GPS/WAAS/Loran Prototype System

by

Chad Schweitzer, Paul Schick Dean Gervasi,
Eric Wiley and Linn Roth, Ph.D., FRIN, Locus, Inc.

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Outline

- Program Overview/Goals
- GPS/WAAS Chipset and Antenna Selection
- Hardware Architecture
- Software Architecture
- Status
- Summary

Program Overview/Goals

- Embed GPS/WAAS chipset into existing SatMate 1030 Receiver System and mount GPS/WAAS antenna in H-field with SAG
- Do not compromise performance of either system in comparison to stand alone operation of each
- Provide independent GPS/WAAS and eLoran operation (i.e. no combination of raw data or solutions, with exception of $GPGGA GPS message to calculate real-time quasi-ASFs)
- Add ability to use external clock (e.g. Cs) to discipline the SatMate internal oscillator (TCXO)
- Build and deliver prototypes to FAA
- Period of performance April – October 2005 (work actually initiated in December 2004)

Starting Platform and Program Challenges

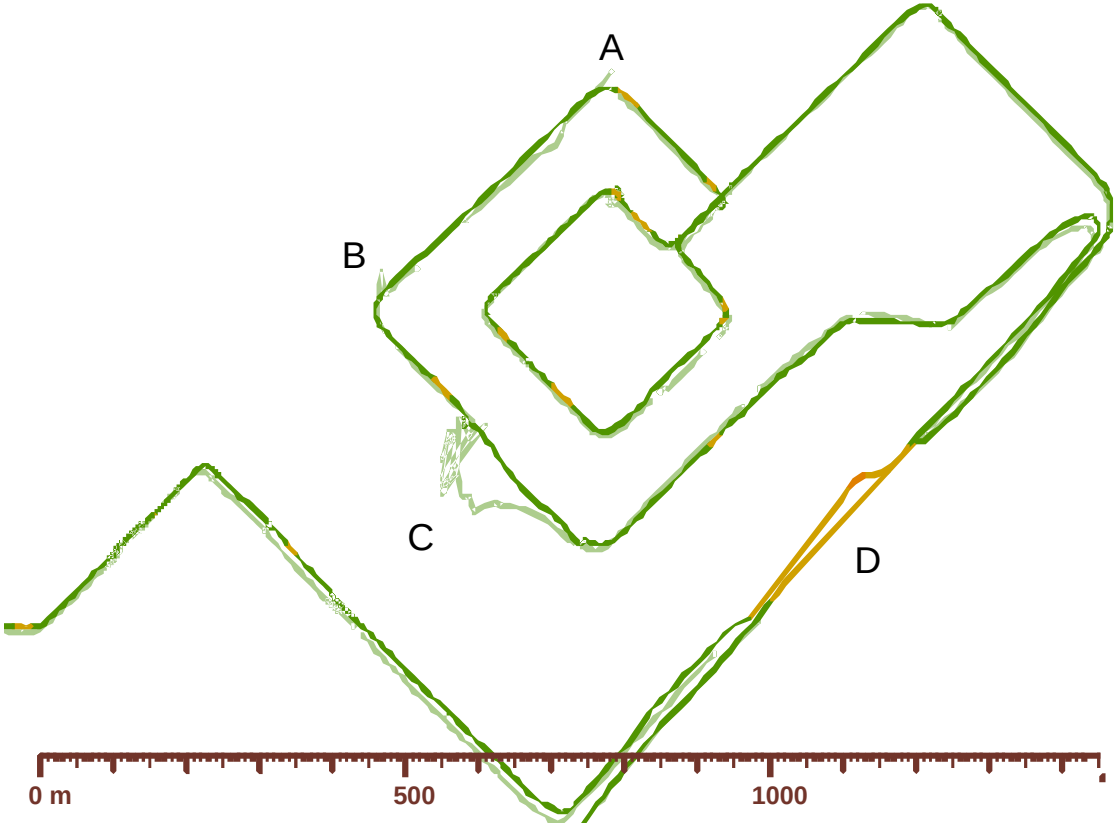
- SatMate 1030
  - Embed and power GPS receiver without compromising GPS or Loran performance
  - Develop hardware, software and user interfaces to GPS

- H-field Antenna
  - Embed and power GPS antenna without compromising stand alone GPS or Loran antenna performance
  - Ensure previously embedded SAG does not compromise GPS performance

GPS/WAAS Chipset Selection

- Example Search Criteria of 44 Embeddable Devices:
  - 12 channel minimum with SBAS (WAAS,EGNOS) capability
  - operate on 3.3 VDC supply
  - footprint <1290 mm^2, interface circuitry required
  - evaluation kit and factory support
  - support antennas with 3 or 5 V supplies
  - NMEA output and serial I/O capabilities
  - ability to change operating characteristics of the receiver
- Initial list narrowed to 5 potential chipsets, and here focus on:
  - capabilities of evaluation kits
  - interactions with factory support
- Variety of static and dynamic tests performed
- Device selected: u-blox TIM-LP

Representative Mobile Tests on u-blox TIM-LP – Downtown Madison



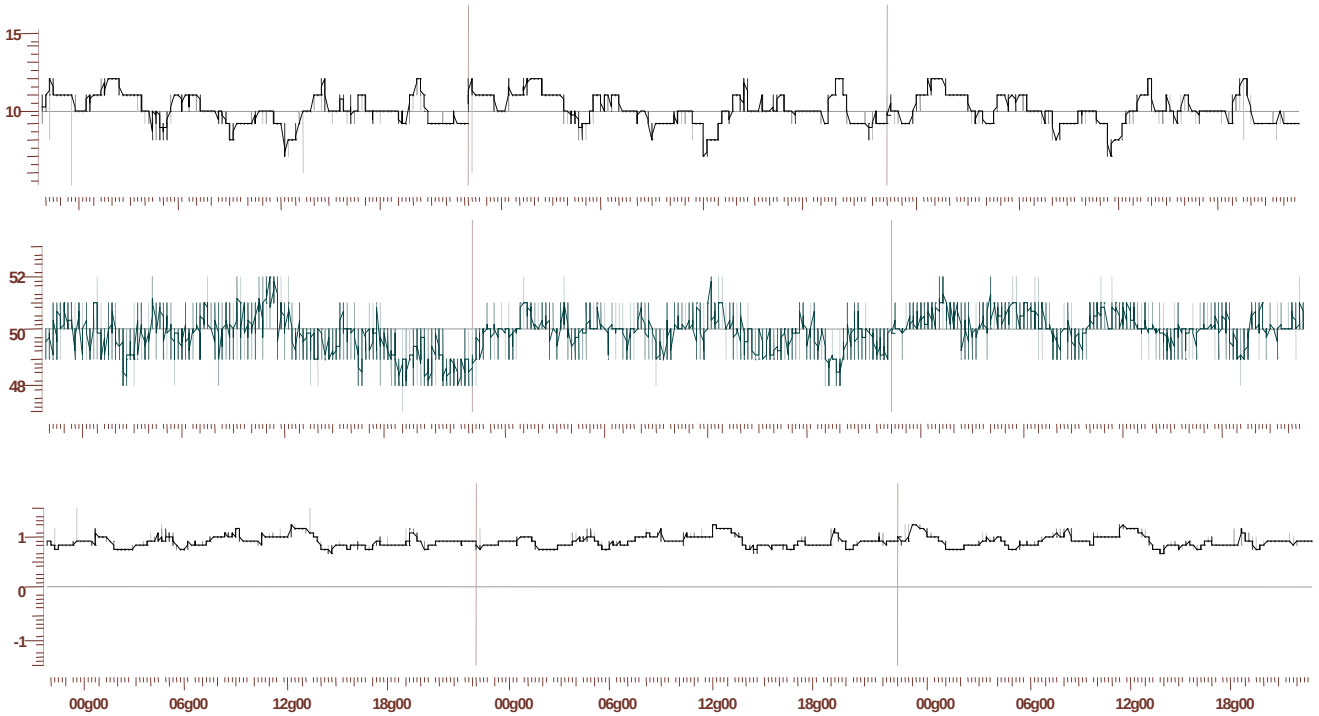
- Comparison GPS/WAAS system more subject to multipath (A,B,C) around buildings
- Systems performed similarly when operated under convention center (D)

Representative Overnight Static Tests on u-blox TIM-LP Using Same GPS/WAAS Antenna

SVs in View

Max C/No in dB

HDOP

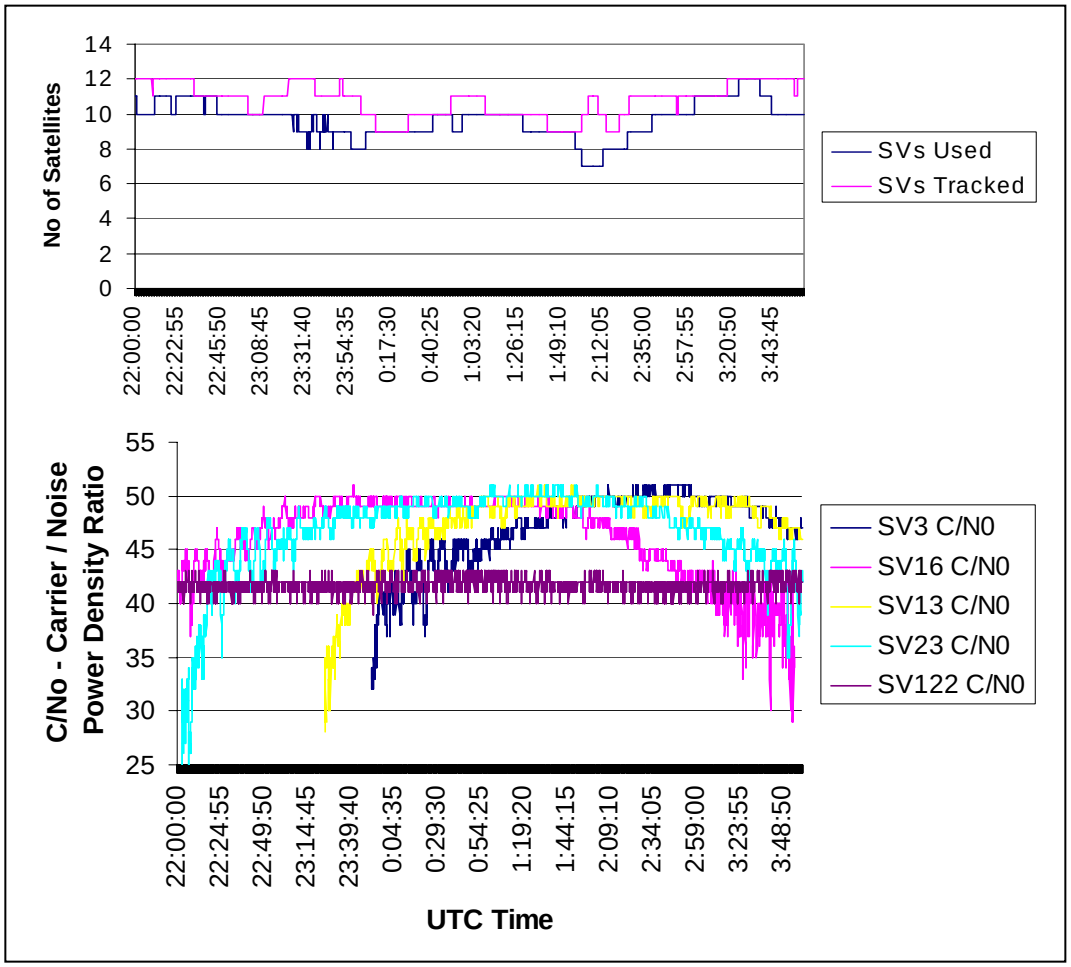


Stand-alone chipset
Stand-alone antenna
CONTROL

Chipset in SatMate
Antenna in H-field

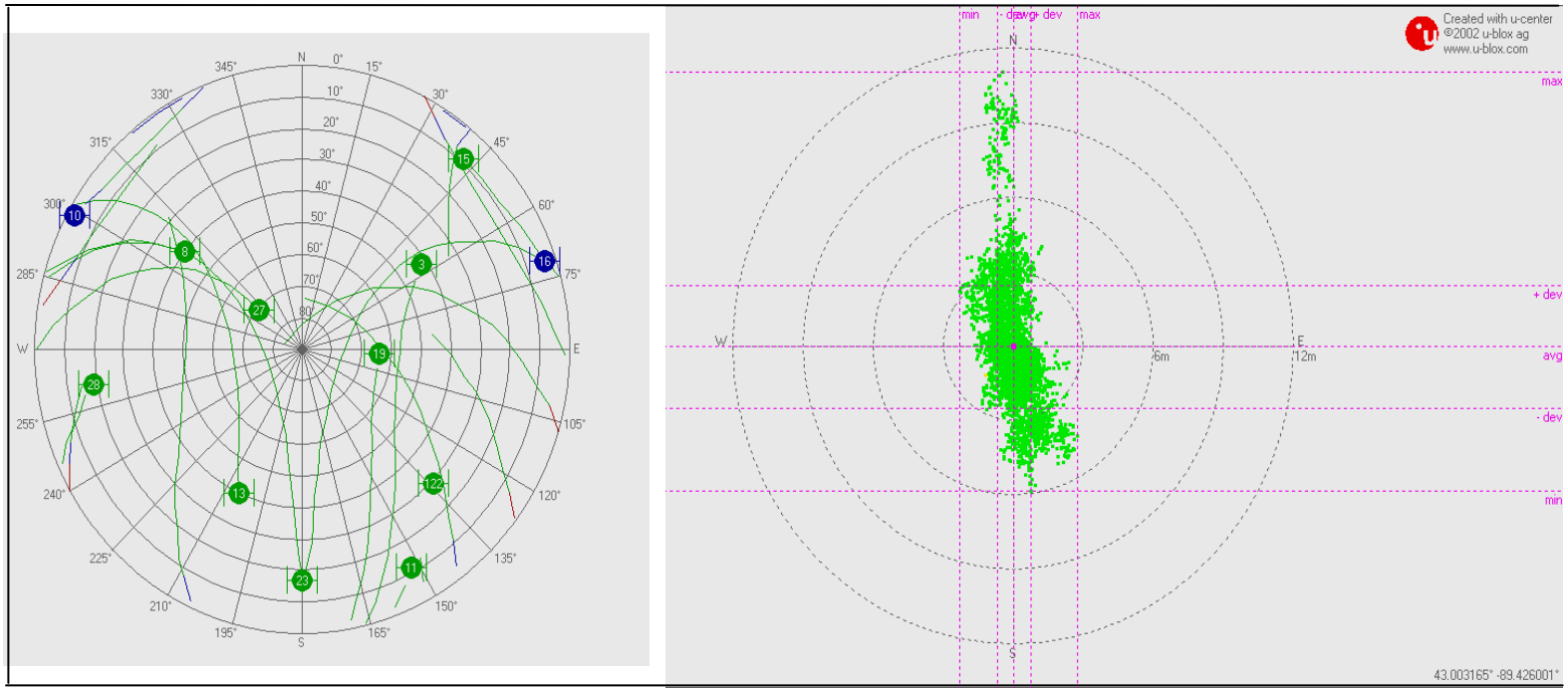
Stand-alone chipset
Antenna in H-field

Representative Static Tests on u-blox TIM-LP Using Combined GPS/WAAS/eLoran Antenna



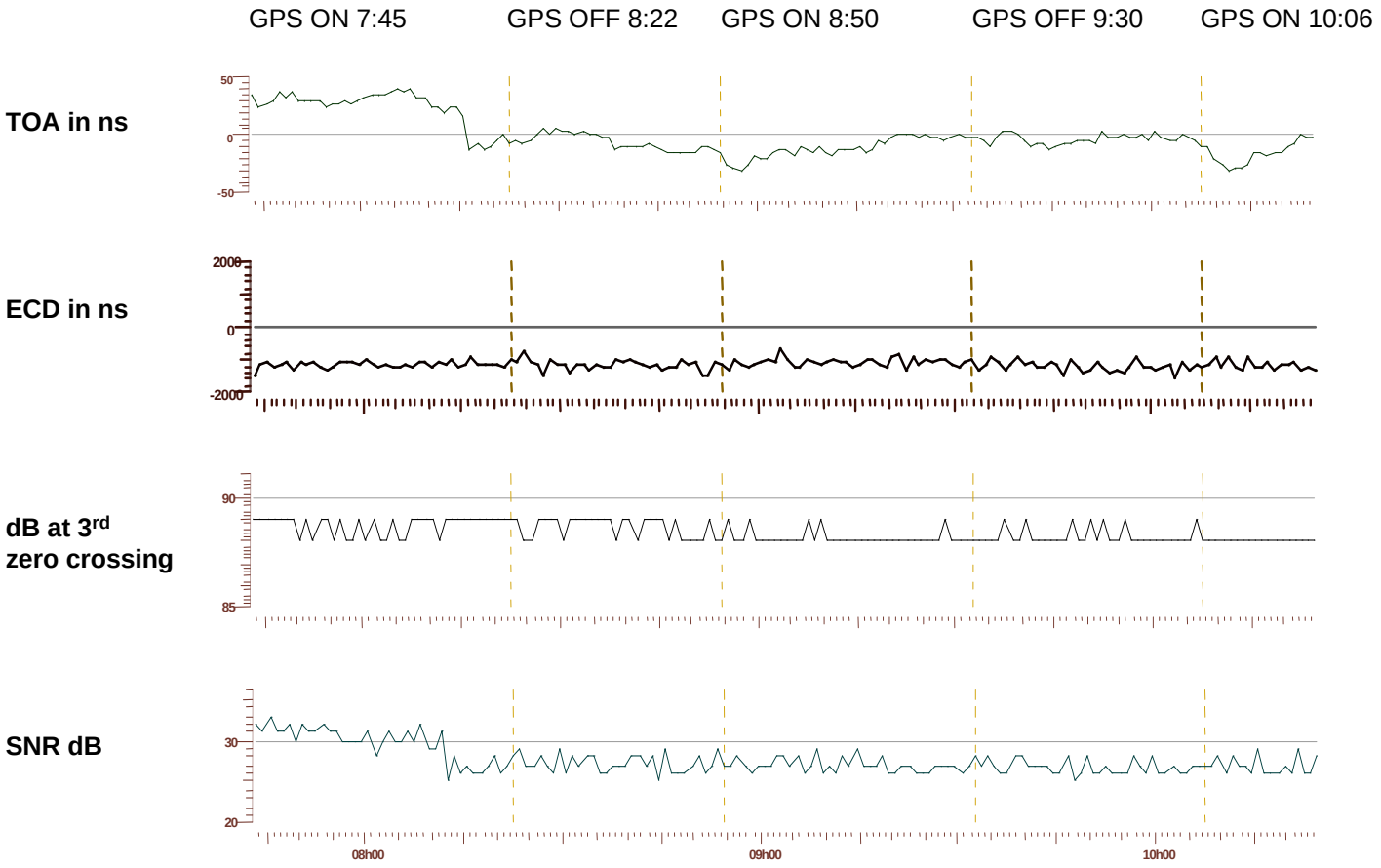
Lower graph limited to 5 SVs for clarity

Representative Static Tests on u-blox TIM-LP Using Combined GPS/WAAS/eLoran Antenna



Orbital Planes and Scatter Plot from Same Test

Representative Static Tests on eLoran Receiver with Embedded u-blox TIM-LP and Combined Antenna



Signals from 8970M Transmitter

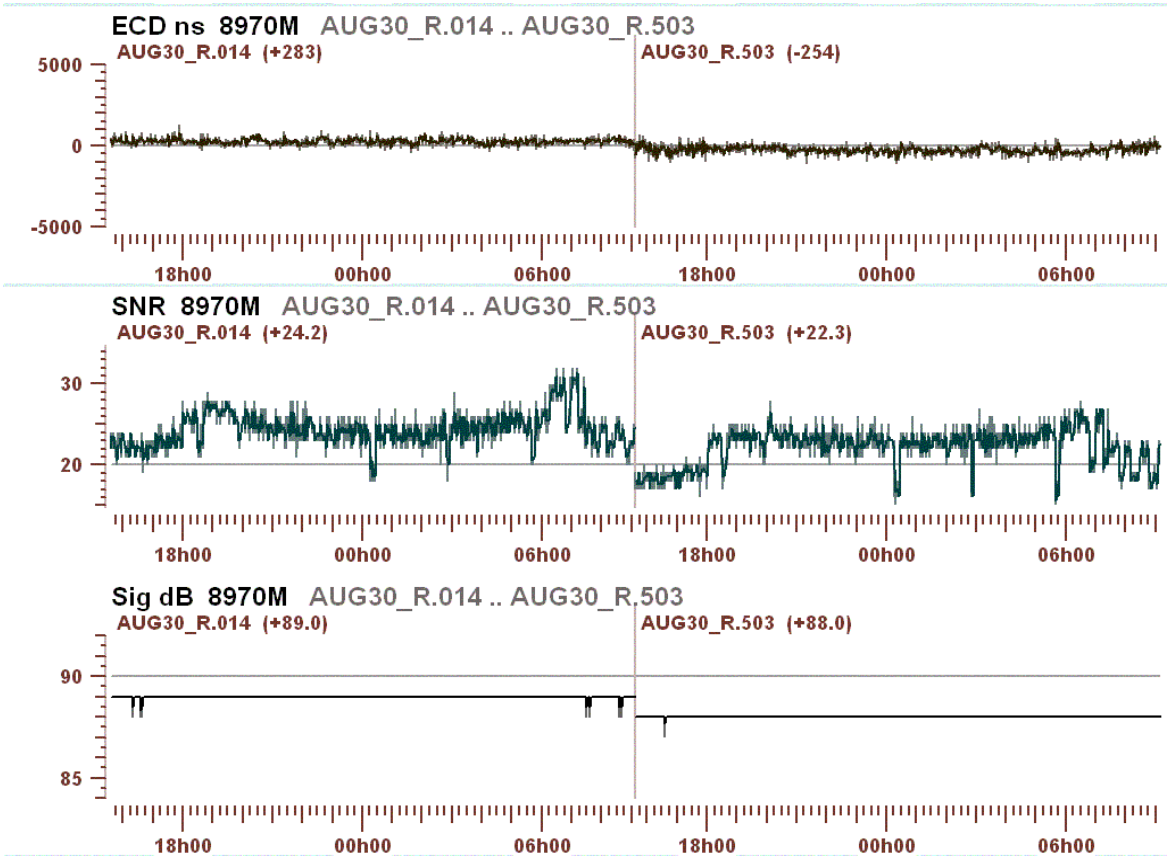
GPS/WAAS Antenna Selection

- Initial Investigation of 12 Devices:
  - 2 eliminated due to periodic oscillations
  - 7 eliminated for carrier to noise or elevation characteristics

- Final candidates evaluated for:
  - signal reception
  - mechanical fit and cable/connectors
  - factory support

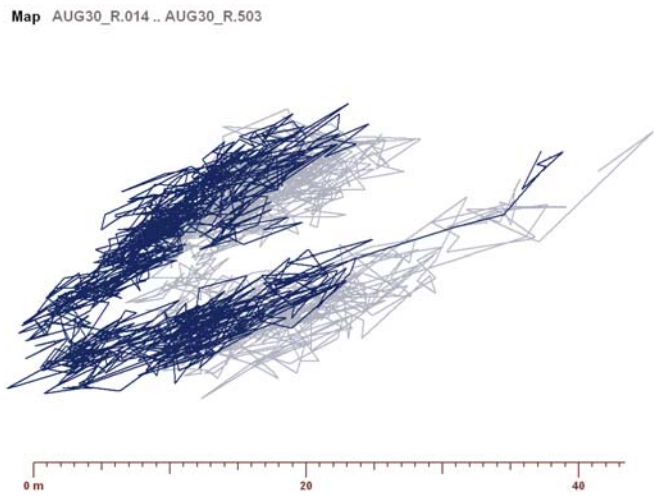
- Device selected: Maxrad 26 dB

Representative Static Tests of Combined GPS/WAAS/H-field with SAG – Loran Data



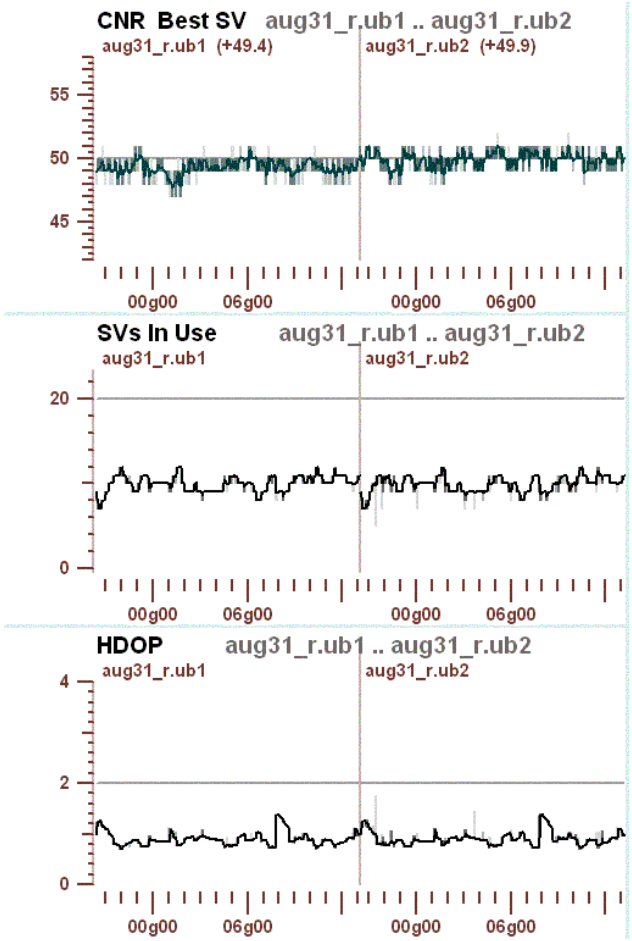
Stand alone Loran
Control

GPS/WAAS/H-field



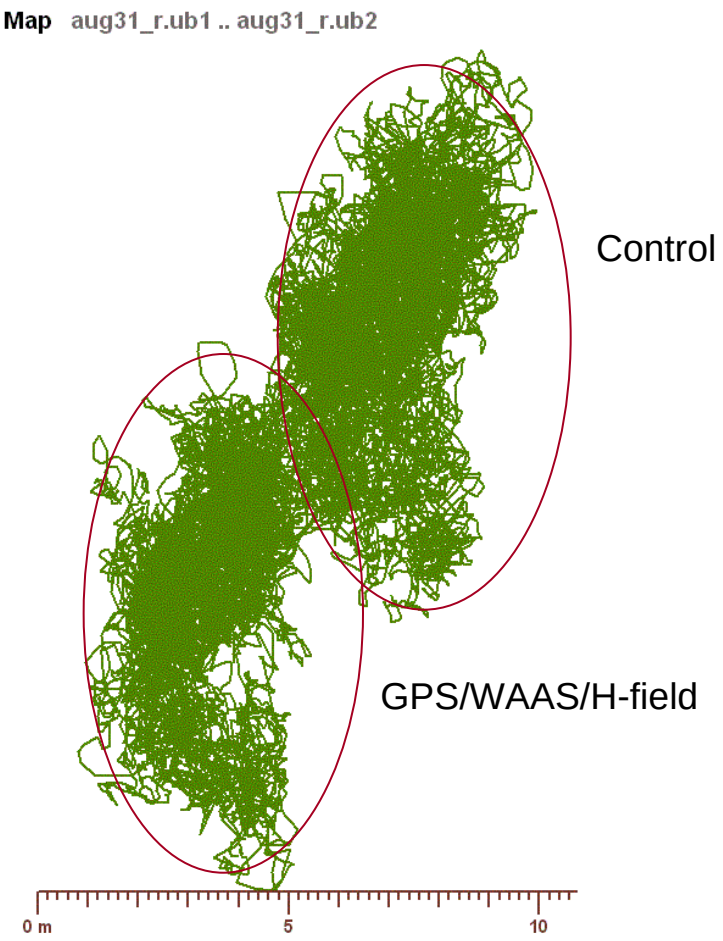
Antennas positioned 6m apart on Locus' roof
Blue – control
Grey – GPS/WAAS/H-field

Representative Static Tests of Combined GPS/WAAS/H-field with SAG – GPS Data



GPS/WAAS/H-field

Stand alone GPS/WAAS Control

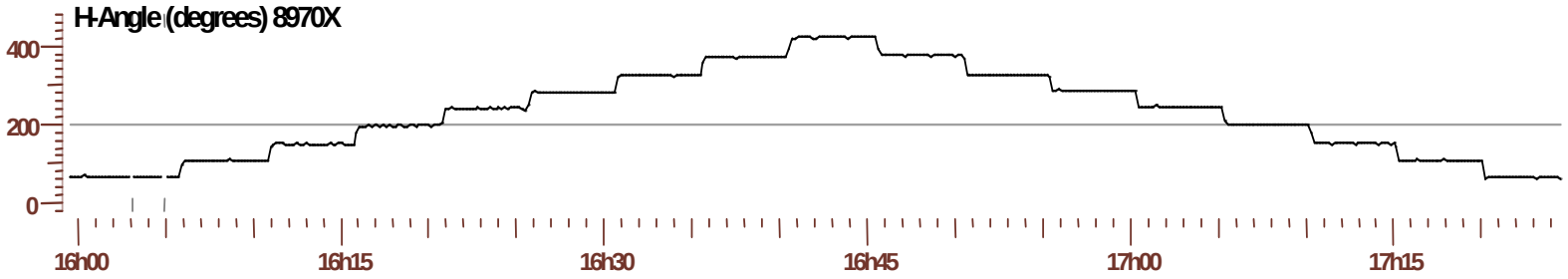


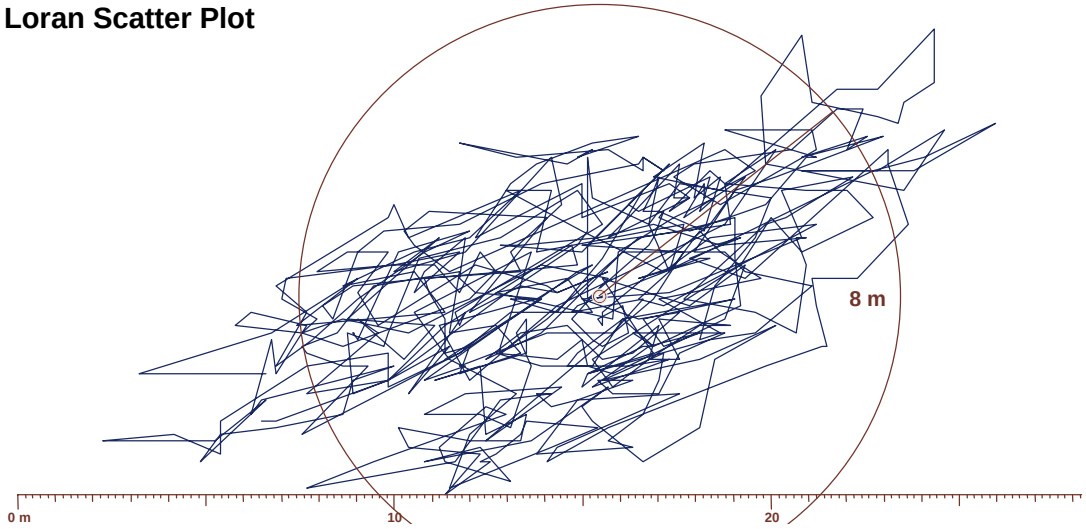
Control

GPS/WAAS/H-field

Antennas positioned 6m apart on Locus' roof

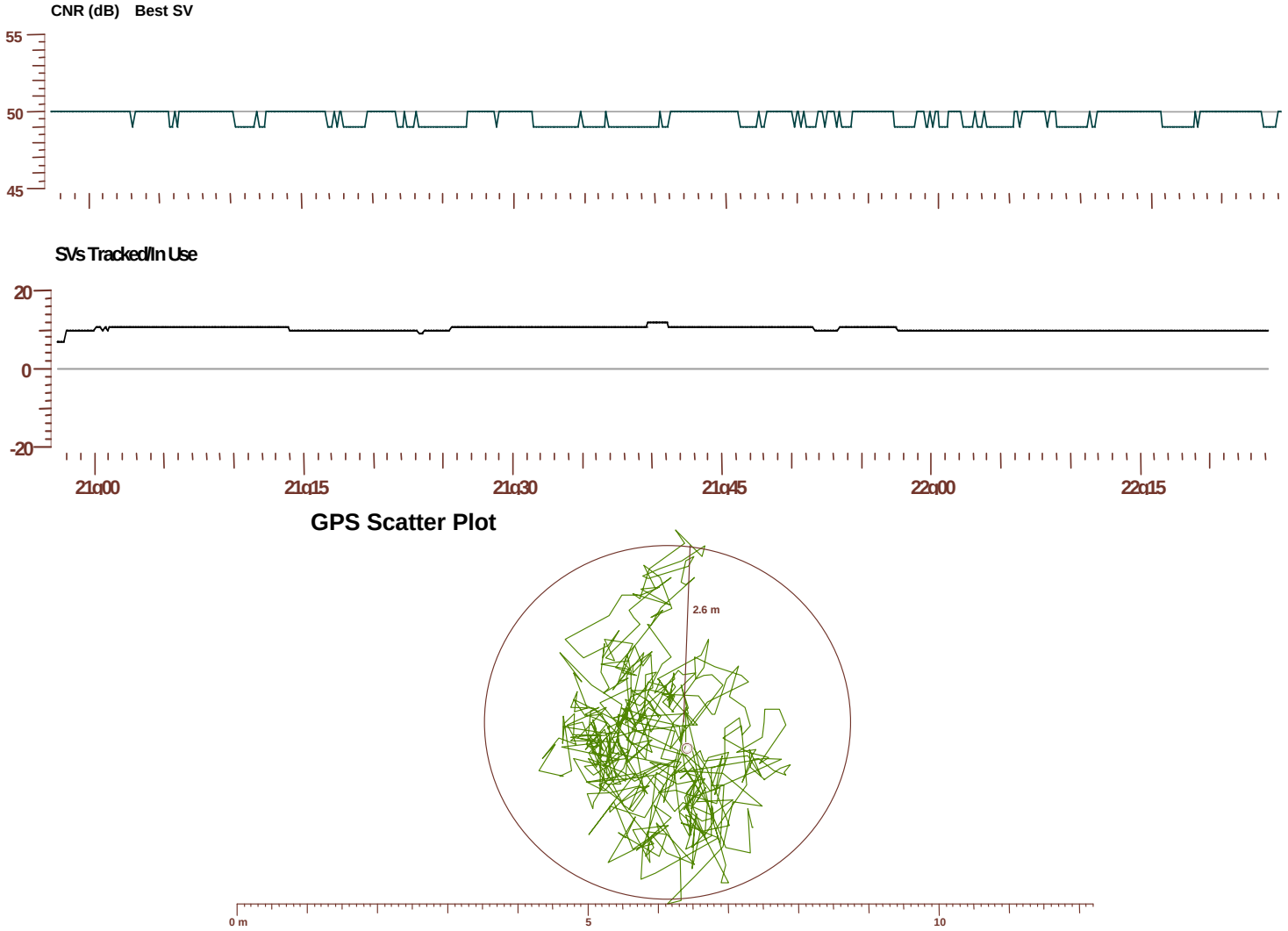
Representative Static Tests of Combined GPS/WAAS/H-field with SAG – Loran Data





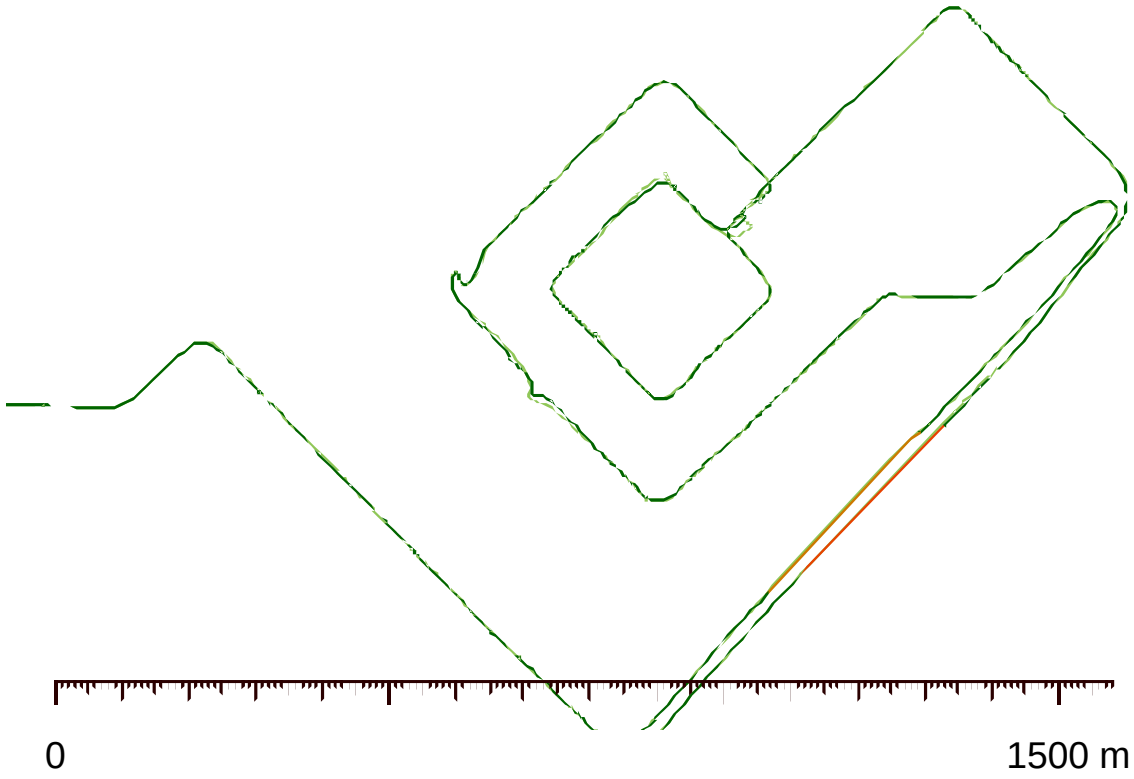
Clockwise/counterclockwise 360° antenna rotation

Representative Static Tests of Combined GPS/WAAS/H-field with SAG – GPS Data



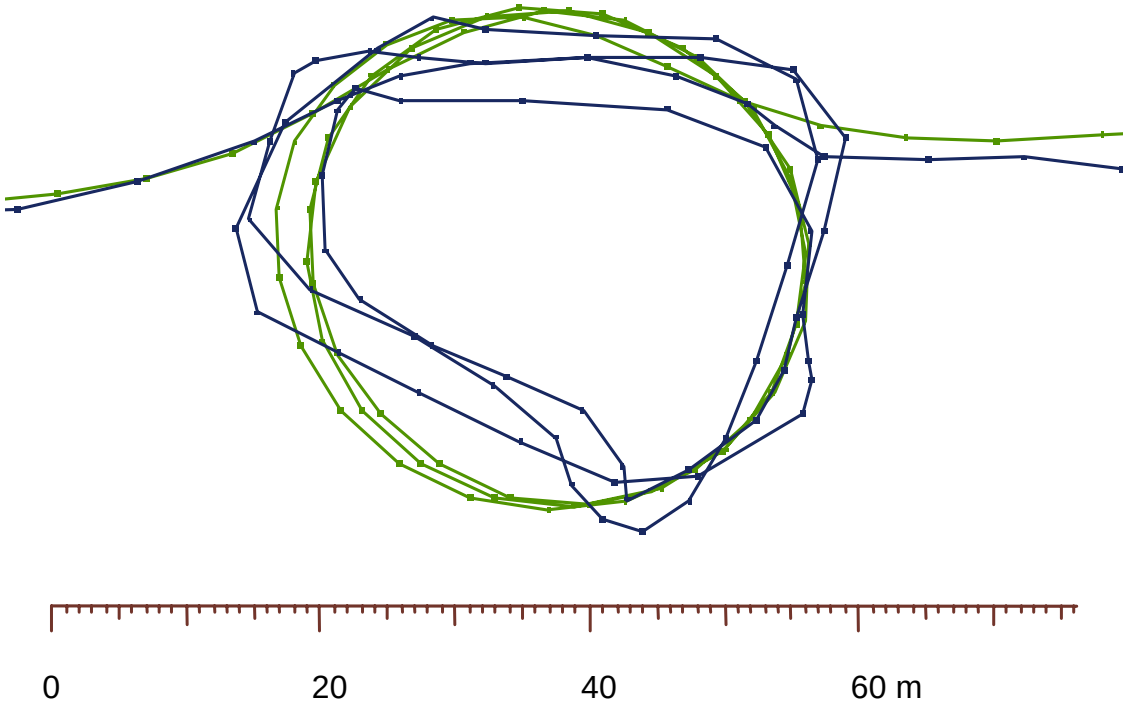
GPS During Same Clockwise/counterclockwise 360° antenna rotation

Representative Mobile Tests on GPS/WAAS Antennas – Downtown Madison



One antenna mounted on eLoran H-field
One antenna stand-alone

Mobile Tests Using u-blox TIM-LP and eLoran as Stand-Alone Systems with Combined GPS/WAAS/H-field with SAG

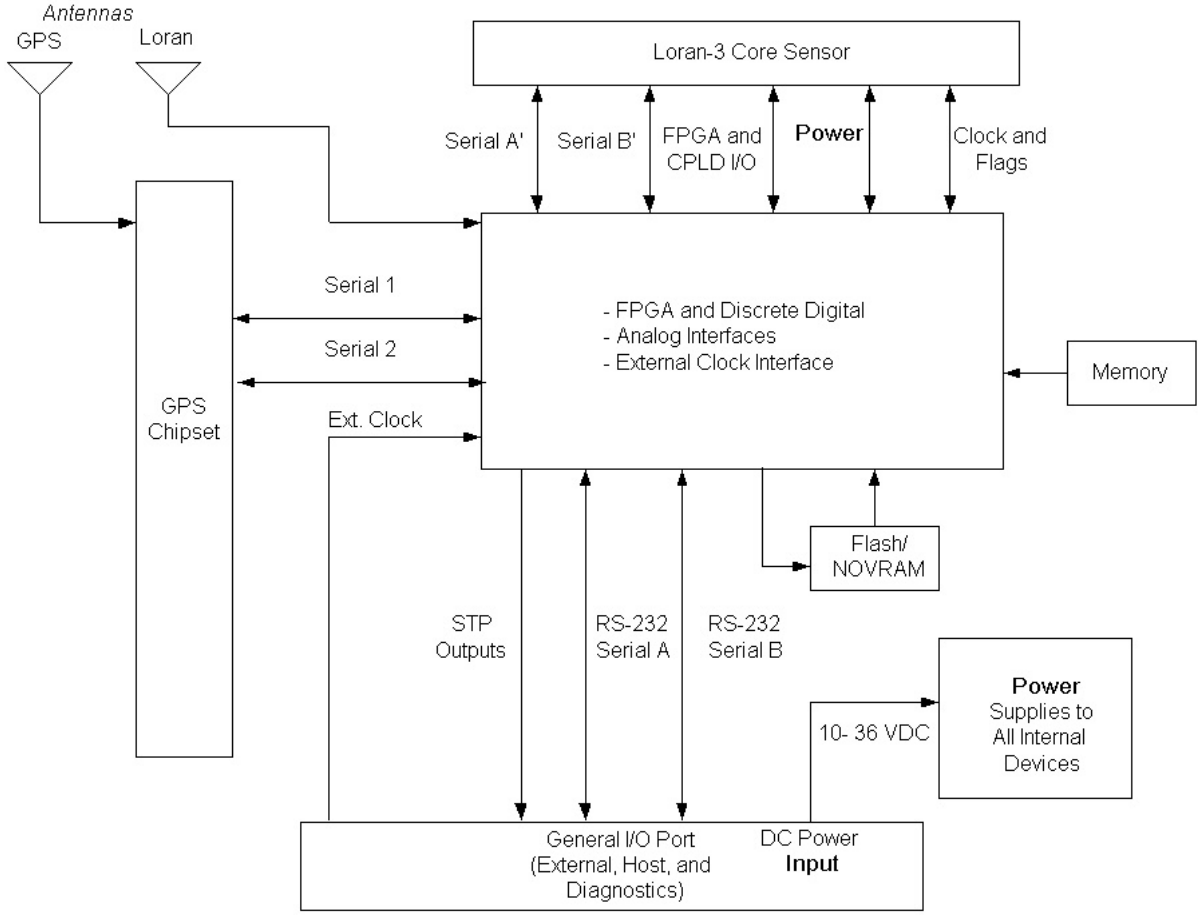


Good station tracking throughout, despite rapid change in antenna/vehicle angle.
Repeatable nature of Loran plot suggests local grid distortion (perhaps buried cables).

GPS/WAAS Chipset and Antenna Selection Summary

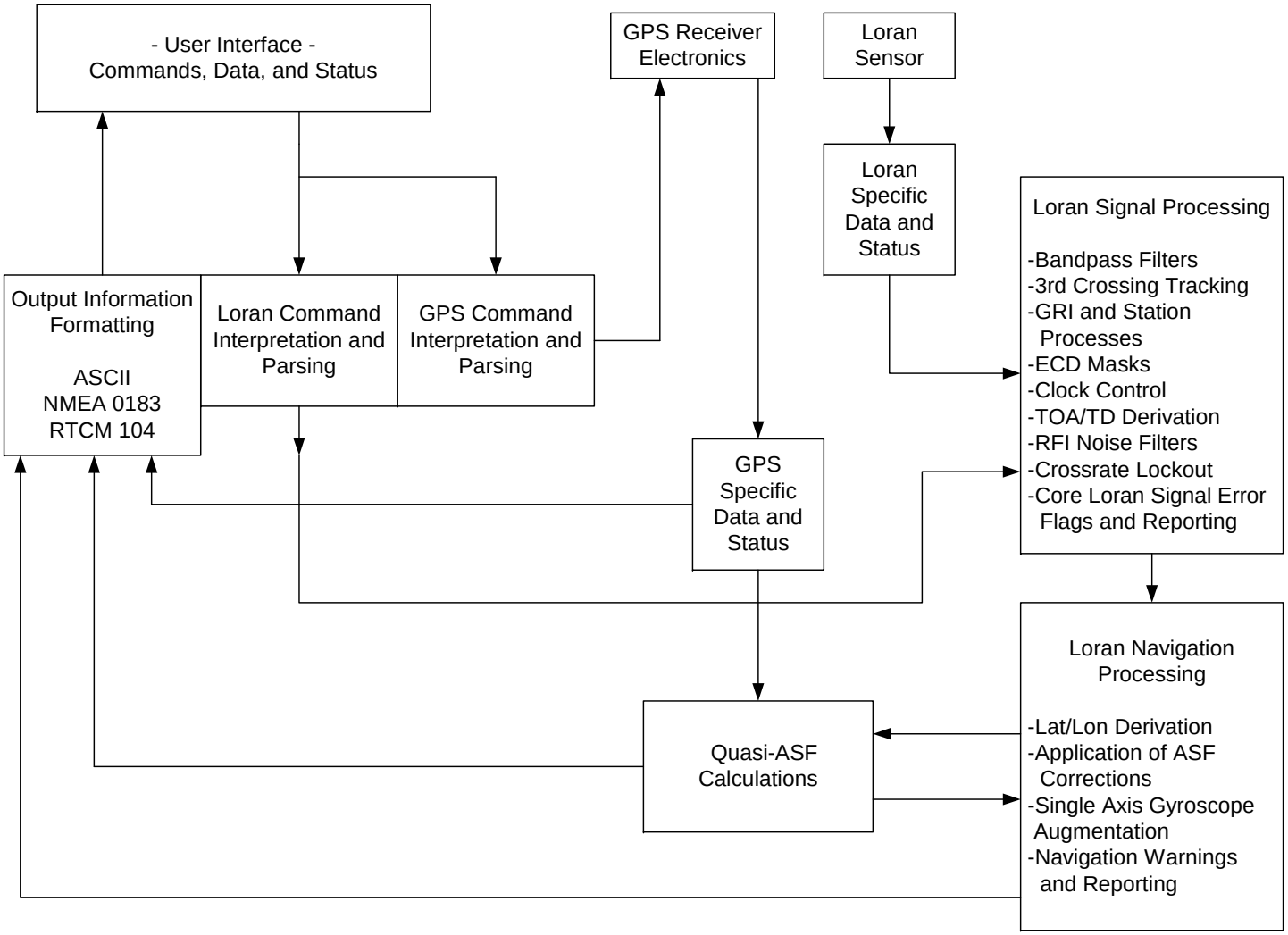
After the initial selection process, a variety of static and dynamic tests confirmed that the performance of the stand alone GPS/WAAS chipset and antenna selected did not degrade when in close proximity to the SatMate 1030 receiver and antenna system. The following slides provide an overview of the actual hardware and software architecture developed for embedding the GPS/WAAS system into the SatMate 1030.

Hardware Architecture – Same eLoran Receiver, new I/O Board



Added ability to use external clock (e.g. Cs) to discipline internal TCXO

Software Architecture – Same eLoran Receiver, new I/O Board



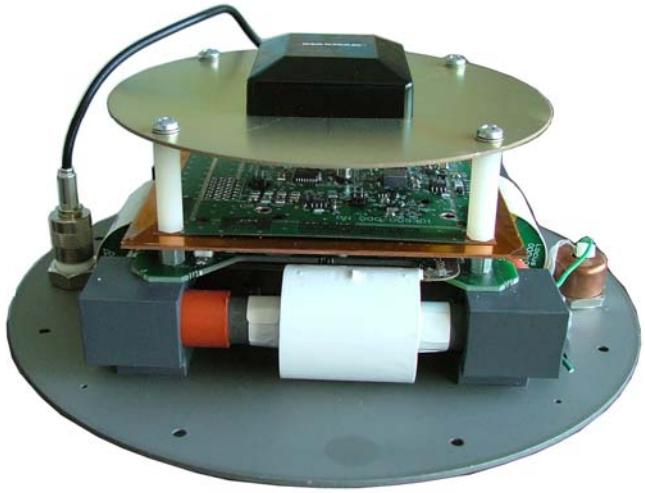
Data Output and Host/User Interface

GPS receiver

- 2 null modem RS-232 serial interfaces
- HyperTerminal for command input and data/status flag output
- Flexible user configuration of GPS and eLoran receiver parameters
- Simultaneous GPS/Loran output
- Detailed quantification of eLoran signals (all-in-view)
- $GPGGA, $GPGSV, and $GPVTG messages and others can be added later
- 2 time/frequency outputs

Status

- The GPS/WAAS receiver and antenna were selected, and using stand-alone systems as controls, a variety of static and mobile tests demonstrated:
  - Presence of GPS receiver does not affect eLoran receiver performance, and vice versa
  - Presence of GPS antenna does not affect H-field, and vice versa
- First article combined GPS/WAAS/H-field antenna with SAG has been built/tested



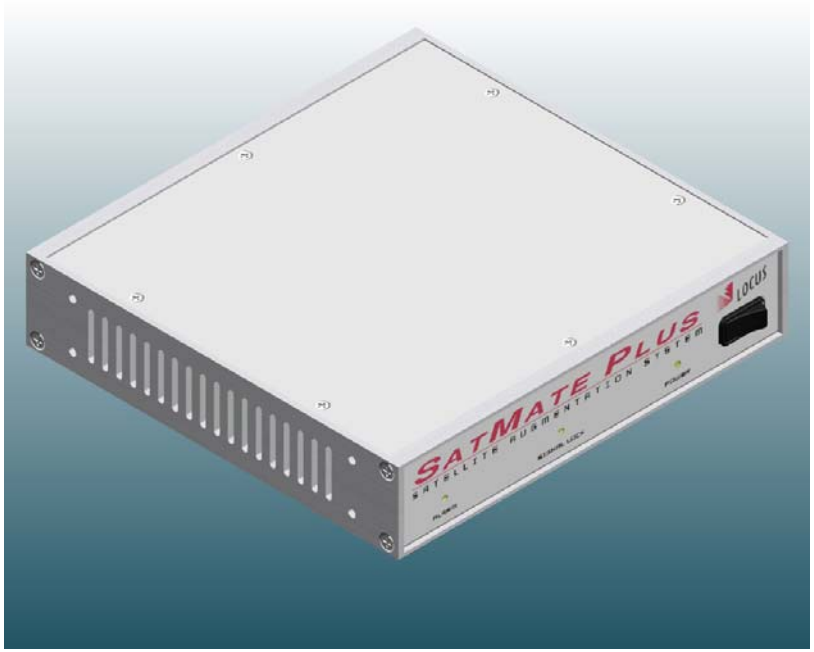
Status

- GPS/WAAS receiver and antenna were selected and using stand-alone systems as controls, a variety of static and mobile tests have demonstrated:
  - Presence of GPS receiver does not affect eLoran receiver performance, and vice versa
  - Presence of GPS antenna does not affect H-field, and vice versa
- First article combined GPS/WAAS/eLoran receiver has been built/tested
- Program is on schedule
- Prototypes to be completed by October 31, 2005

Summary

- A combined GPS/WAAS/eLoran system is well underway.
- Each sensor operates separately, but capabilities are present for later integration.
- Prototype system will be multimodal, and include both navigation and time/frequency capabilities.
- Addition of external clock input is essential step to adaptation for eLoran monitoring and ASF applications.
- Prototype can act as platform for evaluating eLoran performance and directly comparing GPS.

SatMate *Plus* Prototype



Acknowledgements

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