

Telescope Mechanics

TITLE

Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R

Issue: 1.A

Date: 22/06/2017

No. pages: 98

C/D: Yes

Gran Telescopio de Canarias, S.A.

Instituto de Astrofísica de Canarias

Vía Láctea s/n

38200 - LA LAGUNA, TENERIFE, Islas Canarias

Tfno +34 922 315 031 Fax +34 922 315 032

Centro Común de Astrofísica de La Palma

Cuesta de San José s/n

38712 BREÑA BAJA, LA PALMA, Islas Canarias

Tfno +34 922 425 720 Fax +34 922 425 725

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 2 of 98
---	--	--

Approval control

Prepared by	Germán Prieto Engineer of Development Group	Signed in the original copy
Revised by	Benjamin Siegel Engineer of Development Group	Signed in the original copy
	Jose Antonio Rodríguez Engineer of Development Group	Signed in the original copy
Approved by	Germán Prieto Engineer of Development Group	Signed in the original copy
	Javier Castro Head of Development Group	Signed in the original copy
	Luis Alberto Rodríguez Head of Operations Group	Signed in the original copy
	Ramón Ascanio Head of Administration Group	Signed in the original copy
Authorized by	Romano Corradi General Director Date:	Signed in the original copy

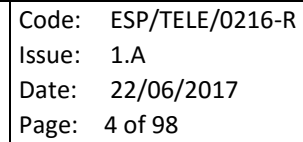


Telescope Mechanics
Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 3 of 98

Changes record

Issue	Date	Section	Change code	Brief description
1.A	22/06/17	All	All	First version



Code	Name
TL-IR-CG	Cassegrain Instrument Rotator
AG-CG-AG-200	AG Mechanics Assembly
CS-IS-CG	Cassegrain Local ISS
CS-AS-CG-200	Cass. Local Control
CS-EC-PC-202	Cassegrain Electronics Enclosure
SE-CG	Cassegrain Support Elements

[illegible]

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 5 of 98
---	---	--

Applicable documents

N°	Document title	Code	Issue
A1	CG-Set Interface Requirements	DCI/TELE/0061-R	1.A
A2	CG-Set – Science Instrument Interface	DCI/TELE/0062-R	1.A
A3	Cassegrain AG Mechanics – Pick Off Mirror	DR/I-AG-AG-018/000	1.A

Reference documents

N°	Document title	Code	Issue
R1	Cassegrain Set (CG-Set) Preliminary Design	RPT/TELE/0442-R	1.A
R2	GTC Coordinate Systems	RPT/STMA/0075-R	2.A

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 6 of 98
---	---	--

List of acronyms and abbreviations

AG	Acquisition and Guiding
CG-Set	Set formed by the Cassegrain Instrument rotator, AG-Mechanics, including Electronics and Control, and Support Elements
COG	Centre Of Gravity
EMC	Electromagnetic Compatibility
FE	Finite Elements
FEM	Finite Elements Model
FOV	Field of View
GCS	GTC Control System
GTC	Gran Telescopio Canarias
HMI	Human-Machine Interface
ISS	Interlock and Safety System
LCU	Local Control Unit
LISS	Local Interlock and Safety System
MPMNT	Mean Preventive Maintenance Night-Time
MPMDT	Mean Preventive Maintenance Day-Time
MTBF	Mean Time between Failures
MTTR	Mean Time to repair
M1	Primary Mirror
M2	Secondary Mirror
M3	Tertiary Mirror
PLC	Programmable Logic Controller
POM	Pick-Off Mirror
RAMS	Reliability, Availability, Maintainability and Safety
RCCB	Residual Current Circuit Breaker
RMS	Root Mean Square
TBC	To Be Confirmed
TBD	To Be Defined

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 7 of 98
---	---	--

TABLE OF CONTENTS

Configuration items	4
Interfaces (only for icd's)	4
Applicable documents	5
Reference documents	5
List of acronyms and abbreviations	6
TABLE OF CONTENTS	7
1 SUMMARY	15
2 INTRODUCTION	15
2.1 THE GTC TELESCOPE AND ITS FOCAL STATIONS	15
2.2 REQUIREMENTS AND GUIDELINES	16
2.3 VERIFICATION DELIVERABLES	16
2.4 UNSTABLE AND UNDEFINED REQUIREMENTS	16
2.5 REQUIREMENTS CODE	17
3 DEFINITIONS.....	17
3.1 CONCEPTS	17
3.1.1 Telescope Tube	17
3.1.2 Science Instrument	17
3.1.3 AG Instrument	17
3.1.4 Pick-Off Mirror (POM) Unit	18
3.1.5 AG Mechanics.....	18
3.1.6 AG System	18
3.1.7 Rotator (or Instrument Rotator).....	18
3.1.8 Electronics Enclosure (and Cabinet)	18
3.1.9 Cassegrain Set (CG-Set)	18
3.1.10 Mean Preventive Maintenance Night-Time (MPMNT)	18
3.1.11 Mean Preventive Maintenance Day-Time (MPMDT)	18
3.1.12 Mean Time between Failures (MTBF)	18
3.1.13 Mean Time to Repair (MTTR)	19
3.2 COORDINATE SYSTEMS AND REFERENCES	19



Telescope Mechanics
Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 8 of 98

3.2.1	<i>Elevation Axis</i>	19
3.2.2	<i>Tube Axis</i>	19
3.2.3	<i>GTC optical axis</i>	19
3.2.4	<i>AG optical axis</i>	19
3.2.5	<i>Cassegrain Coordinate System</i>	19
3.2.6	<i>Pupil</i>	20
3.2.7	<i>Science Instrument Coordinate System</i>	20
3.2.8	<i>AG Instrument Coordinate System</i>	21
3.2.9	<i>Virtual AG Instrument Coordinate System</i>	21
3.2.10	<i>Understanding Co-ordinate systems and geometric constraints</i>	21
4	SCOPE	25
5	CASSEGRAIN SET REQUIREMENTS (RQ/TL-IR-CG/NNN, RQ/AG-CG-AG-200/NNN, RQ/CS-EC-PC-202/NNN)	29
5.1	FUNCTIONAL REQUIREMENTS	29
5.1.1	<i>CG-Set concept</i>	29
5.2	DESIGN REQUIREMENTS	29
5.2.1	<i>Mechanical Requirements</i>	29
5.2.1.1	Total Mass	29
5.2.1.2	Overall Mass Watching Guideline	29
5.2.1.3	Reference Temperature	29
5.2.1.4	Cable and ducts rotation policy	30
5.2.1.5	Cable chains	30
5.2.1.6	Cable and ducts in cable chains	30
5.2.1.7	Cable chains connection panels	31
5.2.1.8	Instrument Protection Cover and Shutter	31
5.2.1.9	Fool-proof design	32
5.2.1.10	Co-ordinate Systems	32
5.2.2	<i>Material Requirements</i>	33
5.2.2.1	Structural material	33
5.2.2.2	Thermal Expansion Coefficient Guideline	33
5.2.2.3	Cooling System Materials	33
5.2.3	<i>Surface Protection</i>	33



Telescope Mechanics Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 9 of 98

5.2.3.1	Surface protection	33
5.2.3.2	Surface protection optical properties	34
5.2.4	<i>Optical Requirements</i>	34
5.2.4.1	Stray light control	34
5.2.4.2	Accessible Field of View Optical Beam	34
5.2.5	<i>Thermal Requirements</i>	35
5.2.5.1	Heat dissipation in the Telescope Chamber	35
5.2.5.2	Thermal Inertia guideline	35
5.2.5.3	Active thermal control	36
5.2.6	<i>Electrical Requirements</i>	36
5.2.6.1	Earthing	36
5.2.6.2	EMC Standards	36
5.2.6.3	Connectors	36
5.2.6.4	Cabling scope	37
5.2.6.5	Cable, Connector and Device labelling	37
5.2.6.6	Cabling Fire Prevention	38
5.3	PERFORMANCE REQUIREMENTS	38
5.3.1	<i>Relative Pupil error AG Instrument - Science Instrument</i>	38
5.3.2	<i>Lateral positioning error (AG Instrument relative to Science Instrument)</i>	39
5.3.3	<i>Lateral position stability (AG Instrument relative to Science Instrument)</i>	40
5.3.4	<i>Axial positioning error (AG Instrument relative to Science Instrument)</i>	40
5.4	ENVIRONMENTAL CONSTRAINTS	41
5.4.1	<i>Climatological Conditions at the Telescope Chamber</i>	41
5.4.2	<i>Gravity orientation</i>	42
5.4.3	<i>Earthquake overload</i>	42
5.4.4	<i>Dust Environment</i>	42
5.5	STANDARDS AND REGULATION REQUIREMENTS	42
5.5.1	<i>Applicable standards and regulations</i>	42
5.5.2	<i>Single components CE mark</i>	43
5.5.3	<i>CG-Set CE mark</i>	43
5.6	LOGISTIC SUPPORT REQUIREMENTS	43



Telescope Mechanics Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 10 of 98

5.6.1	<i>Reliability Requirements</i>	43
5.6.1.1	Reliability Design Criteria	43
5.6.1.2	Service Life Time	44
5.6.1.3	MTBF.....	44
5.6.2	<i>Maintainability Requirements</i>	44
5.6.2.1	Maintenance design criteria	44
5.6.2.2	Maintainability design guidelines	45
5.6.2.3	MTTR.....	46
5.6.2.4	Day Time Preventive Maintenance	46
5.6.2.5	Night Time Preventive Maintenance (MPMNT).....	46
5.6.2.6	Spares list	46
5.6.3	<i>Assembly, Packaging, Handling, Storage and Transportation</i>	47
5.6.3.1	Package dimensions for road transport	47
5.6.3.2	Package unload at the GTC freight area.....	47
5.6.3.3	Handling and Storage.....	48
5.6.4	<i>Safety Requirements</i>	48
5.6.4.1	Functional safety.....	48
6	INSTRUMENT ROTATOR REQUIREMENTS (RQ/TL-IR-CG/NNN)	49
6.1	FUNCTIONAL REQUIREMENTS	49
6.1.1	<i>Instrument Rotator Concept</i>	49
6.2	DESIGN REQUIREMENTS	49
6.2.1.1	Bearing	49
6.2.1.2	Bearing grease replacement system	49
6.2.1.3	Motor.....	50
6.2.1.4	Motor Cooling system.....	50
6.2.1.5	Encoder	51
6.2.1.6	Brakes	51
6.2.1.7	Compressed air system	51
6.2.1.8	Limit Switches / Absolute Switch	52
6.2.1.9	Toggle Mechanism	52
6.2.1.10	Rotation End Dampers.....	52
6.2.1.11	Rotator 0° position	52
6.2.1.12	Instrument Rotator unbalance	52



Telescope Mechanics Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 11 of 98

6.2.1.13	Alignment features	53
6.3	PERFORMANCE REQUIREMENTS	53
6.3.1.1	Rotation Range of Instrument Rotator	53
6.3.1.2	Maximum Instrument mass	53
6.3.1.3	Maximum mass eccentricity	54
6.3.1.4	Maximum Rotator Speed	54
6.3.1.5	Maximum Rotator Acceleration	54
6.3.1.6	Rotator Tracking Speed	54
6.3.1.7	Rotator Tracking Acceleration	55
6.3.1.8	Rotation accuracy and absolute following error	55
6.3.1.9	Emergency Stop time	55
6.3.1.10	Orientation of Science Instrument Coordinate System	55
6.3.1.11	Instrument flange gravity tilt	56
7	AG MECHANICS REQUIREMENTS (RQ/AG-CG-AG-200/NNN)	57
7.1	FUNCTIONAL REQUIREMENTS.....	57
7.1.1	<i>AG Concept.....</i>	<i>57</i>
7.1.2	<i>AG Mechanics functional breakdown</i>	<i>57</i>
7.1.3	<i>Operation modes of AG Mechanisms.....</i>	<i>57</i>
7.2	DESIGN REQUIREMENTS.....	58
7.2.1	<i>Geometrical design constraints.....</i>	<i>58</i>
7.2.1.1	Probe Arm Rotation Axis	58
7.2.1.2	Focus stage 0° position	59
7.2.1.3	AG instrument and POM orientation and position	59
7.2.2	<i>AG thermal constraints</i>	<i>59</i>
7.2.2.1	Mechanisms position holding	59
7.2.2.2	Motors thermal link with the Turn Table	59
7.2.3	<i>AG Mechanics main assembly.....</i>	<i>60</i>
7.2.3.1	AG Mechanics structure top surface.....	60
7.2.3.2	AG Mechanics lifting points	60
7.2.3.3	Structural Temperature sensors	60
7.2.4	<i>Turn Table.....</i>	<i>60</i>
7.2.4.1	Bearing	60



Telescope Mechanics Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 12 of 98

7.2.4.2	Bearing grease replacement system	60
7.2.4.3	Motor	61
7.2.4.4	Encoder	61
7.2.4.5	Limit Switches / Absolute Switch	61
7.2.4.6	Rotation End Dampers	61
7.2.4.7	0° position	61
7.2.4.8	Turn Table unbalance guideline	61
7.2.4.9	Structure thermal inertia	62
7.2.4.10	AG Instrument Electronics box	62
7.2.5	<i>Probe Arm and Rotation Stage</i>	62
7.2.5.1	Rotation Stage specification	62
7.2.5.2	Probe Arm Construction	62
7.2.5.3	Un-obstruction of the AG picked optical beam	63
7.2.5.4	Shadow over the Scientific Instrument	64
7.2.5.5	Probe Arm Temperature sensors	64
7.2.6	<i>Focusing Mechanism for AG Instrument</i>	64
7.2.7	<i>AG Items mounting Repeatability</i>	64
7.3	PERFORMANCE REQUIREMENTS	65
7.3.1	<i>Probe Arm Scanning Range</i>	65
7.3.2	<i>Positioning time</i>	65
8	ELECTRONICS ENCLOSURE REQUIREMENTS (RQ/CS-EC-PC-202/...)	67
8.1	CONCEPT	67
8.2	ENCLOSURE LOCATION AND POSITION	67
8.3	COOLING SYSTEM	67
8.4	ENCLOSURE INTERNAL ENVIRONMENT: TEMPERATURE	68
8.5	ENCLOSURE INTERNAL ENVIRONMENT: DUST AND MOISTURE	68
8.6	HEAT DISSIPATION TO THE TELESCOPE CHAMBER	68
8.7	STRUCTURAL VIBRATIONS	69
8.8	ACOUSTICAL VIBRATIONS	69
8.9	STRUCTURAL INTEGRITY	69
8.10	HANDLING	69
8.11	ENCLOSURE INTERNAL/EXTERNAL CONFIGURATION	70

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 13 of 98
---	---	---

8.12	GTC CONNECTION PANEL.....	70
9	LOCAL CONTROL REQUIREMENTS (RQ/CS-AS-CG-200/NNN).....	72
9.1	FUNCTIONAL REQUIREMENTS.....	72
9.1.1	CG-Set Control System Concept.....	72
9.1.2	GC-Set Operation Modes.....	72
9.1.3	Control Mode switching functionality.....	72
9.1.4	Motion control and monitoring functionality.....	73
9.1.5	Start-up control and monitoring functionality.....	73
9.1.6	Electronics Enclosure temperature control and monitoring functionality.....	74
9.1.7	Rotator Motor temperature monitoring functionality.....	75
9.1.8	Structural temperature monitoring functionality.....	75
9.1.9	Mechanics housekeeping.....	75
9.1.10	Local Safety functionality (RQ/CS-IS-CG/NNN).....	76
9.2	DESIGN REQUIREMENTS.....	76
9.2.1	CG-Set Control System HW architecture.....	76
9.2.2	Cabinet LCU.....	77
9.2.3	Drives.....	77
9.2.4	HMI panels for Local Control.....	78
9.2.5	Electrical protections.....	78
9.2.6	Start-up system.....	79
9.2.7	Equipment connected to the UPS supply.....	80
9.2.8	AG Instrument Fibre Optics connection cable.....	80
9.2.9	DC supply for the AG Instrument.....	80
9.2.10	Local Safety design (RQ/CS-IS-CG/NNN).....	80
10	SUPPORT ELEMENTS SPECIFICATION.....	82
10.1	CASSEGRAIN TRANSPORT CART (RQ/SE-CG-TC/NNN).....	82
10.1.1	Functional requirements.....	82
10.1.2	Design requirements.....	82
10.2	INSTRUMENT DUMMY (RQ/TL-IR-CG-200/NNN).....	83
10.3	POM UNIT DUMMY.....	84



Telescope Mechanics
Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 14 of 98

10.4	AG INSTRUMENT DUMMY	84
11	DOCUMENTATION DELIVERABLES SPECIFICATION	85
11.1	INTRODUCTION	85
11.2	DESIGN DOCUMENT	86
11.3	DIMENSIONAL 3D MODEL	87
11.4	FE MODELS	87
11.5	MECHANICAL DRAWINGS	87
11.6	ELECTRICAL DRAWINGS	88
11.7	SOFTWARE DOCUMENTATION	89
11.8	COMPONENT LIST	90
11.9	COMMERCIAL COMPONENTS DOCUMENTATION	90
11.10	MATERIALS CERTIFICATION	91
11.11	RAMS ANALYSIS	91
11.12	ASSEMBLY, PACKAGING, HANDLING, STORAGE AND TRANSPORTATION PROCEDURE	92
11.13	ACCEPTANCE TEST PLAN	93
11.14	VERIFICATION PROCEDURES	94
11.15	VERIFICATION REPORTS (INSPECTION, TEST, METROLOGY)	94
11.16	OPERATION, MAINTENANCE AND SAFETY MANUAL	95
11.17	CG-SET CE MARK CERTIFICATE	97
11.18	VERIFICATION CONTROL DOCUMENT	97



1 SUMMARY

This document contains the specifications for the CG-Set, composed mainly by the Instrument rotator, the Acquisition and Guiding (AG)-Mechanics and the corresponding Electronics Cabinet. The CG-Set will be mounted on the GTC Cassegrain Focal Station.

2 INTRODUCTION

2.1 The GTC Telescope and its Focal Stations

The Gran Telescopio de Canarias (GTC) is a large optical Telescope with an Altazimuth Mount, i.e. one vertical rotating axis (Azimuth Axis) and one horizontal rotating axis (Elevation Axis). See Fig. 1. The Azimuth axis rotates the whole Telescope (Tube and Mount) with regard to the ground. The Elevation Axis rotates the Telescope Tube with regard to the Telescope Mount from the Horizon to the Zenit, i.e. 90°.

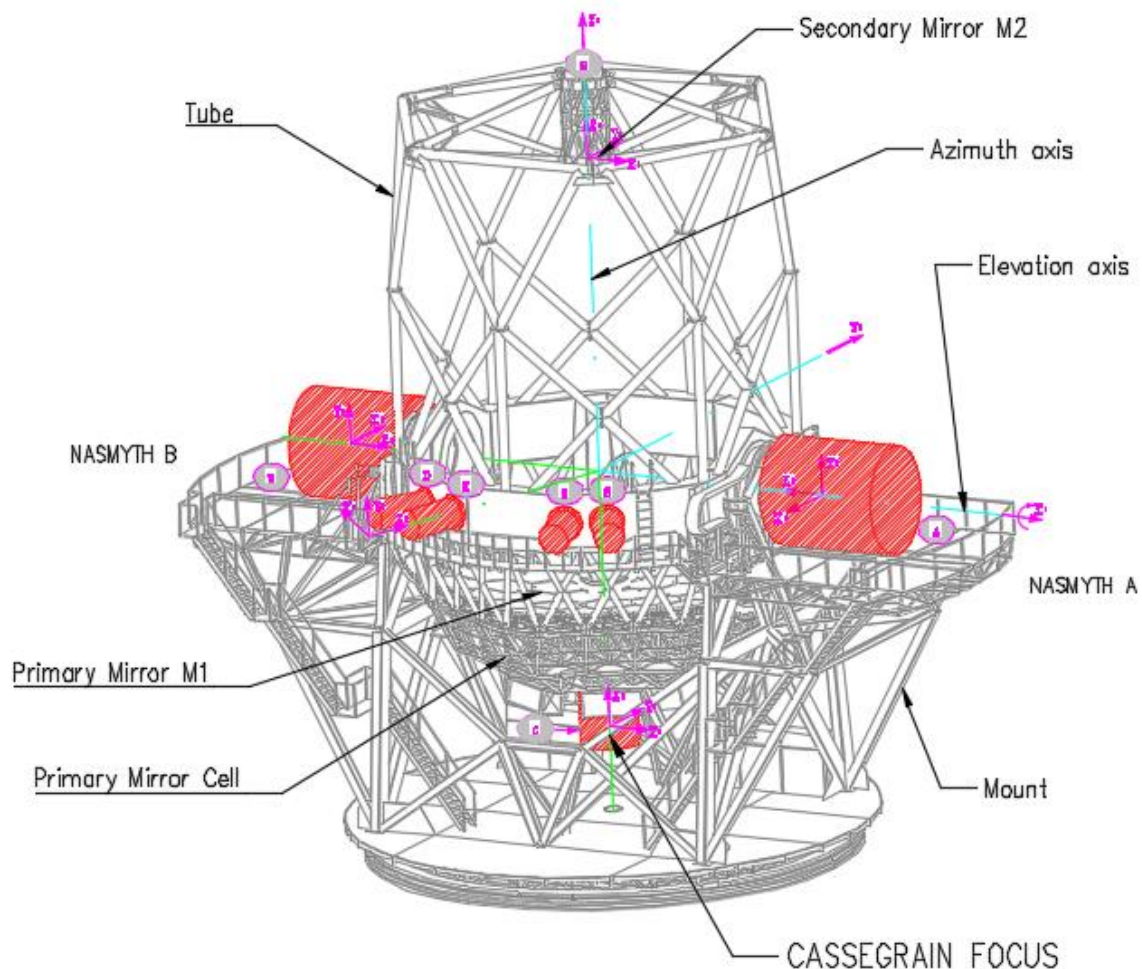


Fig. 1- Location of the Cassegrain Focus (Telescope Tube pointing to the Zenith).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 16 of 98
---	---	---

The light coming from the stars is reflected on a 10m Primary Mirror, then on a Secondary Mirror, and then to several Focal Stations in different locations on the Telescope by means of different mirrors. Science Instruments are attached and integrated into these focal stations and receive the light gathered by the Telescope.

The Telescope rotates around the mentioned Azimuth and Elevation axes in order to point to the desired angle in the sky placing the image of the target star or celestial object on the Science Instrument detector. The Instrument Rotator, keeps focal station oriented with the sky image as the Earth rotates. The Acquisition and Guiding (AG) Instrument, is an auxiliary instrument used to get the input needed to point to a reference star and guide the Telescope during the observation. It gets also some information on the optical beam used to make real time corrections in the optics of the Telescope. All the previous is needed in order to get the image still and sharp in the Scientific Instrument detector though hours for one single observation.

The AG System consists of a small optical Instrument (AG Instrument) and the AG Mechanics that support the instrument and it is capable to place it at any place of the field of view.

2.2 Requirements and guidelines

“Shall” is used for requirements no matter how stable they are, whereas “should” is reserved for guidelines. Requirements are mandatory and guidelines are not mandatory, although their fulfilment should be strongly pursued.

2.3 Verification deliverables

Requirements and guidelines verification is mandatory as long as a Verification Deliverable is specified. Verification Deliverables are documents or section of documents demonstrating design or product compliance with the corresponding requirement at the different Project review milestones through the Design and Product Phases.

Verification Deliverables expected at Design Phase are mostly specifically addressed (trade-offs, analysis or calculations). When referred as design “Description and justification” justification of the requirement compliance is required as well (by any of the mentioned methods or e.g. rationale for a component choice). Requirements whose fulfilment can be straight forward demonstrated with a mere “Description” of the corresponding aspect of the design are referred as such in the Verification deliverables paragraphs

During the Product Phase, the kind of written justification expected to show compliance is specified rather than a particular test or analysis (with exceptions). Specific test, analysis, etc... shall be proposed by the contractor within the verification matrix/verification plan, unless otherwise required. When “Inspection Report” is required compliance shall be visually or manually verified and certified in a written manner with the signature of the verifier. Inspection and/or Test Reports can be grouped in one or several documents, as desired.

2.4 Unstable and undefined requirements

Unstable or undefined requirements are identified by “TBC” or “TBD” respectively.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 17 of 98
---	---	---

2.5 Requirements code

Requirements are numbered with the code in the upper level title (between quotes) before the Requirement. The coding has the following format RQ/EC/NNN where:

“RQ” is fixed and means Requirement.

“EC” is the Configuration Element code (GTC Product Tree) to which the Requirement applies.

“NNN” is the Requirement number (used for this document chapter hierarchy).

In the example, bellow, all requirements hanging from 5.2 have the code SP/TL-IR-CG/... The “Instrument Rotator Concept” Shall have the code SP/TL-IR-CG/5.2.1.1.

5.2 Instrument Rotator (SP/TL-IR-CG/NNN)

5.2.1 Functional Requirements

5.2.1.1 Instrument Rotator Concept

In the case two codes appear between quotes, there shall be two identical requirements with different codes.

3 DEFINITIONS

3.1 Concepts

3.1.1 Telescope Tube

Is the structural part of the GTC Telescope subject to motion in elevation axis, it supports the Primary Mirror (M1), Secondary Mirror (M2) and Tertiary Mirror (M3) as well as the Cassegrain and Folded Cassegrain focal stations. See 2.1. The Telescope Tube interfaces the CG-Set at the Rotator Attachment flange.

3.1.2 Science Instrument

Equipment used for scientific purpose to be attached to one of the GTC focal stations and gather astronomical data from celestial targets with Science purposes. The Science Instrument is Out of Scope of this specification. The CG-Set interfaces the Science Instrument at the Science Instrument flange. For the purpose of this specification the Science Instrument shall be considered as a mass connected to the Science Instrument interface flange of the Instrument Rotator but it will not introduce any stiffness to that flange.

3.1.3 AG Instrument

Optical Instrument designed to support astronomical observations with Science Instruments (3.1.2). It consists in an optomechanical assembly and an electronic detector. The AG Instrument is Out of Scope of this specification. The AG Instrument interfaces the CG-Set at the linear stage surface in the Probe Arm. For the purpose of this specification the AG Instrument shall be considered a rigid body with a mass as specified.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 18 of 98
---	---	---

3.1.4 Pick-Off Mirror (POM) Unit

The POM is a flat mirror used to derive a small field of the GTC light beam to the AG Instrument (3.1). The POM Unit consist on the POM and its mount. The POM Unit is Out of Scope of this specification. The POM unit interfaces the CG-Set at the flange in the Probe Arm end. For the purpose of this specification the POM Unit shall be considered a rigid body with a mass and c.o.g. as specified.

3.1.5 AG Mechanics

Machine supporting the AG Instrument and Pick-Off Mirror and placing these in the desired position in the optical field of the GTC.

3.1.6 AG System

Assembly consisting of AG Mechanics, AG Instrument and POM Unit.

3.1.7 Rotator (or Instrument Rotator)

Machine supporting the Science Instrument and the AG Mechanics and rotating these to carry out field de-rotation, i.e. counteract the Earth rotation.

3.1.8 Electronics Enclosure (and Cabinet)

The Electronics **Enclosure** includes the thermal and structural envelope and its cooling system, but not the GC-Set electronics inside.

The Electronics **Cabinet** refers to the Enclosure plus the Electronics inside.

Sometimes is necessary or useful to refer to the "Cabinet" as a physical unit.

3.1.9 Cassegrain Set (CG-Set)

Consists of the Instrument Rotator, AG Mechanics, Electronics Cabinet (including Local Control HW and SW) and Support Elements.

3.1.10 Mean Preventive Maintenance Night-Time (MPMNT)

The MPMNT is the average fraction of night-time per year that the system is not available for operation due to planned (preventive) maintenance tasks.

3.1.11 Mean Preventive Maintenance Day-Time (MPMDT)

The MPMDT is the average fraction of day-time per year that the system is not available for operation due to planned (preventive) maintenance tasks.

3.1.12 Mean Time between Failures (MTBF)

The MTBF for a system is the mean time between two consecutive failures of the system.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 19 of 98
---	---	---

3.1.13 Mean Time to Repair (MTTR)

The MTTR for a system is the mean time spent in unplanned (corrective) maintenance to repair the system.

3.2 Coordinate Systems and references

3.2.1 Elevation Axis

Rotation axis of the Telescope Tube (3.1.1). There are physical references at the Telescope defining this axis.

3.2.2 Tube Axis

The Tube Axis is the axis of symmetry of the Telescope Tube (3.1.1). It is perpendicular to the Elevation Axis. There are physical references at the Telescope defining this axis.

3.2.3 GTC optical axis

It is the optical axis of the GTC optics (Primary and Secondary mirrors). Nominally coinciding with the Tube axis.

3.2.4 AG optical axis

It is the optical axis of the AG Instrument Optics.

3.2.5 Cassegrain Coordinate System

A coordinate system defined in R2 as follows (see Fig. 2):

- Origin at the Cassegrain focus of the telescope (in the Tube Axis, 7400 mm “bellow” the Elevation Axis).
- X-Axis is parallel to the Elevation Axis and points towards the Nasmyth A platform.
- Z-axis in the direction of the Tube Axis towards the secondary mirror (M2).
- Y-Axis forms a right-handed coordinate system with the two previous.

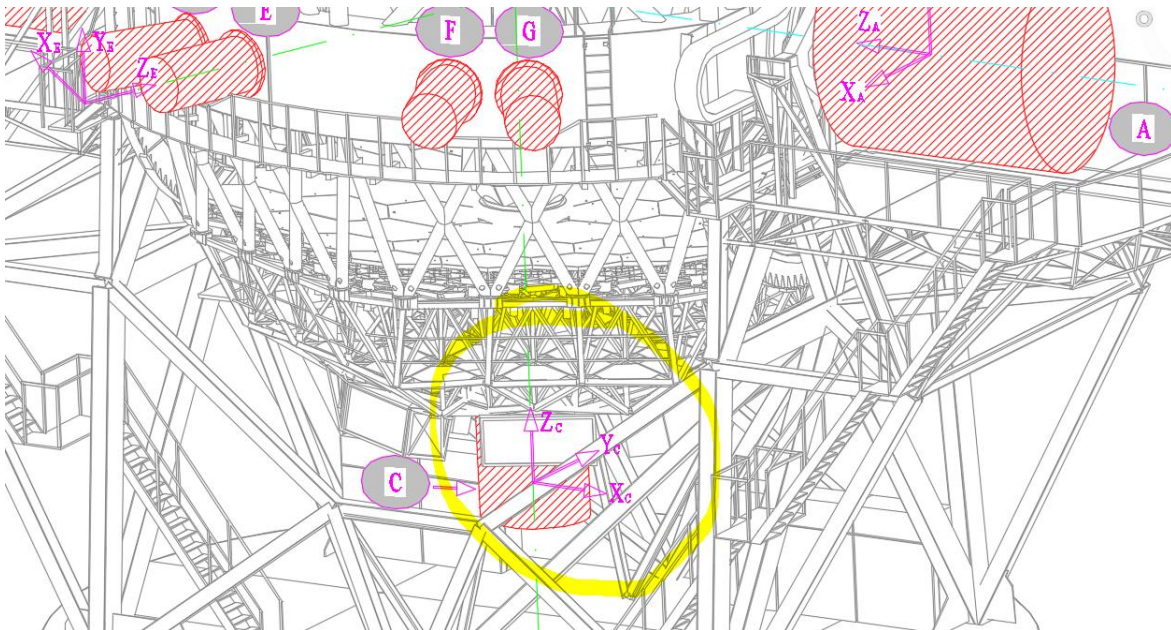


Fig. 2- Detail of the Cassegrain coordinate system

The Cassegrain Coordinate System rotates with the Telescope Tube around the Elevation Axis (see 3.1.1).

3.2.6 Pupil

The pupil of the telescope is the optical image of the aperture stop of the Telescope. For GTC the aperture stop is the Secondary Mirror (M2) and therefore it acts also as Exit Pupil.

As a geometrical reference, the nominal Pupil Plane is fixed to the Telescope Tube, perpendicular to the Cassegrain Z axis, located at $z = 18136.45$ mm from the Cassegrain origin (see Fig. 13). It is taken as reference to define some features of the CG-Set.

3.2.7 Science Instrument Coordinate System

The Science Instrument Coordinate System coincides with the Cassegrain Coordinate System for the nominal design. However, it is solidary attached to the Science Instrument, and therefore subject to gravity or manufacturing displacements and rotations of the Science Instrument flange.

It can be defined by:

- The Z-axis:
 - perpendicular to the Science Instrument flange plane (average if deformed)
 - intersects the Science Instrument flange plane at the centre of the centring diameter
 - positive towards the Pupil.
- The origin: at the Z axis, at -196mm from the Science Instrument flange plane.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 21 of 98
---	---	---

- The X axis: pointing to the same mounting pin of the flange as the X-axis of the Cassegrain Coordinate system does.
- The Y-axis forms a right-handed coordinate system with the X and Z axes.

3.2.8 **AG Instrument Coordinate System**

A coordinate system defined by physical references in the AG Instrument (out of scope) as follows:

- The origin is the centre of the AG Instrument aperture stop.
- The Z-axis runs in direction of the optical axis of the AG Instrument Optics against the incoming light.
- The Y-axis is perpendicular to the interface plane between the AG Instrument and the Focusing Mechanism, positive sense of Y-axis going away from the base plate.
- The X-axis forms a right-handed system with the two previous.

It depends therefore exclusively on the position and orientation of physical AG parts, rather than on the incoming light axes.

For practical purposes, the AG Instrument shall be considered rigid and therefore its co-ordinate system can be considered as part of the linear stage focus system in the AG Probe Arm. The relative position of the linear stage and the AG Coordinate System can be seen at A1.

3.2.9 **Virtual AG Instrument Coordinate System**

Is the virtual co-ordinate system obtained by reflection of the AG Instrument Coordinate System (3.1) on the Pick-Off Mirror of the Probe Arm, i.e. it is the AG Instrument Coordinate System as seen from the Cassegrain Focal Plane (see 3.2.10 Understanding Co-ordinate systems and geometric constraints).

The origins and Z-axes of the Virtual AG Instrument Coordinate System and the Cassegrain Coordinate System coincide when the POM is placed at the centre of the field of view, assuming nominal ideal conditions (no gravity, fabrication and alignment errors).

3.2.10 **Understanding Co-ordinate systems and geometric constraints**

The main references for the design are the ***Cassegrain Co-ordinates System*** (3.2.5 and the ***Pupil*** (3.2.6). These are fixed to the Telescope Tube, considered rigid for the purposes of this specification.

The nominal ***Science Instrument Co-ordinate System*** (3.2.7) is located at the centre of the Instrument focal plane¹ and coincides with the ***Cassegrain Co-ordinates System***.

The aim of the AG Instrument is to scan the Scientific Instrument focal plane. But the AG Instrument cannot be placed directly at the Instrument focal plane. Therefore, the AG optical beam must be folded by a pick-Off Mirror and taken to the AG Instrument in a different position. The ***AG Instrument Co-ordinate System*** (3.2.8) represents the actual position of the AG Instrument. The ***Virtual AG***

¹ Actually the focal surface is spherical rather than plane

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 22 of 98
---	---	---

Instrument Coordinate System (3.2.9) represents the position where the AG Instrument would be on the Scientific Instrument focal plane if it was possible to place AG instrument directly on the focal plane, as it is the Science Instrument. See Fig. 3

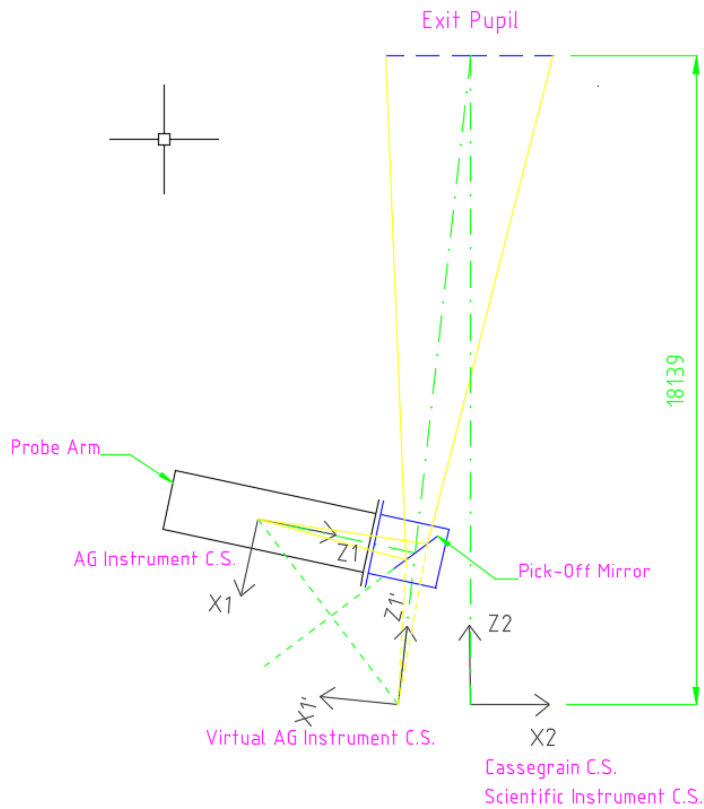


Fig. 3 - AG Instrument vs. Virtual AG Instrument coordinate systems

Requirement 7.2.1.1 (Probe Arm rotation axis passing through the Exit Pupil centre) constraints the movement of the Virtual AG Instrument origin to a sphere with the centre in the Pupil and passing through the Scientific Instrument Origin. The image of the sky produced by the telescope, the so called Focal Plane, is formed in a spherical surface centred in the optical axis but with a radius much smaller than the distance of the Exit Pupil, a focusing mechanism is needed to place the origin of the Virtual AG Instrument CS on this focal surface. See Fig. 4

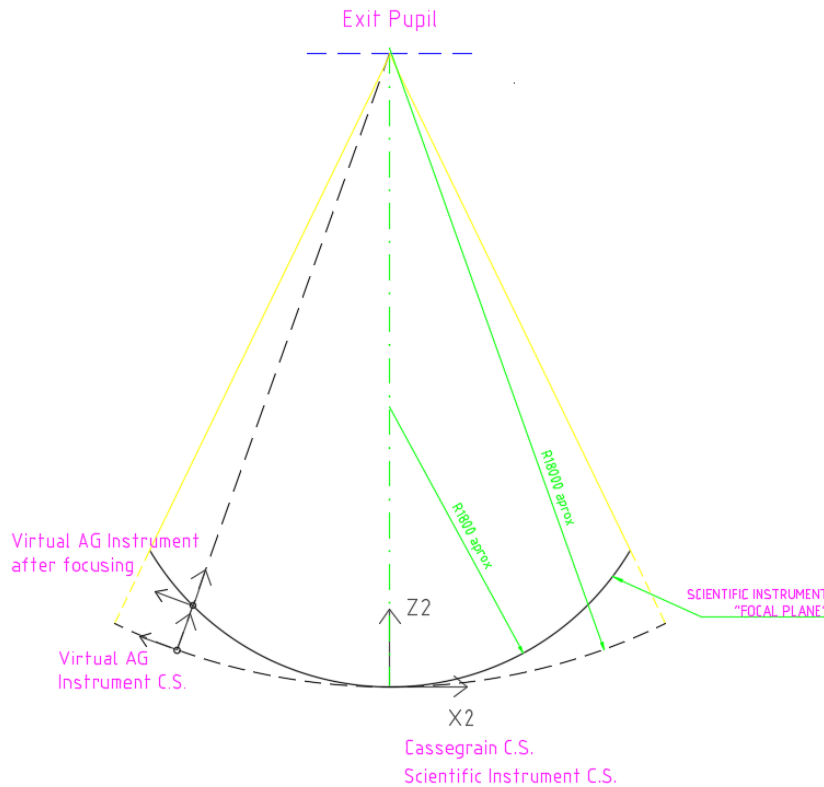


Fig. 4- Virtual AG Instrument w.r.t the Scientific Instrument Focal Plane

It is not necessary to constrain completely the position of the POM and AG Instrument. The parameters d , β and μ in Fig. 5 may vary as long as other requirements are fulfilled. Nevertheless, these parameters have been assigned a nominal value in the preliminary design with the criteria of minimizing the shadow of the Arm over the Scientific Instrument and minimizing the size of the whole system.

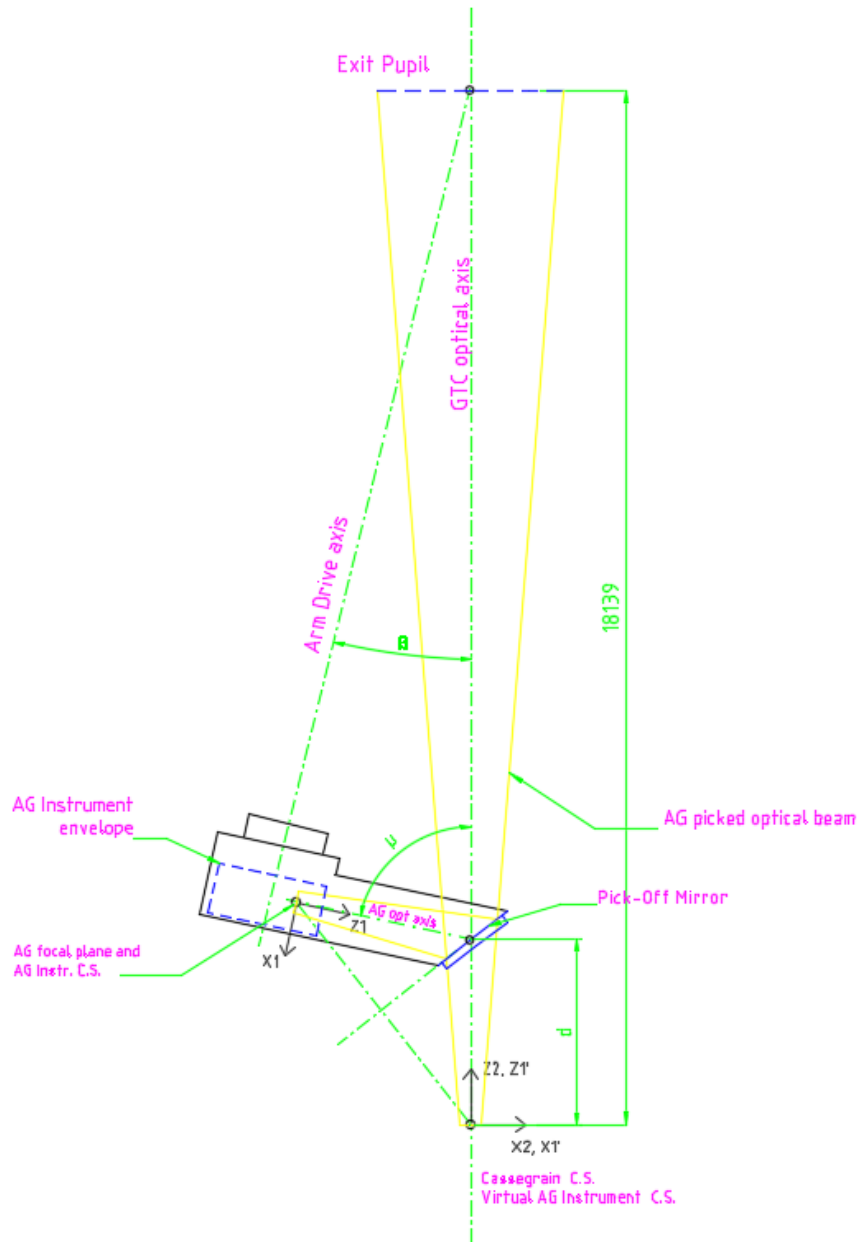


Fig. 5 - Geometrical restrictions (Probe Arm centred in the GTC optical field). Parameters d , β and μ are not fixed

Finally, *Virtual AG Instrument Coordinate System* and *Science Instrument Co-ordinate System* may deviate from their nominal positions under different gravity orientation, load, temperature, mechanisms position, etc... Some performance requirements hereafter constraint the deviations of these co-ordinate systems from their nominal position within certain limits.

4 SCOPE

The Requirements in this document apply to the Science Instrument Rotator and AG Mechanics of the Cassegrain Focal Station, as well as the corresponding Electronics Cabinet, including the Electronics inside and the Local Control System, and the corresponding support Elements (Transport Cart and Dummy Instrument). For simplicity, this all is called the Cassegrain Set or CG-Set.

General Requirements in 5 apply to any elements of the CG-Set.

Out of the scope of the present Requirements definition are the AG-Instrument and POM (Pick-Off-Mirror) Unit, as well as the Science Instrument cable chain, which is specific of the Instrument for this focal station.

The Transport Cart specified in this document and any Test Bench needed for any Test Campaign are different items. The Test Bench shall not be delivered at the GTC.

The reference document R1, *CG-Set Preliminary Design*, can be considered as a base for the Detailed Design of the CG-Set, which is the goal of the present Requirements definition. However, the design in R1 is not mandatory.

Fig. 6 shows the main subsystems of the CG-Set.

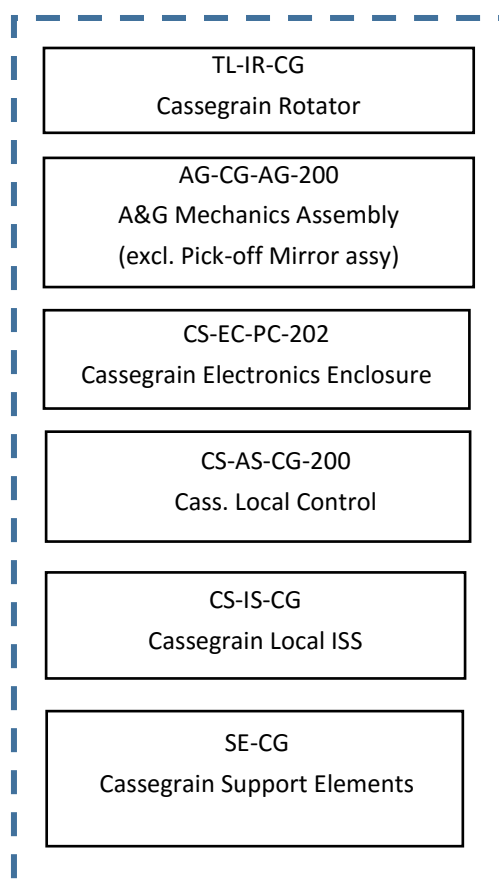


Fig. 6 - CG-SET SCOPE

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 26 of 98
---	---	---

These subsystems are grouped in 4 modules:

- Rotator + AG Mechanics (Core module of the CG-Set)
- Dummy Instrument
- Electronics cabinet (Enclosure+Control and Power Electronics)
- Transport Cart

The fig. hereafter shows other GC-Set subsystems and how these fit into the GTC Product Tree. Subsystems shown in grey are out of scope. Subsystems shown in White are within scope

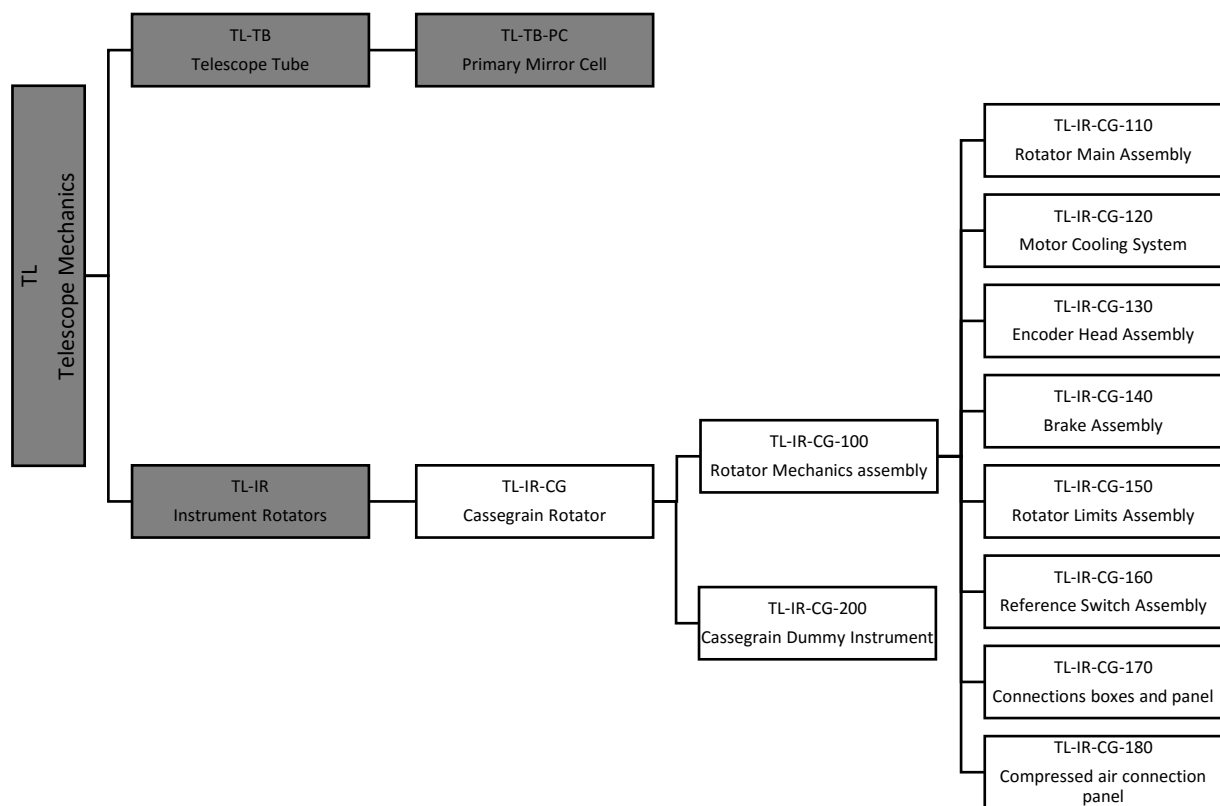


Fig. 7 - Rotator Product Tree (out of scope in grey)



Telescope Mechanics
Cassegrain Set (CG-Set) Specifications

Code: ESP/TELE/0216-R
Issue: 1.A
Date: 22/06/2017
Page: 27 of 98

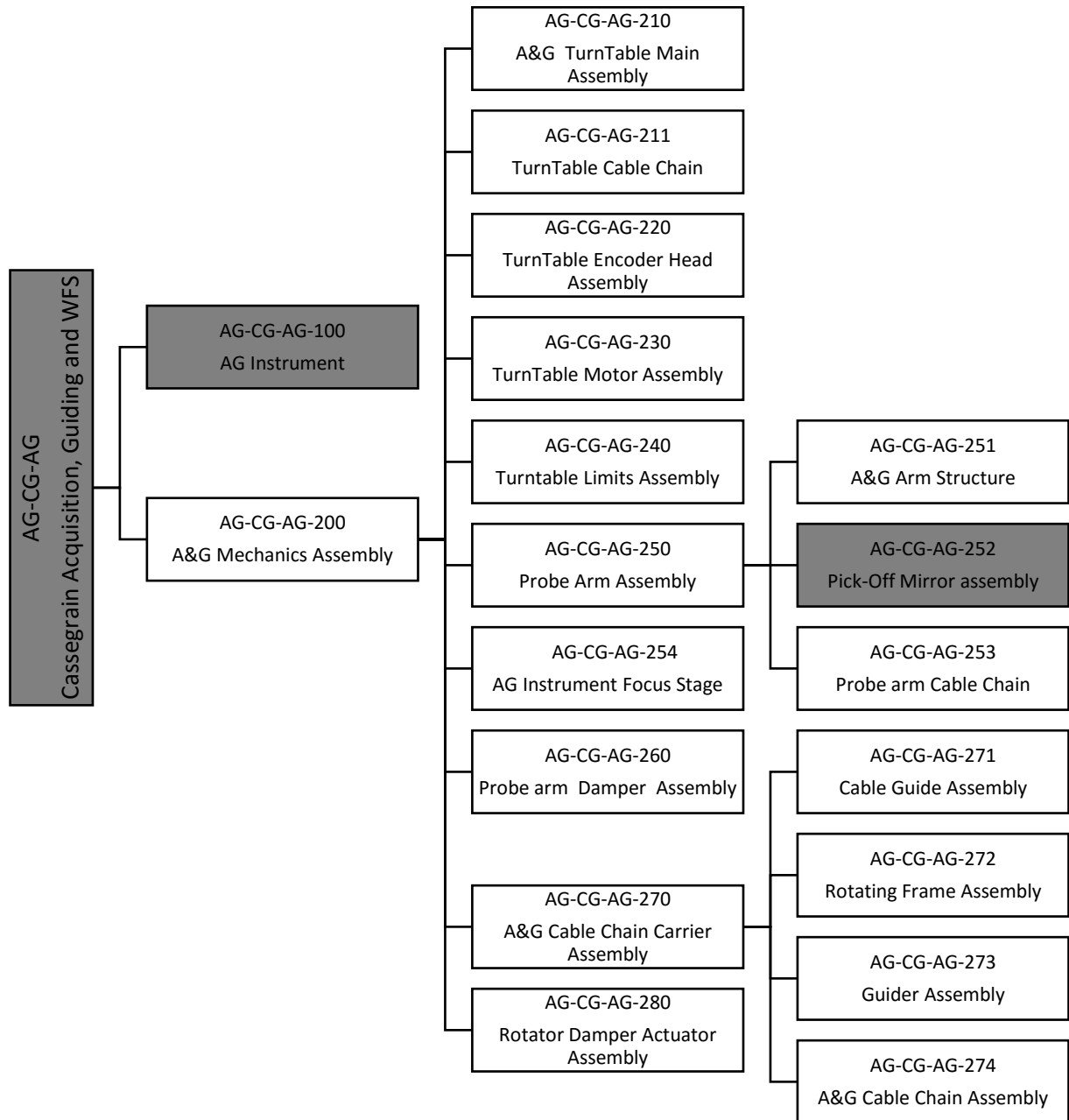


Fig. 8 - AG Product Tree (out of scope in grey)

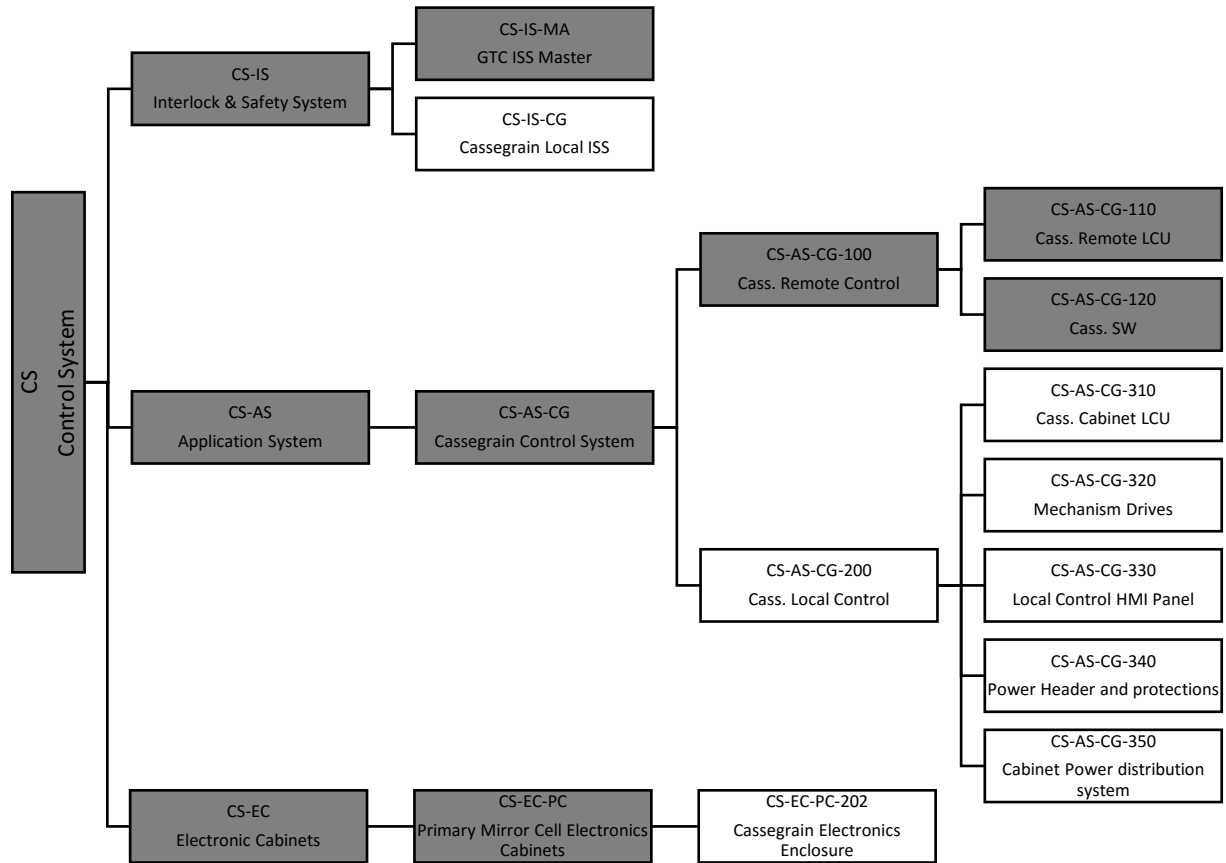


Fig. 9 - Control System Product Tree (out of scope in grey)

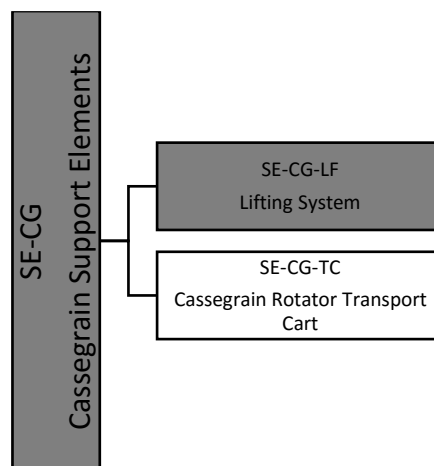


Fig. 10 - Support Elements Product Tree (out of scope in grey)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 29 of 98
---	---	---

5 CASSEGRAIN SET REQUIREMENTS (RQ/TL-IR-CG/NNN, RQ/AG-CG-AG-200/NNN, RQ/CS-EC-PC-202/NNN)

5.1 Functional requirements

5.1.1 CG-Set concept

The main functionalities of the CG-Set shall be (see Fig. 13):

- Support and rotate the Science Instrument (3.1.2), AG Instrument (3.1) and Pick-Off Mirror (3.1.4) simultaneously to compensate the rotation of the field of view during the movement of the Telescope
- Place the Virtual AG Instrument Coordinate System and Pick-Off mirror accurately with regard to the Telescope Pupil (3.2.6) and to the Science Instrument
- Keep the relative position of Science Instrument and AG Instrument throughout the astronomical observation.

Verification Deliverables

None

5.2 Design Requirements

5.2.1 Mechanical Requirements

5.2.1.1 Total Mass

The mass of the Instrument Rotator (TL-IR-CG) + AG Mechanics (AG-CG-AG-200) assembly shall be lower than 2500 kg (goal 2400kg).

Verification Deliverables

Design phase: Design document (mass budget). 3D model.

Product Phase: Test Report (weighting test).

5.2.1.2 Overall Mass Watching Guideline

Any possible mass reduction should be kept in mind during part design and component selection.

Verification Deliverables

Design phase: Design document (design trade-offs, if applicable).

5.2.1.3 Reference Temperature

The reference temperature for all the dimensions and tolerances, unless otherwise specified, shall be 8.5°C. This affects all drawings and metrology reports requiring possible extrapolations.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 30 of 98
---	---	---

Verification Deliverables

Design phase: All drawings must specify the reference temperature.

Product Phase: Metrology reports shall specify measurement temperature, measurements and extrapolated dimensions to reference temperature.

5.2.1.4 Cable and ducts rotation policy

Any device requiring services as cooling water, compressed air or electrical power shall be placed in the non-rotating part of the rotator, except for the AG system, which will have a specific cable chain. The cable chain connecting the Telescope and the Scientific Instrument is out of scope.

Verification Deliverables

Design phase: Design Document (description). 3D model.

Product Phase: Inspection report

5.2.1.5 Cable chains

The following cable chains shall be used to guide cable and ducts movement from the “static” part to the “rotating” part

- AG Chain: From the Telescope Tube to AG Mechanics
- Turn Table Chain: From AG Structure to AG Turn Table
- Probe Arm Chain: From AG Turn Table to AG Probe Arm

Cable chains section shall be dimensioned with at least a 30% free section for future cabling.

Cable chains length shall be dimensioned with reasonable safety margin over the maximum rotation angle (rotation end dampers completely compressed) at each side.

It shall be possible to detach the whole chain from the assembly and substitute the cables inside it, if possible without the need to dismount the whole chain.

Cable rotator guiding elements should be coated or covered with Teflon or a similar material in order to reduce friction.

Verification Deliverables

Design phase: 3D model. Design document (description). Drawing (cable chains section). Component List.

Product Phase: Inspection report. Functional test report (vertical & horizontal).

5.2.1.6 Cable and ducts in cable chains

All the conducts going through the cable chains shall be specific for use inside cable chains. In case of cable chain bending in two directions with various cables/ducts on top of each other, conduct-braids shall be formed.

All the cable and ducts shall have a lower allowable minimum dynamic bending radius than the smallest bending radius of the cable chain.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 31 of 98
---	---	---

Verification Deliverables

Design phase: Cable and ducts list.

Product Phase: Inspection report

5.2.1.7 Cable chains connection panels

Each cable chain shall have a connection panel at one end:

- AG Chain- From Rotator “fixed” module to the AG main structure. Panel at fixed module
- Turn Table Chain- from the AG main structure to the Turn Table. Panel at AG main structure
- AG Arm Chain: From the Turn Table to the AG Arm. Panel at the Turn Table

Distribution boxes for sensors, switches, etc. shall be placed on the panels reducing the number of cables going through the cable chains.

Rotator Panel shall be dimensioned with at least a 15% free space for new connectors.

Easy access to connection panels shall be guaranteed.

Clearance between connectors shall allow the space needed for the tools used to install the connectors on the panels as well as for either the hands or the tools needed to make the connections.

Connectors on the panels shall be “aerial” on the cable going towards the devices involved in maintenance operations and towards the Electronic Cabinet and “back-panel mounted” on intermediated sections of the cables (TBC depending on the foreseen maintenance).

Connection panels shall be thoroughly documented.

Verification Deliverables

Design phase: Connector panels drawings shall show (several sheets allowed):

- Panel manufacturing drawing
- Connectors mounted in panel
- A table with the fields: hole number in panel, connector code, type, brand/reference, tool for installation, tool for connection
- Some sketches showing the complete panel and the tools Reflected on it demonstrating the space available for maintenance operations

Product Phase: Inspection report. Drawings. Operation and Maintenance Manual.

5.2.1.8 Instrument Protection Cover and Shutter

The GC-Set shall provide a cover between the Scientific Instrument envelope and the probe arm in order to protect the Scientific Instrument against tools drop, water drop, etc...

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 32 of 98
---	---	---

The cover shall have a central hole respecting the Accessible Field of View defined in 5.2.4.2. The hole shall be covered by a shutter which can be opened and closed. Both the cover and the shutter shall stand the weight of a person (for maintenance purposes).

The mechanism used to move the shutter shall comply with the following (TBC):

- The shutter shall allow only 2 positions, closed and open. The default position shall be open. In both positions, the cover shall be clamped, ensuring it does not move for any angle of the Telescope Tube.
- A small electrical box with a push button shall be provided with a 5m cable (TBC) and a connector (type TBD) at the Rotator connection panel. It shall be possible to open/close the shutter with the push button by means of a 0-24V signal. The box shall be ready for wall-mounting with bolts.
- There shall be a sensor to inform the Cassegrain Local Control about the status of the door
- The mechanism and its control shall be as simple and robust as possible
- There shall be always the possibility to open or dismount the shutter manually in less than 15 minutes in order to ensure there is no night time lost in case of the shutter mechanism failure.

The cover and shutter, seen as a maintenance platform, shall be particularly taken into account in the Safety assessment.

Verification Deliverables

Design phase: Design Document (Description and justification), RAMS analysis, 3D model.

Product phase: Inspection report. Test report (functional tests)

5.2.1.9 Fool-proof design

The design of mechanical attachments between components shall avoid human error, without the need to look at the drawings ("Poka-yoke" approach and such), e.g. by making holes matrices different for different components so that only one component can be fixed only at a given location.

Verification Deliverables

Design phase: Design document (descriptions). Drawings, 3D model.

Product Phase: Inspection report.

5.2.1.10 Co-ordinate Systems

Any documentation deliverable (drawings, documents including calculations) shall restrict to the Co-ordinate Systems defined in section 3, unless otherwise agreed.

Verification Deliverables

Design phase: Drawings, 3D model, FEM, Error Budget, Design.

Product Phase: Idem.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 33 of 98
---	---	---

5.2.2 Material Requirements

5.2.2.1 Structural material

All the structure elements shall be made of carbon steel S275.J2.G3C or of higher quality if deemed necessary.

Verification Deliverables

Design phase: Component List. Drawings

Product Phase: Structural parts material certificate

5.2.2.2 Thermal Expansion Coefficient Guideline

The use of non-ferrous metal for the rotator components should be minimised to avoid differential thermal expansions.

Verification Deliverables

Design phase: Component List. Drawings. Design document (identification and justification of non-ferrous important parts)

5.2.2.3 Cooling System Materials

Any material shall be qualified for use with glycol and under the conditions specified for water in A1, with the applicable margins, and for environmental conditions in 5.4.1.

Stainless steel shall be used for connectors and fittings.

The cooling system shall be verified against leaks at a pressure at least 50% higher than the working pressure.

The system shall be delivered full of water and free from air.

Verification Deliverables

Design phase: Design document (Motor, Enclosure). Component List

Product Phase: Inspection report. Test Report (leak tests).

5.2.3 Surface Protection

5.2.3.1 Surface protection

All surfaces shall be adequately protected against climatological conditions.

All functional surfaces normally not painted, such as attachment flanges, shall be accordingly and permanently protected against the climatologic conditions while respecting the respective specified surface tolerances. Mere use of oil or grease is not admitted.

Verification Deliverables

Design phase: Design document (description and justification). Manufacturing drawings

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 34 of 98
---	---	---

Product Phase: Surface treatment/coating certificates.

5.2.3.2 Surface protection optical properties

All parts of the CG-Set facing to the Science Instrument aperture (seen by the detector) or the inside of the Telescope Tube shall be painted with a high absorbance paint (optically black) and uniformly scattering characteristics (for example Nextel Velvet-Coating 811-21, or black nitrocarburizing or matt black nickel plating for small pieces, handles, etc...).

Verification Deliverables

Design phase: Design document (description and justification). Manufacturing drawings

Product Phase: Surface treatment/coating certificates.

5.2.4 Optical Requirements

5.2.4.1 Stray light control

Any part of the CG-Set emitting light (encoders, signalling LEDs ...) shall be covered to avoid any stray light on the Science Instrument.

Verification Deliverables

Design phase: Design document (list of light emitting components and solutions)

Product Phase: Inspection Report.

5.2.4.2 Accessible Field of View Optical Beam

The Optical Beam corresponding the Accessible Field of View is defined as the truncated cone in Fig. 11.

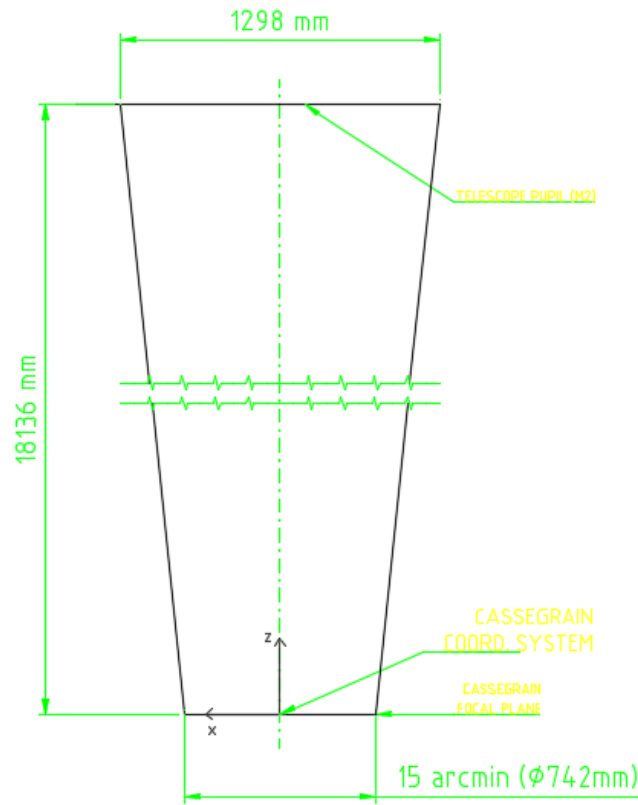


Fig. 11 Accessible Field of View

No part of the CG-Set shall obstruct the section of the Accessible Field of View, except for the AG Probe Arm when it is deployed.

Verification Deliverables

Design phase: 3D model, drawings, with the optical beam represented.

Product Phase: Inspection report (measurement)

5.2.5 Thermal Requirements

5.2.5.1 Heat dissipation in the Telescope Chamber

The maximum heat dissipation to the air by the CG-Set modules shall be 150W for the Rotator and AG Mechanics and 150W for the Electronics Cabinet.

Verification Deliverables

Design phase: Design document (thermal budget, cooling system calculations).

Product Phase: Test report (TBD).

5.2.5.2 Thermal Inertia guideline

Thermal inertia should be minimized.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 36 of 98
---	---	---

Verification Deliverables

Design phase: Design document (description and justification).

5.2.5.3 Active thermal control

If passive thermal control is not enough to meet requirement 5.2.5.1 and 5.2.5.2, active thermal control systems shall be implemented to remove the heat away from the focal station. There is cooling water available for this aim at a location close to the CG-Set with the specifications in A1. Motors shall be cooled using cooling circuit V and heat exchangers in the Electronic Cabinet with cooling circuit IV.

Interface connectors with GTC are defined in A1.

Verification Deliverables

Design phase: Design document (Cooling system design and calculations).

Product Phase: Inspection report, Test report (functional).

5.2.6 Electrical Requirements

5.2.6.1 Earthing

Metallic structures shall be electrically connected to the Telescope structure. Electrical apparatus shall be additionally connected to the GTC electrical supply earthing. Earthing ways should have a star like connection, avoiding loops and guaranteeing the functionality of Ground Fault Switches according to the applicable regulations.

Verification Deliverables

Design phase: Design document (description and justification). Electrical drawings.

Product Phase: Inspection report. Test report (electrical resistance measurements)

5.2.6.2 EMC Standards

Each subsystem of the CG-Set shall meet the electromagnetic emission generic standard UNE-EN 50081-2 and the electromagnetic immunity generic standard UNE-EN 50082-2, or equivalent present directives EN61000-6-X comprising them.

Verification Deliverables

Design phase: Identify electronic components with no CE mark. UNE-EN 50081-2 and UNE-EN 50082-2 must be covered by the standards fulfilled by those components.

Product Phase: CE mark of CG-Set

5.2.6.3 Connectors

All individual connections leaving or arriving to single or multipolar terminal blocks should be finished with an equivalent section crimped ferrule with back sleeve. With single or

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 37 of 98
---	---	---

multipolar connectors with covers, cables leaving or arriving to internal pins should be carefully soldered and protected with heat shrink sleeves.

Connectors physical configuration shall avoid human errors in pairing couples not belonging to each other, even if both pairs look the same (“Poka-yoke” approach and such), e.g. by rotating the pin matrix with regard to the connector body.

Verification Deliverables

Design phase: Cables and connectors list. Design Document (description)

Product phase: Inspection report.

5.2.6.4 Cabling scope

Within scope:

- Cabling between Electronics enclosure and Rotator /AG Mechanics.
- Cabling between AG Instrument electronic box and Electronics enclosure (DC power)
- Cabling between AG Instrument electronic box and Electronics enclosure (Fibre Optics)

Out of Scope:

- Cabling from GTC Control System to Electronics enclosure
- Cabling from GTC electrical supply to Electronics enclosure
- Cabling from GTC Interlock and Safety System to Electronics enclosure

Verification Deliverables

Design phase: Electrical drawings. Cable list

Product phase: Inspection report.

5.2.6.5 Cable, Connector and Device labelling

All cables, connectors and shall have identification:

- The connector code, consistent with the corresponding electrical drawing
- A unique identification allowing to pair connector couples (male-female) without looking at the drawings, e.g. the name of the device, “Encoder”. This may be skipped if both connector in a couple have the same code or share part of the code so that there is no possibility of mistake when making the connection.
- Mechanical stability and ambient resistance shall be guaranteed.

This requirement applies to devices foreseen to be involved in maintenance operations as well.

Verification Deliverables

Design phase: Component list

Product phase: Inspection report.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 38 of 98
---	---	---

5.2.6.6 Cabling Fire Prevention

Cabling shall be selected to prevent fire from spreading through it, according to current regulation.

Verification Deliverables

Design Phase: Cable List, Design Document (List of applicable Standards and Regulations).

Product Phase: Idem.

5.3 Performance Requirements

5.3.1 Relative Pupil error AG Instrument - Science Instrument

The optical axis (**Z-axis**) of the **Science Instrument Coordinate System** (3.2.7) and the **Z-Axis** of the **Virtual AG Instrument Coordinate System** (3.2.9) shall intersect with the **Exit Pupil plane** (3.2.6) at the same point with a deviation less than 5.9mm:

- under the temperature variations in 5.4.1
- for any position of the probe arm on the accessible field of view (5.2.4.2)
- for any Telescope Tube orientation (5.4.2)

See Fig. 12.

The alignment error of the POM relative to the AG Instrument shall not be considered.

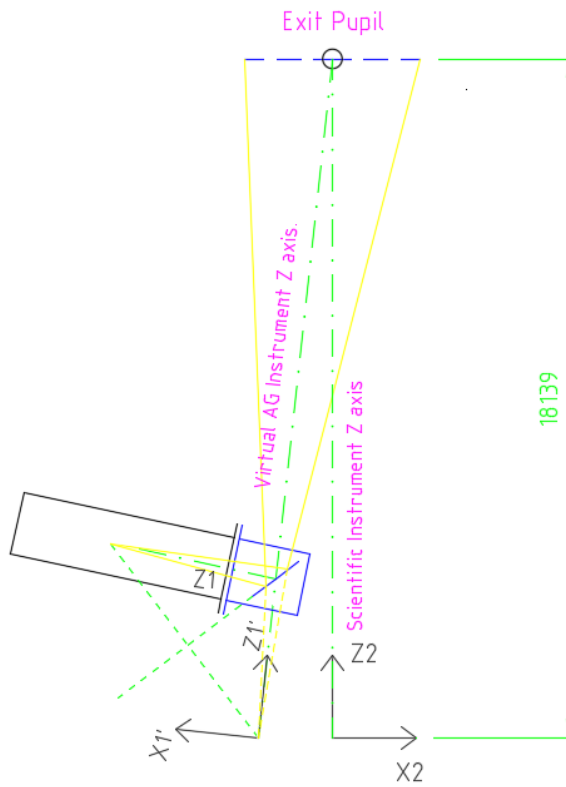


Fig. 12 – Schematic representation showing the Probe Arm in an off-axis field. In the nominal case the **Science Instrument Optical Axis** and the **Z axis of the Virtual AG Instrument Coordinate System** intersect the **Exit Pupil** at the same point for any field.

Verification Deliverables

Design phase: Design Document (Error budget updated). FE analysis

Product phase: Test report (at least validating the FE model with an appropriate bending test). Metrology reports. Final Error Budget (corrected with estimated/measured/specified values)

5.3.2 Lateral positioning error (AG Instrument relative to Science Instrument)

The RMS two-dimensional lateral positioning error of the AG Instrument (virtually at the focal plane) with respect to the Science Instrument shall be better than $82.4\mu\text{m}$ (0.1 arcsec):

- after any point to point movement. Errors in a point to point movement shall be understood as the difference between final position (Probe Arm stationary and brake applied) and demand position.
- after dismounting and re-mounting of the POM or the Linear Stage.
- under any temperature variations in 5.4.1.
- for any position of the probe arm on the accessible field of view (5.2.4.2) and corresponding position of the focus linear stage, or any Telescope Tube orientation (5.4.2).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 40 of 98
---	---	---

Fabrication and mounting errors shall not be considered since relative positions shall be calibrated once both Instruments are installed at the GTC.

Geometrically, this requirement refers to the Virtual AG Instrument Coordinate System X-Y-position relative to the Science Instrument Coordinate System.

Verification Deliverables

Design phase: Design Document (Error budget updated). FE analysis

Product phase: Test report (at least validating the FE model with an appropriate bending test, encoders calibration, non-repeatable terms, linear positioner). Final Error Budget (corrected with estimated/measured/specified values)

5.3.3 Lateral position stability (AG Instrument relative to Science Instrument)

The RMS two-dimensional lateral position stability of the AG Instrument (virtually at the focal plane) with respect to the Science Instrument shall be better than $58.3\mu\text{m}$ (0.071 arcsec):

- while Rotator is turning (whole range considered), being Arm and Turn Table previously stopped.
- under any temperature variations in 5.4.1.
- for any position of the probe arm on the accessible field of view (5.2.4.2) and corresponding position of the focus linear stage, or any Telescope Tube orientation (5.4.2).

Geometrically, this requirement refers to the stability of the Virtual AG Instrument Coordinate System X-Y-position relative to the Science Instrument Coordinate System.

Verification Deliverables

Design phase: Design Document (Error budget updated). FE analysis

Product phase: Test report (at least validating the FE model with an appropriate bending test). Final Error Budget (corrected with estimated/measured/specified values)

5.3.4 Axial positioning error (AG Instrument relative to Science Instrument)

The axial positioning error of the AG Instrument (virtually at the focal plane) with respect to the Science Instrument shall be better than $55\mu\text{m}$:

- after any point to point movement. Errors in a point to point movement shall be understood as the difference between final position (Probe Arm stationary and brake applied) and demand position.
- after dismounting and re-mounting of the POM or the Linear Stage.
- under any temperature variations in 5.4.1.
- for any position of the probe arm on the accessible field of view (5.2.4.2) and corresponding position of the focus linear stage, or any Telescope Tube orientation (5.4.2).

Fabrication and mounting errors shall not be considered since relative positions shall be calibrated once both Instruments are installed at the GTC.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 41 of 98
---	---	---

Geometrically, this requirement refers to the Virtual AG Instrument Coordinate System Z-position relative to the Science Instrument Coordinate System.

Verification Deliverables

Design phase: Design Document (Error budget updated). FE analysis

Product phase: Test report (at least validating the FE model with an appropriate bending test, non-repeatable terms). Final Error Budget (corrected with estimated/measured/specified values)

5.4 Environmental Constraints

5.4.1 Climatological Conditions at the Telescope Chamber

The CG-Set shall be designed to operate and survive under the conditions stated in Table 1.

	Nominal conditions	Limit of operation	Survival limit
Temperature	-2°C to +19°C	N/A	-15°C to +35°C
Thermal variation (at night) in 15 minutes	0°C to 0.9°C	N/A	N/A
Thermal variation (at night) in 1 hour	0°C to 1.8°C	N/A	N/A
Thermal variation (at night) in 2 hours	0°C to 2.4°C	N/A	N/A
Relative humidity	2% to 87%	90% (or condensation)	0% to 100% with condensation
Atmospheric pressure	770 to 790 mbar	N/A	N/A
Wind	13m/s	22m/s with gusts up to 27m/s	55m/s with gusts up to 67m/s

Table 1 Climatologic conditions.

Nominal conditions are those in which the specified performances shall be matched without any degradation.

Exceeding the nominal conditions and until the **limit of operation** it shall be possible to operate the system accepting performance degradation.

The **survival limit** shall be reached not necessarily in operative status.

Note: Usually, on the telescope site the relative humidity reaches very low values what can lead to problems with the electronics. There are also problems with hygroscopic materials which can become fragile under these conditions (i.e. cable ties made of polyamide 6.6), ...

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 42 of 98
---	---	---

Design phase: Individual components specs showing operation ranges. NOTE: this requirement is verified at other requirements verification which need to have these conditions into account for designing and modelling.

Product Phase: Inspection Report. Component List. NOTE: this requirement is verified at other requirements verification which need to have these conditions into account for designing and modelling.

5.4.2 Gravity orientation

The CG-Set shall operate at nominal performances at any position of the Telescope Tube, i.e., -1° to 91°.

Verification Deliverables

Design phase: FEM analysis.

Product Phase: Test report. All requirements where fulfilment is specifically required for any orientation shall be verified at least in their worst-case orientation.

5.4.3 Earthquake overload

The CG-Set shall withstand seismic acceleration overloads without damage. The seismic overload can be considered as quasi-static loads of 0.3g in any direction without damage.

Verification Deliverables

Design phase: FEM analysis.

5.4.4 Dust Environment

The CG-Set shall be able to operate without degradation of the required performance during and after episodes of Saharan dust with concentrations of 100µg/m³ during 12h. Equipment at the GTC shall include protection means for dust or cleaning procedures if deemed necessary. The operation and preventive maintenance activities shall consider three episodes of 100µg/m³ during 12h per year.

Verification Deliverables

Design phase: Design document (design solutions description). 3D model.

Product Phase: Cleaning tasks and corresponding procedures in the Maintenance documentation, if necessary, etc...

5.5 Standards and Regulation Requirements

5.5.1 Applicable standards and regulations

Any equipment, software or documentation shall conform to the corresponding applicable Spanish and/or European standards and regulations at the time of delivery, particularly those related to safety. The contractor is responsible for the identification, application and certification, when needed, of such standard and regulations.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 43 of 98
---	---	---

From the point of view of the European Machinery Directive, the CG-Set shall be considered as a Machine instead of as a quasi-machine to be integrated in the GTC machine.

In case of conflict of the applicable regulations with the requirements in the present document, applicable regulations have prevalence over requirements. In such case, the contractor shall inform GRANTECAN as soon as the conflict has been identified.

Verification Deliverables

Design phase: Design Document (List of applicable standards and regulations). RAMS (applicable Safety Standards and Regulations)

Product Phase: List of applicable standards and regulations updates at the time of acceptance. Certificate of compliance with the standards and regulations.

5.5.2 Single components CE mark

Any single part and component of the CG-Set, except for mechanical workshop parts, shall have the CE mark. Exceptions must be justified by a written report and are subject to approval.

Verification Deliverables

Design phase: Component List shall have a field for CE marking.

Product Phase: Inspection Report.

5.5.3 CG-Set CE mark

The CG-Set shall be certified for CE mark.

Verification Deliverables

Design phase: CE mark certification draft

Product Phase: CE mark certification

5.6 Logistic Support Requirements

5.6.1 Reliability Requirements

5.6.1.1 Reliability Design Criteria

The design shall maximize reliability, between others, by using the following design criteria, where possible:

- Design margins
- Part tolerances in drawings
- Selection of off-the-shelf materials, parts, equipment and processes in accordance with proven standards, proved technology design solutions and based on widely available trade mark components (Non-standard items shall be identified and declared within the design documentation).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 44 of 98
---	---	---

- Redundancy
- Minimize complexity and number of components
- Use of fail-safe elements

Verification Deliverables

Design phase: RAMS analysis (Reliability Analysis)

5.6.1.2 Service Life Time

The service life time of the CG-Set shall be at least 50 years.

Verification Deliverables

Design phase: RAMS document (all sections), Spares list, Maintenance Procedures.

Product Phase: Operation and Maintenance Manual (Anything expected to be done within the next 50 years, potential component replacement expected, etc...)

5.6.1.3 MTBF

The Instrument Rotator shall have an MTBF of at least 16000h and the AG-Mechanics of at least 9000h.

Verification Deliverables

Design phase: RAMS (Reliability analysis).

5.6.2 Maintainability Requirements

5.6.2.1 Maintenance design criteria

The following criteria shall be taken into account through the design and the documentation of the Logistic Support activities:

- Prioritize reliability over maintainability, within cost constraints
- Prioritize spares to repair, within cost constraints
- Maintenance levels: by order of preference, maintenance shall take place at:
 - The GTC premises
 - Local workshops or dealers in La Palma or Tenerife islands
 - At the provider premises, somewhere else
- Minimize daytime maintenance, eliminate night time maintenance
- Minimize personnel and skills required for maintenance activities.
- Parking position of the telescope when non-operating is horizontal pointing.

Verification Deliverables

Design phase: RAMS document (all sections), Component List, Spares list, Maintenance Procedures.

Product phase: Operation and Maintenance Manual

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 45 of 98
---	---	---

5.6.2.2 Maintainability design guidelines

The design shall maximize maintainability, between other, by the following guidelines:

- Modularity. Divide the System into modules using functional, integration or verification, operation or maintenance criteria, limit maintenance to the removal of one module, use plug-in modules where possible.
- Accessibility. Make key components and components requiring frequent maintenance directly and easily accessible, access openings adequate in size and optimally located, use access doors with hinges.
- Handling, Mounting and dismounting. Use slides or pins to facilitate module installation, provisions to preclude the installation of the wrong module, provide lifting points and warning labels for heavy items.
- Fasteners. Minimize fasteners and use quick-release type where possible
- Standardization. Use the same components through different subsystems and the same or similar as in other GTC subsystems. Use off-the-shelf components, if possible, found at local dealers.
- Adjustments and alignments. Minimize adjustments requirements and frequency.
- Calibration. Minimize calibration requirements and frequency
- Maintenance tools. Minimize use of tools, use standards tools for access, handling, adjustments and any other maintenance activity.
- Human factor. Incorporate provisions for potential human error minimization.
- Ergonomics- incorporate ergonomics provisions in accordance with maintenance activities (stand-offs, handles over the centre of gravity, module size, weight and location, panel displays and controls accessible).
- Self-test provisions. Automatic self-test provisions with warnings according to the level of complexity.
- Test points. Provide accessible test points for problem diagnosis.
- Product marking. Label modules, access doors, test points, safety warnings, exchangeable parts and pieces, cables and hoses. Use nomenclature consistent with drawings. Labels must be short but meaningful, short and readable, in a visible place, firmly attached and protected against friction and environment.

Verification Deliverables

Design phase: Design Document (design descriptions). RAMS Document (Maintainability section, refer to each of the stated criteria and how it has been taken into account. Accessibility list, taking into account the Telescope structure in the 3D model supplied by GRANTECAN).

Product phase: Inspection report (accessibility and others TBD). Operation and Maintenance Manual

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 46 of 98
---	---	---

5.6.2.3 MTTR

The Instrument Rotator shall have an MTTR of less than 6h and the AG-Mechanics of less than 2h. Failures requiring dismounting the Scientific Instrument to repair the Rotator or AG Mechanics shall consider 8h time to dismount and mount the Instrument.

Verification Deliverables

Design phase: RAMS (Reliability analysis).

5.6.2.4 Day Time Preventive Maintenance

The daytime preventive maintenance for the FC-Set shall be less than 1 person-hour per month (TBC).

Verification Deliverables

Design phase: RAMS-Maintenance Procedures (preventive tasks).

Product Phase: Operation and Maintenance Manuals (preventive tasks).

5.6.2.5 Night Time Preventive Maintenance (MPMNT)

The CG-Set shall have an MPMNT of 0 hours.

Verification Deliverables

Design phase: RAMS (Maintenance Procedures).

Product Phase: Operation and Maintenance Manuals.

5.6.2.6 Spares list

At least the following spares shall be supplied for five years operation:

- 1 Rotator motor electronic drive
- 1 AG Turn Table electronic drive
- 1 Probe Arm electronic drive
- 1 Focus linear table electronic drive (in case drives for Probe Arm and Focus linear table are different)
- Parts for the Cable Chain (crossbars, separators, cable holders,...)
- Parts for the Cable chain system (rollers, axis,...)
- 2 encoder heads each kind
- Paint
- 1 limit switch each kind
- 1 fan for the heat exchanger
- 1 fan for each Servostar Drive
- Any other spare deemed necessary from the from the reliability and/or maintainability analysis

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 47 of 98
---	---	---

Design phase: RAMS (spares list).

Product Phase: Inspection report. Operation and Maintenance Manual.

5.6.3 Assembly, Packaging, Handling, Storage and Transportation

5.6.3.1 **Package dimensions for road transport**

Items to be transported and integrated at the GTC site, ORM, La Palma, shall comply with the dimensions indicated in the table below (TBC).

	Recommended limit	Maximum limit
Elevation (including package)	2.7 (trailer height 1.3 m)	3.1 m (trailer height 0.9 m)
Total elevation	4 m	4 m
Plant: width x length (including package) ²	Anywhere from 4.5m x 6m to 2.5m x 8m	Anywhere from 5.5m x 5.5m to 2.5m x 12m
Mass (excluding package)	12t	19t

The provider shall be responsible for safe transportation of the item up to the place in the GTC where the item is going to be unpacked, including adequate packaging, lifting provisions, etc..., Special transportation permits may be needed. See GRANTECAN personnel.

Verification Deliverables

Design phase: Assembly, Packaging, Handling, Storage and Transportation Procedure.

Product Phase: Idem updated.

5.6.3.2 **Package unload at the GTC freight area**

Additional constraints apply to the items or modules to be unloaded from a track into the GTC freight area. The most significant ones are:

- Freight Area Door height: 4450 mm
- Freight Area available width: 4200 mm (TBC)
- Freight Area Bridge Crane load capacity: 5 ton
- Bridge Crane hook height from the floor: 4500 mm

Package design shall have these limitations into account.

Verification Deliverables

Design phase: Assembly, Packaging, Handling, Storage and Transportation Procedure.

² These dimensions are limited by the radii of curvature of the access road to the ORM. Therefore, the wider the piece, the shorter is the trailer, and vice versa. Standard trailer width is 2.5m.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 48 of 98
---	---	---

Product Phase: Idem updated.

5.6.3.3 Handling and Storage

The design of the items and packages shall prevent them from damage under the Survival Conditions in 5.4.1, 5.4.3, 5.4.4, when handled and stored at the GTC facilities.

Verification Deliverables

Design phase: Assembly, Packaging, Handling, Storage and Transportation Procedure.

Product Phase: Idem.

5.6.4 Safety Requirements

5.6.4.1 Functional safety

The GC-Set shall fulfil the safety functions derived from the corresponding safety assessments according to the applicable regulations. The safety assessment shall consider personnel as well as equipment safety.

Verification Deliverables

Design phase: RAMS (Safety analysis). List of applicable safety regulations. Design document (Safety functions and safety system implementation description and justification).

Product Phase: Test Report (specific Safety functional tests derived from the applicable Safety Regulation). Integration Operation and Maintenance Documents (Any documentation required by the applicable safety regulations). Certificate of compliance with applicable safety regulations.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 49 of 98
---	---	---

6 INSTRUMENT ROTATOR REQUIREMENTS (RQ/TL-IR-CG/NNN)

6.1 Functional Requirements

6.1.1 Instrument Rotator Concept

The Instrument Rotator shall rotate the Science Instrument and the AG System simultaneously to compensate the rotation of the field of view during the movement of the telescope.

For scientific purposes, the Instrument Rotator shall have two operation modes³:

- Point-to-point: The rotator will move from the current position to the demanded one as quick as possible.
- Tracking: The rotator shall follow continuously a demanded profile trajectory.

Verification Deliverables

None.

6.2 Design Requirements

6.2.1.1 Bearing

The rotator bearing shall have at least the following characteristics:

Encoder tape slot in rotating ring

Sealed

Verification Deliverables

Design phase: Design document (Description). Component List.

Product Phase: Inspection Report.

6.2.1.2 Bearing grease replacement system

There shall be an automatic pressurized grease replacement system consisting at least of:

- Grease tank.
- Grease pressurizing system
- Clean Grease Distribution
- Dirty grease collection system (TBC)

The system shall be activated from the Local HMI. Any rotator movements sequence required shall be as autonomous as possible.

³ Further, it shall implement additional modes for maintenance and commissioning

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 50 of 98
---	---	---

Access shall be guaranteed to old grease collecting points or locations.

Verification Deliverables

Design phase: Design document (Description and justification). 3D model.

Product Phase: Test Report (functional). Operation and Maintenance Manual

6.2.1.3 Motor

The rotator axis shall be moved by a direct drive torque motor, with the windings ring fixed to the static structure and the magnets ring to the rotating structure.

The motor shall have an autonomous over-temperature protection system.

Phase commutation sensors shall avoid the wake and shake initialization method.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List.

6.2.1.4 Motor Cooling system

Complete motor cooling installation shall be provided ready for connection to the telescope glycol water circuit (see 5.2.5.3).

The cooling system shall consist at least of:

- Water heat exchangers, to remove the heat of the coils
- PT100 sensors at the coils, provide the temperature values
- An on/off solenoid valve
- A fine particle filter
- A flow checker in a visible place
- An autonomous leak control system
- Stop valve

Parts subject to maintenance and potential leak sources shall be centralized in the +Y outer part of the Rotator⁴

Verification Deliverables

Design phase: Design Document (cooling system description, thermal calculations).
Component List.

Product Phase: Cooling system tests.

⁴ This is the lower part of the rotator when the Tube is horizontal minimizing the effects of a potential leaks.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 51 of 98
---	---	---

6.2.1.5 Encoder

The encoder shall be from the ERA 7400 C series from Heidenhain, unless otherwise agreed with GRANTECAN. The encoder system shall be protected against scratches and sealed against dust. The protection shall provide easy access to the scanning heads for adjustment. Absolute positioning shall be obtained from two reference marks anywhere within the rotation range.

The scanning heads should be mounted on the static part of the rotator to save cabling to the rotating module.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List

Product Phase: Inspection Report.

6.2.1.6 Brakes

The brakes shall be a fail-safe-type, i.e. spring applied and pneumatically released. They shall operate only in case of emergency, e.g., if the limit switches were activated or power supply to the motor was interrupted.

In opened position the brake pads shall not touch the brake disc independently of the tube position.

Verification Deliverables

Design phase: Design Document (Description). Component List.

Product Phase: Test Report (functional tests).

6.2.1.7 Compressed air system

The air circuit shall include at least the following items:

- Pressure switch to provide a signal if the system is pressurized
- Flow regulator, in order to be able to regulate braking time
- Air filter (TBD)

Any compressed air items (filters, gauges, etc...) shall be installed in the Electronics Enclosure ready for connection to the GTC clean air circuit (see A1).

An autonomous, and preferably mechanical, safety system against overpressure in the Enclosure shall be provided. This shall stop air flow (or provide air exhaust) in case a hose is accidentally broken or disconnected inside the Enclosure.

Verification Deliverables

Design phase: Design Document (Description and justification, pneumatic schematics, Electronics Cabinet internal layout). Component List.

Product Phase: Test Report (functional tests).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 52 of 98
---	---	---

6.2.1.8 Limit Switches / Absolute Switch

The rotator axis shall have electrical safety limit switches after the software limits in 6.3.1.1, as well as an absolute switch indicating if the rotator is in the positive or negative part of the rotating range.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List.

Product Phase: Inspection report. Test Report (functional safety).

6.2.1.9 Toggle Mechanism

Since the rotation range is larger than one turn, the mechanical end stops shall need a toggle mechanism.

The toggle mechanism of the mechanical end stop system shall be isolated avoiding intentional or unintentional manipulation. It shall have a transparent cover for visual inspection of its functionality.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List.

Product Phase: Inspection report. Test Report (functional).

6.2.1.10 Rotation End Dampers

The rotation axis shall have rotation end dampers, which protect the rotator against mechanical damage in case of failure of the electrical limit switches.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List.

Product Phase: Test Report (functional safety).

6.2.1.11 Rotator 0° position

The 0° position shall be in the middle of the overall rotation range defined in 6.3.1.1 within $\pm 0.25^\circ$.

Verification Deliverables

Design phase: Design Document (Description)

Product Phase: Test Report (functional tests).

6.2.1.12 Instrument Rotator unbalance

The Instrument Rotator shall have a maximum mass eccentricity of 50 Nm around the rotation axis over the usable rotation range. It shall include counterweights to correct any future unbalance up to 100Nm. The aim is to reduce as far as possible electric power consumption and heat emission.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 53 of 98
---	---	---

Verification Deliverables

Design phase: Design Document (mass budget). 3D model

Product Phase: Inspection Report. Test report (unbalance torque).

6.2.1.13 Alignment features

The following alignment features shall be designed and provided to adjust the position and orientation of the Rotator during integration at the GTC:

- Lateral position with regard to the Tube Axis. Lateral alignment mechanisms shall be placed at a minimum of 3 nodes of the Telescope tube structure. Range $\pm 10\text{mm}$, minimum resolution $\pm 0.25\text{mm}$.
- Axial position and orientation with regard to the Tube Axis. A calibrated shim set shall be design and provided consisting of (a set consists of several shims to complete the whole perimeter of the attachment flange. See A1):
 - 1 set 5mm thick
 - 1 set 2mm thick
 - 2 sets 1mm thick
 - 10 set 0,1mm thick
 - 1 set of 0,05mm

Verification Deliverables

Design phase: Design Document (Description). 3D model. Shim drawings.

Product Phase: Inspection report.

6.3 Performance Requirements

6.3.1.1 Rotation Range of Instrument Rotator

The useable range of movement between software limits shall be 570° with an additional range for electrical limit switches, end stop damper and safety margin for the AG cable chains.

Verification Deliverables

Design phase: Design document (Description).

Product Phase: Test Report (performance tests). Operation and Maintenance Manual (Product Specifications).

6.3.1.2 Maximum Instrument mass

The rotator shall be able to operate at nominal performances carrying the Science Instrument Mass specified in A2.

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 54 of 98
---	---	---

See A2.

6.3.1.3 Maximum mass eccentricity

The rotator shall be able to operate at nominal performances (both motor and brakes) carrying the Science Instrument Unbalance specified in A2 and the unbalance of the Rotator itself specified in 6.2.1.12.

Verification Deliverables

Design phase: Design document (Description and calculations).

Product Phase: Test Report (performance tests). Operation and Maintenance Manual (Product Specifications).

6.3.1.4 Maximum Rotator Speed

The maximum rotator speed in Point-to-Point operation mode shall be higher than $10^\circ/\text{s}$ with a goal of $15^\circ/\text{s}$.

Verification Deliverables

Design phase: Design document (Description and justification).

Product Phase: Test Report (performance tests). Operation and Maintenance Manual (Product Specifications)

6.3.1.5 Maximum Rotator Acceleration

The maximum rotator acceleration in Point-to-Point operation mode shall be higher than $5^\circ/\text{s}^2$, with a goal of $10^\circ/\text{s}^2$ for any environmental or load condition (see A2).

Verification Deliverables

Design phase: Design document (Calculations).

Product Phase: Test Report (performance tests, performance tests, worst case).
Operation and Maintenance Manual (Product Specifications)

6.3.1.6 Rotator Tracking Speed

For Tracking operation mode, the rotator speed shall range from 0 to $0.5^\circ/\text{s}$ for any environmental or load condition (see A2).

Verification Deliverables

Design phase: Design document (Description and justification).

Product Phase: Test Report (performance tests, worst case). Operation and Maintenance Manual (Product Specifications)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 55 of 98
---	---	---

6.3.1.7 Rotator Tracking Acceleration

For Tracking operation mode, the rotator acceleration shall range from 0 to $0.005^{\circ}/s^2$ for any environmental or load condition (see A2).

Verification Deliverables

Design phase: Design document (Description and justification).

Product Phase: Test Report (performance tests, worst case). Operation and Maintenance Manual (Product Specifications).

6.3.1.8 Rotation accuracy and absolute following error

The point to point rotation accuracy shall be lower than 13 arcsec rms under any specified operation, environmental or load condition (see A2).

In Tracking operation mode, the absolute following (or tracking) error shall be lower than 13arcsec rms.

NOTE: Rotation accuracy and absolute following error both refer to the difference between the REAL and demanded positions, instead of the difference between the MEASURED and demanded positions.

Verification Deliverables

Design phase: Design document (description and justification). Error budget

Product Phase: Error budget updated. Test Report (performance tests, worst case).

NOTE: Following error shall be tested at speeds as low as $0.005^{\circ}/s$. The point to point functionality shall be tested in the full range.

This shall be tested both in horizontal and vertical position, both including the instrument Dummy. Test details shall be agreed with GRANTECAN.

6.3.1.9 Emergency Stop time

In case of Emergency Stop the rotator shall stop in less than 1s at any specified environmental or load conditions (see A2).

Verification Deliverables

Design phase: Design document (Description and calculations).

Product Phase: Test Report (performance tests, worst case). Operation and Maintenance Manual (Product Specifications)

6.3.1.10 Orientation of Science Instrument Coordinate System

The orientation error of the Science Instrument Coordinate System with regard to the rotation axis at any rotation angle shall be lower than $50\mu rad$ (including therefore flange perpendicularity and flatness errors as well as bearing wobble)

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 56 of 98
---	---	---

Design phase: Error Budget. Drawing tolerances

Product Phase: Test Report (measurements). Error budget updated. Operation and Maintenance Manual (Product Specifications).

6.3.1.11 Instrument flange gravity tilt

The rotation between the Rotator Attachment flange and the Science Instrument flange when the telescope moves in elevation from vertical to horizontal position shall be less than 0.100 mrad.

This requirement applies when loading the Instrument Rotator with a Science Instrument with the mass and centre of gravity specified in A2.

Verification Deliverables

Design phase: FEM calculation.

Product phase: Test report (FEM validation with bending test)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 57 of 98
---	---	---

7 AG MECHANICS REQUIREMENTS (RQ/AG-CG-AG-200/NNN)

7.1 Functional Requirements

7.1.1 AG Concept

The AG Mechanics shall position the centre of the Pick-off Mirror anywhere in a section of the accessible field of view defined in 5.2.4.2 allowing to feed the AG Instrument with the optical beam defined in 7.2.5.3 and re-focusing the image at the same time.

Verification Deliverables

None. Verified in other requirements.

7.1.2 AG Mechanics functional breakdown

The AG Mechanics can be divided into 3 main functional groups of components:

- Probe Arm: This element supports a Pick-Off Mirror Unit and houses the AG Instrument⁵.

Note for bidders: Pick-Off Mirror Unit and the AG Instrument are not included in the scope of delivery.

- Focusing Mechanism: Mounted in the Probe Arm, provides the AG Instrument with the translational movement to focus the AG Instrument to the telescope focal surface compensating its curvature.
- Turn Table and Probe Arm Rotation Stage: Both mechanisms together give the two-axis motion necessary for the Pick-off Mirror to scan the accessible field of view of the focal station.

Verification Deliverables

None. Verified in other requirements.

7.1.3 Operation modes of AG Mechanisms

The mechanisms of the AG Mechanics shall be able to operate in two modes:

- Point-to-point: The mechanism shall move from the current position to the demanded one as quick as possible.
- Tracking: The mechanism shall follow continuously a demanded profile trajectory.

Verification Deliverables

None. Verified in other requirements.

⁵ The Pick-Off Mirror feeds the AG Instrument with a small portion of the telescope field of view picked from any position of the accessible field of view of the focal station.



7.2 Design Requirements

7.2.1 Geometrical design constraints

7.2.1.1 Probe Arm Rotation Axis

The nominal rotation axis of the Arm Rotator shall pass through the centre of the telescope Exit Pupil for any angle of the Turn Table (see Fig. 13).

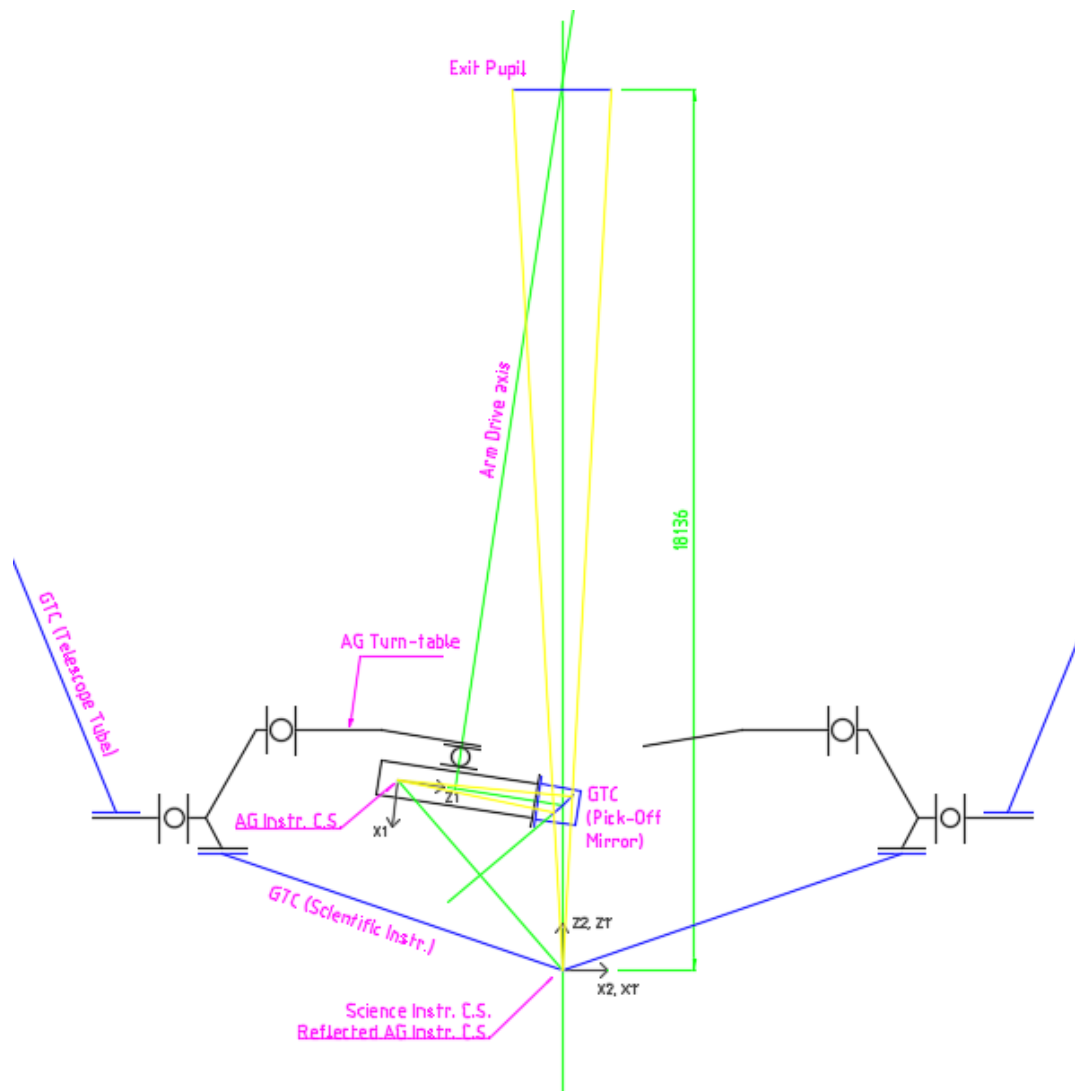


Fig. 13- Schematic view for the definition of the CG-Set main Coordinate Systems with an on-axis optical beam and the Probe at the centre of the accessible F.O.V.

Verification Deliverables

Design phase: Design Document (Description), 3D model, drawings

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 59 of 98
---	---	---

7.2.1.2 Focus stage 0° position

The nominal position of the AG Instrument and the POM with regard to the GTC optical axis and the Pupil shall be such that, when the POM is at the centre of the optical axis and the focus stage at 0° position, the Virtual AG Instrument C.S. and the Scientific Instrument C.S. origins and Z axis coincide. See 3.2.10.

Verification Deliverables

Design phase: Design Document (Description), 3D model

7.2.1.3 AG instrument and POM orientation and position

The POM and AG instrument positions shall be as defined in A1 unless otherwise agreed with GRANTECAN⁶. The POM and AG Instrument positions and orientations determine the design of the Probe Arm and the position of the linear stage inside.

Verification Deliverables

See corresponding requirement in A1.

7.2.2 AG thermal constraints

7.2.2.1 Mechanisms position holding

The AG motors shall be unpowered once they have reached the required position and shall maintain this position by mechanical means in order to limit the heat dissipated close to the optical beam.

Verification Deliverables

Design phase: Design Document (Description and justification).

Product Phase: Inspection Report. Test Report (functional report).

7.2.2.2 Motors thermal link with the Turn Table

The AG motors housings shall have a direct Thermal link to the Turn Table structure in order to allow the heat spread as much as possible to the structure and avoid convection hot spots close to the optical beam.

Verification Deliverables

Design phase: Design Document (Description).

Product Phase: Inspection Report. Test Report (functional report).

⁶ Position and orientation of POM and AG Instrument are not fully constrained by other requirements, but have been assigned arbitrarily by GRANTECAN during the preliminary design process. See 3.2.10.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 60 of 98
---	---	---

7.2.3 AG Mechanics main assembly

7.2.3.1 AG Mechanics structure top surface

The top surface of the AG Mechanics structure (Telescope Tube vertical) should remain as clear as possible from cables, blots, etc... so that a person can step on top of it if needed for maintenance purposes. A permanent anti-slip surface shall be provided on the stepable surfaces.

Verification Deliverables

Design phase: Design Document (Description). 3D model

Product phase: Inspection report.

7.2.3.2 AG Mechanics lifting points

There shall be 3 lifting points shall at the top surface in a diameter TBD. The lifting parts (eyebolts...) shall be detachable.

Verification Deliverables

Design phase: Design Document (Description). 3D model

Product phase: Inspection report.

7.2.3.3 Structural Temperature sensors

To monitor the temperature of the AG Mechanics structure four temperature sensors 4-wire PT100 class A shall be mounted on the main AG structure at 90° with each other, as far as possible from the heat sources, in order to average the temperatures.

The sensors shall be connected to the Cabinet LCU for remote temperature monitoring only. See A1.

Verification Deliverables

Product Phase: Inspection Report.

7.2.4 Turn Table

7.2.4.1 Bearing

Requirement 6.2.1.1 applies.

Verification Deliverables

Requirement 6.2.1.1 applies.

7.2.4.2 Bearing grease replacement system

Requirement 6.2.1.2 applies.

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 61 of 98
---	---	---

Requirement 6.2.1.2 applies.

7.2.4.3 Motor

The turn table shall be driven by two motor/reducer units whereas one works against the other eliminating tooth play. The units shall have built-in resolver and holding brake.

Verification Deliverables

Design phase: Design Document (Description). 3D model. Component List.

7.2.4.4 Encoder

Requirement 6.2.1.5 applies.

Verification Deliverables

Requirement 6.2.1.5 applies.

7.2.4.5 Limit Switches / Absolute Switch

Requirement 6.2.1.8 applies.

Verification Deliverables

Requirement 6.2.1.8 applies.

7.2.4.6 Rotation End Dampers

Requirement 6.2.1.10 applies for the Turn table

Verification Deliverables

Requirement 6.2.1.10 applies for the Turn table.

7.2.4.7 0° position

The 0° position shall be in the middle of the overall rotation range within $\pm 0.25^\circ$. It coincides with the X-axis of the Cassegrain coordinate system if the instrument rotator axis also is in its 0° position (TBC).

Verification Deliverables

Design phase: Design Document (Description)

Product Phase: Test Report (functional tests).

7.2.4.8 Turn Table unbalance guideline

The turn table should include counterweights to minimise the unbalance torque around the rotation axis over the usable rotation range of the turn table and the probe arm motor.

For the calculations see masses and COGs of AG Instrument and POM Unit (out of scope) in A1.

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 62 of 98
---	---	---

Design phase: Design Document (mass budget). 3D model

Product Phase: Inspection Report. Test report (unbalance torque).

7.2.4.9 Structure thermal inertia

The construction of the turn table should be lightweight and stiff and shall have ventilation holes minimising thermal inertias.

Verification Deliverables

Design phase: Design Document (Description). 3D Model. FEM thermal inertia representative test

7.2.4.10 AG Instrument Electronics box

There shall be a metallic box bolted to the Turn Table. This box shall house the AG Instrument electronics (out of scope). The attachment bolts shall be accessible from outside of the box. The box shall be thermally linked to the Turn Table. The box shall be close to the Probe Arm. The minimum internal envelope of the box shall be 330x150 mm, 100mm in height.

Verification Deliverables

Design phase: 3D Model

Product Phase: Inspection Report.

7.2.5 Probe Arm and Rotation Stage

7.2.5.1 Rotation Stage specification

The Probe Arm motor shall be a commercial rotation stage combining bearing, motor, reducer, encoder and limit switches.

Verification Deliverables

Design phase: Design Document (Description). Component List.

Product Phase: Inspection Report

7.2.5.2 Probe Arm Construction

The probe arm shall be a rigid and lightweight structure supporting the Pick-off Mirror Unit and housing and protecting the focusing mechanism and AG Instrument against dust and mechanical impacts.

The Probe Arm shall allow access for dismounting the AG Instrument.

A hole for the conducts of the AG Instrument shall be foreseen (size and position TBD, expected to be used for a 24V power cable and a USB3.0 communication cable).

Verification Deliverables



Design phase: Design Document (Description). 3D Model

Product Phase: Inspection Report. Test report (accessibility tests)

7.2.5.3 Un-obstruction of the AG picked optical beam

The Probe Arm Design will not obstruct the Optical Beam picked by the AG Instrument. This Optical Beam corresponds to the circular field of view of $\varnothing 16,5\text{mm}$ at the focal plane, anywhere on the Accessible field of view, as defined in 5.2.4.2.

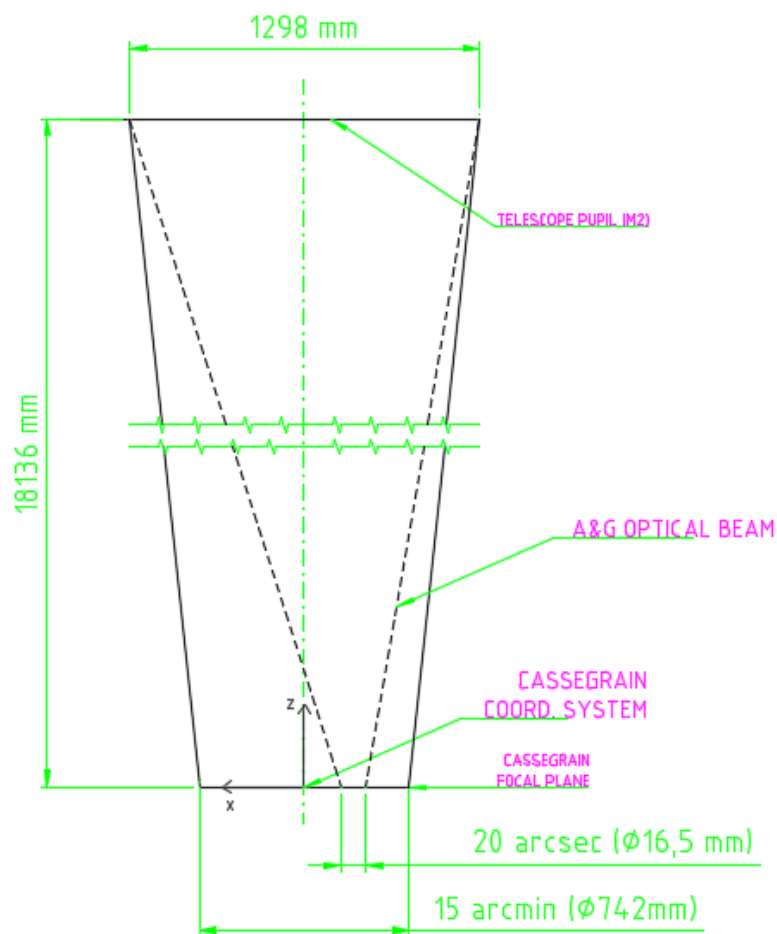


Fig. 14- Part of the Accessible field picked by AG (optical beam folding by the POM not represented).

Verification Deliverables

Design phase: 3D model. Drawings.

Product Phase: Metrology report

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 64 of 98
---	---	---

7.2.5.4 Shadow over the Scientific Instrument

The Probe Arm Design, within its flexibility and geometrical constraints, should minimize its shadow over the Scientific Instrument.

Verification Deliverables

Design phase: Design document (description and justification). 3D model.

7.2.5.5 Probe Arm Temperature sensors

To monitor the temperature of the Probe Arm one temperature sensors 4-wire PT100 class A shall be mounted on the Arm.

The sensor shall be connected to the Cabinet LCU for remote temperature monitoring.

Verification Deliverables

Design phase: Design Document (Description)

Product Phase: Inspection Report.

7.2.6 Focusing Mechanism for AG Instrument

The linear stage shall support and position the AG Instrument.

The travel range needed for the focusing mechanism shall be from -10 to +50mm from the 0-position specified in 7.2.1.2. Positive direction is defined moving the AG Instrument towards the incoming light.

The linear stage shall be Physik Instrumente M-404.42S.

Verification Deliverables

Design phase: Design Document (Description, Component List).

Product Phase: Inspection Report.

7.2.7 AG Items mounting Repeatability

It shall be possible to dismount and remount the hereafter listed items without the need of realignment:

- Rotation Stage
- Probe Arm
- Focusing Mechanism

Verification Deliverables

Design phase: Design Document (Description and justification), 3D model, tolerance in drawings.

Product Phase: Test Report (mounting repeatability)



7.3 Performance Requirements

7.3.1 Probe Arm Scanning Range

The rotation range of the Turn Table and Probe Arm Motor shall ensure that the centre of the POM of the Probe Arm (See A3) can scan anywhere within the section of the Accessible Field of View (5.2.4.2), as shown in Fig. 15.

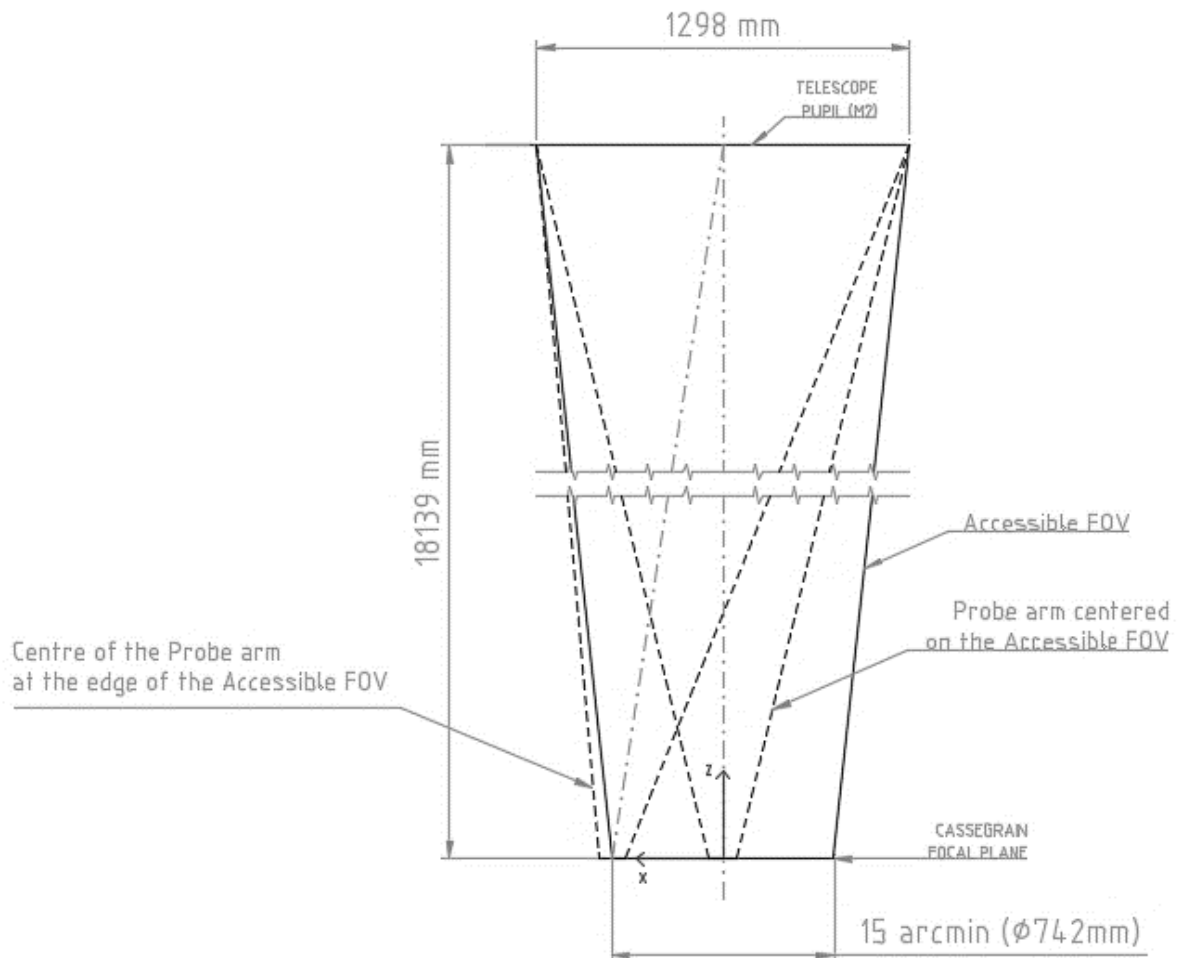


Fig. 15- Probe arm scanning range with regard to the Accessible FOV

Verification Deliverables

Design phase: Design document (description, fig. or drawing demonstrating fulfilment). 3D model.

Product Phase: Test Report (Mechanisms performance tests).

7.3.2 Positioning time

It shall be possible to position the centre of the pick-off mirror and focus the AG-Instrument on any position on the accessible FOV of the AG-Instrument in less than 10s, starting from any other position.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 66 of 98
---	---	---

Verification Deliverables

Design phase: Design document (justification).

Product Phase: Test report (performance tests).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 67 of 98
---	---	---

8 ELECTRONICS ENCLOSURE REQUIREMENTS (RQ/CS-EC-PC-202/...)

8.1 Concept

The requirements in this chapter apply to the physical enclosure (3.1.8) hosting the CG-Set electronics. Requirements for the electronics are out of scope of this chapter.

The Enclosure shall consist basically of:

- A structural frame
- Insulating wall panels (including cable glands and connector panel) and door.
- Enclosure Cooling system

Other solutions may be proposed to GRANTECAN but are subject to approval.

The electronics enclosure shall:

- Protect the GC-Set electronics from the environment:
 - Dust and moisture
 - Extreme temperatures
 - Shocks or collisions
- Protect the environment from the GC-Set electronics:
 - Heat
 - Vibrations

Verification Deliverables

Design phase: Design Document (Description, Electronics layout inside the Enclosure). Enclosure 3D Model.

Product Phase: Inspection Report

8.2 Enclosure location and position

The Electronics Enclosure shall be “hanging” from the Telescope Tube Structure. See 3D model annex to R1. The Enclosure shall be “horizontal” when the Telescope Tube is vertical. The Enclosure shall permit access and maintenance with the Telescope Tube in vertical and horizontal position.

The Enclosure orientation with regard to gravity shall change with the Telescope Tube Elevation angle (5.4.2).

Interface requirements with the Telescope Structure are found in A1.

Verification Deliverables

Design phase: Design Document (Description).

8.3 Cooling system

The cooling system shall remove the heat produced by the electronics inside the Enclosure.

The cooling system shall consist at least of:

- Water-air heat exchanger with fan

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 68 of 98
---	---	---

- A door switch, ensuring the fan is powered as long as the door is closed.
- A minimum of 3 PT100 sensors at the worst-case points, providing the ambient temperature values
- A solenoid valve, to let the water flow as required by the controller.
- A flow checker, visible from outside the Enclosure
- An autonomous leak control system

These shall be connected to the Cabinet LCU hosting the temperature control loop.

The cooling system shall be located either inside the enclosure or at its wall such a way and location to minimize the chance of water reaching the electronics in case of a leak in any possible orientation of the Enclosure at the Telescope Tube.

Verification Deliverables

Design phase: Design Document (cooling system description). Component List.

Product Phase: Inspection report.

8.4 Enclosure internal environment: temperature

The cooling system shall be able to keep the internal ambient temperature at a maximum of 20°C under the external environmental conditions in 5.3.

Verification Deliverables

Design phase: Design Document (cooling system description, calculations, reference to parts data sheets).

Product Phase: Test report (Cooling system test with equivalent internal dissipation and extrapolation of water temperature, external temperature and altitude

8.5 Enclosure internal environment: dust and moisture

The protection degree of the enclosure should be IP53 (UNE 20324/EN 60529) or higher.

The internal relative humidity should be kept between 20% and 75% under the external environmental conditions in 5.3⁷.

Verification Deliverables

Design phase: Design Document (Tightness assessment, moisture control system specs).

Product Phase: Inspection

8.6 Heat dissipation to the Telescope chamber

The enclosure isolation shall meet requirements 5.2.5.1 and 5.2.5.2 for the internal temperature in 8.3 under the external environmental conditions in 5.3.

⁷ This can be easily achieved by using commercial self-regenerating dessicators.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 69 of 98
---	---	---

Verification Deliverables

Design phase: Design Document (Isolation description and calculations).

Product Phase: Test report (Thermal dissipation Test, e.g. internal heat source until steady state is reached, with corresponding extrapolations)

8.7 Structural vibrations

The eigen-frequency of the translational eigenmodes of the cabinet hanging from its silent blocks shall be lower than 10 Hz.

Verification Deliverables

Design phase: Design document (calculation based on silent blocks choice).

Product phase: Inspection.

8.8 Acoustical vibrations

The wall panels and door of the cabinet should not induce acoustical vibrations bellow 50 Hz. To this aim it is encouraged to isolate any vibration source inside the Cabinet.

Verification Deliverables

Design phase: Design document (Description)

Product phase: Inspection report

8.9 Structural integrity

The enclosure shall maintain its structural integrity (nominal electronics inside + extra 50% load) under any orientation in 5.4.2 or handling operation in 8.10.

Verification Deliverables

Design phase: Design Document (Description and justification, specs or simple FEM).
3D Model

Product Phase: Inspection Report

8.10 Handling

The design of the enclosure shall allow handling for the following operations:

- Transport the enclosure (nominal electronics inside + extra 50% load) from factory to the GTC
- Transport the enclosure (nominal electronics inside + extra 50% load) within the GTC facilities (see GRANTECAN Personnel about the support elements available at the GTC)
- Lift the enclosure (lying on one side) up to the Primary Mirror Cell at the Telescope

Verification Deliverables

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 70 of 98
---	---	---

Design phase: Design Document. Assembly, Packaging, Handling, Storage and Transportation Procedure

Product Phase: Inspection Report.

8.11 Enclosure internal/external configuration

The Enclosure shall be metallic and any part shall be bonded to ensure equipotentiality (even dismountable parts such as wall panels).

There shall remain at least a 35% internal space free for mounting of additional electronics inside the enclosure.

The internal structural frame shall be off the shelf, preferably from Rittal. The frame shall allow mounting of any standard accessory of the enclosure brand.

Any component that may transmit vibrations to the enclosure shall be mechanically isolated, at least, the heat exchanger fans.

The door shall be in the outer wall of the cabinet (semi-vertical with the Telescope Tube vertical). A way to hold the door securely while opened shall be provided.

The rest of the enclosure wall panels shall be dismountable in order to access any equipment either standing on the floor or installed at the Telescope.

Cable entrance shall be at (or close to) the enclosure base at the right side of the enclosure door (when Telescope Tube vertical). This is the closest location to the rotator connections panel.

A sealing system shall be provided for cables and hoses passing through the enclosure walls, preferably from Roxtec. The sealing system shall meet requirements 8.4, 8.5 and 5.6.2.2.

The sealing system shall have a 50% margin for additional cables out of the scope, of different diameters, and allowing to pass connectors through it.

Verification Deliverables

Design phase: Design Document (Description, internal layout). 3D Model

Product Phase: Inspection Report

8.12 GTC connection panel

There shall be a connection panel for the interface connectors with GTC, i.e. the connectors are defined at A1 (electrical supply, control and ISS interfaces).

The connection panel shall be at one of the wall panels of the Enclosure (TBC). The location at the Enclosure wall shall be TBD.

The panel design at the Enclosure wall shall guarantee the thermal isolation and water tightness required for the Enclosure.

The panel shall provide at least 35% space extra to install new connectors while keeping thermal isolation and water tightness.

Verification Deliverables

Design phase: Design Document (Description). 3D Model

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 71 of 98
---	---	---

Product Phase: Inspection Report.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 72 of 98
---	---	---

9 LOCAL CONTROL REQUIREMENTS (RQ/CS-AS-CG-200/NNN)

9.1 Functional Requirements

9.1.1 CG-Set Control System Concept

The CG-Set shall be a self-standing system including anything necessary to be controlled and tested independently of the GTC, but at the same time it shall implement all the interfaces required in A1 to be remotely controlled by the GTC Control System (GCS) and the Interlock & Safety System (ISS).

The Cassegrain Local Control shall have a Cabinet Local Control Unit (Cabinet LCU) to provide the control function required.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: Inspection report. Test report (local control functionality).

9.1.2 GC-Set Operation Modes

There shall be 2 control modes:

- Remote Control mode (from the GCS), the default mode, with full functionality.
- Local Control mode (from the Local Control HMI panel), with reduced motion control functions, intended for testing and maintenance operations.

Functionality for both modes is specified in the Control Functional Requirements hereafter. When Local Control is active, the GCS can receive monitors from the Cabinet LCU but cannot send commands to the Cabinet LCU or the Drives and cannot monitor the drives directly.

Safety related control functions shall be active in both modes.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: Test report (local control functionality).

9.1.3 Control Mode switching functionality

There shall be a switching function between both Remote and Local control modes:

- The default mode shall be the Remote-Control Mode.
- The Local Control Mode shall be activated with a physical switch (button or key) in the HMI panels. The same switch shall be used to go back to the Remote-Control Mode.
- When the Remote-Control mode is active, motor drives are controlled directly by the GCS. When the Local Mode is active motor drives are controlled from the Cabinet LCU.
- The former conditions shall be subject to changes depending on the Safety Assessment and the corresponding Safety Functions which shall always have prevalence over any other condition.

The Cabinet LCU shall inform the GCS about the active operation mode, as specified in A1

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 73 of 98
---	---	---

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: Functional test report. Detailed PLC Software Documentation.

9.1.4 Motion control and monitoring functionality

Each mechanism (Rotator, AG turn table, AG Arm and AG Instrument focusing linear table) shall have the following functionality:

- Enable/disable
- Jogging (continuous motion at a given velocity profile)
- Point to point (relative and absolute)
- Tracking (following a discrete demand of position, velocity or acceleration, interpolated)
- Homing
- Stop
- State and error monitoring

This functionality shall be provided by digital servo drives (see 9.2.3).

In local mode each of the motor drives (Rotator, AG turn table, AG Arm, AG Instrument focusing linear table) shall have the following functionality when in Local mode:

- Enable/disable
- Jogging at several speeds (TBD) both directions
- Point to point (predefined parking position, others?) (TBC)
- Homing (TBC)
- Stop
- State and error monitoring

In Remote mode, the commands for motion control shall be provided to the servo drives by the GCS and the drives shall provide monitors to the GCS. The configuration of the servo drives shall be compatible with the remote control using the interface defined in A1.

In local mode, the commands for motion control shall be provided to the servo drive by the Cabinet LCU.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).
Component list (drives).

Product Phase: Test report (local control functionality). Detailed PLC Software Documentation.

9.1.5 Start-up control and monitoring functionality

The Cassegrain Local Control shall allow to switch on/off all or part of the electronics used to control de CG-Set bot in Local or Remote operation modes.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 74 of 98
---	---	---

The Cabinet LCU shall be switch on directly when power is applied to the Enclosure Cabinet, permitting to perform the start-up function.

Electrical/Electronic devices in the Enclosure shall be electrically grouped as defined in 9.2.6.

The start-up function shall allow to:

- Switch on/off all groups
- Switch on/off group any group independently
- Monitor the state (on/off) of any group.

The start-up control shall include a preconfigured Automatic Switch on/off sequence including every device in the Cabinet. It shall be possible to activate or deactivate the automatic switching sequence either from the Local HMI or the GCS, and this configuration will be persistent in case of Cabinet LCU switch-off.

If automatic start-up is deactivated each group shall be switched on/off when receiving the corresponding signal from the Local HMI or the GCS (see A1)

The Cabinet LCU shall provide the information about the status of the automatic Start-up to the Local HMI and to the GCS (see A1).

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: Test report (local control functionality). Detailed PLC Software Documentation.

9.1.6 Electronics Enclosure temperature control and monitoring functionality

There shall be a temperature control loop running in the Cabinet LCU in order to maintain the enclosure internal temperature within the established range adequate for the electronics and compliant with the Enclosure heat dissipation allowed to the Telescope Chamber (8.6).

The control algorithm shall be defined by the Contractor.

Internal temperature of the enclosure for the loop shall be measured at several points with Pt100 sensors depending on the temperature acquisition strategy.

It shall be possible to configure the parameters of the internal temperature control loop (set point, hysteresis, etc...) both in Local Mode (from the HMI panel) or in Remote Mode (from GCS commands, as specified in A1). The applied configuration shall be persistent in case of Cabinet LCU switch-off.

The Cabinet LCU shall provide the following parameters to the Local HMI:

- Each PT100 temperature
- Water flow
- Fan relays state

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 75 of 98
---	---	---

Product Phase: Test report (Enclosure Cooling system tests). Detailed PLC Software Documentation.

9.1.7 Rotator Motor temperature monitoring functionality

The Cabinet LCU shall monitor the temperature signal from the temperature sensors in the Rotator motor windings.

The Cabinet LCU shall provide the referred monitors to HMI and GCS. Interface as specified in A1.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: See A1. Detailed PLC Software Documentation.

9.1.8 Structural temperature monitoring functionality

The Cabinet LCU shall monitor the temperature signal from PT100 sensors in the AG Mechanics structure and Probe Arm.

The Cabinet LCU shall provide the referred monitors to the GCS. Interface as specified in A1.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: See A1. Detailed PLC Software Documentation.

9.1.9 Mechanics housekeeping

The Cabinet LCU shall control and monitor the services needed for operation and maintenance of the mechanisms. At least the following functions shall be included:

- Rotator and AG Mechanics bearings grease replacement systems shall be activated from the Local HMI. If the operation requires a motion sequence it shall be automatically activated as well.
- The Cabinet LCU shall monitor the pressure of air circuit. This parameter shall be shown in the HMIs
- The Cabinet LCU shall switch on/off the motor cooling system solenoid valve whenever the Rotator motor servo-drive is enabled/disabled. The valve status shall be shown in the HMI. It shall be possible to change the status of the solenoid valve from the HMI.

Verification Deliverables

Design phase: Design document (Control architecture and functional description).

Product Phase: Test report (local control functionality). Detailed PLC Software Documentation.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 76 of 98
---	---	---

9.1.10 Local Safety functionality (RQ/CS-IS-CG/NNN)

The Cabinet LCU shall implement the safety related control functions derived from the GC-Set Risk Assessment according to the applicable regulations. This functionality, called Local Interlock and Safety System (LISS), will become part of the of the GTC Interlock and Safety System.

The LISS shall implement as well the necessary HW, SW and procedures to recover the system once the safety issue has been solved.

Any safety functionality should be implemented using the servo drives used for motion control as long as this allows to fulfil the safety function integrity level deemed necessary from the Safety assessment.

The LISS shall be autonomous and shall provide the required safety for the GC-Set as a stand-alone system. Nevertheless, it can receive some commands from the GRANTECAN Interlock and Safety System (ISS). These commands can be received independently of the active operation mode. The interface with the GRANTECAN Interlock and Safety System (ISS) is specified in A1.

The Local HMI shall provide the following control and monitoring functionality:

- Safety elements (stop buttons, interlock keys, limits) individual status monitoring, indicating which one is affected (location, code, etc...)
- Monitoring of the connection to ISS.
- Limit bypass (There shall be a way to prevent limits from remaining bypassed once the system has been moved back within limits and referenced.
- Any other LISS functionality as specified above.

Verification Deliverables

Design phase: RAMS (Safety Assessment), Design document (Safety functions and safety system implementation description and justification).

Product Phase: Test report (functional safety test, anything required by the applicable regulations). CE certification. Detailed safety SW Documentation.

9.2 Design Requirements

9.2.1 CG-Set Control System HW architecture

The CG-Set control system architecture shall be based on the diagram on Fig. 16. unless otherwise agreed with GRANTECAN (blue items are out of scope, interfaces with the GTC are highlighted in red). The LISS (see section 9.1.10) is included.

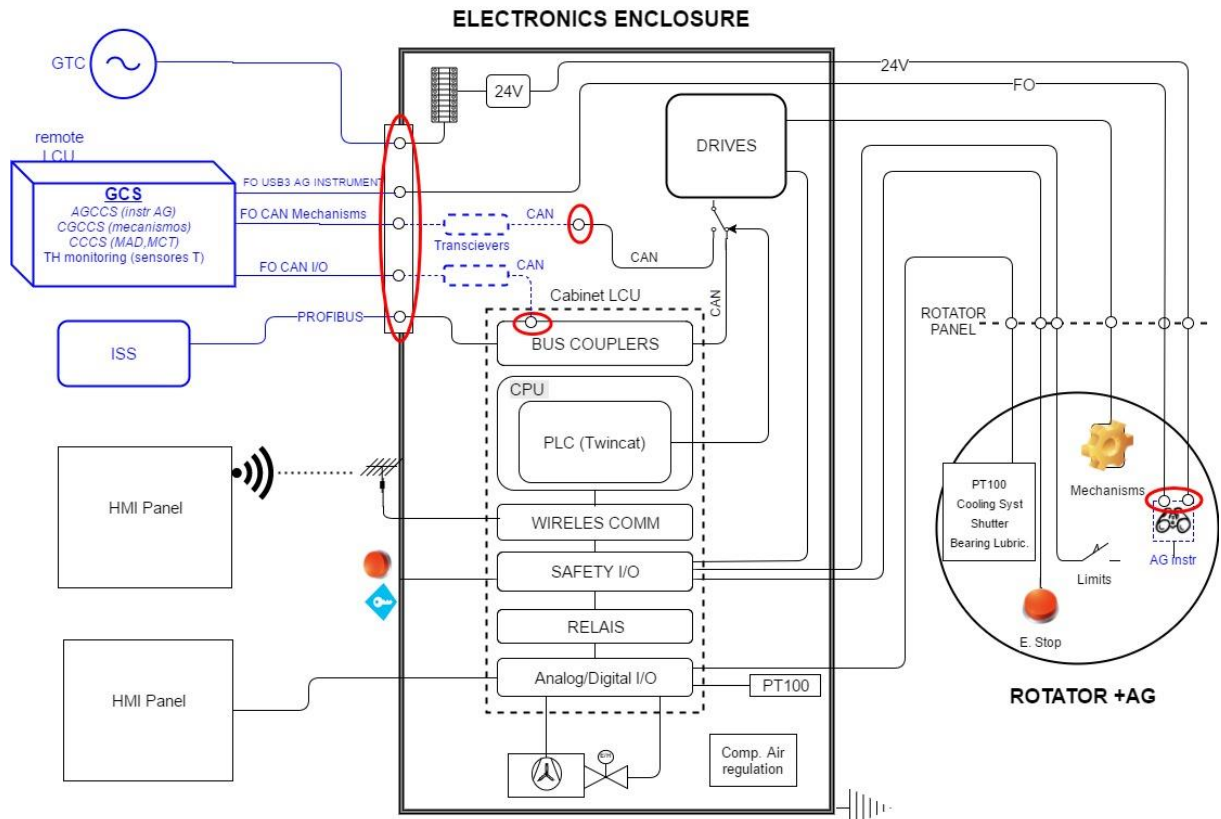


Fig. 16- CG-Set HW Control Architecture. In blue, out of scope of GC-Set Tender. In Red Interface with GTC

Verification Deliverables

Design phase: Design document (Control architecture description).

Product Phase: Inspection report.

9.2.2 Cabinet LCU

The Cabinet LCU shall be an automation PLC system including all I/O and communications terminals necessary to perform the functions in 9.1. Additionally, there shall be 6 channels of digital I/O for future use.

The LCU Cabinet components shall be from Beckhoff.

The Cabinet LCU definition includes corresponding SW.

Verification Deliverables

Design phase: Design document (Control architecture description and component choice justification). Component List.

Product Phase: Inspection report.

9.2.3 Drives

The drives for the mechanism motors shall be:

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 78 of 98
---	---	---

- Rotator: One Servostar 700 from Kollmorgen.
- AG Turn Table: Two Servostar 700 (master/slave) from Kollmorgen.
- AG Arm: One iPOS XXX(TBD) from Technosoft.
- AG Focus: One iPOS XXX(TBD) from Technosoft.

Verification Deliverables

Design phase: Component List.

Product Phase: Inspection report.

9.2.4 HMI panels for Local Control

The Local HMI panels shall comply with the following:

- There shall be 2 panels
 - One wireless, charge base with wall mounting attachment
 - One wall mounting, with a cable 10 m long from the Enclosure or 5m long from the Rotator connecting panel (cable lengths TBC).
- IP65 protection.
- Touch screen, minimum 10"
- Screen and LEDs covered or powered off when not in use. The HMI cannot emit any light during night observations.
- Emergency buttons for the Rotator and AG mechanism.
- Local Interlock keys as required by Risk Assessment
- User interface SW integrating the needed screens for the functionality described in 9.1. Functionality shall be grouped in different screens in a user friendly and intuitive manner. The screens designed shall be agreed with GRANTECAN.

Verification Deliverables

Design phase: Design document (HMI HW and User Interface description and justification). Component List

Product Phase: Inspection report. Test report (local control functionality).

9.2.5 Electrical protections

Any electrical device (fuses, circuit breakers, filters ...) required for the protection of the GC-Set, personnel, or other GRANTECAN equipment shall be included in the GC-Set.

Header Electrical Protections shall include:

- over current
- surge secondary protection
- general filter (interference and harmonics)
- 300mA Residual Current Circuit Breaker switch (RCCB)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 79 of 98
---	---	---

Additionally, main devices (drives) should also have 30mA individual RCCB (SI class, TBC) and magnetothermal circuit breakers, according to the manufacturer specifications.

Particular transients shall be identified and protections consequently chosen.

Verification Deliverables

Design Phase: Design Document (description and justification). Electrical drawings.

Product Phase: Inspection report. Electrical drawings.

9.2.6 Start-up system

The electrical supply to the electronics, according to the start-up sequence, shall be divided in groups as follows:

GROUP NR.	COMPONENTS	COMMENTS
0	Cabinet LCU, cooling system	Directly connected to the power supply header. Switched on as soon as the Enclosure gets power.
1	Power Rotator servo drive	
2	Power AG turn table servo drives	
3	Power Probe arm servo drive	
4	Power Focus stage drive	
5	AG Instrument	24 V power supply
6	Logic Power Supply for all Servo Drives	

Zero crossing solid state relays shall be used to start each group (TBC).

Verification Deliverables

Design phase: Design document (Control architecture and functional description).
Electrical drawings.

Product Phase: Inspection report. Test report (local control functionality)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 80 of 98
---	---	---

9.2.7 **Equipment connected to the UPS supply**

Any devices in the Electronics Cabinet for which a power interruption can be considered critical (at least, the Cabinet LCU) shall be connected to the UPS power supply (see A1 for electrical supplies provided by the GTC at the Cassegrain focal station).

Verification Deliverables

Design phase: RAMS (power interruption analysis). Electrical drawings

Product Phase: Inspection report.

9.2.8 **AG Instrument Fibre Optics connection cable**

Two Duplex Fibre Optics Cables (for redundancy) shall be installed from the AG Instrument Electronics Box location (see 7.2.4.10) to the AG chain connection panel (see 5.2.1.7).

The cable shall be Multimode OM3. Connectors, see A1.

Verification Deliverables

Design phase: Cable list.

Product Phase: Inspection report.

9.2.9 **DC supply for the AG Instrument**

The AG Instrument shall be fed from a 24V DC soft start power supply. The requirements for the power supply are:

- Input: 100-240V (PFC, $\cos \phi > 0.95$)
- Output: 24V

The AG Instrument consumption is estimated in 2A (TBC)

The cable from the power supply to the AG instrument shall be 3 G 0,75mm².

Verification Deliverables

Design phase: Component list. Electrical drawings.

Product Phase: Inspection report

9.2.10 **Local Safety design (RQ/CS-IS-CG/NNN)**

The safety functions, the safety system design and devices to perform those functions shall be derived from the safety assessment according to the applicable Spanish and/or European standards and regulations.

Safety components shall be used in the Cabinet LCU according to the safety assessment. The Cabinet LCU shall incorporate 6 additional safe channels for future growth.

The emergency stop buttons locations shall be, at least:

- Inside the Electronics enclosure
- Top surface of AG mechanics structure (the inclined part in order to let the horizontal surface free to step on it)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 81 of 98
---	---	---

- HMI panels

The interlock keys locations shall be at the HMI panels.

Any light indicators shall be installed visible from the Telescope Rotating Floor and shall be switched off when working in Remote Control Mode (to eliminate any light source during observations)

Smoke and fire detection system shall be installed inside the cabinet.

Verification Deliverables

Design phase: RAMS (Safety Assessment), Design document (Safety functions and safety system implementation description and justification).

Product Phase: Inspection report. Test report (functional safety)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 82 of 98
---	---	---

10 SUPPORT ELEMENTS SPECIFICATION

10.1 CassegrainTransport cart (RQ/SE-CG-TC/NNN)

10.1.1 Functional requirements

The items to be supported and transported are:

- The Rotator + AG Mechanics assembly specified in sections 0 and 0.
- OSIRIS (Scientific Instrument)

The transport cart shall be used, at least, to:

- Support the Rotator after unpacking at the GTC facilities
- Perform Rotator On Site Testing
- Perform the POM alignment before Integration at the Focal Station⁸
- Carry the Rotator or the Science Instrument through the Annex building and the Telescope Chamber up to the Focal station location.
- Place the Rotator or the Science Instrument bellow the focal station for lifting.
- Receive the Rotator or the Science Instrument when dismounted from the Focal Station
- Perform maintenance operations in the Rotator or the Science Instrument

The transport cart shall support these items steadily for storage and maintenance operations.

The general aim is to minimize mass and storage volume of Support Elements at the GTC⁹.

Verification Deliverables

Design phase: Design document (Functional Description), 3D Model

Product Phase: Inspection report.

10.1.2 Design requirements

The transport cart shall comply with the following:

- Maximum mass to be carried: see A2.
- Maximum cart mass: 1000 kg (TBC)
- Maximum total envelope: 3.25m length, 3.00m width, and 3.65m height (TBC)
- Attachment interface to the Science Instrument defined in A2.
- The Rotator position shall be with its rotation axis vertical and the attachment flange facing downwards (ready to be lifted into its nominal position at the Telescope Tube being vertical).

⁸ Tasks from here on (this one included) are out of scope.

⁹ This is the reason to require a specific Transportation Cart rather than reusing the Test Bench for that purpose.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 83 of 98
---	---	---

- All Rotator+AGMechanics assembly items shall be accessible either from top or from the bottom of the assembly.
- There shall be a beam on top of the rotator at 0,5 m (TBC) from the rotator top. The beam shall be supported on the Cart. The beam shall be easily dismountable to allow to lift the rotator from the lifting interface points defined in A1. The aim of the beam is to hold and roughly orientate a small mirror 0,5 m (TBC) on top of the AG Mechanics. The beam shall provide a bending moment of inertia higher than 50 cm⁴ (TBC) in both bending axes. The beam shall hold a plate 120x120mm centred on the rotator axis. The plate shall be orientable in one axis parallel to the beam and easily fixed with a bolt. The interface with the mirror shall be at four threaded holes in the plate (holes diameter and location TBD).
- Movement system (wheels, air skids system, ...)
 - lineal displacement and turn (or lineal and lateral displacement)
 - adequate for concrete surfaces and metal treadplate
 - easy displacement/turn by own mechanic means, alternatively a maximum of 4 person
 - dismountable by means of bolted flanges at a TBD height over the floor (this is to allow movement system substitution if needed).
 - Maximum punctual pressure 1daN/cm²(TBC)
- Braking system- enough to safely allow any maintenance operation when stationary.
- The Cart shall be dismountable with a considerable space saving in order to be stored during long periods.
- The system shall have the CE mark independently from the CG-Set

Verification Deliverables

Design phase: Design document (Description and justification), 3D Model, FE model, Component list

Product Phase: Inspection report. Test Report (functional). CE Mark certificate

10.2 Instrument Dummy (RQ/TL-IR-CG-200/NNN)

An instrument dummy mass shall be provided. The dummy shall be configurable with 3 modules:

- 1 main module of 1600kg
- 2 supplement modules of 400kg each (or what is needed to complete the maximum Instrument mass and worst case c.o.g. position specified in A2).

The mass eccentricity and rotation inertias specified for the Instrument in in A2 apply only to the complete configuration. In configurations with 1 or 2 modules the c.o.g. Z position shall approach the Rotator proportionally to the mass variation (TBC).

The main module shall be dismountable/foldable with a considerable space saving.

The Dummy shall include a simple movement system in order to carry it straight from the Cassegrain focal station to the storage place at the GTC building and vice-versa. The

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 84 of 98
---	---	---

requirements for this movement system are the same as in 10.1.2 (TBC), except that it is not necessary to detach it from the dummy. The movement system will remain with the Dummy when stored or mounted on the Cassegrain focus.

Verification Deliverables

Design phase: Design document (Description and justification), 3D Model

Product Phase: Inspection report. Test Report (functional)

10.3 POM Unit Dummy

The Probe Arm shall include a removable dummy at its end simulating the mass and COG of the POM unit, as specified in A1, for testing purposes.

Verification Deliverables

Design phase: 3D Model

Product Phase: Inspection Report

10.4 AG Instrument Dummy

The Probe Arm shall include a removable dummy simulating the mass of the AG Instrument, as specified in A1, for testing purposes.

Verification Deliverables

Design phase: 3D Model

Product Phase: Inspection Report

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 85 of 98
---	---	---

11 DOCUMENTATION DELIVERABLES SPECIFICATION

11.1 Introduction

The list of items specified for each of the documents bellow is the minimum requested. The requested information can be grouped in a different document structure but this shall be subject to approval by GRANTECAN.

The contents specified for each item shall be completed before Final Acceptance. Previous releases shall be developed so far as possible according to the phase of the project in which the document is to be released, as by the corresponding Statement of Work. For example, photos of the hardware cannot be used to describe an assembly operation within the CDR documentation but should be there in the Factory Acceptance documentation.

The requirements hereafter shall be verified for compliance by documents inspection before delivery and its compliance shall be registered within the compliance matrix.

Format

The Contractor shall deliver documents in paper and an electronic copy with the formats specified for each kind of document hereafter. Other formats must be previously authorized by GRANTECAN.

Electronic copies shall be delivered in a pen drive organized in a clear directory structure. Directory and file names shall be self-explanatory.

Paper documents and drawings shall be colour printed, DIN A4 size, 2 copies, unless otherwise agreed. All documents shall be grouped in bundles adequate to be managed as units (not too heavy) and to be stored in a shelf.

Templates

The Contractor should use the templates established and provided by GRANTECAN for documents. If this is not possible, the document templates used by the Contractor shall include at minimum:

- The GTC Project identification.
- The date and the Contractor code (GRANTECAN will provide the Contractor code).
- The Status of the document (draft, as-built, etc.)
- The section corresponding to changes record.
- The sections corresponding to applicable and reference documents.
- The table of contents

Language

English shall be used both for text in drawings and documents, except for the Operation, Maintenance and Safety Manual which should be preferably in Spanish.

Document Contents

The contents of each kind of document shall be as specified in the sections hereafter, unless otherwise agreed with GRANTECAN.

Units

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 86 of 98
---	---	---

The Contractor shall use the international system of units. Any exception shall be previously authorized by GRANTECAN and shall be widely used in engineering practices within the European Union.

Dates

The date system shall follow the format: day-month-year.

New editions of documents

Every new edition of any document or drawing shall be clearly identified by the Contractor.

11.2 Design document

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Product Tree breakdown
- General Design description and justification (with reference to mechanical and thermal analysis, calculations, RAMS, assembly, packaging, handling and transportation analysis).
- Subsystem/component design description and justification (idem)
- Control architecture
- Electrical design
- 3D model description
- FEM model description and analysis (thermal, mechanical)
- Assembly, packaging, handling and transportation analysis
- Other Calculations and analysis
- Error Budget
- System budgets breakdown (mass and inertia, thermal dissipation, electrical power)
- Annexes
 - Error Budget spreadsheet (MS Excel)
 - 3D and FEM models
 - List of applicable Standards and Regulations
- Reference documents
 - RAMS
 - Requirement and Interface documents
- Applicable documents, at least:
 - Drawings
 - Compliance Matrix
 - Component List

NOTE: Every model and calculation shall be referred to the Coordinate Systems defined in section 3.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 87 of 98
---	---	---

11.3 Dimensional 3D model

FORMAT

Creo Parametrics 3.0 or compatible

CODIFICATION

The assemblies, subassemblies and parts shall be named after the Product Tree codes.

CONTENTS

It shall include at least the Coordinate Systems defined in section 3.

Material properties shall be provided to all parts for mass and inertia calculations.

11.4 FE models

FORMAT

Compatible with Ansys 17.0, APDL, alternatively Ansys Workbench

CODIFICATION

The assemblies shall be named after the Product Tree codes

CONTENTS

Results shall be referred to the Coordinate Systems defined in section 3.

The model shall have all what is necessary, including load cases, in order to run the simulations.

11.5 Mechanical Drawings

FORMAT

Electronic: AutoCAD 2016, PDF (optionally in Creo Parametrics 2D)

Paper: 2 copies, DIN A3 size, Colour Printed. Bigger formats must be agreed with GRANTECAN.

CODIFICATION

Drawings shall be coded the following way:

DR/XX-XX-XX-NNN/nnn (e.g. DR/ AG-GC-AG-200/000)

Where XX-XX-XX-NNN is the Product Tree Item and nnn is an arbitrary number, usually 000 for high order assemblies, then 100, 200,.. for lower order assemblies, etc...

Interface drawings shall be coded the following way:

DR/I-XX-YY-NNN/nnn (ej. DR/I-AG-AG-017/000)

Where I-XX-YY-NNN is the Interface code (see A1 and A2) and nnn is an arbitrary number.

The contractor may use their own coding system for fluid hoses and connectors coding in drawings with the same requirements as for cables and electrical connectors in 11.6 .

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 88 of 98
---	---	---

CONTENTS

The Contractor should use the templates established by GRANTECAN for the elaboration of drawings. If this is not possible, the drawing templates used by the Contractor shall at minimum:

- Include the GTC Project identification.
- Use the codes for drawings established by GRANTECAN hereafter.
- Use the codes for configuration elements, components and interfaces, established by GRANTECAN (sections Configuration items and Interfaces (only for icd's)).

Everything shall be referred to the Coordinate Systems defined in section 3.

11.6 Electrical Drawings

FORMAT

Electronic: EPLAN compatible

Paper: 2 copy DIN A4 or A3 size, Colour Printed.

CODIFICATION

The contractor may use their own coding system for Cables, hoses and connectors coding with the following requirements:

- The codification of cables and connectors in drawings shall be consistent with labelling of physical items. Furthermore, the label in a physical item must allow to locate the item in a given drawing if the item is far apart from the rest of the equipment.
- Plugs and corresponding sockets must be identified and labelled with the same code or part of the code must coincide in both defining the match uniquely.
- The specific cable and connector coding system shall be presented to GRANTECAN and is subject to approval
 - The coding system must comply with international standards (IEC if possible). The coding system must be anyhow described more specifically in a written manner and sent by e-mail or included in the documentation.
 - The coding system must specify any distinction between "external" and "internal" cables. "External" means those cables between subsystems components, or modules, usually attached to the structure or running through a cable chain, i.e., cables between Electronics Enclosure and Rotator. "Internal" are those inside electronic cabinets and small enclosures.
 - The coding system must clearly specify how to identify the same cable:
 - Within a drawing
 - On the label
 - Within cable lists or tables

I.e. which part of the code is used in each of the previous cases.

CONTENTS

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 89 of 98
---	---	---

Electrical drawings shall fulfil the CEI/IEC 61082 standard.

There are cables with two different scopes whose information is treated in a different way:

- External Cables/ducts between modules, e.g. between Cabinet and AG Structure, between AG Structure and Probe Arm, etc...
- Internal cabling (mainly electronic cabinet)

The Preliminary Design Document provided by GRANTECAN includes:

- External cables and connectors general layout (drawing)
- External cables and connectors list (spreadsheet)

The subsequent phases shall produce the following information:

- External cables and connectors
 - Electrical drawings
 - General layout (updated) showing panel or device at both ends of each cable. Each cable shown as a single line, identifying at least:
 - Cable code (see above)
 - Cable reference
 - Connectors code (see above)
 - Individual cable information in subsequent pages (table and drawings):
 - Cable conductors
 - Cable code
 - Cable commercial reference
 - Connectors code
 - Connectors commercial reference
 - Pin-out
 - Cable list (updated)
 - Mechanical drawings (with mechanical information, e.g. together with cable chains drawings)
 - Cable Type (power, signal, data, water, air, oil,)
 - Description
 - Number
 - Origin
 - Destination
 - Routing (cable chain, structure,)
 - Length
 - Section
 - Min. Radius of curvature
- Internal cabling
 - Electrical drawings
 - Usual electrical drawings

11.7 Software documentation

FORMAT

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 90 of 98
---	---	---

Electronic: MS-Word

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Mapping between functional description and CAN objects.
- Detailed PLC Software Documentation:
 - POU's,
 - data types,
 - resources (global variables, sampling trace, PLC configuration, task configuration, watch and recipe manager),
 - call trees of POU's and data types
 - cross reference list

11.8 Component List

FORMAT

Electronic: MS-Excel

Paper: 2 copy DIN A4 or A3 size, Colour Printed.

CODIFICATION

TBD

CONTENTS

The Component List shall have a tree structure following the Product Tree(PT) in section 4, down to the lowest level.

For each component:

Component code (PT code)
Component Name
Commercial Reference/Drawing code
Quantity
Quantity of Spares
Supplier

11.9 Commercial components documentation

FORMAT

Electronic: MS Word, PDF.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 91 of 98
---	---	---

Paper: 2 copy DIN A4 or A3 size, Colour Printed.

CONTENTS

Design phase:

Component List with at least: Part code, Name, Quantity, Commercial Reference, Description

Product phase:

Dossier containing drawings, specs sheets, user manuals, conformity certifications, etc...

11.10 Materials certification

FORMAT

Electronic: PDF

Paper: 2 copy DIN A4 or A3 size, Colour Printed.

CODIFICATION

TBD

CONTENTS

Raw material certifications.

Commercial components Compliance sheets, etc...

11.11 RAMS analysis

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Reliability Analysis
 - MTBF/MTTR analysis from the MTBF/MTTR of the components.
 - Identification of:
 - critical-useful-life items (short-life items requiring preventive or corrective maintenance).
 - MTBF of the critical-useful-life items.

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 92 of 98
---	---	---

- non-standard items.
- Spare Component List (Name, Reference, Quantity, Supplier, Maintenance Task, Subsystem, Needed from - verification, integration, commissioning, operation)
- Reliability Design criteria compliance, at least for each design criterium in 5.6.1.1, addressing corresponding design solutions where possible. Identify problems in criteria fulfilment compatibility and make the corresponding trade-offs.
- Maintainability analysis
 - Preventive and Corrective Maintenance tasks identification according to the Reliability Analysis anticipating for each task, where possible: duration, frequency, spare parts and supplies, tools and equipment, facilities, personnel and skills, special computer resources, safety issues.
 - Maintainability design criteria Compliance, at least for each criterium in 5.6.2.1 , addressing corresponding design solutions for each where possible. Identify problems in criteria fulfilment compatibility and make the corresponding trade-offs.
 - Maintainability Design guidelines compliance, at least for each design criterium in 5.6.2.2, addressing corresponding design solutions where possible. Identify problems in criteria fulfilment compatibility and make the corresponding trade-offs.
 - Accessibility list. Main components requiring maintenance. For each of those, what kind of maintenance and how these can be accessed.
 - Maintainability estimates (MTTR, MPMNT, MPDMT) according to maintenance tasks and assumptions. Estimates shall be compared with the corresponding figures allocated
- Safety Analysis
 - Hazard identification and analysis according to the applicable regulations.
 - List of Applicable Safety regulations
 - Any other Safety documentation imposed by the applicable regulations according to each Project phase

11.12 Assembly, Packaging, Handling, Storage and Transportation Procedure

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 93 of 98
---	---	---

- Assembly step by step, based on photos and relevant data for each step (items to assemble, bolts, preload, special tools or conditions,...) including inspection points.
- Packaging according to kind of transportation and associated environmental conditions at transportation and storage.
- Packaging, number and size
- Lifting and handling provisions at transported item and/or packaging.
- Transportation up to the GTC. Compliance to maximum dimensions, permits, environment.
- Storage needs, location, time, environment, ...

11.13 Acceptance Test Plan

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Brief description of all verification campaigns, grouped by sort of verification or by the configurations for verification, for example:
 - Verification of interfaces and dimensions
 - Other inspections
 - Measurements of gravitational deformations or static stiffness
 - Functional Tests (in vertical and horizontal position)
 - Performance Tests (in vertical and horizontal position)
- Verification Matrix, per requirement:
 - Requirement Code
 - Requirement Title
 - Requirement Text
 - Campaign
 - Test/Inspection (title, reference to Test/Inspection procedure when applicable)
 - Expected value
 - Expected Conformance record (document)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 94 of 98
---	---	---

- Comments
- Reverse verification matrix, per test/inspection:
 - Campaign
 - Test/inspection code
 - Test/inspection title
 - Test/inspection short description
 - Equipment configuration (horizontal, vertical, with dummy, etc....)
 - Parameters measured
 - Requirements verified
 - Expected kind of report
 - Comments

Every requirement applicable to the contract must have a Test (functional or performance tests, other measurements, procedures performance or simulation,..) or inspection (visual inspection of HW, SW, models or documentation revision) associated.

11.14 Verification Procedures

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Per test/inspection:
 - Objective, parameters measured and requirements tested
 - Description
 - Set-up, tools, facilities
 - Equipment configuration, initial conditions
 - Sequence
 - Acceptance Criteria

11.15 Verification Reports (Inspection, Test, Metrology)

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 95 of 98
---	---	---

CONTENTS

Per Test/Inspection, the following sections:

Test Objective

Set-up description, tools, facilities, initial conditions.

Procedure (in brief or reference to another document) and Incidences

Results analysis

Conformance assessment (Results, Acceptance criteria,...)

11.16 Operation, Maintenance and Safety Manual

FORMAT

Electronic: MS-Word, PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

- Safety
 - Risk Assessment
 - Any documentation required by the applicable safety regulations
- System description
- Installation (making reference to interface drawings)
 - Handling
 - Attachment
 - Alignment
 - Connections.
- Operation
 - System description (reference to design document)
 - System operation (operation modes, 0° position, start and stop sequences...). Use of images where possible.
 - System recover from emergency conditions
 - User and Interface Manual of the Power Electronics: All the functions and the electronic interfaces present on the CG-Set power electronics shall be documented

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 96 of 98
---	---	---

by the Contractor to an extent that allows to fully develop operational interfacing hardware and software by GRANTECAN.

- User and Interface Manual of the Local Control System, including HW, SW description and interface.
- List of maintenance tasks (per subsystem/component). For each item in the list:
 - Task name
 - Type (preventive, corrective)
 - Description (including photos)
 - Periodicity (if preventive)
 - Manpower (number, qualification)
 - Duration
 - Components/Spares
 - Special tools, supplies
 - Special conditions
- Spares list
 - Reference (mark and model, reference number)
 - Supplied (Y/N)
 - Task for which it is intended
 - Number (or quantity) in inventory
 - Suppliers data
 - Estimated procurement time
 - Special storage requirements/expiry term
- Product Specifications summary

Summary of the performances, as well as main physical characteristics according to the requirements list in previous sections, where applicable. Indicate where the parameter has been measured or estimated.

 - Mass (from measurements)
 - Power consumption (from measurements)
 - Heat dissipation (from measurements)
 - Mechanisms operation ranges
 - System performance, from measurements of Performance Requirements

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 97 of 98
---	---	---

- MPNTM, MPDTM, from RAMS
- Nominal, Operational and Survival ranges (from climatological conditions and gravity orientation)
- Service life time
- List of Applicable Regulations
- References, at least to:
 - RAMS
 - Design Document
 - Assembly, Packaging, Handling, Storage and Transportation procedure

11.17 CG-Set CE mark certificate

FORMAT

Electronic: PDF

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

As stated by the corresponding standards and regulations.

The Contractor shall provide the CE Declaration of Conformity of the Machinery in accordance to the Spanish and European Machinery Regulations.

The delivered documentation shall be complete as Technical File for Machinery stipulated by the European Machinery Regulations.

11.18 Verification Control Document

Note: One document per verification milestone.

FORMAT

Electronic: MS-Word, PDF, MS-Excel

Paper: 2 copy DIN A4, Colour Printed.

CODIFICATION

TBD

CONTENTS

Compliance Matrices. The provided Template shall be used.

Applicable documents (Specification and Interface documents subject to verification)

	Telescope Mechanics Cassegrain Set (CG-Set) Specifications	Code: ESP/TELE/0216-R Issue: 1.A Date: 22/06/2017 Page: 98 of 98
---	---	---

Compliance Matrices, per requirement:

Requirement code

Requirement Title

Requirement Text

Specimen Id. (serial, etc...)

Conformant

Conformance record (report code, section)

Comments (including corresponding NC code, if non-compliant)

ANNEX- Non-conformances application

If a requirement applies to more than one physical item there are two options:

- One row per requirement. The conformance document records shall have conformance record for all items.
- One row per requirement and item. Indicate item reference or serial number for each row.