

Task 329. Tracking and Monitoring Suborbital Commercial Space Vehicles



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**Research Faculty, 2.4-meter Telescope
(NM Tech/Magdalena Ridge Observatory)**

COE CST Meeting, October 26 - 28, 2015



Project Overview

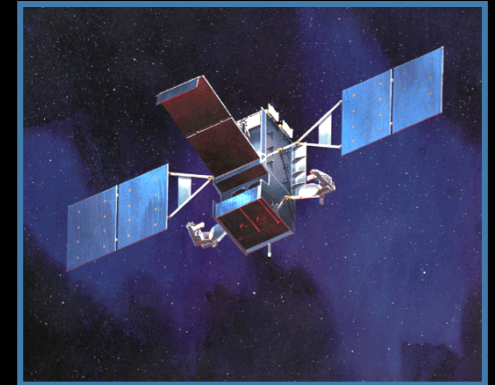
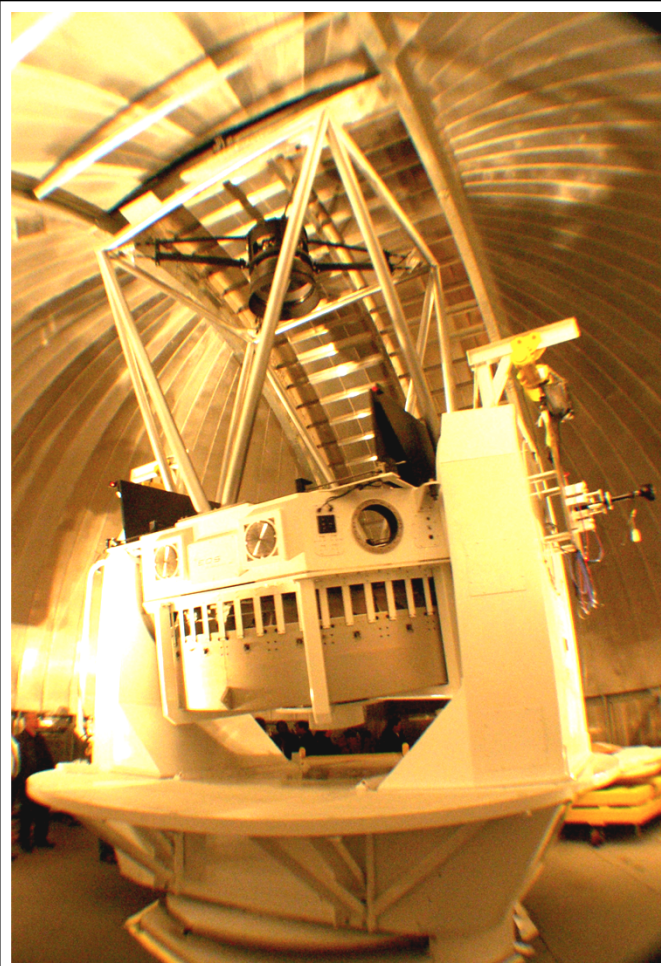
Ultimately: develop an asset ~100 km northwest of Spaceport America in New Mexico that can be utilized to **assess spacecraft health**, assist in **anomaly resolution**, and provide data for **mishap investigation** for Commercial Space Vehicle launches

Pilot Project: Develop the required tracking capabilities for this asset

The **Magdalena Ridge Observatory 2.4-meter telescope facility** (operated by the New Mexico Institute of Mining and Technology) will be used for this task. The observatory researchers have extensive experience tracking fast-moving natural and manmade objects in orbit, and this pilot project will allow for the extension and enhancement of that capability such that the launch of terrestrial objects can also be monitored.

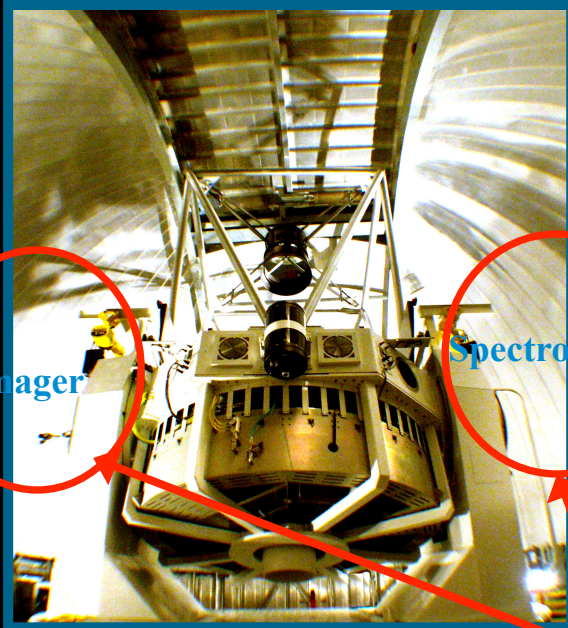
PI: Dr. Eileen Ryan **Director, MRO 2.4-meter Telescope**
Co-I: Dr. William Ryan **Research Faculty, NM Tech R&ED**
NM Tech Mech Eng Undergraduate

Magdalena Ridge Observatory 2.4m: **Operational Sept 2008**

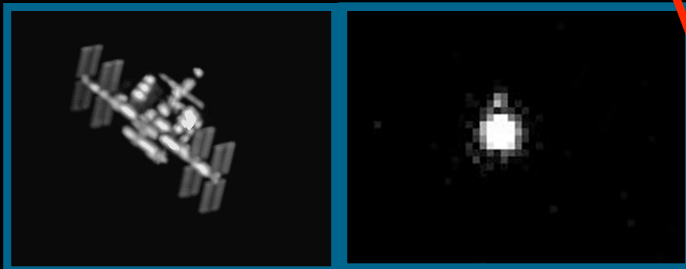


- **Near-Earth Objects:** astrometric follow up and characterization
- **DoD mission – SSA:** sensor development and surveillance
- Supporting and enhancing NM education and outreach

Telescope Specifications



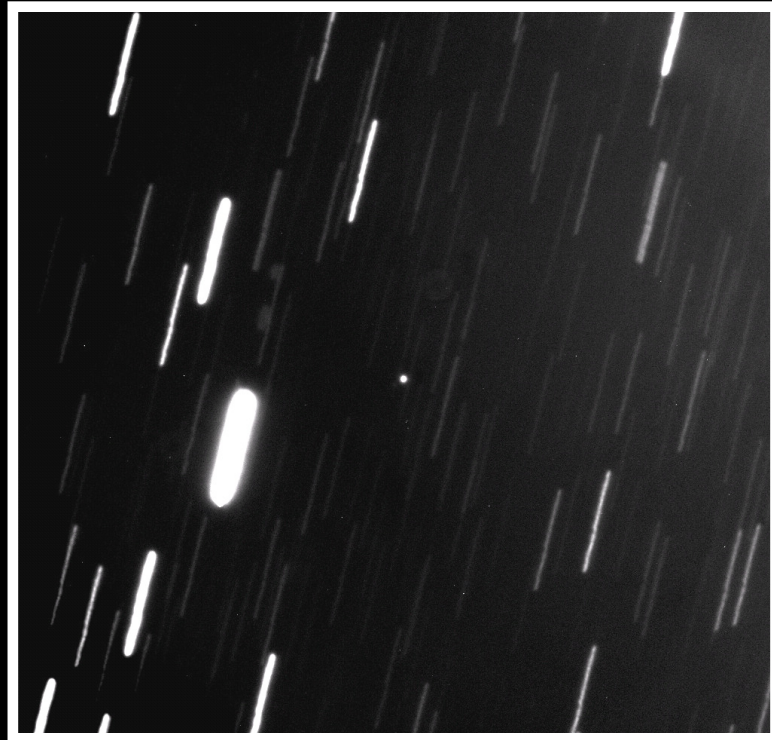
- **Blind pointing is within 3 to 4 arcseconds**
- **Slewing and tracking rate is $10^\circ/\text{sec}$**
- **Acceleration is 3 degrees per sec^2**
- **Settling time is 5 sec after full sky slew**
- **Open loop tracking: at astronomical rates, 0.5 arcsec deviation over 5 minutes (over most gimbals angles)**
- **Ability to point 2 degrees below horizontal, retaining arcsec seeing at low elevations**
- **Can mount multiple instruments simultaneously**



Images of the International Space Station (left) and resolved binary asteroid Kalliope/Linus (right) taken with the 2.4m telescope.

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Near Earth Asteroid Tracking Precision

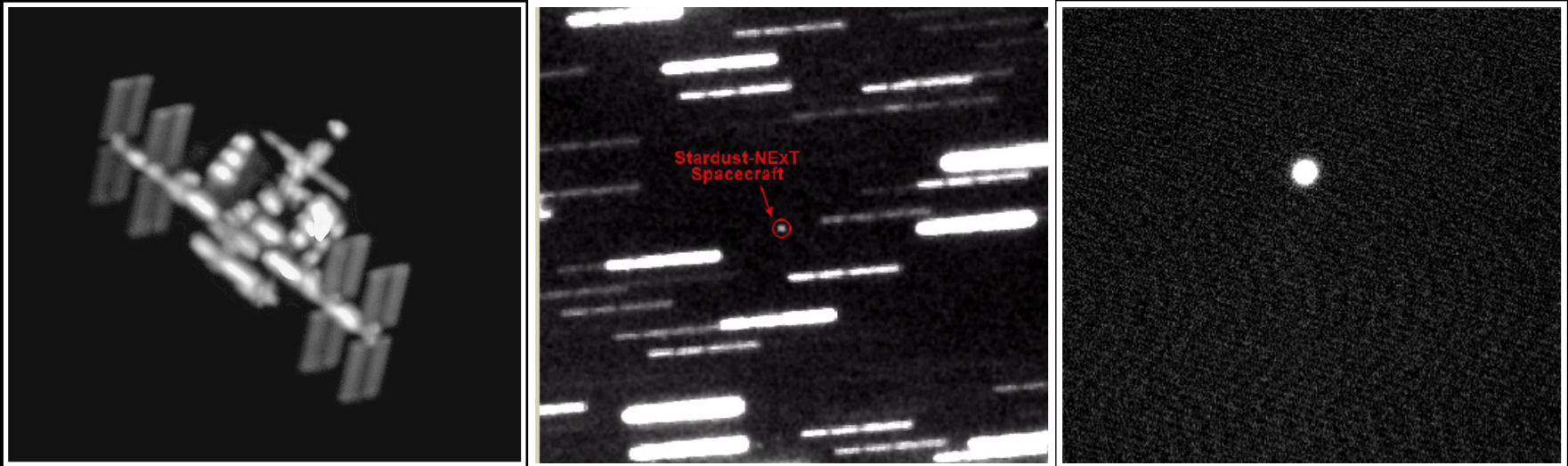


Tracking asteroid 2007 FK1 with the 2.4m Telescope on May 14, 2007.

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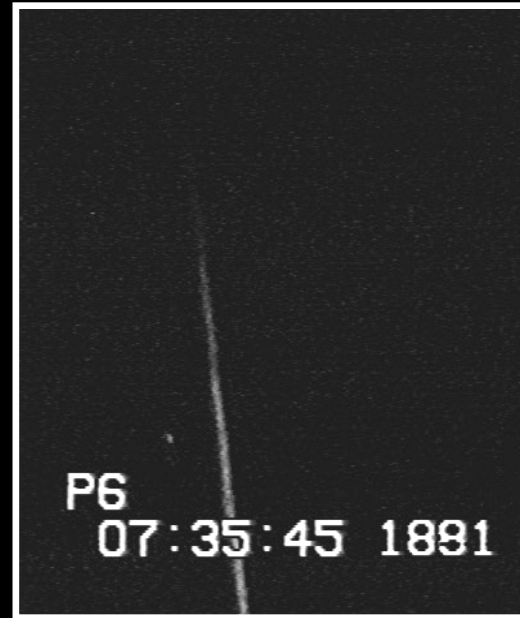
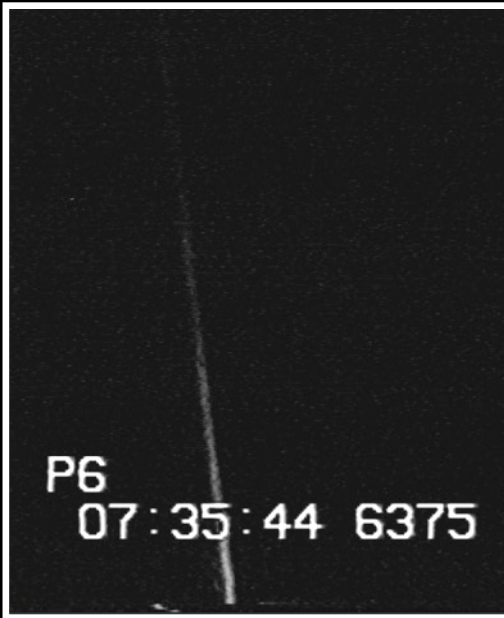
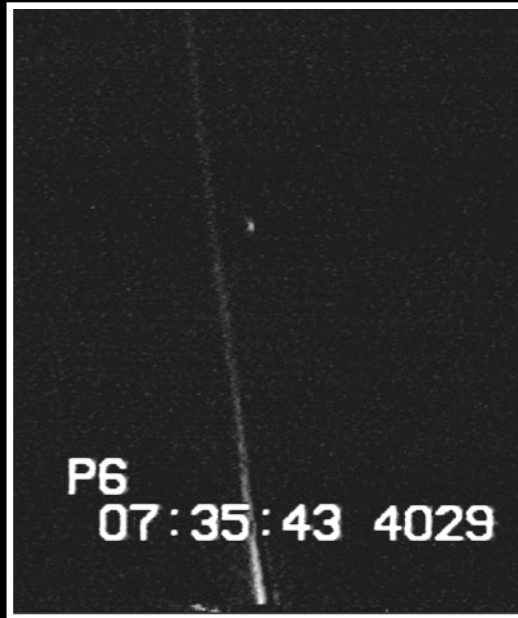
Artificial Target Tracking



A single, resolved image (left) of the **International Space Station (ISS)** taken with the 2.4-meter telescope on December 14, 2010. An unresolved image (middle) of **Stardust-NExT spacecraft during Earth gravity assist flyby** taken on Jan 3, 2009, and a tracked image (right) taken with the 2.4-meter telescope of newly generated space debris: the **tool-bag lost by a shuttle astronaut** while servicing the ISS on November 19, 2008.



Upper Atmospheric Research: Tracking a NASA Sub-Orbital Rocket



GPS open-loop tracked time sequence covering a 3 second period during launch for a **NASA Black Brandt rocket** imaged by the MRO 2.4-meter telescope in 2014. The sub-orbital rocket was launched at **White Sands Missile Range** and the second-stage burn is visible in the center of the image sequence. Other artifacts in the images are background stars.

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Pilot Project

Current tracking capability based on offsets being performed to a predefined telescope track. Terrestrial target motions are governed by less predictable variables, hence relying on a predetermined track is less desirable.

- **Develop software to perform fully autonomous, closed-loop tracking using both acquisition telescope (AT) and 2.4-meter imager data (NM Tech Mech. Eng. Senior)**
- **Analyze test tracking data, identify limitations, then improve (8 half-nights of observing time)**

Test Targets

NASA launches a series of very large stratospheric balloons from Fort Sumner, NM each year. Fort Sumner is approximately 275 kilometers due east-northeast of the MRO facility and the stratospheric balloons would provide good test targets for the new tracking.



A stratospheric balloon prepares for take off at Fort Sumner, N.M.

- **100 km/hr @275 km ~ ½ deg/min**
- **½ deg(AT FOV)@275 km ~ 2.4 km**
- **4.5 arc-min(2.4m FOV)@275 km ~ 400 meters**
- **candle@275 km V~16**

Milestones in 2016

- **Software algorithms for autonomous closed-loop tracking of fast-moving terrestrial targets.**
- **Collected observations of suborbital balloon launches or other test targets (over an 8-half night time period).**
- **Data reduction and analysis with associated performance assessment. New strategies for tracking will be implemented if the first trial efforts need significant improvement.**
- **Dissemination of results & required outcome reporting.**