Maunakea Operations and Engineering Workshop

Critical Failures and Lessons Learned

12/8/2016

Rich Matsuda, WMKO Chief of Operations

What is a Critical Failure?

Different for every observatory, but includes these two main aspects:

- Serious injury or loss of life.
- Damage or destruction of equipment which creates extended negative impact on observing, or project, or mission.

Impacts of Critical Equipment Failures

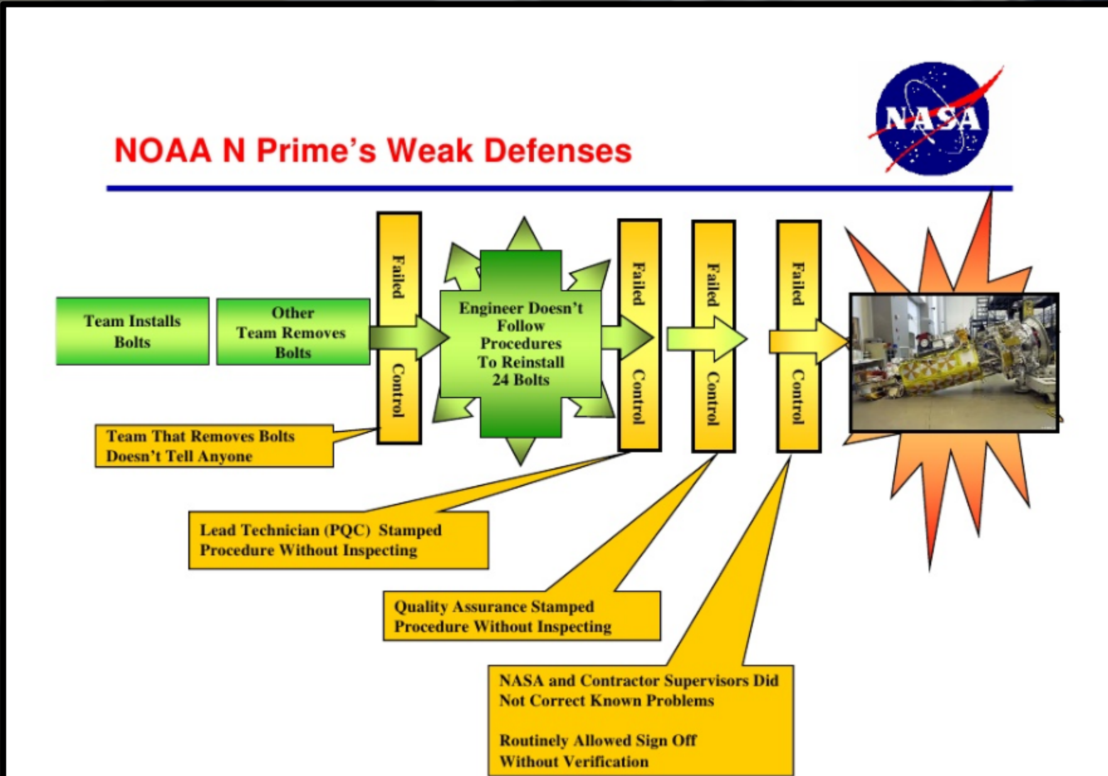
- Worker lost time
- Liability
- Opportunity costs:
  - lost science knowledge
  - lost productivity
- Project schedule delays
- Repair/recovery cost
- Loss of one-of-a kind hardware, not easily replaced
- Loss of confidence – board, science community, staff

Contributors to Critical Technical Failures

You cannot stop at the proximate (immediate) cause. You need to keep asking “WHY?” until you reach the root cause. Could it be:

- Organization’s Culture?
- Management?
- Work Processes and Procedures?
- Training?
- Safety Practices?
- Integration and Commissioning Approach?
- Design and Verification?

Case Study: NOAA N-Prime Accident Root Cause



Slide credit: NASA Office of Safety and Mission Assurance, "Learning from NASA Mishaps: What Separates Success From Failure?" Feb. 2007 (http://www.slideshare.net/NASAPMC/chandler-faith)

Root Cause: Lack of Procedural Discipline

Lessons Learned in General

- Design errors are the root cause of many failures, but process and work climate issues are major contributors.
- Mishaps provide valuable case studies for identifying systemic weaknesses.
- Important to investigate not only proximate causes, but root causes.
- Transparency important to get to root causes.
- Investigations only truly useful if they leads to real improvements (however, difficult to do with limited resources!)
- MKO's share much in common in terms of technology, work practices and organizational culture – useful for us to share lessons learned so we can learn from each other's mishaps.

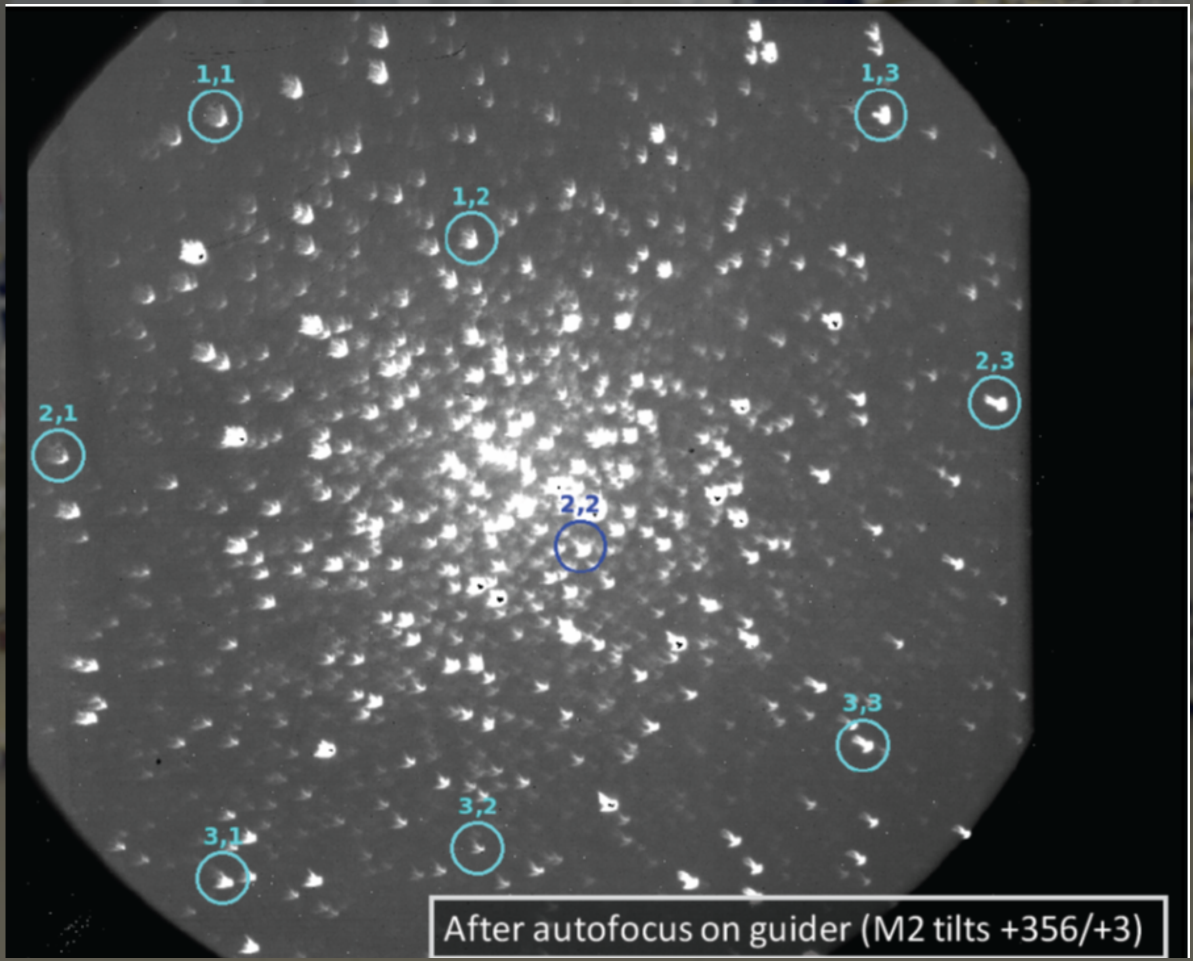
Agenda

Time	Topic	Speaker
10:50	Session Intro and MOSFIRE incident	Rich Matsuda, WMKO
11:05	Lesson learned form NSFCam explosion	Mike Connelley, IRTF
11:15	Gemini North Shutter System improvements	Marcel Tognetti, Gemini
11:25	Megacam L Coating Failure and Removal	Tom Benedict, CFHT
11:35	Performance and reliability modifications for Megacam filter juke box	Greg Green, CFHT
11:45	Subaru Hatch failure	Hirofumi Okita, Subaru
11:55	Pau	

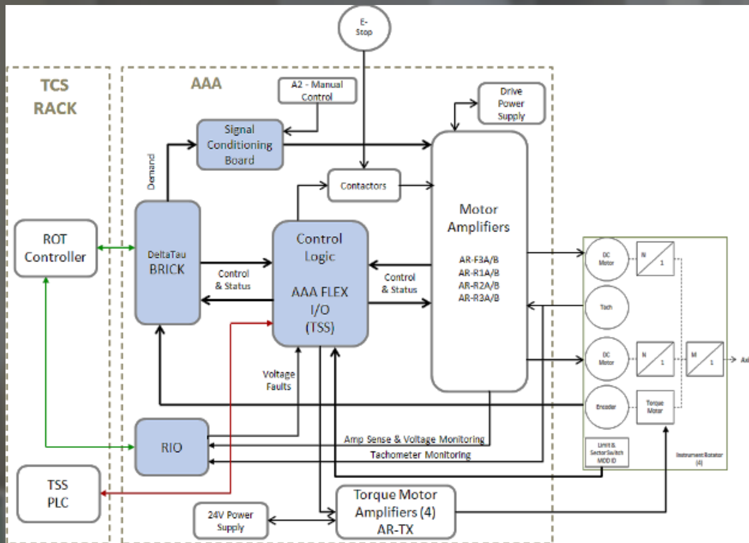
MOSFIRE Incident

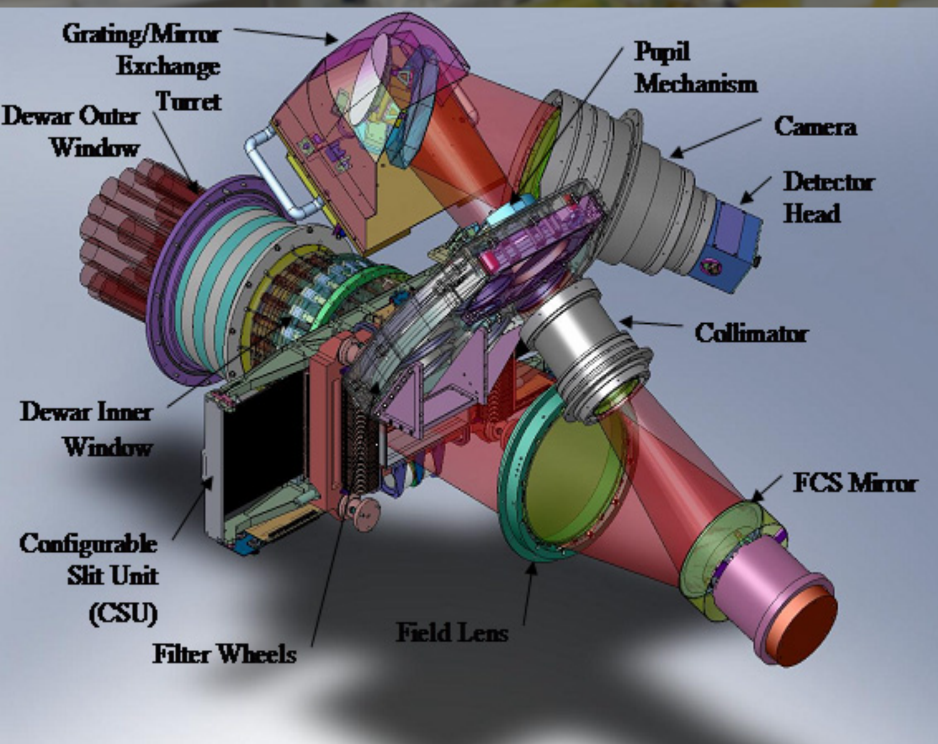
- Telescope Control System Upgrade in the process of commissioning.
- Engineering night test indicated poor rotator tracking performance.
- On September 13, 2016, daytime testing of rotator was performed to understand and improve tracking performance.
- Engineer conducted test remotely from Waimea including modification of rotator servo gains and other parameters.
- Rotator mechanism went into oscillation and shook the instrument for ~2 minutes before it was noticed and test was stopped.
- Subsequent tests of MOSFIRE showed image quality – unusable for science.
  - Poor image quality
  - Image displaced
  - Spectral lines broadened
  - Autocollimating scope looking in from front window indicates a tilted lens element

Image Degradation



Rotator System





MOSFIRE:

- NIR Multi-object spectrograph
- Keck 1 Cassegrain
- Designed/built by UCLA, CIT, UCSC
- PI's Ian McLean, Chuck Steidel
- 6.1' x 6.1' FOV
- Teledyne H2RG 2k x 2k detector at 77K w/ SIDECAR ASIC
- Cryogenic Slitmask up to 46 slits
- Imaging mode
- .97 to 2.41 um, Y,J,H,K bands
- R~= 3,000
- First light Feb 2012

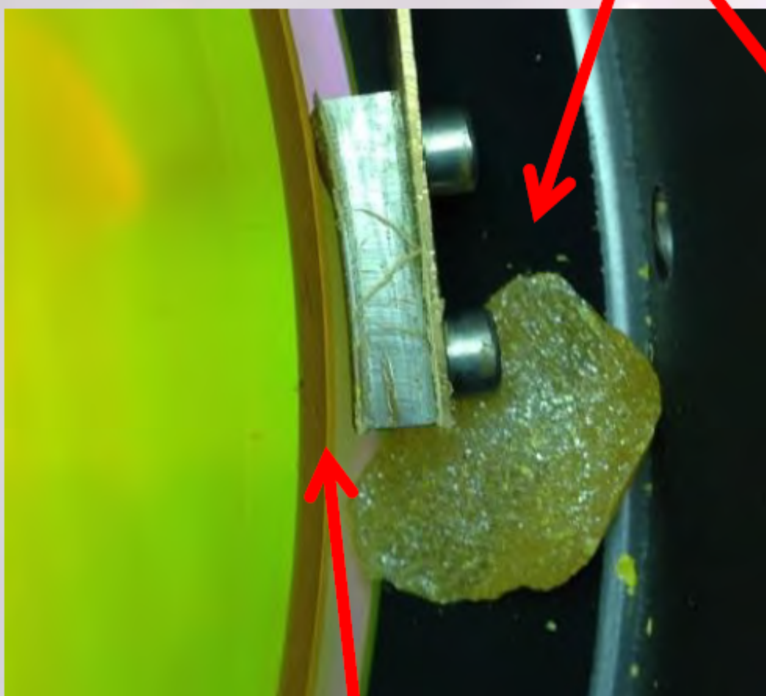
Grand Opening 6 Nov

Keith, Ian, Chuck

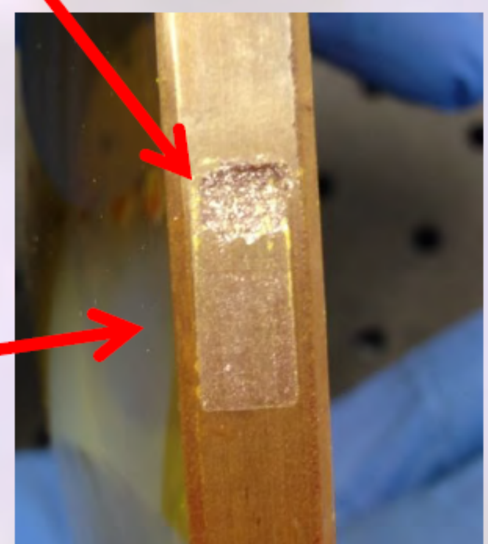
Collimator Barrel

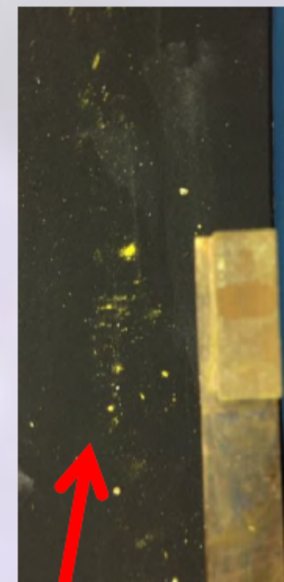
Col Lens #3 – Mostly Good

Chipping



Surface Scratches or Cracks (2 mm)





Bonding Failure x 6

Debris: lens & coating

Investigation Process

- Incident (9/13/16)
- Incident Report (9/30/16)
  - Included in depth analysis of rotator telemetry data taken during test
  - Data fed to MOSFIRE design team for analysis – led to decision to open MOSFIRE at Keck
- Investigation including outside technical experts (10/18/16)
- External Review of work culture, work processes. (12/1/16)
  - Focus was on management and engineering practices related to modifying critical operational systems.
- Observatory Task Force being formed by Director to implement recommendations (Jan-Mar 2017).

Key Findings

- Keck management and the TCSU team were responsible for the accident.
- Keck team is very dedicated and driven to do the best job and to meet objectives.
- Management should have provided additional technical resources to the team (especially system engineering).
- There were pre-cursor incidents that provided early warnings but were not acted upon.
- The rotator servo design did not receive sufficient attention throughout the design process.
- There is insufficient awareness and processes for tests on critical systems.
- Incident reporting system is not consistently followed for equipment safety issues (but is for personnel safety)

Key Recommendations

- Revert from TCSU to DCS while rotator design is revisited, first in the lab, before returning to the summit.
- Provide additional technical oversight and support to the team.
- Prohibit testing remotely except with physical presence on summit.
- Establish a protocol for communicating and approving tests on critical systems. Especially remote testing.
- Improve understanding and convey importance of incident reporting for equipment safety issues.
- Improve clarity and enforcement of responsibility and ownership of critical systems.