GNSS INTO THE FUTURE

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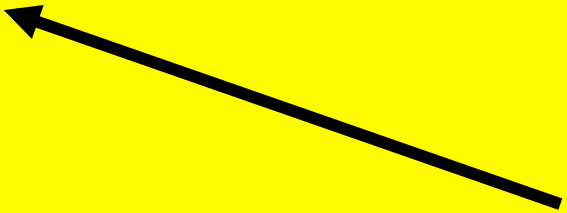
GNSS today

- Thirty-one GPS satellites
  - L1 and L2 carriers modulated with codes and data message
  - Six are ‘modernised’
- Thirteen GLONASS satellites (+ three)
  - Frequency Division Multiple Access (FDMA)
- Two Galileo test satellites
- Four operational COMPASS satellites
  - three GEO, one MEO

GNSS today

- Thirty-one GPS satellites
  - L1



Vast majority of current civilian applications

GNSS today (continued)

- Free differential systems
  - Designed for marine use
- Free space-based augmentation systems
  - Designed for aviation
- World-wide commercial ‘augmentation’ systems
  - Supporting precision agriculture and ‘surveying’
- Commercial RTK systems
  - Supporting engineering surveying and mapping
- Assisted-GPS
  - Mainly from mobile phone service providers
- Scientific support services

That seems plenty! Why do we need more?

- Fear of basing critical infrastructures on one GNSS
- Civil GPS is primarily a single frequency system
  - Little interference protection and poor ionospheric modelling
- Use of the second frequency is sub-optimal
  - Also it's not in the ARNS band
- Current GNSS signals do not have sufficient penetration
- Not enough satellites for urban canyons
- Quality of positioning is not sufficient
  - For some applications/usage

ARNS – Aeronautical Radio Navigation System

What's happening to GNSS?

- GPS is being 'modernised'
  - Started in 2005
- GLONASS is being 'refurbished'
  - Will probably add CDMA (when?)
- Galileo is fully funded and going ahead
- Future Compass signal structure released
- Many more SBASs announced

Features of some or all new GNSSs (1)

- Separation of civilian and military(?) functions
  - Good and bad!
- Built-in integrity (SoL) – protected frequencies
- Increased power
- Three (at least) ‘open service’ frequencies
- Better clocks
- Better geometry
  - at least for Europe

Interference
Ionosphere
Multipath
Acquisition
Range precision
Poor/good signals

Features of some or all new GNSSs (2)

- More sophisticated and faster codes
  - Ten times C/A
- New modulation schemes
  - BOC instead of BPSK
- Pilot signals
  - No data message
- Forward error correction
  - navigation message

Interference
Ionosphere
Multipath
Acquisition
Range precision
Poor/good signals

GNSS into the Future

- 120(?) MEO satellites
  - Four interoperable and compatible systems
- 20(?) GEO satellites
- Extensive ground networks
  - With free and commercial services
  - Sensor network modelling
- ‘Amazing’ new signal characteristics
  - Massive choice of ‘methodologies’
  - Separate and combined solutions

What are the practical benefits?

- Much greater satellite ‘visibility’
  - More satellites, more power, longer codes, pilot signals
  - Fast acquisition (increases land-based kinematic use)
- Much greater ranging accuracy
  - Longer and faster codes, pilot signals, less multipath/ion
  - More SVs will lead to better tropospheric modelling
- More use of Precise Point Positioning
  - Especially through hierarchical positioning
- Better ‘regional modelling’
  - Less dense regional networks
  - Sensor network approach to modelling
- Potential for less power consumption in receivers

more applications

Why Positioning/Time?

- Navigation and tracking
  - Traditional marine and aviation applications
  - Cars/buses/trucks
  - Trains/people/animals/assets ….
- Location Based Services
  - Position + spatial information + comms
- Communications needs time
- Mapping
- Scientific applications (e.g. tectonics/sea level)
- etc

GNSS is the ‘default’ positioning solution but …

Other technologies will be needed even more!

- Inertial systems (especially MEMS)
- Other dead-reckoning (e.g. odometers)
- Radio navigation systems (e.g. eLORAN)
- Mobile phone signals, SoOs
- Pseudolites, UWB etc
- Track-aiding
- Wi-Fi, RF tags
- ‘Reverse’ photogrammetry with digital models

Others?

Few ‘stand-alone’ solutions based on these technologies?

The messages!

- Massive surge in positioning/time applications
- GNSS will increasingly be the default solution
- Because what GNSS can do is changing
  - For the better!
- So is the way we will use it
  - Many more choices
- But, and counter-intuitively, we will need other technologies more that ever