Use of a Closed-Loop Tracking Algorithm for Orientation Bias Determination of an S-Band Ground Station

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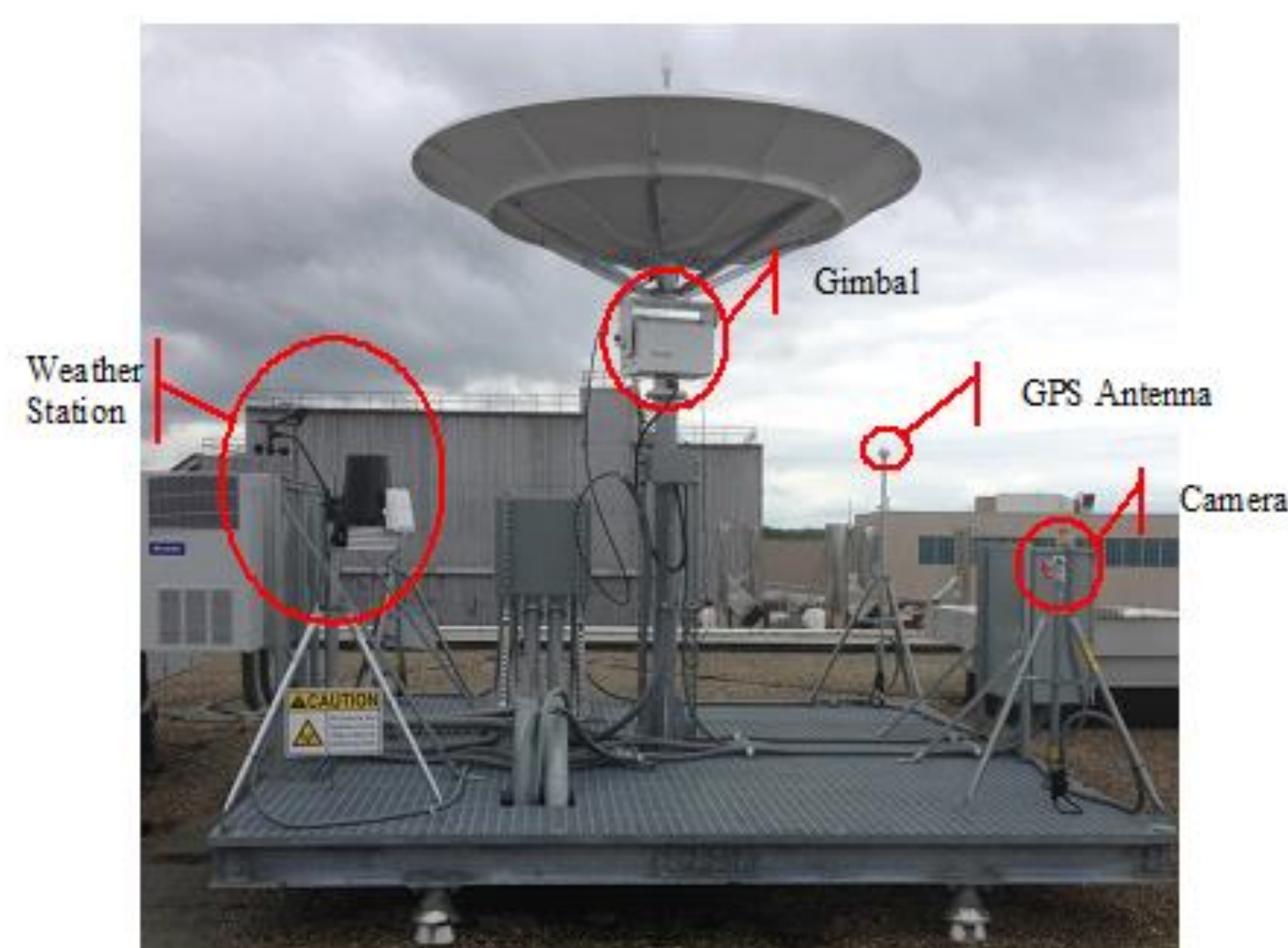*NASA Glenn Research Center, **ZIN Technologies, Inc.

Introduction

In 2015, the Space Communication and Navigation (SCaN) Testbed Project completed installation and checkout testing of a new **S-Band Ground Station** at the NASA Glenn Research Center in Cleveland, Ohio.

One aspect of checkout testing the GRC Ground Station (GRC-GS) was the derivation of misalignment angles associated with the installation of the gimbal to its roof-mounted pedestal.

Ground Station Description

- An ideal ground station would have its **Az**=0° angle aligned with true north
  - In the real world this is not always possible
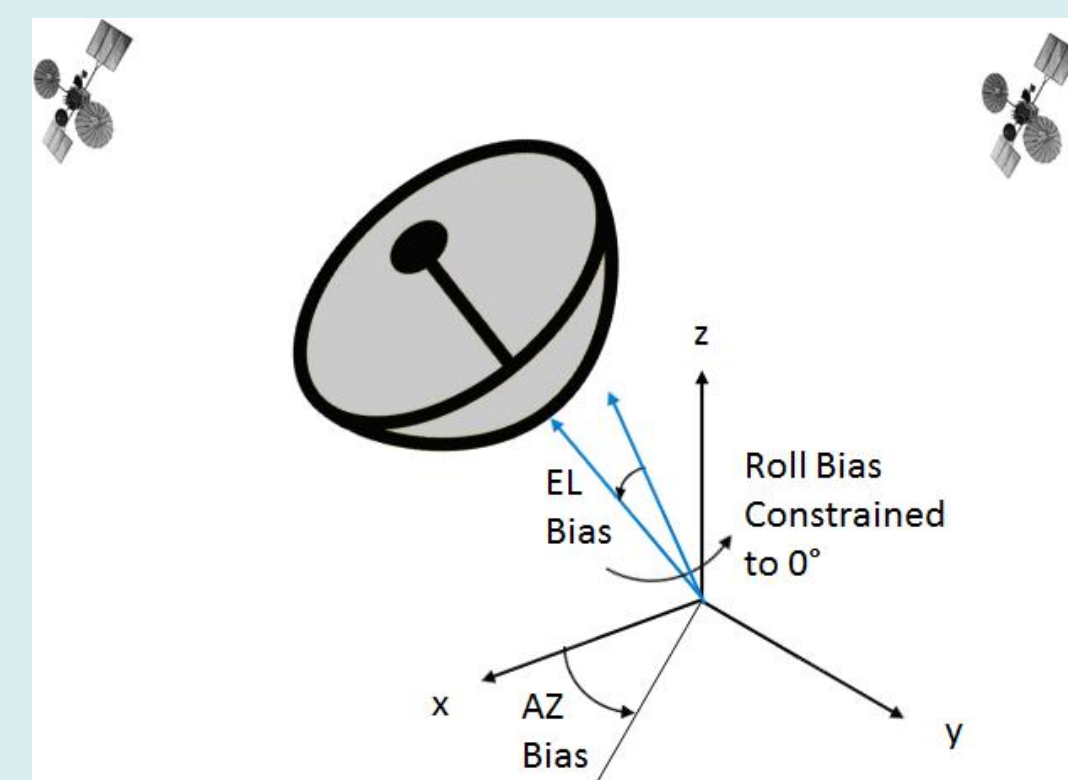 - The Solution is to determine bias angles after installation

GRC-GS Equipment Located on the Roof of Building 110 at the Glenn Research Center
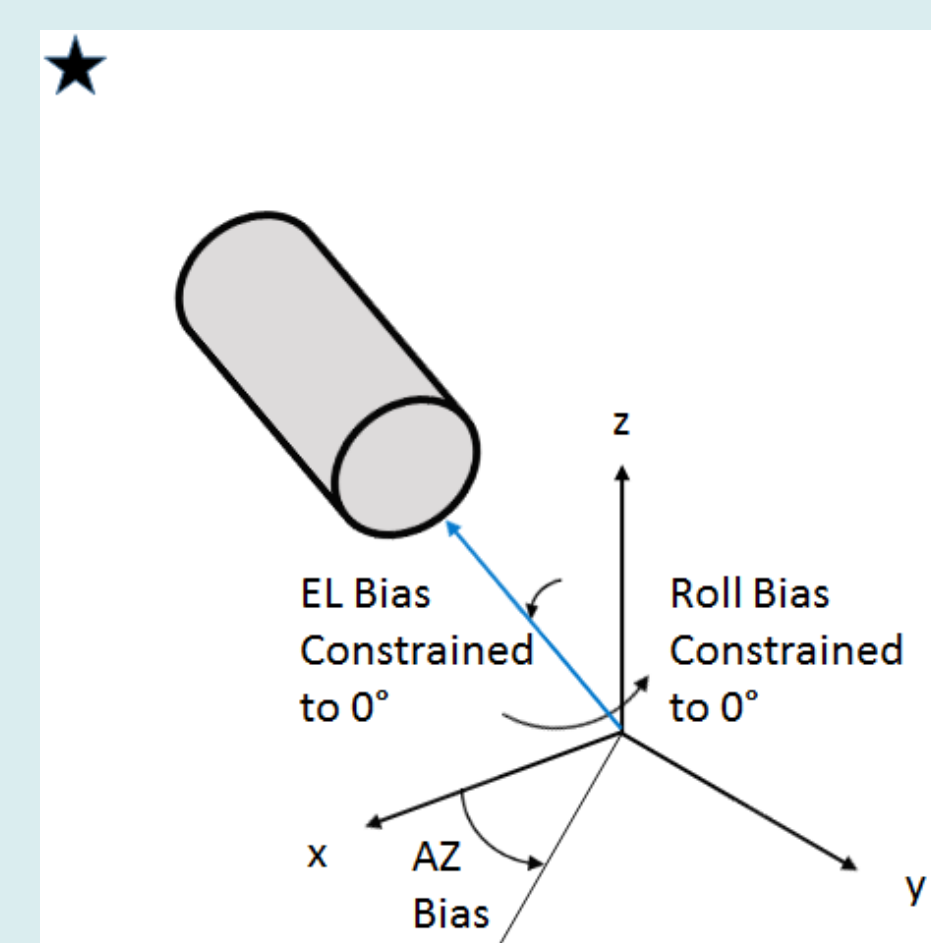
- The primary Equipment of Interest is the Moog QPT-500 Positioner
  - 420° **Az** and 180° **El** range of motion
  - 20°/s in **Az** and 4°/s in **El** slew rates
  - Used for tracking the International Space Station (ISS) and the Tracking and Data Relay Satellites (TDRS)
- Antenna is a 2.4m Parabolic Dish with circularly polarized Feed
  - 3.9° Beam-Width

Alignment Process

- Telescope gimbal manufacturers often use a two-star alignment process to determine the necessary Roll, Pitch and Yaw offsets
  - Can be used to solve for offsets in all three Cartesian coordinates
  - For best results stars must be in distinct regions of the sky

- Alternatively a one-star alignment can be used if we constrain the allowable motion
  - The gimbal must be level and unable to roll

FOR THE GRC-GS A HYBRID APPROACH WAS USED THAT COMPLETED A "ONE-STAR" ALIGNMENT WITH TWO DISTINCT TDRS

RF Alignment via TDRS

SETUP
- Using TDRS East and TDRS Spare Orbital Slots
  - Non-ideal for pointing diversity
  - Two opportunities to solve for bias angles
- SGP4 propagator derived from TDRS Two-Line Element (TLE) data
- GRC-GS measuring received power levels via a spectrum analyzer on a coupled port
  - Measurements feed into closed loop tracking control for the gimbal
  - Important to know predicted power level ahead of time to avoid a false lock on a side lobe

Control Modes
- Spiral Track – Searches for coarse alignment
- Two-Axis Dither – Maximizes received RF power
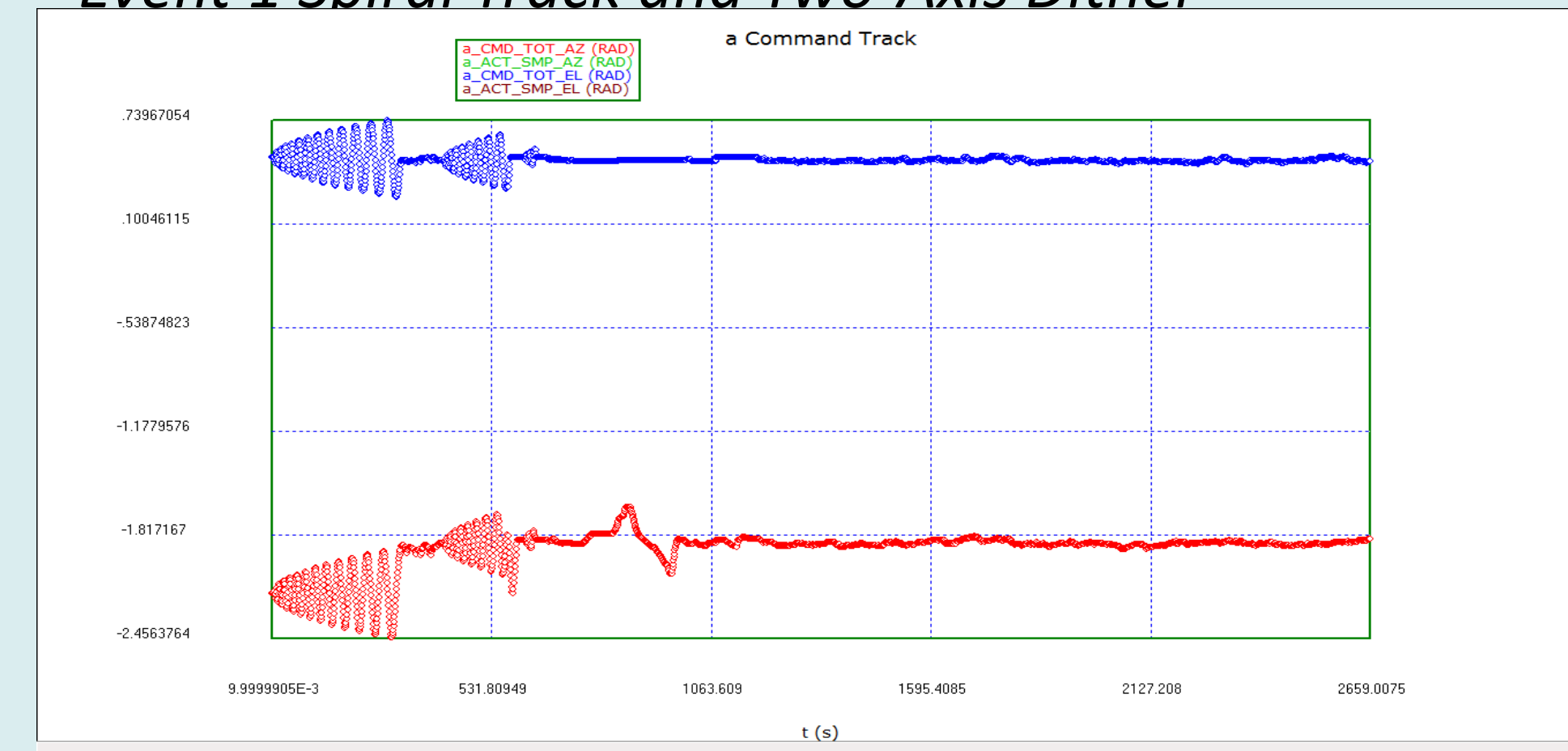
RF Alignment via TDRS

Expected Uncertainty

Error Source	Cartesian Error	Angular Error	Total Error
TDRS Position	50m	7.16E-5°	---
SGP4 GEO Error	910m	1.30E-3°	---
Gimbal Step Size	---	0.01°	---
Wind Oscillation	---	0.02°	---
Cumulative Error	---	---	2.23E-2°

Alignment Test Information

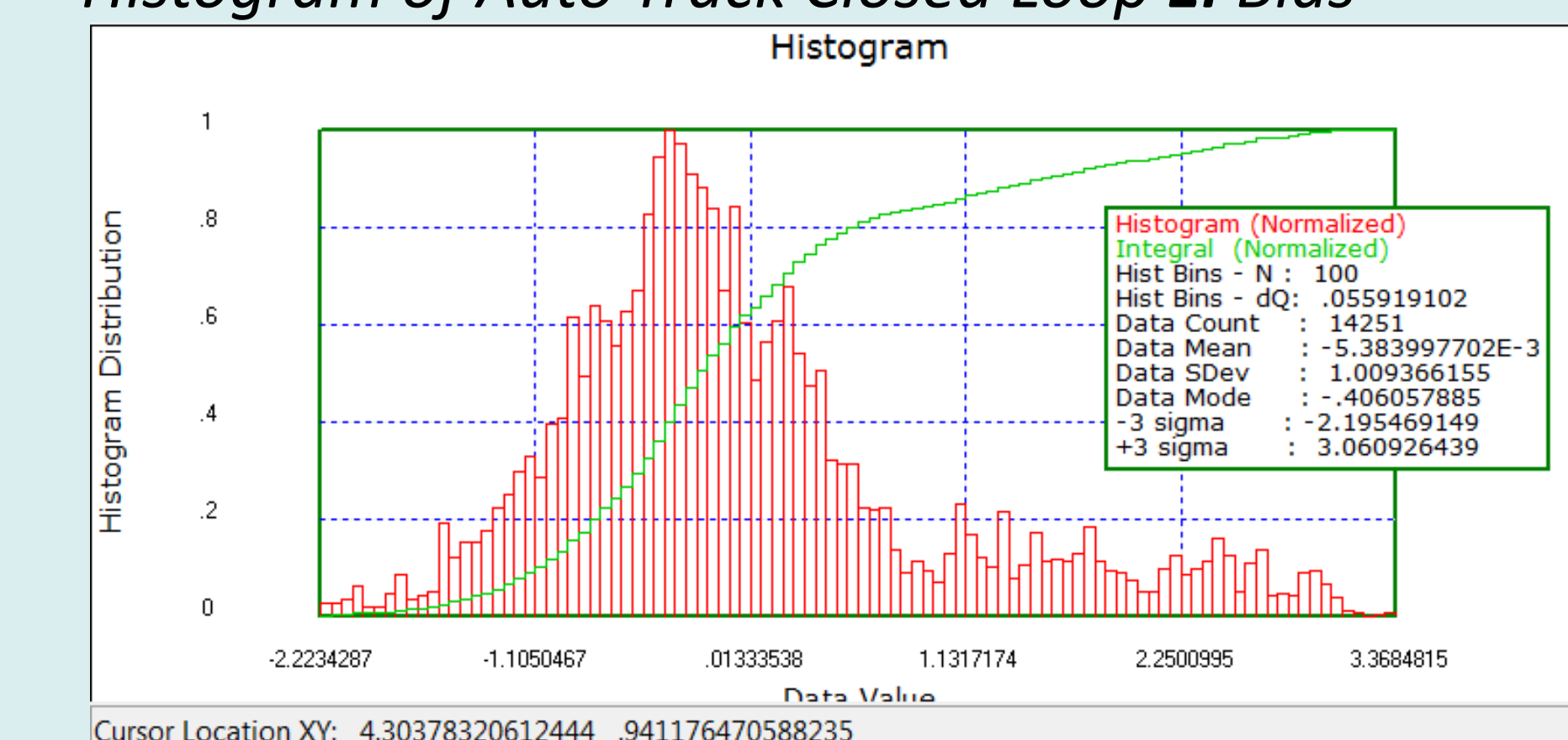| Event	Year	Day of Year	Source	Start Time	Stop Time
1	2014	211	TDE	19:17:00	20:01:12
2	2014	212	TDS	16:44:20	17:24:59

Event 1 Spiral Track and Two-Axis Dither

Histogram of Auto Track Closed Loop Az Bias
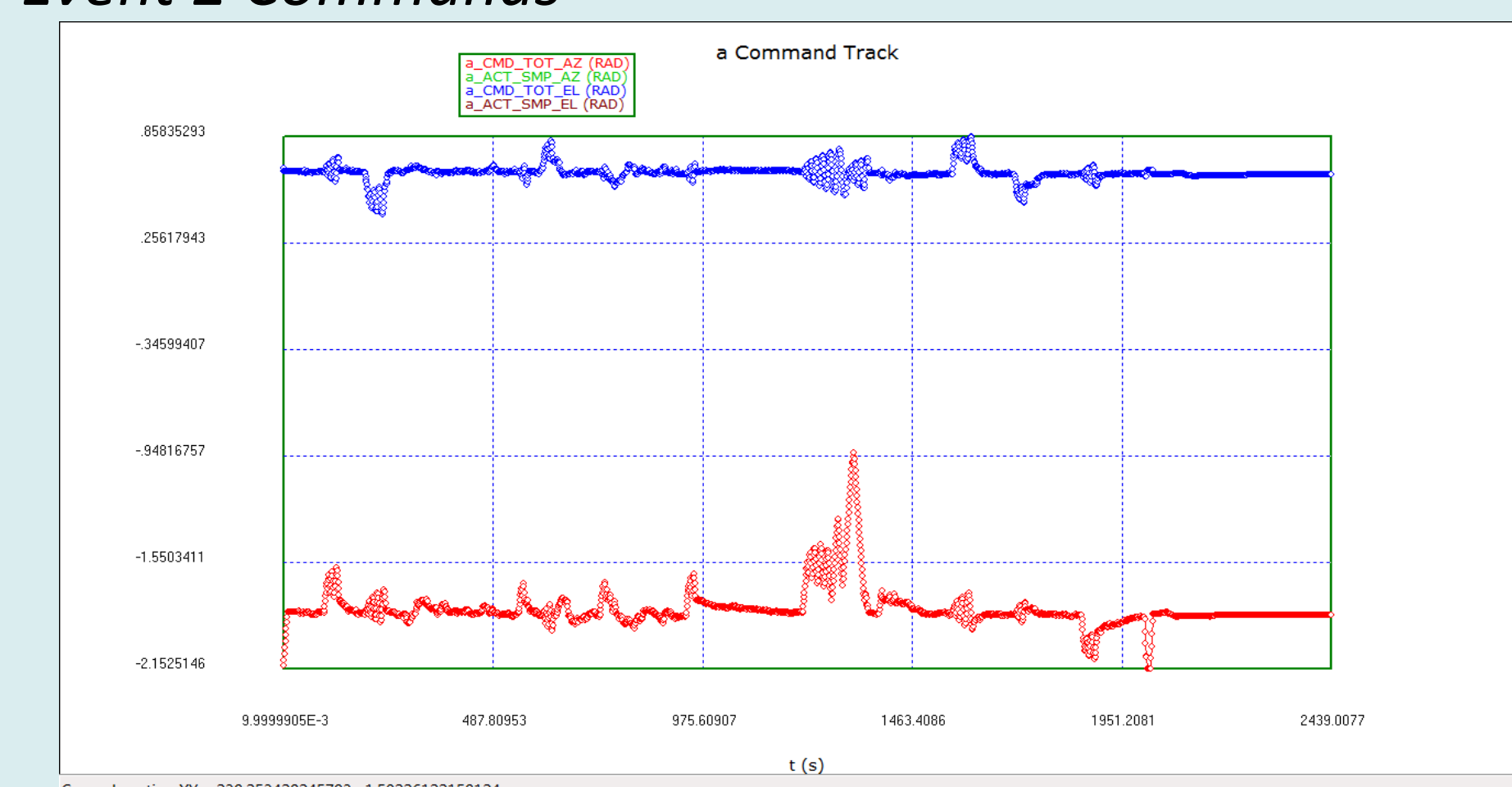

Histogram of Auto Track Closed Loop El Bias

Event 1 Results
- **Auto-track converged on an Az bias of 17.9°**
- **Confirmed El Constraint of 0.0°**

RF Alignment via TDRS

Event 2 Commands

Conclusions

- Able to use Bias angles from event 1 to lock and reacquire during event 2
- Demonstrates this method is a useful alternative to site surveys for determining ground station bias angles
- Several important dependencies
  - RF Source location needs to be stable and well known
  - Requires stable closed loop tracking setup and control
  - RF Source and environment should be well understood

Acknowledgments

References

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