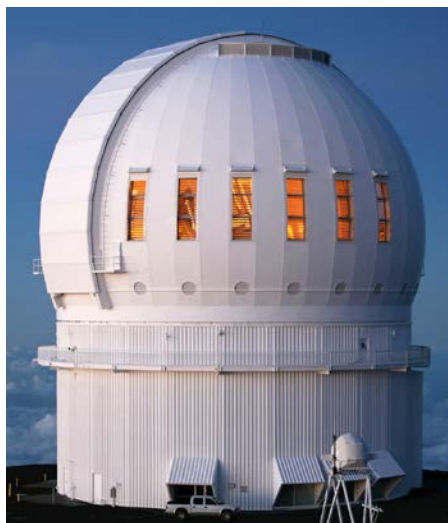




The ghost in the shutter finding and correcting years of wear

Steven E. Bauman

CFHT



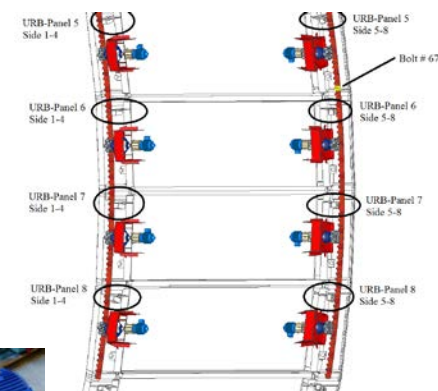


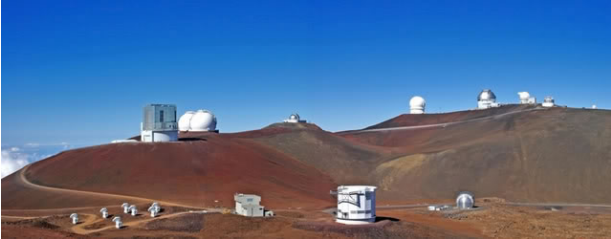


Background

History

- First major failure occurred – Dec 14, 2011
- Catastrophic failure occurred – April 4, 2012
- Observatory out of commission for 67 days
 - Longest period in CFHT history
- Dome weight 565 tons
- Shutter weight 65,000 lbs – rack and climbing pinion drive
- Shutter system comprised of 8 identical drive trains
 - Electric motor, friction disc brake, gear reduction box
 - AB SMC plus A113 – No load sharing, No dynamic deceleration, No smooth starts/stops – ramp up/down





Problems and solutions

- 1st Failure – gearbox housing fractured apart – metallurgical analysis
 - Small crack stress propagation due to impacts & vibration
 - Further investigation – incorrectly specified housing





Problems and solutions

- 2nd Failure – sheared gearbox output shaft – metallurgical analysis
 - Overhung loads exceed shaft capacity – uneven loading
 - Further study – incorrectly specified output bearing





Problems and solutions

- 3rd Failure - Shutter Stuck open – due to less drive motors or ???
 - Further lessons - Gear box(319:1) left engaged into rack

Ongoing:

- Investigation into load bangs and contact interference during motion





Conclusion

- Hard lessons learned – Documentation is important
- Inspection are critical – keep equipment clean
 - Visual – minimum, IR and ultrasonic - better
- Preventative maintenance and lubrication – not to be overlooked
 - Establish regular priority and frequency.
 - Verify lubrication type for application
- Predictive maintenance key to foreseeing issues before they become catastrophic
 - Monitor motor currents, drive parameters, timing sequence, motor controller parameters. – Plot realtime



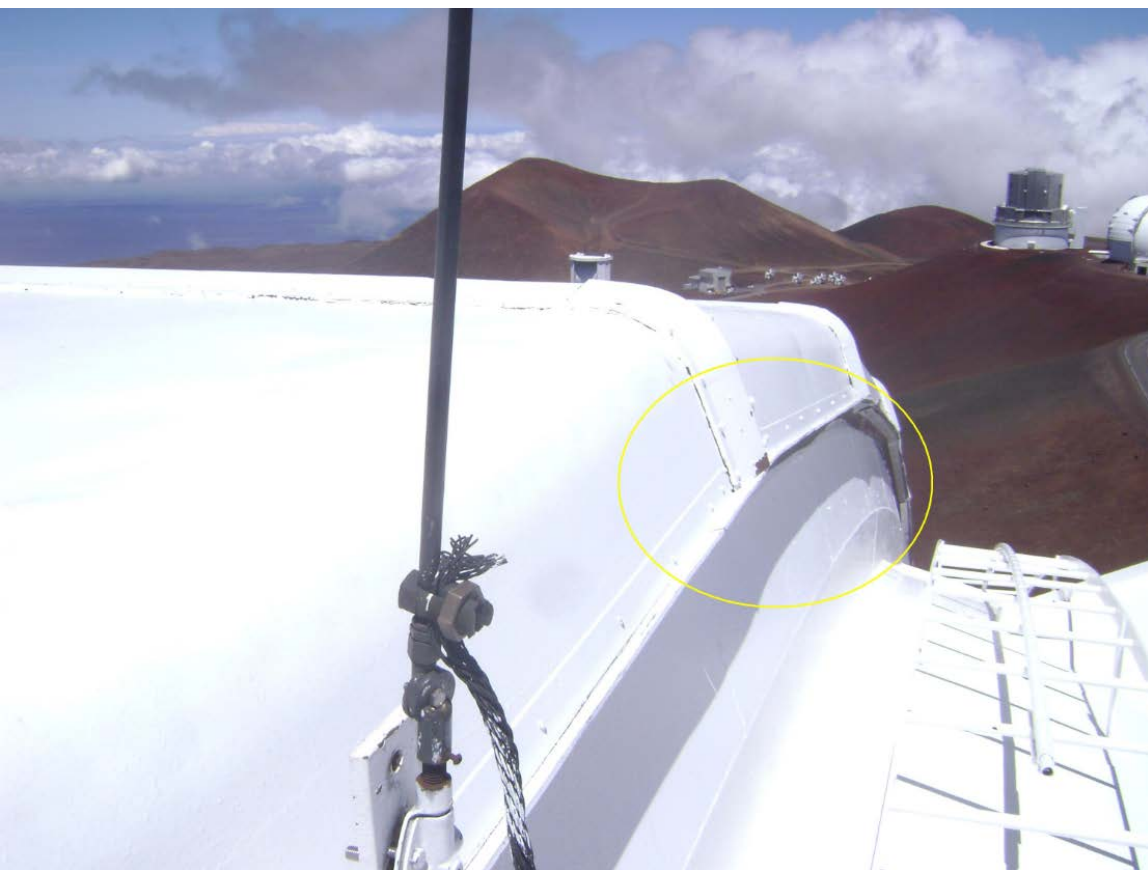


Backup slides





Backup slides



Left Cord Reel: 0%

Elapsed Time (Open): 21

Timeout Threshold (Open): 420

Right Cord Reel: 0%

Elapsed Time (Close): 18

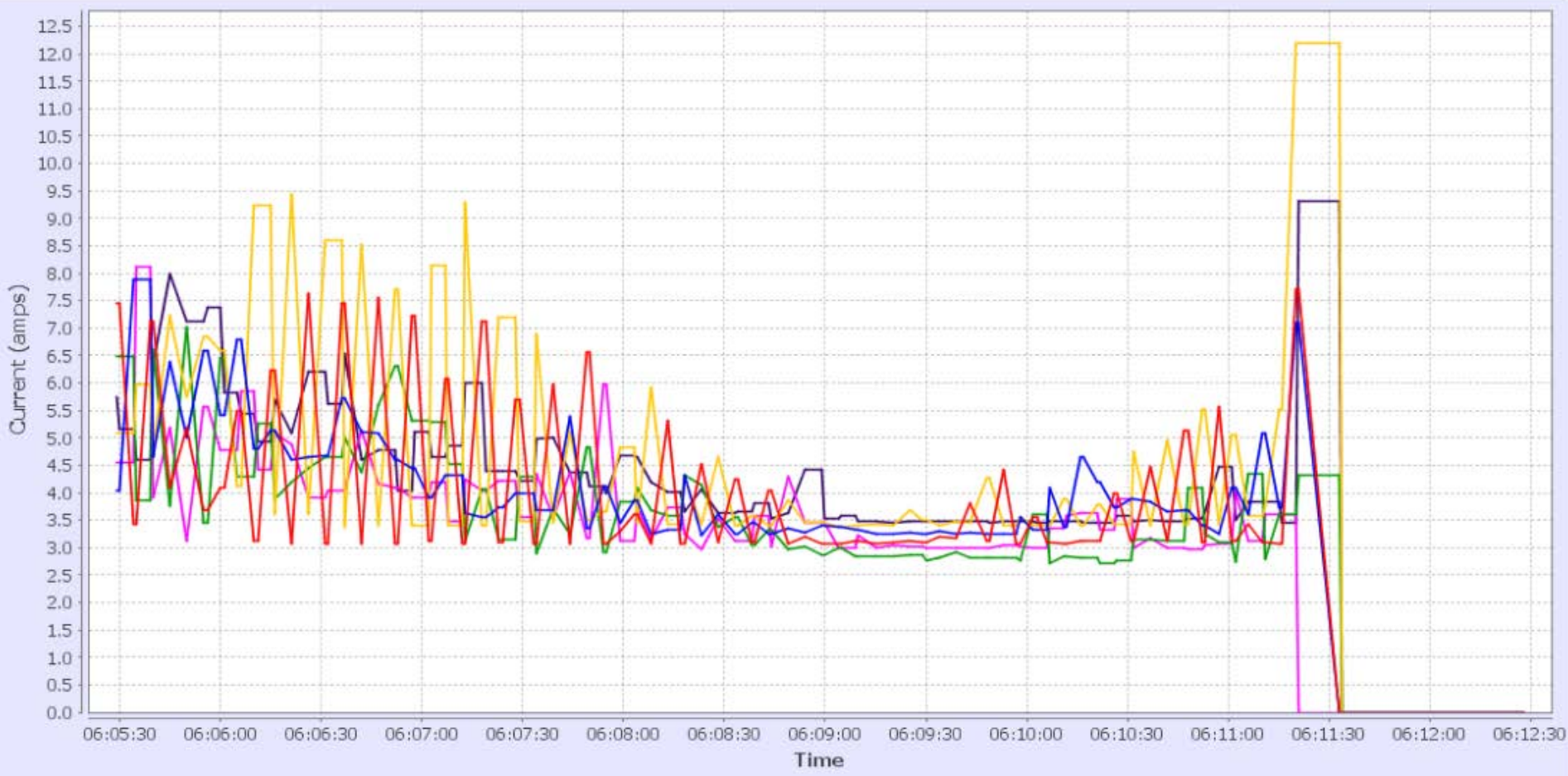
Timeout Threshold (Close): 420

	#1	#2	#3	#4	#5	#6	#7	#8
Live Current (Amps):	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Avg Current (Amps):	13.54	21.62	0.01	15.60	18.28	15.52	0.00	15.15
Max Current - Running (Amps):	13.58	5.87	0.01	7.74	10.17	4.35	0.00	6.61
Max Current - Kickstart (Amps):	16.21	21.62	0.01	18.63	20.50	21.79	0.00	18.77

Motor: 1 2 3 4 5 6 7 8

Move Avg

Close on Apr-11 06:05:23



Motor 1 Motor 2 Motor 4 Motor 5 Motor 6 Motor 8