Enhanced LORAN Receiver (ELR)
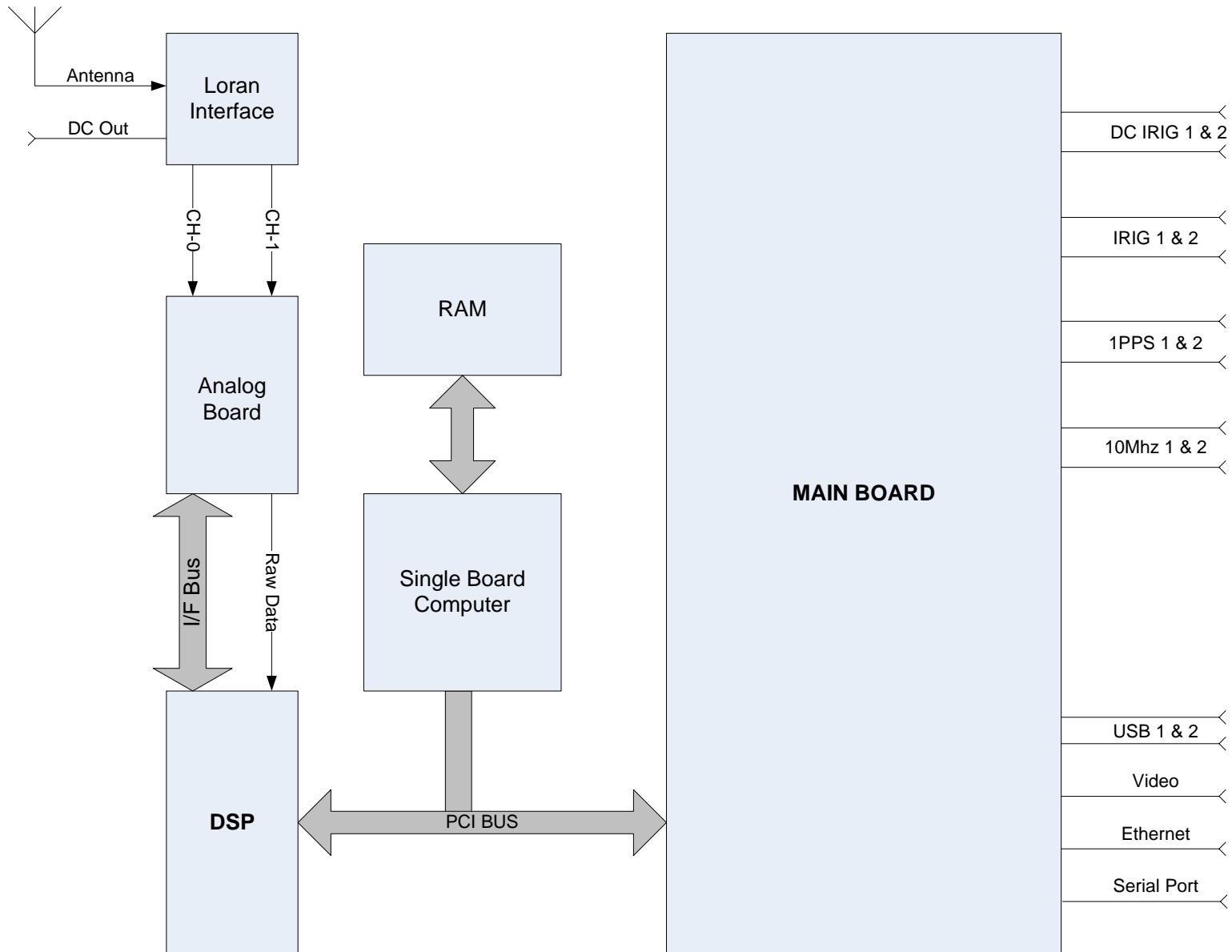
Kirk Montgomery – Symmetricom/Advanced Timing Solutions

2007 Convention and Technical Symposium - ILA-36
Orlando, Florida

Beta User Group
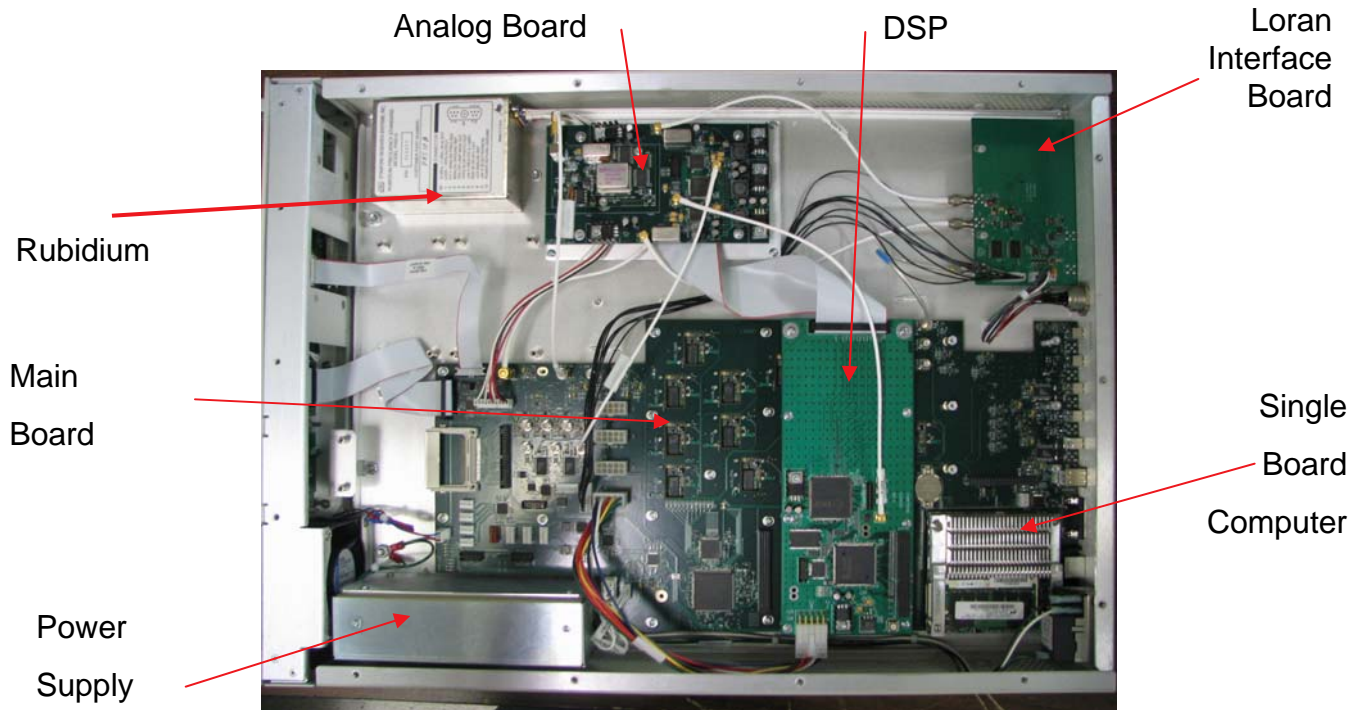
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▶ 8 Units completed Sep 2007.

▶ Identified a Beta User Group
- ✓ USNO   Ed Powers
- ✓ NIST   Mike Lombardi
- ✓ VOLPE   Jim Carroll
- ✓ STANFORD   Sherman Lo / Di Qiu
- ✓ CG Academy   Capt Hartnett/Greg Johnson
- ✓ Ohio U   ?
- ✓ PIG   Ben Peterson
- ✓ Symmetricom   Kirk Montgomery

▶ Beta User's Manual

Current Features

- ▶ E-Field & H-Field Antennas
  - E-Field – 8 Chains
    - User selectable DC Voltage levels.
  - H-Field – 4 Chains
    - Beam forming
    - Heading – Antenna
    - Azimuth – Strongest Signal
    - Bearing – LDC Station
- ▶ User selects
  - Chains
  - LDC Station
- ▶ Modes
  - Timing (Stationary)
  - Navigation
- ▶ User I/O
  - Keyboard/Monitor
  - Ethernet

- ▶ Internal Rb
  - Steered
  - Uses LDC to recover time
- ▶ Outputs
  - 1PPS
  - 10Mhz
  - Tracking Data
  - Demodulated LDC Messages
  - NTP
  - IRIG
- ▶ Inputs
  - 1PPS
  - 10Mhz
  - Reference Station (Timing)

Block Diagram

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Antenna → Loran Interface
DC Out

CH-0
CH-1

Analog Board

I/F Bus
Raw Data

RAM

Single Board Computer

DSP

PCI BUS

MAIN BOARD

DC IRIG 1 & 2

IRIG 1 & 2

1PPS 1 & 2

10Mhz 1 & 2

USB 1 & 2

Video

Ethernet

Serial Port

4

Hardware

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Analog Board DSP Loran Interface Board

Rubidium

Main Board

Single Board Computer

Power Supply

Time/Frequency Recovery

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▶ Raw (decimated) measurements from the Loran Data into the filter were stable.

- No Corrections
- Simply a measure of the Loran Time of Arrival from 8290-X (Gillette WY)

▶ Output from the filter was very stable over the period after the internal clock was locked down

▶ Standard Deviation was ~13nSec over the entire period

▶ The TIC measurement was the difference between the receiver and UTC (Symm)

- Note the RCVR "thought" it was holding the internal clock at UTC
- It appears that after the clock stabilized, the rcvr did hold to within ~25nSec of UTC.
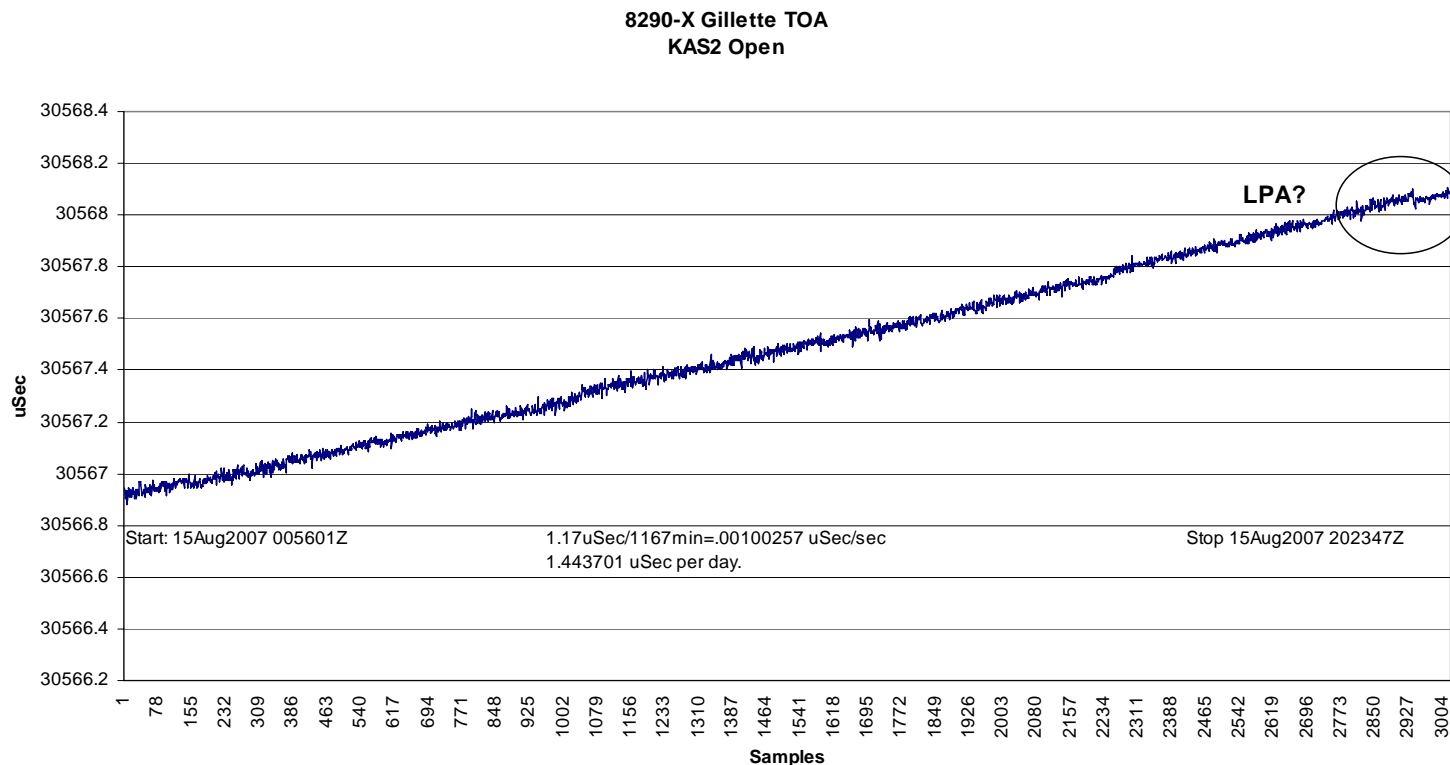
Time/Frequency Recovery

Symmetricom®

**ELR Time Recovery 180019Z - 191621Z Aug 2007**
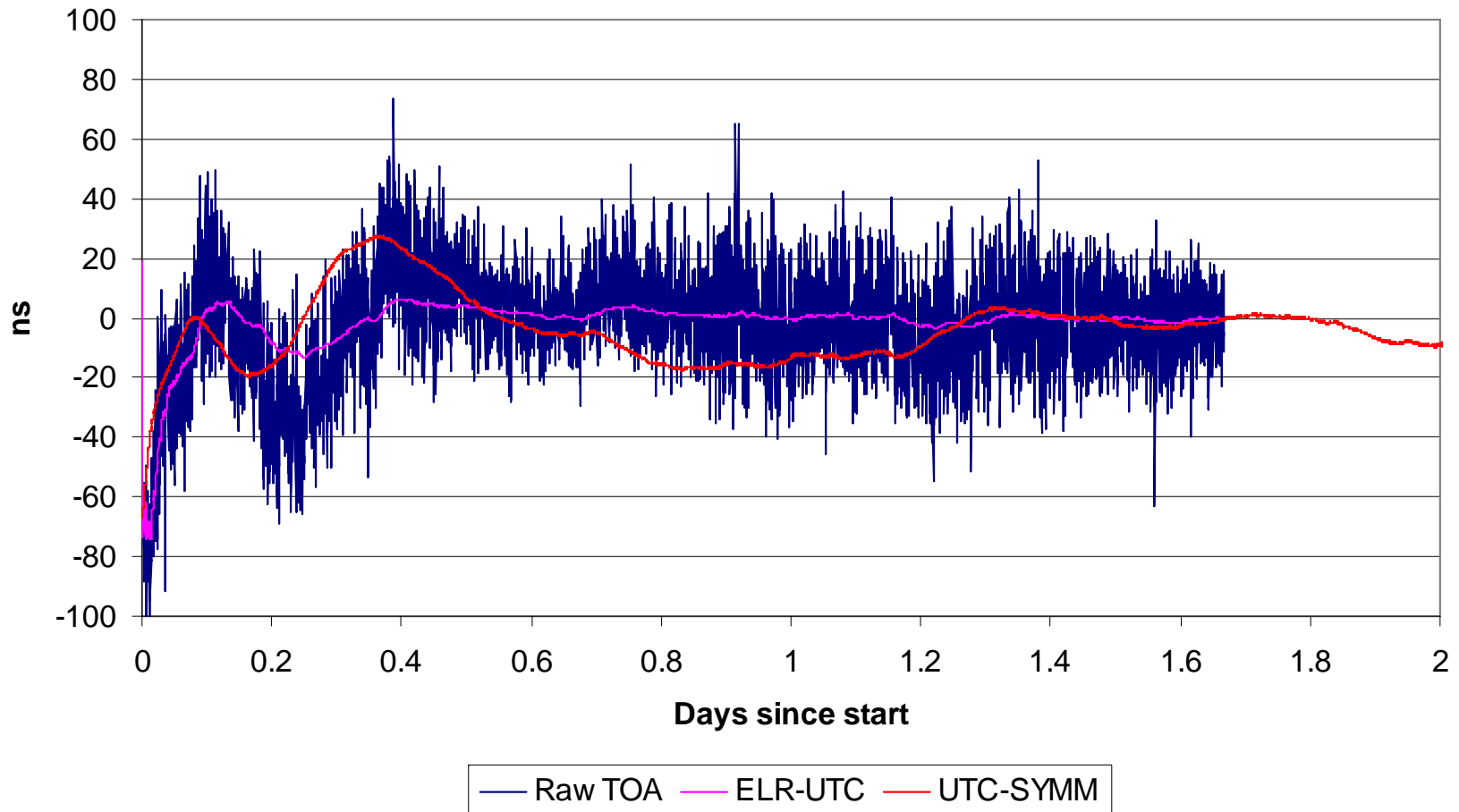
Rubidium Performance

- ▶ Open Loop
- ▶ Measured Rb performance against the received signal
  - ▪ 3 Cesium Ensemble @ the Transmitting Stations vs Internal Rb
- ▶ Drift estimated @ ~1.468uSec per day (9610-M)
  - ▪ Gillette was ~1.443uSec per day (-20nsec LPA)
- ▶ Short term stability ~20nSec

8290-X Gillette TOA
KAS2 Open

Start: 15Aug2007 005601Z   1.17uSec/1167min=.00100257 uSec/sec   Stop 15Aug2007 202347Z
1.443701 uSec per day.

8

System Testing

▶ Tracking performance

- SZC
- ECD measurements
- Signal Strength
- Cross Rate Interference

▶ E-Field & H-Field Antennas

- Looking at the phasing on the H-Field
- Orienting the antenna to the NORTH (Stationary)

  –Rotated the antenna from 0 to 359 degrees in 45 degree steps

  –Tracked very well

Next Steps
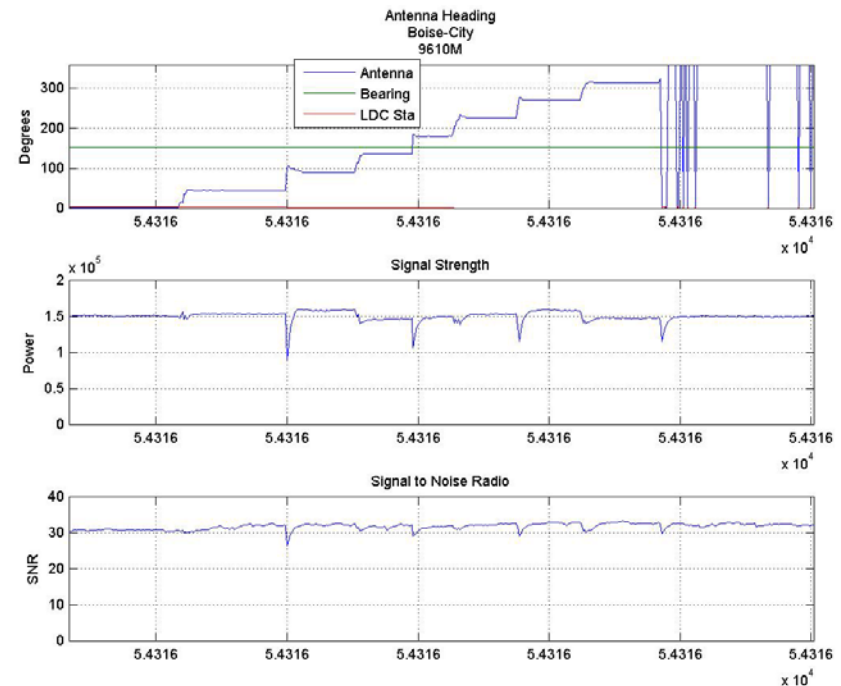
▶ Optimize receiver gain

▶ Provide Raw Data (I & Q) over Ethernet

▶ User Interface

- Web Interface
- Front Panel Interface

▶ Differential Reference Station

▶ Loran Data Channel

- Generating & forwarding corrections
- Decoding the broadcasted corrections
- Closing the loop (integrity)

▶ 1PPS Calibration

▶ Tracking Status

▶ Alarms

▶ JAMFEST 2007 (5-9 Nov 2007)