

Maunakea Operations and Engineering Workshop 2016

Gemini North Shutter Repairs

GN Shutter Repairs

Introduction: Dome, Shutter and Chains



- 12/13: 1W/1Z failure, ~50 nights lost
- 5/14: 1X/1Y failure, ~21 nights lost
- 8/16: 2X/2Y failure, ~14 night lost
- 8/16: found 2W/2Z damaged

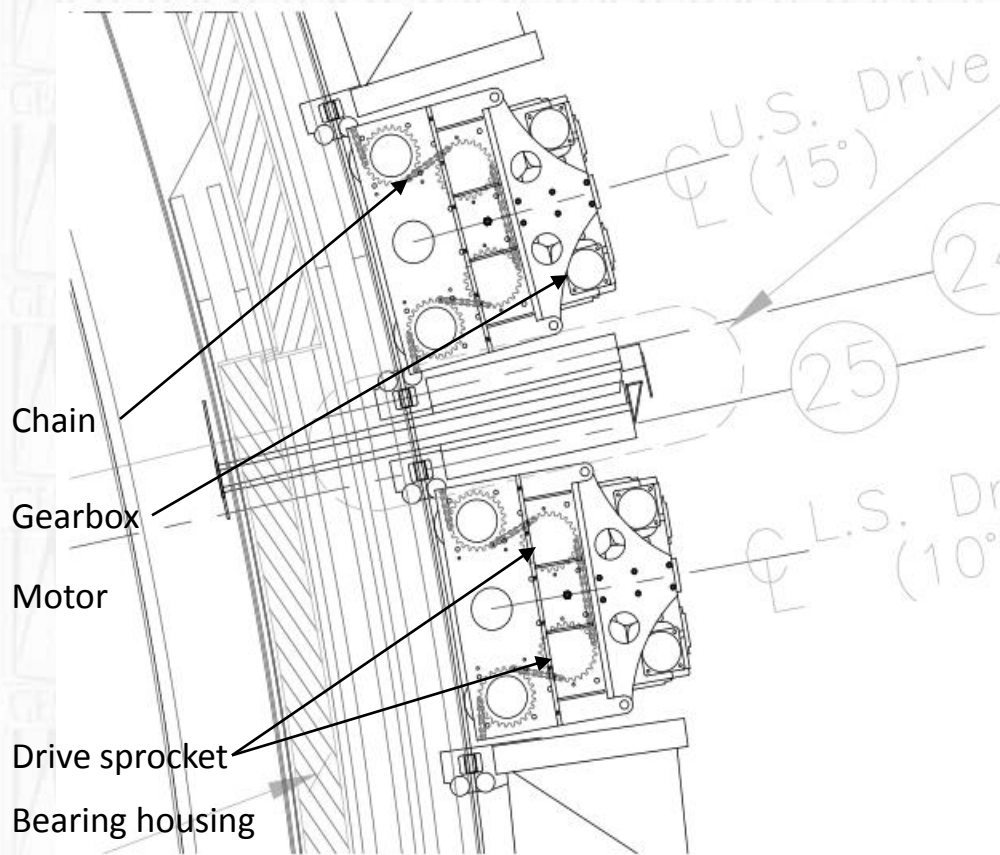
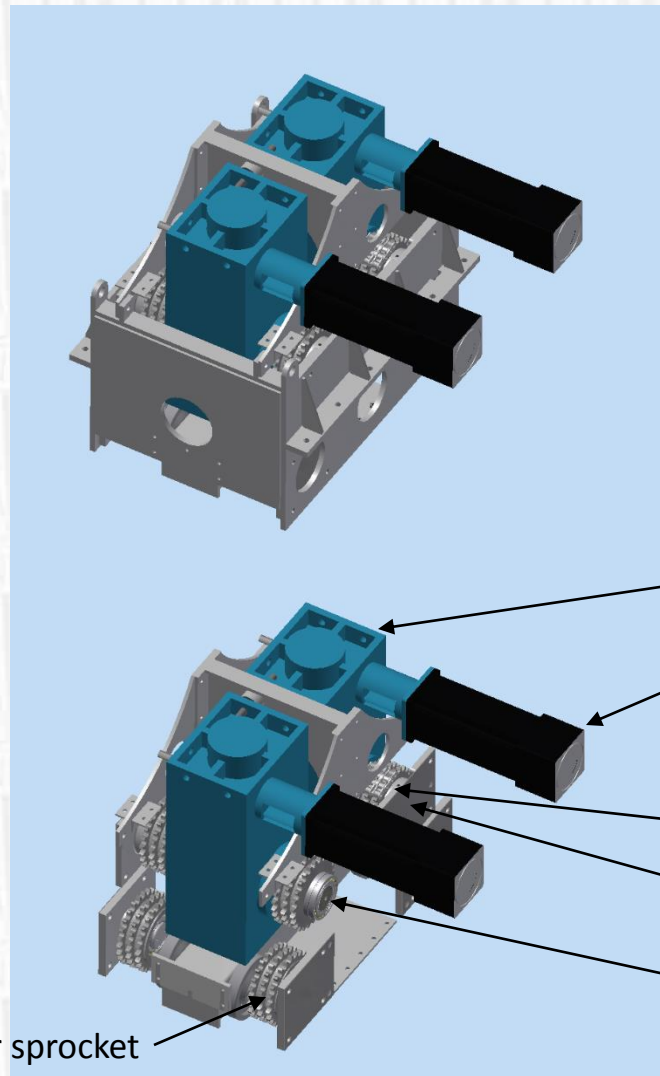
Bottom shutter locked out, overhaul planned for 2017

Fixed chains
Bottom anchors

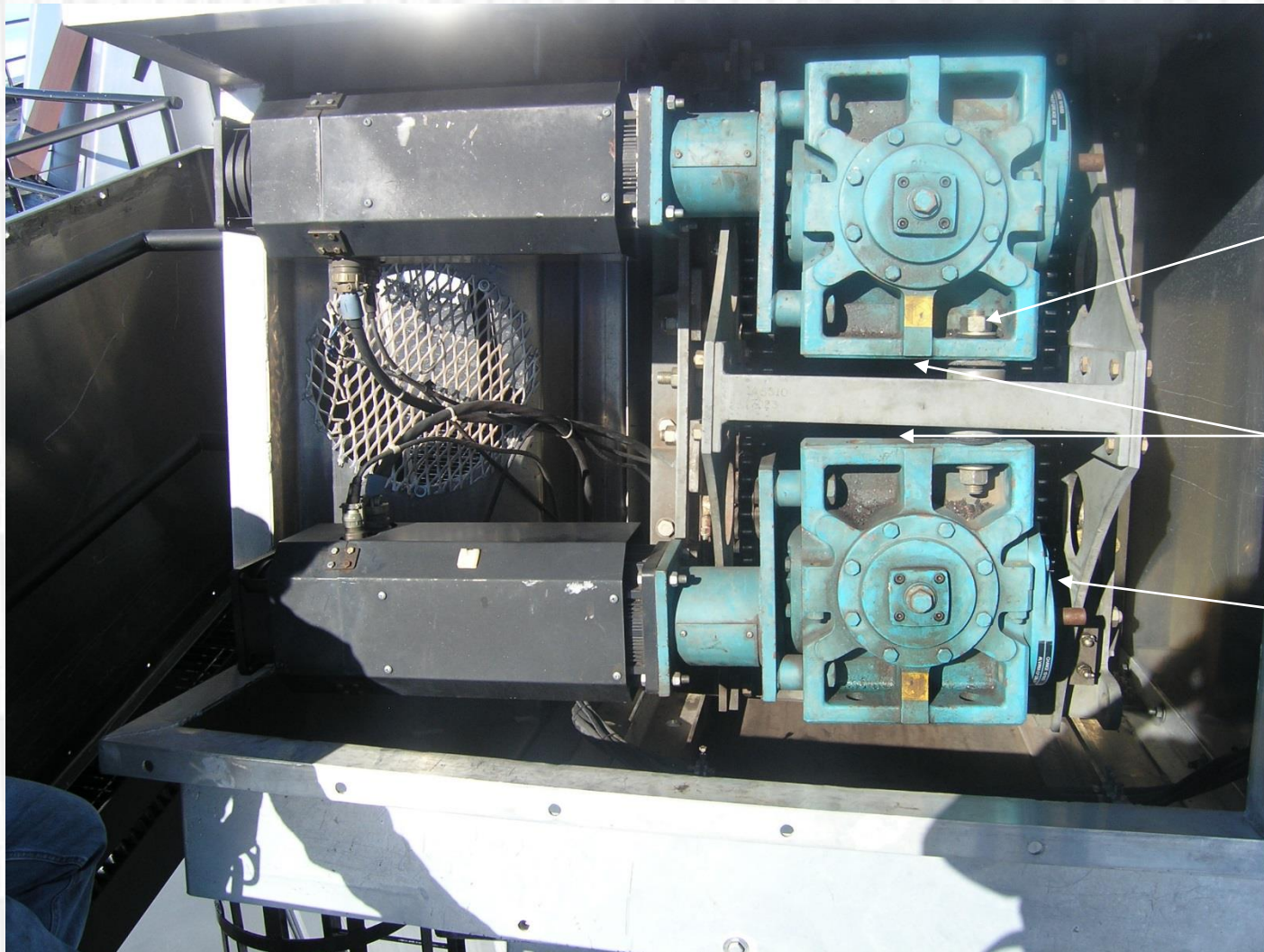


GN Shutter Repairs

Introduction: Shutter Drive Boxes



Failure Shutter Drive Boxes



Torque arm

Gap skewed for
lower gearbox

This drive shaft
bearing is broken

Failure Shaft and Bearing



Drive shaft and sprocket



Bearing and housing

Top W/Z Failure December 2014

Causes, Facts and Corrective Actions

Causes

- Lack of lubrication and maintenance
- Bearings damaged during assembly of the drive box

Facts

- No early warning in motor current due to 4x over power
- Bearing loaded less than 50% nominally
- Bearing expected lifetime > 1000 years
- Drive shaft bearings have interference fits for both raceways

Corrective Actions

- Redesign tolerances and fits for this drive box, modify parts.
- Replaced gearbox with spare
- Replace all bearings (drive shaft and idlers)
- Clean lubrication nipples and hoses
- Make special tools for mounting and assembly

Top W/Z Failure December 2013

Special lift jig and tools



Top X/Y Failure May 2014

Causes, Facts and Corrective Actions

Causes

- Chain elongation
- Torque arm too tight

Facts

- Chain is stretched in some places
- Motors are driven position controlled
- Bearings have interference fits for both raceways

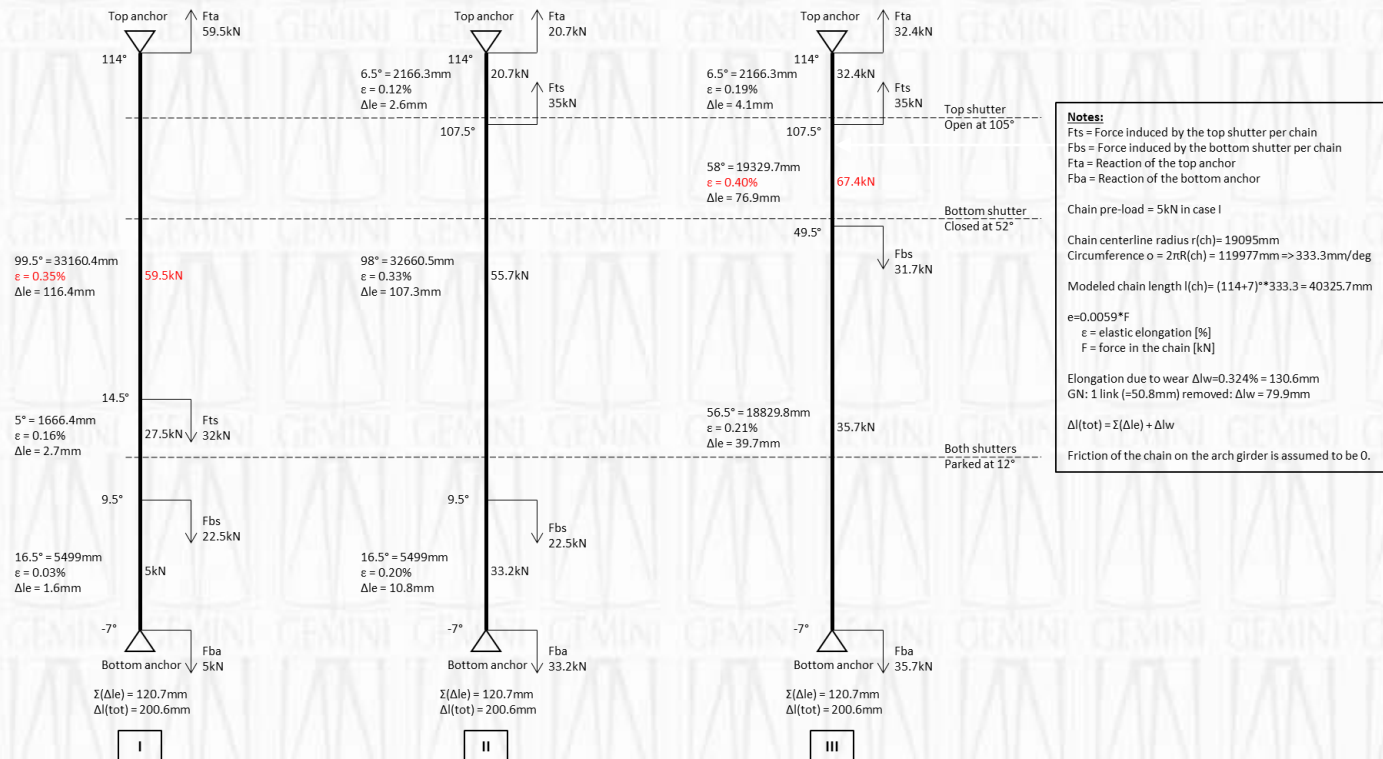
Corrective Actions

- Replaced gearbox with spare
- Replace all bearings (drive shaft and idlers)
- Replace bearing housings with new design
- Clean lubrication nipples and hoses
- Perform in-depth FMEA

Failure Mode Effects Analysis

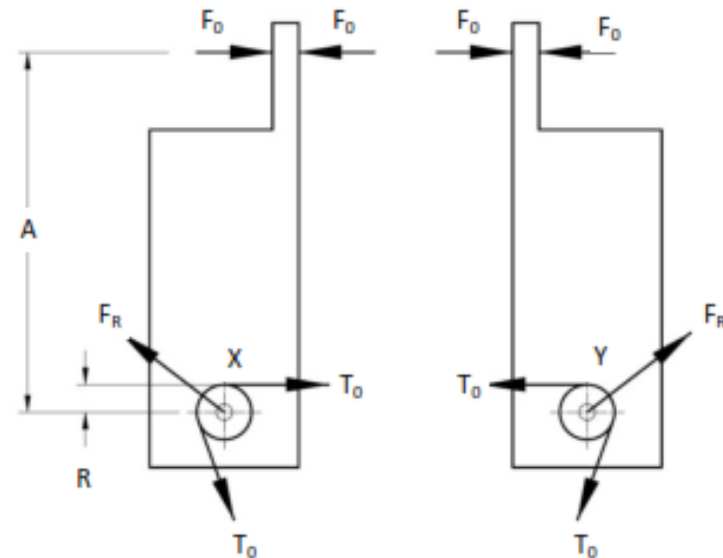
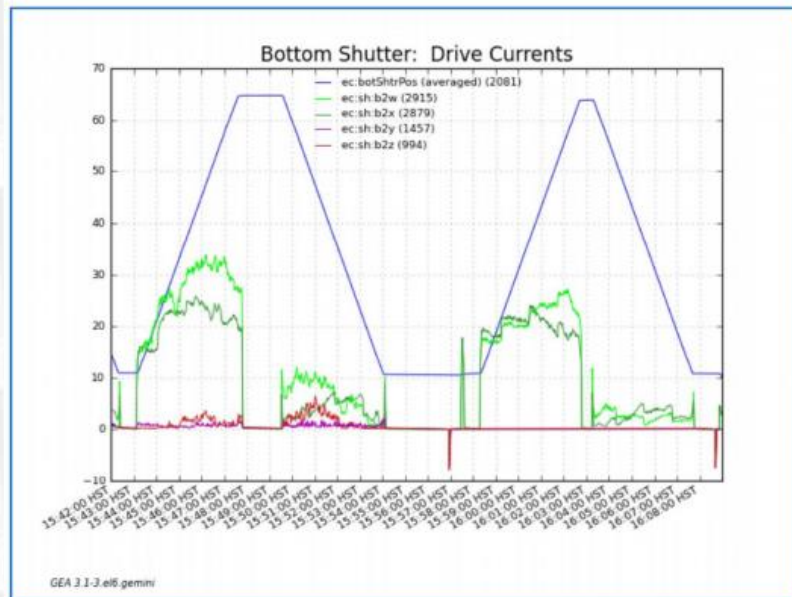
Results 1

- Chain elastic and plastic elongation caused by shutter to shutter weight
- Chain overstretching occurs when the top shutter is open and the bottom shutter is up: chain force 67.4kN vs. 54kN supplier spec.



Results 2

- The torque arm design does not allow the relative movement the gearboxes need to cope with the chain elongation and position controlled motors:



Corrective Actions

- Provide spare drive boxes for both sites (done)
- Redesign torque arm (now being tested at Gemini South)
- Redesign motor drive system (being considered)



Bottom X/Y Failure August 2016

Not again !?!

Causes

- Chain and torque arm

Corrective Actions 1

- Replace drive box with spare (latest revision)

Discovery

- Bottom W/Z bearing also about to fail

Corrective Actions 2

- Lock-out the bottom shutter in the parked position
- Make plans for 2017 to replace chains

Shutter Repair Project 2017

Draft Plan

- Replace the chains
 - Check for stronger chains, pre-lube chains, etc.
- Install the new torque arm design
- Remove all drive boxes and bring them to the latest revision
- Investigate the use of spring loaded tensioners
- Investigate an upgrade of the motor drive system
- Improve the shutter immobilization method
- Inspect and repair chain anchors as necessary
- Inspect and repair shutter guide rollers as necessary
- Improve maintenance methods

Implementation is expected between July 10th and august 25th.

Shutter Repair Project 2017

... and Gemini South?

GS has not experienced these failures, likely due to:

- 2 years younger
- Their original torque arms were adjusted better
- They have the new design torque arms installed

Should a failure occur:

- They have a spare drive box to the latest revision
- We have in-house knowledge on how to repair quickly
- Overhaul should be implemented at the first sign of failures.

Questions?

Thank you!