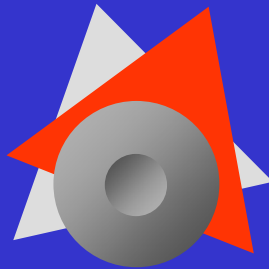


# 2004 STK Conference

## Use of STK and Analysis of EO-IR Point Source Observations for Determination of Satellite Surface Temperature and Reflectance Data



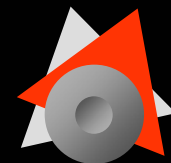
Anil Chaudhary  
Craig Birkemeier  
Applied Optimization  
937-431-5100



Mark Nosek  
Air Force Research Laboratory  
937-255-4174 x4020



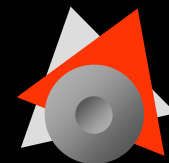
# Outline



- ➔ • Use of STK to Track Space Objects
  - Find Optimal Tracking Conditions
- Processing of Tracking Point Source Data
  - Extract Solar Panel and Body Temperatures
  - Extract Solar Panel and Body Reflectance
  - Create Point Source Signature Map
- Using STK and EO-IR Model
  - for Planning of Observations
  - for SV Status Monitoring
- Conclusion

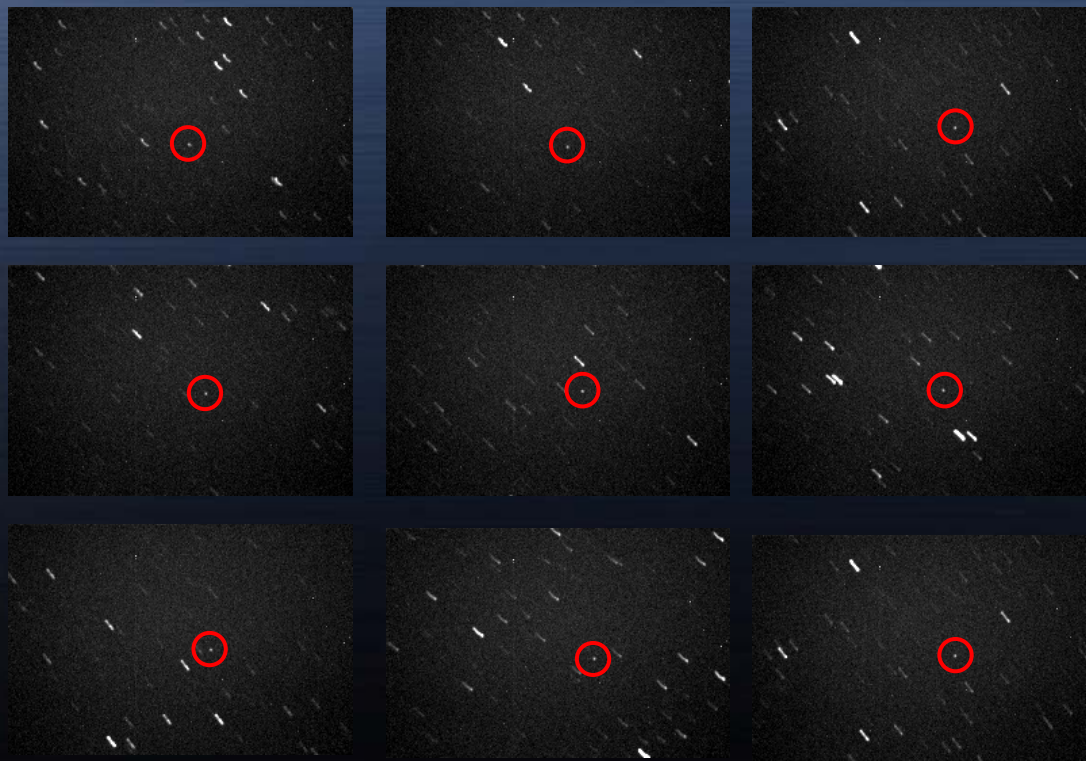


# To Track a Space Object ...



## Second, Make the Observation

First, Plan the Observation with STK

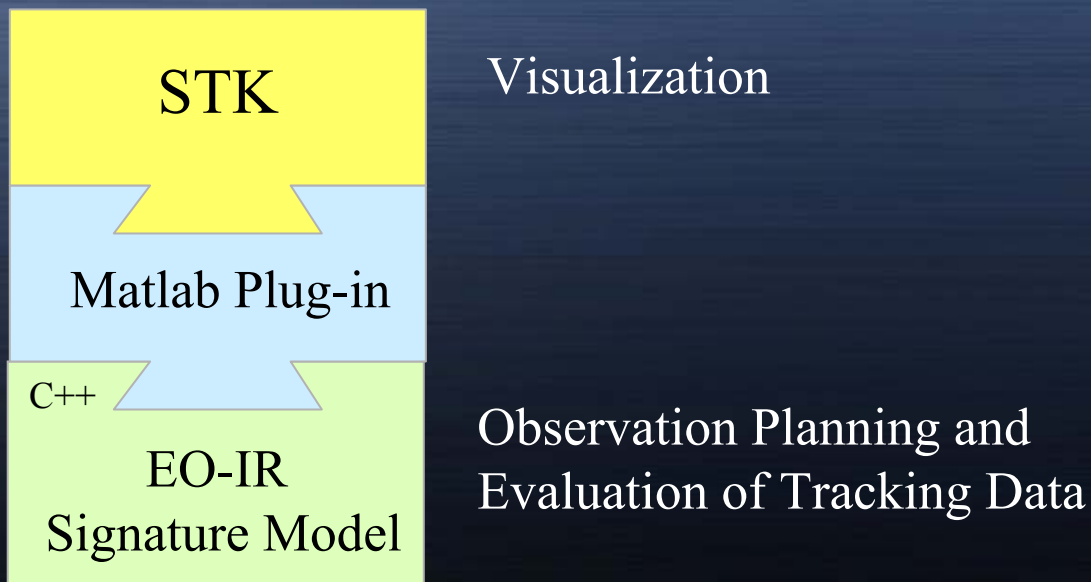
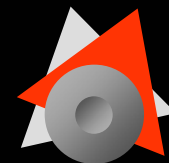


Could we make an observation so that the data reveals more about the object?

Third, Archive the Data



# The EO-IR Model and STK

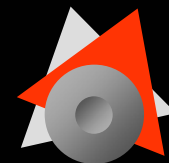


This work is performed under an AFRL/SN Project:

- 2001-03: Satellite Health Monitoring with Point Source Data
- 2004-05: Real-Time Satellite Attitude Determination



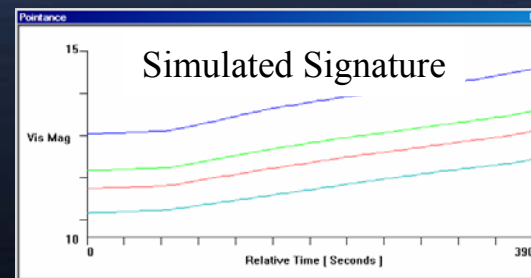
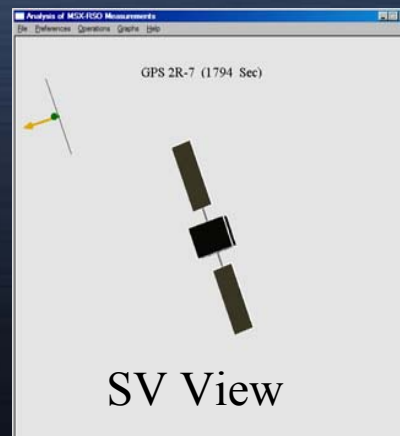
# To Optimally Track a Space Object ...



First, Plan the Observation with STK



Second, Simulate the signature, and look for conditions that result in tell-tale features

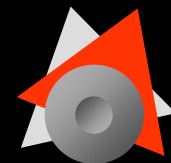


Three, make the observation. And four, archive the data





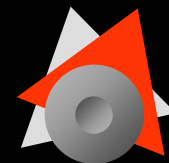
# Outline



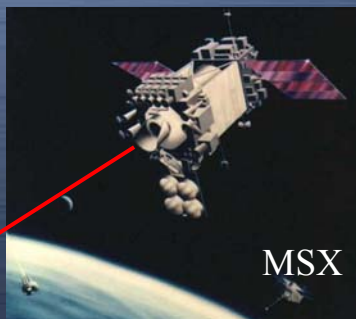
- Use of STK to Track Space Objects
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# Processing of LWIR Point Source Data Sample Results



## Space Based Tracking

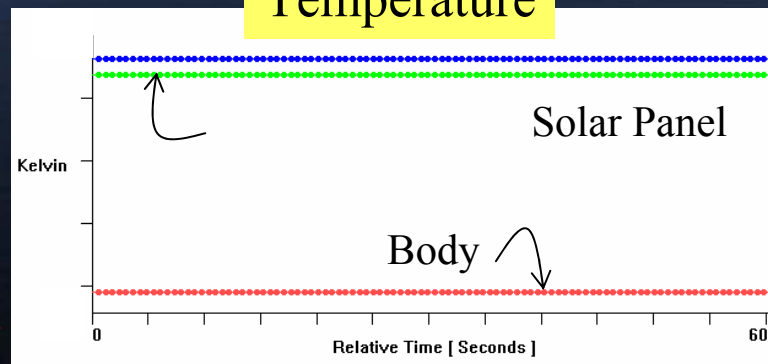


LWIR

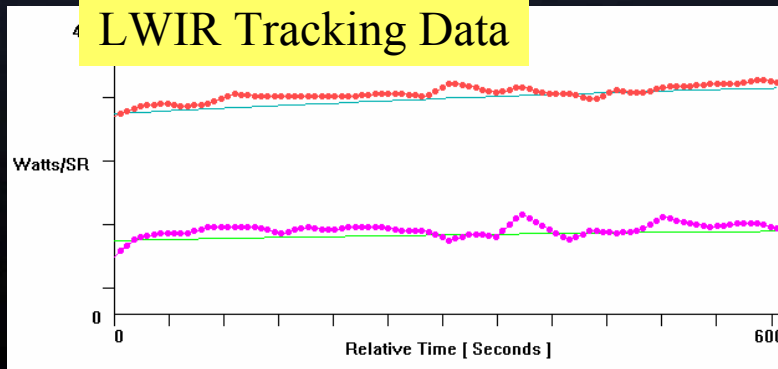
MSX



## Temperature



## LWIR Tracking Data

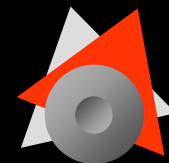


## EO-IR Model



# Processing of Visual Point Source Data

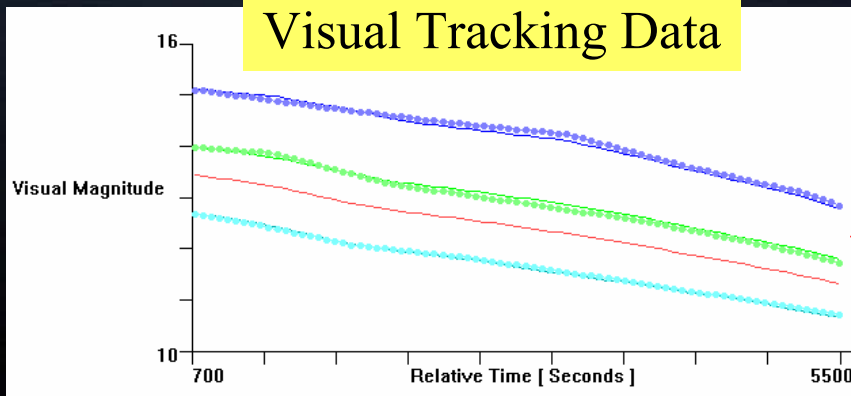
## Sample Results



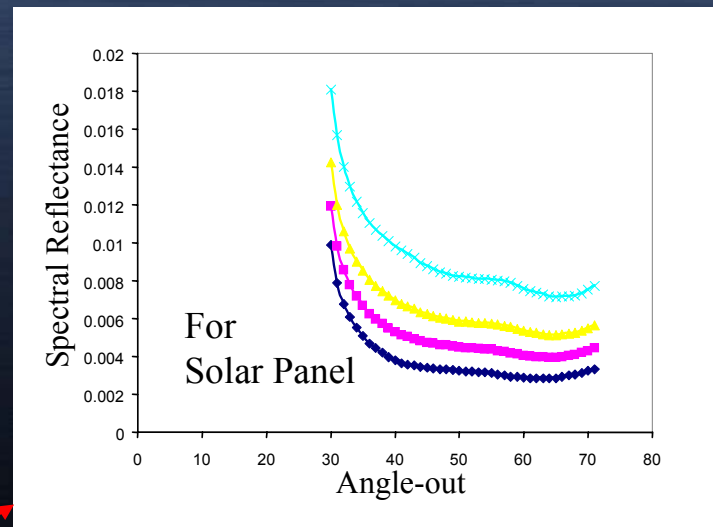
Extract Solar Panel and Body Surface Reflectance from Four-Color Visual Point Source Data

USNO Flagstaff Station

Visual Tracking Data



EO-IR Model

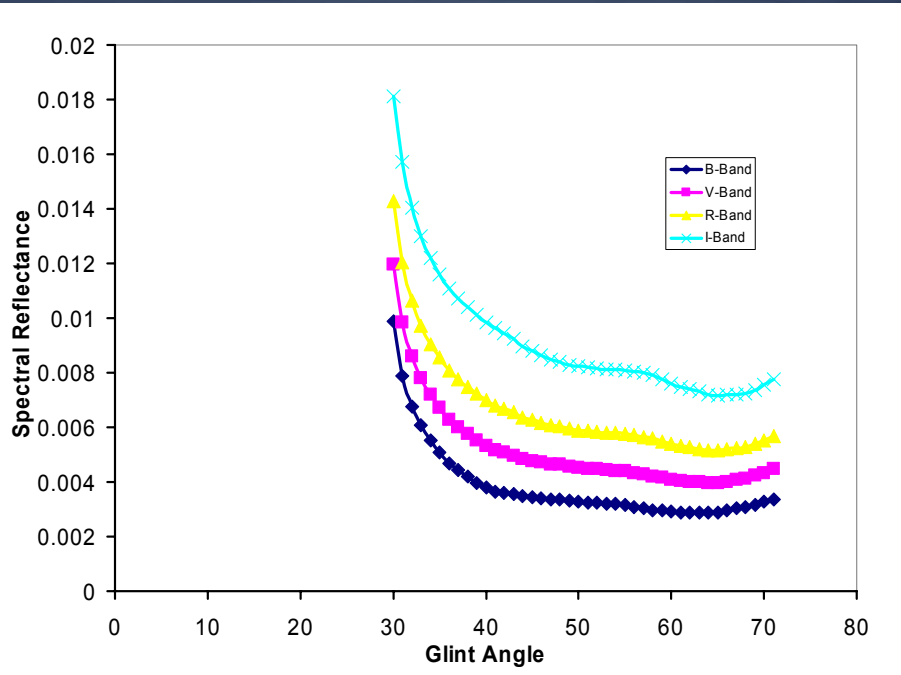




# Biconical Reflectance Function from Processing of Visual Point Source Data

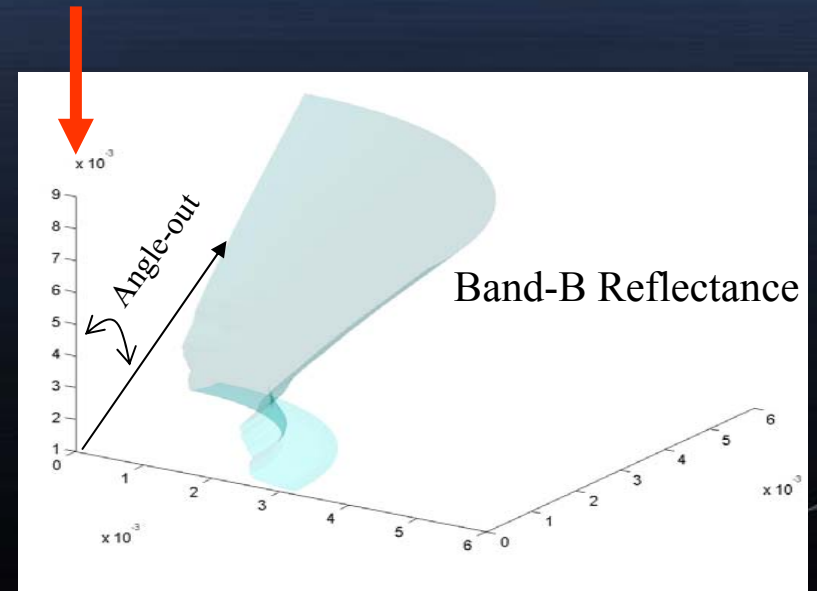


Spectral Reflectance versus  
angle-out for solar panel



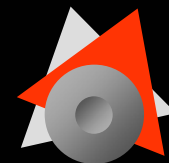
Generate Biconical Reflectance  
Function assuming polar symmetry  
of Spectral Reflectance

Sunlight Incidence Direction





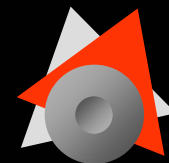
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# Creating Point Source Signature Map



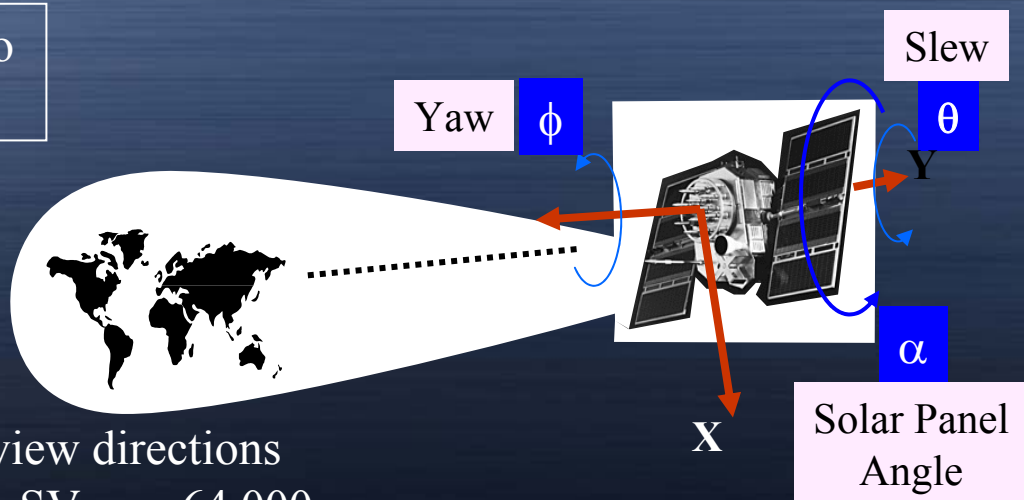
Generalizes the Archived Observation to a Large Number of Viewing Directions

[1] Define View Direction using Euler Angles.

[2] Select a suitable number of discrete view directions that span the  $4\pi$  steradians around the SV, say 64,000  
[Like a notional fly-by sensor]

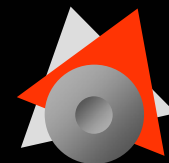
[3] Compute the intensity value at the source [i.e. satellite] using the biconical reflectance for each view direction

[4] Organize the map as an Intensity Look-up Table at the source, as a function of view direction

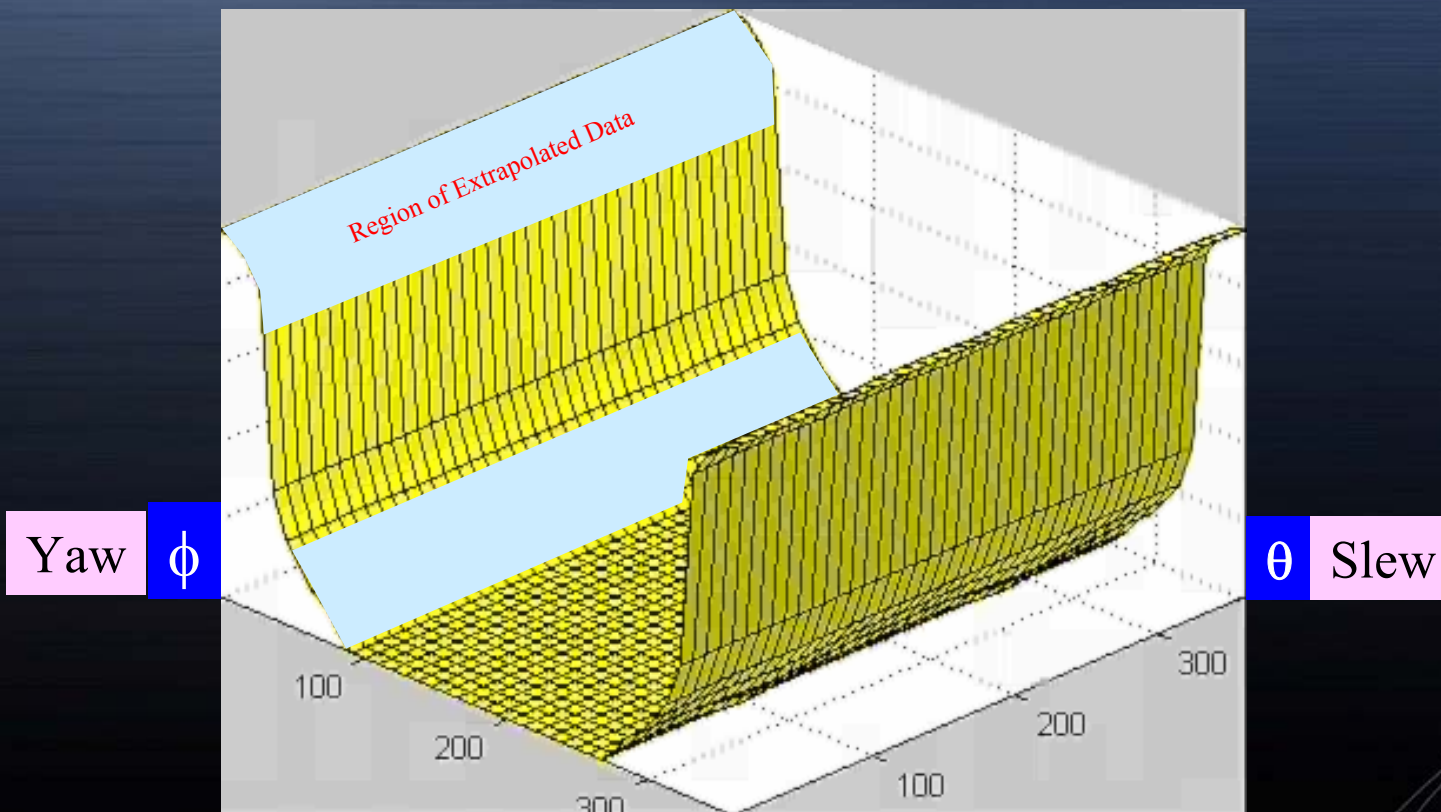




# Example: Point Source Visual Signature Map

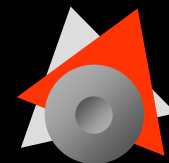


Each Surface is for Constant Solar Panel Angle,  $\alpha$

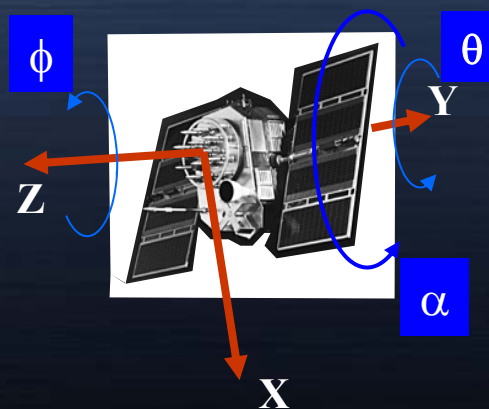
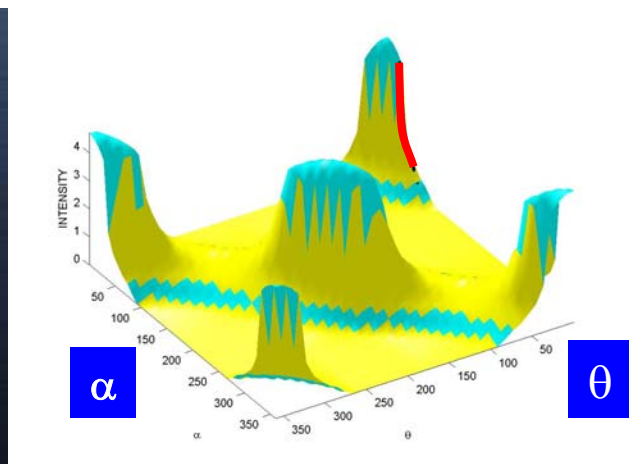




# Plot of Observed Intensity on Signature Map



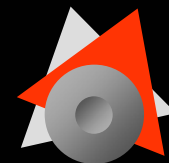
Point Image Map for Band-B Intensity



- The Surface is for a constant  $\phi$
- **Red line is the actual archived data**
- Yellow areas was where biconical reflectance obtained from archived data was used
- Blue area was where it was necessary to extrapolate the reflectance data.



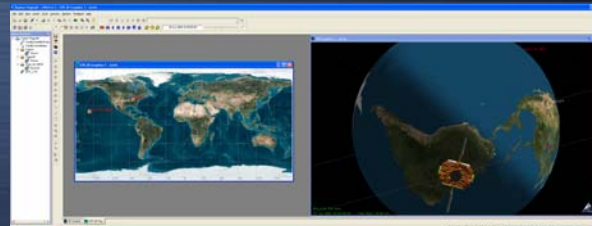
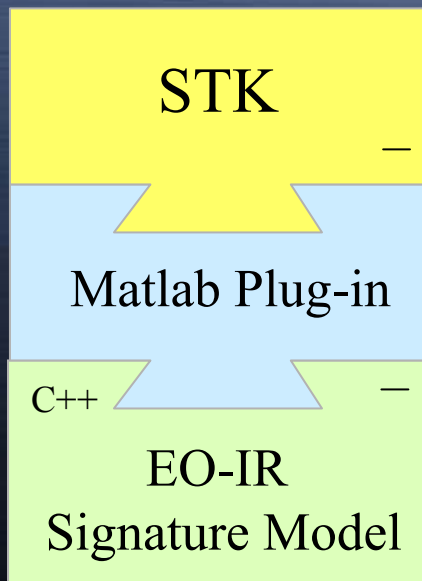
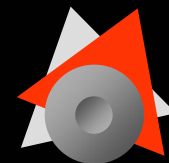
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# Using STK and the EO-IR Signature Model For Planning of Observations



1. Choose an Observation Condition

2. Read in the tracking data

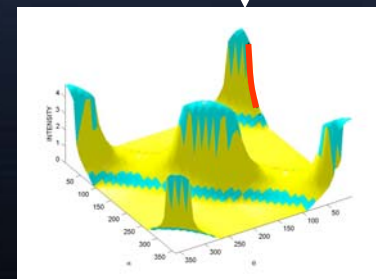
3. Compute Euler Angles

4. Plot Signature Map

5. Scribe Expected Signature on the Map

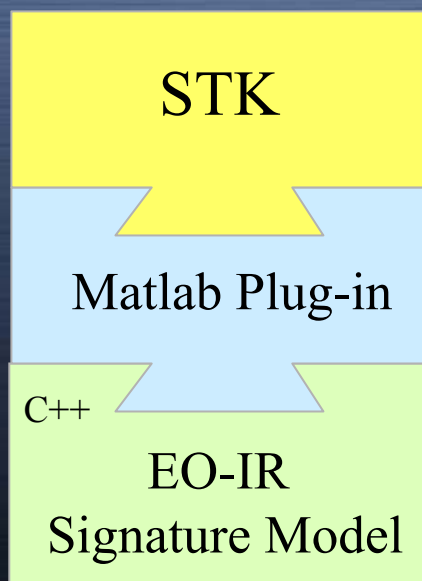
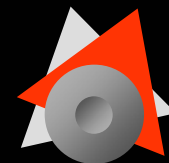
6. Use the Scribe to get a Better Observation

- What is the shape/character of the signature?
- How could we observe a tell-tale signature pattern?
- Can we take observation earlier/later?
- When does the signature change rapidly?
- How would we learn more about the spacecraft?





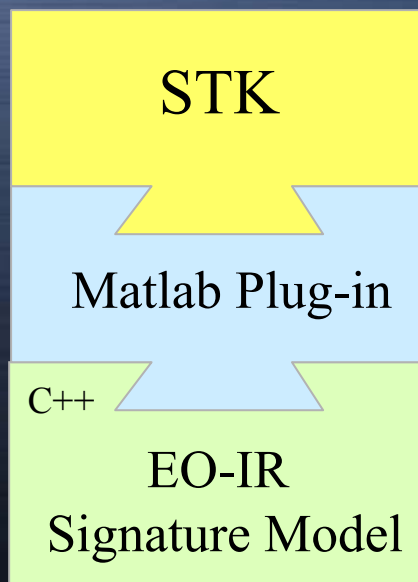
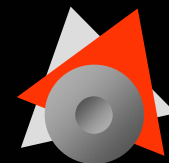
# Using STK and the EO-IR Signature Model For Spacecraft Status Evaluation



1. Choose an Observation Condition
2. Read in the tracking data
3. Compute Euler Angles
4. Compute Surface Temperature/Reflectance
5. Compute/Plot Signature Map
6. Scribe Observed Signature on the Map
7. Compare with Archived Data for Change in Spacecraft Status



# Conclusion



Using STK and the EO-IR Signature Model permits:

1. Improved selection of surveillance observation conditions
2. Monitoring of change in status of spacecraft

Anil Chaudhary [Anil@appliedO.com]

Mark Nosek [Mark.Nosek@wpafb.af.mil]