MST Assembly Area Specifications

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Change log

Issue	Revision	Date	Section/Page affected	Reason / Remarks
1	0	10.03.2023	All	Initial version of the document.
1	1	13.03.2023	All	Revision by A. Steiner

List of abbreviations

AIT	Assembly Integration Test
CMS	Camera Maintenance Structure
CSS	Camera Support Structure
CTA	Cherenkov Telescope Array
CTAN	Cherenkov Telescope Array Northern observatory site
IPS	Integrated Protection System
MAGIC	Major Atmospheric Gamma-ray Imaging Cherenkov
MST	Medium-Sized Telescope
ORM	Observatorio del Roque de Los Muchachos
OSS	Optical Support Structure

Table of Contents

1 General

1.1 Scope

This document defines the specifications for the surrounding area of the MST for the phases of telescope assembly, maintenance and operation.

1.2 Purpose

The purpose of the document is to define the infrastructure needs related to the assembly, operation and maintenance aspects of the MST. Safety aspects during the operation phase are also considered. The specifications shall be taken into account during the design and deployment of the telescope infrastructure elements.

1.3 Applicability

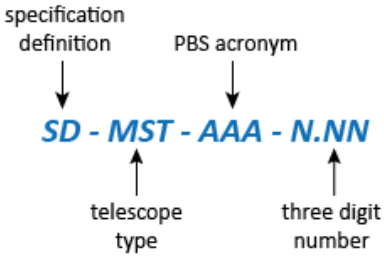
The specifications listed in this document are focused on the specific environment at the CTAN observatory site at the ORM in La Palma, Spain. These specifications raise from the needs of the telescope assembly, maintenance and operation activities. Experience from the MAGIC telescope project in operation for 20 years at the ORM is considered. Input from the CTAO is incorporated [1]. The design of the MSTN infrastructure shall be compliant with these specifications.
Majority of these specifications will also apply for the MSTS on the CTAS site. They shall be revised based on the dimensions of the foundations as well as the site-specific conditions and observatory safety provisions.

The specifications shall be verified following one or more of the proposed verification methods:

- **Analysis (A):** Verification by Analysis consists of the use of analytical data or simulation under defined conditions to show theoretical compliance. Analysis is used where verifying and realistic conditions cannot be achieved or is not cost-effective and when such means establish that the specification is met by the proposed solution.
- **Certification (C):** Verification by Certification consist of written assurance that the product has been developed and can perform its assigned functions in accordance with legal or industrial standards.
- **Demonstration (D):** Verification by Demonstration consists of a qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. The system developer may select verification activities to show that system response is suitable. Demonstration may be uses when specifications are given in statistical terms.
- **Inspection (I):** Verification by Inspection consist of performing an examination of the item against applicable documentation to confirm compliance. Inspection is used to verify properties best determined by examination and observation.
- **Review of Design (R):** Verification by Review of Design consist of using approved records or evidence that unambiguously show that the specification is met. For example, design documents and reports, technical description document end engineering drawings.

- **Test (T):** Verification by Test consist of an action by which the operability, supportability or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. These verifications often use special text equipment or instrumentation to obtain very accurate quantitative data for analysis.

Specifications listed in this document have the following identification number scheme:



where *AAA* is the PBS acronym for the product, e.g. INFRA in case of the infrastructure. *N.NN* is a three digit number. The separation of the number with the dot allows to subdivide the specifications into different categories.

1.4 Applicable Documents

[1] CTAO, "Fencing of MSTs at CTA-North," v1.0, 23.11.2020.

[2] M. Garczarczyk, "Medium-Sized Telescope Technical Design Report," MST-STR-TDR-36121000-00001, 2022.

[3] M. Garczarczyk, "MST INFRA ICD," MST-STR-ICD-36141000-00002, 2022.

[4] CTAO, "Jama Requirements Repository," [Online]. Available: https://jama.cta-observatory.org/.

[5] M. Garczarczyk, "MST-STR Logistics Plan," MST-STR-CO-36113200-00008, 2022.

[6] M. Garczarczyk, "MST Assembly-Integration-Test Plan," MST-STR-UM-26145100-00001.

[7] R. Platzer, "MST Weight Estimate," MST-STR-VVR-36143000-00028.

[8] M. Garczarczyk, "MST-STR Logistics Plan," MST-STR-CO-36113200-00008.

2 Medium-Sized Telescope

Figure 1 shows the design of the MST with highlighted main assemblies [2]. The main dimensions of the telescope are: dish diameter of 12 m, focal distance of 16 m, height of the elevation axis rotation point over the ground of 9 m, as shown in Figure 2. The total weight of the telescope is 90 tons.

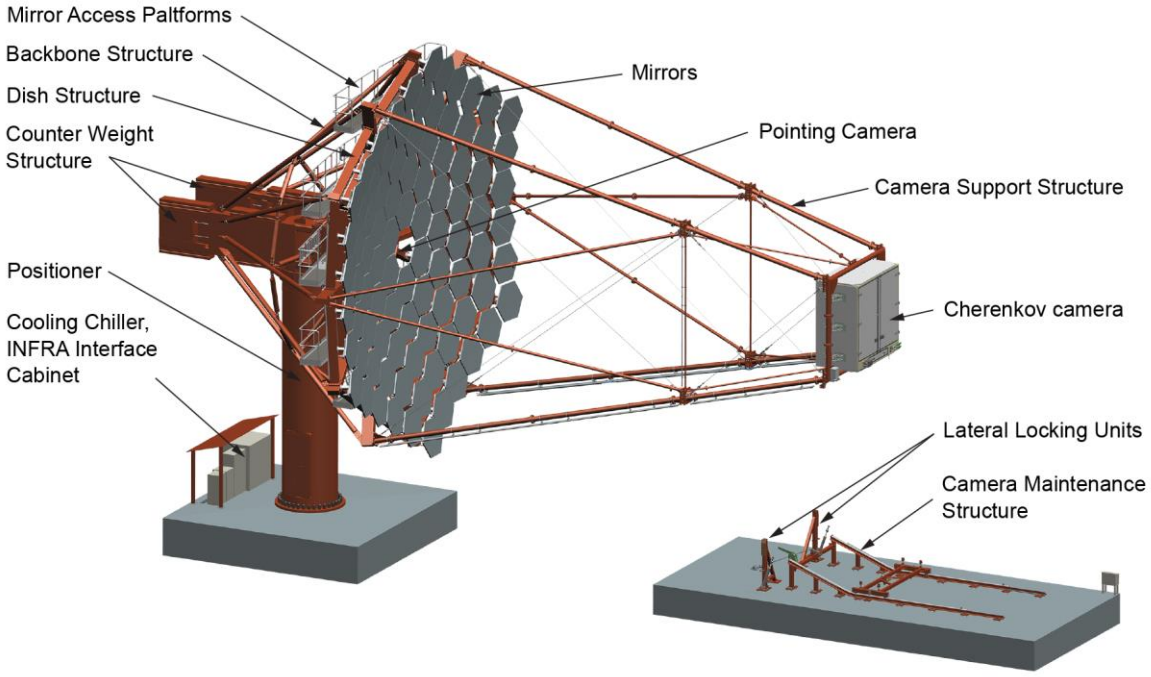


Figure 1: Design of the MST with naming of the main assemblies.

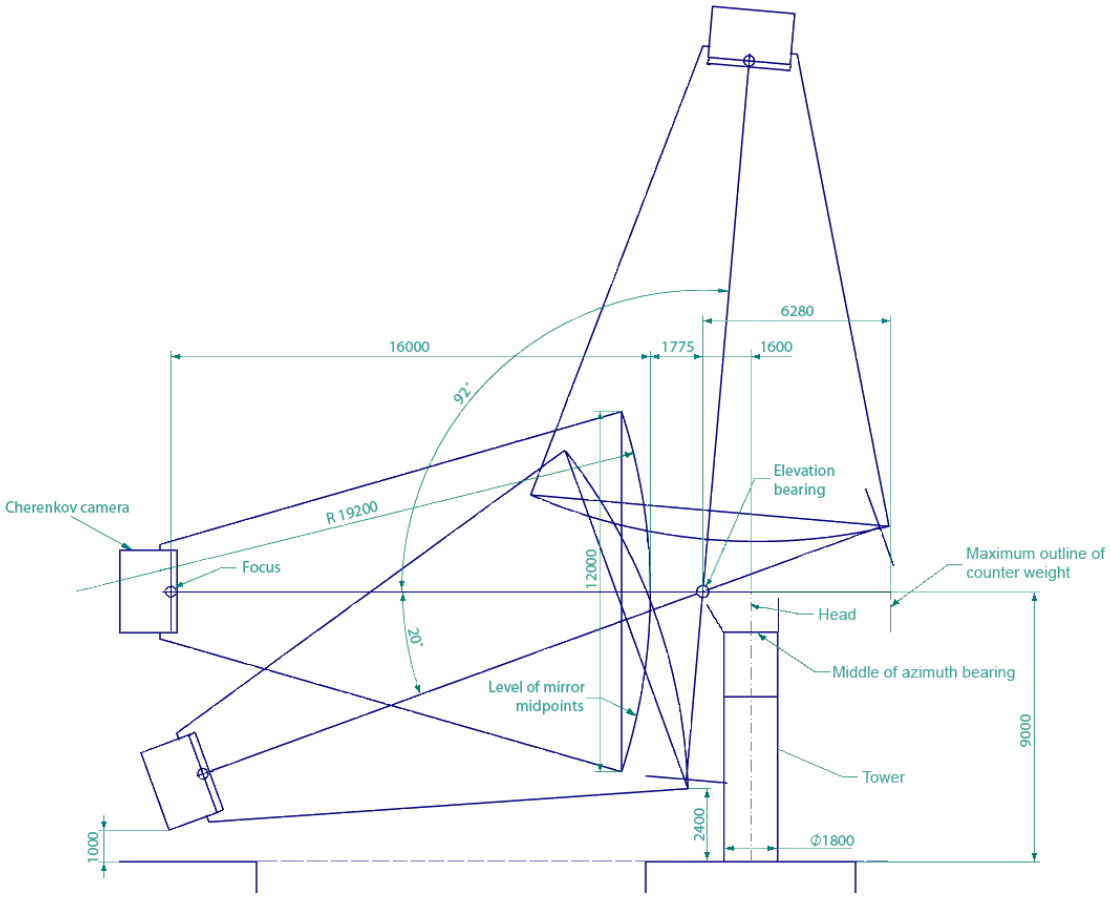


Figure 2: MST main dimensions.

The MST specific site infrastructure elements are shown in Figure 3.

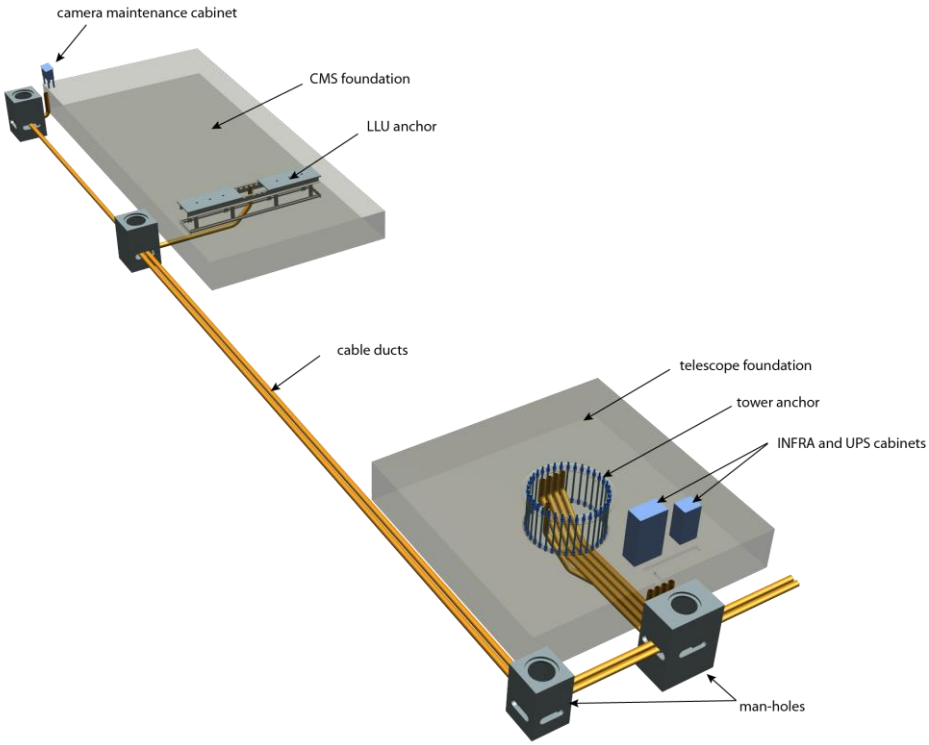


Figure 3: Schematics of the telescope infrastructure components

Among them are two foundations: the telescope foundation and the CMS foundation. The power and data supplies lines are routed through cable ducts, buried under the ground. Manholes are required at various locations. The manhole location and position of the cable ducts are defined in [3]. To some extent the position of the manholes and cable ducts might vary due to the site arrangement, e.g. the position of the access road and routing of the cables between the telescopes.

The telescope operation ranges and limits are shown in Figure 4.

- The safe parking position is located at the azimuth angle of 0° (pointing towards North at CTAN and South at CTAS) and elevation angle of -20°.
- The stand-by or parked-out position is at the azimuth angle of 0° elevation angle of 0°.
- The telescope operational range is a full turn around the azimuth axis with the elevation axis starting from 0° to 91°.
- Pointing below 0° elevation outside of the parking zone shall be made possible for maintenance reasons.
- The telescope camera swing radius is 20 m around the center of the tower.

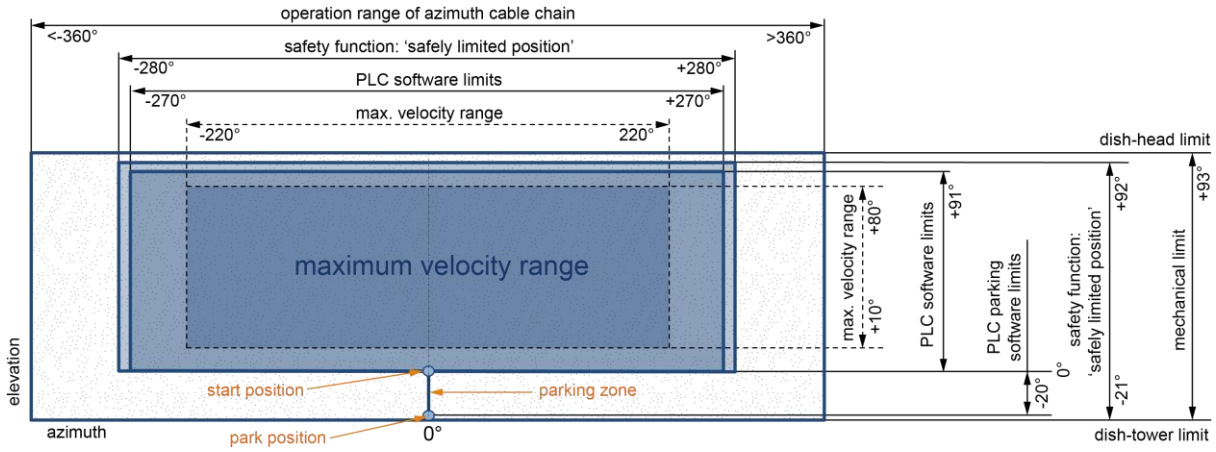


Figure 4: MST operation ranges and limits.

The ORM is located in a national park. The main access road to the observatory is closed with a barrier at night time. Access to the national park is not regulated and monitored during the day time, there are also various hiking paths crossing the site and passing close to the telescopes. For safety reasons each individual telescope needs to be protected against unauthorized access. At CTAN this will be done via a fence with a perimeter sufficient to comply with relevant safety rules at ORM and the EU. The exact position of the fences depends on the extension of the foundations as well as the movement radius of the telescope. Other factors raise from the maintenance and access needs to the telescope. Temporary extension of the fenced area during the telescope assembly might be required, especially when the area around the telescope is accessible due to the slope of the terrain.

Various areas close to the telescope need to be made flat and hardened to allow access by machinery and trucks during the assembly and maintenance of the telescope.

Section 3 contains the specifications related to the fencing of the telescope. Section 5 contains the specifications related to the areas for the telescope assembly and maintenance.

3 Relevant safety rules and CTA requirements

At ORM on La Palma, EU regulations apply, in particular the EU Machinery Directive 2006/42/EC and the connected Harmonized Standards.

Compliance with these regulations is fulfilled through protecting the telescope slew area by means of a fence. In particular the fences are needed for protection of persons and the environment and vice versa that includes smaller animals, e.g. rabbits.
In addition, the CTA requirement specification *B-INFRA-140* [4] specifies:

> *All Telescopes and other array instrumentation must be protected by fencing to prevent unauthorised access of persons and intrusion by animals capable of causing damage.*

The description in [1] extends the definition as follows:

> *A protective fence with lockable access gates around the Telescopes and auxiliary Instruments shall be installed to prevent unauthorised access of persons. The fence shall be 1.8 m high with profiled panels constructed in panel widths of 2.5 m or 2.75 m made from 6 mm or 8 mm drawn steel wires welded (weld mesh fence) at intersections to form 200 mm vertical and 50 mm horizontal apertures. Wires to be protected with a PVCu coating (as per LST1 perimeter fence). Standard powder coated steel posts to be set in a concrete foundation.*

4 Protection of the telescope surrounding

Figure 5 illustrates the positions, dimensions and distances of the MST auxiliary components of the infrastructure elements. Proposed layout of the fencing line around the telescope is shown in green. The proposed distances shown in the figure are based on the specifications listed in this document. The position of the entrance gates is not included in the figure. The position of the gates depends on the location of the access road. The position shall be defined by the architects for each telescope individually.

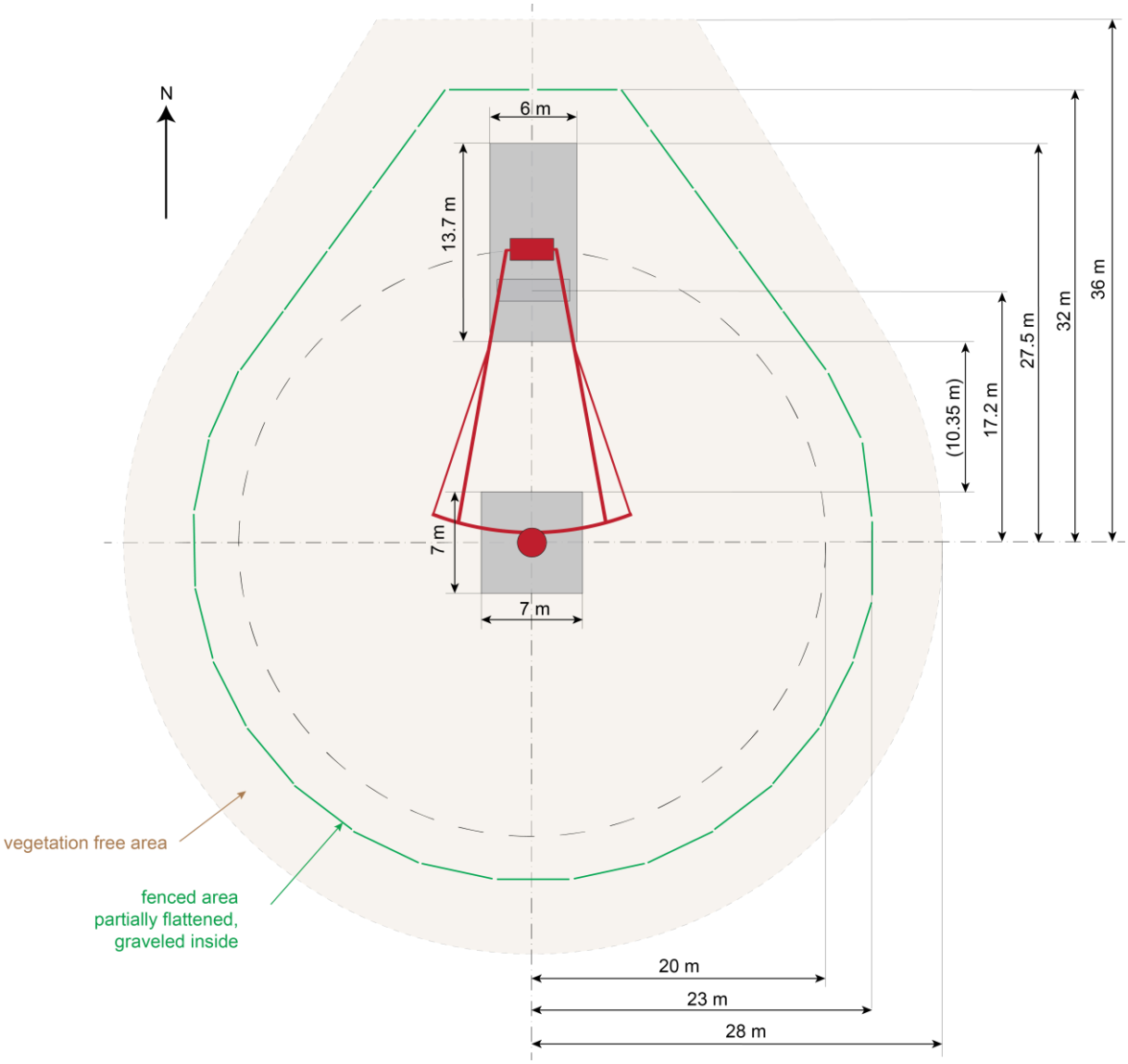


Figure 5: Tentative master layout of the telescope fences.

ID	Description	Verification
SD-MST-INFRA-1.01	The operational ranges of the telescope shown in Figure 4 shall not be limited by any infrastructure elements or natural objects.	R
SD-MST-INFRA-1.02	Movement of the telescope around the azimuth axis with the elevation axis pointing towards horizon (0°) shall not be limited by any infrastructure elements or natural objects. *Note: The telescope movement radius is 20 m, referenced to the center of the tower.*	R
SD-MST-INFRA-1.03	For maintenance reasons pointing of the telescope to elevation axis of -20° shall be possible in a continuous region of ≥90° in azimuth. The safe parking position shall be located within this region.	R

SD-MST-INFRA-1.04	The telescope shall be fenced to protect unauthorised access.	R
SD-MST-INFRA-1.05	The fence line shall have sufficient distance to the telescope structure as well as to any telescope auxiliary elements, e.g. the CMS foundation and elements installed on it, when considering the movement ranges of the telescope. The minimum distance of the fence line to the telescope structure elements and auxiliary components shall be 1.5 m.	R
SD-MST-INFRA-1.06	In an emergency case, e.g. failure of the telescope power or drive system, it shall be possible to move around and access to the telescope structure at any time and at any telescope pointing orientation by a pickup car or a cherry picker[1]. *Note: Access scenarios for all possible telescope orientations within the movement range shown in Figure 4 shall be investigated. The site topography shall be included considered in the analysis.*	R
SD-MST-INFRA-1.07	It shall be possible to move around and access by a pickup car or a cherry picker to all sides of the telescope structure when the telescope is in parking position. In this case sufficient space behind the telescope tower foundation (with the auxiliary systems and cabinets installed on and nearby the tower) and the CMS foundation (with the auxiliary systems installed on it) to the fence or any other elements shall be possible.	R
SD-MST-INFRA-1.08	Access inside the fenced area for vehicles (sufficient of entering with 40ft container transport or crane) and pedestrians shall be provided.	R
SD-MST-INFRA-1.09	The access gates shall be lockable.	R
SD-MST-INFRA-1.10	The entrance gates shall be equipped with interlock switches. The interlock switches shall be connected to the MST Safety PLC.	R
SD-MST-INFRA-1.11	Cable ducts between the entrance gate interlock switches and the INFRA power and network cabinet (located at the telescope tower foundation) shall be provided.	R
SD-MST-INFRA-1.12	The assembly and maintenance area inside the	R

[1] In this case a minimum distance of 3 m between the fence line and the telescope structure elements is proposed, as shown in Figure 5.

	fences shall be free of any vegetation, e.g. bushes, to allow movement by vehicles, storage of containers during the telescope assembly as well as for fire protection reasons.	
SD-MST-INFRA-1.13	The vegetation free area shall extend by 5 m from the fenced line for fire protection reasons. In addition, the vegetation shall be thinned out by additional 5 m to reduce the density of inflammable materials.	R

5 Assembly and maintenance areas

The MST structure elements should fit into four 40-feet-container and five 20-feet-container. Figure 6 shows a possible arrangement of the components in containers. From top left:

- 20ft container with the pre-assembled head, mirror spacers and AMC components
- 20ft container with the yokes and Mirror Support Units (MSU)
- 20ft container with the backbone structure and CMS
- 20ft container with the CWS
- 20ft container with the mirror access platforms (MAP)
- 40ft container with the pre-assembled tower, azimuth drive unit, cables etc.
- 40 feet container including 90 mirror segments
- 40 feet container with the Camera Support Structure (CSS)

Not included in the list is the Cherenkov camera and its electronics. Detailed packaging description of the containers can be found in [5].

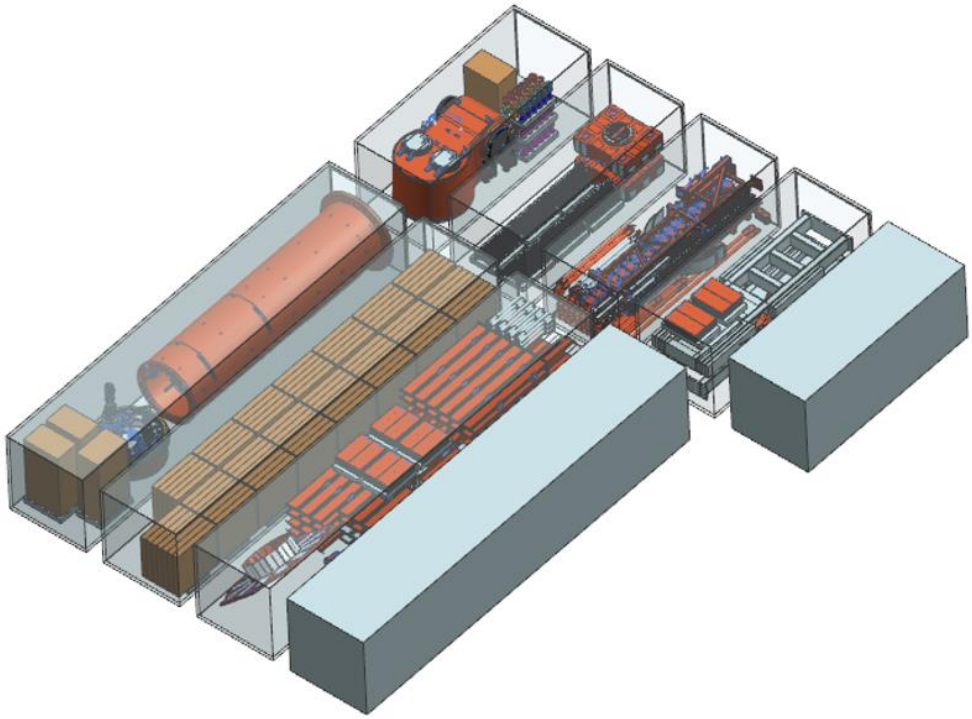


Figure 6: Possible arrangement of telescope structure components in containers.

Figure 7 illustrates various telescope assembly steps in one view. Detailed AIT procedures are described in [6]. The following aspects shall be considered when defining the space for the telescope assembly:

- Access to the site with trucks for unloading of the containers shall be possible.
- The site shall allow to host the containers described before. The space shall be sufficient to allow unloading of the components from the containers and access to the components by a crane or fork lift.
- Assembly of the telescope foresees the pre-assembly of the dish structure on the CMS foundation. Access by a crane to and around the pre-assembled dish structure shall be possible.
- Assembly of the CSS is planned to be performed nearby the pre-assembled dish structure, as shown in Figure 7. Sufficient space to access to and around the pre-assembled CSS shall be possible.
- Access to the site large vehicles, e.g. a crane or trucks with containers, shall be possible while the dish structure and CSS are pre-assembled on the ground, as shown in Figure 7.
- Installation of the CSS on the dish structure and the movement of the complete OSS on the positioner is planned with a large 100 t crane located at the position shown in Figure 7.

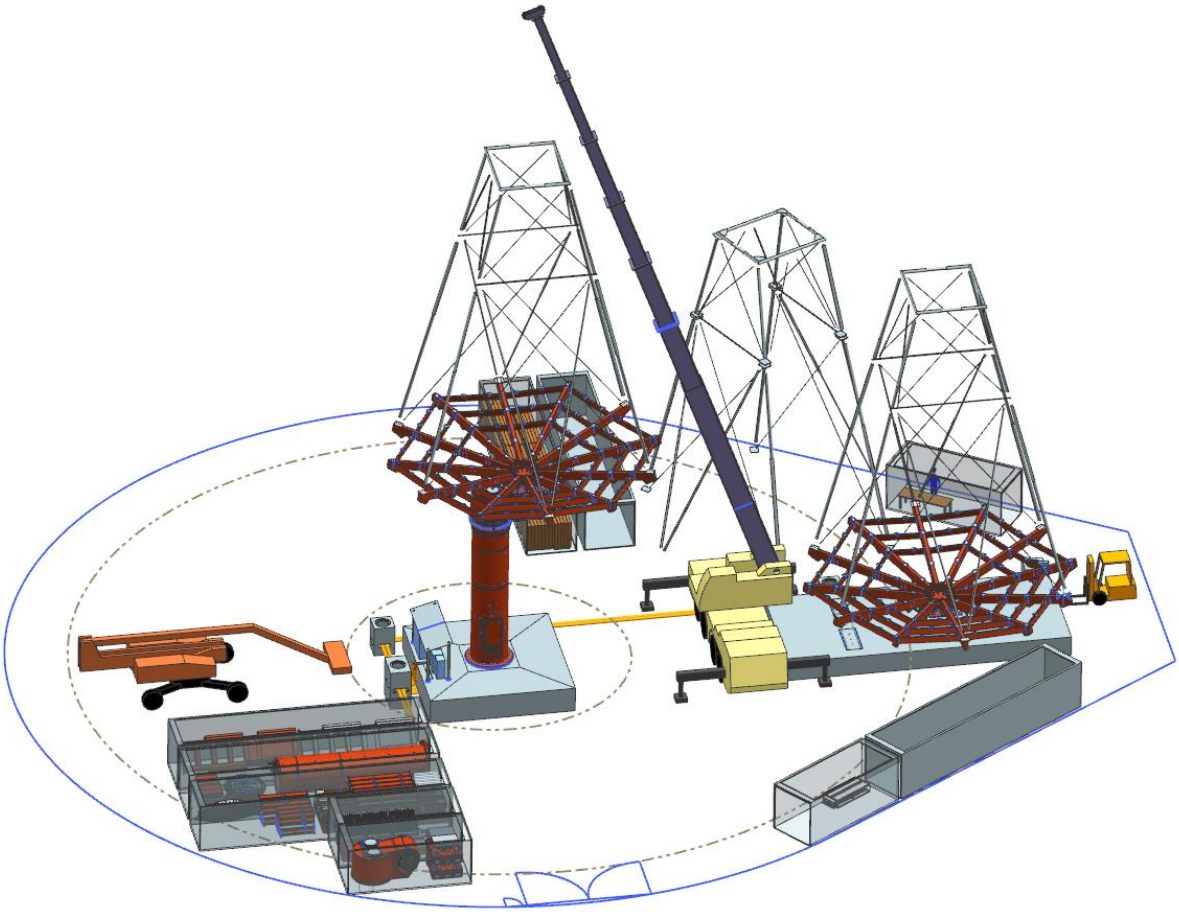


Figure 7: Illustrative view of the telescope assembly process. The location of the containers is for illustration.

Figure 8 shows an example for various loading radii for the Liebherr LTM 1100-4.2 crane. The rings as seen from inside are: 22 m for a maximum load of 24.2 tones, 24 m with a limit of 22 tones, 32 m for a limit of 15 tones and 36 m for a limit of 13 tones. The best position of the crane shall be evaluated by the architects, based on the locally common and available crane models. The following weight estimates [7] shall be considered:

- CSS with the Cherenkov camera included: 8 tones
- Complete OSS (CSS + dish structure incl. mirrors etc.): 28 tones

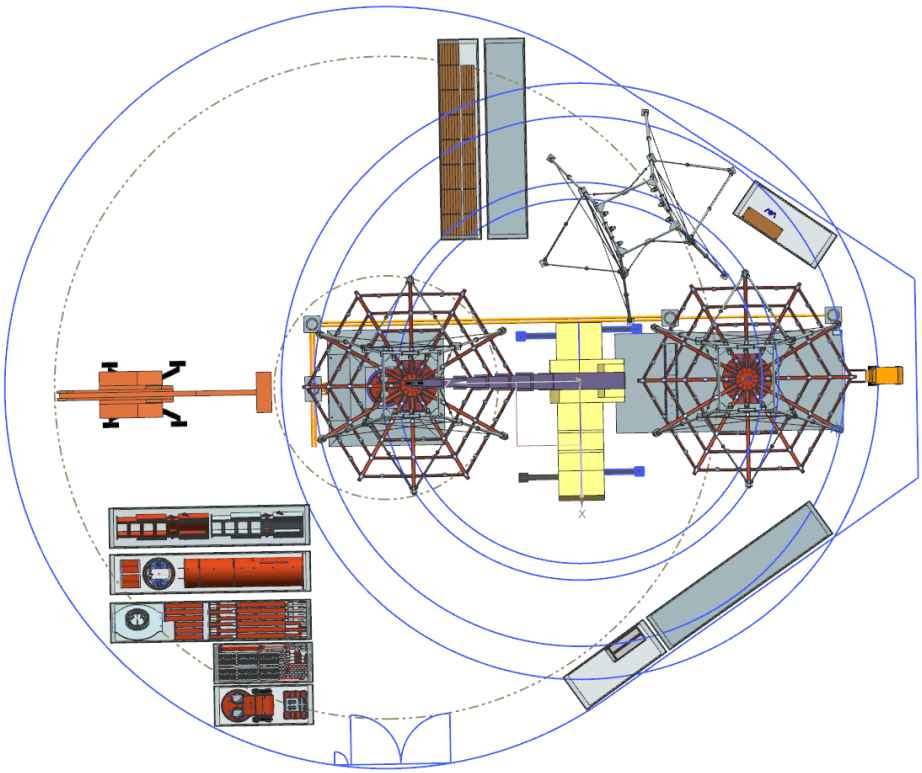


Figure 8: Movement range of a 100 t crane (Liebherr LYM 1100-4.2).

ID	Description	Verification
SD-MST-INFRA-2.01	The area surrounding the telescope shall be accessible by a heavy truck when delivering a container or a crane.	R
SD-MST-INFRA-2.02	The surface allocated for storage of the containers, pre-assembly steps and movement of the machinery shall be compacted. *Note: Compacted soil with gravel stone layer is suggested.*	R
SD-MST-INFRA-2.03	The assembly area shall be large enough to store components with a volume transported by 5x 20ft and 3x 40ft container. Access to the site and the components by a truck or crane shall be possible with all the components stored at the site.	R

SD-MST-INFRA-2.04	Levelling of the surface within the fenced area shall not lead to local rain water accumulation.	R
SD-MST-INFRA-2.05	Sufficient space and soil strength shall be allocated for the movement of a large crane during the pre-assembly of the OSS and its installation on the positioner.	R