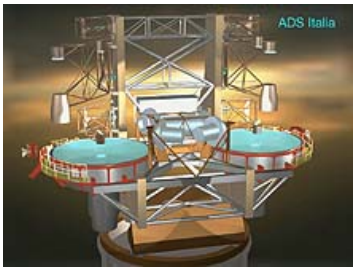

LBT PROJECT
2x8,4m TELESCOPE

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LBT PROJECT

2 X 8,4m OPTICAL TELESCOPE

Instrument Rotator and Cable Chain Technical Specifications

	Signature	Date
Prepared	Dave Ashby, Shawn Callahan, Robert Meeks	October 11, 2006
Reviewed	Dave Ashby, John Hill, Dave Thompson, Walter Seifert	November 27, 2006
Approved	Joar Brynnel	November 27, 2006

1. Revision History

Issue	Date	Changes	Responsible
a	14-Nov-05	First draft	Dave Ashby
b	19-May-06	Second draft	Shawn Callahan
c	11-Oct-06	Release after Conceptual Design Review	Robert Meeks

2. Table Of Contents

3. Applicable Documents

[RD 1]	002s004	Telescope Specifications for the Large Binocular Telescope
[RD 2]	677a000	Technical Report for Instrument Rotators Mechanics
[RD3]	674x004	Direct Gregorian Rim Gear
[RD 3]	674a003	Details Cable Wrap
[RD 4]	674x008b	Bearing instruments, two-ro angular contact ball bearing
[RD 5]	674x009b	Gregorian Rotator Bearing – Cable Wrap
[RD 6]	671x000b	Nasmyth Rotator Bearing–two-row angular contact radial bearing
[RD 7]	671x001b	Nasmyth Rotator Bearing–cable wrap
[RD 8]	670a025	Plan View Nasmyth Instruments
[RD 9]	670a000	Gregorian Rotator General Assembly
[RD 10]	674x000c	Gregorian Rotator Locking Device Positioning
[RD 11]	504s003	Treehouse Space Allocation

4. Purpose

The purpose of this document is to specify and/or clarify the design requirements for the LBT instrument rotators. The scope of this specification extends to the direct Gregorian rotators and associated cable chains as well as the bent Gregorian rotators and associated cable chains.

In the case of discrepancy between this document and applicable documents, this document will supersede any other reference documents.

5. Overview

LBT is equipped with a total of ten focal stations equipped with instrument rotators. [RD 9] The two prime focus stations (LBC) are outside of the scope of this document. The remaining focal stations are: left/right direct Gregorian (LDG, RDG), left/right front bent Gregorian (LFBG, RFBG), left/right center bent Gregorian (LCBG, RCBG) and left/right rear bent Gregorian (LRBG, RRBG) focal stations. Because of the requirements of the specific instrument expected to populate these eight focal stations, only the LDG, RDG, LFBG and RFBG will be equipped with rotators at this time. The design should easily accommodate the remaining rotators should the instruments be changed.

Each instrument rotator is equipped with two motors. These two motors are intended to act together to form a counter torque pair in order to minimize gear backlash. Instrument umbilical connections are intended to pass though a driven cable-chain system that co-rotates with the instrument rotator. This mechanism is driven by a single motor. Brakes will be required for both the rotator and cable-chain. [RD 3]

Some components have been manufactured for the direct Gregorian rotators and cable chains before this requirements document was written. These existing components will place constraints on the design. All rotator and cable chain hardware must not interfere with the instrument locking devices. [RD 10]

6. General Specifications

6.1. Environmental Specifications

According to [RD1], the environmental specifications are as follows:

Storage Temperature	-30 to +50 ºC
Operating Temperature	-20 to +25 ºC [1]
Storage Pressure	500 to 760 Torr
Operating Pressure	500 to 600 Torr
Storage Humidity	5 to 95% [2]
Operating Humidity	5 to 95%
All Surface Temperatures	T_A-1 ºC to T_A+1 ºC [3]

6.2. Operating Modes

Performance is specified for two modes: service and observing. Service mode is used for maintenance or positioning an instrument for observation. Observing mode is used for derotating an instrument during an observation. The modes are distinguished in this specification by their acceleration limits, balance requirements, and heat dissipation allowance. (Bob: I believe we will only have to relax the surface temperature and the tracking specification)

6.3. Reliability

6.3.1. Mean Time Between Failure

The MTBF for each rotator shall be no less than 10,000 hrs with a goal of 100,000 hrs.

6.3.2. Failure Modes

Over travel shall not be possible as a result of a single failure. This includes both cable chains over travel and rotator to cable chain relative travel.

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[1] This operating temperature applies only to components located outside of the treehouse. The components located inside the treehouse will not experience temperatures below 0 ºC.

[2] Corrected inconsistency in [RD1].

[3] This constrain applies to components located outside of the treehouse. This specification only applies to observation mode.

6.4. Maintainability

6.4.1. Rotation Lock

A mechanism to physically prevent rotation during maintenance shall be provided.

6.4.2. Counterweights

Bolt-on counterweights shall be provided to allow static balancing of an instrument to reduce the imbalance to within the limits specified for observing mode.

6.4.3. Handling and Installation

All heavy parts of the rotators will be installed with the overhead crane. All lifting points, fixtures, and attachment points will be specified. An installation procedure will be specified for all heavy parts. All lifting hardware will be rated and provided before installation.

6.5. Safety

6.5.1. Emergency Stop

The emergency stop (EStop) circuit is a fail-safe fiber-optic circuit to which all motion control subsystems must respond. The appropriate EStop response for the rotators and cable chains is to de-energize the drive power supplies and apply the brakes. During recovery, the system must be manually reset using a local reset button. No part of the EStop system should rely on software to function.

6.5.2. Hard Stop

A hard stop shall be provided to physically limit the relative rotation of each cable chain and instrument rotator. The hard stop shall begin to engage when the relative position differs by 2.7 degrees in either direction and shall completely prevent relative motion of more than 3 degrees in either direction.

6.5.3. Brakes

A brake shall be provided on each motor to prevent uncommanded rotation. The brakes shall be capable of preventing rotation under full motor torque plus the full imbalance torque. If the cable chain is capable of back-driving its drive motor, brakes must also be installed on the cable chain.

6.6. Status Devices

6.6.1. Limit Switches

Adjustable limit switches shall be provided to prevent over travel of the cable chain with respect to the telescope.

6.6.2. Temperature Sensors

Temperature sensors to monitor the temperature of external surfaces as well as other key components (e. g. motor windings) shall be provided.

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6.6.3. Other Sensors

Additional sensors to monitor to monitor health and status shall be provided.

6.7. Software, Communications and Synchronization

6.7.1. Software Specification

The software specifications and command interface will be described in a separate document. (we need to define the can number)

6.7.2. Communications

Commands to the rotators and cable chains must be delivered using an Ethernet interface.

6.7.3. Synchronization

The system must be able to synchronize with main axis control system to within 22 microseconds in order to maintain the specified tracking tolerances.

6.8. Space Requirements

6.8.1. Allowable volume

The allowable volume for the instrument rotator hardware and cable wraps is described in 670a025c.

6.8.2. Space for Electronics

On-telescope electronics must conform to the space provide in RD 11.

6.9. Power Dissipation

The following power dissipation specifications apply when all instrument rotators are operating simultaneously.

6.9.1. Service mode

When operated in service mode the heat dissipation shall be less than 5000 W.

6.9.2. Observing mode

When operated in observing mode the heat dissipation shall be less than 600 W.

7. Direct Gregorian Rotators

7.1. Overview

Much of the mechanical design work has been completed for the direct Gregorian rotator. This includes the bearing, rim-gear and motor pinion gears. The design for the remaining component must work around the remaining error budget.

7.2. General Performance Specification

Angular Velocity (service mode)	5 degrees/second
Angular Velocity (observing mode)	1.5 degrees/second
Angular Acceleration (service mode)	0.3 degrees/second^2
Angular Acceleration (observing mode)	0.3 degrees/second^2
Field Diameter	0.5 degrees
Short Term (5 seconds) On-Sky Error	0.010 arcsec [4]
Instrument + AGW Mass	3500 kg
Maximum Bearing Moment	35000 Nm
Maximum Instrument Imbalance Torque (service mode)	3000 Nm
Maximum Instrument Imbalance Torque (observing mode)	300 Nm
Cable Chain Relative Angle	±5.0 degrees
Cable Chain Tracking Accuracy	±60 arcsec
Cable Chain Operation Rotation Range	540 degrees
Cable Chain Rotational Range	560 degrees
Maximum allowed time for system initialization	5 minutes

7.3. Existing Components

The direct Gregorian rotator rim-gears and bearings have has been manufactured and are installed on the telescope. The rotator gears have the following relevant specifications:

Pitch Diameter	3300 mm
Number of Teeth	550
Pressure Angle	20 degrees
Single Tooth Pitch Accuracy	0.011 mm
Cumulative Pitch Accuracy	0.032 mm

7.4. Cable Capacity

The capacity of the cable chain shall be:[RD 1]

- OPTICAL FIBER PAIRS 10 fiber pairs

[4] Each instrument rotator and guider is allotted 0.015 arcsec rms of error combined. The rotator and guider are assumed to be given equal parts of this budget or 0.010 arcsec.

- AC POWER 3-phase, 5 wires 7 kVA continuous/10 kVA surge (208 VAC, 60 Hz)
- UPS POWER 1-phase, 3 wires 3 kVA continuous (120 VAC, 60 Hz)
- PURGE GAS 60 psi 0.42 MPa, 10 cfm (maximum flow), dry nitrogen (input only)
- COOLANT 100 psi (0.7 MPa) maximum pressure, 5 kW capacity to give 2 degC rise, uninsulated lines
- TWISTED PAIRS 30 shielded twisted pairs (one to three cables)
- COAXIAL CABLES eight 75 ohm coax cables, eight 50 ohm coax cables (mounted with isolated shields) Belden Trade Number 9231
- TELEPHONE four 20 gauge conductors
- HIGH PRESSURE HELIUM GAS 300 psi (2.1 MPa) two 12 mm bore lines
- MISC two 5 cm fexible conduits
- HELIUM RECOVERY 2.5 cm bore vacuum line
- GENERAL VACUUM 2.5 cm bore vacuum line
- Motor Drive Cables (Defined in Design)
- Motor Encoder Cables (Defined in Design)
- Main Encoder Signal and/or Power Cables (Defined in Design)
- Rotator Limit Switch Cables (Defined in Design)

8. Bent Gregorian Rotators

8.1. Overview

Some of the mechanical design work has been completed for the direct Gregorian rotator. The rim-gear and motor pinion gears have not been designed.

8.2. General Performance Specifications

Angular Velocity (service mode)	5 degrees/second
Angular Velocity (observing mode)	1.5 degrees/second
Angular Acceleration (service mode)	0.3 degrees/second^2
Angular Acceleration (observing mode)	0.3 degrees/second^2
Field Diameter	0.2 degrees
Short Term (5 seconds) On-Sky Error	0.010 arcsec [(5)]
Instrument + AGW Design Mass	3500 kg
Maximum Bearing Moment	20000 Nm
Maximum Instrument Imbalance Torque (service mode)	2000 Nm
Maximum Instrument Imbalance Torque (observing mode)	200 Nm
Cable Chain Relative Angle	±5.0 degrees
Maximum allowed time for system initialization	5 minutes

[5] Each instrument rotator and guider is allotted 0.015 arcsec rms of error combined. The rotator and guider are assumed to be given equal parts of this budget or 0.010 arcsec.

8.3. Existing Components

The bent Gregorian rotator gears have the following relevant specifications:

Pitch Diameter	1880 mm
Number of Teeth	470
Pressure Angle	20 degrees
Single Tooth Pitch Accuracy	0.011 mm
Cumulative Pitch Accuracy	0.032 mm

8.4. Cable Capacity

The capacity of the cable chain shall be:[RD 1]

- OPTICAL FIBER PAIRS 10 fiber pairs
- AC POWER 3-phase, 5 wires 7 kVA continuous/10 kVA surge (208 VAC, 60 Hz)
- UPS POWER 1-phase, 3 wires 3 kVA continuous (120 VAC, 60 Hz)
- PURGE GAS 60 psi 0.42 MPa, 10 cfm (maximum flow), dry nitrogen (input only)
- COOLANT 100 psi (0.7 MPa) maximum pressure, 5 kW capacity to give 2 degC rise, uninsulated lines
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- MISC two 5 cm fexible conduits
- HELIUM RECOVERY 2.5 cm bore vacuum line
- GENERAL VACUUM 2.5 cm bore vacuum line
- Main Encoder Signal and/or Power Cables (Defined in Design)
- Rotator Limit Switch Cables (Defined in Design)

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