TOP Alignment

Current Status of TOP Alignment

Parabolic Trough Workshop 2007
Denver, Colorado
March 8-9, 2007

Tim Moss, Rich Diver

TOP Alignment

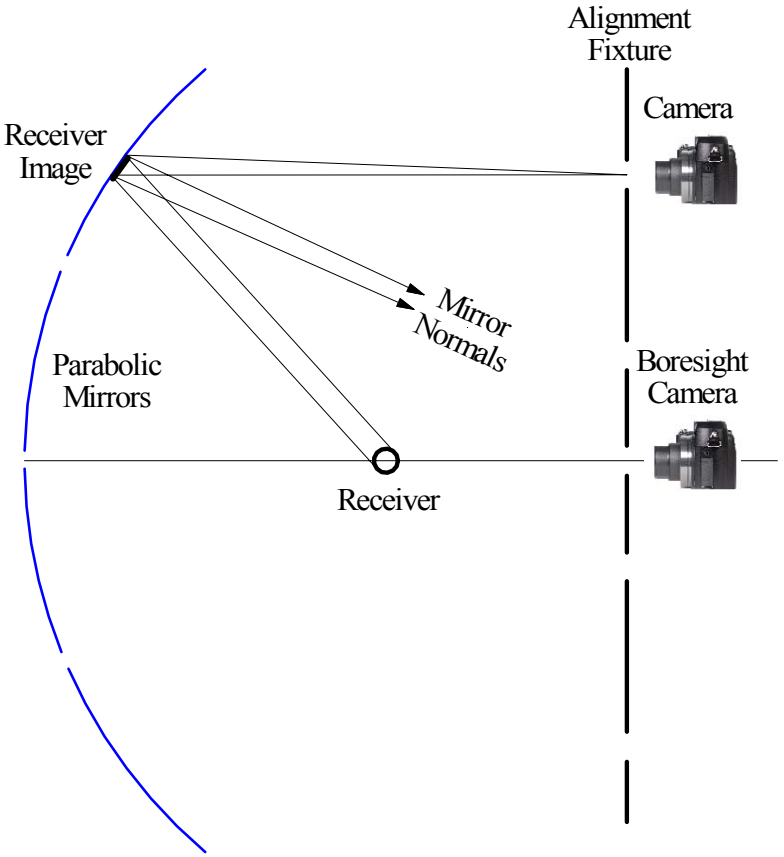
Mirror Alignment – The Ideal Solution*

- **Simple to setup and implement**
- **Minimum of sophisticated hardware**
- **Not require HCE removal**
- **Not require sun or other restrictive weather conditions**
- **Not require line-of-sight to distant observer or light source**
- **Permit accessibility to mirrors for adjustments**

*Richard B. Diver, 1995, "Mirror Alignment and Focus of Point-Focus Solar Concentrators," Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference, Maui, HI.

TOP Alignment

Theoretical Overlay Photographic (TOP) Alignment Approach



Alignment fixture - pole with accurately established camera offsets

Fixture position established by "boresight" centering of receiver on center mirrors

Can be used in between rows of a trough plant

TOP Alignment

TOP Alignment of LS-2 at NSTTF

- **TOP alignment proven**
  - **Tested on LS-2 module at Sandia**
  - **Verified using Distant Observer Technique**
- **Error analysis indicates better than 1 mrad accuracy feasible**
  - **Mirror slope error ~ 2 mrad**

Current Status of TOP Alignment

TOP Alignment trailer at Saguaro Solar Plant (APS) twice

- First trip was general equipment shakedown
  - redesign of fixture
  - Higher resolution cameras
- Second trip was shakedown of software
  - Fixture worked well
  - More work needed on software

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Fixture moves up or down 9 inches using remote control

Fixture can rotate 360º

5 digital video cameras (2 megapixels each) for acquiring images

2 ultrasonic meters
- horizontal distance between fixture and trough
- vertical distance between fixture and trailer bed

Controllers, DAQ, and camera hubs inside weather tight electrical cabinet mounted on fixture

Two 12 V marine batteries supply all power needs

Toolbox for equipment storage

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TOP Alignment fixture has three different positions

Image taking position

Takes less than 1 hour to change from image taking position to travel position

Travel position

lie-down for going underneath crossovers (~ 20 s to change)

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Procedure for Acquiring Images

1: Stop with cameras centered on trough module

2: Align fixture using center camera and boresight gauge

3: Level camera fixture – self leveling program

4: Acquire and store images from all cameras

5: Store data from the two ultrasonic meters

6: Drive to next module

TOP Alignment

Goal was to complete this in less than 60 s/module

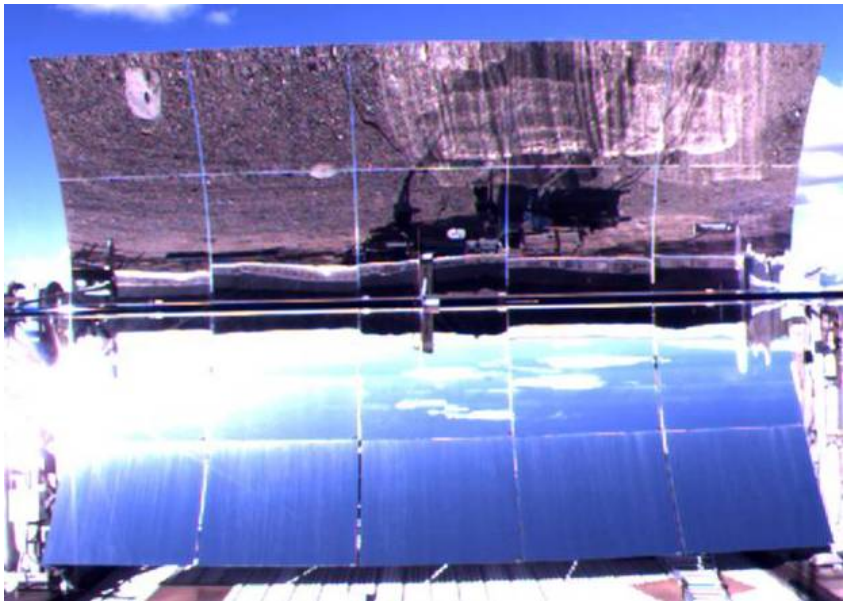
For a SEGS plant → about 4 weeks (40 hours/week)

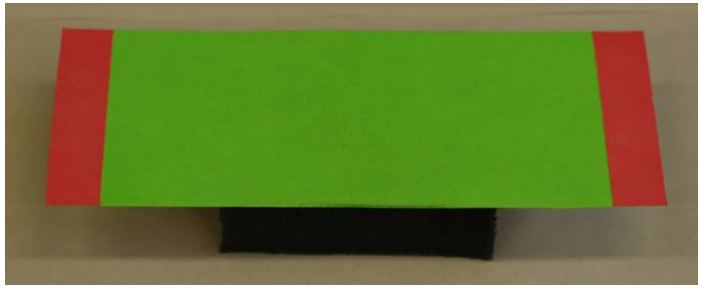
Second trip to Saguaro averaged 70 s/module

Half of this time was to boresight the fixture to the module

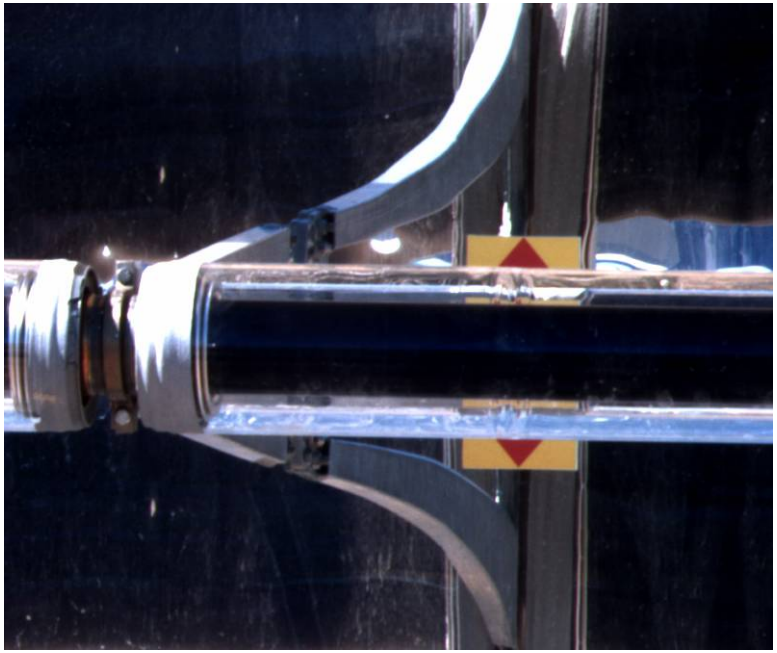
TOP Alignment

First boresight gauge – 6 mm lens





Second boresight gauge – 75 mm lens



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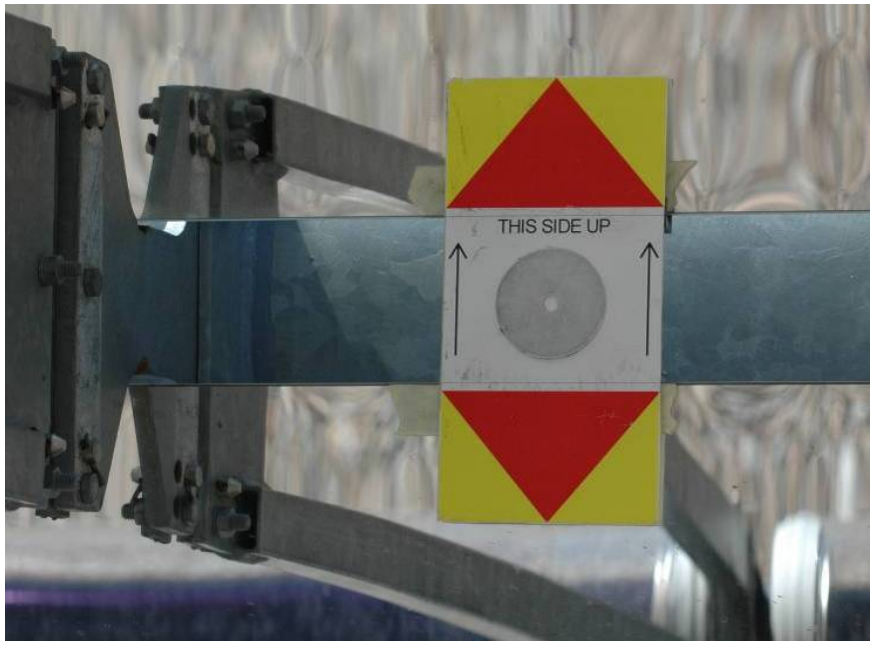
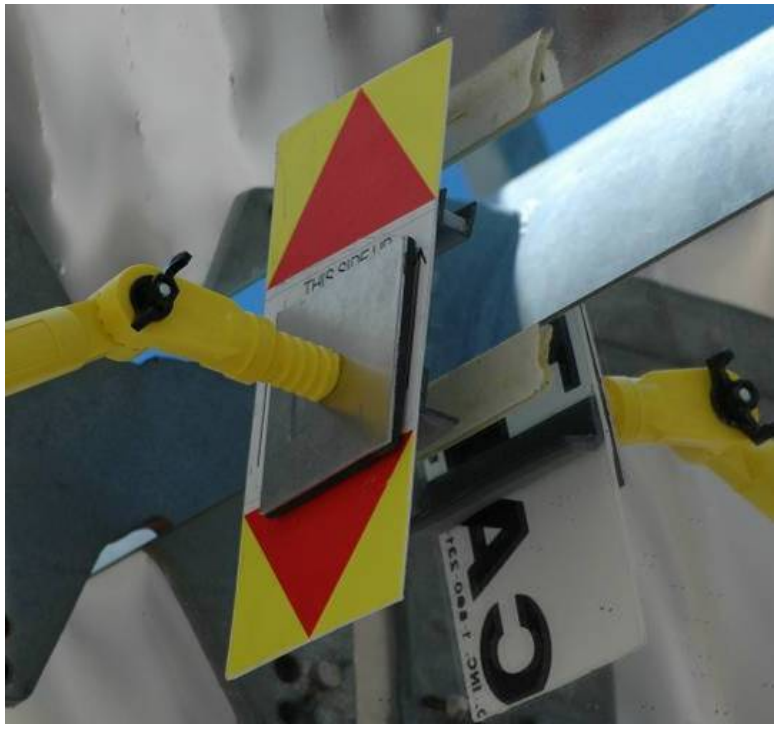
Boresight Gauge Installation

One person installs one boresight gauge per module in a row
Another person follows trailer removing boresight gauges
Both ride back with fixture to beginning of next row





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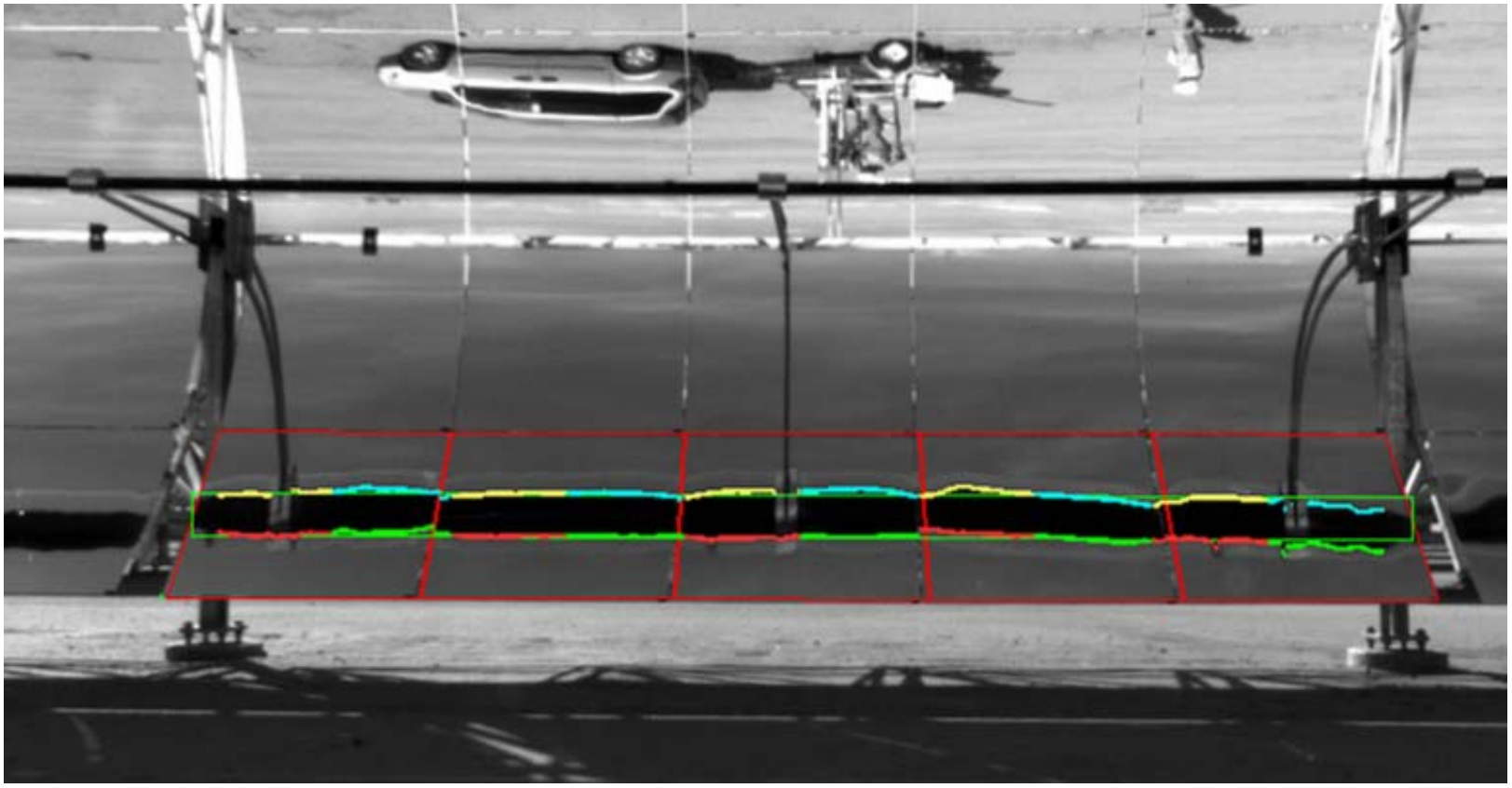
Current status of Software development

- Software written in LabVIEW and Vision
- Software for acquiring data almost complete
- Software for analyzing images 70ish% complete
  - image analysis hampered by wide variety of image exposure levels
  - Overlays are semi-automatic – operator determines mirror edges
- Database management still being developed

TOP Alignment

Computer Overlays on Image of Bottom Row APS Trough Module



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End Result of TOP Alignment will be Worksheet for Crew to Align Mirrors

TROUGH ALIGNMENT SCA: 6D3N

Instructions: East Facing View

	11N		12N		13N		14N		15N	
Row 1										
Row 2										
Row 3										
Row 4										

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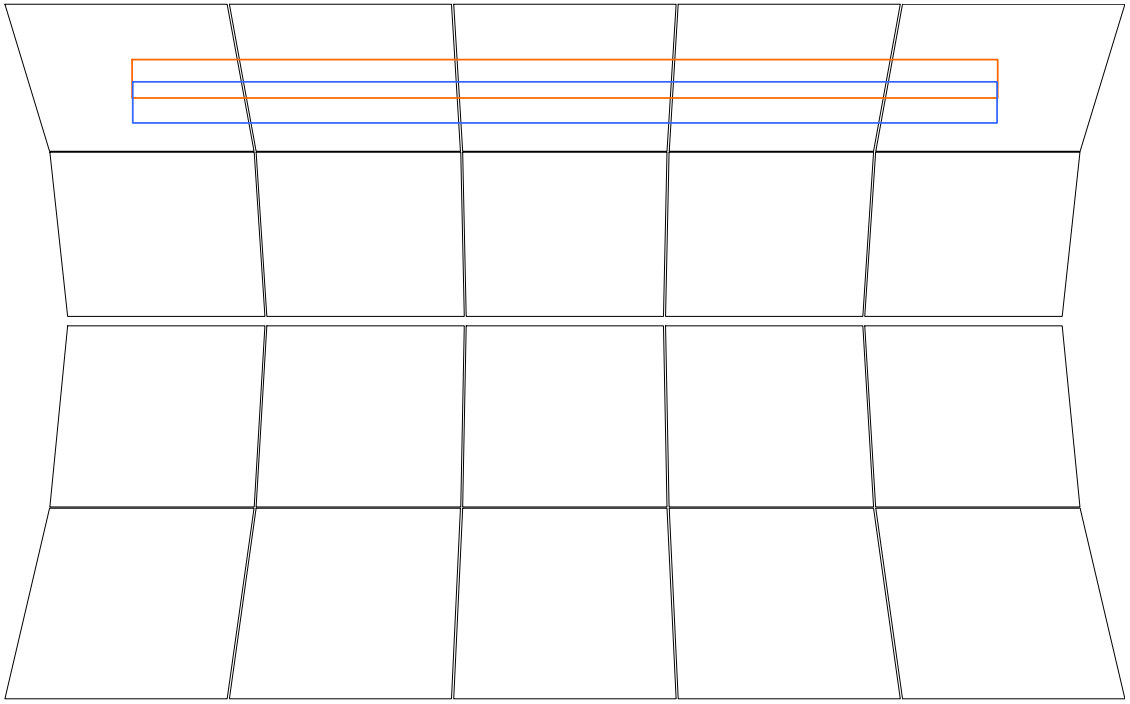
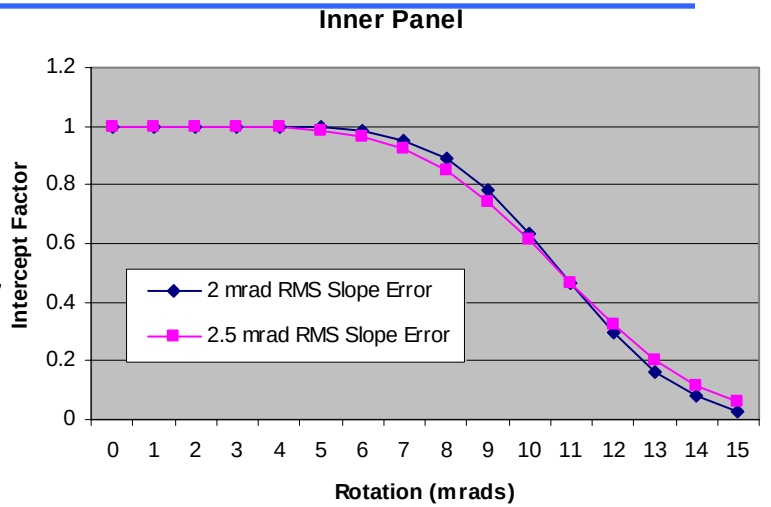
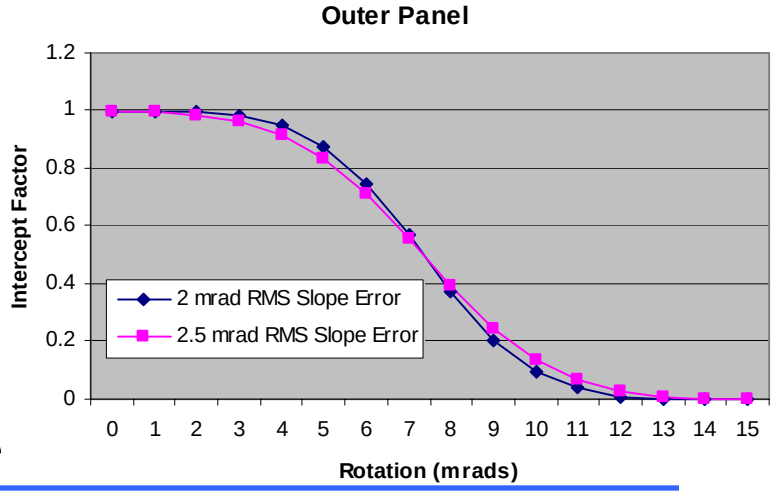
Example of 10 mrad misalignment of row 1

orange box - ideal location

blue box - image of receiver







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Near Future Plans

A third trip needed to a Solar Plant (maybe a fourth too)

- **More software shakedown**
- **Align mirrors for one SCA**
- **Verify alignment and performance improvement**
  - **Using TOP Alignment**
  - **Using temperature data**

TOP Alignment

Ultimate Plans

Commercial operation where:

- **Only one person needed to acquire data (driver)**
- **Images acquired without stopping**
- **Boresight gauges not needed**
- **Worksheets generated overnight for next days crew shift**