Development of A 3-Dimenstional RADAR Based Airspace Instrument

Technical Development Team

- Principle Investigator:
  - Gregory Walker Gregory.Walker@gi.alaska.edu
- Co-Investigator:
  - Denise Thorsen dlthorsen@alaska.edu
- Research Assistant:
  - Scott Otterbacher sotterbacher@alaska.edu
- Electronics Engineer
  - David Giessel d.giessel@ieee.org
- RF Emitter Design
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- Software (User Interface) Engineer
  - Jonathan Sawyer jon@gina.alaska.edu
- Structural (Antenna) Engineer
  - Matthew Van Atta

Concept

- **Develop an airspace monitoring instrument**
  - …
  - Develop techniques to test the performance of small RADAR units.
- **Specific Capabilities**
  - …
  - Operate on moving platforms, such as boats, or trucks.
- **Multiple Units Provide**
  - Coverage of each others blind spots (cone of silence, etc.)
  - Improved statistical accuracy
  - Improved reliability
  - Potential coverage of a larger area

Work Plan

- Use the Military surplus AN/PPQ-2 P-STAR RADAR
  - Merely a basic RADAR unit – a good starting point.
- Add a RADAR Interface Module
- Add a Log and Process (Server) Element
- Add a Display System

Progress

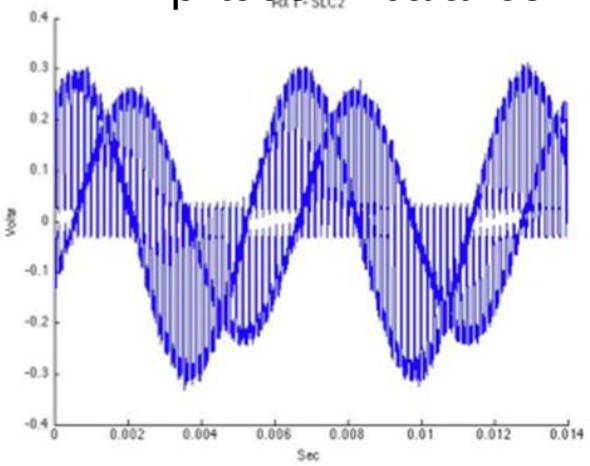
- As of 2010 CGAR Meeting
  - Developed methods to evaluate and compensate for a “surplus” RADAR’s deficiencies
  - Created a 3-D RADAR from the basic 2-D RADAR
  - Created a RADAR interface module
  - Created a data server for managing the data along with other related data sources
  - Created a web-based display server
  - Testing both individual components and the complete system
- As of 2011 CGAR Meeting
  - Completed the 3-D RADAR development
    - Taken the P-STAR surplus to the limits of the hardware
  - Incorporated ground-based TCAS into the system
  - Improved the interface module
    - Added improved power supply
    - Added cell phone network capability
    - Added mobile platform capability
  - Enhanced the display with suggestions from users
  - Further testing in multiple communities

2010 Status

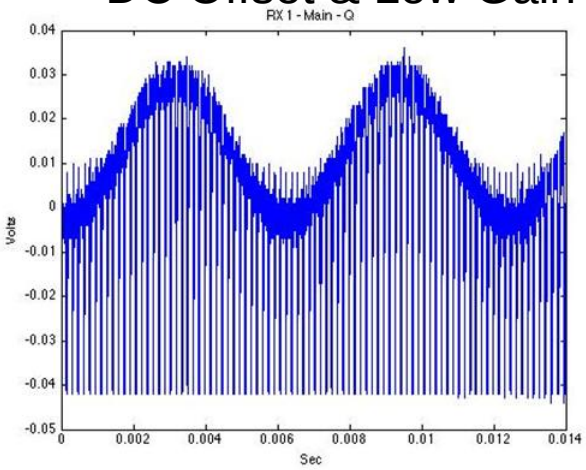
- **Developed methods to automatically compensate for deficiencies in a “surplus” RADAR**

Receiver Testing

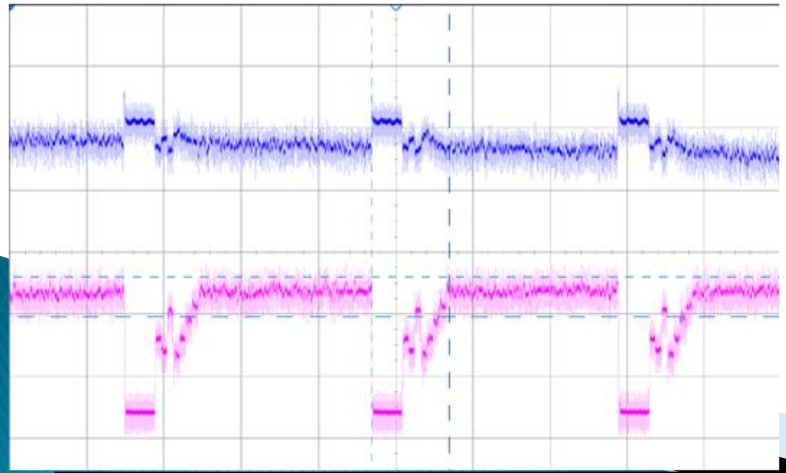
Amplitude Imbalance



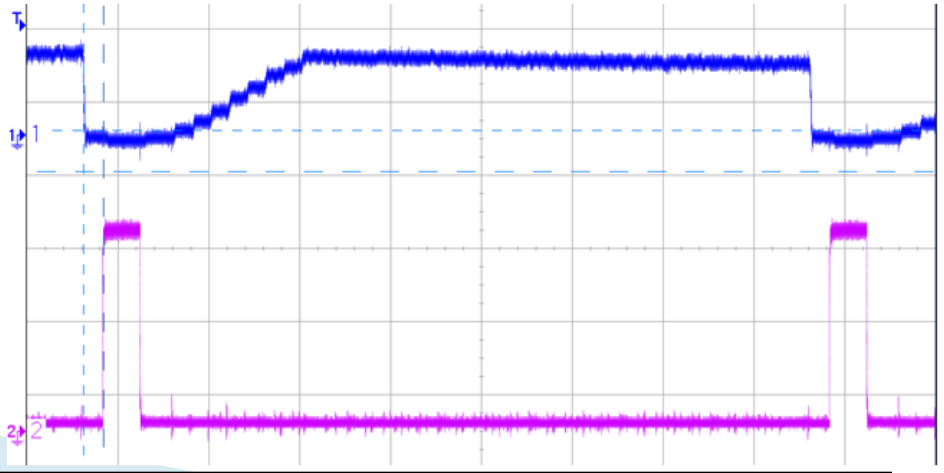
DC Offset & Low Gain



Erroneous Attenuation

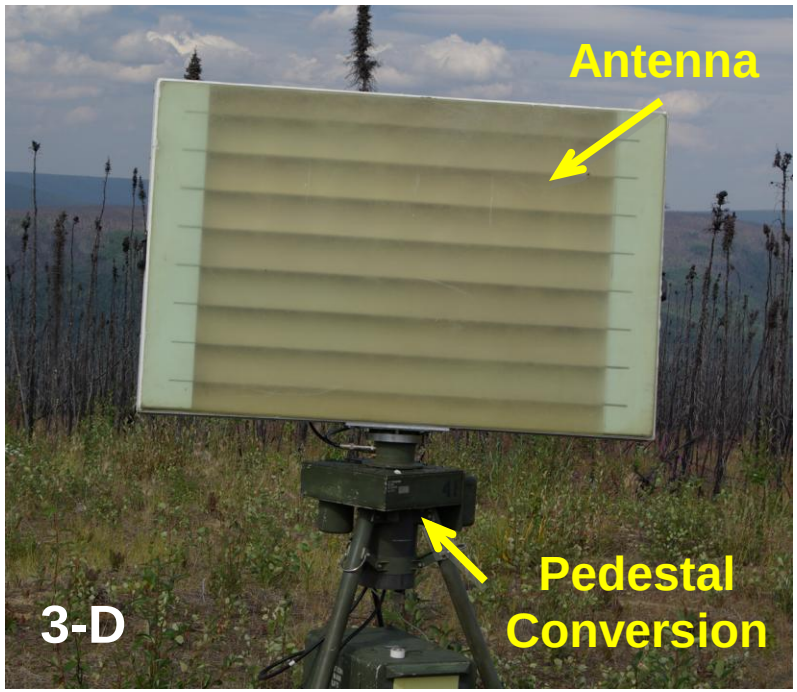


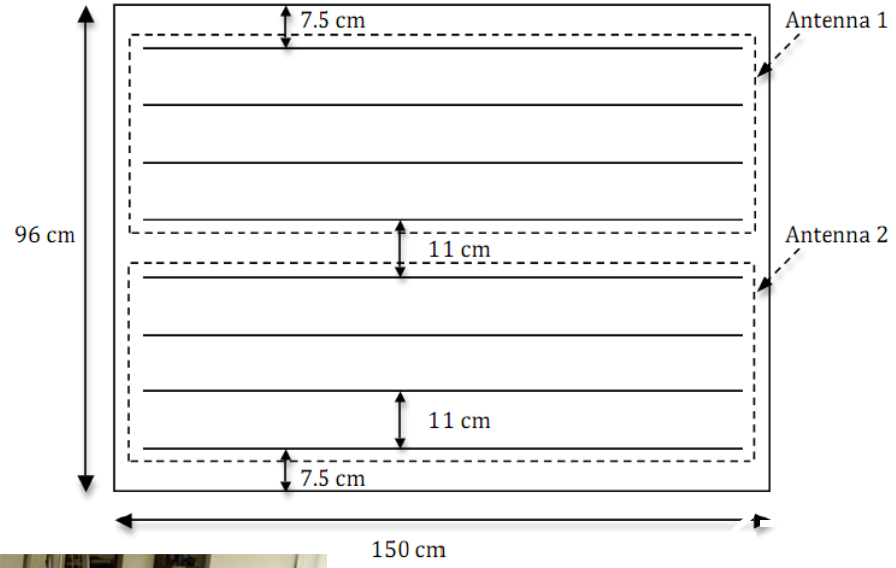
Correct Attenuation



2010 Status

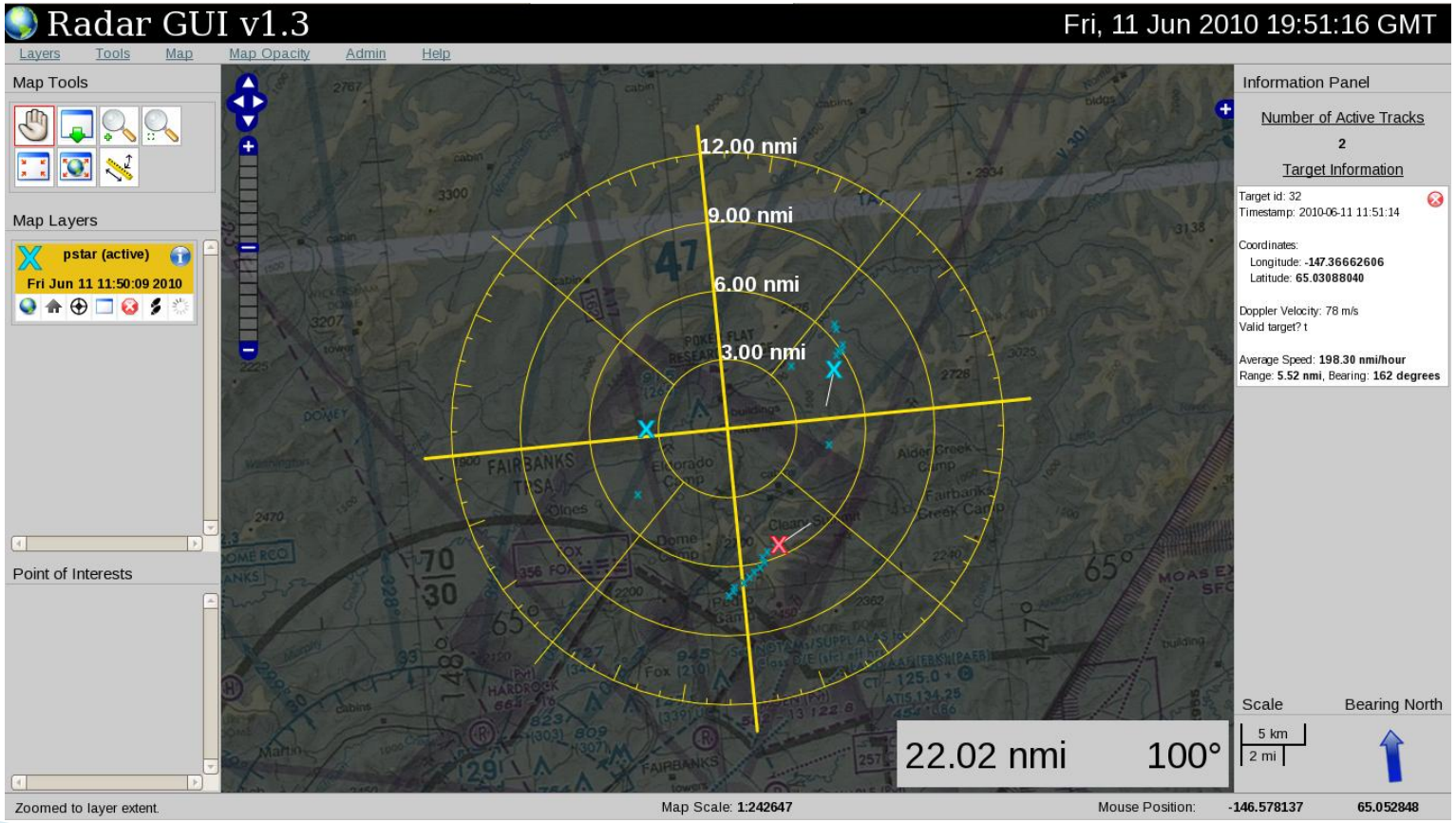
- Completed 3-D hardware modifications





2010 Status

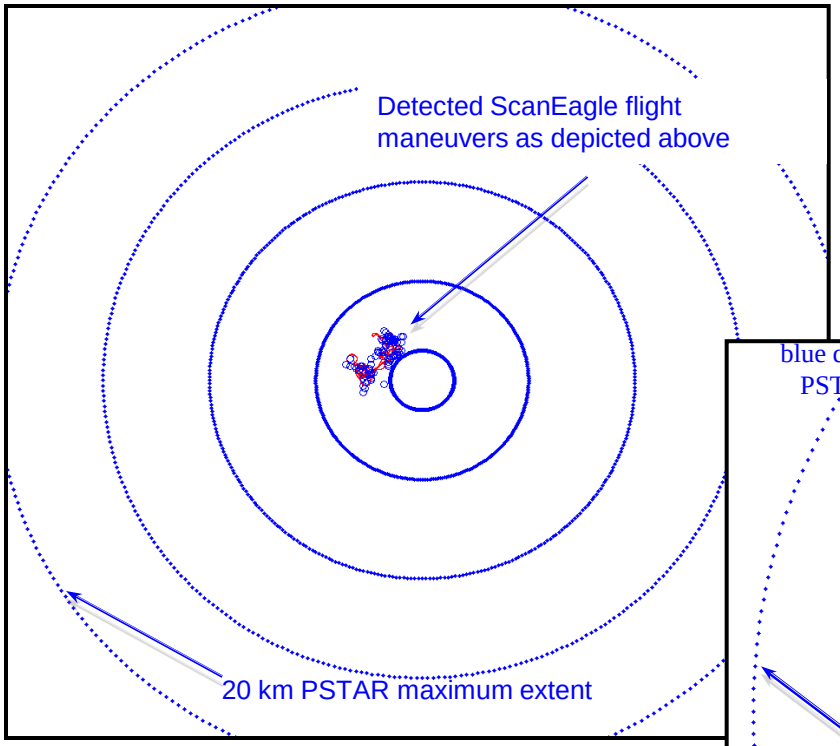
- Operational web-based data display

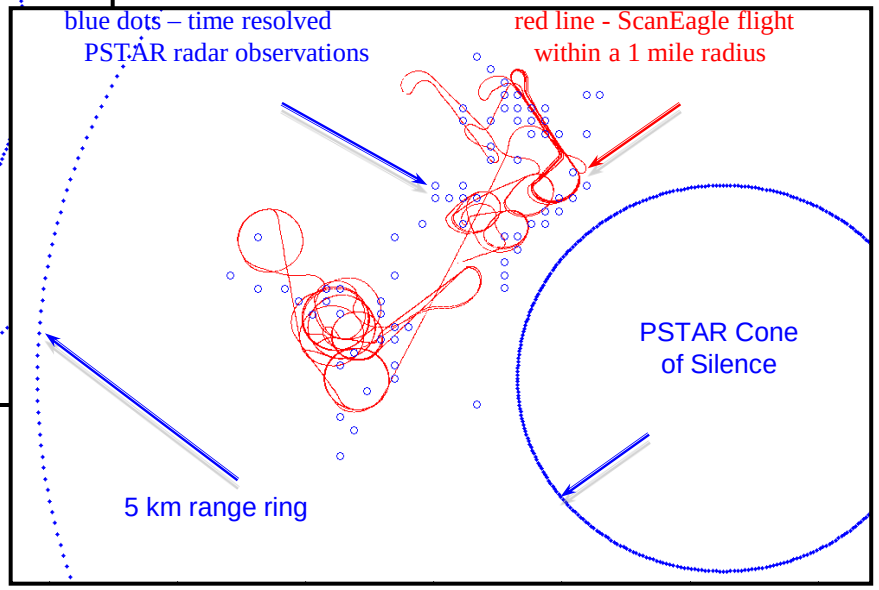


Version 1.3 (June 11, 2010)

2010 Status

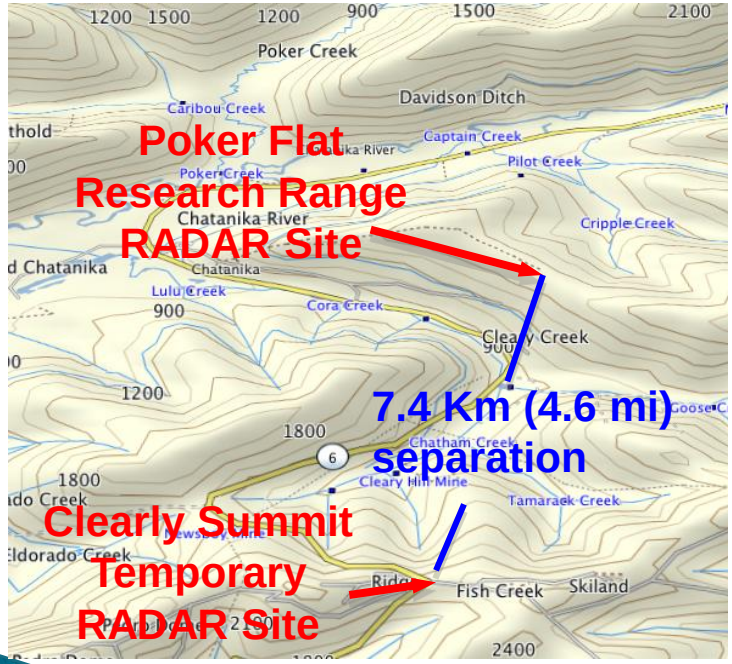
- Testing (varying target size) (Alaska)

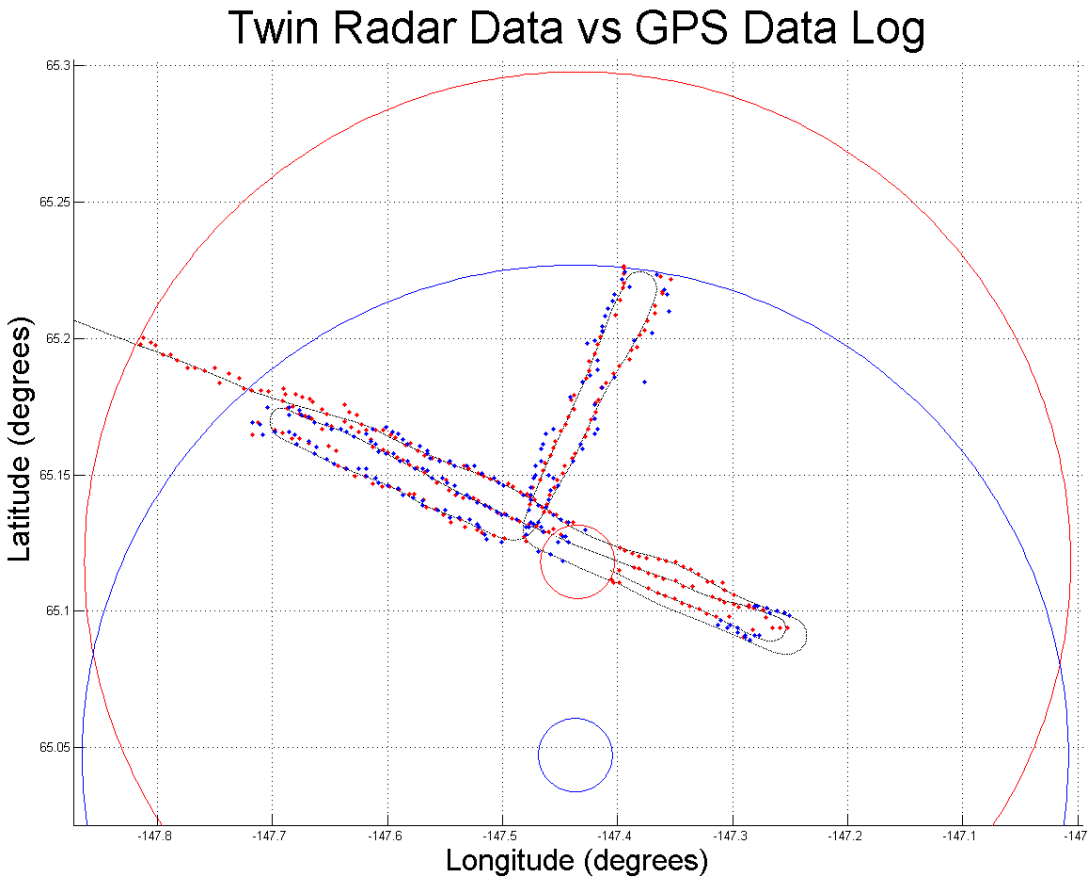




2011Status

- Testing (multiple RADAR simultaneously) (Alaska)



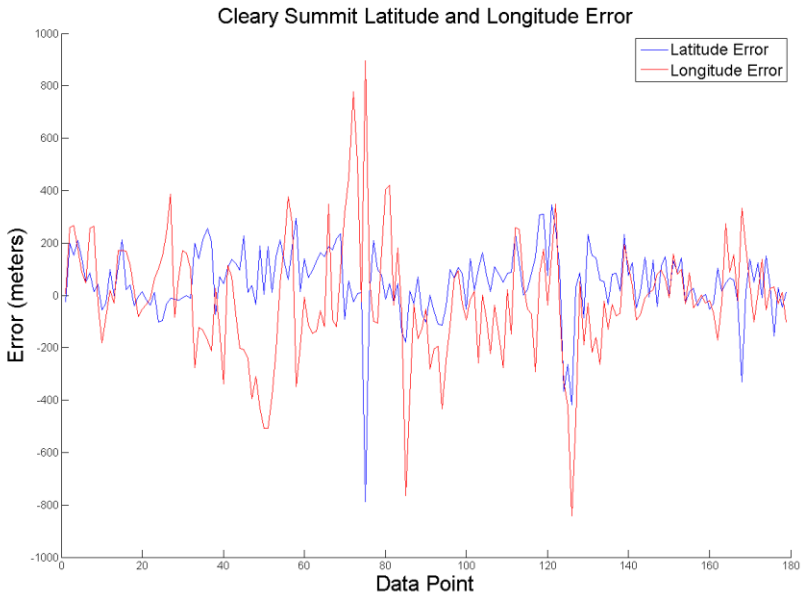


June 8, 2010 RADAR operation at Poker Flat and Clearly Summit Alaska

2011Status

- Accuracy Analysis Simultaneous Multiple Sites

Combination of Spatial Error and Temporal Error



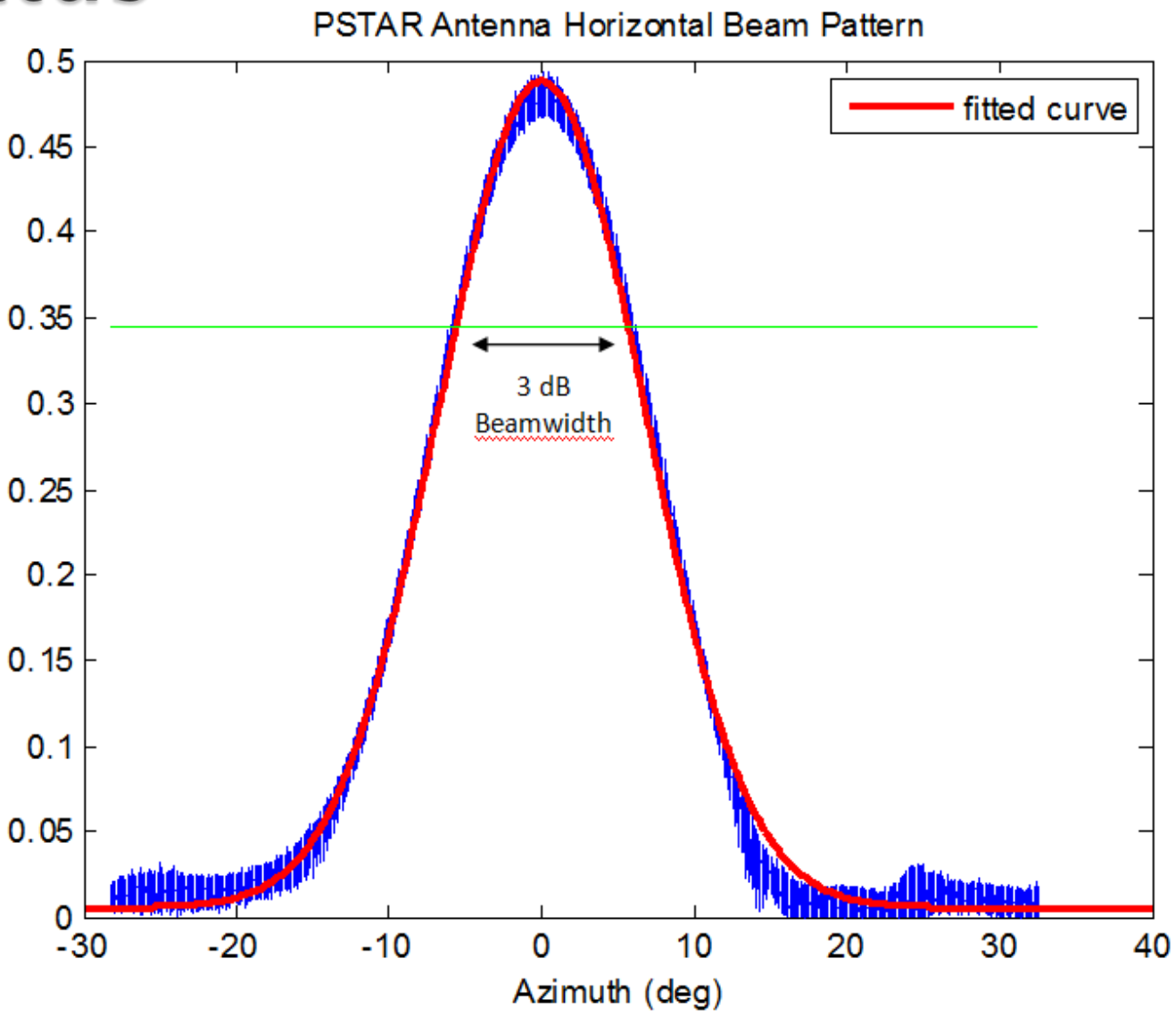
Radar #1 Average Error:
Lat - 50.3 m
Long - 2.9 m

Radar #2 Average Error:
Lat - 49.8 m
Long -16.9 m

RMS Average Error:
Lat - 50.1 m
Long 12.1 m

2011 Status

Beam Pattern Analysis



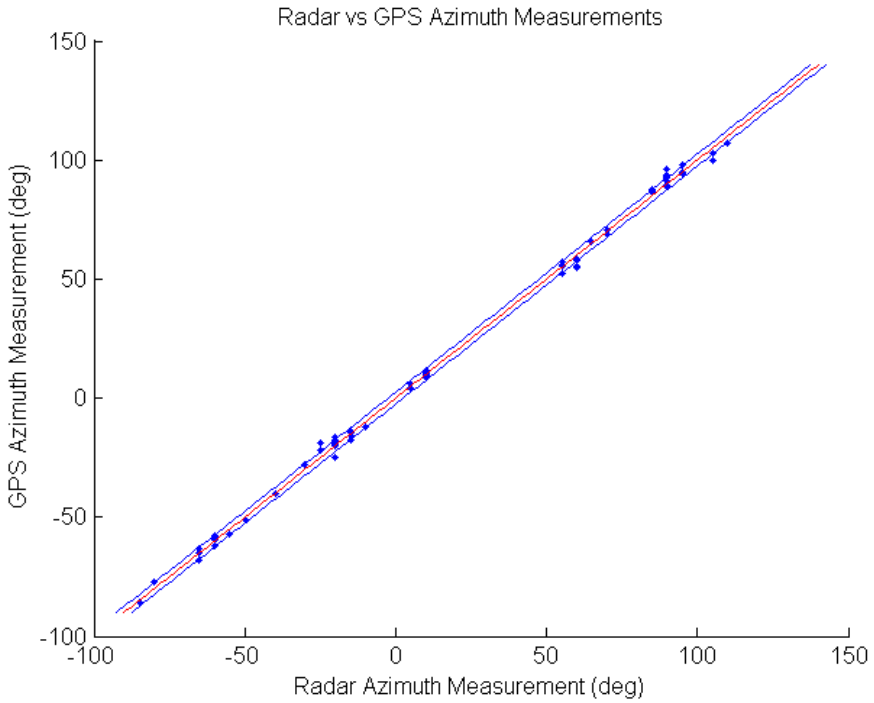
2011 Status

Testing and Verification

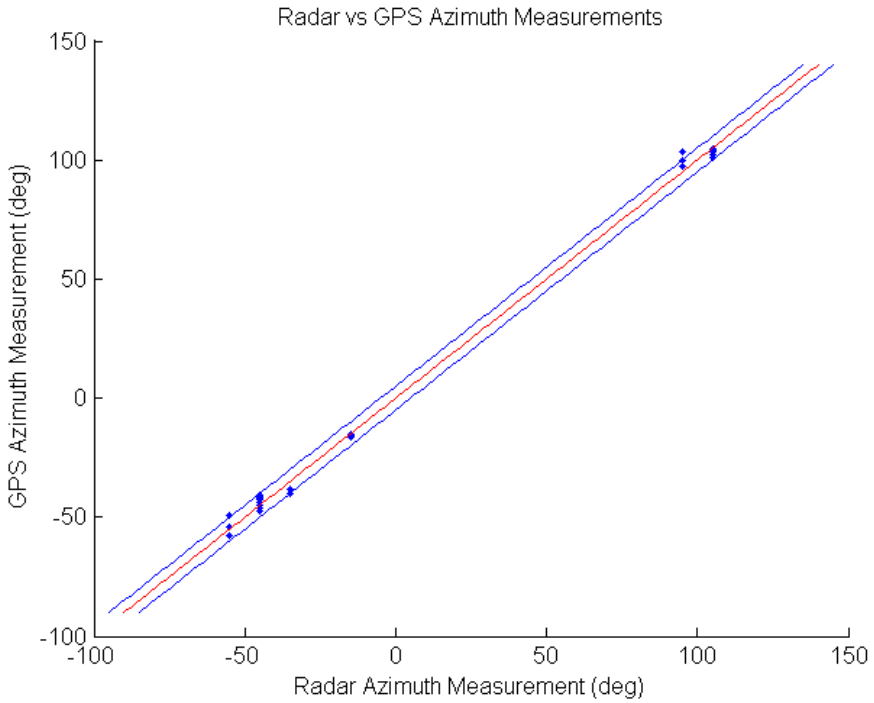
Test Data From A Cooperative Target

- Azimuth

5° Azimuth Spacing



10° Azimuth Spacing



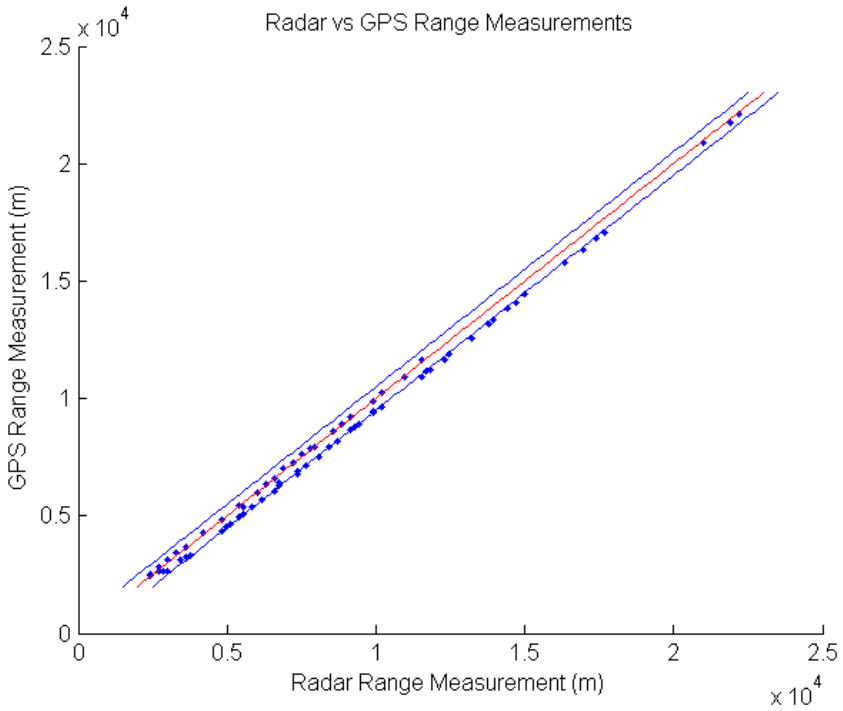
2011 Status

Testing and Verification

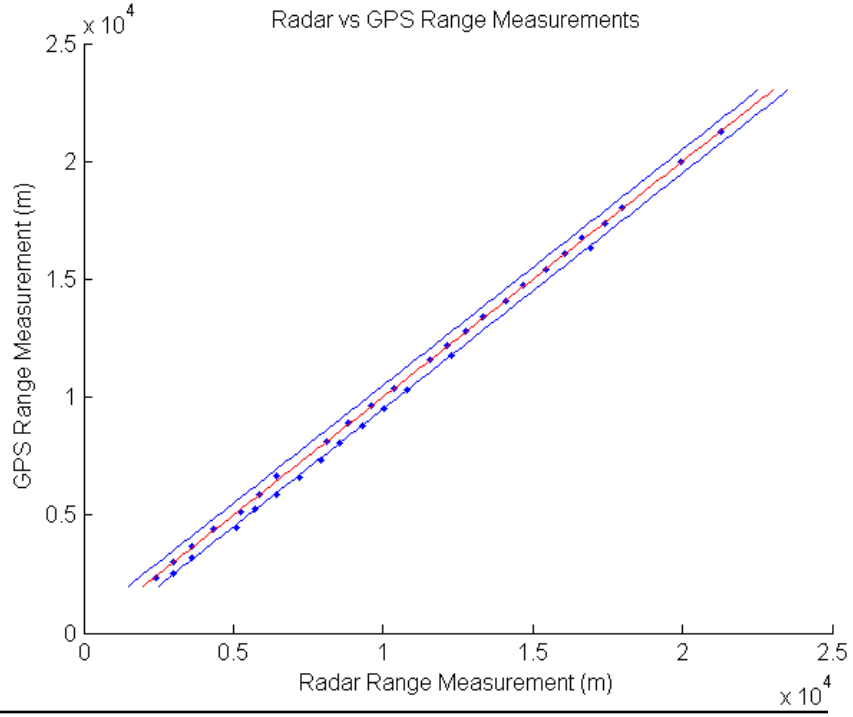
Test Data From A Cooperative Target

- Range

5° Azimuth Spacing



10° Azimuth Spacing



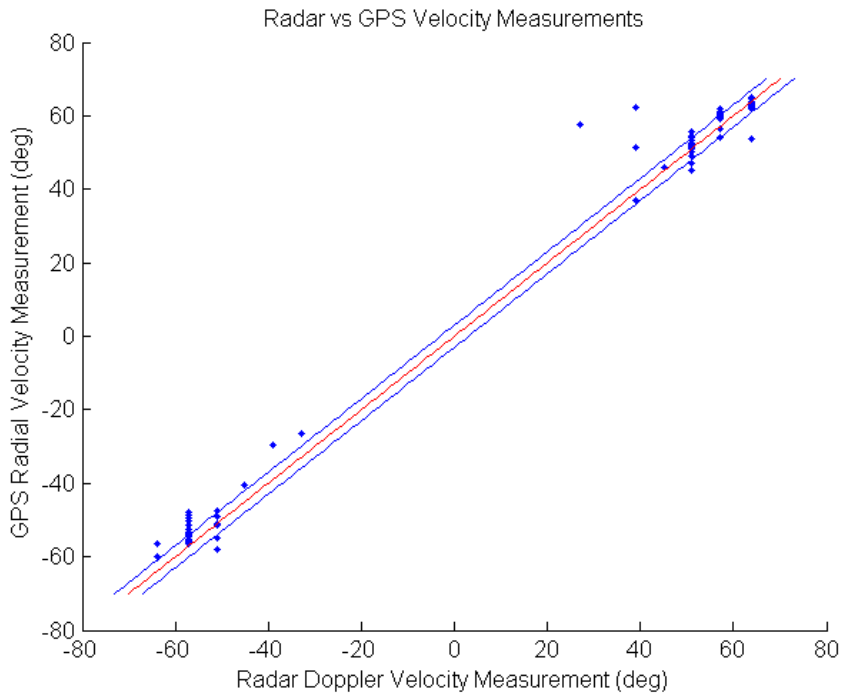
2011 Status

Testing and Verification

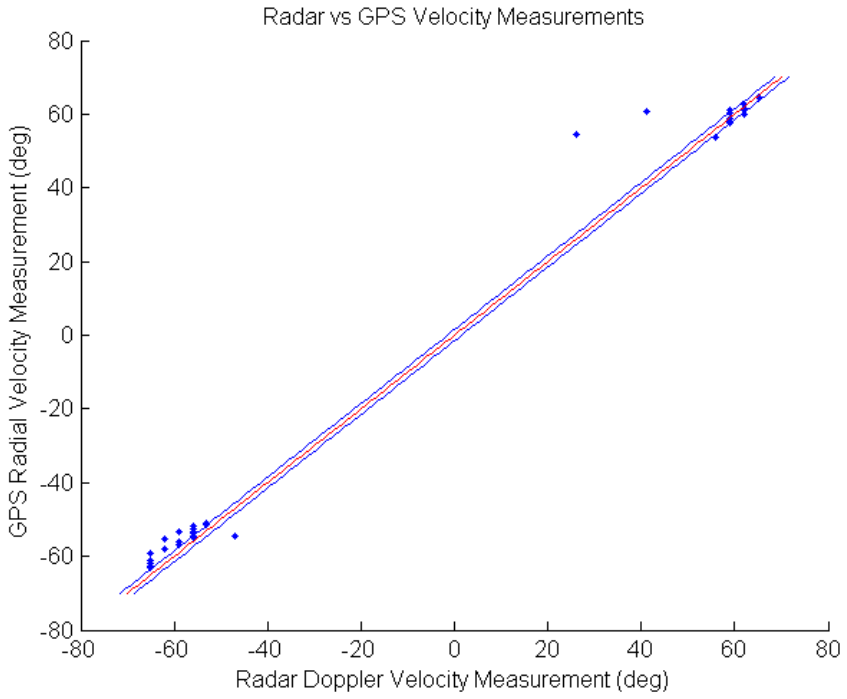
Test Data From A Cooperative Target

- Doppler Velocity

5° Azimuth Spacing



10° Azimuth Spacing



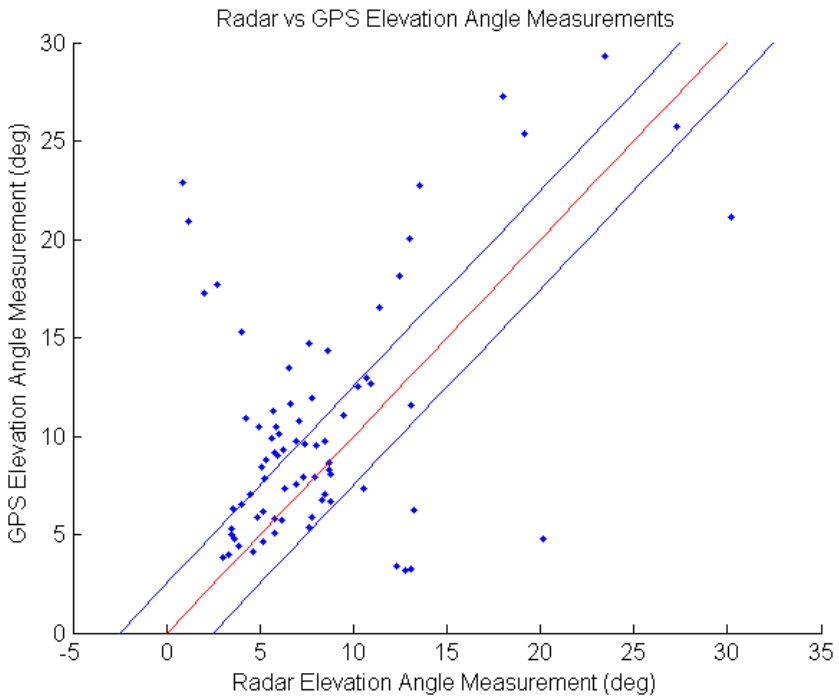
2011 Status

Testing and Verification

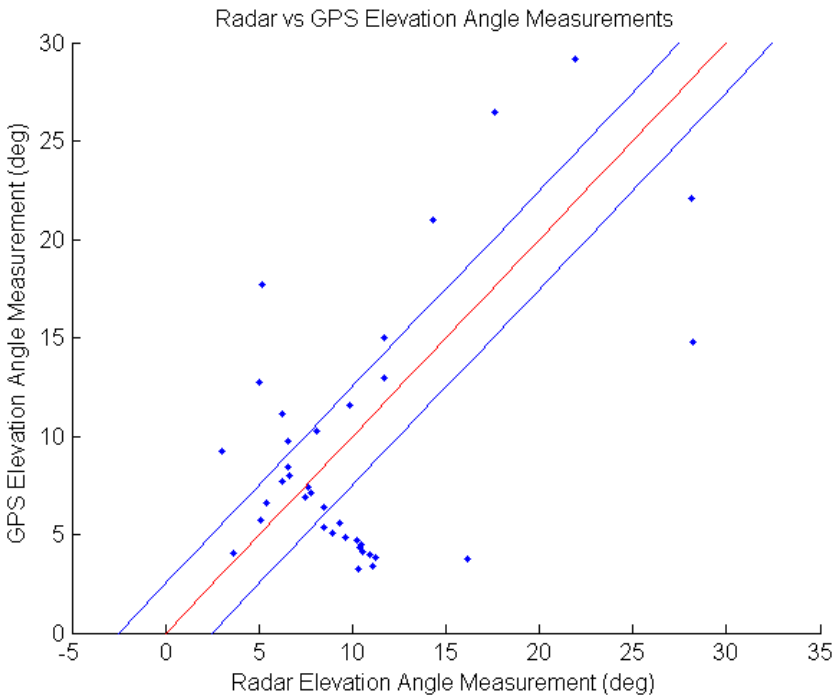
Test Data From A Cooperative Target

- Elevation Angle

5° Azimuth Spacing



10° Azimuth Spacing



2011 Status

(a) 5^o Azimuth Spacing

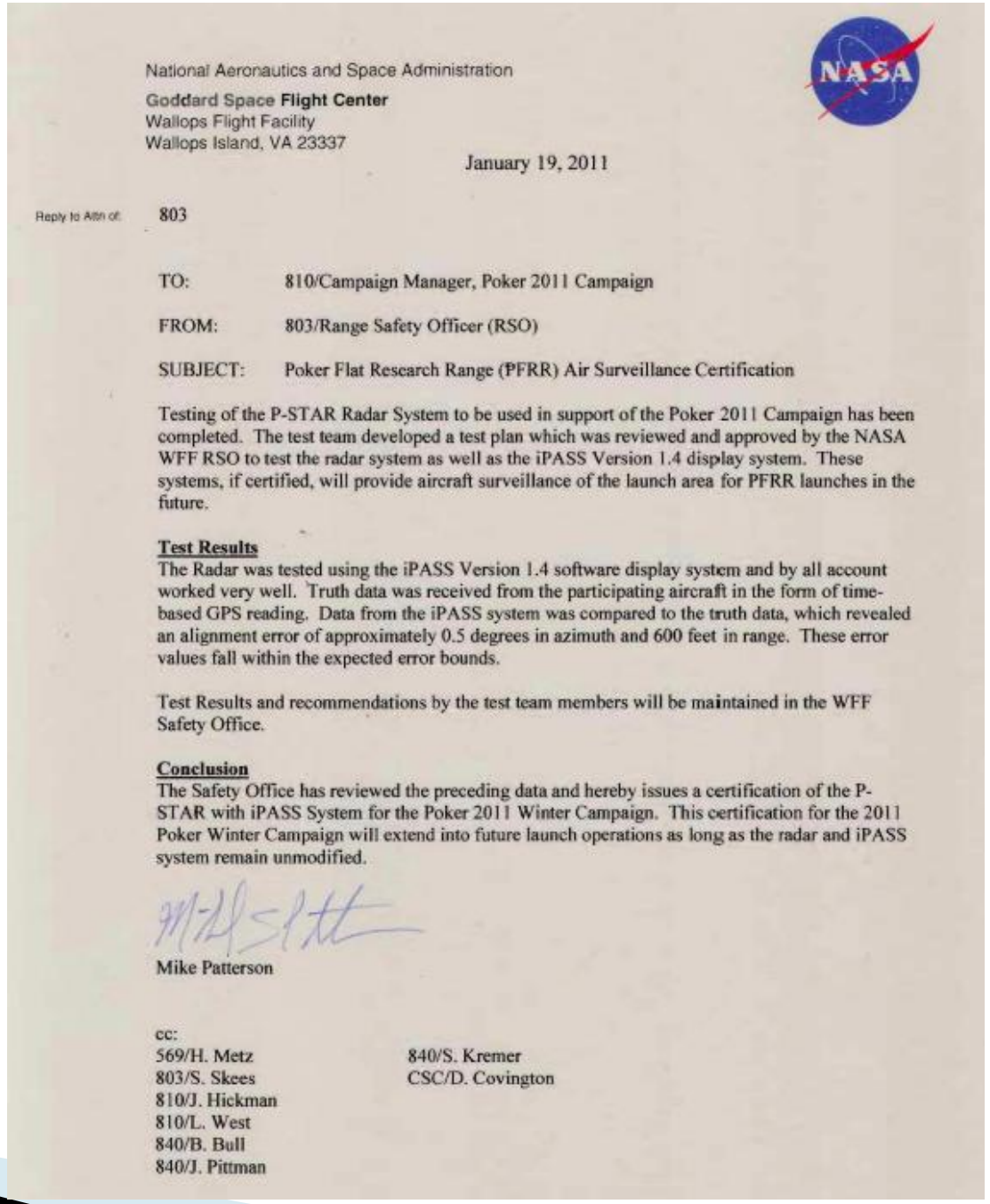
	Range Error (m)	Az Error (^{o})	Elev Angle Error (^{o})	Vel Error (m/s)
Max	649	5	15	105
Min	-163	-6	-22	-31
Mean	282.3	-0.4	-2.6	-0.9
St. Dev.	284.6	2.3	5.9	13.5

(b) 10^o Azimuth Spacing

	Range Error (m)	Az Error (^{o})	Elev Angle Error (^{o})	Vel Error (m/s)
Max	619	5	13	8
Min	-183	-8	-13	-29
Mean	159.1	-0.2	0.8	-2.9
St. Dev.	278.2	2.7	5.9	6

2011 Status

NASA certification for Poker Flat Rocket launch activities to monitor the uncontrolled airspace



National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

January 19, 2011

Reply to Attn of: 803

TO: 810/Campaign Manager, Poker 2011 Campaign

FROM: 803/Range Safety Officer (RSO)

SUBJECT: Poker Flat Research Range (PFRR) Air Surveillance Certification

Testing of the P-STAR Radar System to be used in support of the Poker 2011 Campaign has been completed. The test team developed a test plan which was reviewed and approved by the NASA WFF RSO to test the radar system as well as the iPASS Version 1.4 display system. These systems, if certified, will provide aircraft surveillance of the launch area for PFRR launches in the future.

Test Results
The Radar was tested using the iPASS Version 1.4 software display system and by all account worked very well. Truth data was received from the participating aircraft in the form of time-based GPS reading. Data from the iPASS system was compared to the truth data, which revealed an alignment error of approximately 0.5 degrees in azimuth and 600 feet in range. These error values fall within the expected error bounds.

Test Results and recommendations by the test team members will be maintained in the WFF Safety Office.

Conclusion
The Safety Office has reviewed the preceding data and hereby issues a certification of the P-STAR with iPASS System for the Poker 2011 Winter Campaign. This certification for the 2011 Poker Winter Campaign will extend into future launch operations as long as the radar and iPASS system remain unmodified.

Mike Patterson

cc:
569/H. Metz
803/S. Skees
810/J. Hickman
810/L. West
840/B. Bull
840/J. Pittman
840/S. Kremer
CSC/D. Covington

2011 Continuing Work

- Automatic North Alignment
- Vertical Beam Pattern Characterization
- Phase Characteristics
- Testing Parrot Target
- Developing an Intelligent Parrot
- Documentation (DOT Report Format) on Methods To Test A Portable RADAR System
- Incorporation of Optical Techniques

- Traffic Use Studies

Work That Cannot Be Executed

- Real-Time 3D solution based on the P-STAR hardware
  - Internal transmitter resets are only detectable in the custom receiver in a post-process manner
  - Optical?
  - New transmitter?
    - Off Military frequencies
    - Modern efficient RF design

Oh yea, Some other project news

- Scott Otterbacher has received his MS in Electrical Engineering (May 2011)
  - His outstanding thesis was based on the 3-D system design research
  - With two friends he has launched a company to exploit this work and to turn the technology into a system useful for others to use with small UAS operations. The initial focus is to develop a system that is one-person-portable with an iPad user interface for law enforcement operational safety
  - However, his first contract is to help us with the ongoing Navy, NASA, Corporate, and FAA work

Questions

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