New GNSS Developments and the Impact on Providers and Users of Spatial Data Infrastructure

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Outline of Presentation

- *Review Current Situation with GNSS*
- *Latest developments with the key Technologies*
  - *GPS Modernisation*
  - *GLONASS Revitalisation*
  - *Europe's New Galileo System*
- *Latest developments with Institutional Arrangements*
- *Implications of GNSS Developments for Providers and Users SDI*

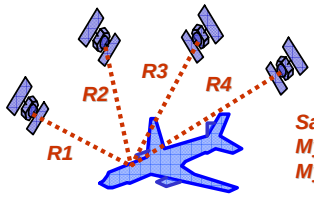
Global Navigation Satellite Systems

GNSS

Current Use of GNSS is Focussed on GPS

So let's review the situation now…

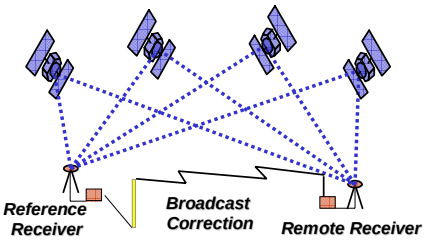
Point Positioning



Satellites are saying
My Time is …
My Position is …

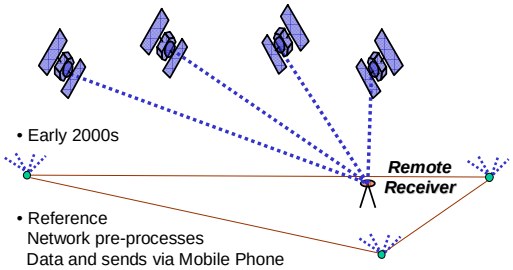
- The basic technique as designed
- Basic Civilian Receivers < $ 500

Differential Positioning



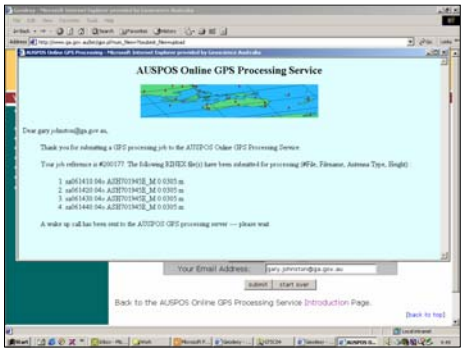
- 0.5m to 10m - depending on correction method
- Real Time or Post Processed
- Commercial Real Time services are available

State of the Art – GNSS Surveying



- Early 2000s
- Reference
  Network pre-processes
  Data and sends via Mobile Phone
- Observation period per new point 10s of seconds
- Data processed in Real Time – centimetre accuracy
- Users work as though they are stand-alone

AUSPOS Online GPS

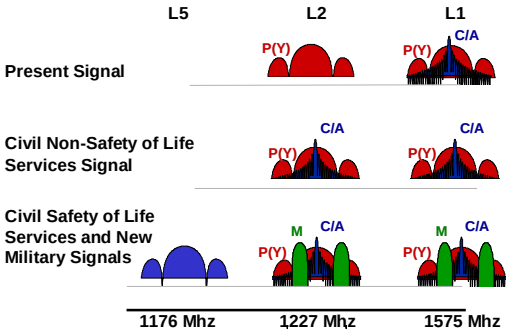


Future Improvements to GPS

Errors for a Single Point Position (SPP)

- *GPS Accuracy used to be downgraded but with that effect (SA) set to Zero the largest contribution to Error Budget is the Ionosphere*
- *Ionospheric error is proportional to frequency so it can be corrected with 2 frequencies*
- *Civil code on second frequency will allow less expensive receivers to measure on both frequencies and be more accurate*

GPS Modernization



GPS Modernization Plan

Increasing System Capabilities ◆ Increasing Defense/Civil Benefit

Block IIA/IIR

- Basic GPS
- Std Service (16-24m SEP)
  - Single frequency (L1)
  - C/A code navigation
- Precise Service (16m SEP)
  - Two frequencies (L1&L2)
  - P-code navigation

Block IIR-M, IIF

IIR-M: IIA/IIR capabilities plus
- 2nd Civil Signal on L2 (L2C)
- Earth coverage M-Code on L1 & L2

IIF: IIR-M capability plus
- 3rd Civil Signal on L5

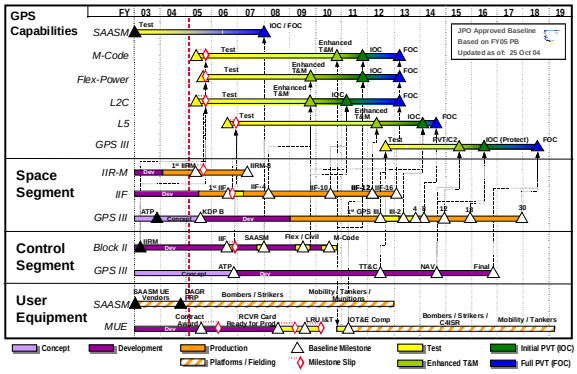
Flex Power upgrade adds ability to increase power on both P and M-Code signals to defeat low level enemy jamming

Block III

GPS III
- Navigation Surety
- Increased Accuracy
- Assured Availability
- Controlled Integrity
- System Survivability
- Continuation of Legacy Signals

Skalski, 2003

GPS Enterprise Perspective Schedule
FY05 PB Baseline



Oct 2004

From GPS *to* GNSS

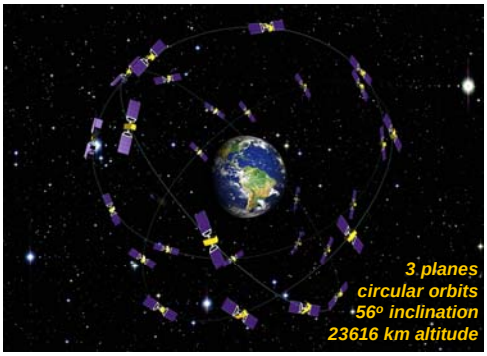
GLONASS

- *Russian Federation's GLObal NAvigation Satellite System*
- *First launch Oct 1982*
- *Uses 3 orbital planes rather than 6 with GPS*
- *GPS - same frequency but different codes GLONASS - same code, different frequency*
- *Channel of Standard Accuracy (CSA) 60m horizontal, 75m vertical (99.7% confidence)*
- *Restricted access to Channel of High Accuracy*
- *Launched 3 more satellites in Dec 2003*
- *In late 2004 announced India will contribute funds!*
- *More satellites available = more robust solution*

GALILEO

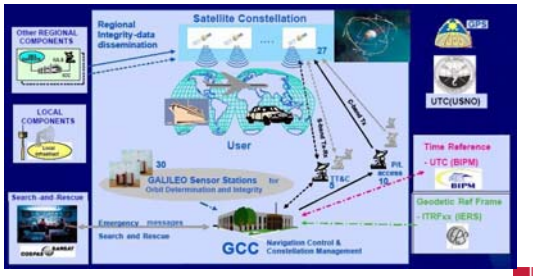
The European Union's GNSS

Galileo Constellation

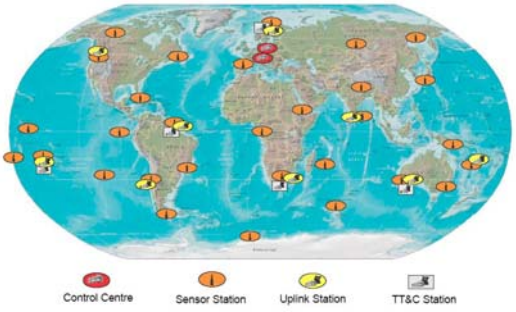


Constellation Deployment

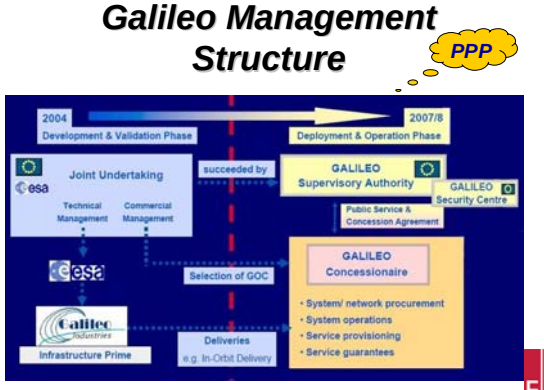
Galileo System Architecture



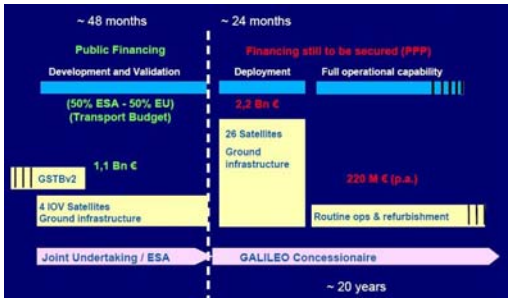
Galileo Ground Segment



Galileo Management Structure



Galileo Schedule and Cost



Galileo Services

OPEN SERVICE

- **Provides position velocity and time services to mass market users**
- **Similar to the future Standard Positioning System provided by modernised GPS**
- **Accuracy better than 7 m worldwide and on an availability of 99%**
- **Free of charge but, the quality of services is not guaranteed**

COMMERCIAL SERVICE

- **Access commercially controlled**
- **Provides improved service (accuracy, integrity,…)**
- **Ranging and timing service to knowledgeable professional (surveying, meteorological forecasting, time calibration…)**
- **Through use of local elements, hybridisation, communication, etc...**

PUBLIC REGULATED SERVICE

SAFETY OF LIFE SERVICE

SEARCH AND RESCUE SERVICE

Benefits from GPS + Galileo

- *Agreement between EU and USA was signed in June 2004*
  - *Cooperation agreement addresses national security, economic, and technical issues*
  - *Protects compatibility*
  - *Encourages civil interoperability*
- *So what can we expect from combined systems?*

Benefits of Broader GNSS (1)

- *GPS and GLONASS combined have already demonstrated the benefits of extra satellites and Galileo brings all that and more.*
- *Extra satellites improve* **continuity**:
  - *GPS and Galileo being separate systems means major system problems, unlikely in themselves, are even less likely to occur simultaneously.*
- *Extra satellites can improve* **accuracy**:
  - *More observations mean a given level of accuracy can be achieved sooner.*
  - *Position is also less susceptible to influence of satellite geometry.*
  - *Galileo also has the ability to deliver improved accuracy directly in the receiver through the commercial service.*

Benefits of Broader GNSS (2)

- *Extra satellites can improve* **efficiency**:
  - *For Carrier Phase Measurements (centimetre accuracy) extra satellite signals reduce the time required to resolve ambiguities.*
- *Extra satellites improve* **availability** *(of satellites at a particular location):*
  - *Improved ability to work in areas where satellite signals can be obscured, urban canyons, tree canopies, open cut mines.*
- *Extra satellites improve* **reliability** *(identifying position errors):*
  - *Extra satellites bring redundancy to help identify any problems*
- *Newer systems also bring overall improvements in quality*

Code Navigation Performance: Urban Canyon Operation *(GPS world, June/03)*

Analysis scenario And Constellation	Availability of 20-m 95% 2D accuracy		Accuracy and Availability-satellites only		Accuracy and Availability-differential	
	28GPS only	28GPS +27Gal	28GPS only	28GPS +27Gal	28GPS only	28GPS +27Gal
Open sky	90%	100%	7m/95	4m/95%	3m/95	1.5m/95
Suburban	70%	100%	32m/90	8m/95%	16m/90	4m/95%
Low-rise	30%	90%	17m/50	14m/95%	9m/50 %	7m/95%
High-rise	15%	80%	No-sol.		No-sol.	25m/90 %

Overall availability in urban areas: from 55% to 95%

Latest developments with Institutional Arrangements

UN Action Team on GNSS

International Committee on GNSS (ICG)

- *"Noting the excellent work carried out by the Action Team, the UN General Assembly Resolution 59/2 (paragraph 11) invites GNSS and augmentation providers to consider establishing an international committee on GNSS in order to maximize the benefits of the use and applications of GNSS to support sustainable development".*
- *I will be a member representing International Federation of Surveyors (FIG)*

Institutional Arrangements

- *UN GNSS Action Team -> ICG*
  - *MoU between FIG and UN OOSA*
  - *FIG GNSS Development Task Force*
  - *GPS L2C Coverage Suggestion to US Air Force and State Department*
- *FIG Commission 5*
  - *Represent FIG on ICG*
  - *WG5.3.3 allows FIG members to have input to ICG and Future of GNSS*
  - *ISO Standard on GPS RTK*

Issues for Surveyors

Issues for High Accuracy Applications

- *Latest GPS techniques squeeze millimetres from least possible amount of data, in real time, using all SVs in view and multiple frequencies*
  - *GPS is already a very good tool!!*
- *Towards more **availability, efficiency** and **reliability**:*
  - *L2 C/A receivers and processing less complicated*
  - *L5 will give better accuracy, efficiency and reliability*
  - *Glonass has demonstrated advantage of extra satellites, especially for availability*
  - *Galileo will add all of this again and more*
- *Concerns*
  - *Cost to upgrade to take advantage of new developments?*
  - *There are not 3 common frequencies across GPS and Galileo… L1 and L5 common but not GPS L2*

Issues for SDI

Issues for SDI (1)

- ***Compatibility*** *between SDI data sets and GNSS*
  - *To deliver full advantage of GNSS requires a consistent geodetic infrastructure underpinning all SDI.*
  - *Applications outside SDI's traditional sphere of influence are reliant on GNSS and require a seamless geodetic reference frame across the data sets they use.*
  - *"Safety-of-Life" applications like Civil Aviation or Disaster Management.*
  - *The International GNSS Service has the global infrastructure to help propagate the International Terrestrial Reference Frame .*
- ***Outcome:*** *National Mapping Organisations need to make their geodetic infrastructure more compatible with GNSS and need to liaise with their regional neighbours and international associations to make that happen – AFREF Project is shaping up as an excellent example of a framework for such cooperation.*

Issues for SDI (2)

- ***Broader Role*** *for GNSS Reference Stations*
  - *Reference Station Networks are being seen by Governments as "best practise" for delivering Geodetic Infrastructure in a "digital" way – moving from post processed to real time.*
  - *Need to balance that with needs for ground marks etc.*
  - *Commercial Differential GNSS suppliers being forced to provide more accurate services to maintain market share.*
  - *Safety-of-Life and other applications demanding higher accuracy, reliability and availability (cm, 24/7, anywhere)*
  - *Putting pressure on Reference Station Infrastructure*
  - *Galileo a watershed to focus thinking.*
- ***Outcome****: Increased partnering to provide infrastructure that meets commercial and risk requirements.*

Issues for SDI (3)

- ***Ubiquity*** *of positioning*
  - *GPS+Galileo = Urban Canyon Availability 80% (up from 15%)*
  - *Development of indoor positioning capabilities*
  - *e911 requiring integration into mobile phones*
  - *Integration with other measurement or sensor devices*
  - *Location aware device in your pocket*
  - *Personal Digital Assistant… to… Personal Digital Advisor*
- ***Outcome:*** *Increase in the number of users demanding suitable data from the SDI to overlay their positions and query additional information.*

Issues for SDI (4)

- ***Accuracy*** *and* ***Reliability*** *Improvements*
  - *Premium Galileo Service 0.1m from hand held*
  - *Centimetre accuracy equipment should be cheaper*
  - *Initialisation for centimetre accuracy in 1 Sec*
  - *Centimetre accuracy will move into mainstream mass markets in the next decade (perhaps next 5 years)*
  - *Centimetre accuracy Location Based Services – Real Time Engineering design?*
  - *"Safety of Life" moving from planes to trains and vehicles*
  - *Can SDI and GNSS address road toll?*
- ***Outcome:*** *Users of SDI will demand continually improved accuracy and reliability from spatial data.*

Issues for SDI (5)

- ***More inclusive*** *GNSS Institutional Arrangements.*
  - *GPS officially recognised as a "dual-use" system.*
  - *GLONASS seeking international partners.*
  - *Galileo has a deliberately open architecture and PPP environment.*
  - *UN Mandated International Committee on GNSS*
- ***Outcome:*** *SDI Institutional Arrangements need to move from seeing GNSS as just a tool to a more integral part of the infrastructure used in spatial applications.*