GRAN TELESCOPIO CANARIAS
GTC

Telescope Structure

TITLE

Half Moon Platform
Preliminary Design

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Applicable documents

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Reference documents

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RD 1	Modificaciones del Telescopio – Comparación de Variantes de Diseño	NTE/TELE/0761-R	1.A

List of acronyms and abbreviations

GTC Gran Telescopio Canarias

ISS Interlock and Safety System

TBC To Be Considered

TBD To Be Defined

CONTENTS

1. INTRODUCTION

The Half Moon platform is a movable platform for operation and maintenance of the Cassegrain and Folded Cassegrain foci. It is attached to the telescope mount forming a Half Moon shaped connection between the two Nasmyth platforms. The three main positions are Cassegrain, Folded Cassegrain and Resting Position. The first two positions are for access to the corresponding foci and the resting position for free telescope operation. The possibility to approach the platform to the telescope tube in intermediate positions during exceptional situations is TBD.

The platform is moved by two electromechanical cylinders connecting directly to the porticos of the telescope mount. The moving trajectory is defined by a parallelogram. Due to the nature of the construction, a secondary mechanical security system is implemented.

In the following figures and chapters the platform assembly is described more in detail.

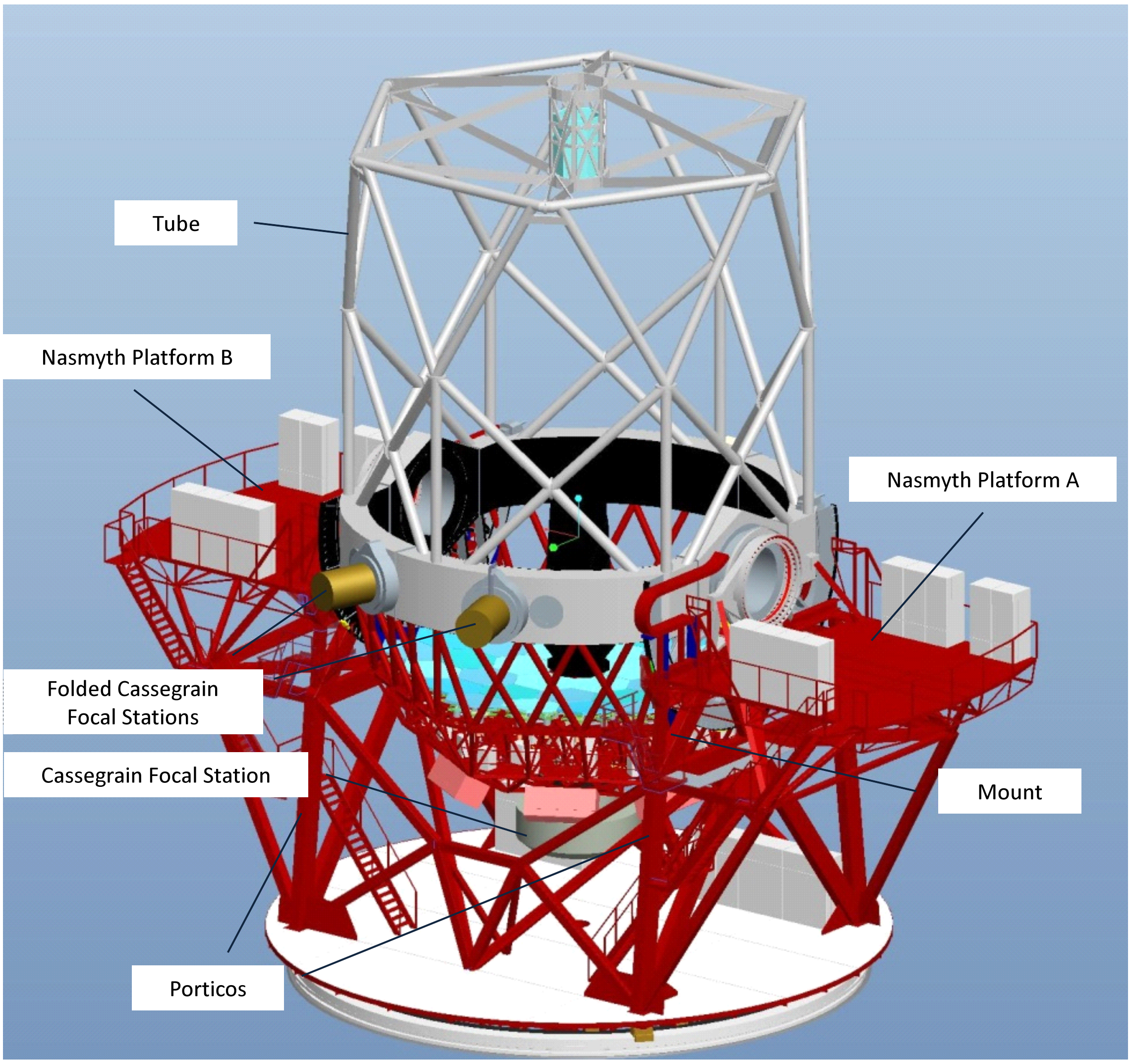

Figure 1 General view of the telescope without Half Moon platform (without access platform).

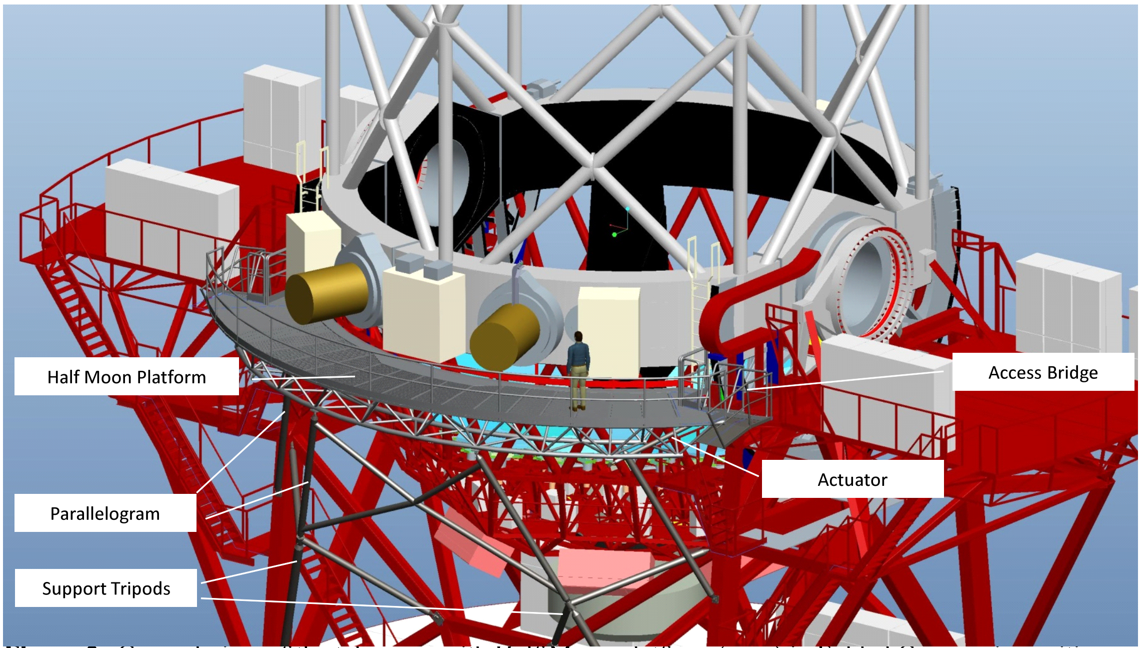

Figure 2 General view of the telescope with Half Moon platform (grey) in Folded Cassegrain position. The platform can approach this position only if the tube is in vertical position.

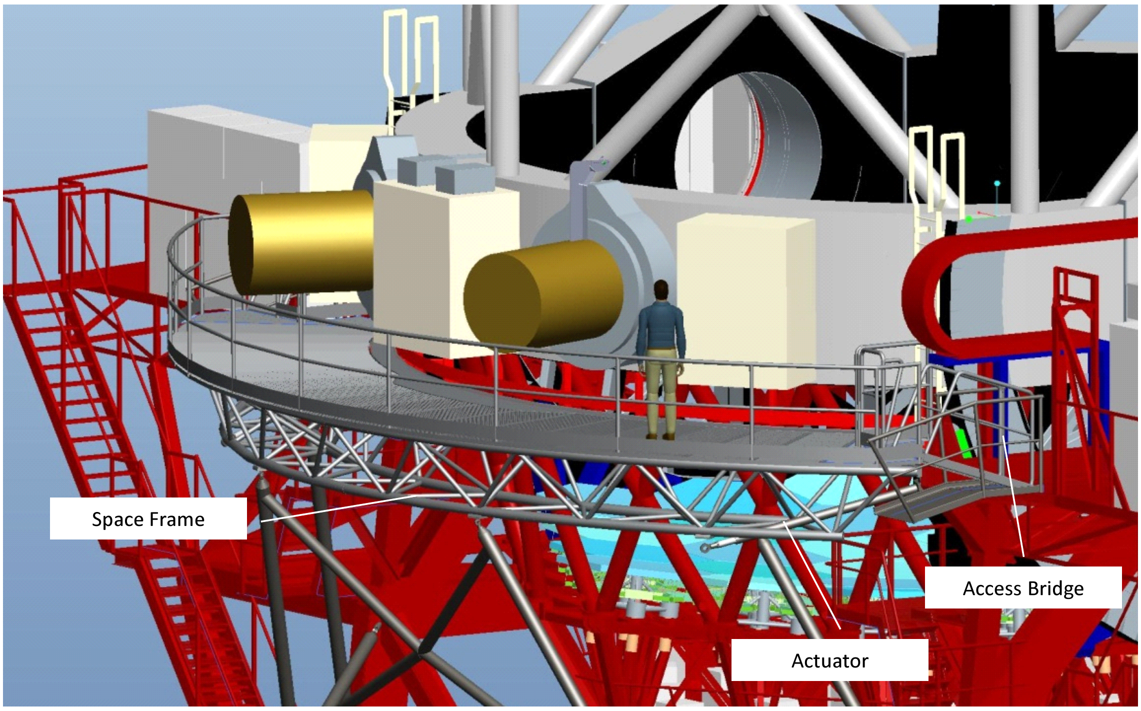

Figure 3 General view of the Half Moon platform (grey) in Folded Cassegrain position.

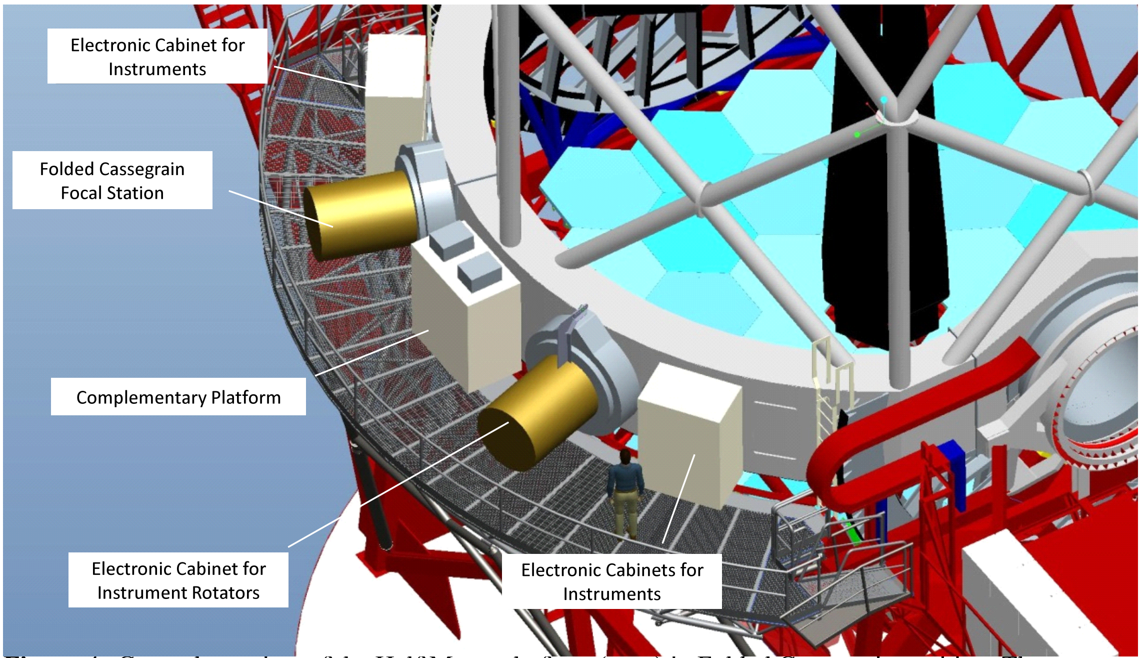

Figure 4 General top view of the Half Moon platform (grey) in Folded Cassegrain position. The complementary platform is fixed to the tube forming a closed and continued floor with the moving part of the platform.

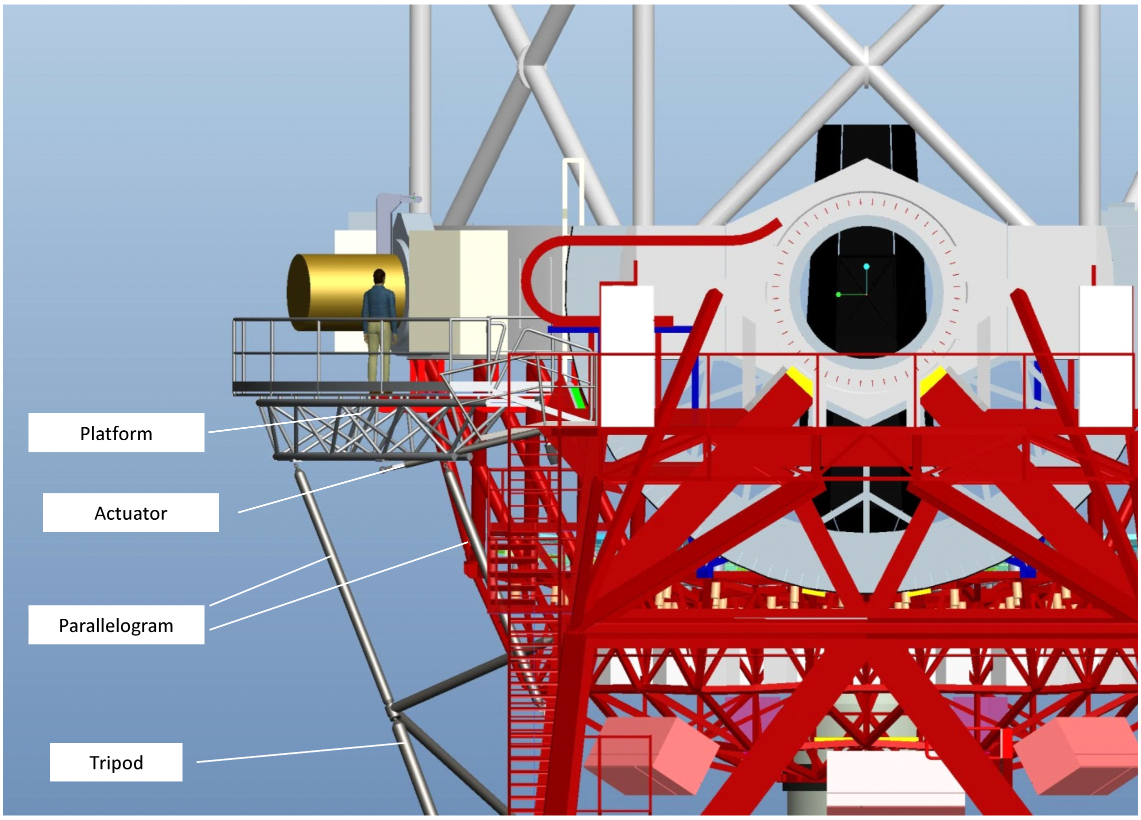

Figure 5 Lateral view of the Half Moon platform in Folded Cassegrain position.

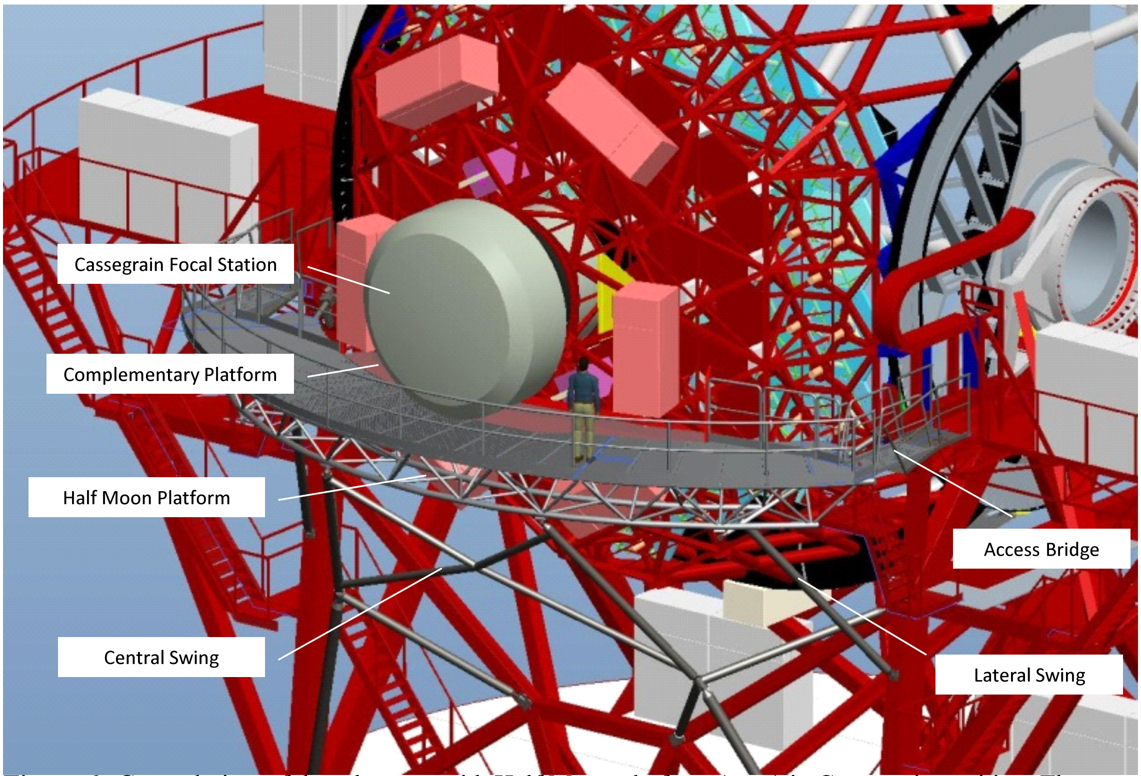

Figure 6 General view of the telescope with Half Moon platform (grey) in Cassegrain position. The platform can approach this position only if the tube is in horizontal position.

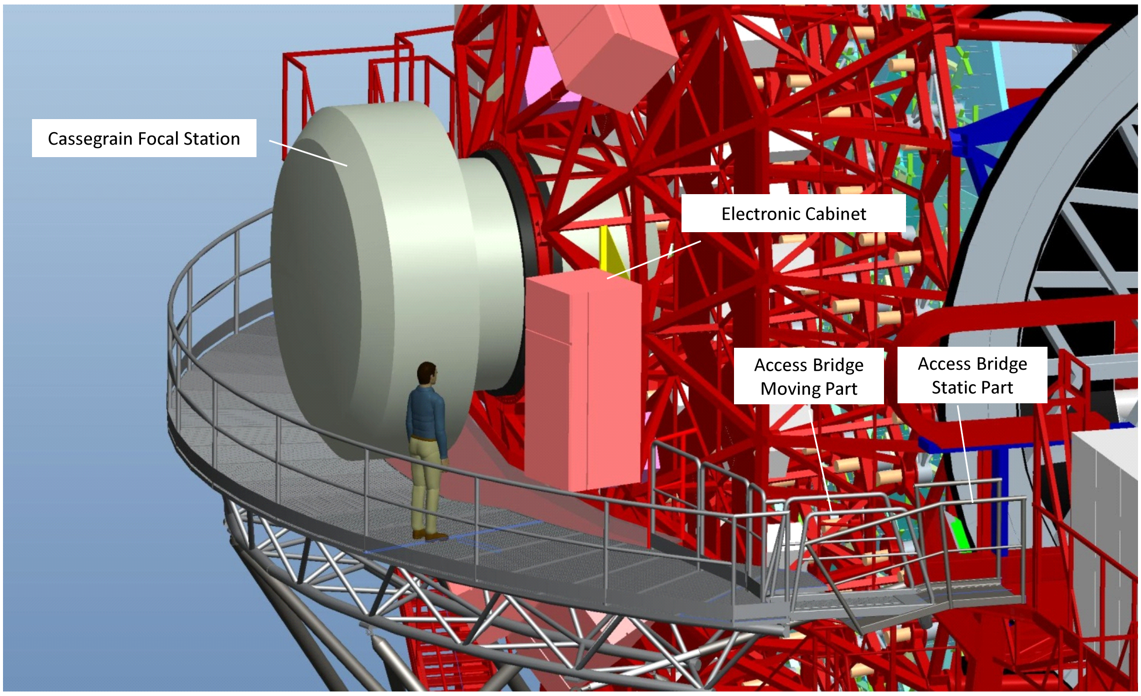

Figure 7 General view of the Half Moon platform in Cassegrain position.

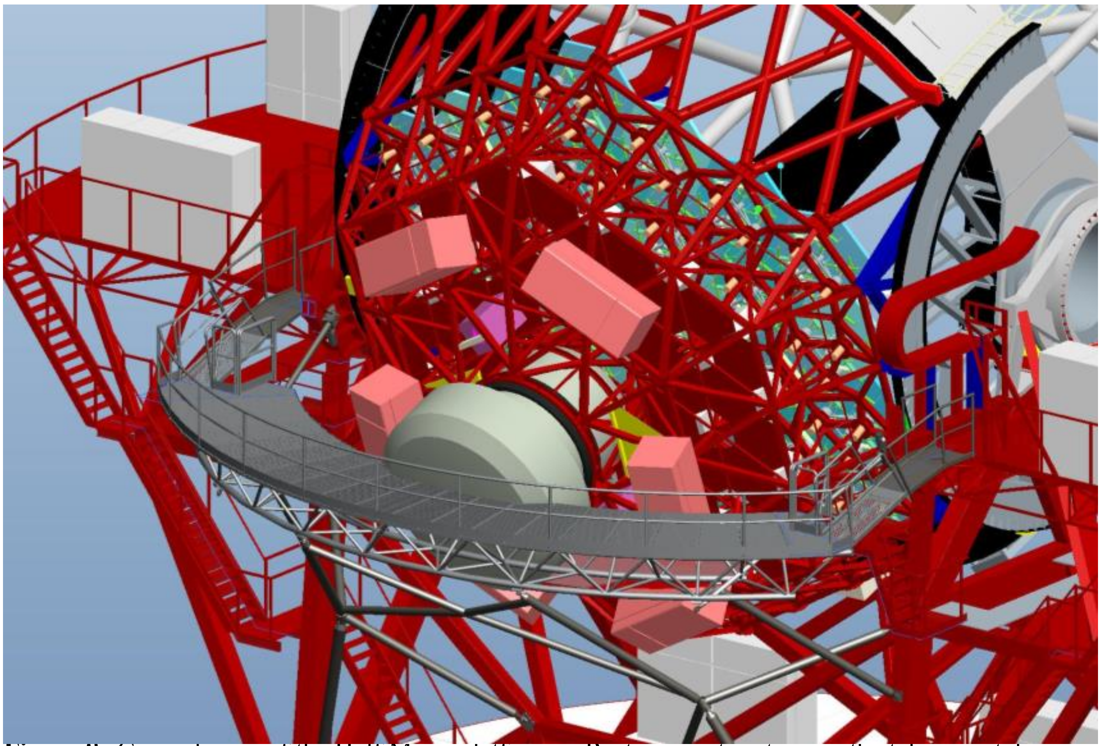

Figure 8 General view of the Half Moon platform in Resting position turning the telescope tube.

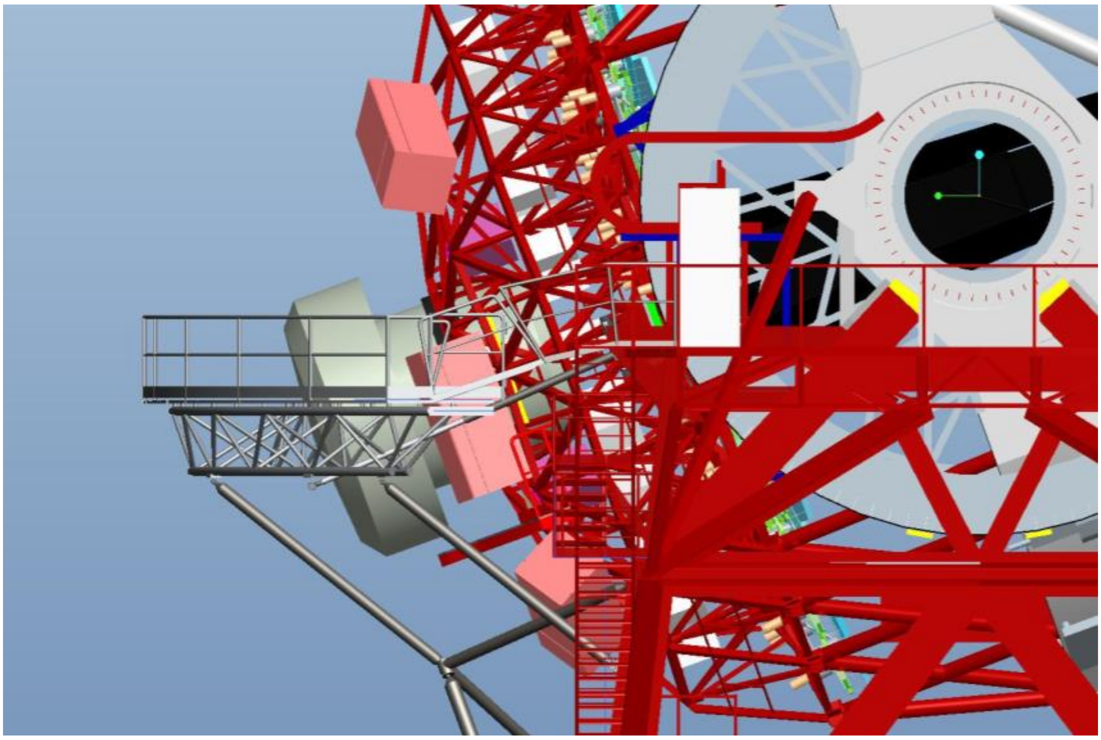

Figure 9 Lateral view of the Half Moon platform in Resting position turning the telescope tube.

2. CONFIGURATION

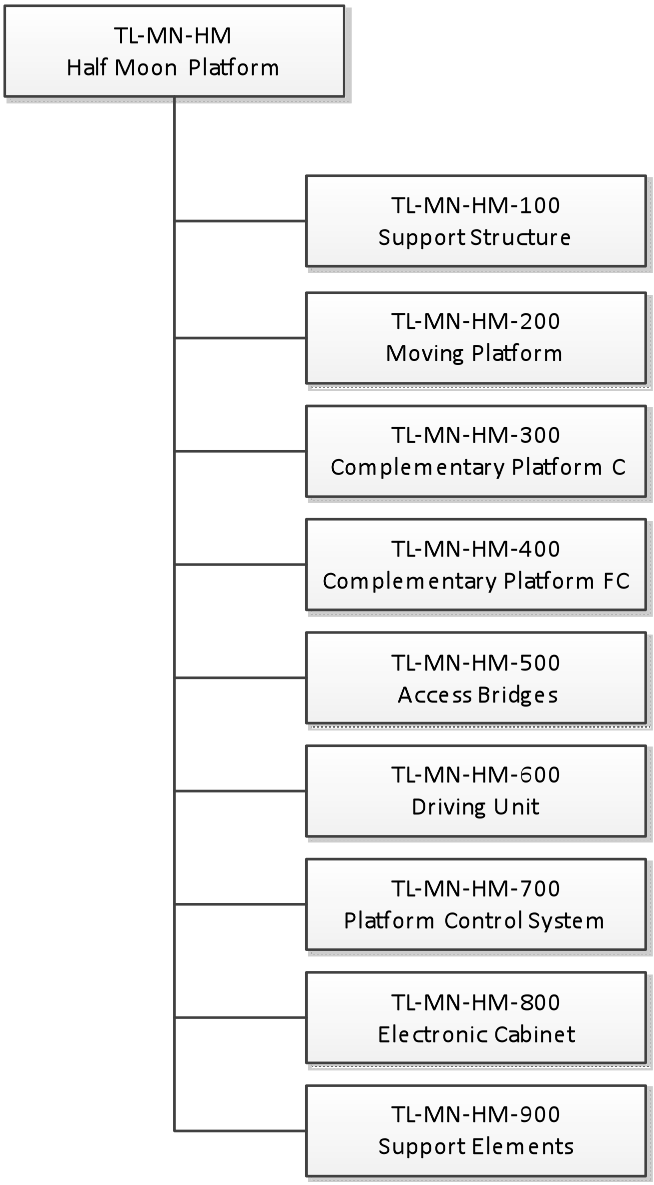

Figure 10 Configuration tree of the platform; can be subject to modifications.
Support elements only if applicable.

3. MAIN CARACTERISTICS

Weights	
Total installed mass	3900 kg
Platform	1380 kg
Support Structure	1480 kg
Parallelogram Swings	1040 kg
Dimensions	
Platform length over all	14.3 m
Platform width	2.3 m
Parallelogram height	3.9 m
Parallelogram aperture	2.23 m
Positions	**Y / Z**
Folded Cassegrain	0 mm / 0 mm
Cassegrain	-900 mm / -500 mm
Resting	-1625 mm / -1202 mm
Electromechanical Cylinders	
Force (max. load on platform)	4800 N (Folded C.) to 11050 N (Resting)
Maximum net travel	1890 mm
Maximum travel time	1 minute

4. SUPPORT STRUCTURE

The support structure consists of two tripods fixed directly to the telescope mount and the guiding parallelogram. The heads of the tripods support the central swing of the parallelogram while the lateral swings are mounted directly to the telescope mount itself.

The heads of the tripods are adjustable in position to align the guiding parallelogram and finally the platform with respect to the telescope structure. For that purpose the rods are adjustable in length and the fixing plates on the telescope mount are adjustable in position. The two upper rods of the tripod form one rigid peace carrying the tripod head in the center and on the extremes adjustable rod ends and support plates. In that way the position of the tripod head can be adjusted mainly in X-Y-direction (horizontal plane).

In Z-direction (vertical) the tripod head can be adjusted with the third rod which is placed almost vertically featuring also an adjustable rod end and a displaceable fixing plate. The material of the tripods is usual construction steel S275 J2G3.

The spherical bearings on the rod ends are commercial pieces but with longer thread allowing in this way certain adjustment capability. The company Durbal for example has standard spherical bearings with longer thread (EM 30-20-501/502). They are maintenance free.

The support structure, as well as the parallelogram, must have adjustment capabilities compensating own fabrication and mounting errors and these ones of the telescope structure.

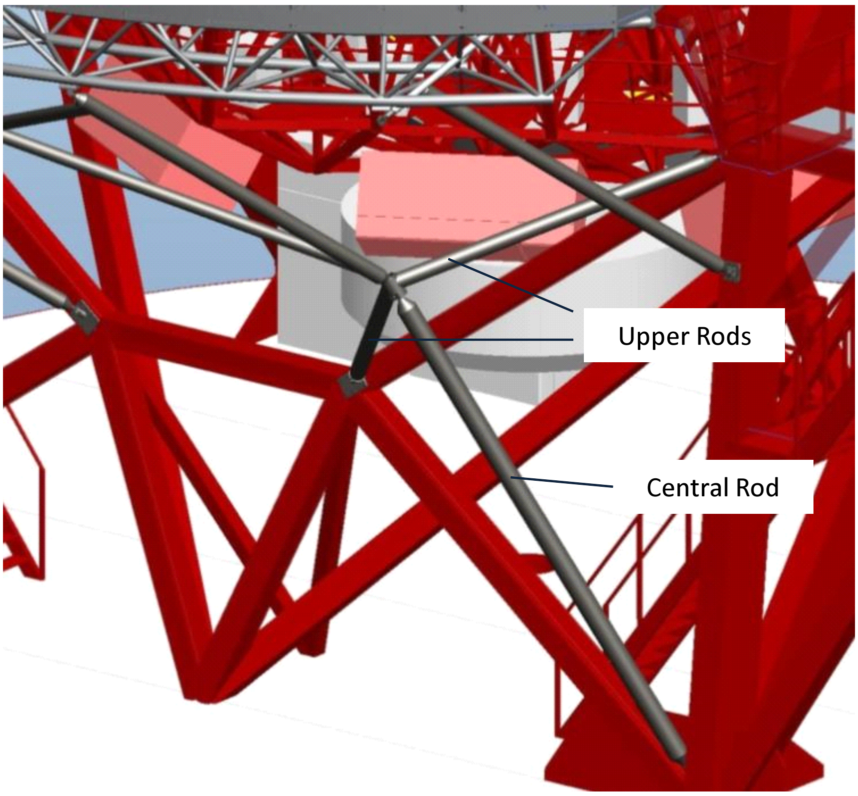

Figure 11 Tripod of side A of the support structure.

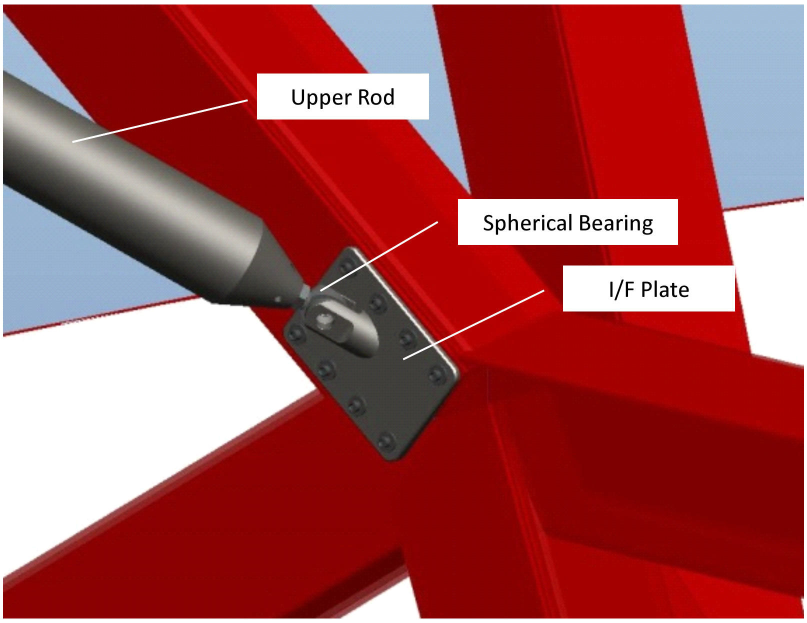

Figure 12 Detail of attachment to the telescope structure.

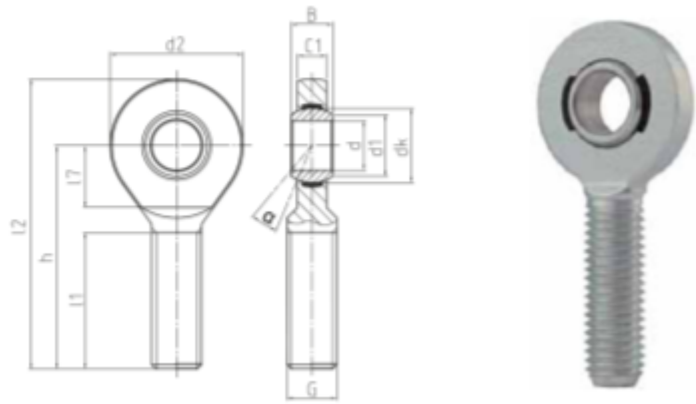

Figure 13 Durbal EM 30-20-501/502 with longer thread.

The movement of the platform is guided by the parallelogram consisting of one central swing and two lateral swings. The arm length is about 3.9 m and the aperture 2.23 m. The positions of the pivoting points and the arm length of the parallelogram are mainly determined by both, the Cassegrain and the Folded Cassegrain positions. Both positions are separated 500 mm in high and 900 mm in the horizontal. The horizontal distance could be less, about 800 mm, but would lead to a larger slewing angle of the parallelogram to reach the resting position. The platform level in Cassegrain position coincides with the level of the Nasmyth platforms, 2000 mm below the elevation axis of the telescope tube. In the Folded Cassegrain position the platform level is on 1500 mm below the elevation axis. The resting position of the platform has no defined level but must situate the platform outside the volume defined by the rotation of the telescope tube.

The central swing is supported by the two tripods and consists of two main rods with spherical bearings on their ends and two crossed rod between them. These crossed rods give the construction its lateral stiffness.

The rods of the lateral swings are simple rods with spherical bearings on their ends mounted directly to the porticos of the telescope mount.

The spherical bearings are commercial pieces with larger sphere allowing bigger lateral slewing angles. The material of the rods is usual construction steel S275 J2G3.

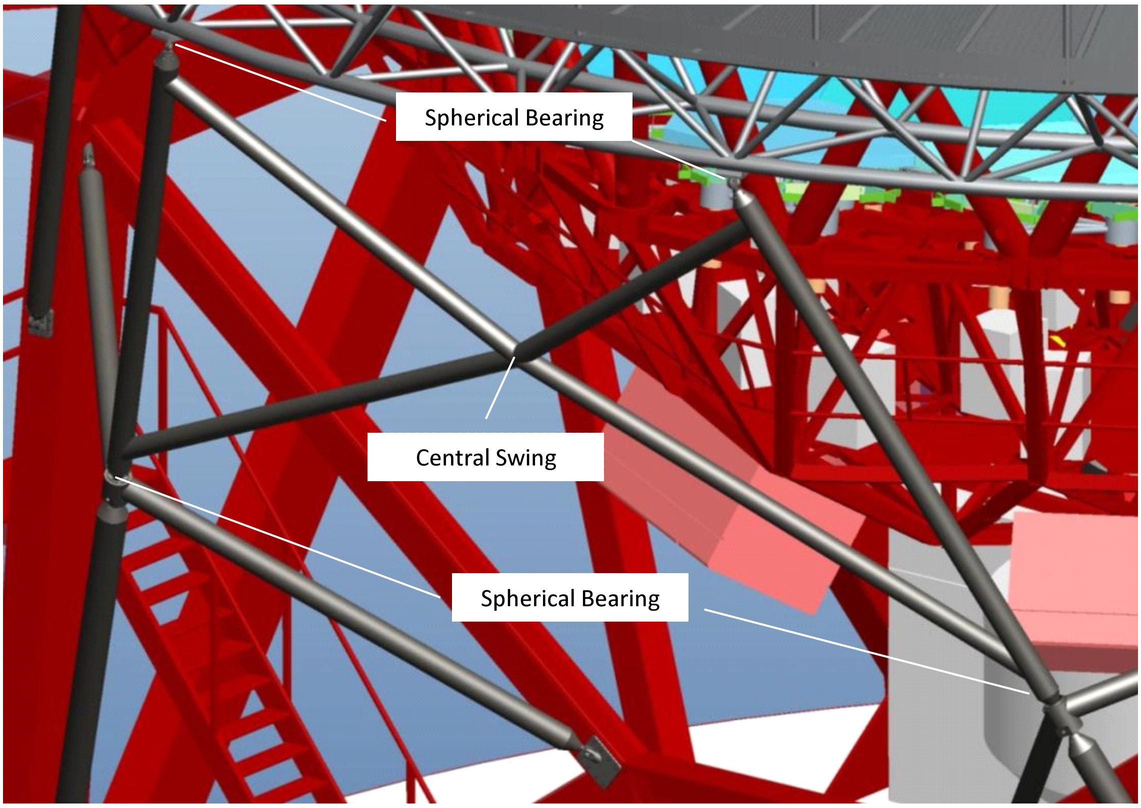

Figure 14 Central Swing of the parallelogram.

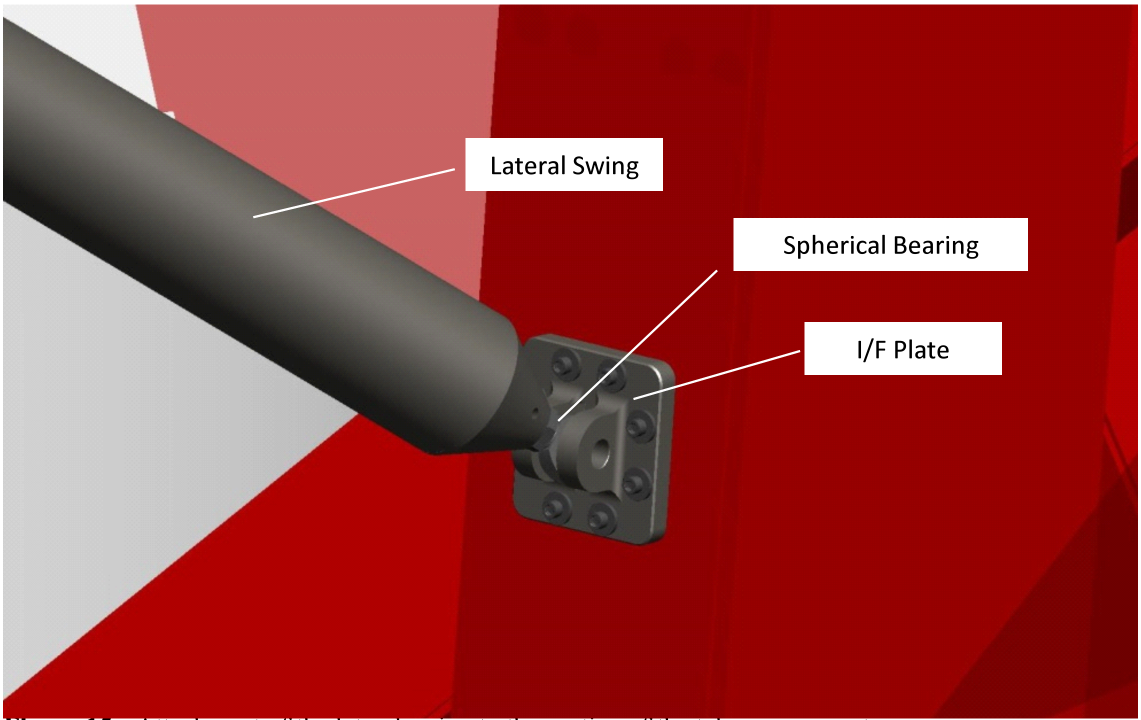

Figure 15 Attachment of the lateral swing to the portico of the telescope mount.

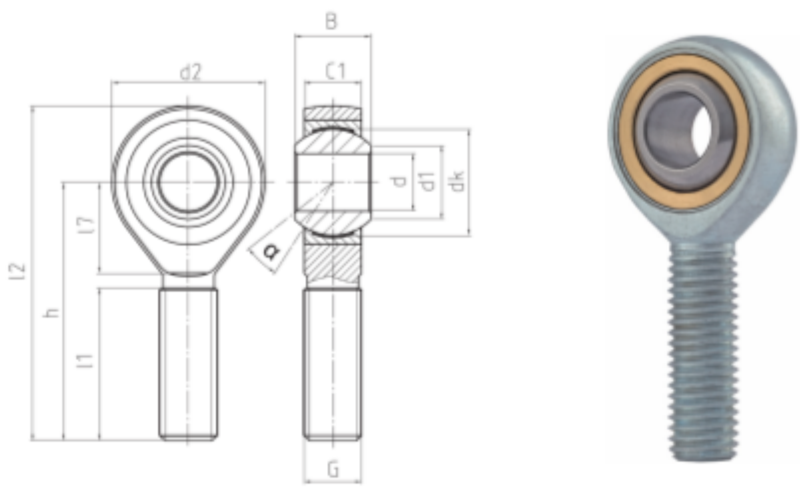

Figure 16 Spherical bearing with larger slewing angle.

5. MOVING PLATFORM

The platform is situated on the top of the parallelogram swings consisting of a simple half-moon shaped space frame which carries the platform floor. The overall span is 14,25 m and the normal width 2,3 m. In the center on the inner radius the platform has a clearance of 3,7 m length and 0,4 m width giving the Cassegrain focal station space to pass if the platform is in the resting position.

The space frame compromises four main struts which are connected by transversal struts forming tetrahedrons. The diameter of the main struts is bigger than that of the transversal struts avoiding accumulation of weld seams on the nodes, in case of a welded construction. This problem does not exist in the case of a bolted space frame made out of struts and spherical nodes. This last construction alternative takes advantage of its small dimensions during transportation.

The floor rests on the space frame consisting in a grating influencing as less as possible the free air circulation in the telescope chamber.

The whole platform, i.e. space frame, floor and hand rails, is made out of aluminum to keep masses and forces low (as lower the installed masses and stiffer the structure as less influence over the azimuth axis of the telescope).

The interfaces with the parallelogram have to be adjustable compensating fabrication and mounting errors.

On the hand rail a life line is installed which is connected to the life lines of the access bridges so that the platform can be entered in any position if required by an exceptional situation.

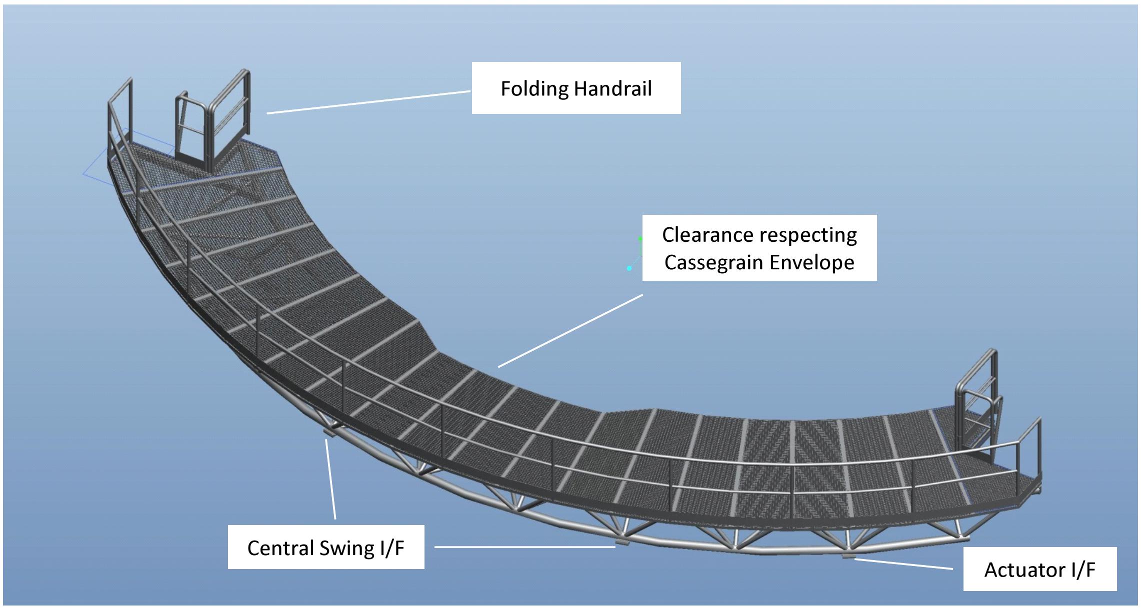

Figure 17 Moving part of the half-moon platform.

On the inner side facing to the telescope structure, folding handrails are installed closing open spaces in Cassegrain Position. In Cassegrain Position they are extended and in Folded Cassegrain Position they are folded. The folding is realized or actively by small actuators or passively by levers and the own movement of the platform.

On the platform there are reserved areas with attachment points for fixing individual equipment such as nitrogen bottles or cabinets for storing filters or similar. The maximum load foreseen for each of the two areas is 250 kg.

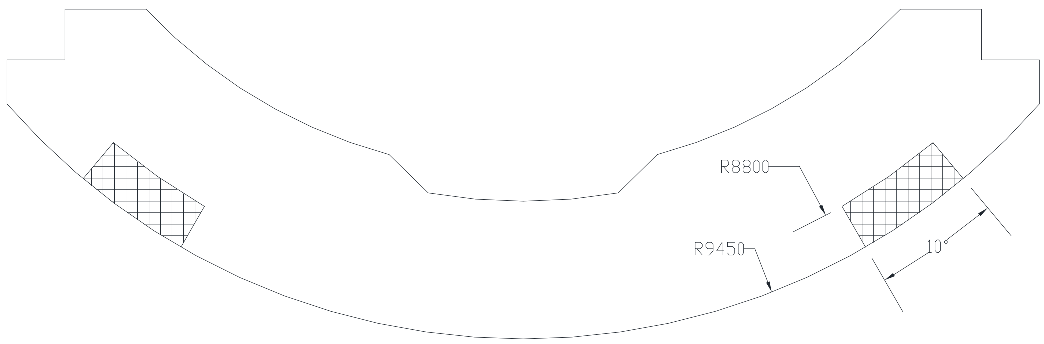

Figure 18 Areas for storing equipment.

The exact area and the matrix of attachment points have to be defined during the detailed design phase.

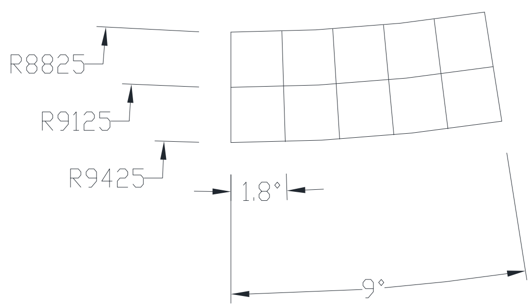

Figure 19 Possible hole-matrix.

6. COMPLEMENTARY PLATFORMS

In Cassegrain position and in Folded Cassegrain position the platform connects to complementary platforms forming a continuous floor. The complementary platforms act as interfaces since the tube structure has different forms in both positions. At the same time they contain channels carrying conducts between cabinets and rotators or other services coming from the telescope. The channels are accessible from the top (in this case the floor is not a grating but a closed sheet) by means of articulated covers with gas-springs and locking mechanism. The complementary platforms are adjustable in position minimizing gaps and steps if the moving part of the platform docks.

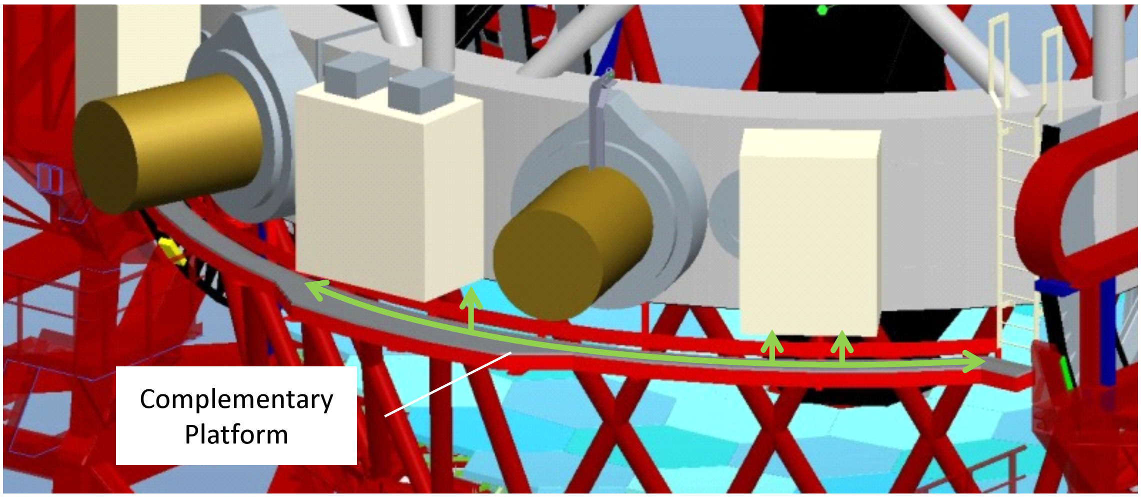

Figure 20 Complementary platform under the Folded Cassegrain foci. Cable channels at the same time.

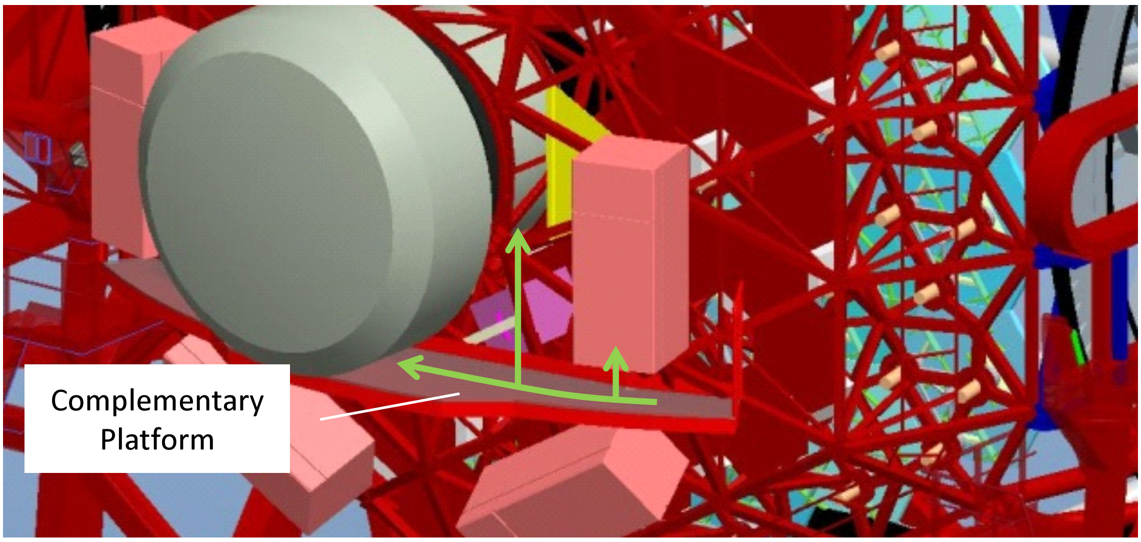

Figure 21 Complementary platform under the Cassegrain focus. Cable channels at the same time.

7. ACCESS BRIDGES

Access bridges with doors are installed on both sides of the platform allowing to access to the platform itself or to pass from one Nasmyth platform to the other.

The access bridges compromise a static part fixed to the Nasmyth platform and a moving part pivotably connected to the platform. The moving part has wheels on one extreme that are guided inside two rails on the fixed part. In this way the platform is accessible independently of its position.

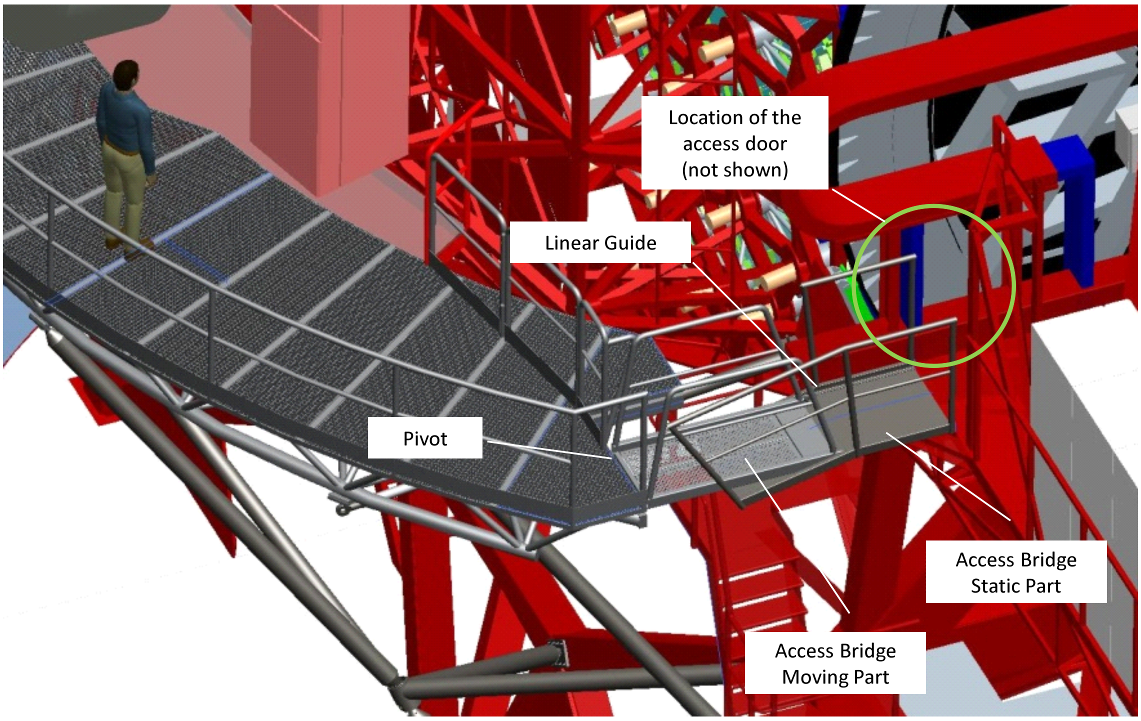

Figure 22 Access bridge connecting Nasmyth platforms with the Half Moon platform.

Figure 23 Rail-wheel system from Winkel for guiding the moving part of the access bridge.

The access doors can be secured opening only when the platform is in Cassegrain o Folded Cassegrain position. A switch with integrated solenoid actuator on each door indicates if the door is closed or opened and if it is locked or unlocked. The doors can be retained in opened position but return automatically (i.e. by spring), if released, to closed position.

Figure 24 Security switch for access doors. Can reach SIL 3.

The integration of an access door in the center of the Half Moon platform, to connect with the scissors platform, is TBD.

8. DRIVING UNIT

8.1 Main Drives

The platform is driven by two electromechanical cylinders mounted between the space frame of the platform and the porticos of the telescope mount. On each end they have spherical bearings working purely under traction or compression. The trapezoidal lead screw makes the mechanism irreversible for more security.

The motor is flanged laterally to one base of the cylinder driving the lead screw over a worm gear. On the other side of the worm gear a free axis stands out of the gear housing. So, in case of motor fail, the platform can be moved by a hand wheel or a drilling machine. Another option could be a ball screw instead of a trapezoidal lead screw mounting a releasable brake on the opposite input.

The selected motors are DBL or AKM series from Kollmorgen with built-in brake and absolute encoder. Last one is required to detect the position of the platform directly after switching on the system without the need of a homing procedure. Both motors are operated by drives from the Kollmorgen Servostar series working in master-slave configuration.

In each of the three nominal positions two position switches, one on each side or six in a whole, confirm the position of the platform. These switches will be connected to the Interlock and Safety System of the telescope. The implementation of travel end switches has to be considered.

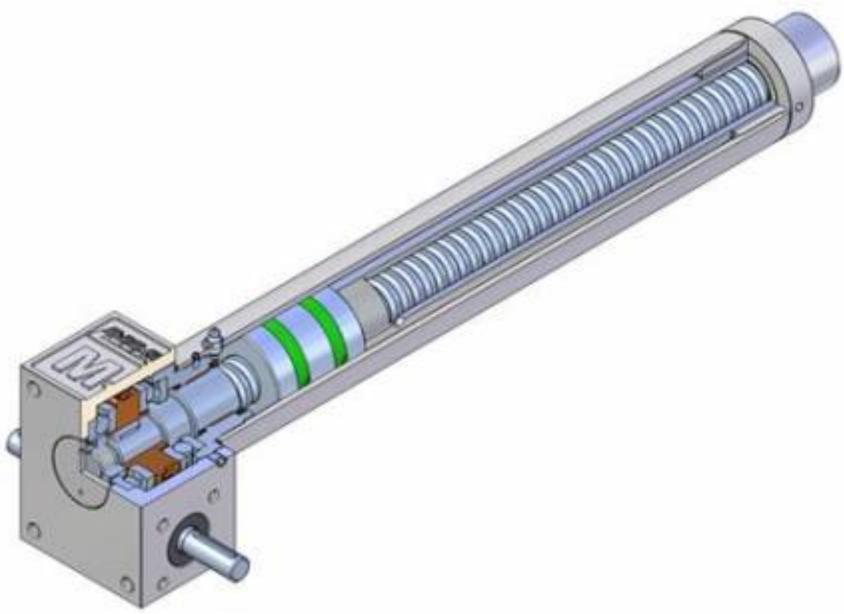

Figure 25 Electromechanical actuator from NIASA.

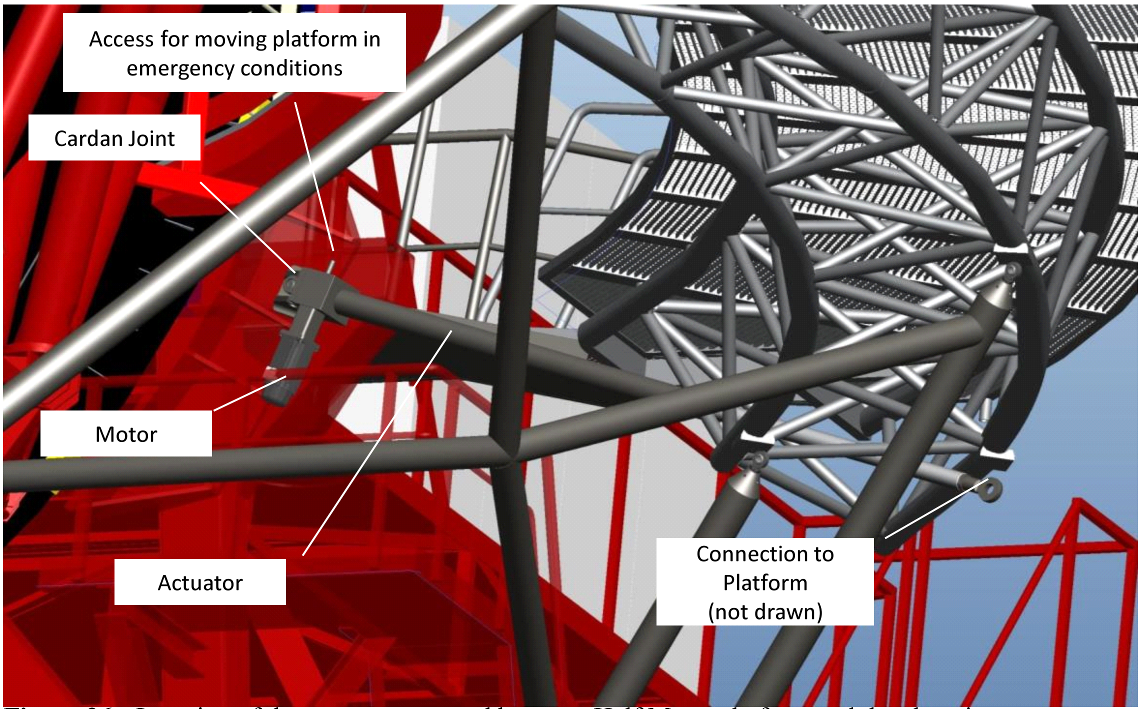

Figure 26 Location of the actuator mounted between Half Moon platform and the elevation motor supports.

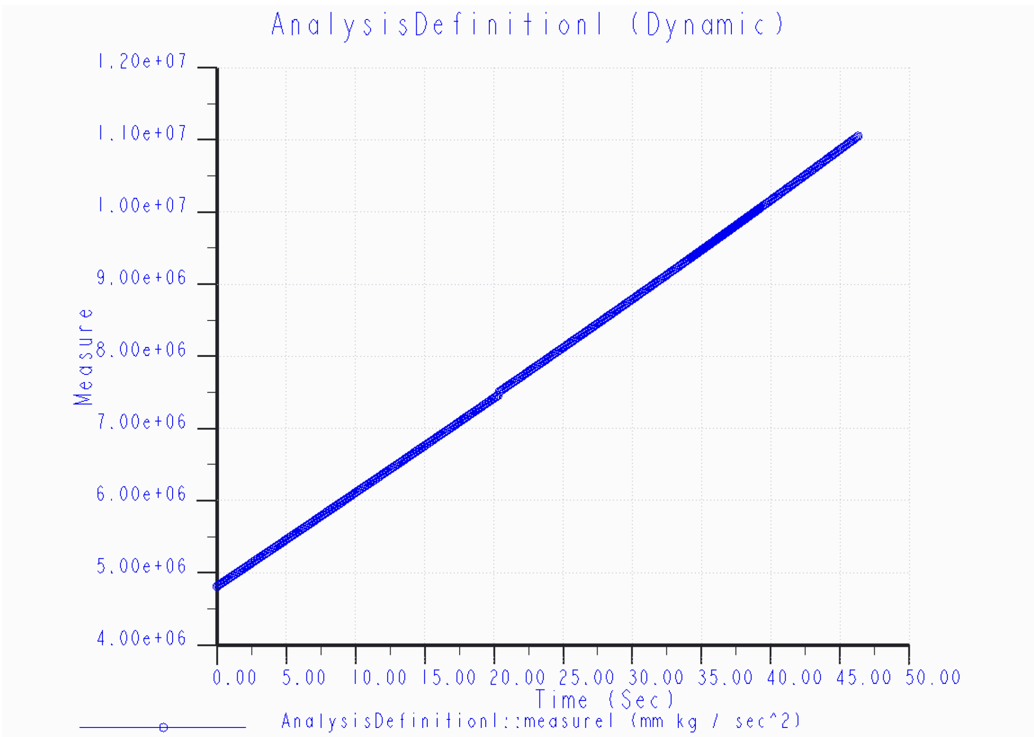

Figure 27 Load on one cylinder traveling the platform between Folded Cassegrain and Resting position.

The load each cylinder has to handle varies between 4800 N in Folded Cassegrain position and 11050 N in Resting position, considering 500 kg of additional load located in the storing areas.

8.2 Emergency Device

The driving unit comprises also an emergency device for mechanical redundancy, i.e. security of the mechanism. This can be realized by two long travel custom spring hangers carrying the most part of the platform weight. In case of complete collapse of one or both of the electromechanical cylinders the emergency devices stop the platform reducing two integrated damper the impact on the end of travel.

The emergency devices are located on both porticos reducing the load and electrical consumption on the driving unit. On the other hand they can be used as support element in case of exchange of components of the main drives.

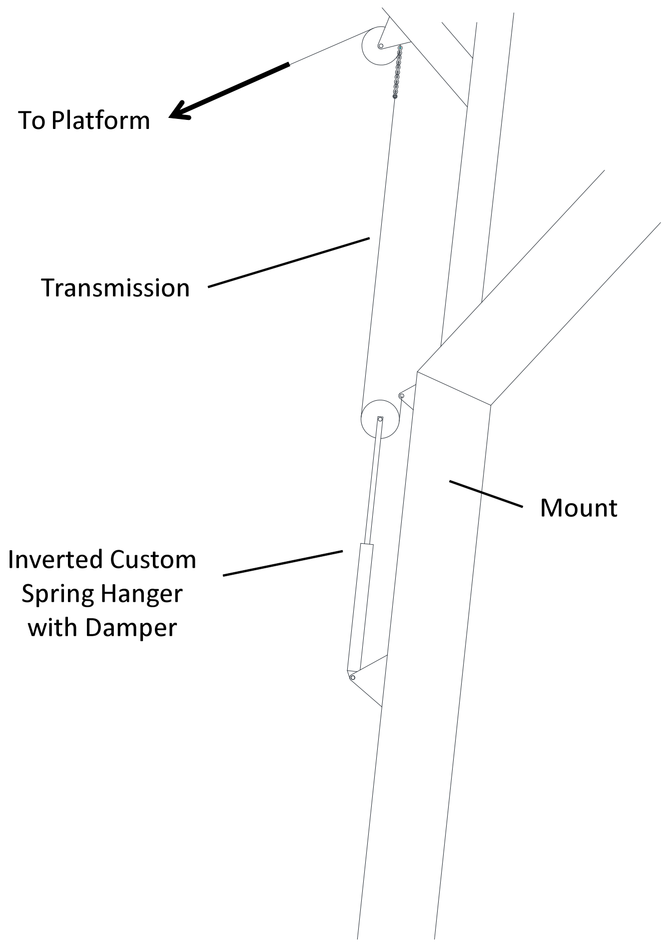

Figure 28 Example for a mechanical back-up of the platform moving mechanism (lateral view from right showing a part of the mount portico).

9. ELECTRONIC CABINET

The electronic cabinet can be located on the level of the rotating floor in the center of the mount and on the side of the half-moon platform. In that manner the cable length between drives and motors will be about 13 m.

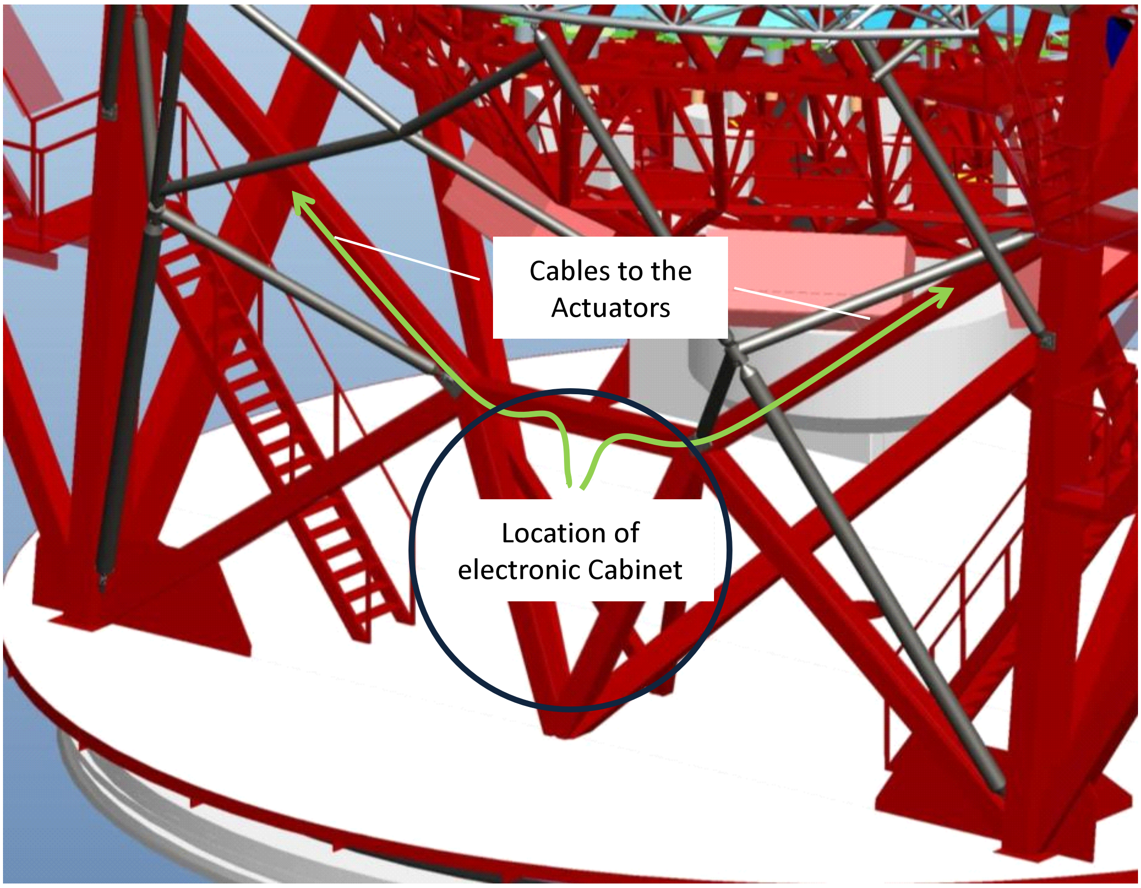

Figure 29 Proposed location for the electronic cabinet. Operation panels will be on the Nasmyth platforms.

10. SUPPORT ELEMENTS

Support elements are foreseen for platform integration on the telescope and for maintenance works such as exchange of a driving component.

11. MECHANICAL INTERFACE

All interface points between platform and telescope structure are bolted connections to avoid welding works. The connections have adjustment capability compensating dimensional deviations of the proper platform construction and the telescope structure.

There are interface points between the telescope mount and the tripods, the lateral swings, the driving unit and the access bridges. Other interface points are located between the tube structure and the complementary platforms. Internal interfaces exist between the moving part of the platform and the complementary platforms.

Exact interface areas are TBD.

To get a more detailed impression of the mount structure some images were compiled in the annex.

12. INTEGRATION

Since the telescope is in operation the design of the platform has to be optimized simplifying the integration. So, alignment and mounting of the different components shall be possible in small and easy steps during day time. For integration the 5 t boom crane of the telescope chamber is available.

13. OPERATION

Right next to each of the two access doors an operation panel is installed with interlock key and emergency button. The panels permit to command the platform to remove or to approach, or to stop the movement. The final maintenance position which the platform can reach, Cassegrain or Folded Cassegrain, will depend on the position of the telescope tube. Another operation panel is integrated in the electronic cabinet for maintenance tasks.

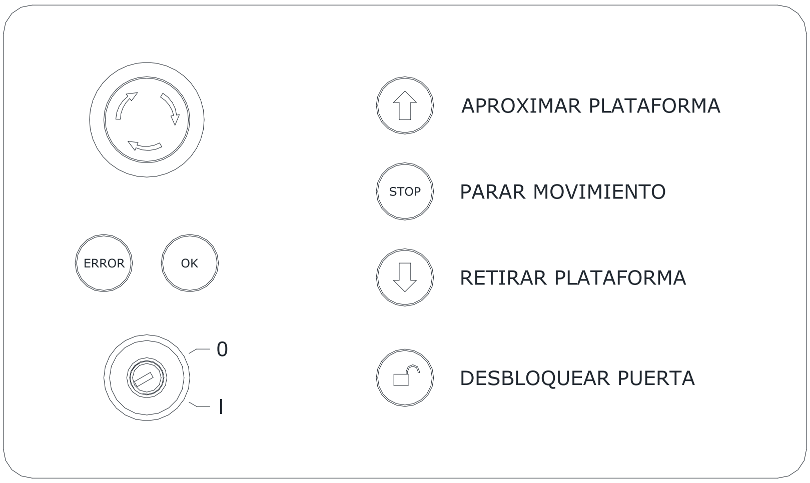

Figure 30 Example of a local operation panel.

13.1 Operation Logic

The platform can be moved from one of the three operation panels. For this purpose the power-key is switched on and the electronics are energized checking several conditions:

On local level both access doors are closed and locked which is checked by the proper electronics of the platform. On global level, the permission to operate sent from the Interlock and Safety System (ISS) of the telescope must be present. This is only possible if the telescope tube is in vertical or horizontal position, its locking pin is inserted and the drives are disabled.

Given all the conditions the platform can be moved between Resting position and Cassegrain or Folded Cassegrain position, depending on the actual tube position. Once the movement stopped power is cut switching off the power-key and access to the platform can be get by pushing the unlock button. The access door is kept unlocked returning to the locked state after 5 seconds. Another strategy could be to unlock the access doors permanently if the platform is in Cassegrain or Folded Cassegrain position. If the worker fixes the door in opened position the platform cannot be moved. However, it will be more safety storing the power-key in the pocket making impossible to move the platform.

Inversely the tube can only be moved if the platform is in resting position, the access doors are closed and its drives are disabled.

Optional function (TBC): Both operation panels have time buttons for crossing the platform. Once pushed, the operation of the platform is inhibited for 1 minute (adjustable) giving time to cross safely from one Nasmyth platform to the other, without carrying the power-key.

13.2 Safety

The platform as a subsystem of the telescope has to execute safety related control functions on local level, acting as an autonomous device. Safety related control functions on global level will realize the Interlock and Safety System (ISS) of the telescope coordinating the interaction of different subsystems.

In result of the definition of local and global safety related control functions, information is exchanged between the control system of the platform and the ISS via an interface module[1] (IM151-1 from Siemens, see Figure 31 Siemens Simatic DP, Interface Module IM151-1.) which is part of the platform electronics. Table 1 and Table 2 list the most important signals that are interchanged between platform and ISS.

№	Signal	Description
1	Position Switch actuated Folded Cassegrain A	Contact closed with position switch actuated and 24VDC present
2	Position Switch actuated Folded Cassegrain B	Contact closed with position switch actuated and 24VDC present
3	Position Switch actuated Cassegrain A	Contact closed with position switch actuated and 24VDC present
4	Position Switch actuated Cassegrain B	Contact closed with position switch actuated and 24VDC present
5	Position Switch actuated Resting Position A	Contact closed with position switch actuated and 24VDC present
6	Position Switch actuated Resting Position B	Contact closed with position switch actuated and 24VDC present
7	Drive A, ready	400 VAC present without incidences
8	Drive B, ready	400 VAC present without incidences
9	Drive A, enabled	
10	Drive B, enabled	
11	Emergency Stop A	24VDC button pushed, 0VDC button not pushed
12	Emergency Stop B	24VDC button pushed, 0VDC button not pushed
13	Emergency Stop RF	24VDC button pushed, 0VDC button not pushed (emergency button on electronic cabinet)
14	Emergency Stop HM	24VDC button pushed, 0VDC button not pushed (emergency rope on platform)

Table 1 Signals available on the interface module IM151-1, to be sent to the ISS.

[1] The implementation of this module depends on the final functions to be handled. In case of a low amount of signals direct cabling is preferred since emergency signals will be sent. In case of a required remote operation mode the signal list can grow significantly converting the interface module in an interesting option.

These signals can be subject to changes during the detailed design phase. Signals 1 to 10 of Table 1 for example could be reduced in "Resting position" and "Active". That means that only if the platform is in resting position the tube can be moved. Inversely, the tube can not move if the platform is active.

Nº	Signal	Description
1	Ready To Be Operated	(permission to move the platform)
2	Emergency Stop	
3	Emergency Disconnection	(TBD)

Table 2 Signals from ISS to platform.

Figure 31 Siemens Simatic DP, Interface Module IM151-1.

13.3 Emergency Stop

Each of the operation panels has an emergency button. Furthermore, over the whole length of the platform railing an emergency rope is installed connected to a pull switch. The rope is guided inside a U-profile preventing unintentional actuation of the emergency switch. The U-profile and the rope are clearly marked to distinguish them from the environment.

If one of the emergency buttons is pushed (pulled) power will be removed immediately from the drives engaging the brakes (if any). A signal is sent to inform the ISS (final use should be a global emergency stop).

Figure 32 Switch for emergency rope.

14. OPERATING CHARACTERISTICS

14.1 Load Capacity

The minimum required load capacity of the platform is defined in 1200 kg temporary load corresponding for example to 10 workers (80 kg each plus 40 kg equipment and tools[2]) or 15 visitors (80 kg each).

Additionally the platform provides a constant load capacity of 500 kg for operation and maintenance equipment (nitrogen bottle, instrument spare parts, etc.).

While the first load (workers, visitors) appears only in Cassegrain and Folded Cassegrain positions the last one (stored equipment) can be permanently present.

Important Note:

In spite of the values indicated in this section, the load capacity of the platform has to comply with the applicable normative for comparable structures.

14.2 Travel Time

The maximum travel time between Resting position and Cassegrain or Folded Cassegrain position is defined in 1 minute.

[2] Values as in Technical Sheet NTP-634 of the National Institute for Safety and Hygiene at Work (Ficha técnica NTP-634 del Instituto Nacional de Seguridad e Higiene en el Trabajo; www.insht.es)

15. STRUCTURAL PERFORMANCE

To analyze the structural performance of the platform a simple wire frame model has been created. It consists of beam and pipe elements, as well as mass elements simulating the platform deck. The pivots of the structure, i.e. the spherical bearings, are modeled with coupled sets. The attachments points to the telescope structure are supposed to be completely rigid.

The aim of the analysis was the dynamic and static behavior of the structure. First one is important since people will walk on the platform. To avoid awkwardly low oscillations being several workers or visitors on the platform the first eigen-frequency was established in minimum 10 Hz. This is valid for Cassegrain and Folded Cassegrain positions since it is not expected, under normal conditions, that a bigger amount of workers will be on the platform when in Resting position.

The static behavior, i.e. deflection and stress under load, is also important but in this case it is not so critical than the dynamic behavior.

15.1 Modell

Component	Material	Real Constant / Section Number	Data	Element Type
Tripods	Steel	RC 1 Central Leg	Dext=200 mm E=12 mm	Pipe
		RC 2 Lateral Legs	Dext=160 mm E=10 mm	
Central Swing	Steel	RC 2	Dext=160 mm E=10 mm	Beam
Lateral Swings	Steel	RC 5	Dext=160 mm E=10 mm	Beam
Platform Space Frame	Aluminum	SN 5 Chords	Dext=120 mm E=7 mm	Beam
		SN 3 diags	Dext=60 mm E=5 mm	
		SN 7 border	L Profile (custom)	
		SN 6 traves	I-Profile (custom)	
Platform Deck	Aluminum	mc / me	Deck Mass = 340 kg[3]	Mass
Actuator Cylinder	Steel	SN 2		Beam
Actuator Lead Screw	Steel	SN 1		Beam

Table 3 FEM model data.

[3] The parameters mc and me are modified during simulation of weight of workers and equipment.

15.2 Load Cases

Three different situations were analyzed:

1) 10 workers (80+40 kg each) on the platform in Folded Cassegrain position with full load in storing areas (2x250 kg).
2) 10 workers (80+40 kg each) on the platform in Cassegrain position with full load in storing areas (2x250 kg).
3) Empty platform in Resting position with full load in storing areas (2x250 kg).

1) First eigen-frequency is 11.7 Hz in terms of torsion over the longitudinal axis of the moving platform. Maximum deflection is less than 2.5 mm on both ends of the platform and maximum stress less than 10 N/mm2 on the space frame of the platform.
2) First global eigen-frequency is 12.6 Hz in terms of bending of the moving platform. Some lower frequency appear on actuators and central swing but still above 9 Hz. Maximum deflection is less than 3 mm on both ends of the platform and maximum stress is 10 N/mm2 on the space frame of the platform.
3) First global eigen-frequency is 13.9 Hz in terms of torsion over the longitudinal axis of the moving platform. Some lower frequency appear on actuators and central swing higher than 6 Hz. Maximum deflection is less than 3.5 mm on the central swing and maximum stress is 10 N/mm2 on the central swing.

Images can be found in the annex. Images were not inverted in color and inserted in this document due to technical problems.

16. ANNEX

16.1 Catalogues

DURBAL-Spherical-Bearing-EM-20-501-a.pdf	High performance spherical bearing with long thread
DURBAL-Spherical-Bearing-DSA-TK.pdf	Standard spherical bearing with larger slewing angle
NIASA-2012.pdf	NIASA – Linear Translation and Elevation Systems
Schneider-Preventa.pdf	Safety Switches

16.2 Images

Telescope-Structure-1.jpg	Right portico of the mount with tube in horizontal position.
Telescope-Structure-2.jpg	Left portico of the mount with tube in horizontal position.
Telescope-Structure-3.jpg	Close view of the upper left elevation motor support.
Telescope-Structure-4.jpg	View from the left on the left portico. The small access platform on the top of the image has to be removed for integration of the Half Moon Platform.
Telescope-Structure-5.jpg	General view from the right.
Telescope-Structure-6.jpg	View of the upper part of the right portico. As well as on the left side the access platform in the upper part of the image has to be removed for platform installation.
Telescope-Structure-7.jpg	General view from the rotating floor.
Telescope-Structure-8.jpg	General view of the central part of the mount.
Telescope-Structure-9.jpg	General view of the Cassegrain Focal Station (Dummy mounted).
Telescope-Structure-10.jpg	General view of two Folded Cassegrain Focal Stations (instrument rotators not mounted). The actual platform will be removed installing the complementary platform.

16.3 Drawings

tl-mn-yk_010-1a.dwg	General dimensions of the telescope mount.
tl-mn-yk_012-1a.dwg	Upper part of the mount portico.
tl-mn-yk_016-1a.dwg	Details of the upper elevation motor support.
gtc_002-1e.dwg	Cassegrain focal station envelope

16.4 Normative

NTP-634.pdf	Nota técnica de Prevención – Plataformas elevadoras móviles de personal.