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
GN Shutter Repairs

Introduction: Shutter Drive Boxes

- Motor
- Gearbox
- Drive sprocket
- Bearing and shaft
- Bearing housing
- Idler sprocket
- Chain
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
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
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
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.
... 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!