Telescope Mount Concept

CCAT

General Dynamics C4 Systems
Satcom Technologies
VertexRSI Controls & Structures

VertexRSI Profile

CCAT

- Presenters:
  - David Finley, Mechanical
  - Ed Reese, Controls
- Our Telescope Projects Include:
  - Green Bank Telescope
  - Hobby*Eberly Telescope
  - SOAR
  - VISTA
  - Very Long Baseline Array (VLBA)

Scope of Design Task

- Design And Fabrication Of The Mount Structure
  - Azimuth Rotating Structure (Alidade)
  - Elevation Rotating Structure Except For The Primary Mirror And the Primary Mirror Support Truss
  - Establishing Panel Layout
- Design Of Elevation And Azimuth Drives
- Design Of Control System For The Mount

Requirements for Subsystem

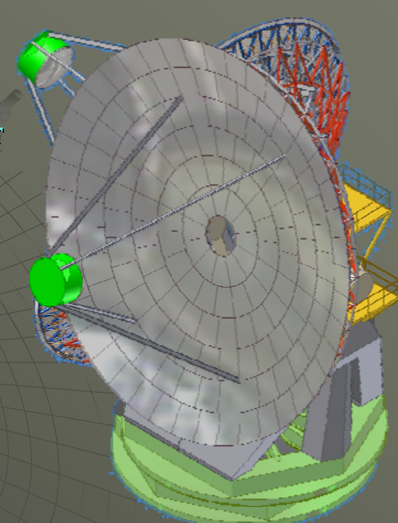
- Alt-az mount
  - Azimuth motion $\pm$ 270°
  - Elevation motion +10° to +90° (mechanical travel)
- Velocities and Accelerations
  - Full Performance 0° To 60° Elevation Angle
  - Scanning velocities 0.2 deg/sec (slow); 1 deg/sec (fast)
  - Scanning accelerations 0.2 deg/sec^2 (slow); 2 deg/sec^2 (fast)
- Pointing accuracy
  - Overall 2 arc-sec, RMS
  - Offset, 1 to 5 deg 0.5 arc-sec, RMS
  - Offset, < 1 deg 0.1 arc-sec, RMS
- Open loop behavior
  - Nonguided image jitter <0.1 arc-sec
  - Open loop drift 0.1 arc-sec in 1 min
  - Open loop drift goal 0.1 arc-sec in 10 min

Key Design Issues

- The Close Spacing Of The Optics Poses Challenges For Designing Support Structure.
- The Dynamics Of Scanning At High Elevation Angles Controls Drive Design And Required Structural Stiffness.
- Installation At A Remote, High Altitude Site Requires The Work To Be Organized To Minimize Time At The Site.

CCAT Mount Overview

- Mirror Truss and quadrapod support primary and secondary mirrors, respectively.
- Reflector Hub Supports Mirror Truss And Elevation Sector Gear
- Elevation Bearings Support Reflector Assembly
- Yoke Arms Support Elevation Bearings And Transmit Reflector Loads Into Azimuth Bearing
- Alidade Rotates In Azimuth, Supported By Hydrostatic Bearing



Reflector

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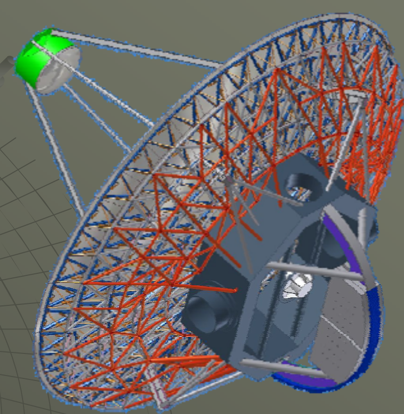
- Quadrapod Provides Support For Secondary Mirror
- Quadrapod Legs Supported On Separate Load Path, So Its Loads Do Not Affect The Primary Mirror.
- Central Hub Supports The Mirror Truss And The Elevation Drive Gear
- Access In Central Hub For Tertiary Mirror
- Bent Cassegrain Port In Hub
- Reflector Assembly Supported On Elevation Bearings



Alidade

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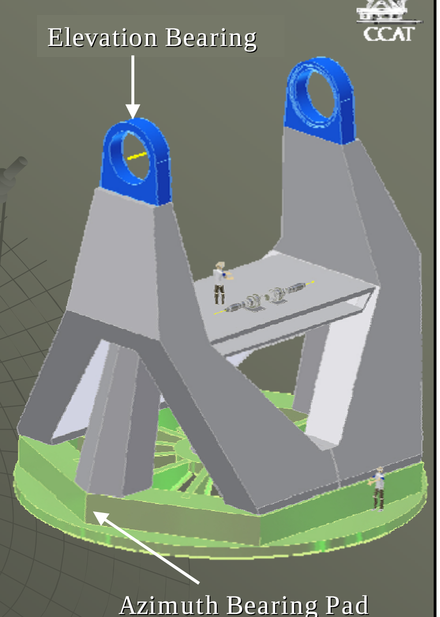
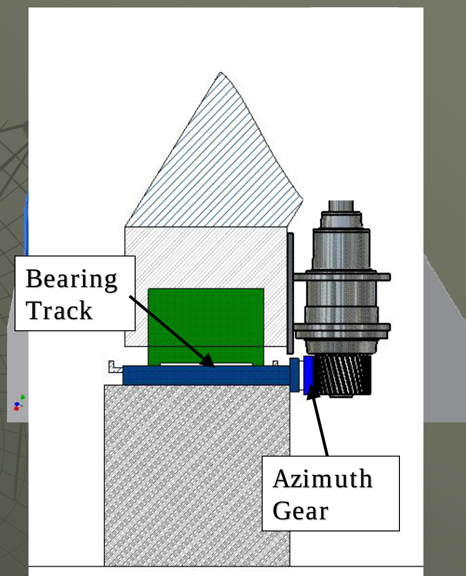
- The Yoke Arms Provide A Direct Load Path Between The Elevation Bearings And The Azimuth Bearing Pads
- Elevation Drive Platform Between The Yoke Arms Support The Elevation Drive Motors
- The Platform Also Ties The Yoke Arms Together To Provide A Greater Stiffness In Sidesway
- Hexagon In The Base Supports The Yoke Arms And Ties The Bearing Pads Together



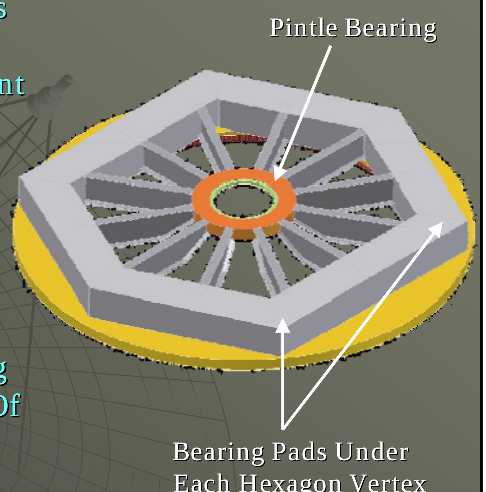
Elevation & Azimuth Drives

- Elevation Drive
  - Reflector Driven By Helical Sector Gear
  - Drive Motors, Driven Against Each Other To Remove Backlash
- Azimuth Drive
  - Helical Gear System
  - Stationary Gear Mounted On Inside Of Azimuth Bearing Track
  - Drive Motors, Gearboxes, And Pinions Located On Moving Structure



Alidade Base

- Hydrostatic Bearing Provides Both Azimuth Rotation And Support For The Entire Mount
- The Center Of Rotation Is Determined By A Rolling Element Pintle Bearing
- The Bearing Pads, Drive Motors, And The Pintle Bearing Are Connected By A Series Of Spokes, Minimizing Deflection Between Motion Of The Motors And The Mount.



Control System and Dynamics

- Preliminary Error Budgets Were Derived, Based On:
  - Vendor Specification Sheets
  - Field Tests From Similar Systems
  - Preliminary Analysis
- Derived Budgets Included:
  - Offset Pointing
  - Tracking
  - Jitter
- Based On This Preliminary Work, The Specification Requirements Appear Achievable
- Performance Requirements Within Current Technology

Performance Requirements

Item	Requirement	Comment
Pointing Accuracy	2 Arcsec RMS	Values of 2-4 Arcsec Achievable
Offset Pointing 1^o To 5^o	< 0.5 Arcsec RMS	Reasonable Requirement for this Application
Tracking Dynamics	0.25 deg/sec 0.01 deg/sec^2	Achievable
Zenith Transit Outage	Nominal 8-10 minutes	Consistent With Tracking Dynamics
Nonguided Image Jitter	< 0.1 Arcsec	Consistent with Similar Designs. Wind Load Needs More Study
Open Loop Drift	0.1 Arcsec/Min	Realistic, SOAR meets this requirement

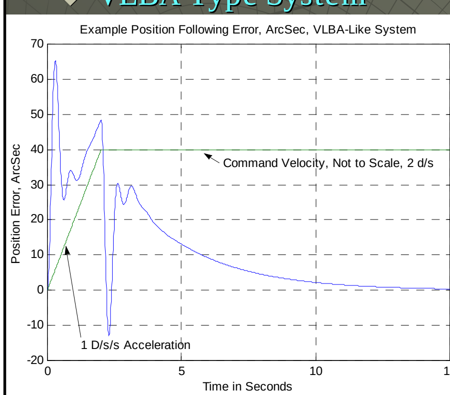
Performance Goals

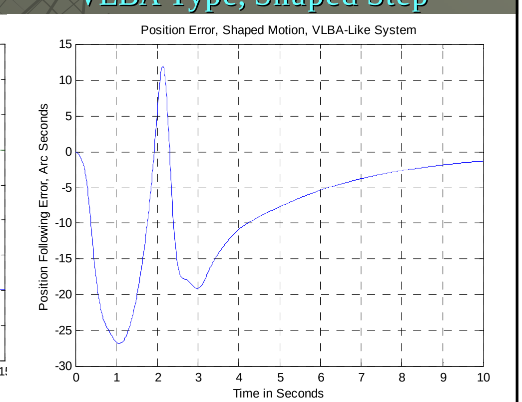
Item	Goal	Comment
Offset Pointing, <1^{o}	< 0.1 Arcsec RMS	Difficult To Analyze And Meet
Open Loop Drift	0.1 Arcsec In 10 Min	Analysis Suggests This Is Difficult To Meet, Yet Our Experience with SOAR Indicates It May Be Possible

Scan Pattern Performance

- Shaped Steps Reduce Following Error
  - Reduces Error Between Commanded Position And Position Vector
  - Shaped Steps Can Improve Peak Following Error, But Increase Mount Dynamics And/Or Increase Motion Time
- VLBA Type System

VLBA Type, Shaped Step





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Control System and Dynamics

- Position Reporting Errors
  - Blind Pointing Errors Plus..
  - Errors Due To Dynamic Deflections
- Depends Upon As-Built Structure And Dynamic Requirements
- Some Example Values For Steady State Error Shown In The Table Below For Reference And Science Consideration
- Probable Structural Values In The 3-7 Hz Range

Acceleration =	$1^o/s^2$	$2^o/s^2$	$3^o/s^2$
Structural Resonance	**Steady State Error, ArcSeconds**		
2 Hz	**23**	**46**	**69**
3 Hz	**10**	**20**	**31**
4 Hz	**6**	**12**	**17**
7 Hz	**2**	**4**	**6**
10 Hz	**0.9**	**1.8**	**2.8**

Critical Risk Assessment

- Optical Layout Imposes Space Limitations For Structure Design
  - An Active Optical Surface Provides An Extra Design Degree Of Freedom
  - The Hub Design Balances Optical And Drive Needs
- Scan Pattern Expectations
  - Further Work With CCAT Program To Establish The Appropriate Pattern
- Installation at a Remote Site
  - We Must Design With The Installation In Mind
  - Confirm Performance Through Factory Testing Before Shipping

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