Telescopio San Pedro Mártir (TSPM)

Telescope Overview

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Applicable documents

Nº	Document title	Code	Date	Issue
A.1	TSPM: High Level Requirements	TSPM/HLREQ/001	2017/08/10	1.I
A.2	TSPM: Product Tree	TEC/TSPM-PDR/008	2017/09/05	1.B
A.3	TSPM: Coordinate System	TEC/TSPM/007	2017/08/28	1.E
A.4	TSPM: System specification	SP/TSPM/001	2016/12/30	1.B
A.5	TSPM: Optical Configurations	TEC/TSPM/004	2016/01/15	2.A
A.6	TSPM: List of acronyms and abbreviations	TEC/TSPM/001	2016/02/02	1.B
A.7	TSPM: Glossary	TEC/TSPM/006	2016/09/20	1.B
A.8	Telescope Specification	SP/TSPM-TL/001	2017/09/18	1.A

Reference documents

Nº	Document title	Code	Date	Issue
R.1	Telescope FEM at the preliminary design	ANA-TSPM-PDR-TL-002	2017/09/29	1.A
R.2	Mass Budget and Moments of Inertia	ANA-TSPM-PDR-TL-004	2017/09/29	2.B
R.3	Oil pumping system	TEC/TSPM-PDR-TL/002	2017/09/29	1.A
R.4	Telescope azimuth and elevation subsystems PD	TEC/TSPM-PDR-TL/003	2017/09/29	1.E

R.5	M2 mechanism PD	TEC/TSPM-PDR-TL/017	2017/09/29	1.A
R.6	TS Tertiary Assembly	TEC/TSPM-PDR-TL/005	2017/09/29	1.D
R.7	Rotators PD	TEC/TSPM-PDR-TL/006	2017/09/29	1.A
R.8	Control System	TEC/TSPM-PDR-TL/007	2017/09/29	1.A
R.9	Interlock System	TEC/TSPM-PDR-TL/008	2017/09/29	1.A
R.10	Telescope assembly & integration and verification	TEC/TSPM-PDR-TL/009	2016/12/13	DRAFT
R.11	Telescope	TSPM-TL-00-00-00-000_00_00-0000	2017/08/21	1.A
R.12	Azimuth Assembly	TSPM-TL-AZ-00-00-000_00_00-0000	2017/09/29	1.A
R.13	Altitude Assembly	TSPM-TL-AL-00-00-000_00_00-0000	2017/09/29	1.A
R.14	Baffles Mechanical Attachment	TEC/TSPM-PDR-TL/014	2017/09/29	1.A
R.15	Tertiary Assembly	TSPM-TL-TS-00-00-000_00_00-0000	2017/09/29	1.A
R.16	Cassegrain Rotator	TSPM-TL-CR-00-00-000_00_00-0000	2017/09/29	1.A
R.17	Nasmyth Rotator	TSPM-TL-NR-00-00-000_00_00-0000	2017/09/29	1.A
R.18	Cable wrap and oil conductions	TEC/TSPM-PDR-TL/012	2017/09/29	1.A

Configuration items

Code	Description

Related configuration items (only for ICD's)

Interface Code	Element 1	Element 2	Name

List of acronyms and abbreviations

Please refer to: TEC/TSPM/001 [A.6]

Glossary

Please refer to: TEC/TSPM/006 [A.7]

Nomenclature

Unless otherwise indicated, all symbols used herein are defined as follows:

a	Acceleration in m/s^2
A	Area in m^2
CG	Center of gravity
D	Diameter in m
d	Thickness in m
E	Modulus of elasticity in N/m^2 or Pa, energy in J
E_p	Potential energy in J
E_k	Kinetic Energy in J
F	Force in N
f	Frequency in Hz
G	Modulus of rigidity in Pa
g	Gravity acceleration in m/s^2
H	Total head m or Pa
I	Moment of inertia in m^4
L	Length in m
M	Moment of force in N-m
m	Mass in kg
P	Power in W
p	Pressure in N/m^2 or Pa
Q	Volumetric flow rate in m^3/s, heat in J
r	Radius in m
R_E	Reynolds number
t	Time in s, Celsius temperature in °C
T	Thermodynamic temperature in K
v	Rate in m/s

W	Weight in N, work in J
α	Rotation acceleration in rad/s^2
γ	Surface tension in N/m
η	Dynamic viscosity or absolute viscosity in Pa-s
μ	Absolute viscosity in
ν	Kinematic viscosity in m^2/s
ρ	Density in kg/m^3
σ	Normal stress in Pa
τ	shear stress in Pa
ω	Rotation rate in rad/s

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1 Summary

This document provides an overview of the preliminary design and a general description of the telescope structure. The Telescope structure is introduced and its first level of the product tree components is described. The mechanical interfaces with optical components (i.e. M1, M2 and M3, etc.) and supports are described as well as interfaces with instruments. This document includes the description of the mechanical subsystems at preliminary design.

2 Scope

The purpose of the work is to show the preliminary design of the San Pedro Mártir Telescope. This document describes the design of the subsystems of TSPM-TL, according to the product tree.

3 Introduction

TSPM will be constructed as a new 6.5m telescope to be installed at the "Observatorio Astronómico Nacional in the Sierra San Pedro Mártir" (OAN-SPM) in Baja California, Mexico. The project is a binational association of Mexican institutions as the "Instituto Nacional de Astrofísica, Óptica y Electronica" (INAOE) and the "Instituto de Astronomía at the Universidad Nacional Autónoma de Mexico" (IA-UNAM), in partnership with the Smithsonian Astrophysical Observatory (SAO) of Harvard University and the University of Arizona's Department of Astronomy and Steward Observatory (UA) (Richer, Lee, González, Jannuzi, & Beatriz Sánchez, 2016).

The telescope's structural-mechanical design is mainly inspired by the Magellan telescopes in Las Campanas, Chile. However, the primary mirror cell must be completely compatible with the Multiple Mirror Telescope's (MMT) Cassegrain focus. The mechanical design is being lead and developed by the "Centro de Ingeniería y Desarrollo Industrial" (CIDESI) in Queretaro, Mexico (Richer, Lee, González, Jannuzi, & Beatriz Sánchez, 2016).

The telescope is planned to be manufactured in Mexico; it will be preassembled in manufacturer' facilities and disassembled to be shipped to San Pedro Mártir Observatory for final integration. The azimuth and altitude structures are planned to be modular construction and it will transported by truck and ship to the final location on OAN where is going to be assembled, verified and tested (Uribe, Bringas, Reyes, Tovar, & Aldo López, 2016).

4 Applicable Standards and Codes

The standards and codes listed below shall form an integral part of the design to accomplish the Technical specifications and requirements.

American Institute of Steel Construction (AISC), Manual of Steel Construction

American National Standards Institute (ANSI), Reference Y14.6

American Welding Society (AWS)

Occupational Safety and Health Administration (OSHA)

International Plumbing Code, 2006 Edition

International Mechanical Code, 2006 Edition

National Fire Protection Association Codes and standards

International Energy Conservation Code, 2006 Edition

National Electrical Code, 2008 Edition

Normas Oficiales Mexicanas (NOM)

Ley de Edificaciones del Estado de Baja California

Ley del Seguro Social (Instituto Mexicano del Seguro Social - IMSS)

Secretaría del Trabajo y Previsión Social (STPS)

Secretaría de Comunicaciones y Transportes (STC).

Manual de Diseño de Obras Civiles, Diseño por Sismo, Comisión Federal de Electricidad, 2008.

Manual de Diseño de Obras Civiles, Diseño por Viento, Comisión Federal de Electricidad, 2008.

Eurocode 8: Design of structures for earthquake resistance: EN 1998-1 (2004) (English) – Part 1: General rules, seismic actions and rules for buildings

Structural Building Code

International Building Code edition 2006

ASCE 7 minimum design loads for building and other structures. 2005

5 Design Requirements

Telescope design is based on requirements and specifications described in the documents Telescope Specification, SP/TSPM-TL/001[A.8] TSPM System Specification, which is traced to the High level Requirements TSPM/HLREQ/001 [A.1] and SP/TSPM/001[A.4].

6 TSPM-TL General Description

6.1 TSPM-TL Structure

TSPM is designed as an Alt-azimuth mount telescope. The telescope structure is considered to be mostly manufactured of structural steel, with rotational Eigen frequencies between 9 and 11 Hz [R.1], depending the optical configuration [A.5] and the position of the OSS (pointing to horizon or to Zenith). The total mass of the TSPM is below 246000 kg [R.2] including all instruments mounted on the focal stations and the telescope rotating mass about azimuth axis is about 193000 kg [R.2]. TSPM should take care of factors such as selection of materials, manufacturing processes and transportation of parts to the site. The design is mainly on welded plates in order to diminish mass and increase the convection heat transfer from structure to keep it near to the ambient temperature. The design was inspired in proven concepts from Magellan Baade and Clay telescopes and from MMT telescope but with its own requirements and capabilities.|

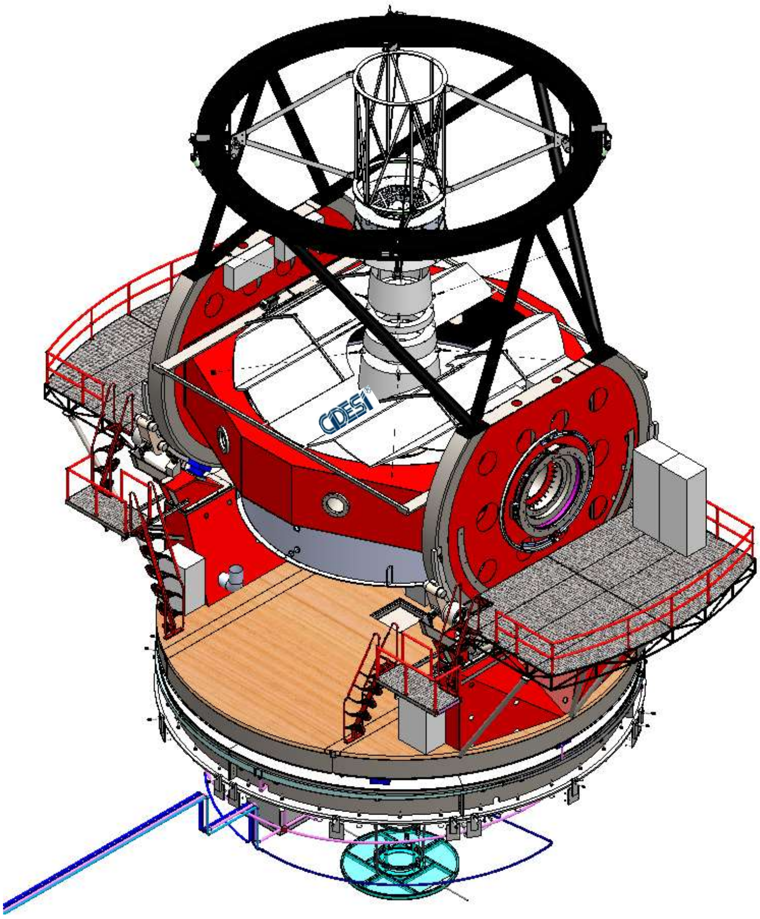

Figure 6-1 TSPM isometric view

6.2 TSPM-TL Product Tree

The subsystem named Telescope is one of the main subsystems of the TSPM, as it is presented in Figure 6-2 with other subsystems belonging to the TSPM system:

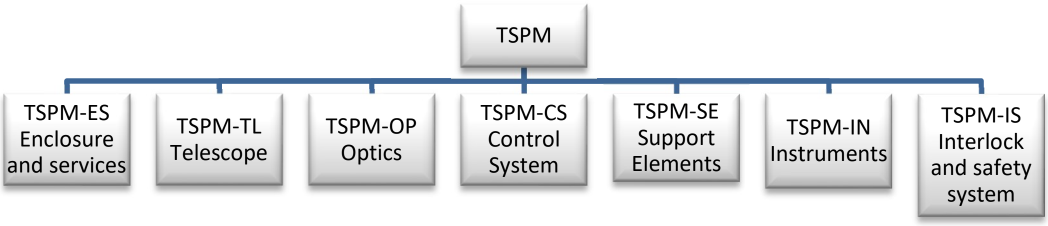

Figure 6-2 TSPM General Product tree

According to product tree, the telescope subsystem it is divided at the next level in the subsystems presented in

Figure 6-3.

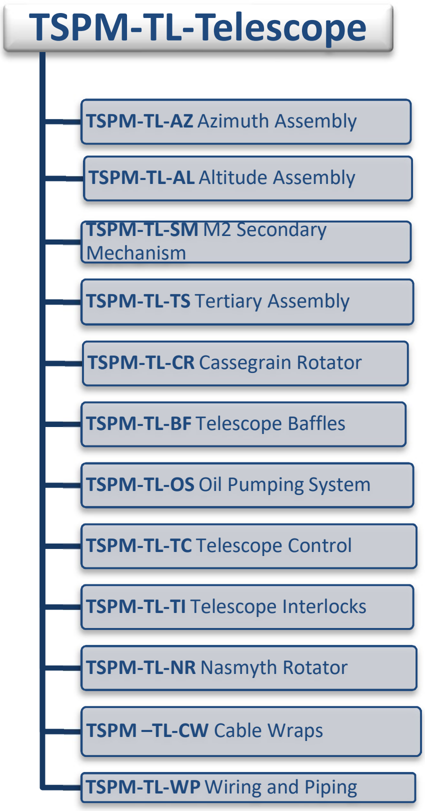

Figure 6-3 TSPM-TL Telescope product tree

Subsystems of the next level belonging to TSMP-TL are listed in

Table 6-1, where most of the names of the product tree from the Figure 6-3 (except Telescope Interlocks and Wiring and Piping) are matched under the column named "description" with the column "PART NUMBER". Under the column "PART NUMBER" are enounced the codification of the 3D model and drawings. All the subassemblies listed on the

Table 6-1 are shown in the ***Figure 6-4*** according to the numbers listed under the "ITEM NO" column.

Table 6-1 TSPM-Tl subsystems and the 3D model codification [R.11].

ITEM NO.	PART NUMBER	DESCRIPTION
1	TSPM-TL-AZ-00-00-000_00_00-0000	Azimuth assembly
2	TSPM-TL-AL-00-00-000_00_00-0000	Altitude assembly
3	TSPM-TL-CW-00-00-000_00_00-0000	Cable wraps
4	TSPM-TL-SM-00-00-000_00_00-000	M2 secondary mechanism
5	TSPM-TL-CR-00-00-000_00_00-0000	Cassegrain rotator assembly
6	TSPM-TL-NR-00-00-000_00_00-0000	Nasmyth rotator assembly
7	TSPM-TL-BF-00-00-000_00_00-0000	Telescope baffles
8	TSPM-TL-TS-00-00-000_00_00-0000	Tertiary assembly
9	TSPM-TL-OS-00-00-000_00_00-0000	Oil pumping system
10	TSPM-TL-TC-00-00-000_00_00-000	Telescope control

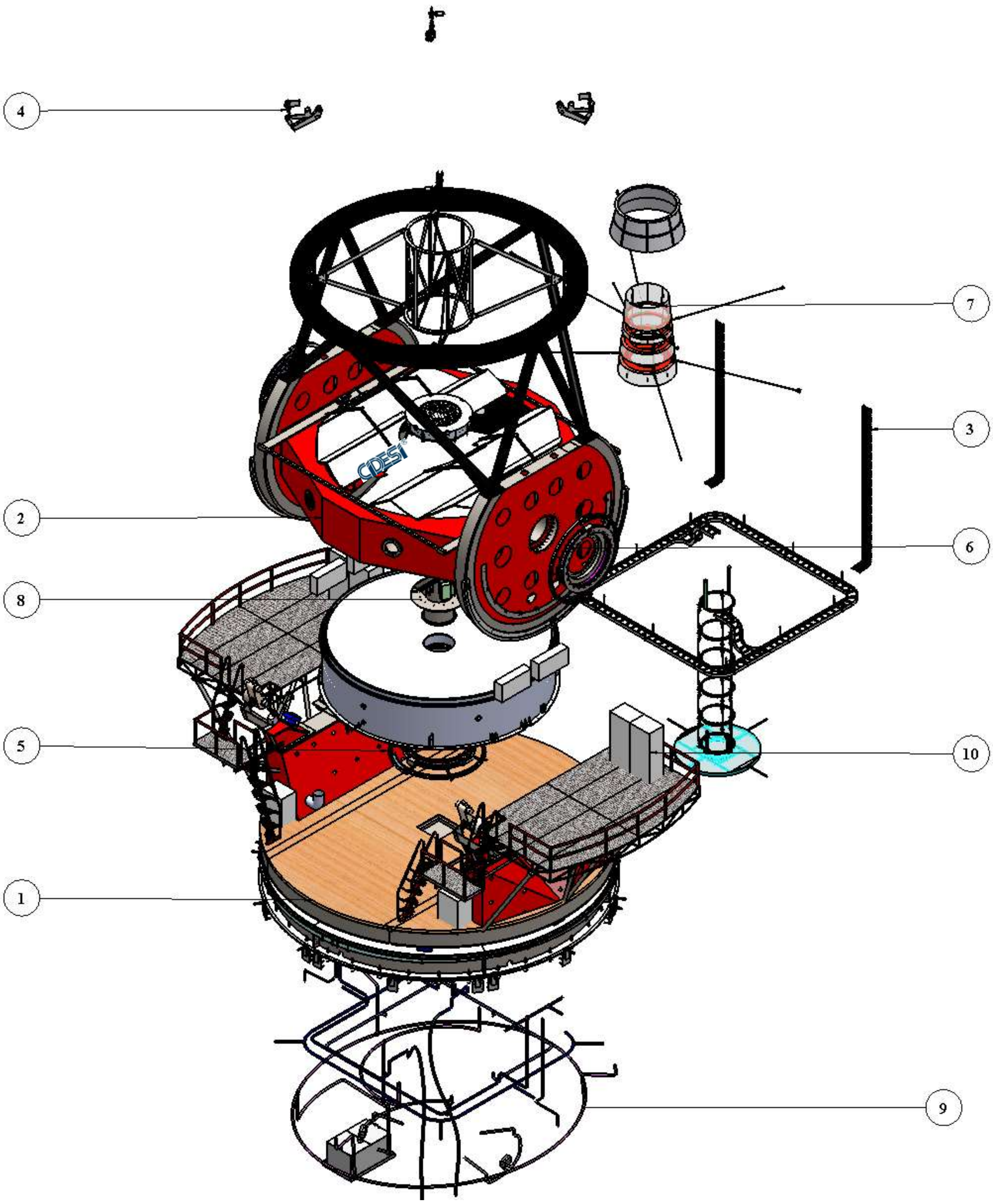

Figure 6-4 TSPM-TL 3D model exploded view [R.11].

6.3 TSPM-TL Coordinate Systems

See TSPM coordinate systems [A.3].

6.3.1 Telescope mount coordinate system

The coordinate system of the telescope mount rotates with the mount around the azimuth axis and is defined as follows (see Figure 6-5):

Origin: At the intersection of the azimuth and the elevation axes.

Z-axis: Pier vertical symmetry axis pointing to the zenith (anti-gravity axis).

Y-axis: Perpendicular to the X-axis and parallel to the rotating floor pointing to the Nasmyth stairs (pointing out of the page in Figure 6-5).

X-axis: Right handed to the two previous axes (i.e., pointing to the Nasmyth A)

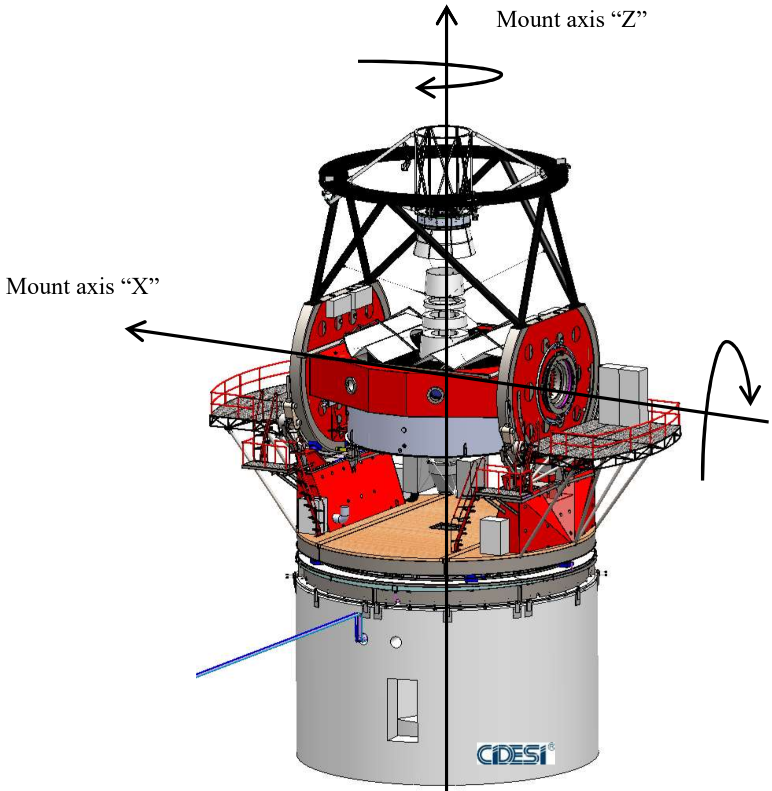

Figure 6-5 Telescope mount coordinate system

6.4 TSPM General Dimensions and Envelopes

The overall dimensions of the telescope are shown in ***Figure 6-6*** and in ***Figure 6-7***.

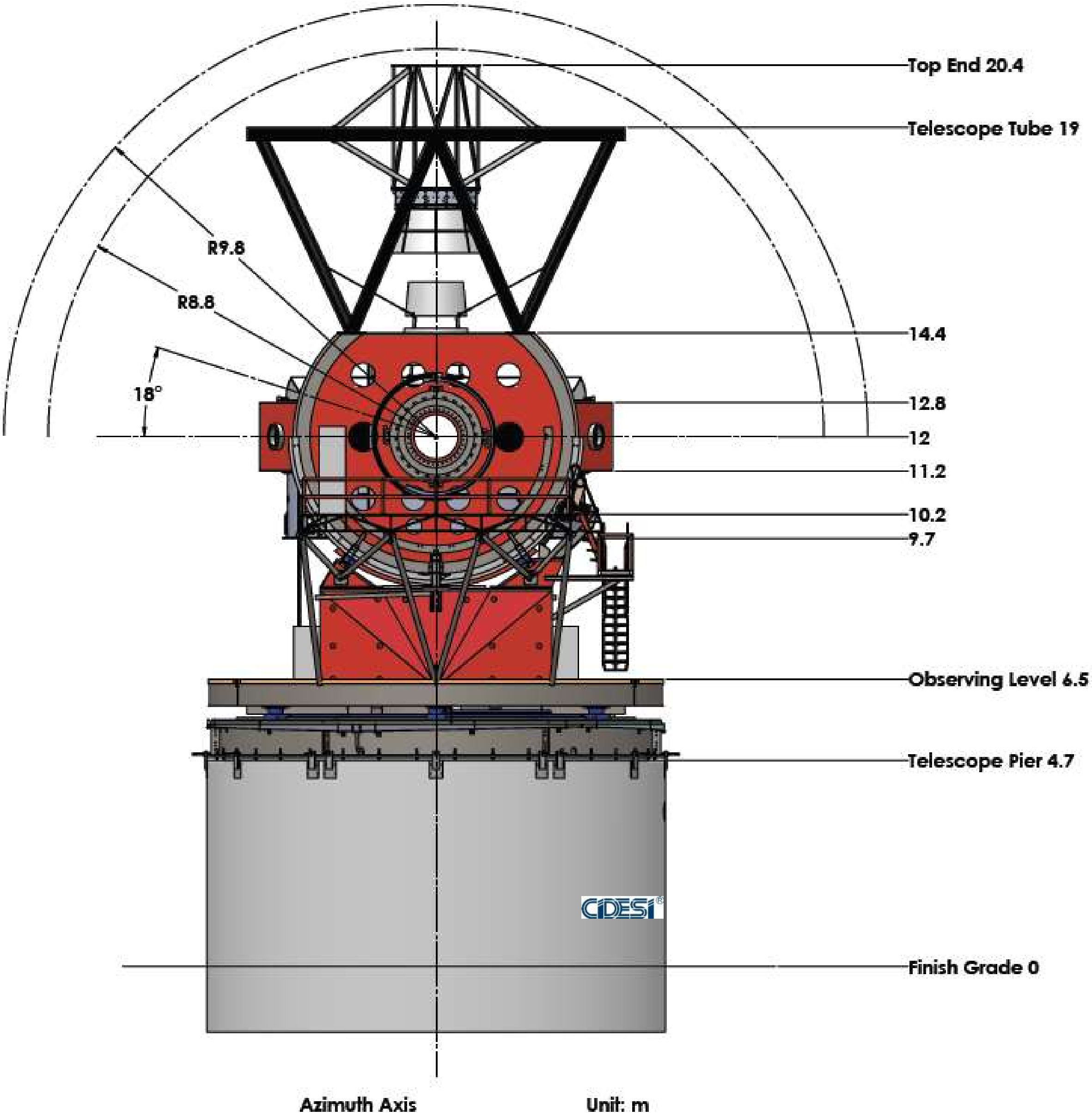

Figure 6-6 TSPM general dimensions left view [R.11].

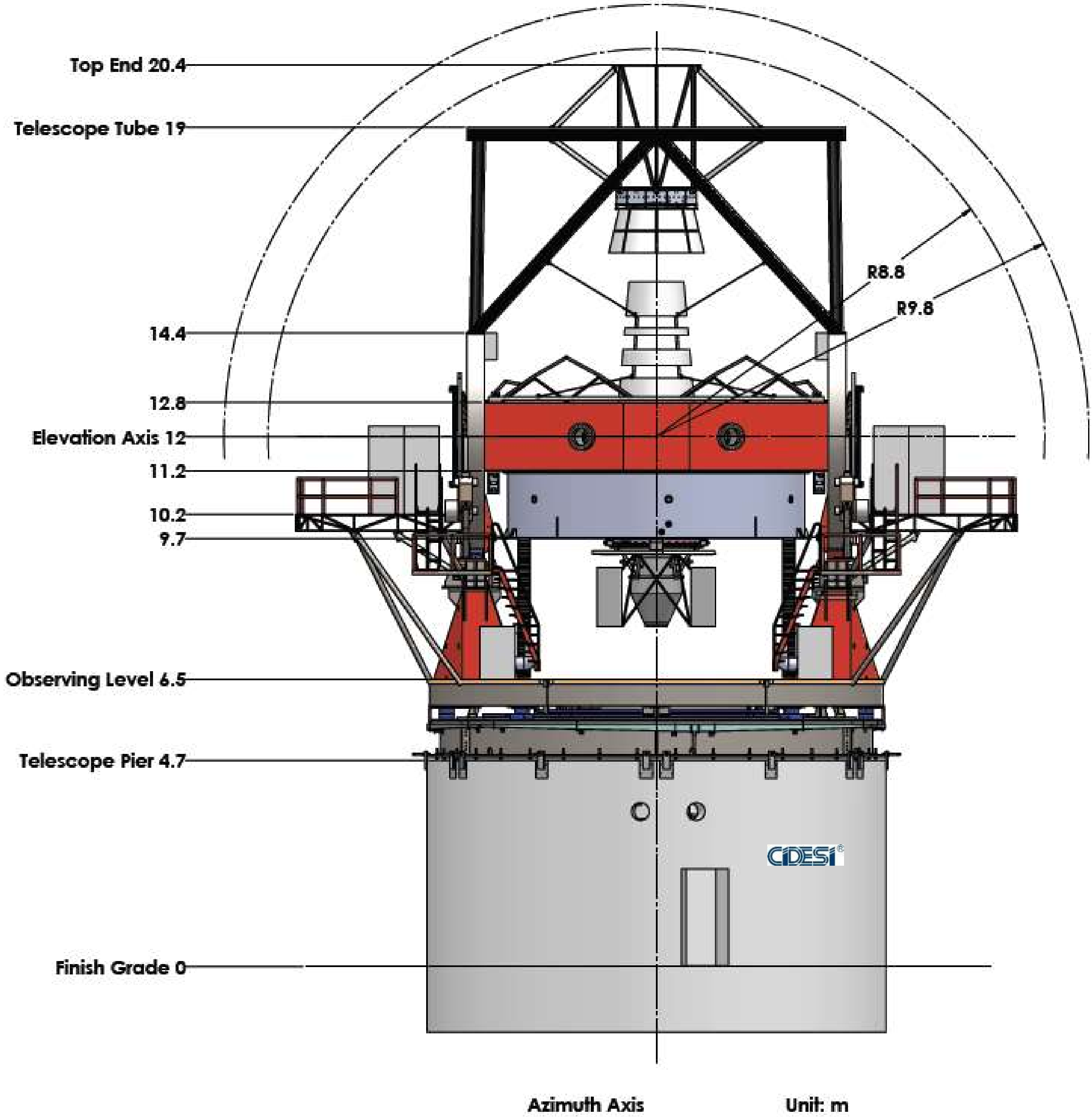

Figure 6-7 TSPM general dimensions front view [R.11].

Figure 6-8 and ***Figure 6-9*** show the TSPM-TL envelopes, the external envelope with height of 15300 mm is the one used for dome design, and the internal with a dimension of 14300 mm is the envelope for telescope design, between them there is a distance of 1000 mm left to avoid interferences between these two subsystems.

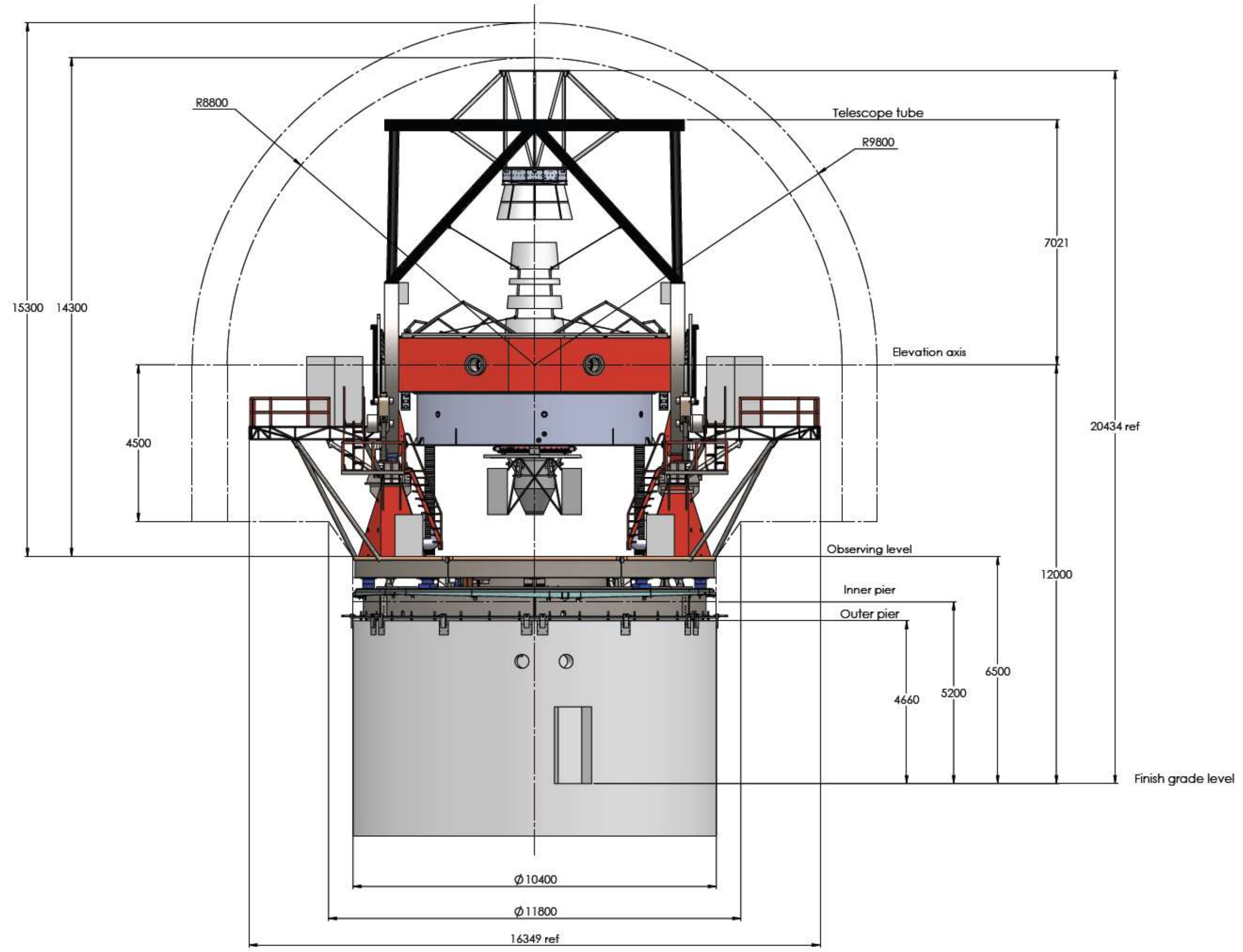

Figure 6-8 TSPM envelope front view [R.11].

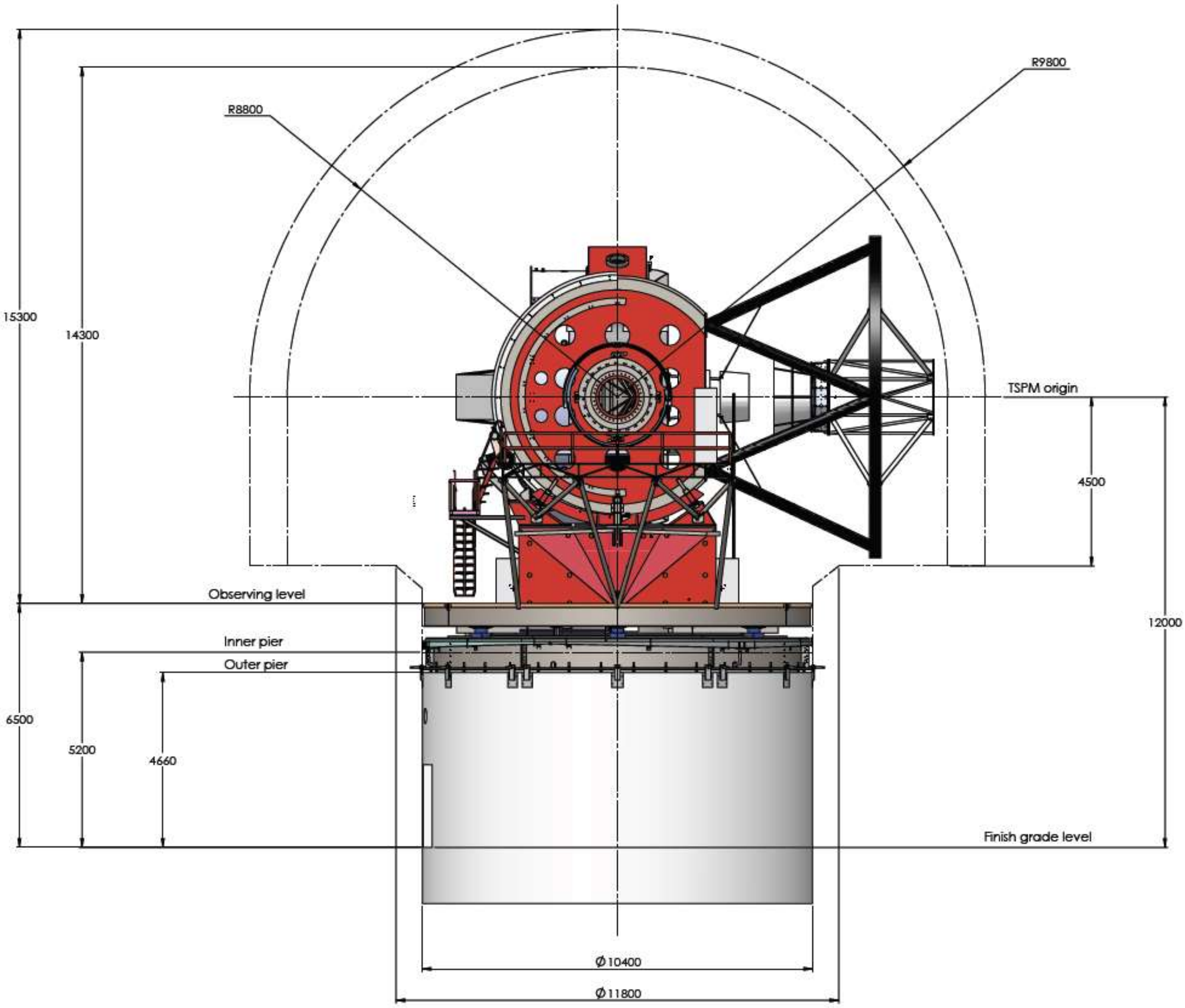

Figure 6-9 TSPM pointing horizon envelope´s right view

6.5 TSPM Motion Ranges

In order to define certain important positions for the telescope operation it is necessary to define for origin, observing ranges and limits of the azimuth and altitude axes.

6.5.1 Azimuth motion range

The origin of the Azimuth movement is defined with the telescope pointing to the North. This mean that the side where the telescope moves in elevation to point from horizon to Zenith is facing to the north when the telescope is at 0º azimuth and, therefore, the side where the stairs are located is pointing out to the south. The telescope parking position is defined at the mid-range between B and C, then the parking position of the telescope is located at 180° (pointing to south and the stairs facing to the north), all these positions are shown in the Table 6-2.

Table 6-2 TSPM Azimuth motion range.

Position	Azimuth	Use
N	0°	Telescope position pointing to the North
A	+65.08°	Alignment parallel to M1 mirror cart rails of the building (TBC)
A+180°	245.08	M1 removal position
B	-90°	Azimuth counter clockwise operational limit
C	+450°	Azimuth clockwise operational limit

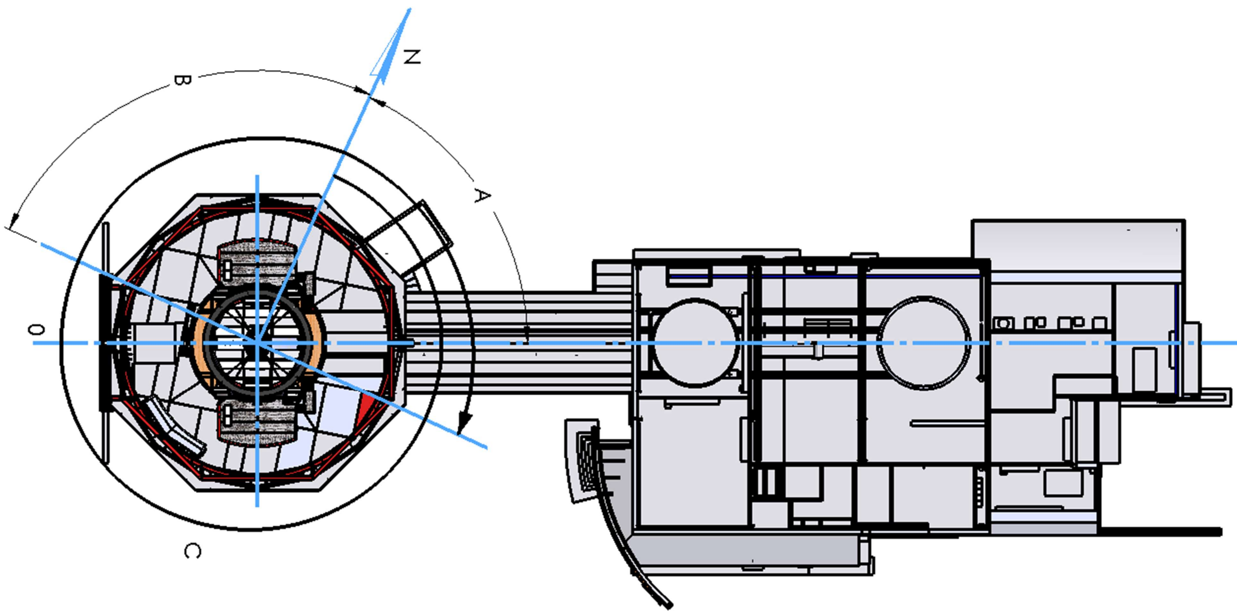

Figure 6-10 TSPM azimuth motion ranges.

6.5.2 Altitude (Elevation) motion range

Table 6-3 TSPM Altitude (Elevation) motion range.

Position	Elevation	Use
Horizon	0°	Minimum allowable physical stop
A	5°	M2 mirror change (and limit switch lower position)
B	15°	Limit switch (operational lower limit switch)
C	18°	Observing lower limit
D	89.5°	Observing upper limit
Zenith	90°	Parking position and operational upper limit switch (M1 mirror change)
E	95°	Limit switch upper position
F	100°	Maximum allowable physical stop

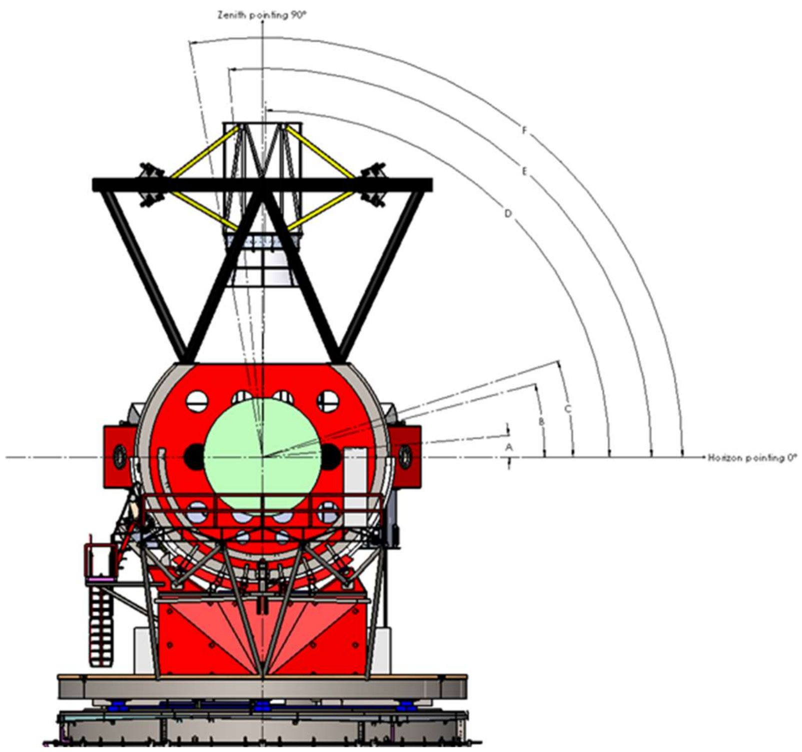

Figure 6-11 TSPM elevation motion angles.

6.6 TSPM focal stations

The telescope is designed to have 7 focal stations: 2 Nasmyth focal stations (NF-A, NF-B), 4 folded Cassegrain focal stations (FC-D, FC-E, FC-F, FC-G) and 1 Cassegrain focal station (F-C). In the ***Figure 6-12*** are shown the positions of the focal stations available to allocate instruments. These instruments are shown in the ***Figure 6-12*** as envelopes with cylindrical shape

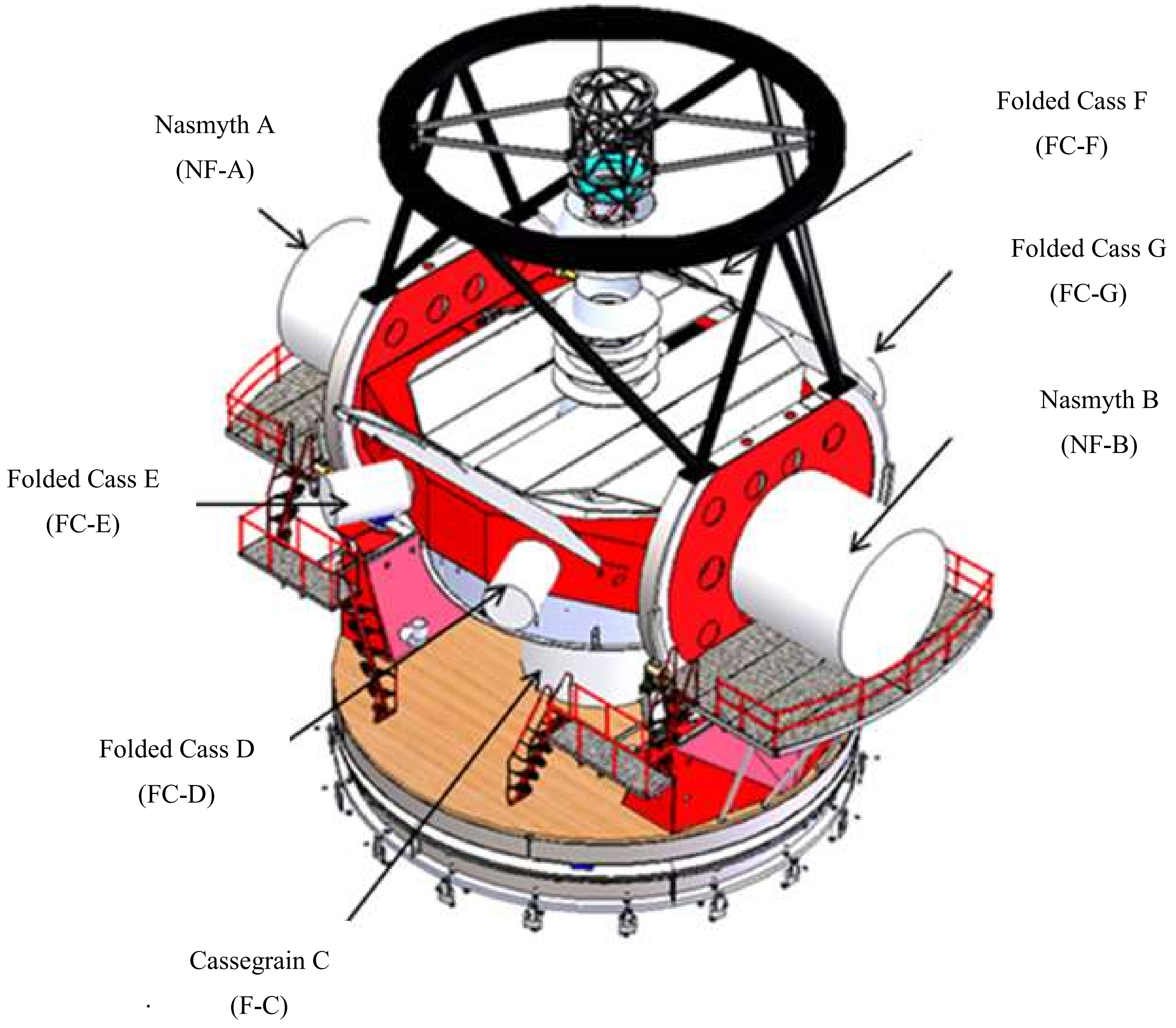

Figure 6-12 TSPM focal stations.

Table 6-4 list the focal stations available in the telescope in order to describe their envelopes and center of mass. Envelope maximum diameters and lengths for each focal station are declared at the column "Instrument envelope". The maximum mass for the instruments to be placed on each focal station is indicated in the "instrument mass" column. The maximum distance for the center of mass measured from the flange of the instrument interface with the telescope is defined at the "Center of Mass" column.

Table 6-4 TSPM Instruments envelope and allowable mass.

Focal Station	Instrument envelope ø/Length (m)	Instrument mass (kg)	Center of Mass position from flange (m)
NF-A NF-B	3/2.7	4000	@ 1.5
F-C	3/2.7	2700	@ 0.76
FC-D FC-E FC-F FC-G	1/1.5	1500	@ 0.75

6.7 TSPM-TL mass & moments of inertia

In order to perform mass, moments of inertial and other calculations, the TSPM telescope subsystem must be considered together with the optical subsystems and instruments that are hosted at the telescope structure. Then, two main groups named: rotating mass about azimuth axis and non-rotating mass are considered. Besides the rotating mass about elevation axis (also named Optical Support Structure) needs also to be considered. This division is shown in ***Figure 6-13.*** and is listed below:

1) Rotating mass about azimuth axis:
   - Azimuth rotating structure
   - Telescope mechanisms (hydrostatic bearing, friction drives, locking pin and shock absorber)
   - Cable wraps.
   - Control cabinets.
   - Rotating mass about elevation axis (in some references this group is also known as Optical Support Structure “OSS”)
     - Altitude assembly.
     - M2 structure and mechanism.
     - Tertiary mirror assembly.
     - Cassegrain Rotator.
     - Primary cover.
     - Telescope baffles.
     - Nasmyth rotator.
     - Optical systems.
     - Science instruments.
     - Counterweights.
     - Cable wraps.
     - Control cabinets.
2) Non rotating mass
   - Azimuth axial track
   - Azimuth radial track (pintle)
   - Cable wrap.

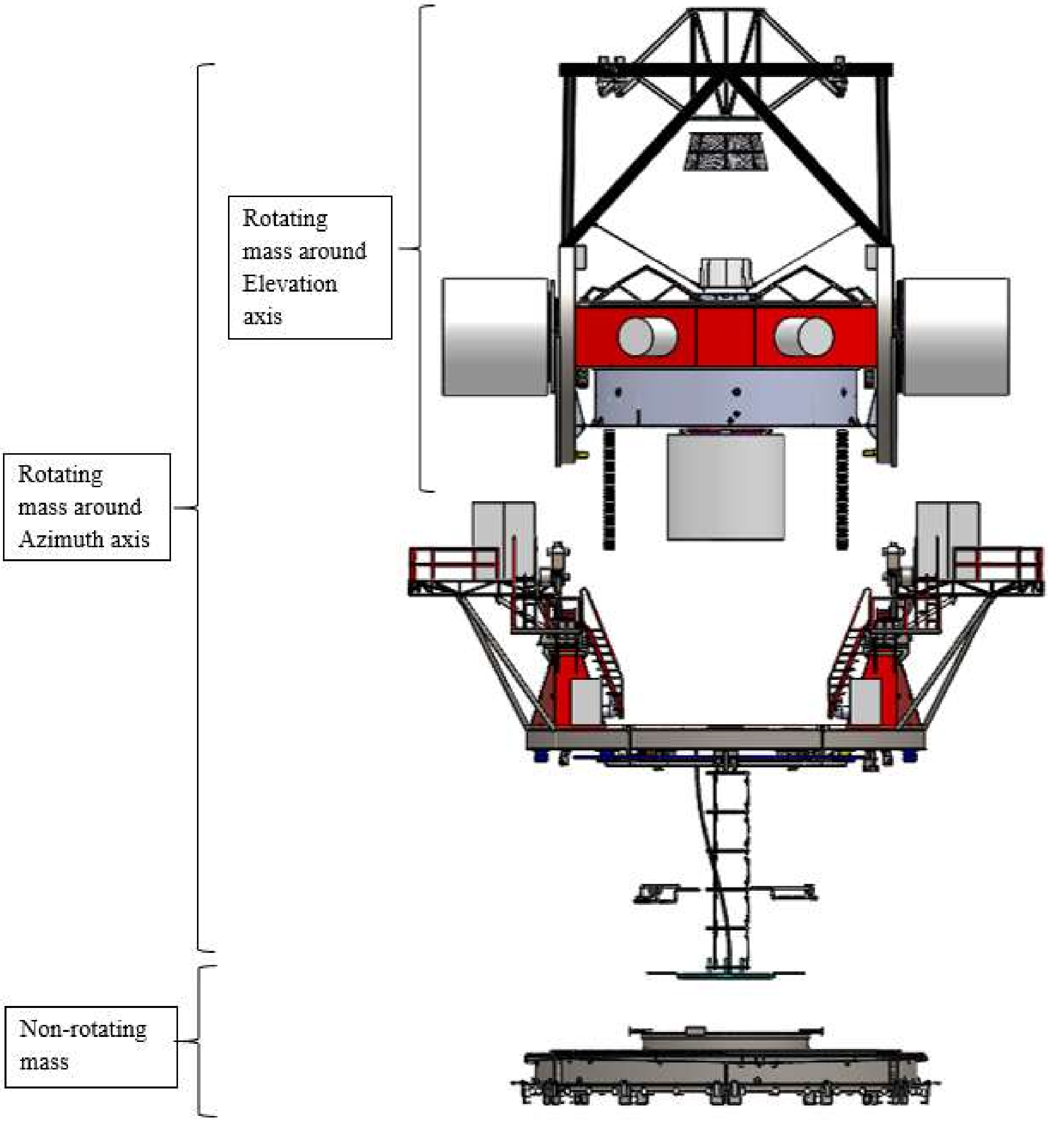

Figure 6-13. TSPM groups for calculations [R.2].

The TSPM will have several optical configurations according to what is stated in the document TSPM Optical Configuration TEC/TSPM/004 [A.5]. In order to make the TSPM design we studied 3 mass configurations: f/5 Nas configuration, f/5 Cass configuration and Day one configuration. The mass for each of these configurations is shown in the executive Mass budget in the Table 6-5 where are compared with the Telescope Maximum allowable mass of 246 000 kg as stated in the Telescope specification [A.8]

6.7.1 Executive mass budget

Table 6-5 summarizes the results of the different configurations and groups where the values of mass for the telescope are deployed. For more details See TEC/TSPM-PDR-TL/004 [R.2].

Table 6-5 TSPM Total mass budget [R.2].

Mass Budget

Telescope Maximum Allowable mass	246000	kg
Telescope mass (Day one configuration)	228619	kg
Telescope mass (without instruments configuration)	228959	kg
Telescope mass (f/5 Nas configuration)	245470	kg
Telescope mass (f/5 Cass configuration)	245659	kg

6.7.2 Day one configuration

Day one configuration (see Table 6.6) is the telescope configuration to start operations. This configuration includes the f/5 Cassegrain secondary mirror, the Cassegrain instrument with the maximum allowable mass to be mounted (2700 kg) and the f/5 corrector. No other instruments, tertiary mirror or Nasmyth rotators are still mounted. For more details see TEC/TSPM-PDR-TL/004 [R.2].

Table 6.6 Mass budget for Day 1 configuration[R.2]

Telescope mass (Day one configuration)	228619	kg		
Rotating mass about Azimuth axis	176203	kg		
Rotating mass about Elevation axis (Day one configuration)			98380	kg
Azimuth assembly rotating structure			69703	kg
Telescope wiring and piping			4600	kg
Telescope mechanisms control system			3520	kg
Telescope Non rotating mass	52416	kg		

6.7.3 Without instruments configuration

This configuration is generated by having the Day 1 configuration as basis for calculation, and the main difference is that the mass of 2 Nasmyth rotators (3040 kg both) is added and the Cassegrain instrument removed (2700 kg).

Table 6.7 Mass budget for Telescope without instruments configuration

Telescope mass (without instruments configuration)	228959	kg		
Rotating mass about Azimuth axis (without instruments configuration)	176543	kg		
Rotating mass about Elevation axis			98720	kg
Azimuth assembly rotating structure			69703	kg
Telescope wiring and piping			4600	kg
Telescope mechanisms control system			3520	kg
Telescope Non rotating mass	52416	kg		

For more details see TEC/TSPM-PDR-TL/004 [R.2].

6.7.4 f/5 Nas configuration

f/5 Nas configuration is one of the heaviest possible configurations for the telescope. It includes the f5/Nasmyth M2 mirror, both Nasmyth rotators, the Cassegrain rotator, instruments on both Nasmyth focal stations with the maximum allowable mass (8000 kg both), all the folded Cass instruments (6000 kg all) and the M3 mirror. No Cassegrain instruments is considered.

Table 6.8 Mass budget for f/5 Nasmyth configuration

Telescope mass (f/5 Nas configuration)	245470	kg
Rotating mass about Azimuth axis	193054	kg
Rotating mass about Elevation axis (f/5 Nas configuration)	115388	kg
Azimuth assembly rotating structure	69546	kg
Telescope wiring and piping	4600	kg
Telescope mechanisms control system	3520	kg
Telescope Non rotating mass	52416	kg

For more details see TEC/TSPM-PDR-TL/004 [R.2].

6.7.5 f/5 Cass configuration

The heaviest configuration possible for the TSPM occurs when the telescope is working in Nas configuration and its changed to Cass configuration keeping mounted the instruments in all the focal stations. Then, the secondary mirror to f/5 Cass and instrument is included while the tertiary mirror is removed.

Table 6.9 Mass budget for f/5 Cassegrain configuration

Telescope mass (f/5 Cass configuration)	245659	kg
Rotating mass about Azimuth axis	193243	kg
Rotating mass about Elevation axis (f/5 Cass configuration)	115420	kg
Azimuth assembly rotating structure	69703	kg
Telescope wiring and piping	4600	kg
Telescope mechanisms control system	3520	kg
Telescope Non rotating mass	52416	kg

For more details see TEC/TSPM-PDR-TL/004 [R.2].

6.7.6 Telescope Moments of inertia

The calculations of moments of inertia for the telescope can be found in the document **TEC/TSPM-PDR-TL/004 [R.2].** This data were obtained including at the 3D model the maximum mass considerations. The moments of inertia of the rotating mass about the elevation axis, the moments of inertia of the rotating mass about the azimuth axis and for the complete Telescope (including fixed mass for pier calculation) are included there.

6.7.7 Telescope Balance

The balance of a telescope is very important to allow the drive systems to work with the possible highest performance. Balance will diminish the risk of sliding due to the increase of loads at the contact zone of the friction drive system.

The telescope balance will depend on the optical configuration being used. Each configuration will unbalance the telescope depending on the instruments and optical components involved and where are located their center of mass.

The basic principle of balance consists in keeping the center of gravity or center of mass (CoG) in the pivots of the system, this pivots are the elevation axis and the azimuth axis. In an asymmetrical system as the rotating mass about the elevation axis of the telescope, in order to balance that system, it is necessary to increase or move the mass in one side to get the sum of moments equal to zero.

The principle of balance of the telescope is accomplished using of two different concepts of balance: one is using fixed masses located at certain points of the telescope, and the other is using mobile masses located under the elevation ring and inside the elevation discs of the telescope. For the rotating mass about elevation axis, all optical configurations of TSPM (f/5 Cass, f/5 Nas and f/11 Nas) affect the balance of telescope and its dynamic and structural performance. For this reason it is important to have consider maximum estimations for the different optical configurations and calculate mass and locations of the fixed counterweights that would be needed to send the CoG to the elevation axis. For further information refer to the document TEC/TSPM-PDR-TL/004 [R.2], where the principles of telescope balance are explained with more detail.

7 TSPM-TL Telescope subsystems

The following sections describe the subsystems concerning to the TSPM-TL according to the product tree described in section 6.2.

7.1 TSPM-TL-AZ Azimuth Assembly

The azimuth assembly is located at the bottom of the telescope structure. This makes interface with the pier of the enclosure and the altitude system. This assembly is grouped into two large assemblies, the Azimuth rotating assembly and the fixed part.

The Azimuth rotating assembly is composed by the rotating floor, left and right supports and the left and right Nasmyth platforms. The fixed part is composed by the axial azimuth track and the radial track (pintle). Besides all azimuth and altitude mechanism are included in the azimuth assembly.

The components of the fixed and rotating groups of the azimuth assembly are shown in the Figure 7-1.

The construction materials for this assembly will be structural steel. For further information refer to the document TEC/TSPM-PDR-TL/003 [R.4] and drawings TSPM-TL-AZ-00-00-000_00_00-0000 [R.12].

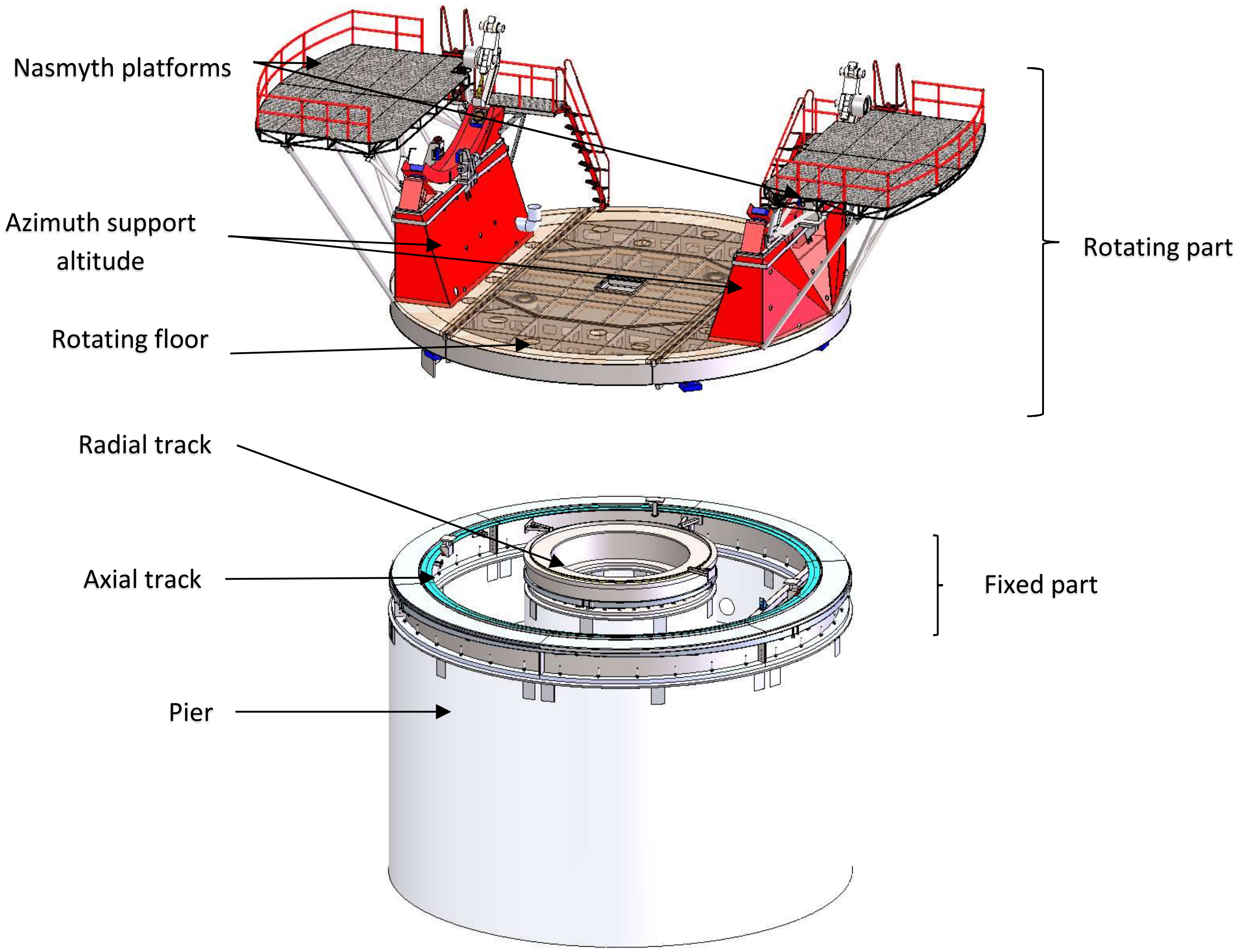

Figure 7-1 TSPM-TL-AZ Components of Azimuth assembly.

7.2 TSPM-TL-AL Altitude Assembly

The altitude assembly (see Figure 7-2) is part of the rotating mass about elevation axis. This is supporting the optical components and moving them in the elevation axis in order to align them with the object studied. The M2 mechanisms as well as the tertiary support (which are kept separated at the Product tree level) will be integrated at the assembly. This is also housing the primary mirror cover at the elevation ring and counterweights (fixed and mobile). For further information refer to the document TEC/TSPM-PDR-TL/003 [R.4] and drawings TSPM-TL-AL-00-00-000_00_00-0000 [R.13].

Table 7.1 Altitude Assembly components

Item No.	Part Number	Description	Qty
1	TSPM-TL-AL-TB-00-000_00_00-0000	Telescope tube	1
2	TSPM-TL-AL-ER-00-000_00_00-0000	Elevation ring	1
3	TSPM-TL-AL-CW-00-000_00_00-0000	Mobile Counterweights	1
4	TSPM-TL-AL-PC-00-000_00_00-0000	Primary cover	1
5	TSPM-TL-AL-SS-00-000_00_00-0000	Secondary structure assembly	1

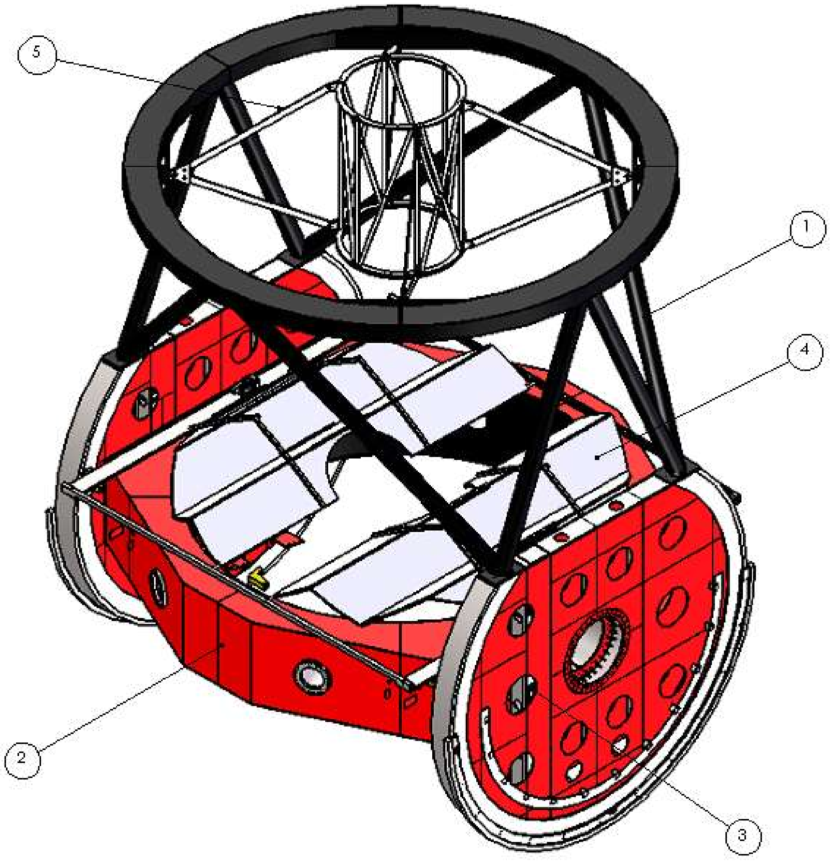

Figure 7-2 Altitude Assembly [R.13].

7.3 TSPM-TL-SM-Secondary Mechanism

The secondary mechanism main function is to compensate the relative position movements when a change in elevation is made. This corrects the position between the M1 mirror cell and the secondary mirror cell thru a spider connected to the mechanism where is located the secondary mirror cell. When the telescope structure is deformed due to a change in the elevation of the Optical Support Structure "OSS" (Rotating mass about elevation axis) this mechanism acts over the spider applying the compensation movements. For further information about M2 mechanism and how it is integrated at the altitude system, refer to the document TEC/TSPM-PDR-TL/017 [R.5], EXT/SENER/001 and 3D model from SENER.

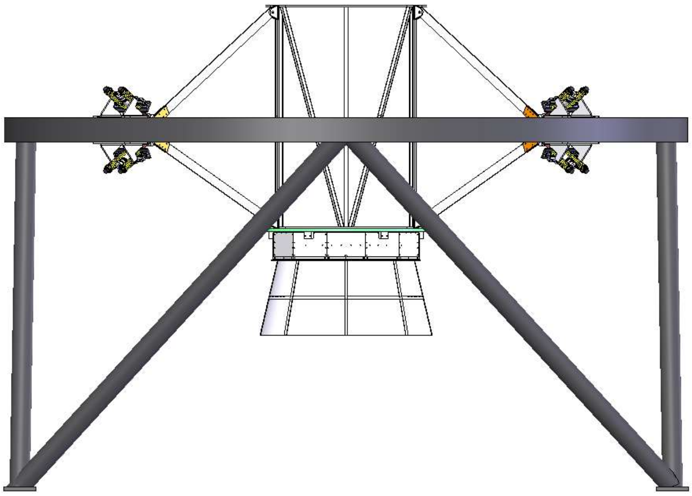

Figure 7-3 Secondary mechanism with f/5 Cass mirror and baffle mounted [R.5].

7.4 TSPM-TL-TS Tertiary Mechanism

The Tertiary Mirror Mechanism is the mechanism in charge of positioning the M3 mirror. The M3 mirror is an oval flat mirror that must be positioned with an inclination of 45º with respect to the main optical axis. The M3 mirror will be used to redirect the path of light to any of the Nasmyth and Folded Cassegrain focal stations, see Figure 7-4. M3 mirror is mounted to the Tertiary Mechanism, which will be mounted at a flange located at the center of the upper face of M1 mirror cell.

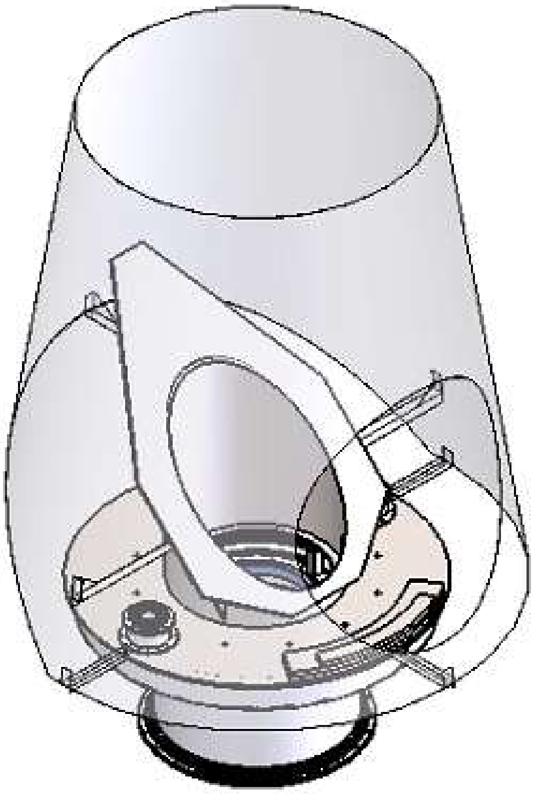

Figure 7-4 Tertiary Mechanism isometric view [R.15]

The Tertiary Mirror Mechanism will provide a rotation range of at least 325° in order to direct the light coming from M2 to the Nasmyth focal stations or to the folded Cassegrain focal stations. This means that the light will be bended 90º degrees. At the same time, most of the light and infrared radiation coming from other sources shall be avoided by the use of baffles.

Table 7.2 Tertiary Mechanism [R.15]

Item No.	Part Number	Description	Qty
1	TSPM-TL-TS-IF-00-000_00_00-0000	Tertiary mirror interface	1
2	TSPM-TL-TS-RM-00-000_00_00-0000	Tertiary mirror rotary mechanism	1
3	TSPM-TL-TS-AM-00-000_00_00-0000	Tertiary mirror adjustment mechanism	1
4	TSPM-TL-TS-BF-00-000_00_00-0000	Baffle for Nasmyth	1
5	TSPM-TL-TS-FC-00-000_00_00-0000	Fixed counterweight	1

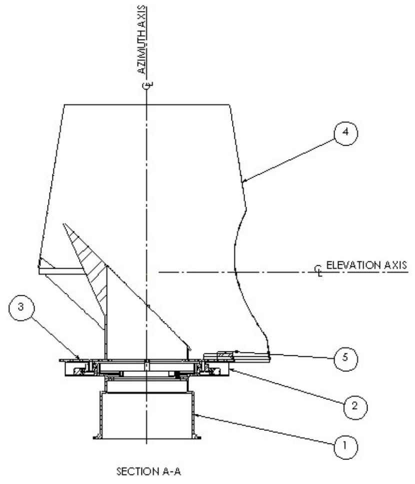

Figure 7-5 Tertiary Mechanism section view [R.15]

For further information about tertiary assembly, refer to the document TEC/TSPM-PDR-TL/005 [R.6] and drawings TSPM-TL-TS-00-00-000_00_00-0000 [R.15].

7.5 TSPM-TL-CR Cassegrain Rotator Assembly

The Cassegrain rotator is located between the primary mirror cell and the instrument at the Cassegrain focal station instrument, see Figure 7-6. The rotator mechanism main function is to de-rotate the field of view when an object not located at the center of the field is being observed.

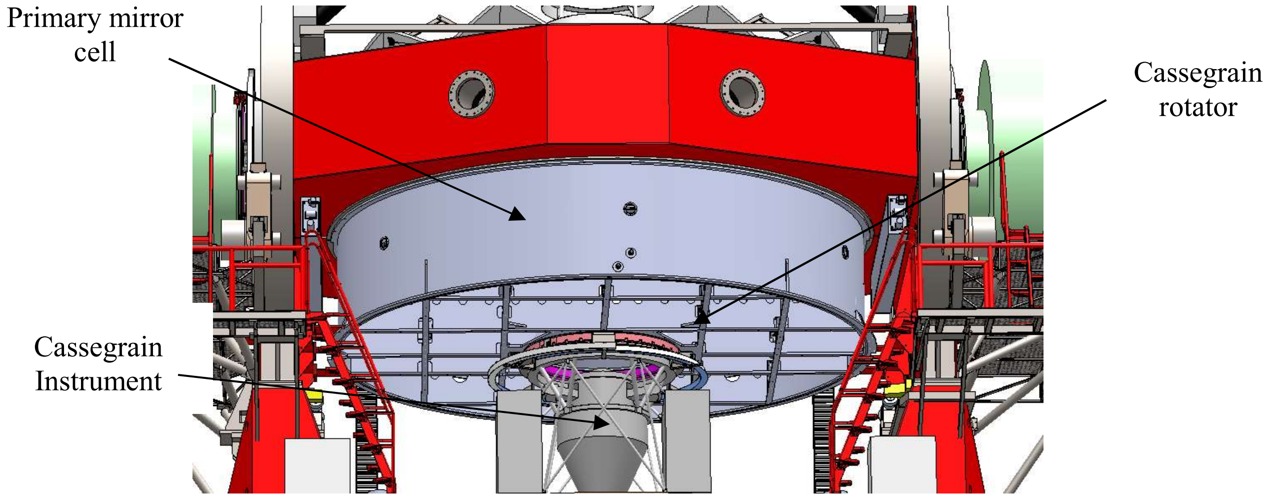

Figure 7-6 Cassegrain rotator with instrument mounted on the PMC

The instrument is attached to a precision bearing integrated into a gear, which is driven by 2 opposite positioned gear boxes (Figure 7-7). Each gear box has 2 embedded servomotors, one working as a “brake” in order to diminish the mechanism backlash.

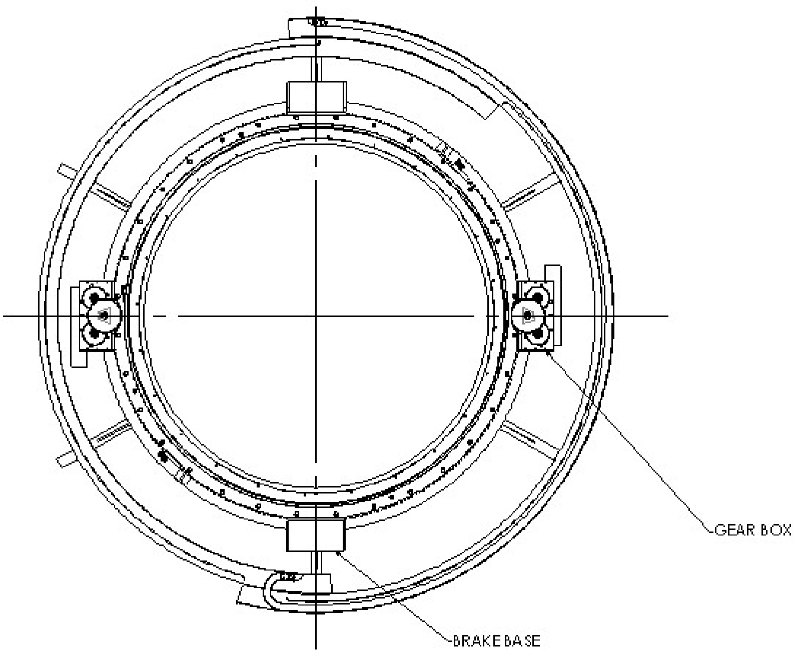

Figure 7-7 Cassegrain rotator with mechanical interface [R.16]

The mechanism and mounting flange should support and rotate a load of 2700 kg with a center of mass located at a distance 0.76 m from the flange.

For further information about Cassegrain rotator, refer to the document TEC/TSPM-PDR-TL/006 [R.7] and drawings TSPM-TL-CR-00-00-000_00_00-0000 [R.16].

7.1 TSPM-TL-NR Nasmyth rotator

The Nasmyth rotator (see Figure 7-8) will be located between the Altitude disc and the rotating Nasmyth instrument. Nasmyth rotator mechanism will be very similar to the Cassegrain rotator. It is attached to a precision bearing integrated into a gear with 2 gearboxes as the Cassegrain rotator. The mechanism and mounting flange will support and rotate a load of 4,000 kg with the center of mass located at a maximum distance to the flange of the instrument of 1.5 m.

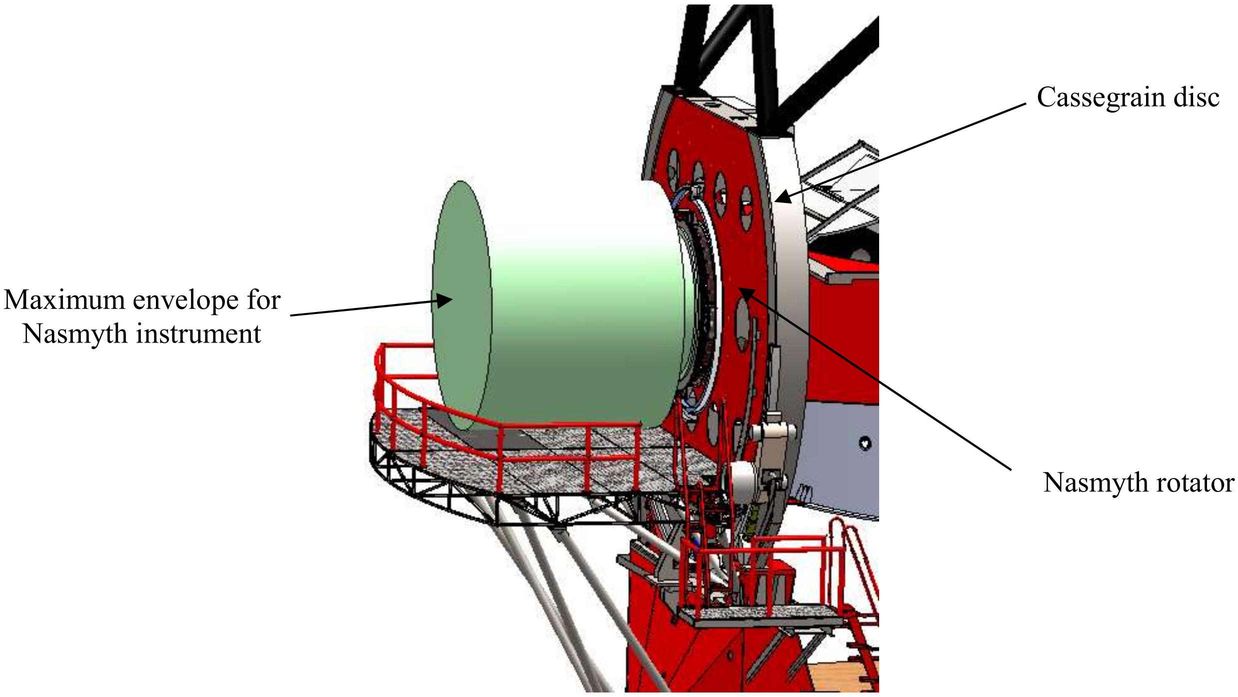

Figure 7-8 Nasmyth rotator with instrument maximum envelope mounted

The Nasmyth rotator use the same hole pattern than the Cassegrain rotator, and uses an interface flange (see Figure 7-9) to be placed at the flange of the altitude disc.

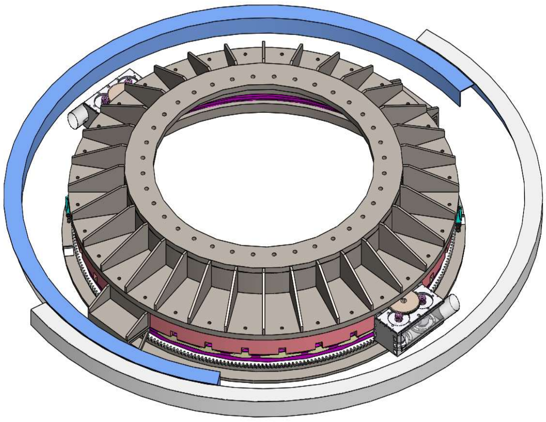

Figure 7-9 Nasmyth rotator with mechanical interface

7.2 TSPM-TL-BF Telescope Baffles

The TSPM will have several optical configurations and, therefore, different baffles configurations will be required. The mechanical design of the baffles for the different optical configurations is included at the document TEC/TSPM-PDR-TL/014

7.2.1 Baffles for f/5 Cass configuration

The design of the baffles for the f/5 configuration (as included at the document TEC/TSPM-PDR-OP/004) is shown at Figure 7-10

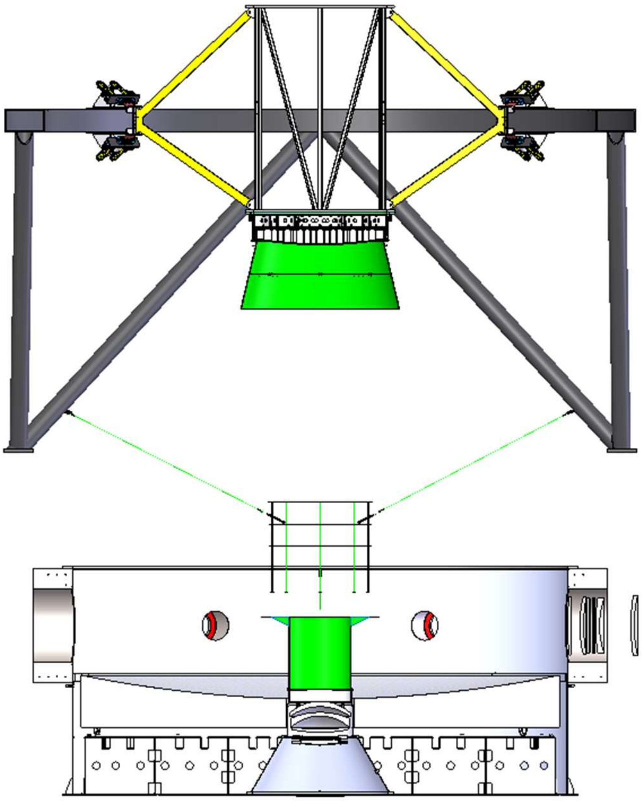

Figure 7-10 Baffles f/5 Nass configuration

7.2.2 Baffles for f/5 Nas configuration

A first proposal for the mechanical design of the baffles for the f/5 Nas configuration (pending of further iteration with the optical team) is also included at the document TEC/TSPM-PDR-OP/004.

7.3 <u>TSPM-TL-OS Oil Pumping System</u>

TSPM uses a similar concept to allow rotation of their axis, as Magellan and other big aperture telescopes. The TSPM has an Oil pumping system to give service to the azimuth and elevation hydrostatic bearings (see Figure 7-11). The hydrostatic bearings are metallic blocks with machined surfaces and small holes to distribute oil on his surface. This oil is used to support the telescope and allow its rotation about azimuth and elevation axis with a very smooth movement. This smoothness is due to the thin layer of oil (70 µm [R.3]), which diminishes the friction to a minimum. This thin film of oil is very important and needs to be carefully maintained because define the stiffness of the telescope.

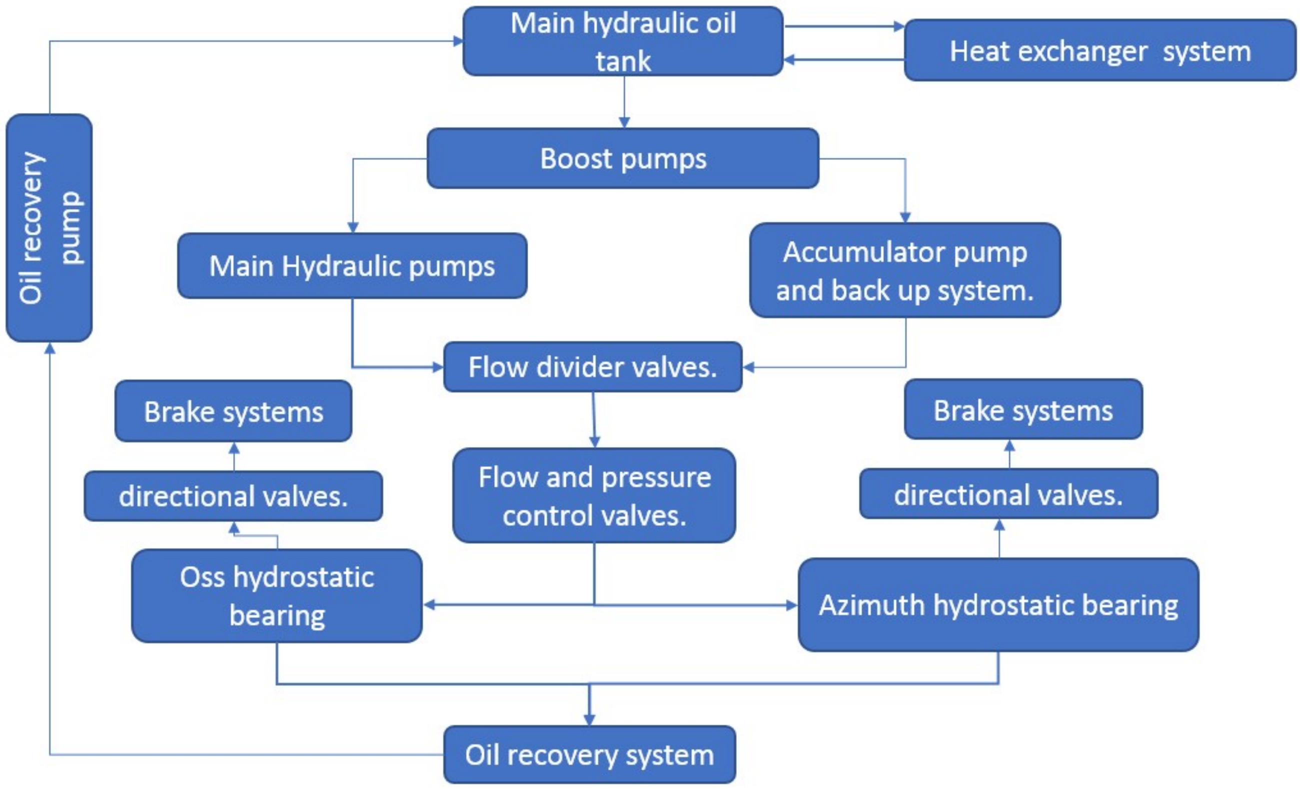

Figure 7-11 Oil pumping system

The design details for the Oil Pumping system can be found in the document: TEC/TSPM-PDR-TL/002 [R.3]. Analytical calculations for the selection of the hydrostatic bearings, number of bearings, arrangement, calculations for stiffness, diameter of the piping and the hydraulic diagram can be found at TEC/TSPM-PDR-TL/011. The position and distribution of the hydrostatic bearings is included at the document TEC/TSPM-PDR-TL/003 [R.4] and drawing TSPM-TL-TL-AZ-00-00-000_00_00-0000[R.13]. The hydraulic diagram and distribution and oil pumping systems components and envelopes can be found in the drawing TSPM-TL-OS-00-00-000_00_00-0000.

7.4 TSPM-TL-TC Telescope Mechanisms Control System

Telescope mechanisms are integrated by actuators and sensors, these elements are controlled and monitoring at low level by local control units, motor drives and other kind of electronic cards.

Each telescope mechanism has a local control unit, which is in charge of reading sensors, transducer signals and command actuators. At the same time low level control processors are connected to high level control processors through Ethernet network for non real-time processes and through EtherCAT network for real-time processes as pointing and tracking to distribute information and execute tasks.

All telescope mechanism low level controls receive commands from high level control, and at the same time feedback signals from low level are sent to high level control. Interactions between telescope mechanism controls and high level control are defined at interface document.

Telescope mechanisms are controlled by National Instruments (NI) processors, Compact RIO series, this technology has several kinds of sensor and transducers input cards, NI has capability to be connected to

Ethernet and EtherCAT networks, NI can works with Heidenhain encoders and it is capable to command Kollmorgen servodrives, which are the servodrives selected to control all motors and direct motors of different telescope mechanisms.

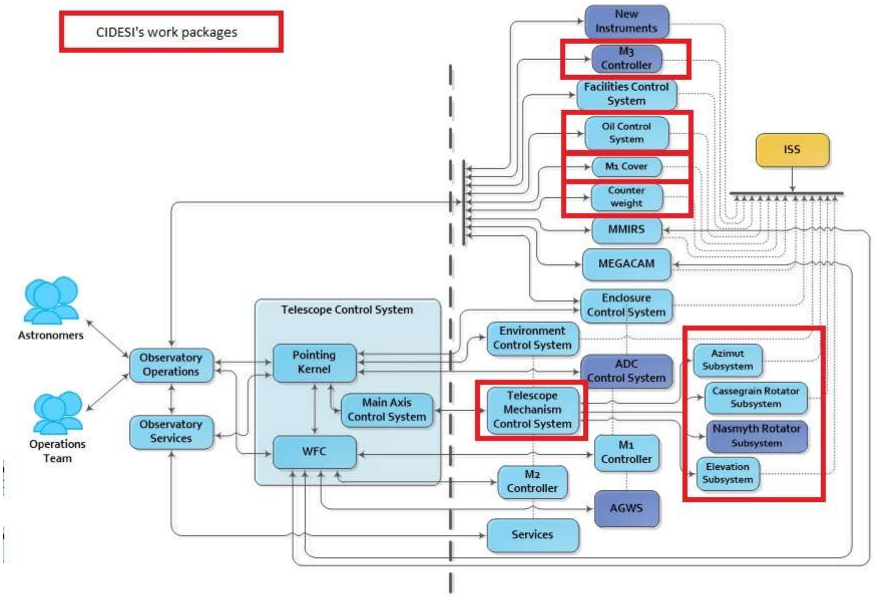

Figure 7-12 SWCS Low Level Domains and Telescope Devices [R.8].

For further information about Telescope Mechanism control system, refer to the document TEC/TSPM-PDR-TL/007 [R.8].

7.5 TSPM-TL-TI Telescope Interlocks

Telescope mechanisms have a modular control and safety architecture. This allows that each system can be integrated, debugged and tested individually where each system is fabricated. Telescope mechanism has a local ISS.

Monitoring status is critical to ensuring that all observatory hardware, software and other elements are functioning properly and safely. The means for this monitoring is within the same hardware, software and other components at all levels of the control architecture via Interlock and Safety System (ISS).

The implementation of safety function in a dedicated system allows the other subsystems to be dedicated to their primary function. This allows the separation of responsibilities, also allows that safety monitoring not affect and is not affected by other subsystems.

The ISS (at the observatory level) has the function of assessing and managing the safety conditions of all observatory systems. Alarm events are activated when an alarm condition is detected by some component.

The global safety standards for machinery are controlled by two organizations, ISO and IEC.

For further information about Telescope Interlocks control system, refer to the document TEC/TSPM-PDR-TL/008 [R.9].

7.6 TSPM-TL-CW Cable Wraps

Services shall be routed through the telescope to the different systems mounted on it like the primary mirror cell, secondary mirror cell, instruments, etc. To do so in an orderly manner, it is necessary to include cable wraps at the azimuth and elevation axes, which provide the adequate routes and space needed to pass through the telescope all cables, hoses and pipes needed for routing services.

Cable wraps will be composed by 3 main sections as shown in Figure 7-13.

The first section is a chain located between the elevation ring and the rotating floor; it allows the bending of the flexible conducts giving services to optical components, instruments and mechanisms located at the elevation subassembly.

The second section is a square rigid structure to support cables, hoses and pipes bellow the Azimuth rotating structure.

The third section is composed by wires anchored to the bottom of the azimuth rotating structure allowing the flexible hoses and pipes to be twisted inside the inner pier allowing the rotation in azimuth.

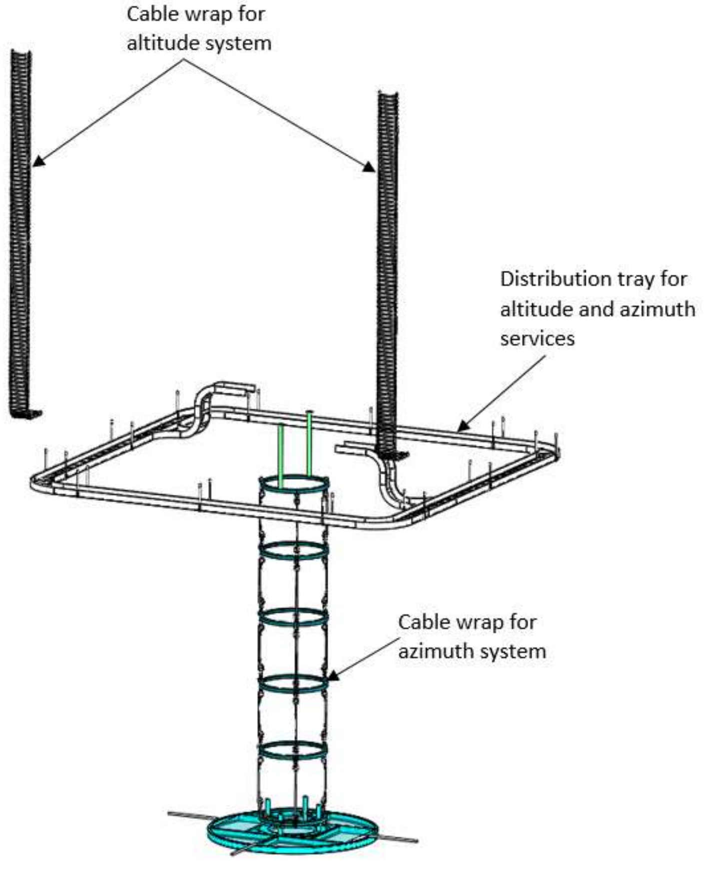

Figure 7-13 sections of the cable wrap [R.18]

The design details for the Cable wraps can be found in the document: TEC/TSPM-PDR-TL/012 [R.18].

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