Lawrence Livermore National Laboratory

Satellite Track Extraction from STARE Images

5/22/13

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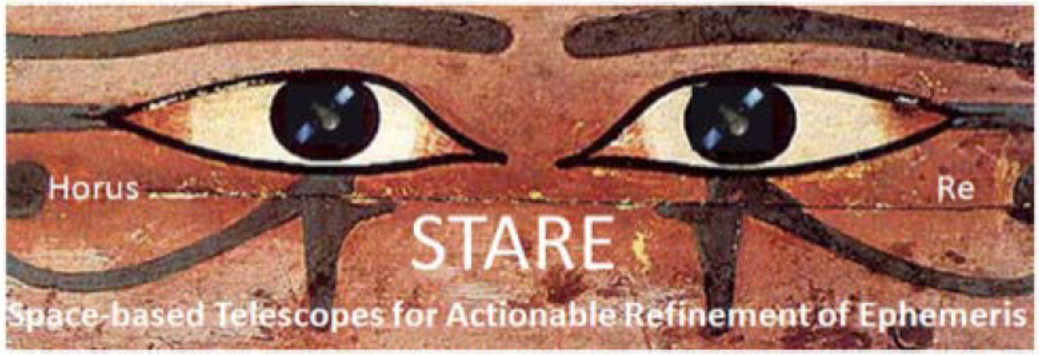
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

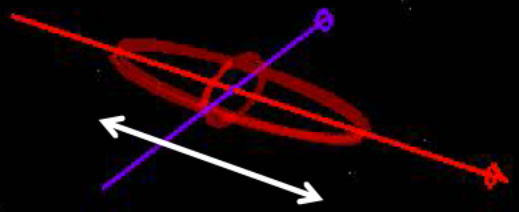
LLNL-PRES-637814

Agenda

- STARE Motivation and Concept
- STARE Track Extraction Algorithm
  - Image Pre-Processing
  - Curved Track Fitting
  - Endpoint Determination
- Conclusion



UNCERTAINTY IN THE ORBIT OF EARTH SATELLITES – WHERE WE ARE NOW



~1000 m

UNCERTAINTY IN THE ORBIT OF EARTH SATELLITES – WHERE WE WOULD LIKE TO BE

Conjunction Threshold Uncertainty and False Alarm Rate

Iridium constellation conjunction rate (Apr-May 2010):

Threshold	Per Month	Per Day	Relative Rate Reduction
10000m	36574	1219	
1000m	354	11.8	99.03%
100m	3	0.1	99.99%

By the time σ < 100m, the false alarm rate has dropped by 99.99%

Enter STARE

Space-based

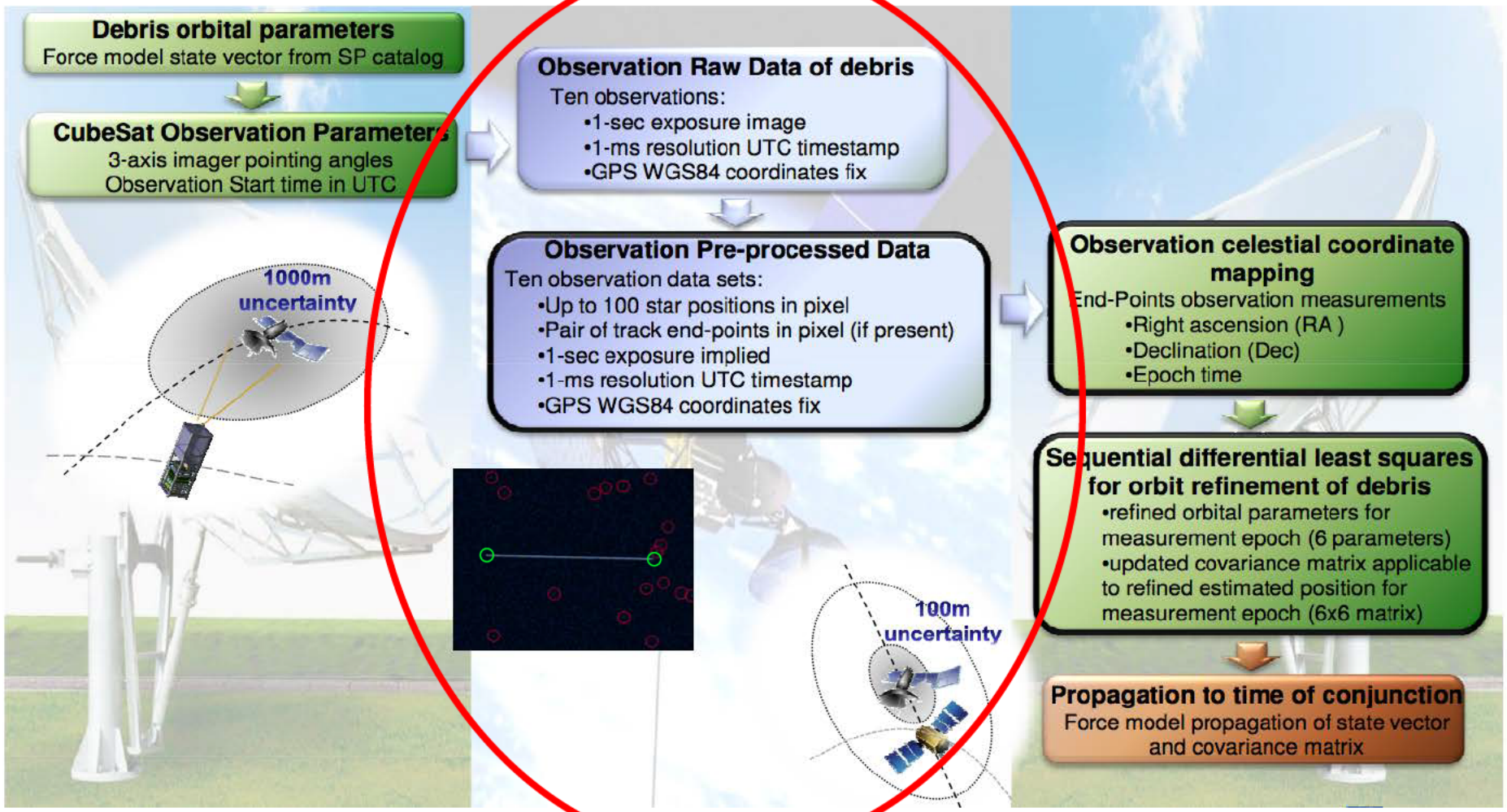
Telescopes for

Actionable

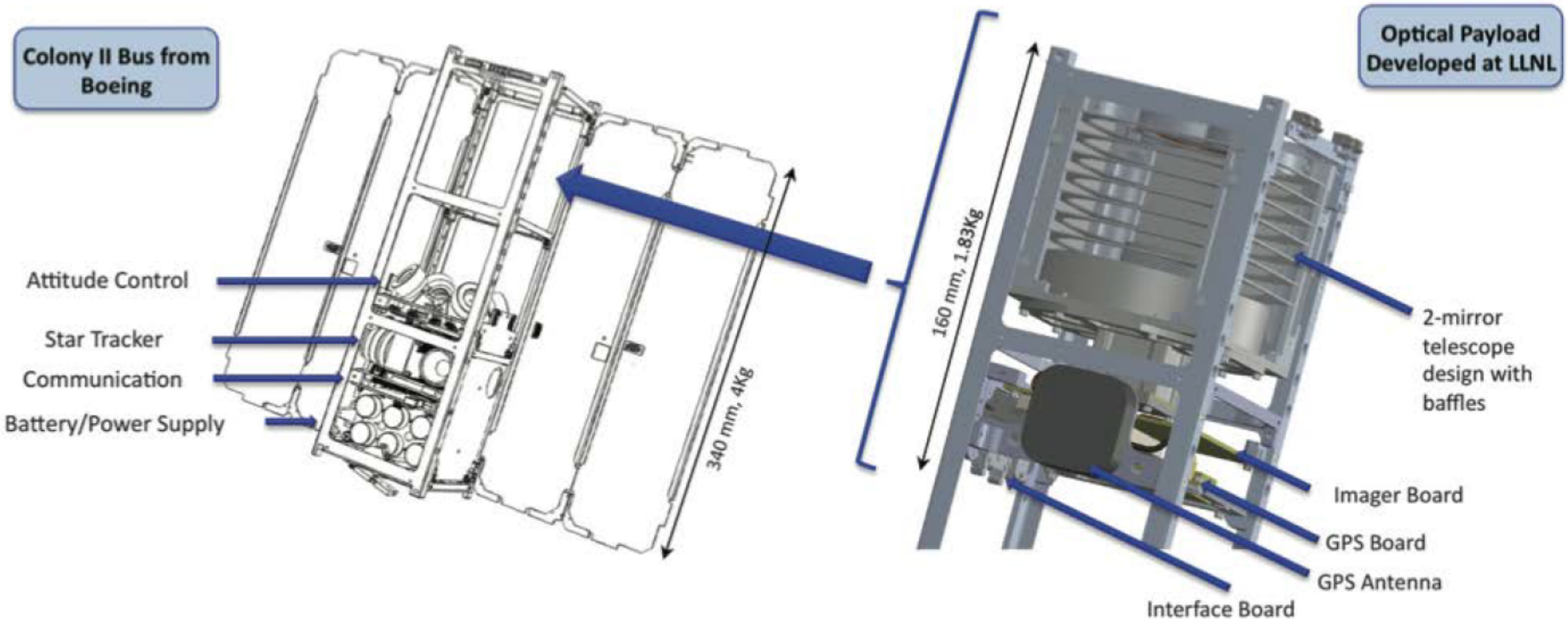
Refinement of

Ephemeris

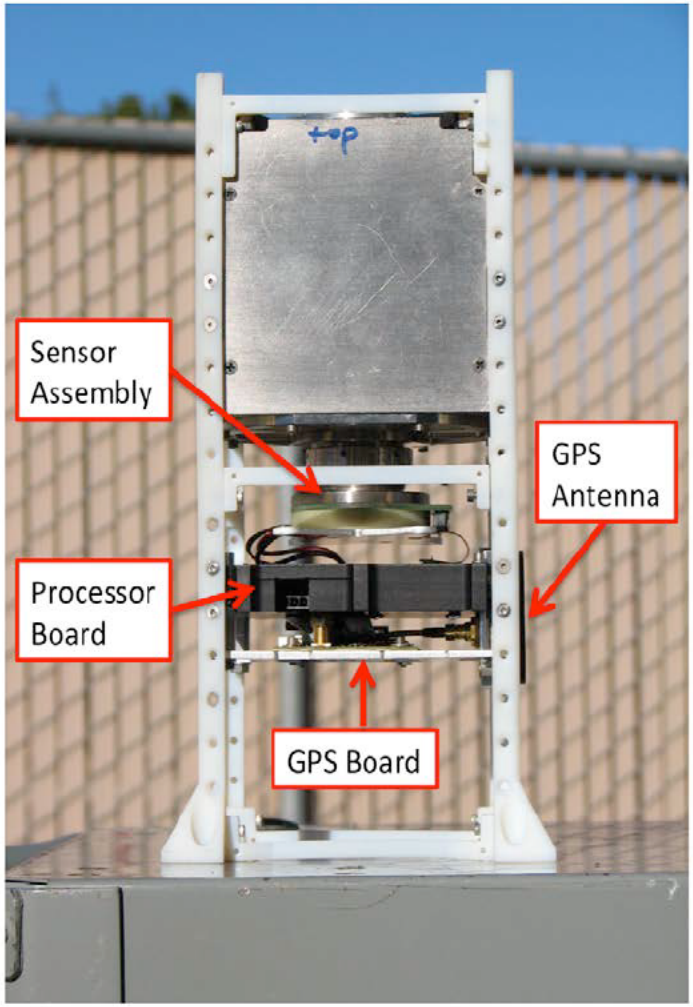
STARE Processing and Data Flow

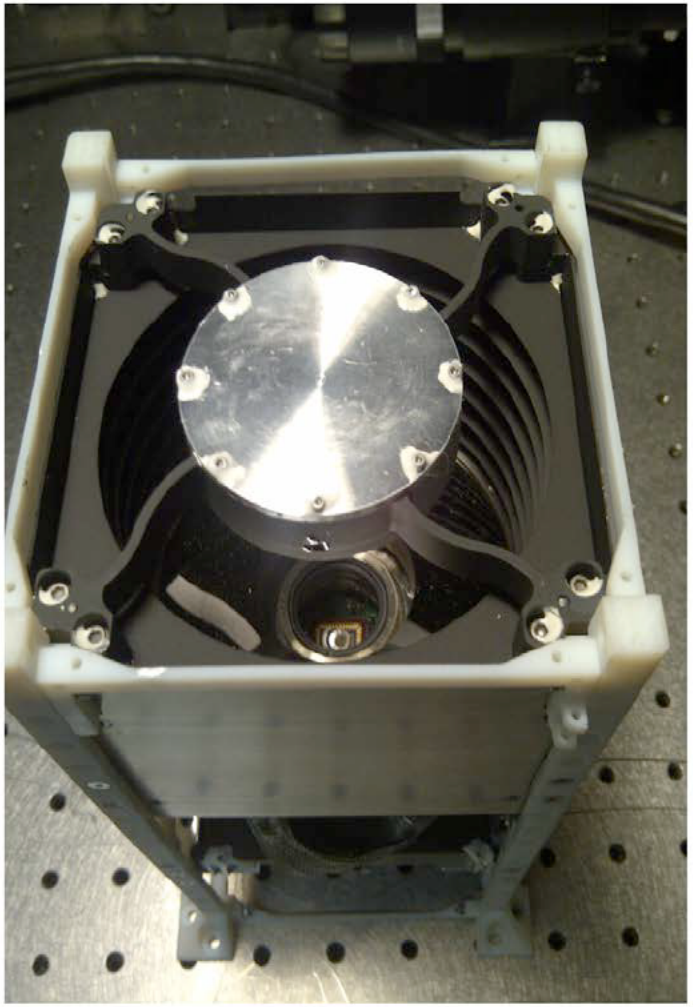


STARE Satellite - Concept

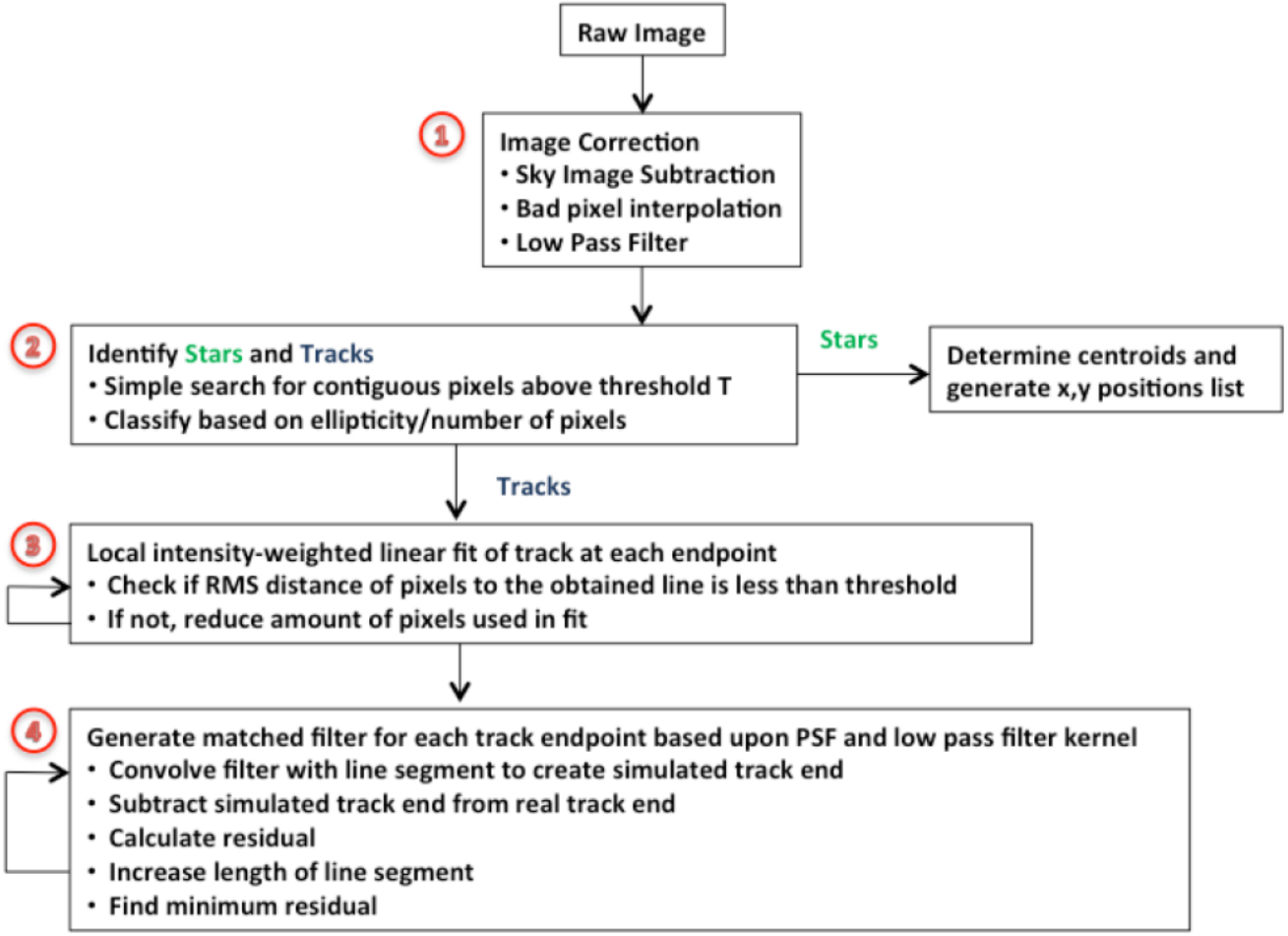


STARE Payload - Pictures



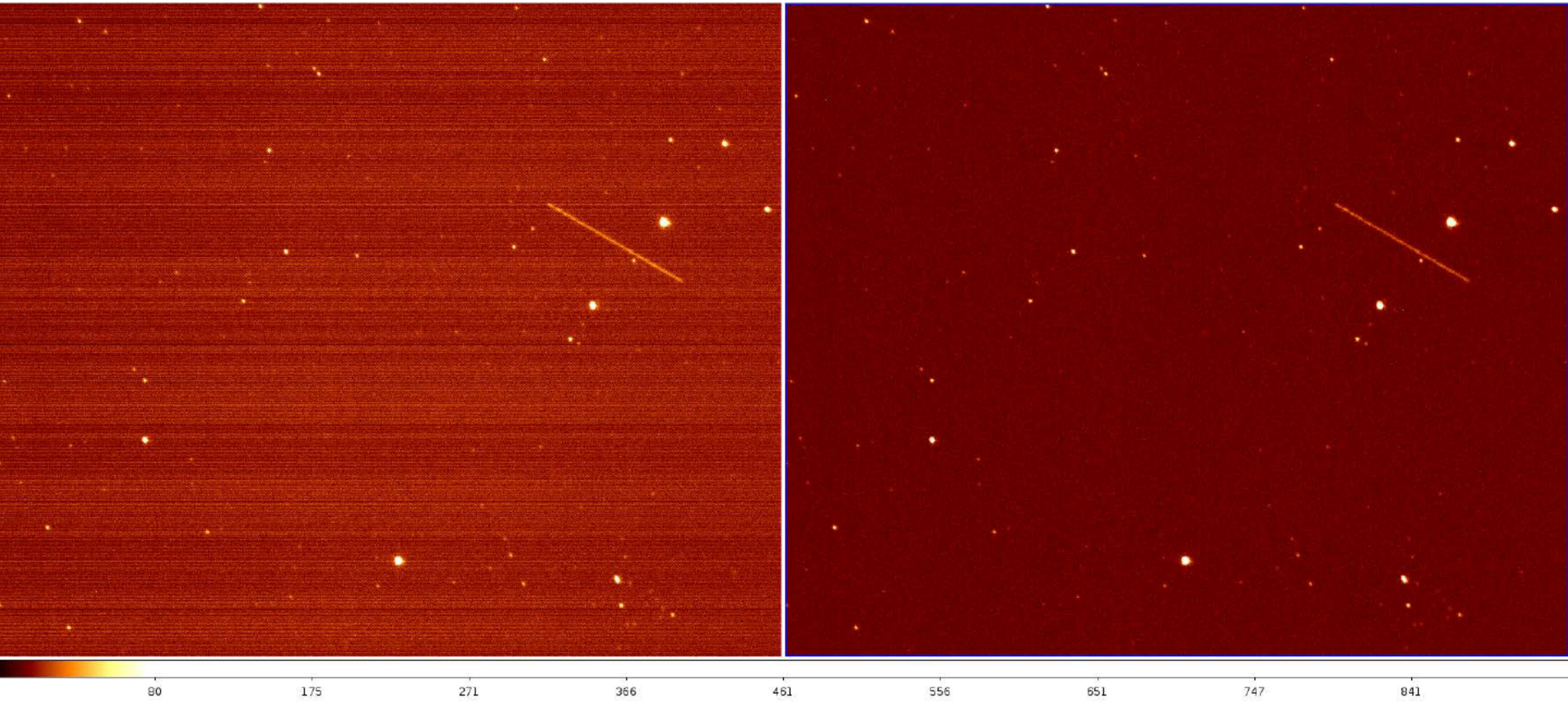


Optical Payload: On-Board Image Processing

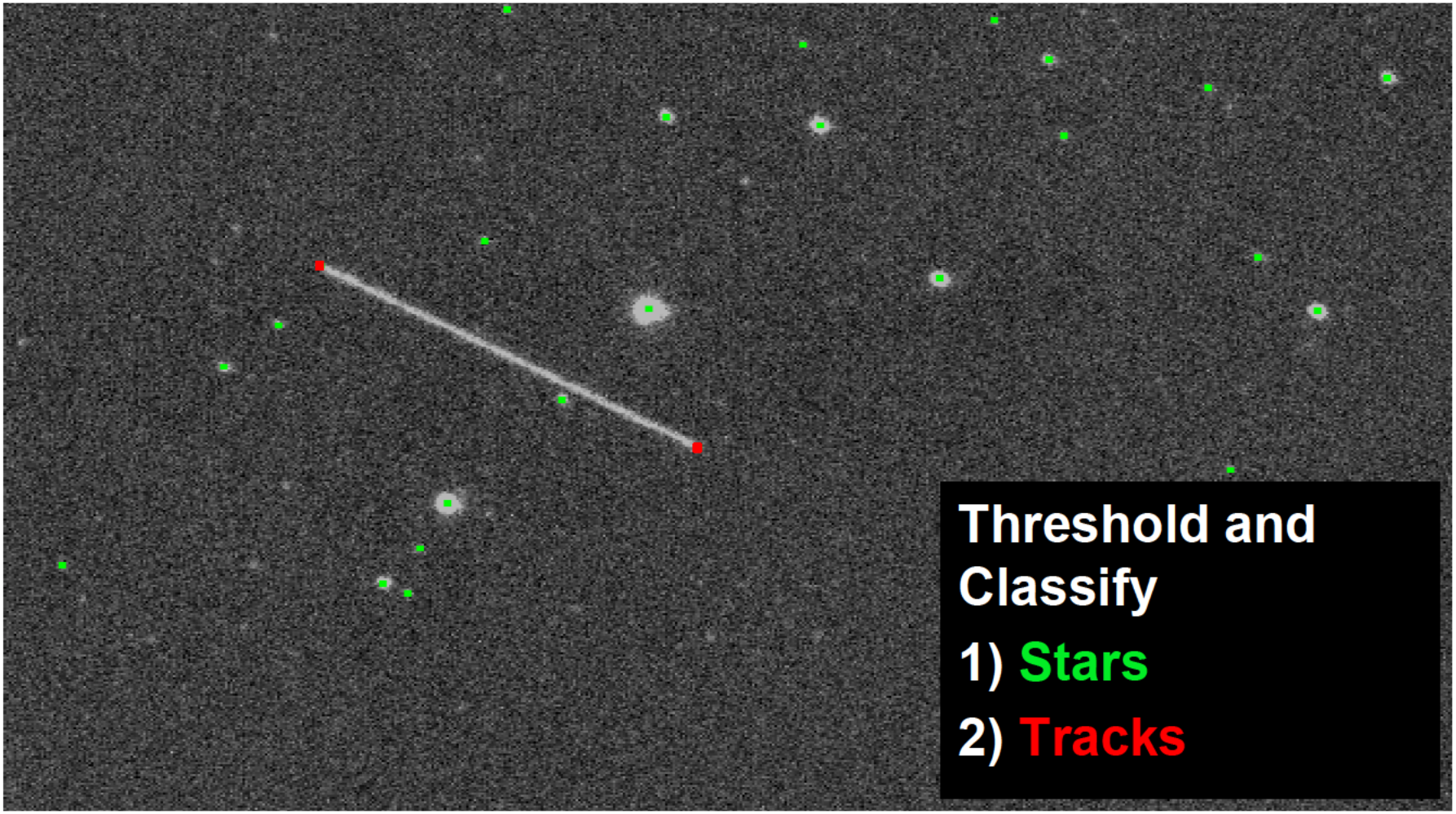


1 Image Correction

Before **After**

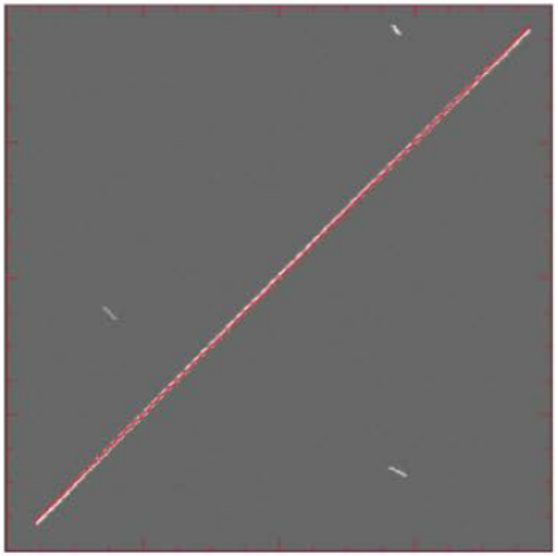


2 Star and Track Detection

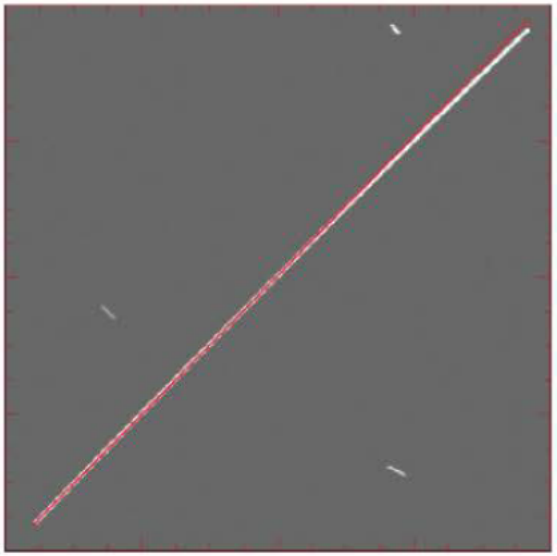


3 Track Fitting

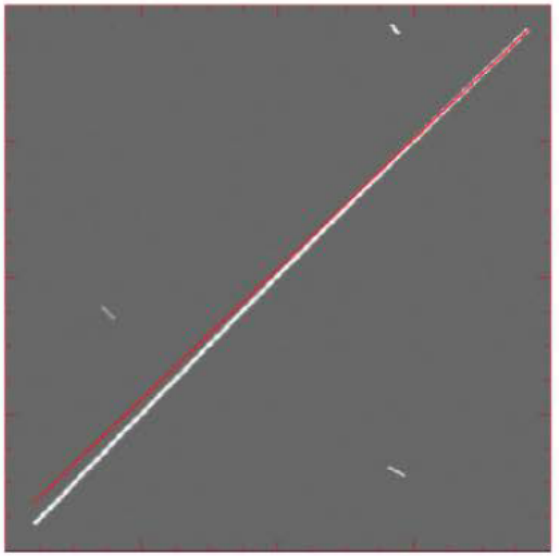
Local Iterative Fitting at each end allows for curvature in track…



Global Fit

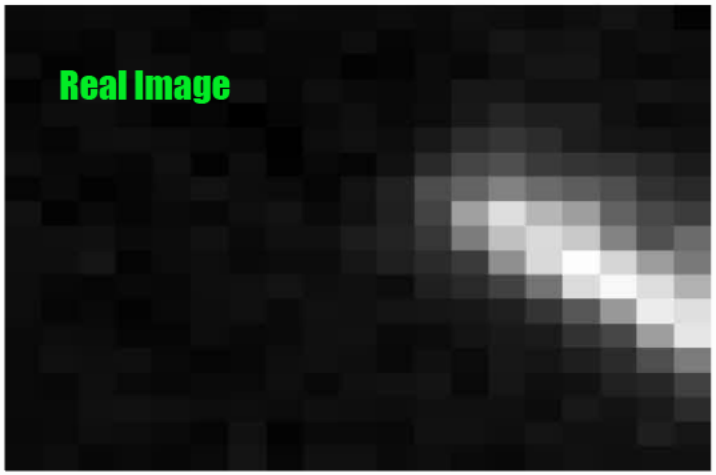


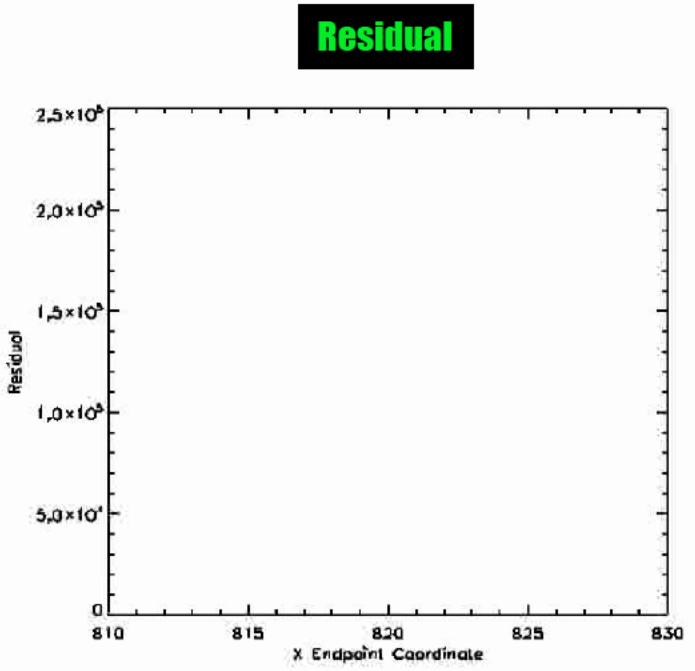
Left Endpoint Fit



Right Endpoint Fit

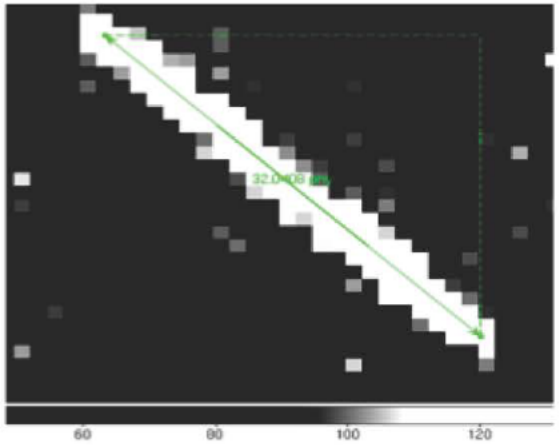
4 Endpoint Determination

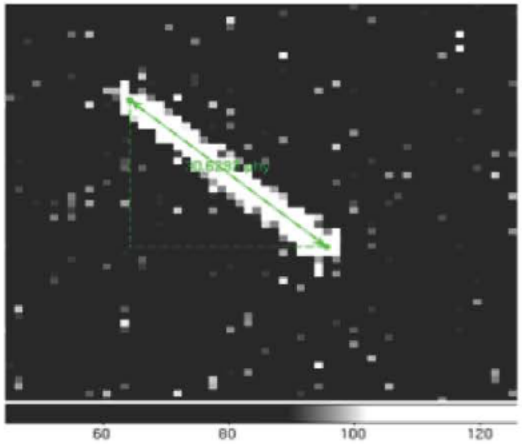


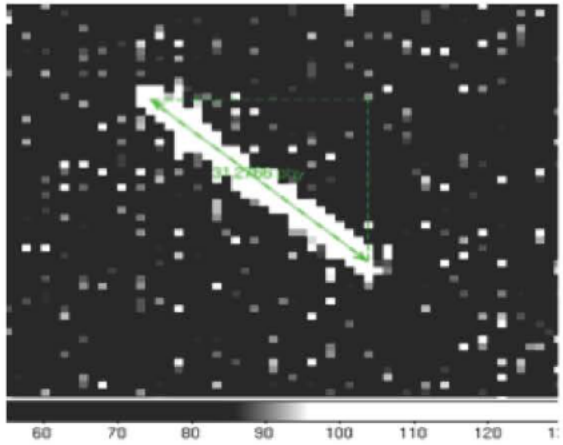


Algorithm Test Results

Test Results on real images show very good performance

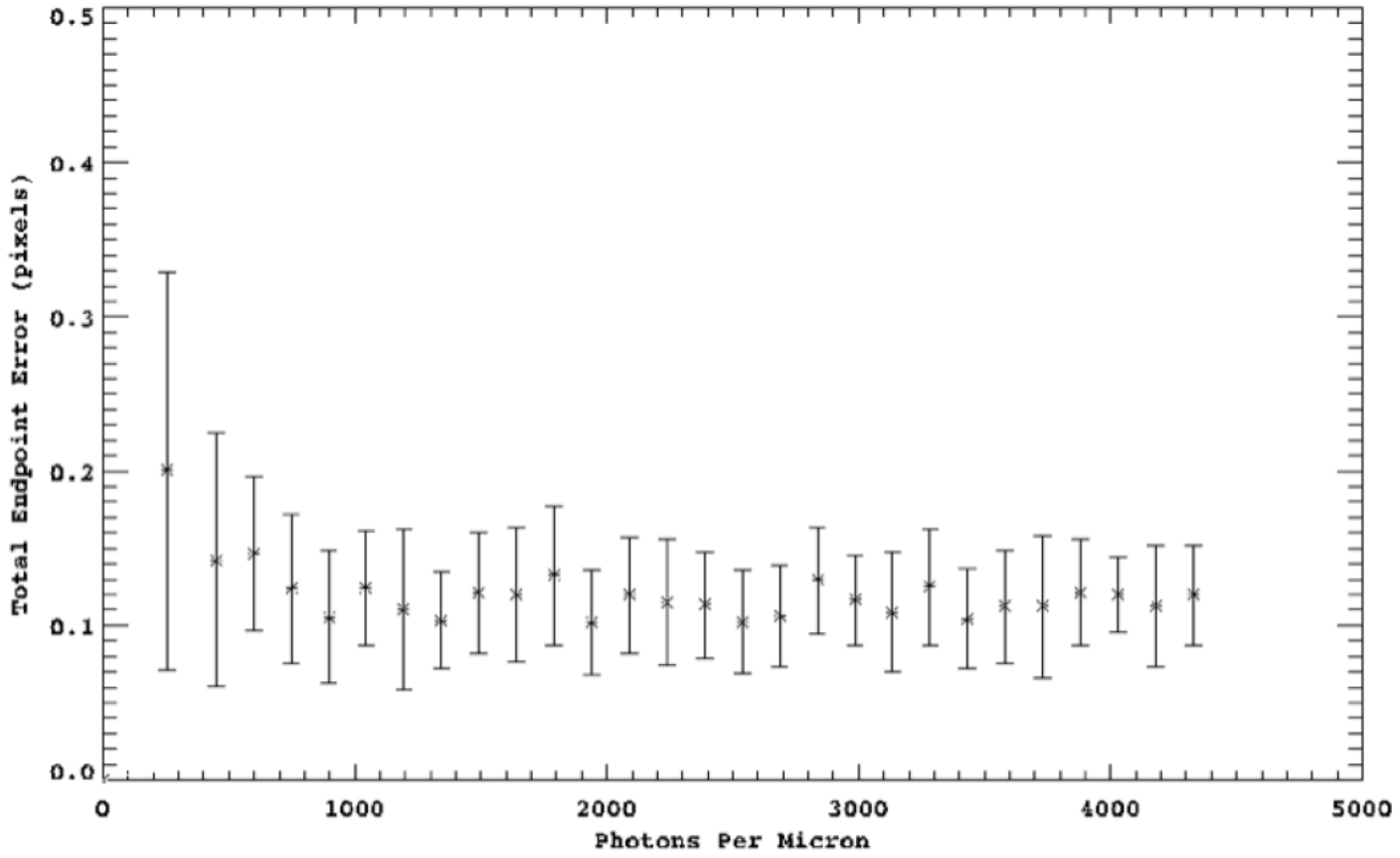






Algorithm Test Results

400 simulated images



Conclusions

- STARE mission will refine orbits of space debris and satellites down to 100 meter accuracy
  - About 0.8-1.0 pixel accuracy needed
- Endpoint detection algorithm allows for 0.1 pixel accuracy

Image Processing: Endpoint Determination

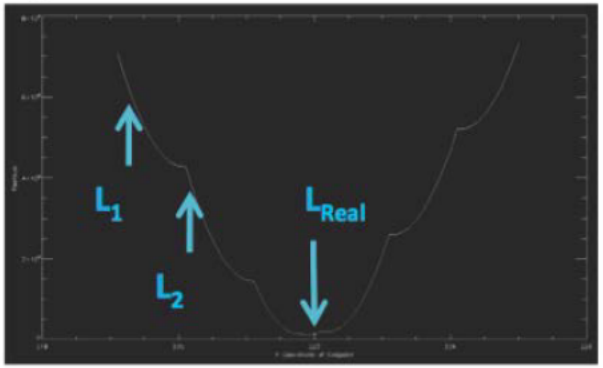
Fit endpoints with track segment convolved with PSF

1) Start with real track

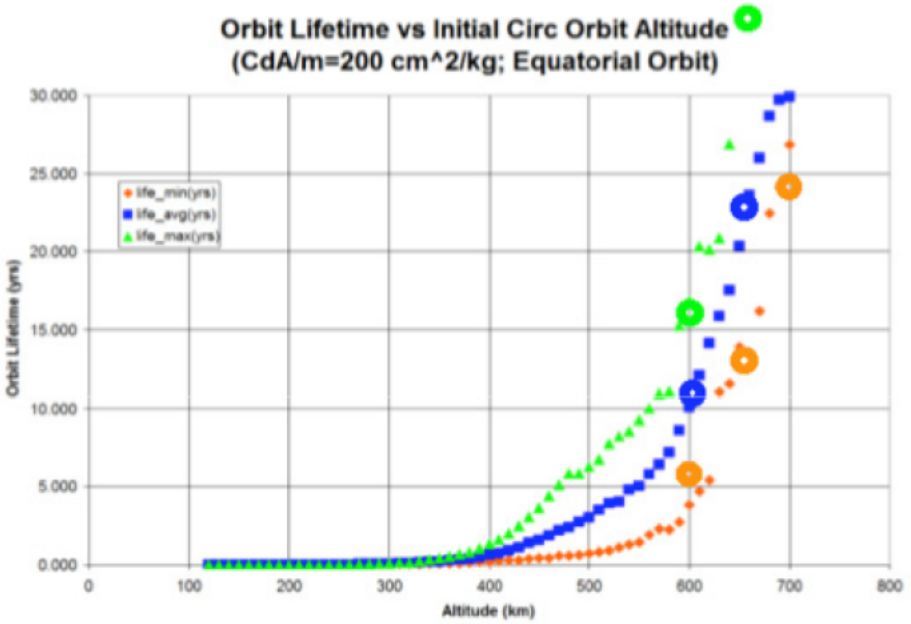
2) Generate track of length L_1

3) Increase length to L_2

4) Find minimum in residual



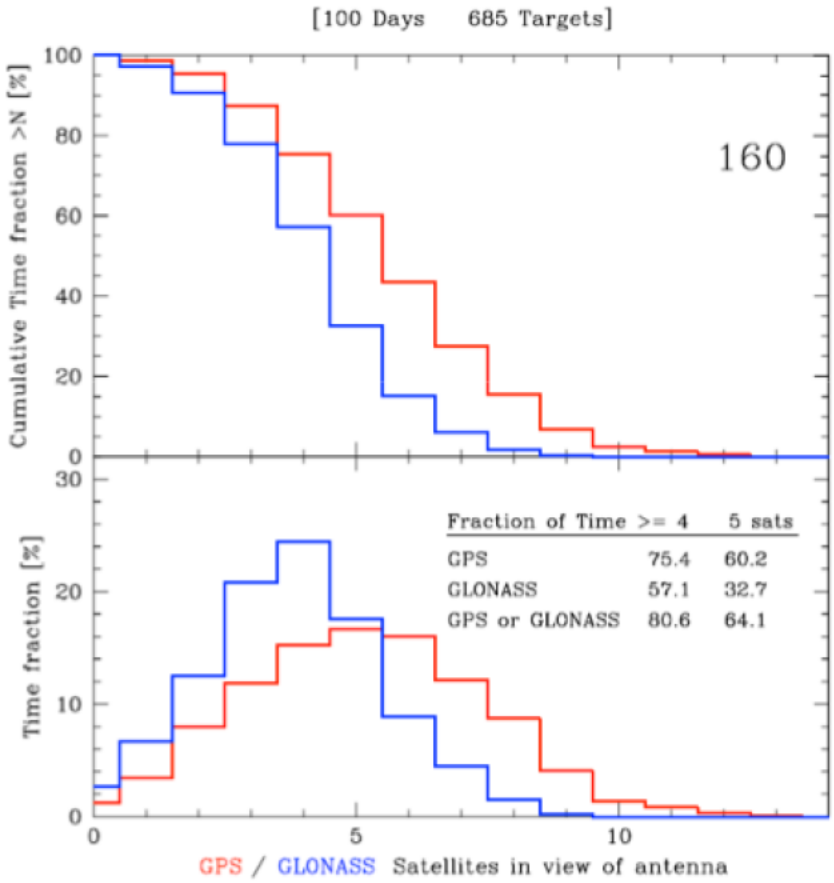
Additional Slides



Taken from "Space Systems – determining orbit lifetime", 2007, ISO International Standard working document, ref ISO/WD/27852, and LLNL computation (Wim D.)

Surface Area [m2]	Average [years]	Minimum [years]	Maximum [years]
0.03 (3U only)	57.0	31.1	>100
0.05	38.8	19.7	55.8
0.10	20.0	10.4	32.2
0.14 (Baseline eff)	14.6	7.5	23.3
0.15	13.6	7.0	22.0
0.21 (Baseline max)	9.9	5.0	16.0

Additional Slides



- 700km polar orbit
- Representative observation schedule for 100 days
- Side antenna with expected effective angle in space of < 172degrees