Australian Centre for Space Engineering Research (ACSER)

An ANZ GPS Receiver for ANZ Cubesats and Launches

Presented by

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at

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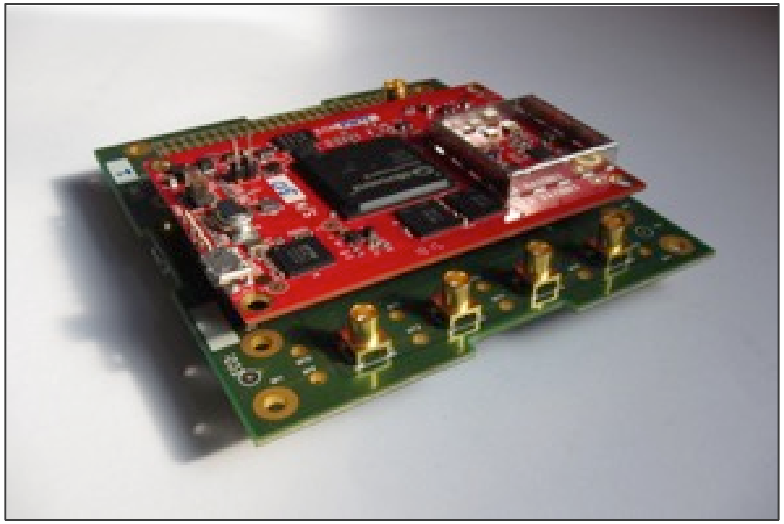
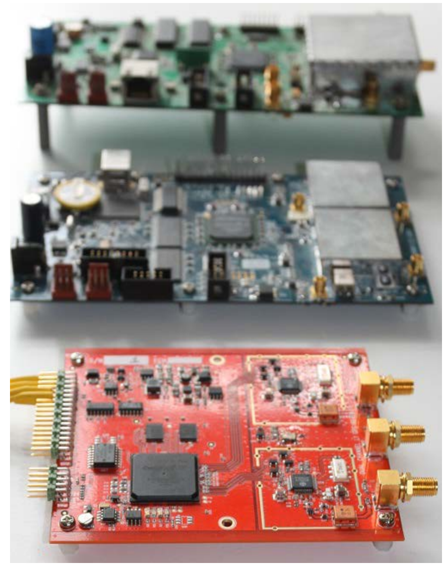


Australian & New Zealand GPS Heritage

- Namuru FPGA based GPS receivers in development since 2003
- Developed by General Dynamics Ltd (NZ), UNSW's ACSER & SNAP Lab, and Embedded GNSS Pty Ltd
- Kea V4.1SB hardware suited for CalPoly Cubesat standard, Namuru V32R3A suited for Boeing Colony 2 designs
- Firmware capable of autonomous in-orbit operation (acquisition, tracking, navigation and timing) and high-G acceleration (suitable for launch)
- Namuru V32R3A flying on DST Group Biarri (Point & Squad)
- Kea V41SB flying on DST Group Buccaneer Risk Mitigation Mission, UNSW EC0 QB50 and USyd Inspire2 QB50 cubesats

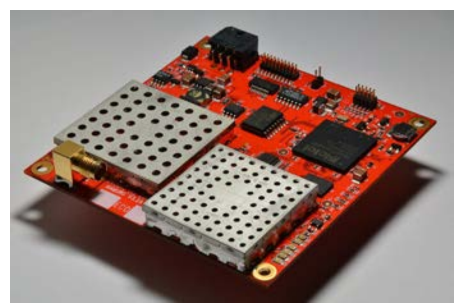
Selected Past Receiver Designs



Namuru V1

Namuru V2R4

Namuru DLR



Namuru V32R3A

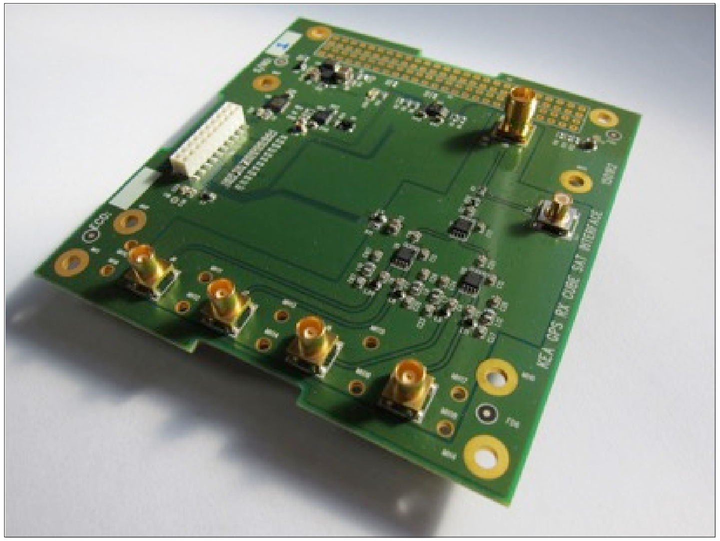
Kea V4.1SB Receiver Module

- Hardware design developed/owned by General Dynamics Ltd (NZ) and marketed through Kea GNSS Pty Ltd (NZ)
- Credit card sized
- SmartFusion2 SOC
  - Large flash based FPGA with 50k or 80k logic elements and enhanced SEU immunity
  - Powerful 166 MHz ARM Cortex M3 processor

- 512 Mb of SECDED LPDDR SDRAM
- 8 MB of serial Flash
- 8 kB of FRAM (ferromagnetic RAM)
- CMOS RF ASIC capable of L1/E1 operation
- Super-capacitor powered RTC
- Support for disciplined VC-TCXO and reference frequency output
- USB2 interface for debugging and data-capture

CalPoly CubeSat Interface Board

- Hardware design developed/owned by General Dynamics Ltd (NZ) and marketed/sold through Kea GNSS Pty Ltd (NZ)
- Convert credit-card sized Kea to CalPoly form-factor
- Different interface boards for different customers
- Support includes:
  - PC104/CalPoly Cubesat bus interface
  - USB UART serial port interface
  - GPS antenna switching



Aquarius GPS Firmware

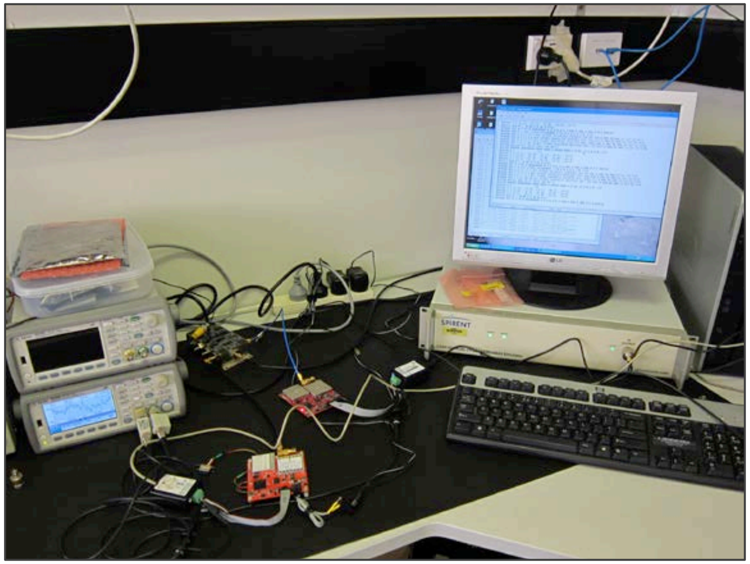
- C code developed/owned by Eamonn Glennon since Namuru V1 (2004)
- Fully licensed to UNSW
- Features
  - Simple RTOS with tasks, signals, semaphores, timers; recently ported to FreeRTOS
  - GPS driver API for frequency plan portability (GP2015, BL2627)
  - Carrier smoothing
  - VC-TCXO Syntonization (±10 ppb)
  - Synchronization (<±20 ns, 95%)
  - 1 Hz carrier phase output for L1 carrier phase precise navigation
  - NMEA inspired commands and reports
  - QZSS capable, 1 channel allocated to QZSS
  - Adaptions for operation in LEO, including ±40 kHz frequency search, orbit aware Kalman filter, TLE aided warm start, high dynamics, respectable tracking sensitivity
- Ported to Altera NIOS-2 and ARM Cortex M3 (~160 kB)

FPGA Correlator IP

- Two sets of IP developed/owned by UNSW
- Multi-channel GPS correlator design based on the Zarlink 2021 design
  - Typically instantiated with 11 or more correlator channels
  - Ported to Altera Cyclone FPGAs, Microsemi SmartFusion2 SoCs and Microsemi ProASIC3E FPGAs
  - 3 (ProASIC) to 4 (SF2) code phase taps, ½ chip separation
  - Timing pulse output circuitry
- A Delay Doppler Map Accelerator (DDMA) hardware block used to calculate DDMs for GPS-Reflectometry
  - Ported to MicroSemi SmartFusion and SmartFusion2 SoCs
  - Size of DDMA depends on FPGA memory resources

Spirent Simulations

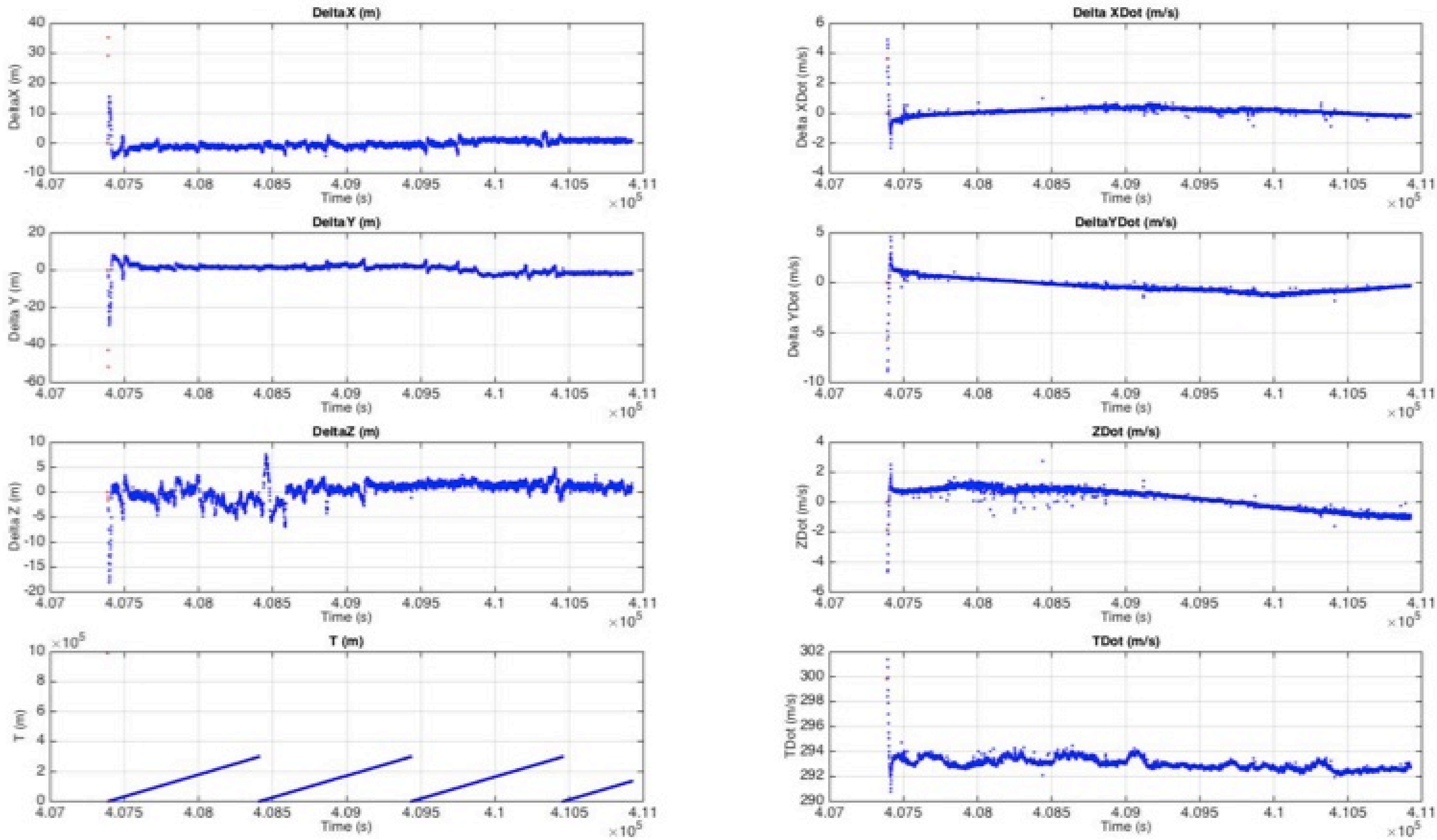
- Spirent simulation performed to test for LEO operation and multi-stage launch to orbit
- LEO accuracy is shown in WGS84 ECEF coordinates
- Rocket launch accuracy is shown in the radial, along and cross-track dimensions
- Rocket launch dynamics
  - Up to 40 m/s/s of acceleration in this scenario (tracking loops expected to handle more than this)
  - Up to 7000 m/s speed
  - 1 Hz navigation solution update



Namuru V32R3A testing

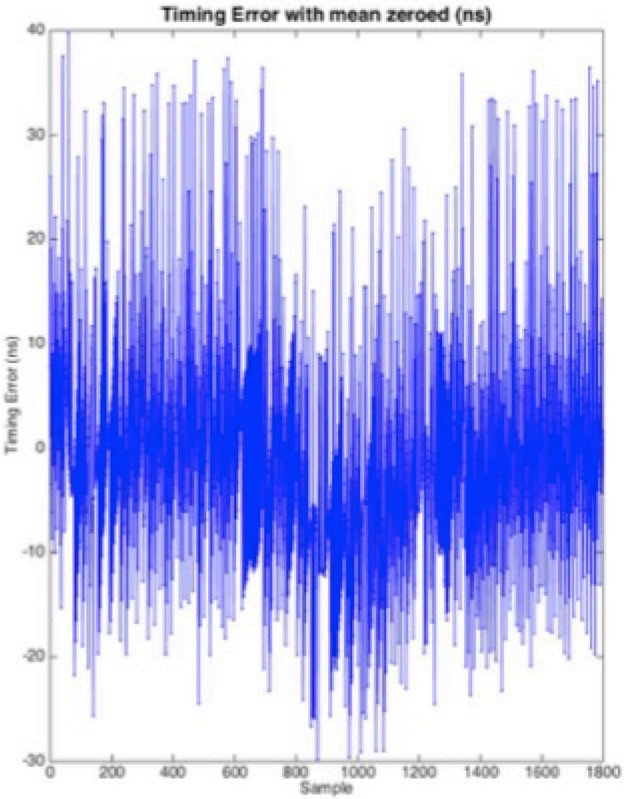
Low Earth Orbit (LEO) Accuracy 1

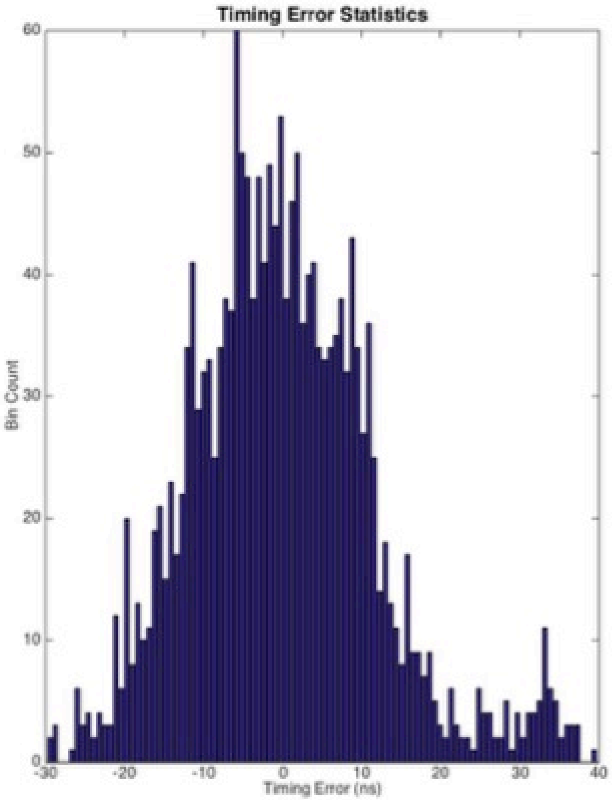
- Accuracy of low earth orbit test with Spirent GPS simulator (no ionospheric errors)



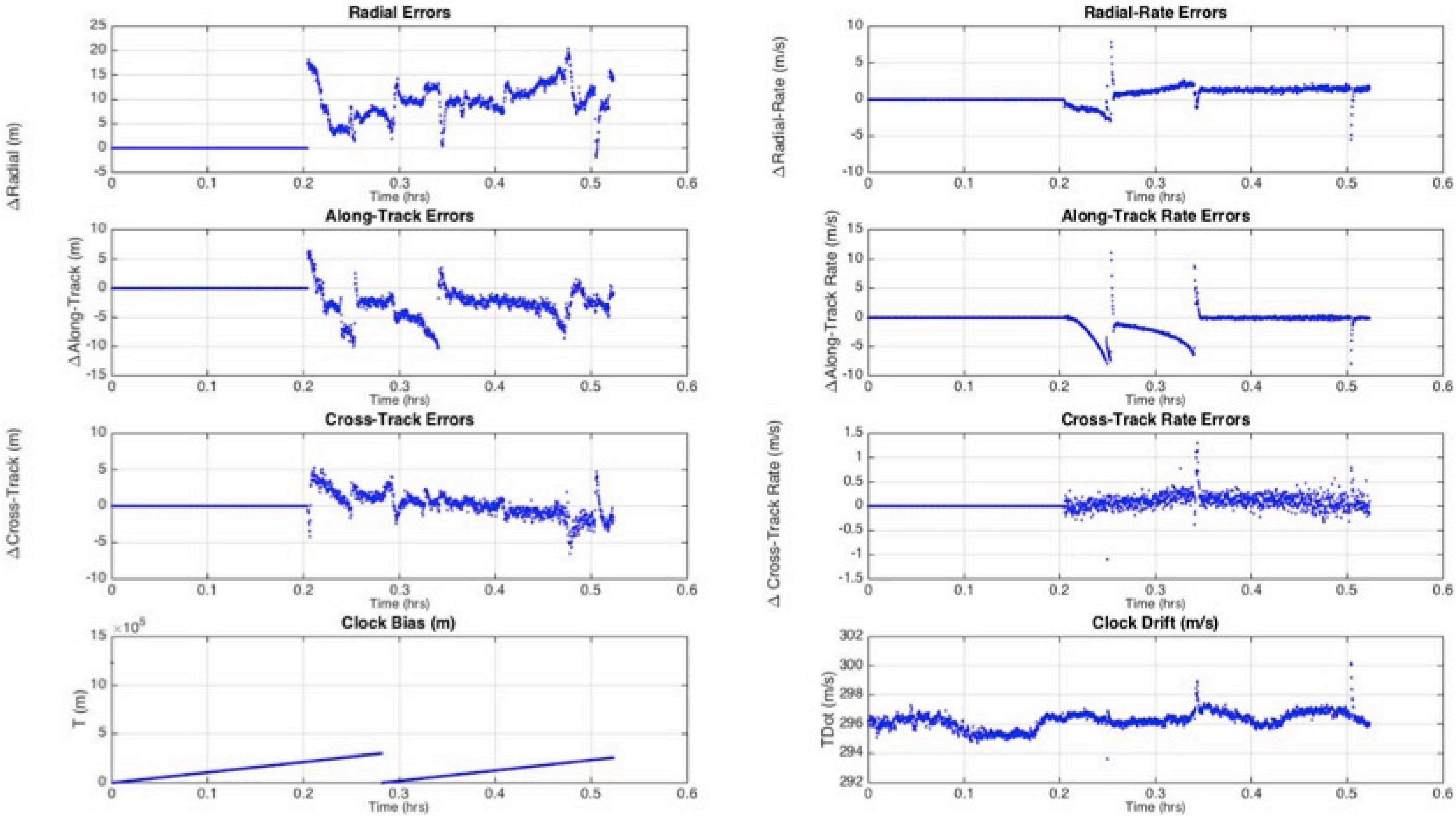
Timing Precision Test in LEO

- 1PPS timing precision tested with Spirent simulator





Rocket: Radial/Along/Cross Track Errors



Summary

- An Australian and New Zealand developed GPS receiver is available for cubesat and launch applications
- Design can be customized for different applications
- For more information, contact Mr Kevin Parkinson, Dr Eamonn Glennon, or Prof Andrew Dempster via the email addresses below or talk to us during the tea break
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