IGNSS 2015, NPI Workshop

PNT Research

High Precision GNSS Positioning

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Presentation Overview

• Current status of high precision GNSS positioning
  – The multi-GNSS environment
  – Analysis Centre Software (ACS)

• Navigation trends: “looking beyond precise positioning users”
  – Growing application market, e.g., LBS and C-ITS

• Future of PNT infrastructure – “Assured PNT”
  – Paradigm shift in navigation and sensor integration
The Multi-GNSS Environment

- Space-based PNT refers to the capabilities enabled by:
  - Global Navigation Satellite Systems (GNSS)
    - U.S. GPS
    - Russia GLONASS
    - Europe Galileo
    - China BeiDou
    - Japan QZSS, regional coverage
    - India IRNSS, regional coverage
  - Ground and space-based augmentation systems like GBAS and SBAS
    - WAAS, EGNOS, GAGAN, SDCM, MSAS etc.
    - Various DGPS services
Benefits from GNSS Modernisation

• Multi-frequency and multi-constellation GNSS:
  – Improved ambiguity search techniques → fast, more reliable
  – Better error modelling → higher reliability
  – Only slightly better accuracy

• Slightly stronger signals (higher transmit power)
  – Improved tracking capabilities under foliage areas
  – More multipath tolerant

• Faster signal acquisition margin, e.g. L2C

• L5 frequency in ARNS band → more secure for jamming, increased immunity to interference

• Galileo, BeiDou, QZSS and IRNSS might offer additional data (“augmented”) services

• With benefits come challenges and difficult design choices
Challenges

• Heterogeneous system and equipment
  – Compatibility issues such as reference frames, clocks, orbits, hardware biases
  – Signal diversity $\rightarrow$ characterisation and standardisation of noise, biases, phase centres etc.

• Lots of useful, but also lots of “redundant” signals for high precision GNSS (Q, I+Q, E6B, E6(B+C), E6(A+B+C))
  – CPU load for tracking and processing
  – Real-time data aggregation and analytics

• Handling updates of new system and changes
  – Leap seconds, new satellites, test satellites, spare satellites $\rightarrow$ Integrity?

• Extremely wideband $\rightarrow$ jamming resistance?
ONE VISION
Instantaneous GNSS positioning anywhere, anytime, with the highest possible accuracy and integrity

THREE DRIVERS
1. National Positioning Infrastructure
2. Multi-GNSS
3. PPP-RTK

Barriers to adoption
Real-time tropospheric and ionospheric models
Multi-GNSS orbits & clocks
Ambiguity resolution PPP-RTK user platform

PPP-RTK network processing
Real-time Communications
Dynamic datum

Analysis Centre Software (ACS)

Positioning Program Research Portfolio
Advances in PPP-RTK. Any Breakthroughs?

• Why are PPP-RTK corrections needed?
  – to get *instantaneous* cm-level positioning

• What is needed to compute corrections?
  – Network of GNSS stations
  – *PPP-RTK looks suspiciously like RTK*

• Is PPP-RTK a solution?
  – Australia is a REALLY big country
  – Biggest challenge → ionospheric modelling as cm-level is required!
  – Multi-frequency PPP
  – *Trustworthy* positioning

• Define national service levels
  – Scalability of PPP and flexible positioning
Limitations……and Moving Forward

• There exists a line between where GNSS precise positioning will work and where it will not work

• The boundary line is created by “difficult” environments
  – GNSS challenged environment, e.g. urban canyons
  – CORS infrastructure, e.g. baseline distance
  – Communication data coverage, e.g. mobile cellular network

• R&D will continue to push boundaries, i.e. speed, reliability, accuracy, integrity, continuity, availability

• Integrated and coherent systems → GNSS + non-GNSS
  – Flexible and adaptive blend with other sensors

• Users demand for consistent and standardised position information, e.g. data formats, service performance and access
  – Users are evolving with expectations
Market Growth (GNSS Market Report 2015, GSA)

- Global installed base of GNSS devices of 3.6 billion units is predicted to grow to 7 billion by 2019 (almost one GNSS receiver for every person on the planet!!)
  - Smartphones: Largest market → emerging applications with demanding requirements (no prize for guessing)
  - Automotive: 2nd largest market → high accuracy, high reliability for safety related apps.

- The primary region of global market growth will be Asia-Pacific
  - Forecasted to grow 11% per year, from 1.7 billion in 2014 to 4.2 billion devices in 2023

- GNSS receiver market is changing dramatically. New markets, devices and regions offering substantial market growth

- Consumer equipment and new government initiatives will open new markets
Looking Beyond Precise Positioning Users

Location-based services (LBS) present some of the hottest opportunities in mobile commerce for both businesses and mobile operators.

One of the most popular PNT devices today.

More than 365M sold to date.

GNSS Market Report 2015, GSA
Integrated PNT Systems for C-ITS

Multi-Sensor Positioning and Multi-Infrastructure Communication
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Future NPI Should Consider….

- **Flexible designs** to support a combination of new/modernised GNSS constellations, cellular and space-based connectivity, and increasing penetration of augmentation technologies

- Emergence of **real-time data analysis**

- **Uniform** and **traceable** Service Level Management procedures

- **GNSS is not an infallible system**. Non-GNSS alternatives must also be considered, e.g., Locata, eLoran etc.

- Application base is rapidly growing, e.g., LBS, ITS, precision farming, indoor navigation, asset tracking, banking, etc.
  - New applications create technological challenges, and these in turn fuel new applications and opportunities

- No single sensor to provide required level of accuracy, integrity, continuity and portability of PNT for “assured PNT” → **Integrated**
Are We There?

...not quite...

There are still many challenges and many problems to solve...

...and... many more PhD theses to write on the topic of “Assured PNT” before (if ?) we reach the holy grail of PNT.

Accuracy is addictive but we must also focus on integrity and continuity of PNT information.
Thank You!

IT'S A GOOD THING
NOT EVERYONE HAS A SMARTPHONE

SOMEONE HAS TO HONK
WHEN THE LIGHT TURNS GREEN