# Future of GNSS Receivers

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## 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

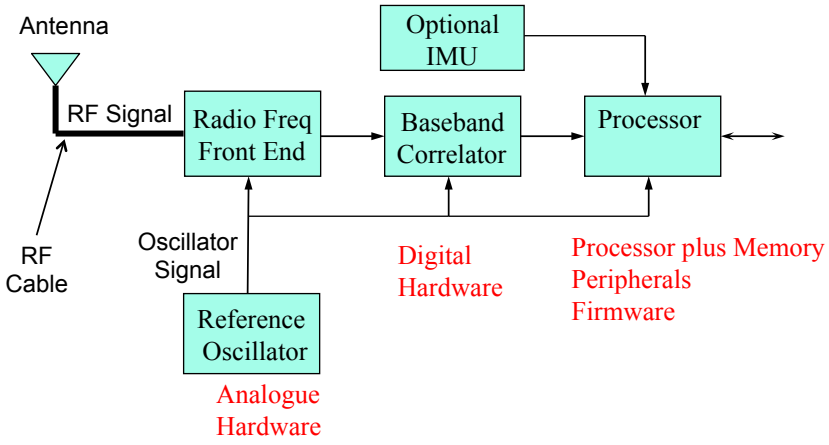
- Baseline is multi-GNSS (GPS,GLONASS), multi-frequency (L1,L2,…) including support for new systems (Galileo,Beidou,QZSS,…)
- OEM boards and products, Software Defined Radio, …
  - High power consumption, high output data rate
  - Large mechanical and antenna dimensions
  - Specific applications requiring 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



# 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