Future of GNSS Receivers

Éamonn Glennon

GNSS Futures Workshop, UNSW 7 – 8 July 2014
Future of GNSS Receivers?

• What have we got now?
• What do customers want?
• What does government want?
• What are the problems with current receivers?
  What type of receivers?
  What functions do those receivers perform?

➔ New GNSS receiver designs
Current Situation - Consumer

- Single frequency multi-GNSS (GPS, GLONASS, SBAS) for consumer and low cost OEM market
- New systems coming on line (Galileo, Beidou, IRNSS,…)
- Receiver characteristics:
  - Very low cost chips at volume (<~US$3 / unit)
  - Low cost OEM boards (<~US$30 / unit at volume)
  - Generally high sensitivity, but limited accuracy
  - Carrier phase generally not provided
  - Excellent power consumption, but low output data-rate (1 Hz)
  - Integration with low cost IMUs on some units
  - Small dimensions: The antenna is often larger than the board!
  - Integrated into phones, PNDs, tablets, fitness devices, …
- New and expanding applications
  - UAVs, femto-cells/timing, internet-of-things, …
Consumer GNSS Issues

- Urban availability, especially indoors
- Accuracy – insufficient for lane level positioning
- Price – cut-throat competition
- Spoofing/jamming susceptibility
- Industry consolidation / barriers to entry
  - Qualcomm, Broadcom, MediaTek, u-Blox, CSR, …
Government Mandates

• “Europe Weighs Mandate of Galileo Chips in Mobile Phones” (GPS World, 30 June 2014)
• “GLONASS to Be Required For Phones Sold in Russia” (GPS World, 12 November 2013)
• “China Mandates Use of Beidou GNSS on Some Commercial Vehicles” (Inside GNSS, 15 January 2013)

• Good for GNSS manufacturers, good for government and all it costs is a more expensive phone for the customer!
• Expect mandatory use of IRNSS in India once operational
• Workarounds
  – Switchable RF FE tuning
  – Use Beidou if in China, GLONASS if in Russia, …
Current Situation – High-end

- Baseline is multi-GNSS (GPS,GLONASS), multi-frequency (L1,L2,…) including support for new systems (Galileo,Beidou,QZSS,…)
- OEM boards and products, Software Defined Radio, …
  - High power consumption, high output data rate
  - Large mechanical and antenna dimensions
  - Specific applications requiring integration into other systems
  - Performance, accuracy and reliability are critical
  - Dual/triple frequency (L1, L2, L5, …)
  - RTK, PPP, NTRIP, …
  - Specialized features and applications such as attitude sensing, remote sensing, spaceborne receivers, …
  - Integration with high end IMUs’
  - Markets include mining, agricultural automation, surveying, aviation/ADS-B
  - Low volumes
High-end GNSS Issues

• **Price**
  – Too expensive, difficult to get economies of scale

• **Accuracy**

• Too many signals? Too many systems?
  – More complex receivers
    => More engineering & higher power consumption

• **Spoofing/jamming susceptibility**
A GNSS Receiver

Antenna

RF Signal

Radio Freq Front End

Optional IMU

Reference Oscillator

Oscillator Signal

Baseband Correlator

Digital Hardware

Processor

Processor plus Memory Peripherals Firmware

Analogue Hardware

RF Cable
Radio Frequency Front Ends

• Multi-frequency and/or multi-GNSS require multi-frequency RF front ends
  – GPS: 1575, 1227, 1176
  – GLONASS: 1598-1605, 1242-1248, 1202
  – Galileo: 1575, 1279, 1192
  – Beidou: 1590, 1561, 1207, 1192

• Multi-frequency RF front ends not commonly available
  – Expect this to change over time as demand for multi-frequency receivers increases
  – Integrated into consumer chips for volume produces (eg. GPS/GLONASS, GPS/???)

• Mr Kevin Parkinson from General Dynamics Pty Ltd has new RF FEs that will be incorporated into future Namuru designs
System Architectures

- More systems & signals require more processing!
  - Higher power, more complex firmware
- Tradeoff between flexibility of software/firmware and throughput/power consumption of hardware
  - Delineation between baseband hardware and firmware is not as clear cut as before
  - Embedded processors now also include FPGA capability thereby allowing more flexibility between HW & FW
    eg. MicroSemi SmartFusion2, Intel Atom E6x5C, Altera Cyclone V SoC
  - Custom hardware or microcode now an option
  - Range of signal-types makes a 1 size fits all approach difficult
- Mr Vinh Tran, a PhD candidate at UNSW is researching alternatives to the traditional analog/baseband/processor architectures
Algorithms / Firmware

- Multi-GNSS mandatory
  - More powerful processors, more firmware & complexity
  - Cross verification between systems
- Increased use of DGPS
  - PPP via NTRIP/RTCM or
  - Satellite delivered corrections such as QZSS-LEX
- Hybrid positioning
  - Eg. GNSS/Locata, GNSS/Wifi, GNSS/4G-PRS
  - Low cost IMUs => GNSS/MEMS IMU
- Interference mitigation
Conclusions

• Still opportunity for improvement
• New GNSS coming on line generating new work
• Developing receivers that can use all available GNSS while keeping power consumption and cost down is still a challenge
• Addition of low cost IMUs / sensors / communications adds an additional layer of complexity, but also will improve performance
• Government mandate and legislation a key driver