	C8Q	L8Q
			I+Q	C8X	L8X
	E6	1278.75	A PRS	C6A	L6A
			B C/NAV CS	C6B	L6B
			C no data	C6C	L6C
			B+C	C6X	L6X
			A+B+C	C6Z	L6Z

Interoperability with GPS

„The IGS in a changing field of developing GNSS“, Urs Hugentobler, EUPOS Symp, Berlin, 1 December 2009

Instrumentation Issues…

e.g. Galileo Signals

Galileo	E1	1575.42	A PRS	C1A	L1A
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			C no data	C6C	L6C
			B+C	C6X	L6X
			A+B+C	C6Z	L6Z

Novatel 15A

JPS Delta-G2T

Septentrio GeNeRx1 *)

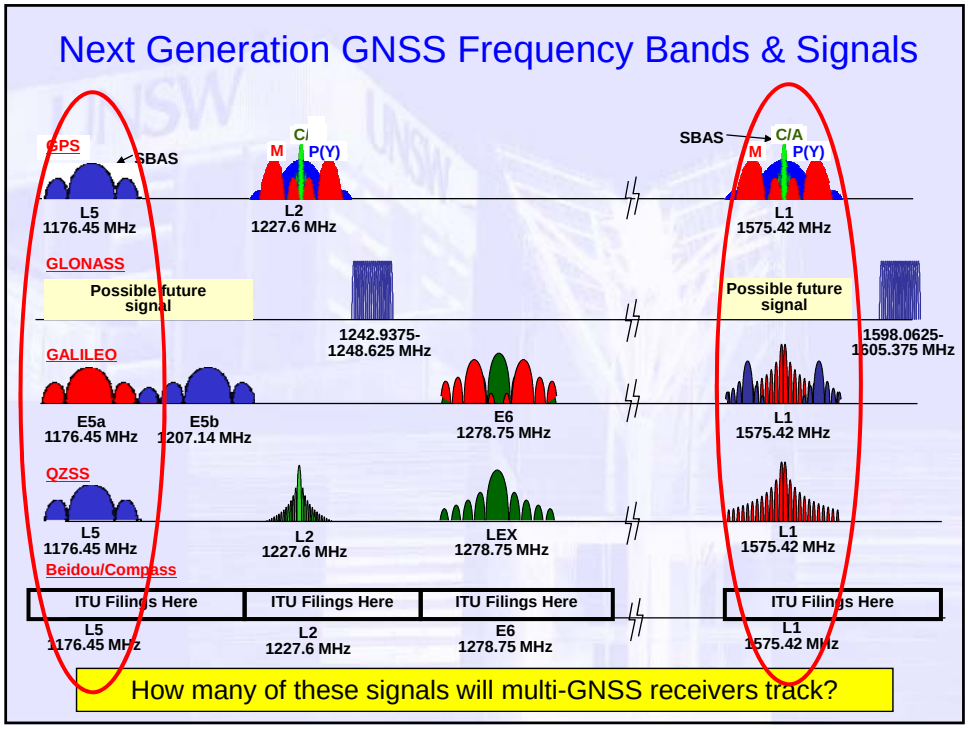
Leica GRX1200 GGPRO

*) depending on receiver configuration

„The IGS in a changing field of developing GNSS“, Urs Hugentobler, EUPOS Symp, Berlin, 1 December 2009

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?*



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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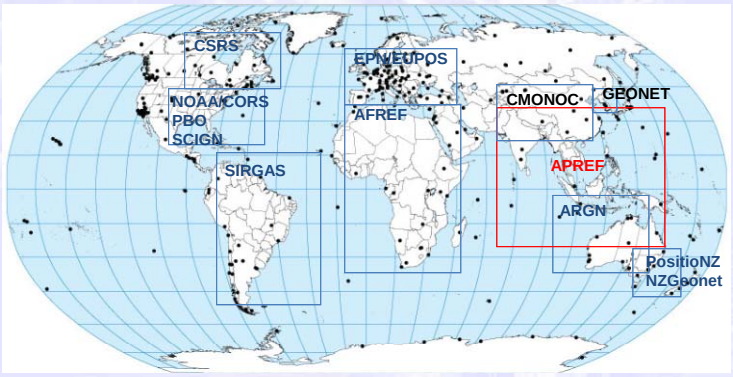
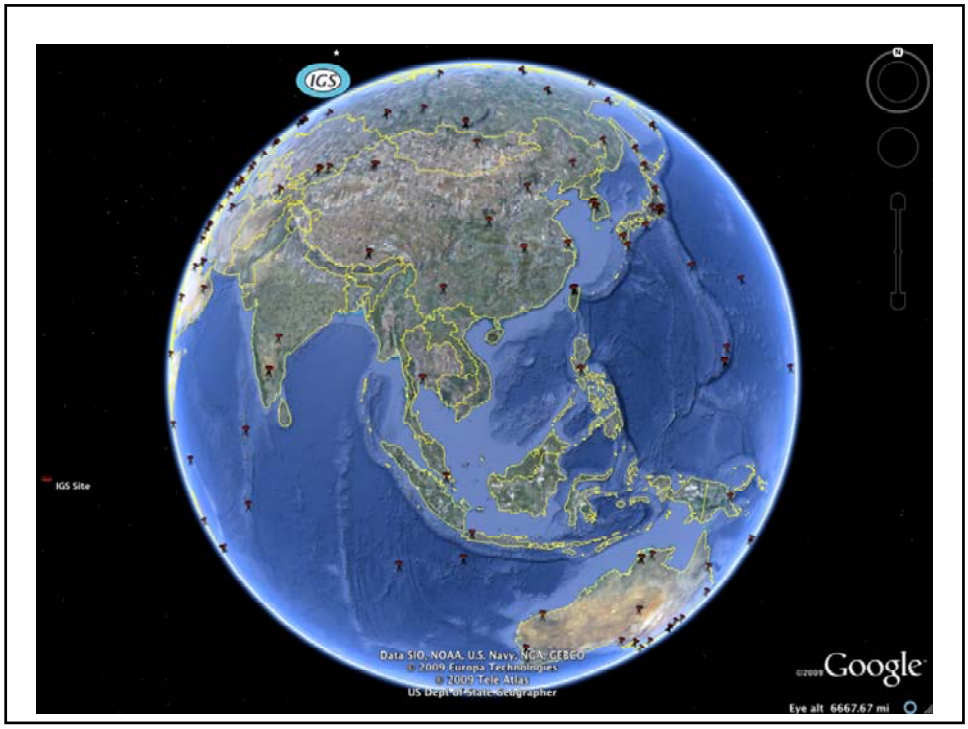
From National & Scientific CORS to Global Infrastructure

IGS network upgrade influenced by CORS elements…
Australasian regional stns & networks are vital components



„The IGS Reference Station Guidelines", Steven Fisher, FIG Regional Con, Hanoi, Vietnam, 19-22 October 2009


IGS
IGS Site
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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US Dept of State Geographer
Google
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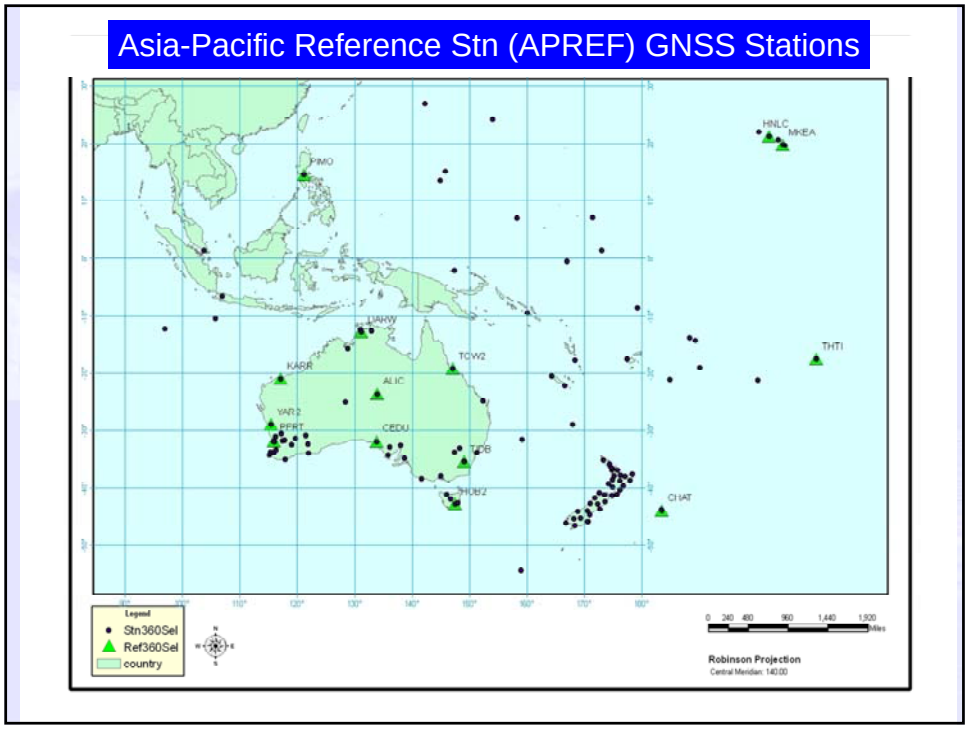
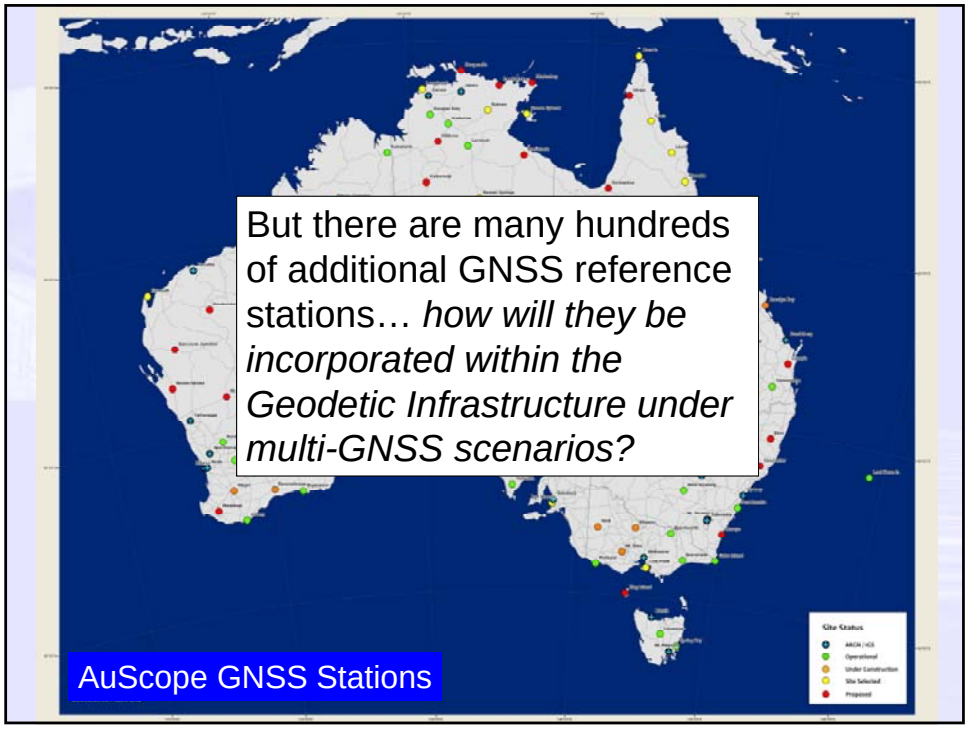

Asia-Pacific Reference Stn (APREF) GNSS Stations
HNLC
MKEA
PIMO
DARW
KARR
TOW2
ALIC
YAR2
PERT
CEDU
HOB2
CHAT
THTI
Legend
Stn360Sel
Ref360Sel
country
Robinson Projection
Central Meridian: 140.00



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 *heirarchical*:

(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*.

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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*.

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

Specify

Specify System
- Target Density, Coverage Reliability and Availability
- Site Quality
- Equipment Quality
- Geodetic Reference Frame
- Data Services Produced
- Data Access Policy

Stations

Own Stations
- Site Selection
- Site Construction
- Equipment Purchasing
- Station Data Comms
- Site Maintenance
- Equipment Replacement Cycle

Network

Network the Data
- Data Comms from Network Stations
- Control Centre
- Data Archive

Process

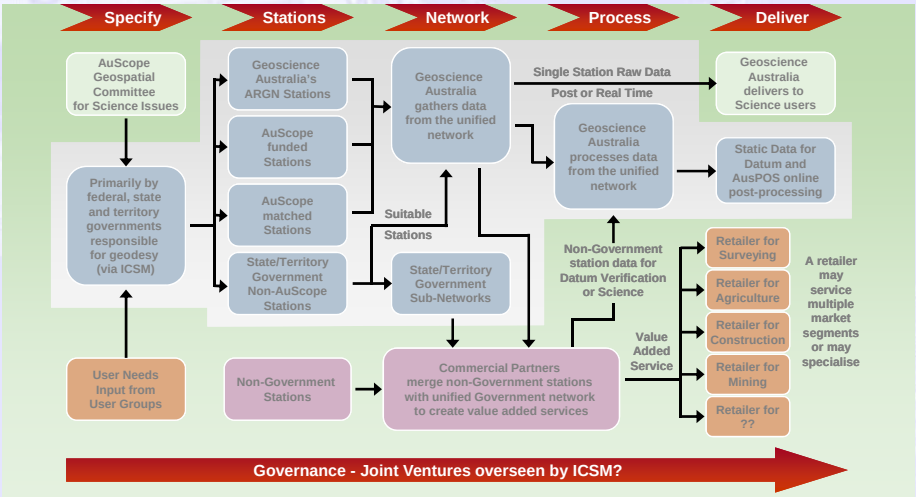
Process Network
- Copy of Network
- Data Processing (for RTK)
- Production of Data Streams
- Distribution of Data Streams
- Data Wholesaling
- Retailer Support

Deliver

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



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*