Passive Geo-location of an RF Transmitter

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Group 105

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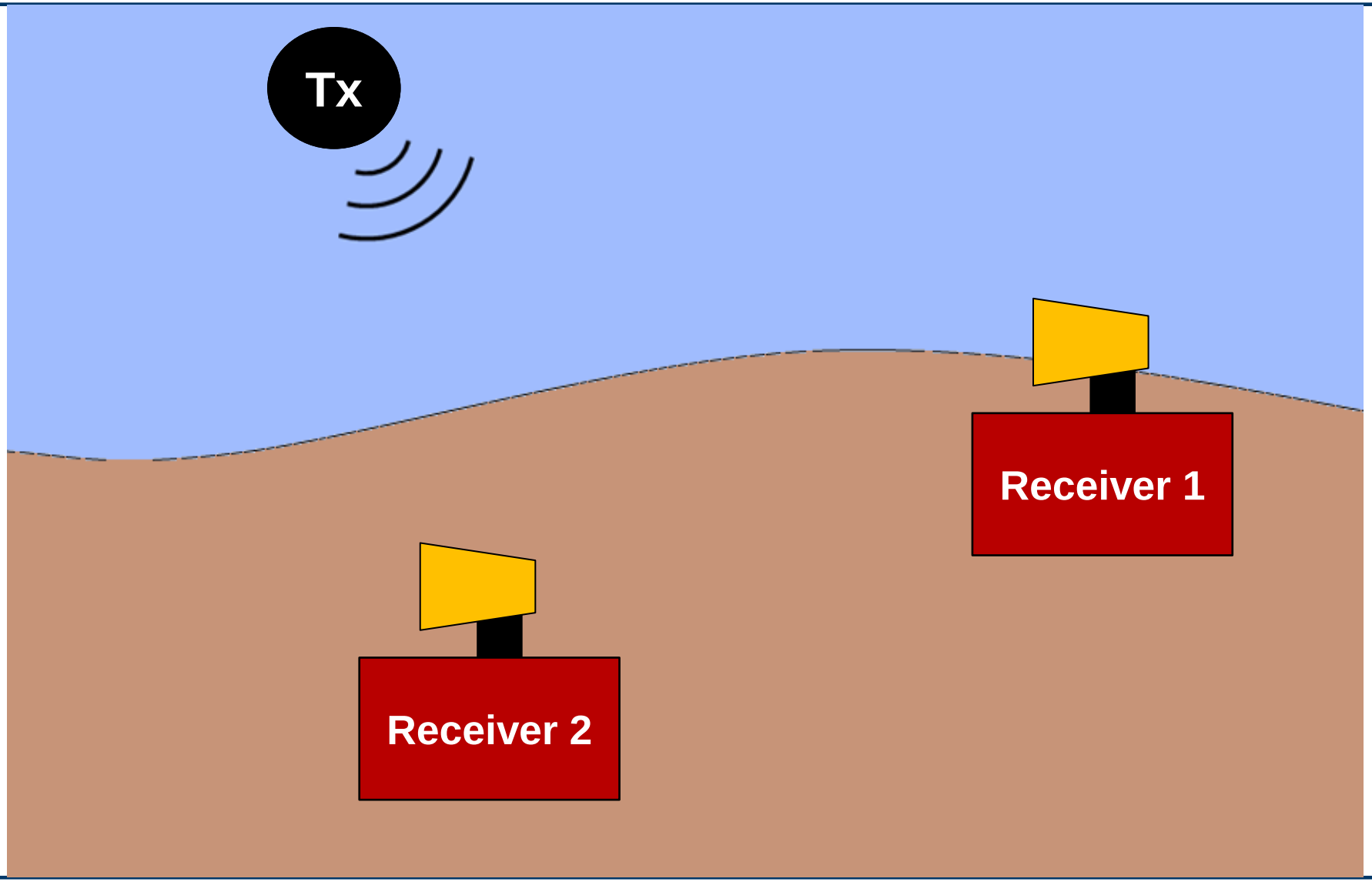
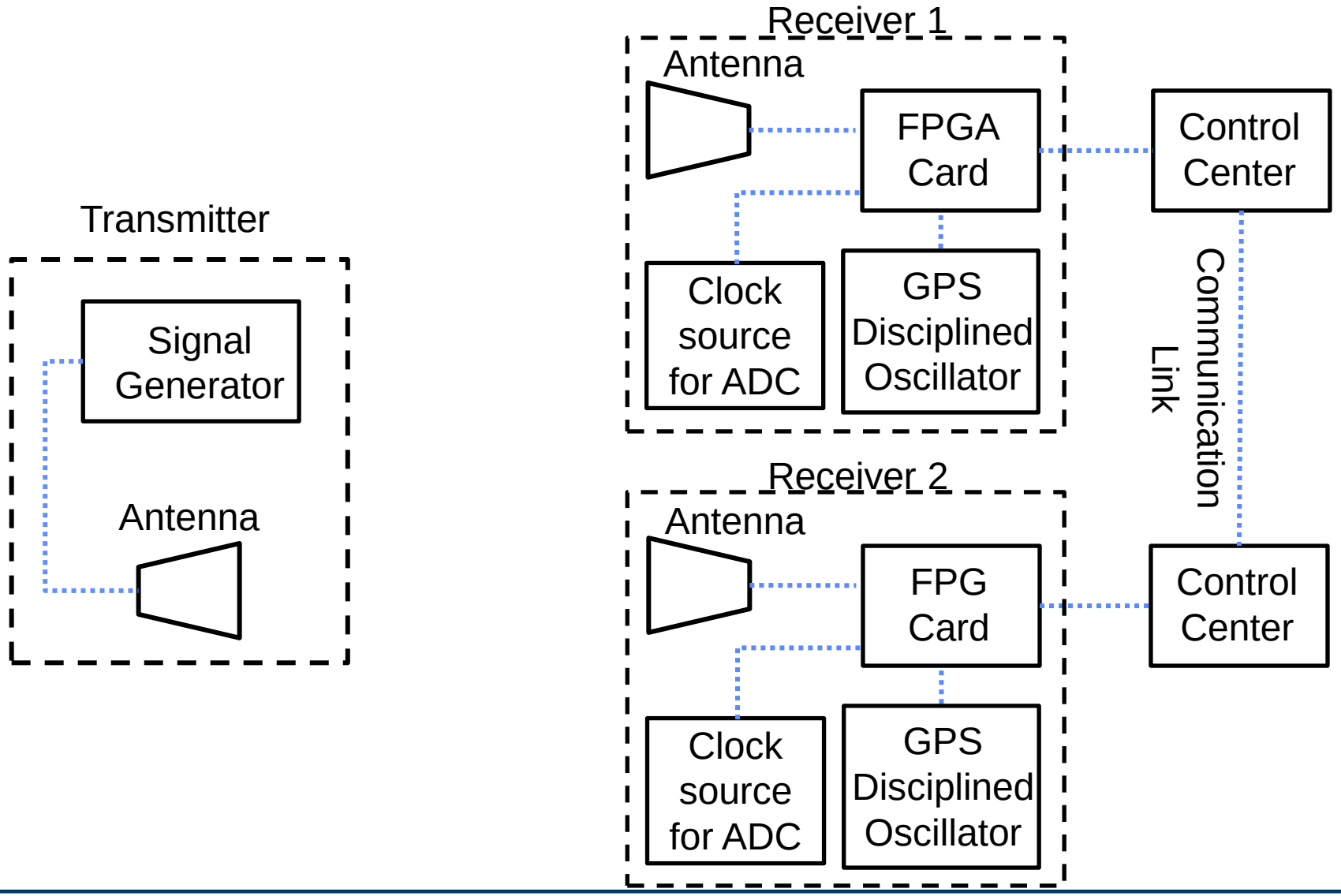
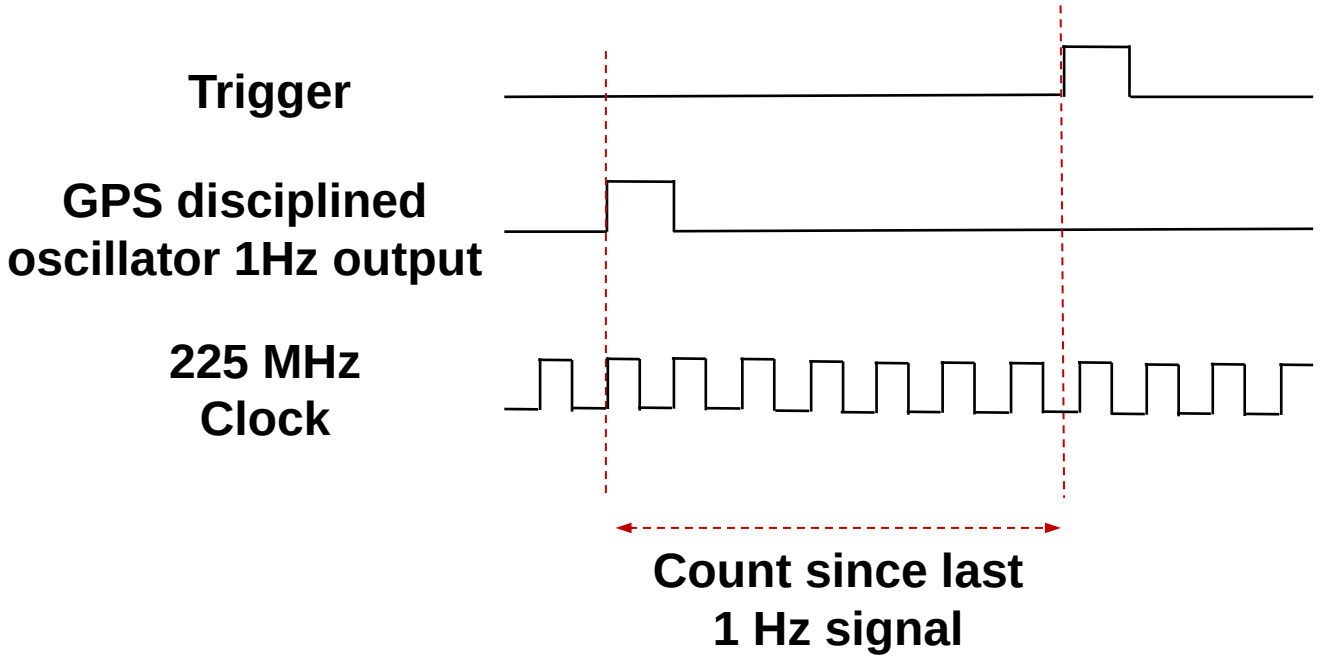
Problem

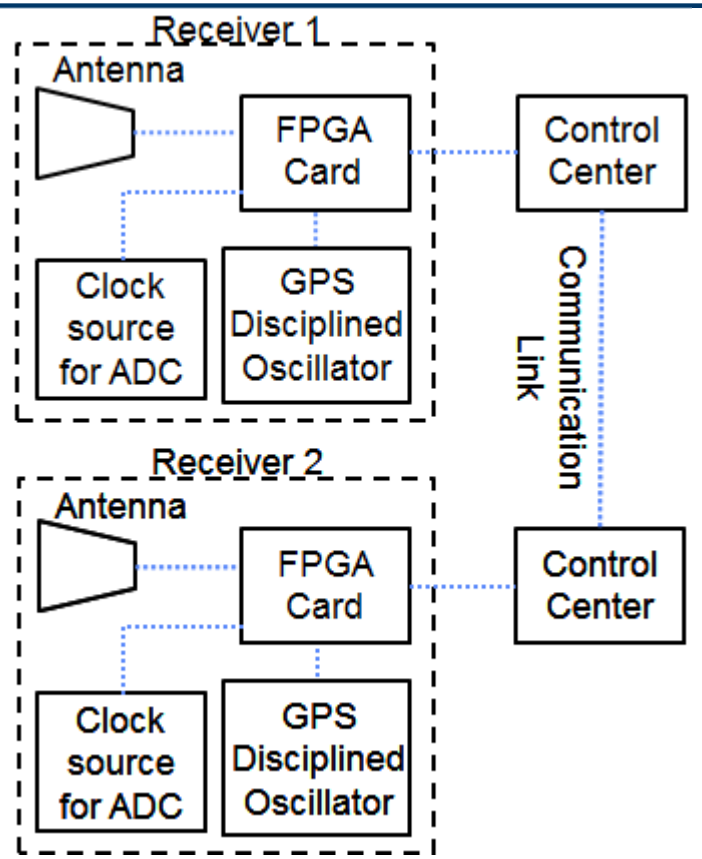


System Concept: Block Diagram

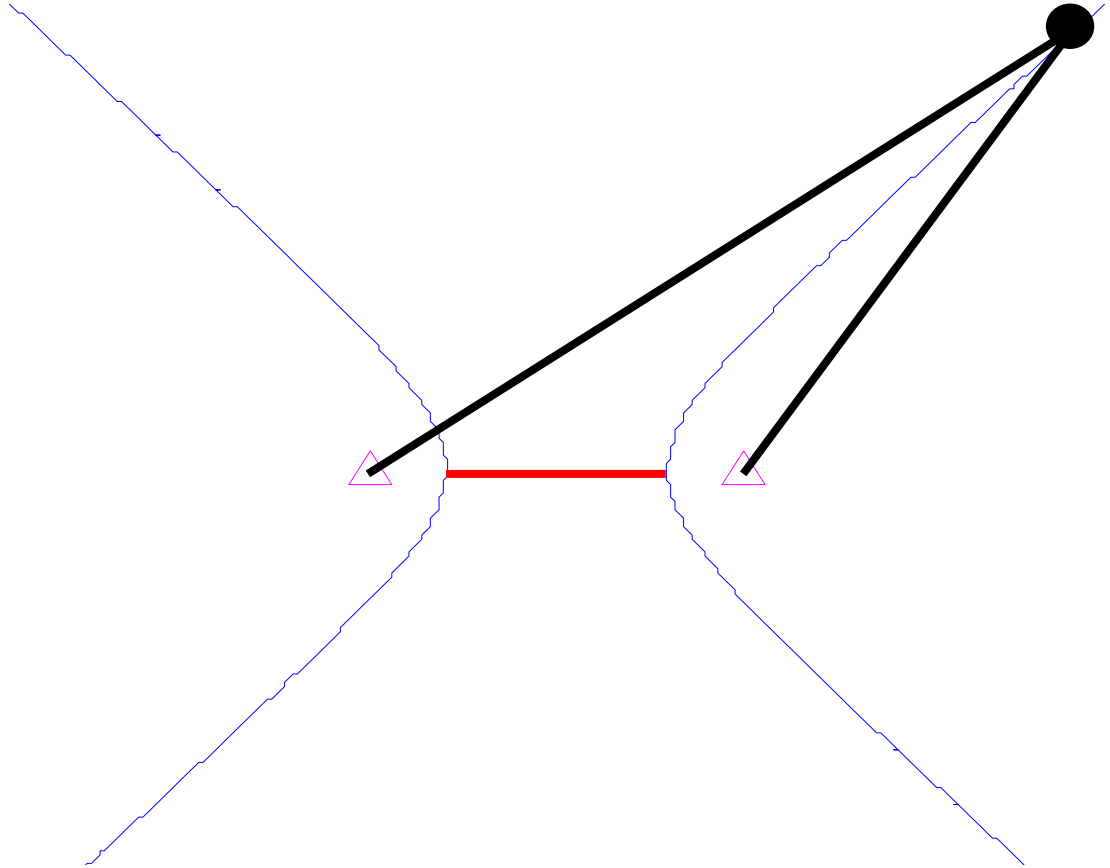


Time Synchronization





Geo-location Technique: Time Difference of Arrival



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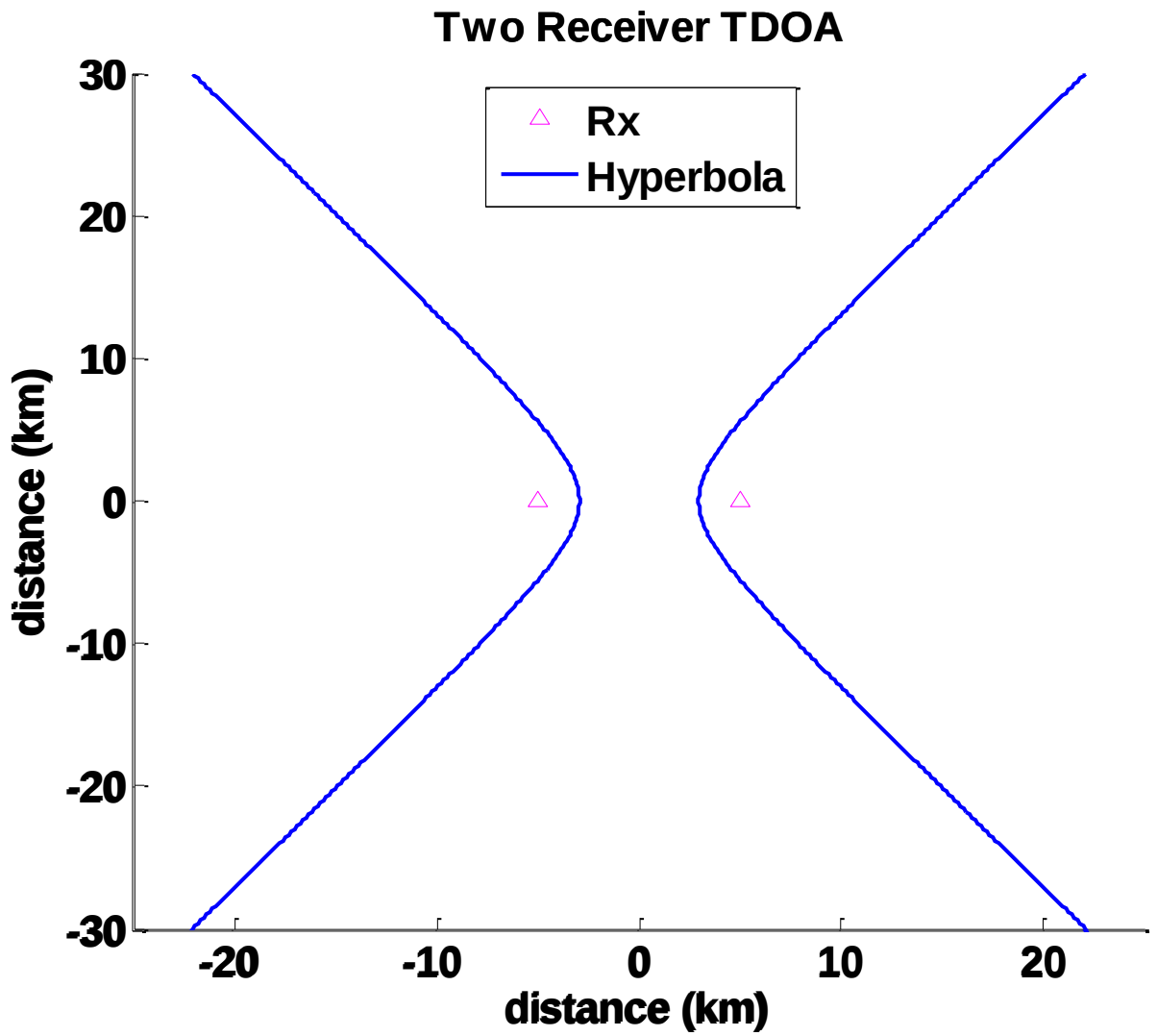
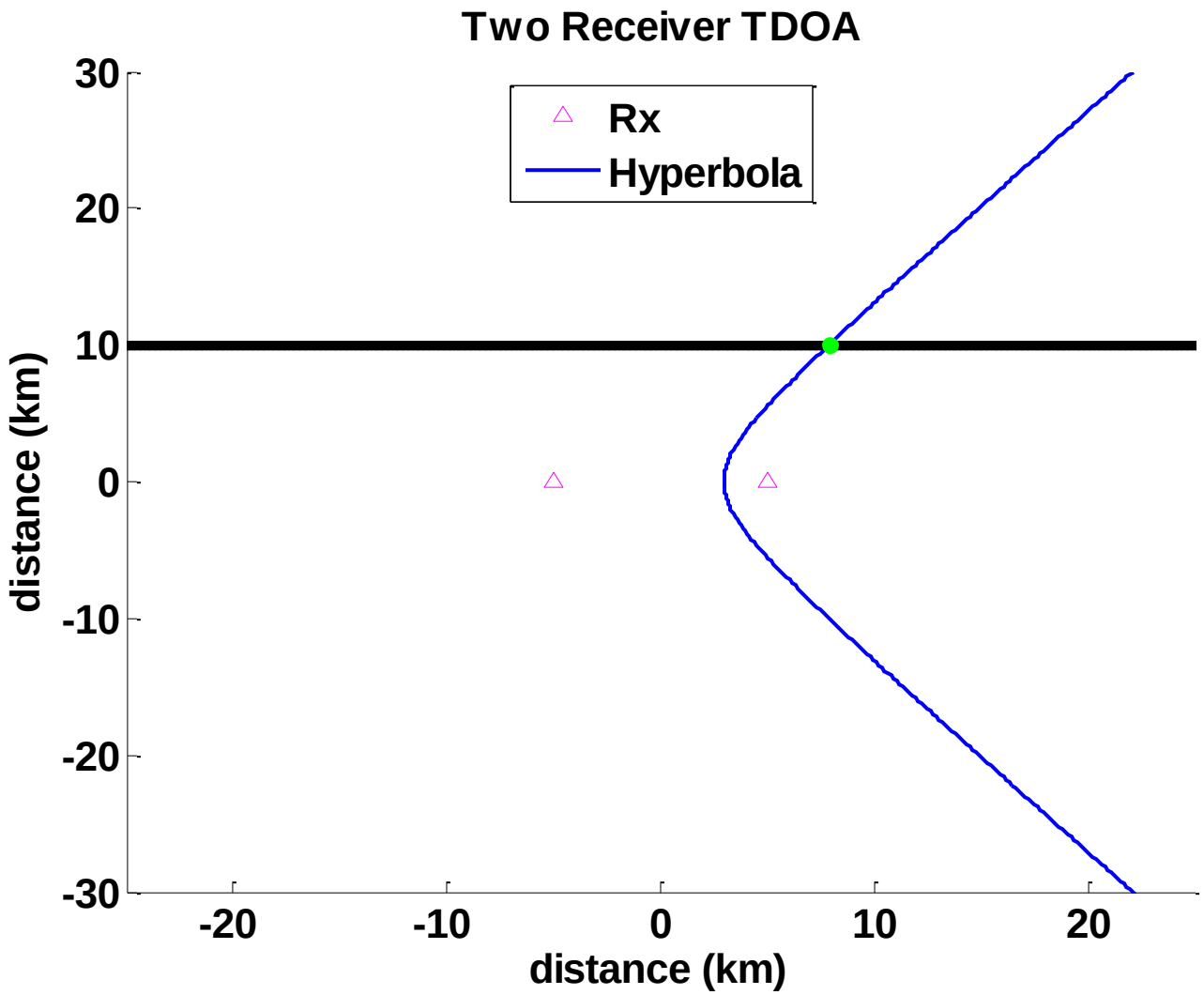


Geo-location Technique: Time Difference of Arrival



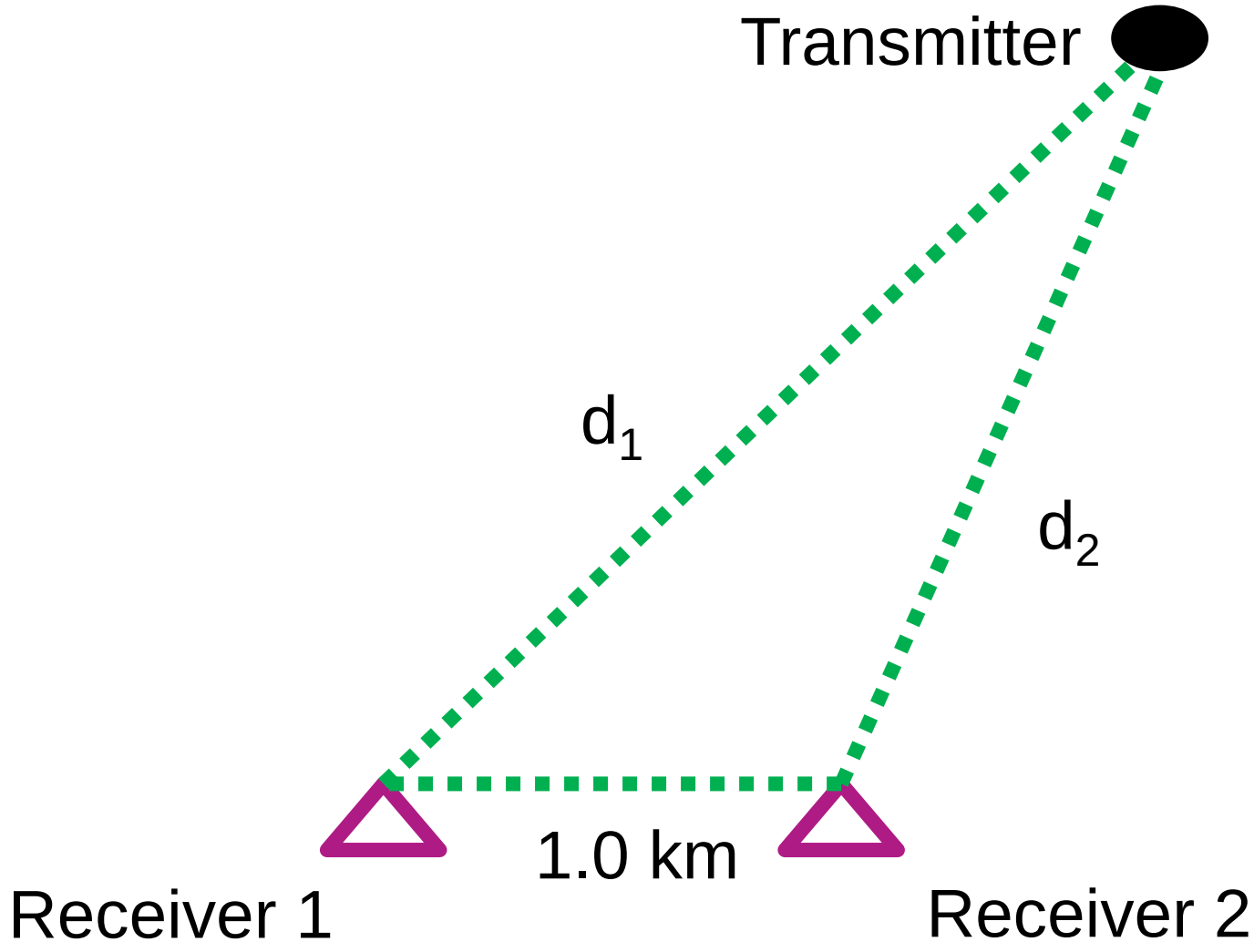
Time Synchronization

Receiver 1 at (-0.5, 0)
Receiver 2 at (0.5, 0)
Transmitter at (75, 100)
(All in kilometers)

So d_1 = 125.3 km
So d_2 = 124.7 km

Time signal travels along:
d_1 is 415.7 ns
d_2 is 417.7 ns

TDOA = 2.0 ns



How Precise?

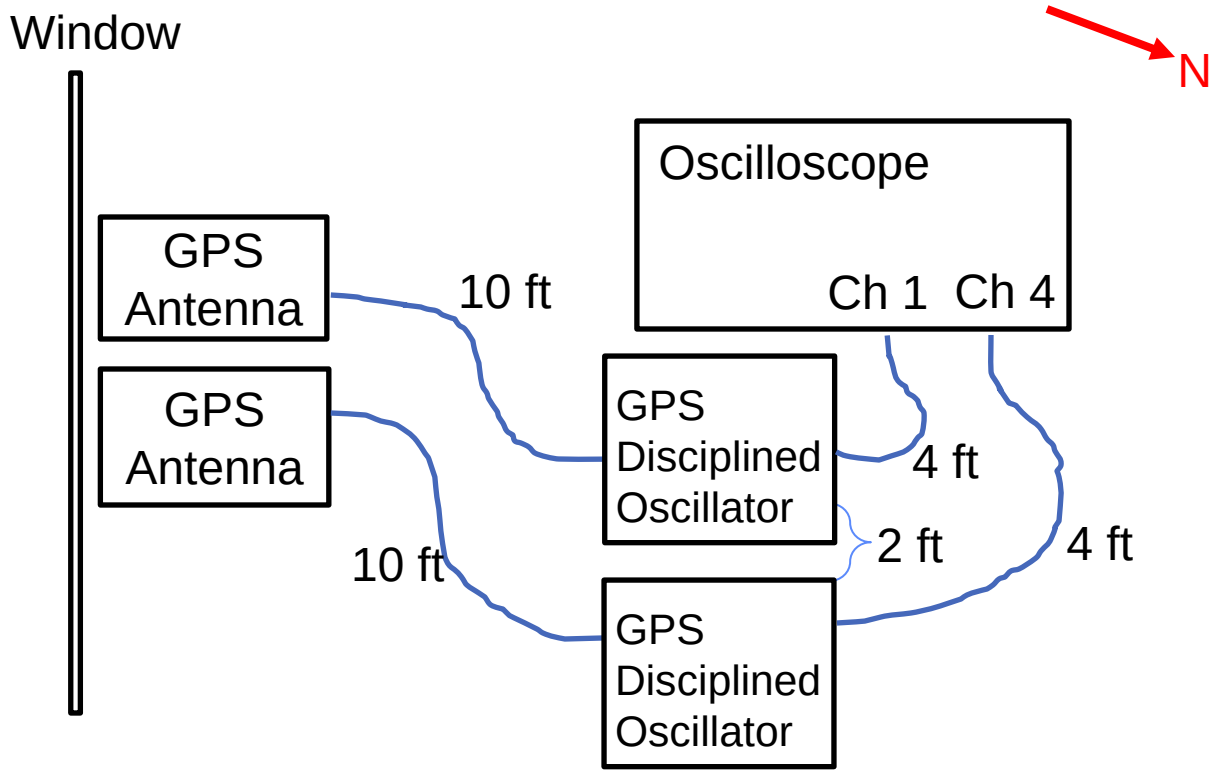
- **The target should be located to within 1.5° in both azimuth and elevation, from the view of receiver one 70% of the time**
- **This requirement corresponds to a timing error of within ±60 ns**

Testing Outline

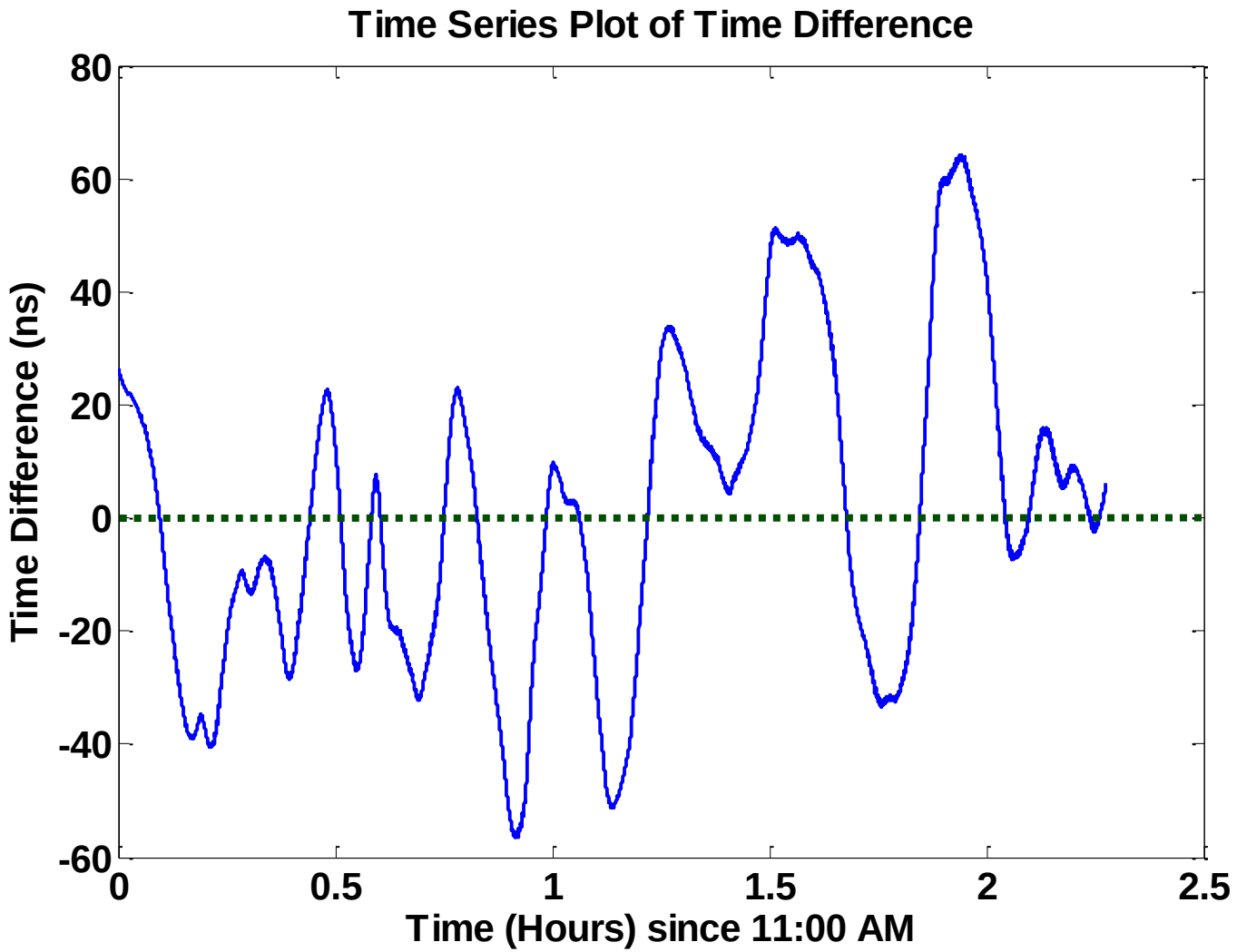
Step	Result
Test GPS units outside of system	
Test GPS units in the system in the lab	
Test GPS units in the system in the field	

Time Synchronization

- **1 Hz disciplined output**
- **2hr 16 min capture time**
- **11 captures**



Time Synchronization



Time Synchronization

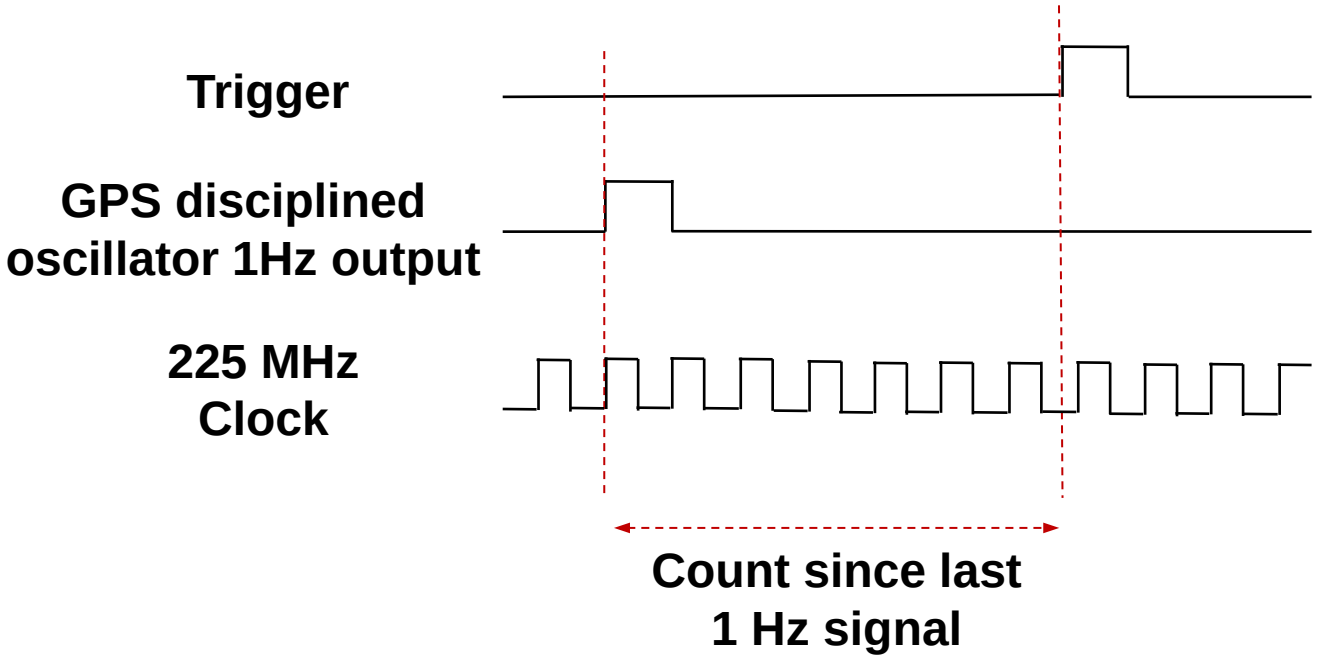
Total Runs	Mean (ns)	Standard deviation (ns)	Percentage of time differences within ±60 ns	Percentage of time differences within ±40 ns	Percentages of time differences within ±30 ns
11	**11.0**	**34.0**	**90.5%**	**73.5%**	**61.6%**

These tests show that the requirement was exceeded. The times are within ±60 ns over 70% of the time

Testing Outline

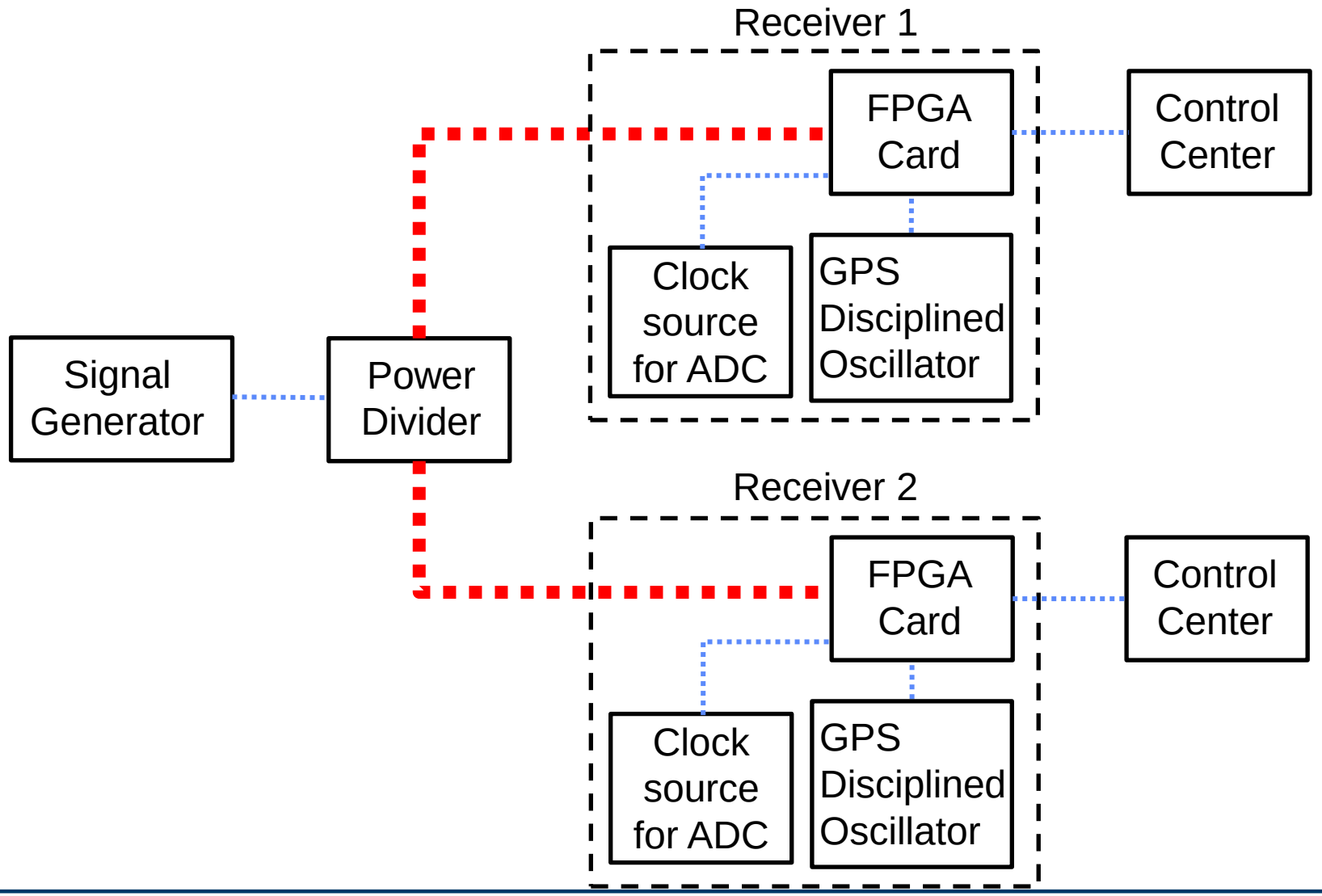
Step	Result
Test GPS units outside of system	Success
Test GPS units in the system in the lab	
Test GPS units in the system in the field	

Time Synchronization



Lab Test

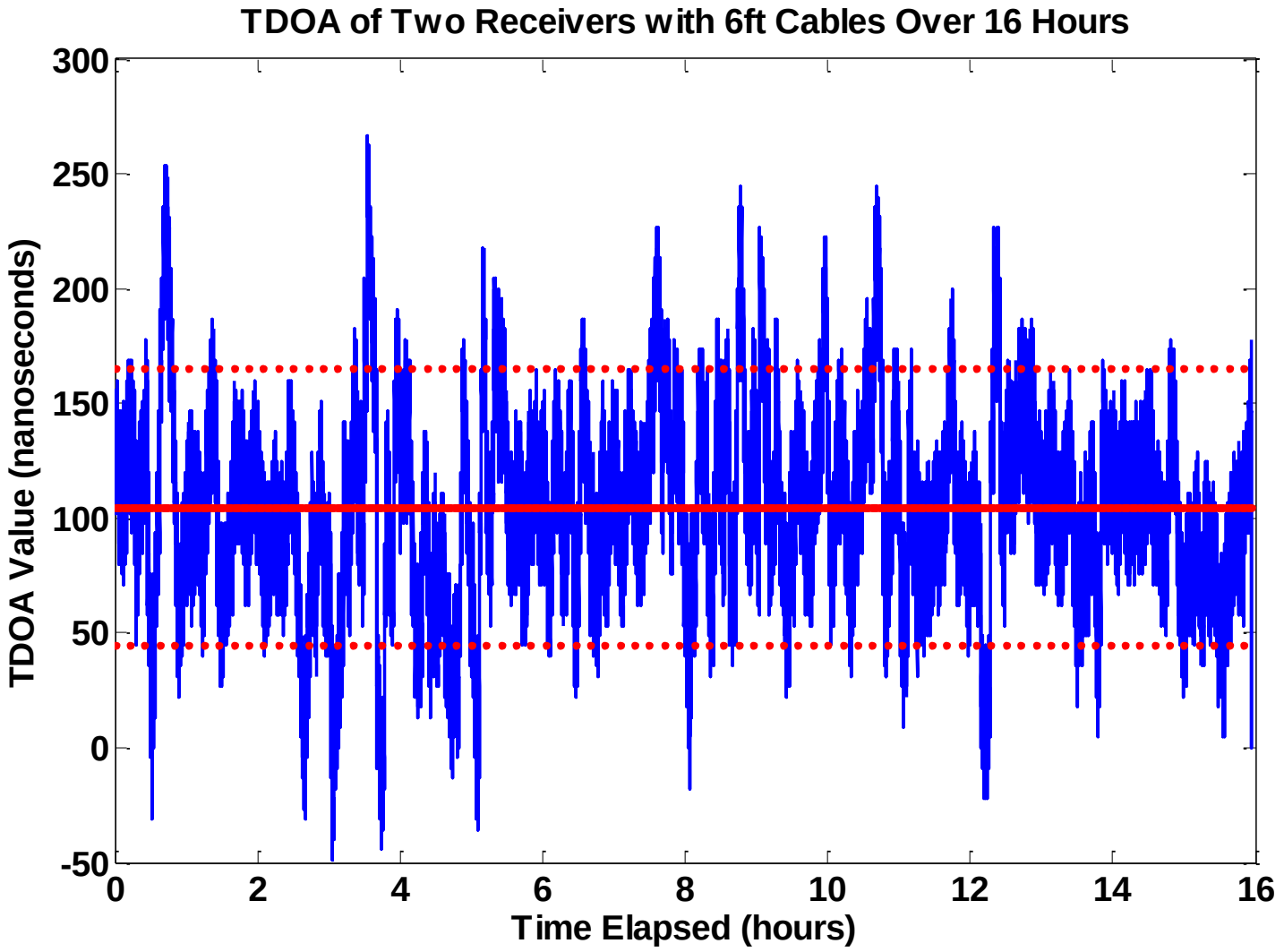
- **-15 dBm**
- **2.4 GHz**
- **1 ms pulse repetition interval**
- **100 µs pulse width**



Lab Test: Zero Time Difference of Arrival

- 3 ft cable to power divider, 6 ft cable to both receiver
- 86% within ±60 ns of the mean
- 105 ns mean

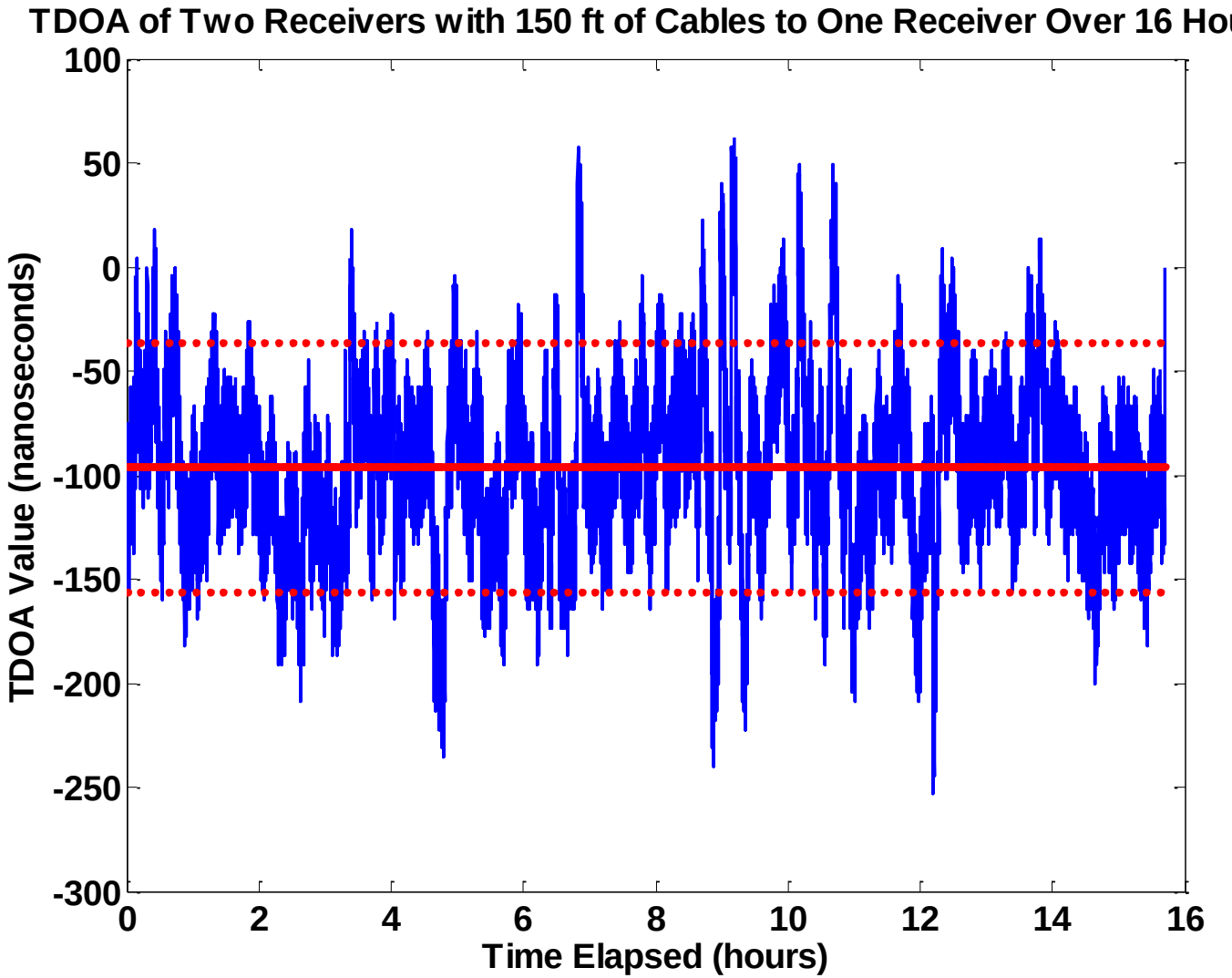
- **Expected TDOA: 0 ns**
- **Actual (with offset): 105 ns**



Lab Test: Cable Delay

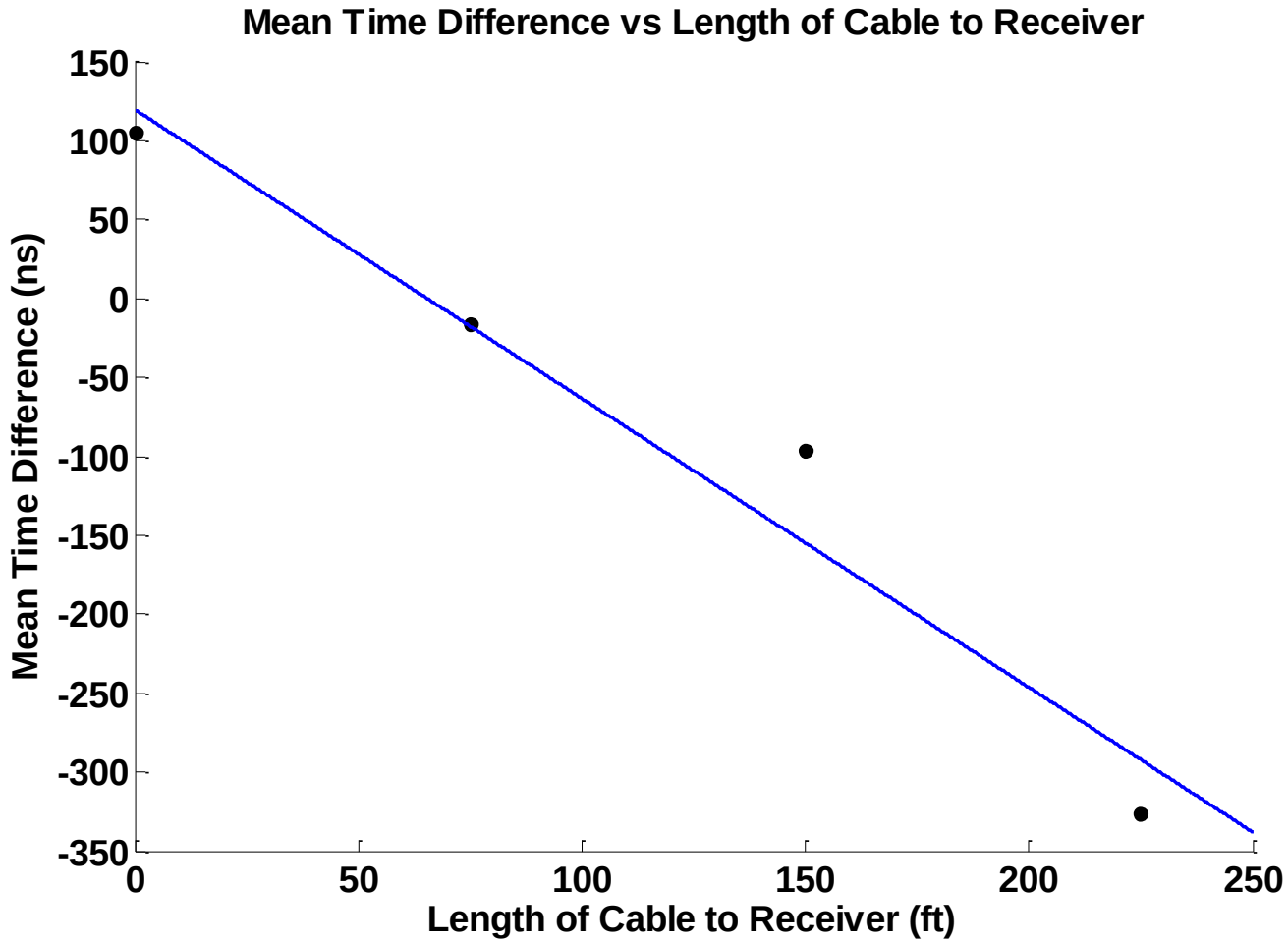
- 3 ft cable to power divider, 6 ft cable to one receiver and 150 ft to the other
- 87% within ±60 ns of the mean
- -96 ns mean

- **Expected TDOA: -180 ns**
- **Actual (with offset): -201 ns**



Lab Test: Cable Delay

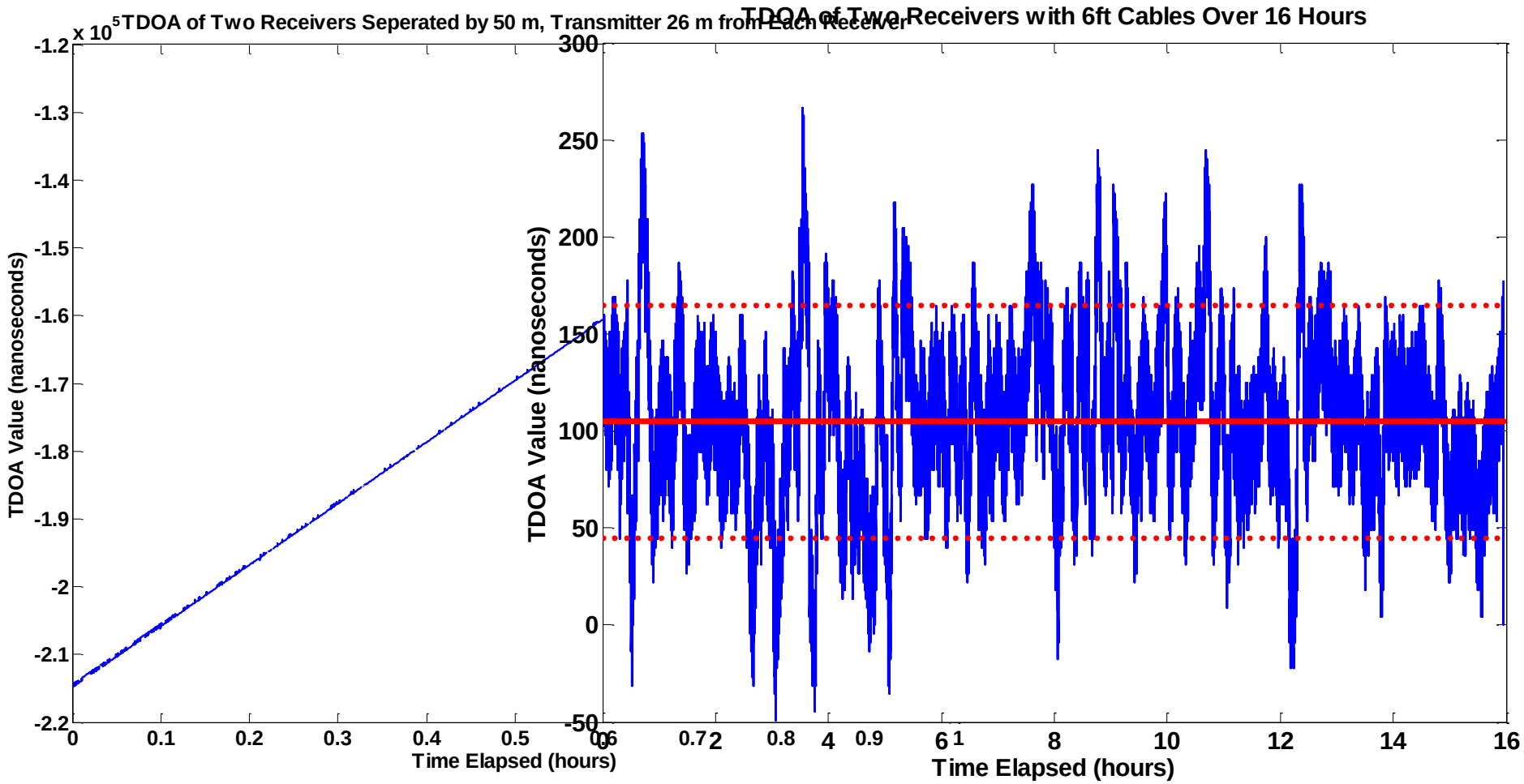
- **Cable delay, according to data sheet should be 1.2 ns/ft**
- **Estimated cable delay was 1.8 ns/ft**



Testing Outline

Step	Result
Test GPS units outside of system	Success
Test GPS units in the system in the lab	Success
Test GPS units in the system in the field	

Field Test

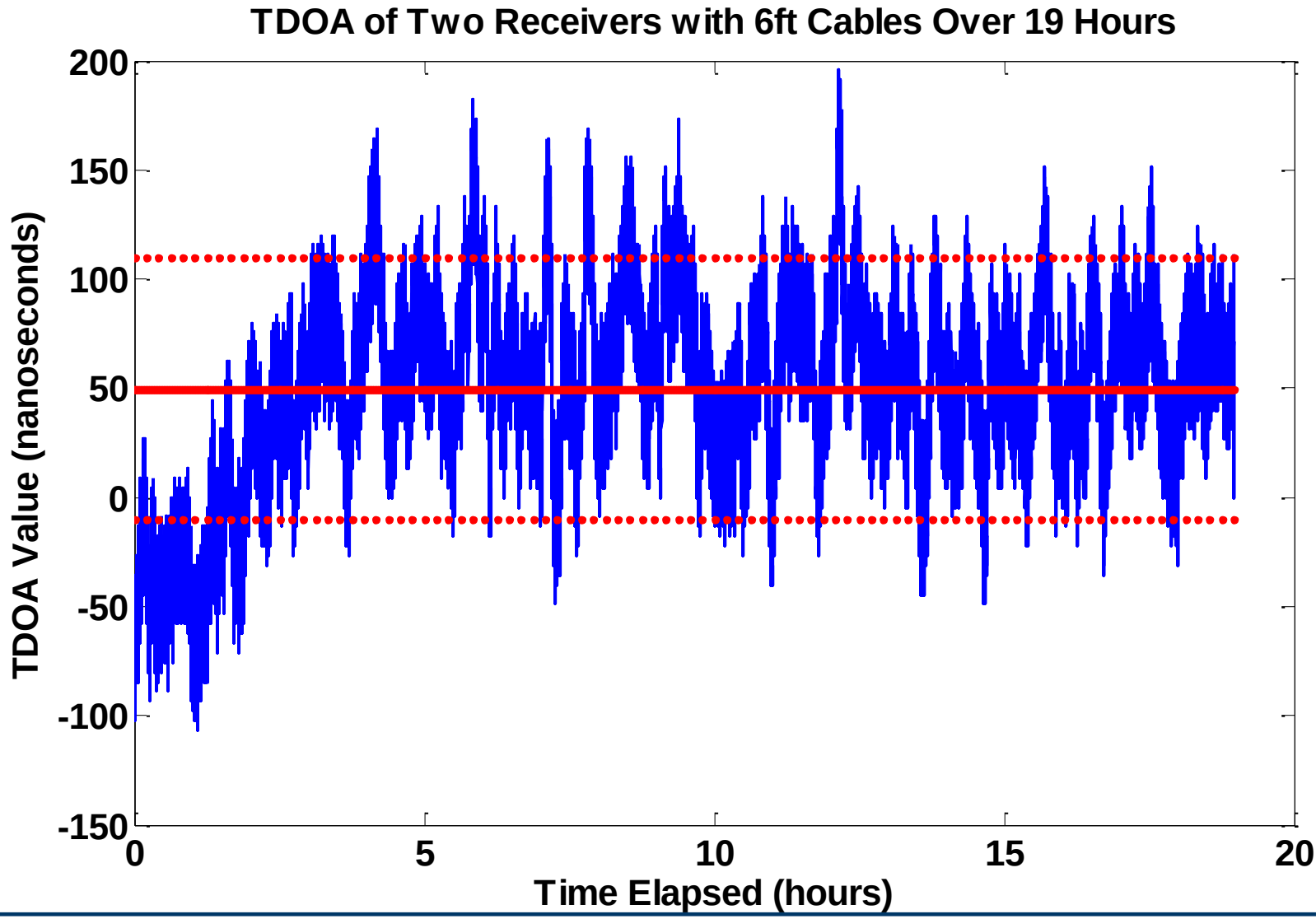

TDOA of Two Receivers Seperated by 50 m, Transmitter 26 m from Each Receiver
x 10^5
TDOA Value (nanoseconds)
Time Elapsed (hours)
-1.2
-1.3
-1.4
-1.5
-1.6
-1.7
-1.8
-1.9
-2
-2.1
-2.2
0
0.1
0.2
0.3
0.4
0.5
0.6
TDOA of Two Receivers with 6ft Cables Over 16 Hours
TDOA Value (nanoseconds)
Time Elapsed (hours)
300
250
200
150
100
50
0
-50
0.7
0.8
0.9
1
2
4
6
8
10
12
14
16

Testing Outline

Step	Result
Test GPS units outside of system	Success
Test GPS units in the system in the lab	Success
Test GPS units in the system in the field	Failure

Lab Test: System After Startup

- 3 ft cable to power divider, 6 ft cable to both receivers
- 85% within ±60 ns of the mean
- **Stabilized to a mean of 60 ns**



Testing Outline

Step	Result
Test GPS units outside of system	Success
Test GPS units in the system in the lab	???
Test GPS units in the system in the field	Failure

Summary

- GPS disciplined oscillator's time error small enough to meet the 1.5° requirement 70% of the time
- System Testing
  - Offset discovered but source still unknown
    - Offset independent of cables
    - Startup conditions affect the offset
  - Field Test
    - More lab testing required before further field testing can be conducted
- Results acquired useful to Group 105

Future Work

Lab testing: Is offset in GPS disciplined oscillator or the rest of Receiver Hardware?

- **Input 1 Hz signal from signal generator into both receivers instead of GPS disciplined oscillator output**

GPS Disciplined Oscillator

- **Analyze satellite data – Signal to noise ratio and number of satellites over time**
- **Test other 1 Hz disciplined outputs**

Other Receiver Hardware

- **Test 1 Hz signal input to FPGA card. Test 1 Hz signal at every connection in the FPGA that it passes through**
- **Lock the signal generator to the GPS disciplined oscillator 10 MHz disciplined clock output as stable reference for the pulse repetition interval**
- **Test all connections in system**

Acknowledgements

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Thank You

Questions?