eLoran 103 – User Equipment

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Overview

- Legacy receivers
- Receiver development incentives
- Signal Clean-up
  - Threats & solutions
  - Examples
- H-field antennas
- eLoran receiver developments
  - Receivers for Maritime and Aeronautical applications
  - Performance example (maritime)
- Conclusions

Legacy Receivers

- The 1996 US Federal Radionavigation Plan indicated termination of Loran operation by the end of 2000
- Due to uncertain future of Loran worldwide all developments into modern receivers were virtually halted in 1997
- Many pre-1997 receivers are single (or maybe dual) chain, hard-limited receivers
- These receivers have not profited from the increase in processing power and decrease of hardware prices

Legacy Receivers Cnt'd

Si-tex Koden 787-C

Austron 2100

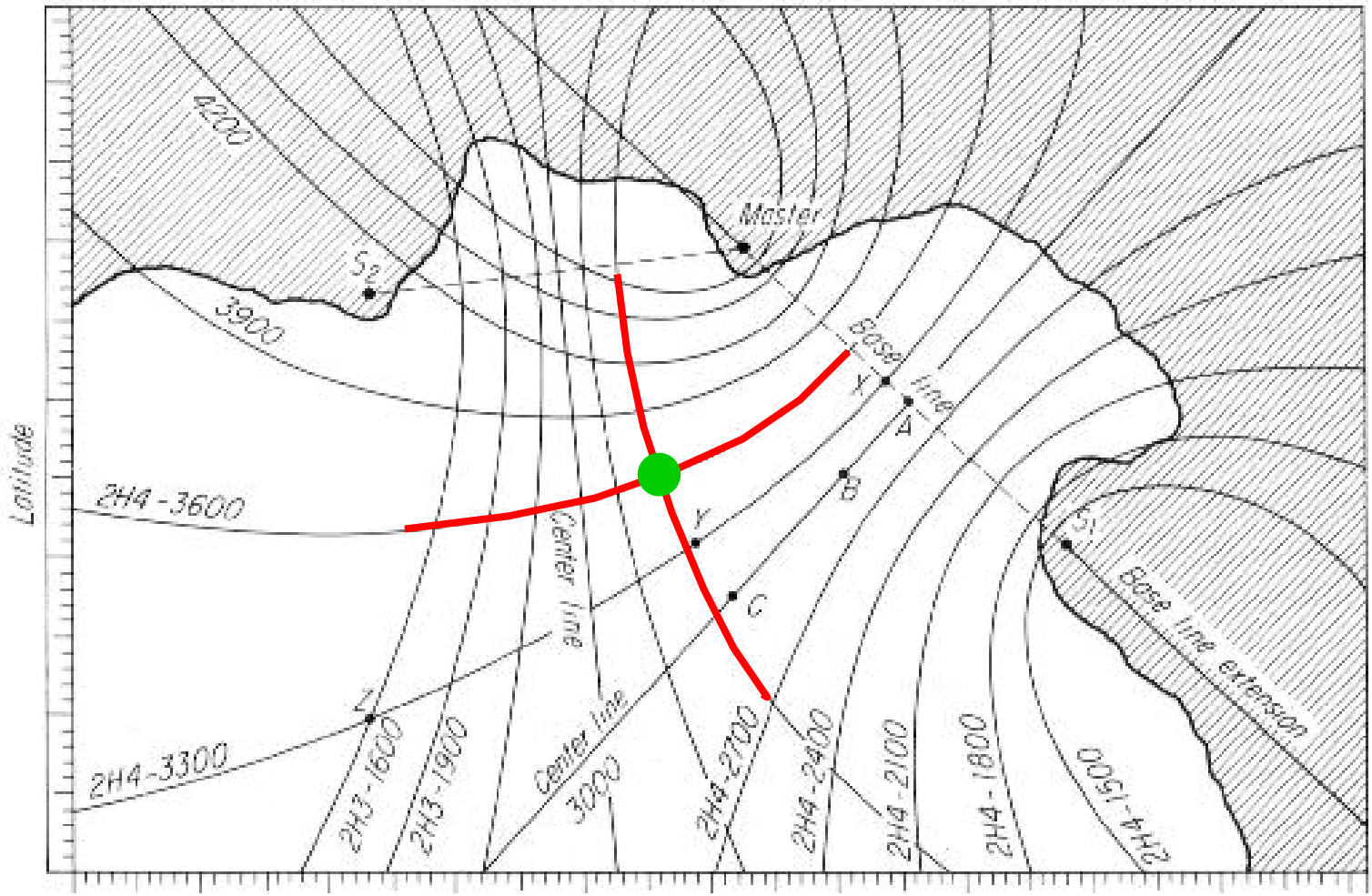
Furuno LC 90

Texas Instruments 9000

Legacy Receivers Cnt'd

- Positioning based on Time Difference measurements on Loran Charts
- System Area Monitors keep Loran accuracy within limits at SAM sites
- TD's may vary at other locations due to different propagation delays and simple timing control
- Advertised absolute accuracy ¼ Nautical Mile (= 463 m)
- Repeatable Accuracy ± 50 m

TD positioning on Loran Chart



(Graphic courtesy of Electronic Communications)

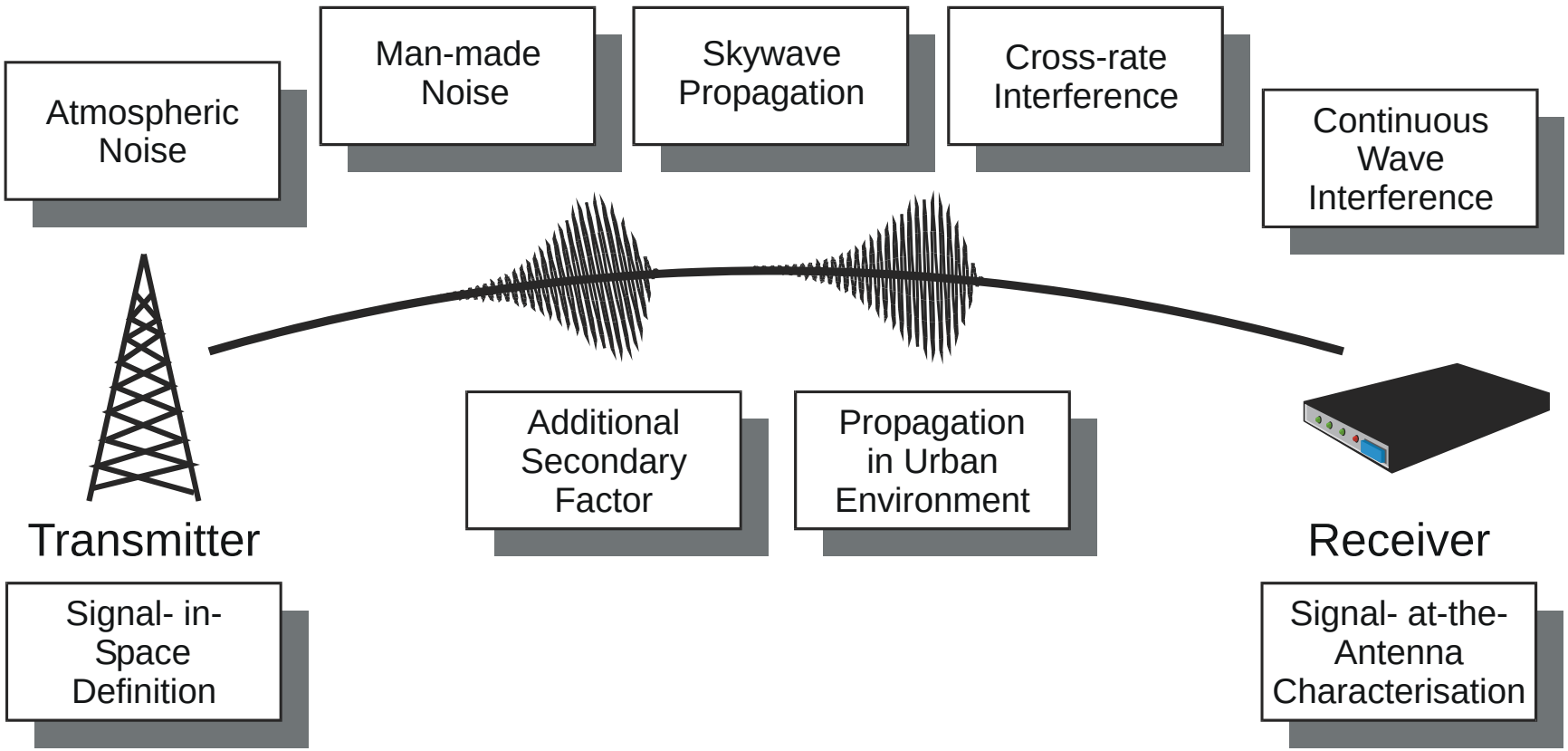
New Loran-C receiver developments

- Under incentive of FAA's Loran recapitalization program new Loran receiver concepts and implementations have started
- Core receiver engines on new DSP hardware have been developed
- Maritime receiver for Harbor Entrance and Approach
- Aeronautical receiver for Non Precision Approach

Key features of new receivers

- Multichain all-in-view Loran signal tracking
- Fast acquisition (<30 s) & regular position updates
- Interference mitigation
  - Continuous wave interference
  - Cross-rate interference
  - Local interference (car engines)
- Groundwave / Skywave separation
- Reliable Cycle Identification
- ASF and Differential Loran capabilities
- Integration with GPS
- Data demodulation and decoding
- Use of H-field antennas to mitigate P-static
- Cope with high receiver dynamics

Signal clean-up - threats

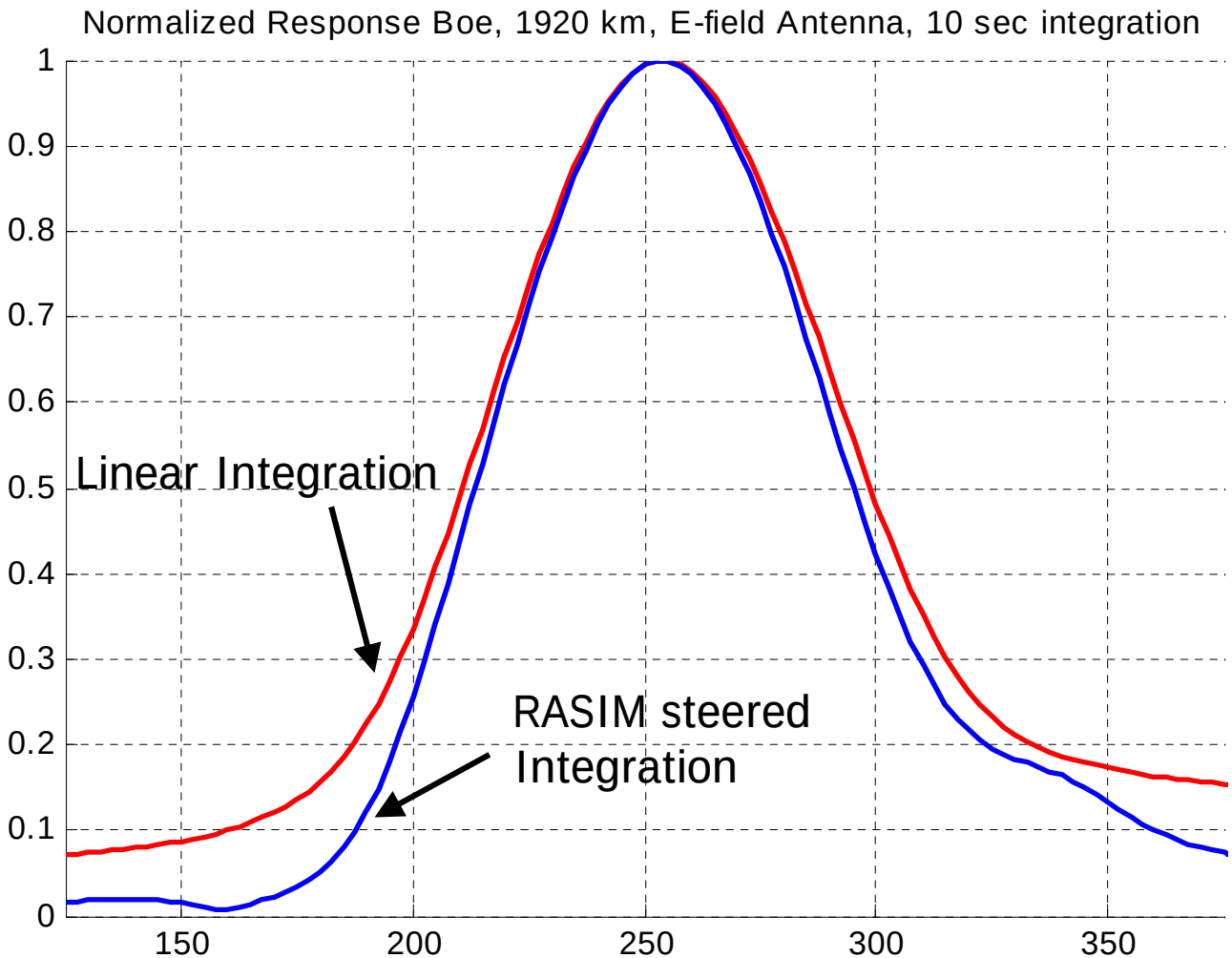


Signal Clean-up - solutions

Interference source		Mitigation method	Performance
Continuous wave		Detect and notch	Good
Atmospherics	low amplitudes	Averaging	Moderate
	large amplitudes	Detect and drop	Good
Cross-rate		Beam Steering	Fair
		Detect and drop	Fair/Good
		Estimate and repair	Good
		Frequency domain Comb filtering	Good
Skywave separation		Tracking early in pulse	Moderate
		GW/SW separation	Good
Local Interference		Detect and drop	Moderate
		Estimate and repair	Good
Additional Secondary Factor		Models	Moderate
		GPS Calibrated	Good
		Differential Loran-c	Good

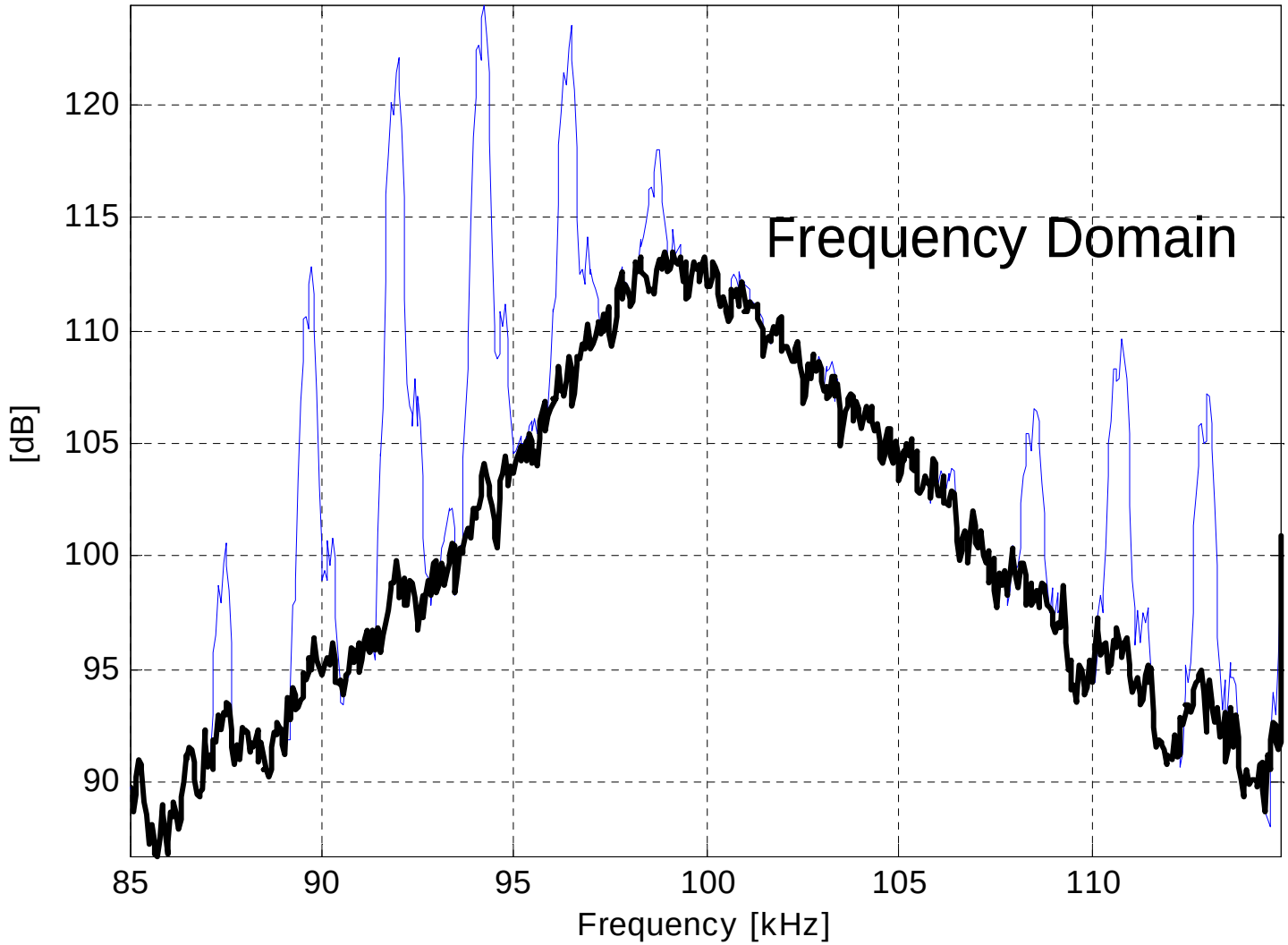
Signal Clean-up

Cross-rate & Atmospherics filtering



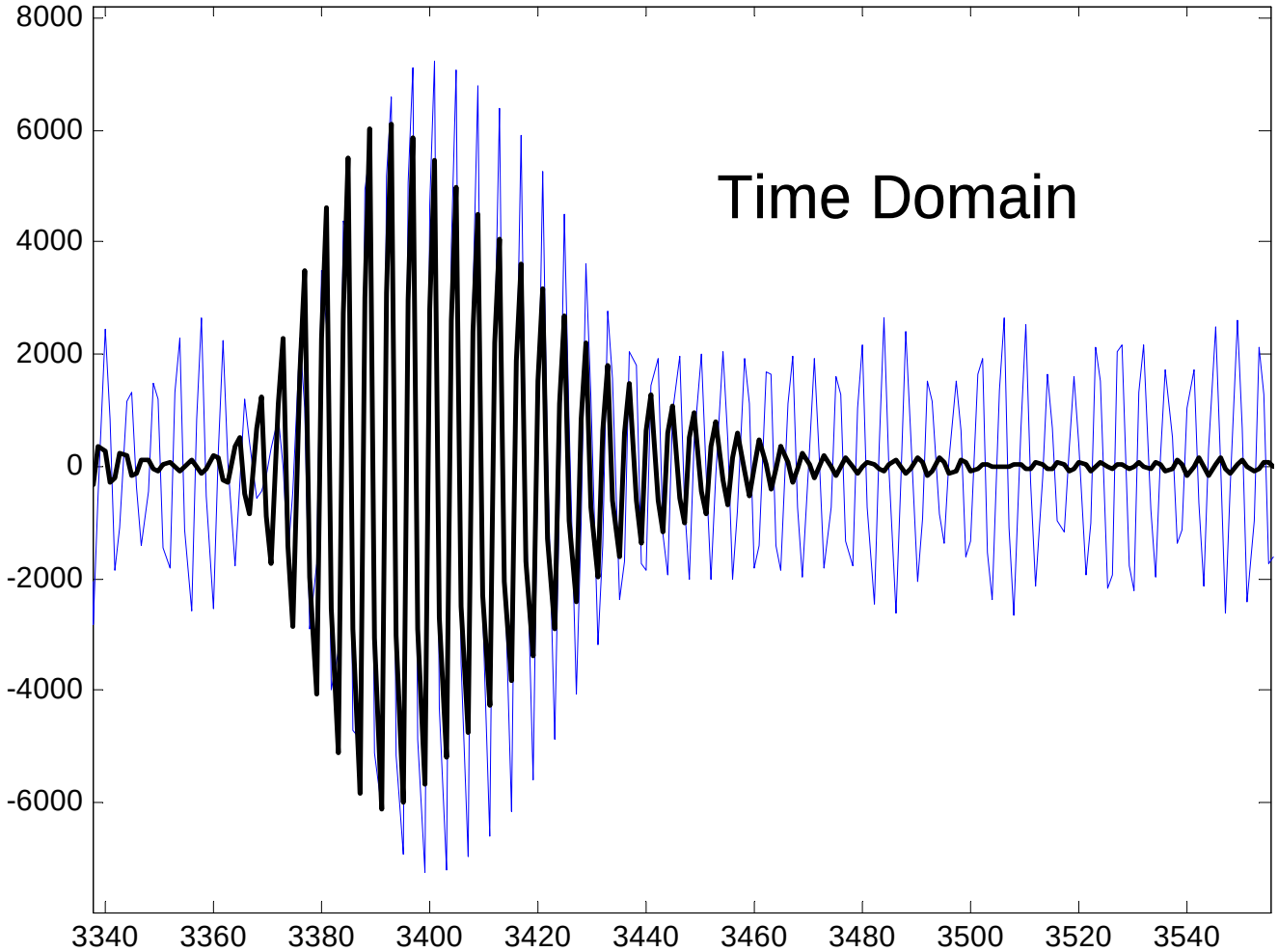
Signal Clean-up

Local interference suppression



Signal Clean-up

Local interference suppression



H-field antenna developments

- H-field antennas do not suffer from P-static
- H-field component is better available in urban and mountainous environment
- H-field requires processing of two channels, which is more complex than single channel E-field
- Advantages of two channels:
  - Possibility of null-steering
  - Possibility to detect reradiation
- Design of H-field antenna is sensitive to
  - E-field susceptibility
  - Cross-talk
  - Tuning

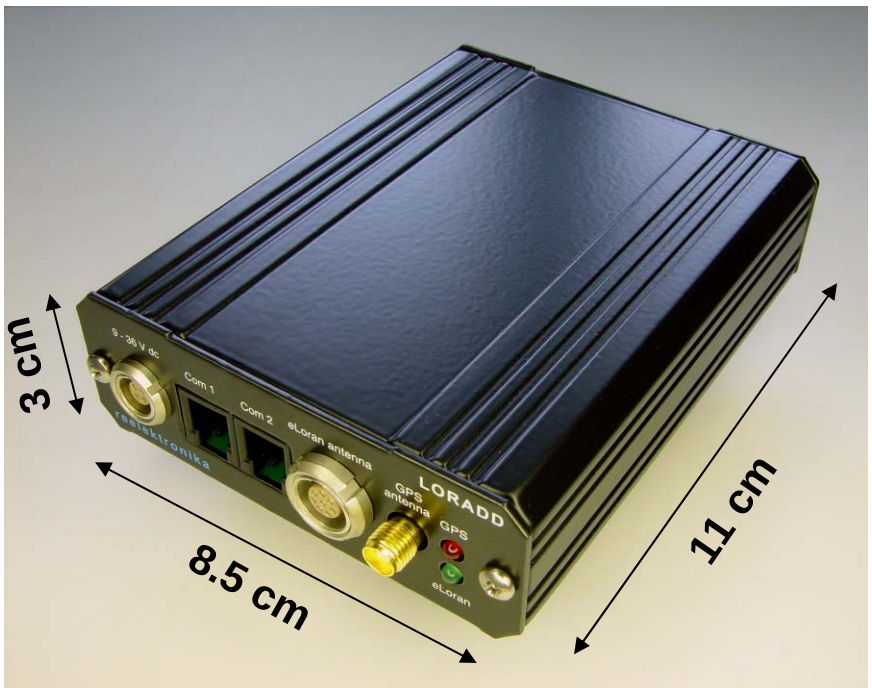
H-field antennas currently available

reelektronika's
Dual-loop H-field antenna

Locus'
Dual-loop H-field antenna

eLoran receivers - General

reelektronika's integrated eLoran/GPS receiver



Locus' SatMate 1030

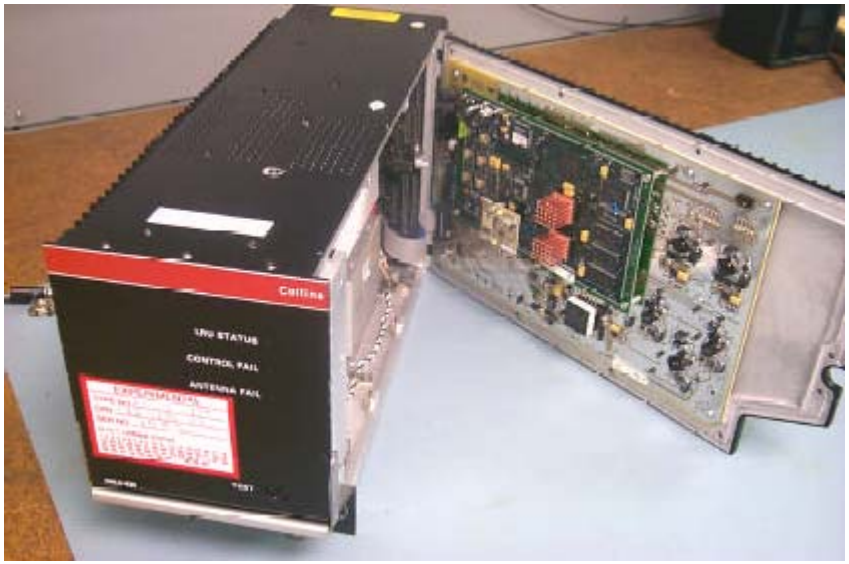
Further developments by:

- Detectis (Germany)
- US Coast Guard Academy
- Others…

eLoran receivers - Maritime

Si-tex Koden integrated eLoran/GPS receiver

eLoran receivers - Aviation

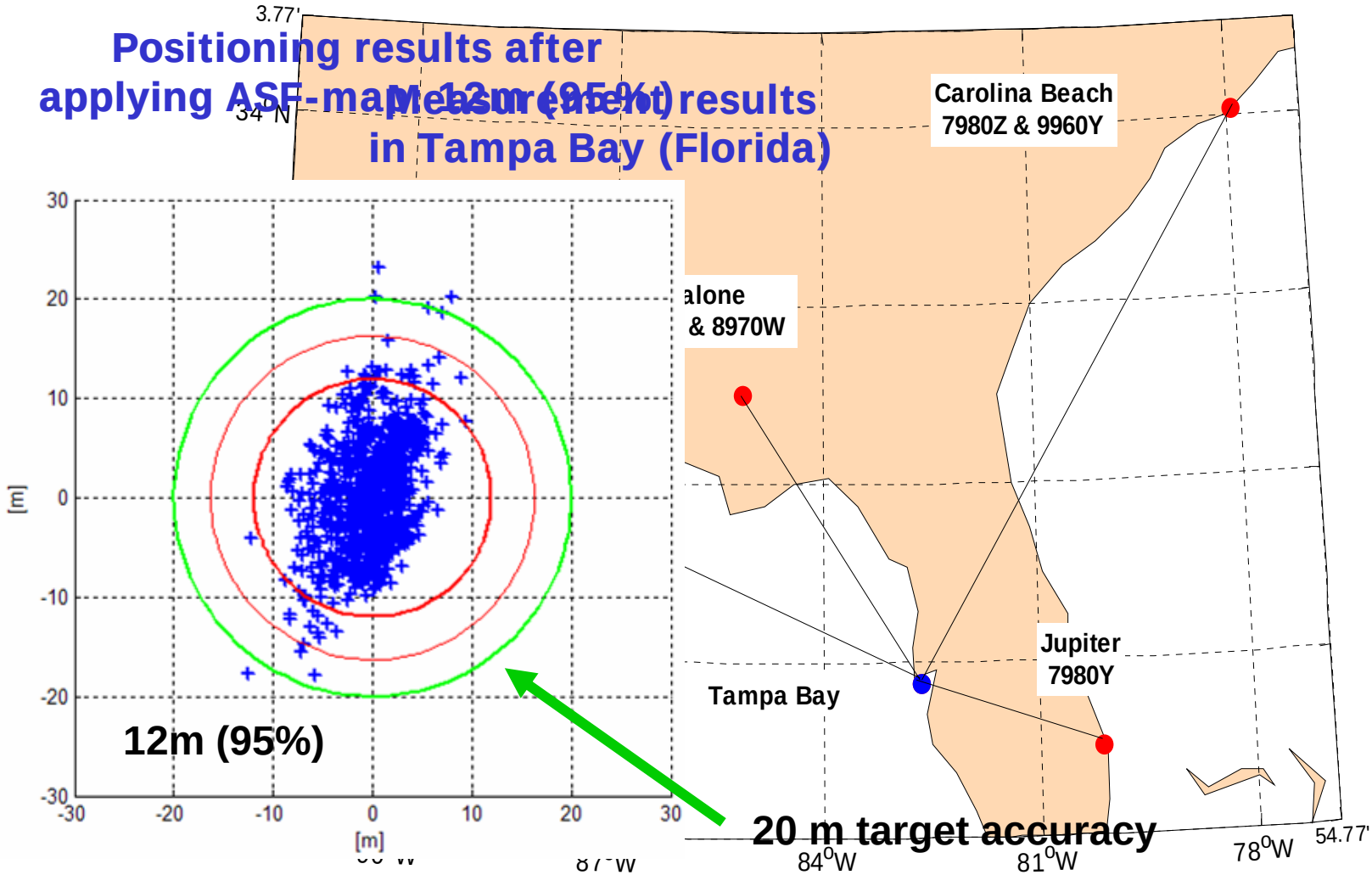


Rockwell Collins
Multimode Aviation Receiver

Free-flight
Integrated GPS/Loran Receiver

Example - Maritime performance

Positioning results after applying ASF-map (measurement) results in Tampa Bay (Florida)



Conclusions

- Modern eLoran receivers apply state-of-the-art digital signal processing techniques
  - All-in-view Loran signal tracking
  - Advanced interference mitigation
  - Performance levels have highly increased
- The FAA evaluation has shown the potential of new eLoran receiver technology
- Core receiver technology can be adapted for Maritime, Aviation or Timing applications
- New digital receivers are under development and coming to market as we speak!
- Look out for more detailed presentations on later sessions

Thanks!

Any Questions?