Construction Project

Requirement Specification
for
On-Site Networking Infrastructure for CTA North – Short Project

Prepared by *Carla Crovari* 11-01-2019
Power and Data Network Planning Date

Approved by *Signature*
Lead System Engineer Date

Released by *Signature*
Date

Change Log

Issue	Revi-sion	Date	Section/Page affected	Reason/ Remarks / Initiation Documents
1	a	20-11-2018	all	New document
		10-12-2018		Feedback from lead SE
		11-01-2019	New Table of content, addi-tion of Appendix1. Change to sections 2 and 3	Changes to format. New version of AD2 available.

List of Contributors

Name	Organization	Contribution
Stephen Brown	CTA PO	Drawings in Section 3.1 (3.1.1-2 and 3.1.1-3)
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Peter Wegner	CTA PO	Specifications in Section 3.1 and 3.2

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List of Abbreviations

CTA	Cherenkov Telescope Array
ACE	Array Common Elements
LST	Large Sized Telescope
MST	Medium Sized Telescope
ORM	Observatorio del Roque de los Muchachos
CTA-N	CTA Northern Array
CTA-S	CTA Southern Array
PPDC	Patch Panel in Datacentre
PPT	Patch Panel in Telescope side

1 Scope

This specification establishes the performance, design, development and test requirements for the **On-Site Networking Infrastructure**.

2 Applicable Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of the specification shall be considered a superseding requirement.

[1] INFRA-DES-100-019 N P6
[2] INFRA-DES-600-03 N P1
[3] Concept Design for CTA On-Site ICT Infrastructure v1.0, 13.12.2018
[4] Environmental Requirements for the CTA Sites SYS-REQ/161123 (EnvFEArangesv0.5.pdf, 25.04.2017)

3 Requirements

3.1 Item Definition

3.1.1 Item Description & Diagrams

The Cherenkov Telescope Array (CTA) is a multi-national endeavour to build the next generation observatory for very high energy astronomy.
CTA will be split across two sites (at Armazones, Chile in the Southern hemisphere, and La Palma, Canary Islands in the Northern hemisphere), abbreviated as CTA-S and CTA-N. At each site, there will be an array of telescopes, of up to three different sizes; Large, Medium and Small Sized Telescopes (LST, MST, SST) with Small telescopes deployed at the Southern site only. The planned telescope array layout for CTA-N can be found at AD 1.
At each CTA site, in addition to telescopes, there are a number of central buildings and facilities needed for the operation of the array, as well as auxiliary devices, all of which have corresponding connectivity needs.

This document serves to summarise the CTA requirements that are specific to the On-Site Network Infrastructure, proposed to be delivered for the Detailed design of the first phase of CTA-N.
The first phase of CTA-N, that is also called Short Project, includes the Infrastructure necessary for 3 additional LSTs (as there is already one under construction), 1 MST, and some instruments needed for calibration and weather monitoring called Array Common Elements (ACE). The infrastructure for all these elements includes civil works, power system, and network cabling.
The Array Common Elements for the Short project include the following list (pending approval):

- 3 Weather Stations
- Fram
- Raman Lidar
- Ceilometer
- Illuminator

The On-Site Network Infrastructure is composed of the network cabling topology, the connections between the telescopes and the data centre, and the IP Address structure. The main parts of the cabling are the network array topology, the data centre topology and the office topology.

The on-site network infrastructure is described with detail in AD 3.
It includes the following items:

a. Cabling topology (physical layer of the cabling)
b. Connections between telescopes (and other elements in the Array) to the Datacentre
c. IP Address structure

a. **Cabling topology**

Includes the following elements:

i. **Network Array topology**: includes the cable paths from the data centre to the telescopes, and also to the other elements in the Array such as ACE and Building;

and the appropriate interface connection plugs like the LC duplex patch panels in the interface cabinets and the data centre.

ii. **Datacentre and Control room topology**: includes the network wiring in the computer room and the network connections to the control room.

iii. **Office topology**: includes all connections from the data centre to the offices and meeting rooms.

From the item a. Cabling Topology, **only the Network Array Topology is described in this document**.

The Datacentre and Control room topology, and the Office topology are not described in this document. The first one will be part of the Datacentre requirements document, and the second one will be part of the Technical Building requirements document.

b. Connections between telescopes to the Datacentre

Includes the description of the functionality of the fibers between the Datacentre and the telescopes, as each pair of fibers has already a defined and mostly agreed functionality. This item is described with detail in AD 3.

c. IP Address Structure

Is part of the Computing requirements document.

a.i. Cabling Topology – Network Array Topology

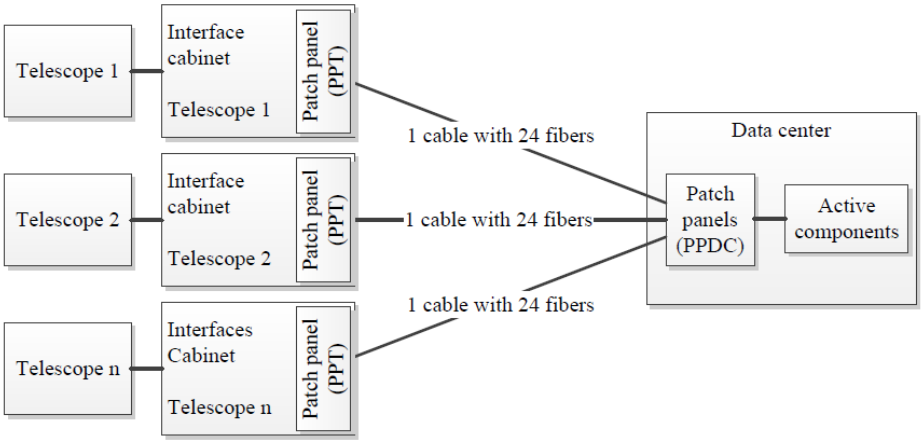

Figure 3.1.1-1 Cable paths between the On-Site Datacentre and the connection point at the telescope location for CTA North

A preliminary layout with the cable topology for the Short Project, can be found at AD2; which is also represented in Appendix 1 of this document.
For the Short Project, the Datacentre will be located in a Container as shown in the diagram. The Datacentre to be used has been installed as part of the LST-1 Prototype project. The data

cabling from the telescopes and instruments will be laid towards the Data Centre in the container via cable ducts as shown in AD2 and Appendix 1.
In the next expansion stage the telescope array will be completed and the Operation Building will be installed (Expansion 2). In this stage the Datacentre will be moved to its final position in the Operation Building.
The Expansion stage 2 array layout can be seen in Figure 3.1.1-2, which also shows the final layout for the cabling. As it can be seen the network cabling that is laid for the Short Project towards the Datacentre, will be laid from this point to the Technical Building, together with the additional cabling from the new telescopes and instruments that will be part of Expansion 2.
It must be noted that the drawings are referential and the final coordinates for the telescopes and civil works may have small changes. The same applies to the Instruments such as Weather stations, FRAM, Lidar, Ceilometers, which final positions, and whether they are part or not of the Short Project has not yet been confirmed.

Appendix 1 and Figure 3.1.1-2 layouts are proposals that will need to be authorized by the local authorities during the detailed design of each phase of the project (Short Project and Expansion 2).

Appendix 1 includes a road named “Alternative road and bridge over barranco” that has changed position to the south-west of LST-2.

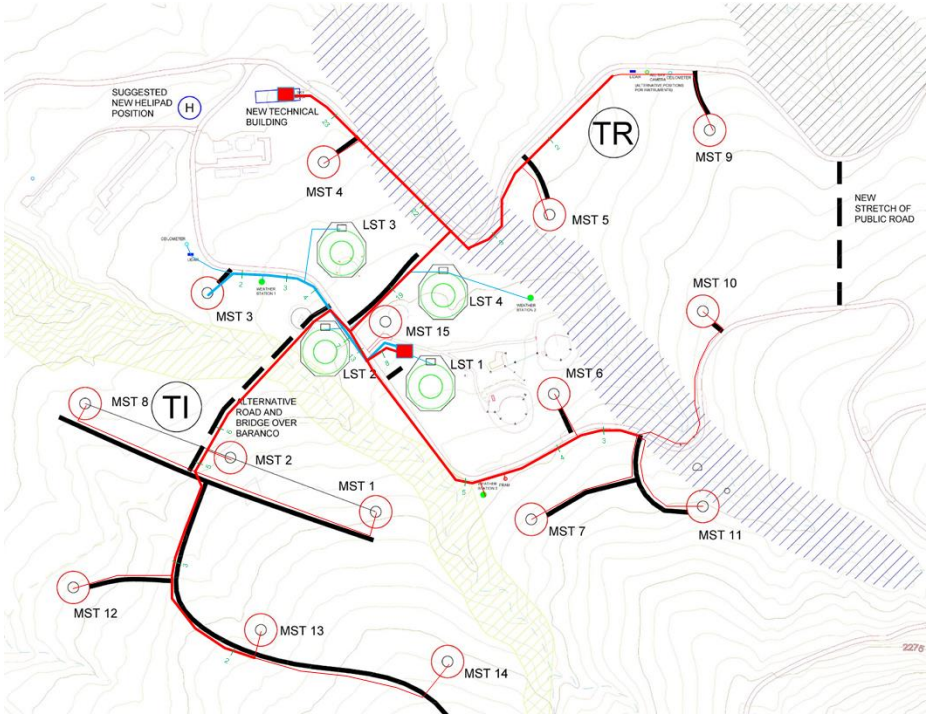

Figure 3.1.1-2 Network Array Topology for final layout (Expansion 2) (Alternative road over barranco to be changed) to be updated

3.1.2 Interface Definition

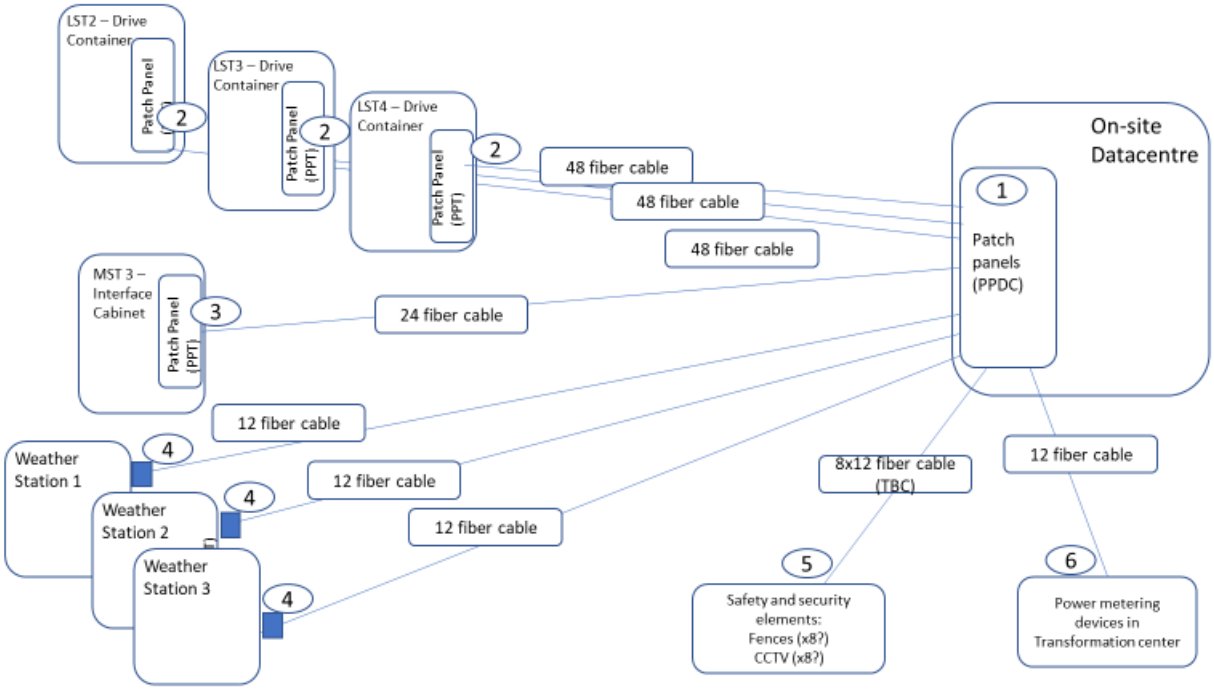

Figure 3.1.2-1 Diagram with the Interfaces for the Network Array Topology

3.1.2.1 Interfaces for the Cabling topology – Physical Characteristics

3.1.2.1.1 Network Array topology

Figure 3.1.2-1 shows the interconnection between the Fiber optic cables and the following elements:

1. To the Datacentre: The interface is a Patch panel in the Datacentre (PPDC). The PPDCs will consist of 24 LC duplex ports and each one will be able to serve the connections of one telescope, which means 48 optical fibres, in case of LST and two telescopes in case of MST. And also additional PPDC need to be considered for the ACEs.
2. To the LST telescopes: The interface to each telescope is the patch panel at each telescope (PPT) location (at the drive container for LSTs). One PPT will be needed per LST's drive container, and this PPT will have 24 LC duplex ports, for handling the 48 fibres going to each telescope.
3. To the MST telescope: The interface to each telescope is the patch panel at each telescope (PPT) location (at the Interface cabinet for MST3). One PPT will be needed per MST Interface cabinet, and this PPT will have 12 LC duplex ports, for handling the 24 fibres going to each telescope.
4. To the Array Common Elements (ACE): Interfaces are the transceiver at the fibre end that will be connected by the ACE team to its own equipment (to be specified and agreed with the ACE team)
5. To safety and security equipment at the site: additional optical fibers are foreseen. Access control and CCTV at the fence around each telescope will need communication to a central point (Datacentre?). It is possible to physically connect the safety and security devices at the fence to a switch located at the interface point (Interface

cabinet for MST and drive container for LST).

6. To the Power system: Fiber optic cables will connect the Transformation center to the central point where a Power monitoring system will be hosted (to be defined if will be the datacentre)
7. To Civil Infrastructure: the cables will be laid in ducts inside trenches, both ducts and trenches will be provided by Infrastructure-Civil Sub Work Package. Following the "dig once" concept, duct shall be laid as spares, and ducts for Expansion 2 shall also be laid where needed (according to Figure 3.1.1-2).

3.1.2.1.2 Interfaces for the Datacentre and Control room topology

Interfaces are not described in this document as will be part of the Datacentre Requirement Specifications document.

3.1.2.1.3 Interfaces for the Office topology

Interfaces are not described in this document as will be part of the Technical Building Requirement Specifications document.

3.1.2.2 Interfaces for the Connections between telescopes to the Datacentre (Functional characteristics)

The connections are the Interfaces between the systems identified in the table 3.1.2-1 in the columns "Connection from" and "Connection to".

The "number of lines" in Table 3.1.2-1 represent pairs of fibers for bi-directional transmission (one fibre for transmit and one for receive, for each functionality).

Number of lines			Name of connection	Rate per line (Gbit/s)		Connection	
						From	To
LST	MST	SST		LST & MST	SST		
6	4	2	Camera	10	10	Cherenkov camera	Camera Servers
1	1	1	Critical telescope control & monitoring	10	10	Telescope switch	Central Switch
1	1	1	Clock distribution	1	1	Cherenkov camera	Central Clock Distribution
1	1	1	Safety & Alarm System	1	1	Interface cabinet	Data centre
1	1	1	Interface cabinet switch	10	10	Interface cabinet switch	Central Switch
1	1	1	Additional telescope control & monitoring	10	10	Telescope switch	Central Switch
13	3	5	Spares	10	10	open	open

Table 3.1.2-1 Functional Characteristics of the network array topology interfaces

3.1.3 Major Component List

- Patch Panel at the Datacentre. Patch panels shall be 24 Port LC-Duplex with 1RU and the quality of OS2.
- Patch Panel at each Telescope location (at the Interface Cabinet for the MST and at the Drive Container for the LST). Patch panels shall be 12 Port LC-Duplex with 1RU and the quality of OS2 for MST, and 24 Port LC-Duplex with 1RU and the quality of OS2 for LSTs.

3.1.4 Customer Furnished Property List

Currently the LST team has deployed for the LST-1 Prototype, one Patch panel in the Data-centre. Pending the characteristics of the existing patch panel

3.1.5 Customer-Loaned Property List

Not applicable

3.2 Characteristics

3.2.1 Performance Characteristics

For the performance of the connection fibers between telescopes and Datacentre, Table 3.1.2-1 shows the bandwidth necessary for each connection in the columns “Rate por line in Gbit/s”. For the rest of the items the Physical characteristics are described in the Section 3.2.2.

The following requirements need input from the Safety and security System Engineering, for the definition of specifications for the topology and connections:

B-INFRA-0130 Access Control	All access to the site and to individual buildings must be controlled, with the access control system connected to the Safety and Alarm System.
B-INFRA-0260 Fire Safety	All infrastructure supporting Telescopes and other on-site hardware as well as buildings and access routes on site must be designed and constructed in compliance with the applicable fire safety regulations.

The following requirement for Infra, seems to be part of LST Work Package.

B-INFRA-0735 LST Trigger Cable	Fibre links between all pairs of LSTs must be provided for the purposes of the LST stereo trigger operation, with a maximum length of 200 m.

3.2.2 Physical Characteristics

3.2.2.1 Network Array cabling for telescopes

Regarding fibers, due to the large amount of data exchanged between the telescope and the Datacentre, each LST / MST needs a dedicated fiber optic cable with 48 / 24 fibres and should be spliced in between as less as possible. Each telescope is connected directly, via different patch panels, to the data centre by a fibre cable. For the LST this fibre cable is holding 48 single-mode optical fibres allowing 24 single connections (two fibres are used for one connection in RX/TX mode) of up to 10 Gbit/s. In Case of the MST the fibre cable is holding 24 single-mode optical fibres allowing 12 single connections of up to 10 Gbit/s. All optical fibres used on-site shall be single-mode fibre. Due to the long distances between the telescopes and the data centre, single-mode fibres are required and multi-mode cable cannot be used. Even in case of short distances multimode are not recommended, to avoid confusions between single- and multimode cables and transceivers. It is recommended that only one type of fibre is installed on-site for all telescopes. The type of fibre is defined in the norm ITU-T G.652.D. However, due to the differences between production lines and vendors concerning attenuation and fibre asymmetry, it is highly recommended to have only one production line for each construction phase as this will reduce the number of measurements needed for the calibration of the White Rabbit System.

Regarding the paths, the planned cable routing of the telescope array shall be orientated along existing roads and also roads that are part of the project, as far as possible, as it is now at the Observatorio Roque de los Muchachos.
The empty pipes of the ductwork shall be provided with taut wires during the construction for easy cable pulling later. Cable pits (manholes) must be provided in narrow bends, junctions as well as in straight sections within a suitable distance of 50 meters or less.
Within the existing ORM infrastructure cable pits with pipes of 200 mm diameter are used. If possible, the same diameter and similar cable pits shall be used for the new ductwork.
Near the 400 V substation, a lot of cables will be necessary. Within this narrow area parallel pipes shall be used. In the first pipe all fiber optic cables of the first expansion stage shall be placed. The second and may be third parallel pipe shall be foreseen for the second expansion stage of the telescope array.
In the peripheral zone of the telescope array, where only few cables are necessary, a smaller pipe diameter can be used. It shall be avoided to pull additional cables in a partly filled pipe. All planned cables should be pulled at one time through the empty pipe.
As far as possible the data cables (optic fibres) shall be laid separately from the power cables, maybe in the other shoulder of the road or, if only a few cables are needed, at least in a separate pipe.

In the section towards the future position for the Operation Building to the first bend near the planned position of LST4 the maximum number of data cables is needed. Therefore at least 3 empty pipes for data cabling shall be foreseen.

For the Short Project, a proposal for the number of ducts is included in Appendix 1, that considers the ducts for the cabling for the expansion stage 2.

In expansion stage 2 the Datacentre will be moved to the Operation Building. As the cables should be spliced as less as possible only one splice box shall be used for the extension to the new location. This concept is shown in Figure 3.1.1-2. The cabling used in Stage 1 is shown in blue color. The additional cabling is shown in red color. The cable packages from the south eastern area and from the south western area will be laid until the old location of the datacentre and then, without splicing, together with the extended old cabling in the same trench to the Operation Building. The red numbers along the lines give the figures of parallel cables in each part of the routes. In the trenches which will be used during Stage 1 and Stage 2 the appropriate number of empty pipes shall be laid in Stage 1 (Short Project) to be used in Stage 2.

3.2.2.2 Network Array cabling for the Array Common Elements (ACE):

One Single Mode Fiber Optic cable, between the Patch Panel in the Datacentre and the interconnection point at each ACE location shall be included. The number of fibers per cable is pending to be specified

3.2.2.3 Patch Panels

The PPTs and the PPDCs are the endpoints of the fibres for all the telescopes and instruments as shown in Figure 3.1.1-1. The PPDCs will consist of 24 LC duplex ports and will be able to serve the connections of one telescope, which means 48 optical fibres.

One patch panel will be at the telescope interconnection point, and will have 24 LC duplex ports for handling the 48 fibres going to each telescope for the LSTs and 24 fibres for the MSTs.

3.2.2.4 Ethernet switch at the Interface cabinet for MST3.

The Ethernet switch will be used to connect the following devices at the Interface cabinet: Access Point (AP) for Wireless LAN (WLAN), and metering devices for power devices at the Interface cabinet. This switch can also be used to connect the safety and security elements at the fence of each telescope.
The switch will be directly connected to the PPT. It will have 24 1Gbit-Ports in RJ45 and one 10Gbit single-mode uplink.
For the LSTs, the position of the switch needs to be defined.

3.2.2.5 Access Point for wireless LAN, at the Interface cabinet for MST3.

For LST position to be defined.

3.2.2.6 Connections between Telescopes and Datacentre

This item has the physical characteristics explained for the Network Array cabling for telescopes.

3.2.2.7 Fibers between LST for stereo trigger operation

pending requirements for specification

3.2.2.8 Fibers between the fence around each telescope and the Datacentre.

pending requirements for specification, part of Short Project?

3.2.3 Reliability

3.2.3.1 Functional Lifetime

B-INFRA-0995 Network Cabling Lifetime	The lifetime of the network cabling hardware must be at least 15 years.

The network cabling hardware shall function for a period of at least 15 years, starting at the end of commissioning under the conditions specified in Sections 3.2.5 and 3.2.6

3.2.3.2 Reliability

The reliability requirements for the CTA Instrument are expressed in terms of MTBF TBD

For Availability, the following Requirement must be complied.

B-INFRA-0770 Network Connection Availability	The Network links must operate with an availability of more than 98% to each Telescope during Observations and to each Controllable System during Operation.

For Adaptability and future upgrades, the following Requirement must be complied

B-INFRA-0700 On-site ICT Infrastructure Adaptability	The on-site ICT infrastructure must provide extra capacity beyond that needed by the baseline design. The ICT infrastructure must be flexible, adaptable and upgradable, with the possibility for additional instrumentation to be included and for adaptation to new technology.

3.2.3.3 Failure Definitions

The following functional mishaps are considered as failure in the sense of MTBF*: TBD*

3.2.3.4 Maintainability

Requirements concerning

a) Mean time between maintenance actions
b) Man-hours per specific maintenance action
c) Frequency of preventive maintenance
d) Maintenance complexity (e.g. number of people and skill levels, variety of maintenance equipment) TBD

B-ONSITE-0510 Maintenance Plans	Maintenance planning and procedures for covering access to, and repair / replacement of, any LRU must be provided.
B-ONSITE-0520 Spare Parts	The level of spare parts needed for long-term System maintenance must be documented.
B-ONSITE-0530 Documentation	Systems must be fully documented in terms of operational use and composition/design.

3.2.3.5 Environmental Conditions

The environmental conditions for the site are available in the document AD 3.

3.2.3.6 Transportability

Not applicable

3.3 Design and Construction

3.3.1 Materials, Parts and Processes

For the selection of materials, parts and processes, the localization and the remoteness of the observatory site shall be considered.

For environmental, equipment and occupational safety and health: the European Union (EU) law shall be applied, e.g. RoHS 2 Directive 2011/65/EU

Particular attention shall be paid to the altitude of the observatory sites above 2400 m and the risk of earthquakes.

The following CTAO-wide standardized existing components shall be used: TBD

The following parts and materials shall NOT BE used: the EU Directive RoHS 2 Directive 2011/65/EU is applicable.

Only cables that do not generate toxic gases in case of a fire shall be used.

3.3.2 Electromagnetic Compatibility (EMC)

The CTA system shall meet the requirements defined the European Directive 2004/108/EC and the associated Harmonized Standards, see https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/electromagnetic-compatibility_en

3.3.3 Name Plates and Product Marking

a) The subsystems and auxiliary equipment shall be labeled or engraved with name-plates visible after installation of said subsystems or equipment. The labels shall contain as a minimum the following information:
b) Assembly / component name and sequential number wherever applicable.
c) Manufacturing month and year.
d) Name and /or logo of manufacturer.
e) Labels to guide disassembly or handling, if deemed necessary
f) All dismountable parts, except standard parts like screws or washers, shall be marked or equipped with identification plates. The markings and identification plates shall be visible after installation and shall contain the following information:

   a. Custom manufactured parts, or modified purchased parts:
      i. Part/assembly number which shall include the product code number
      ii. Drawing number including revision
      iii. Manufacturing month and year

   b. Purchased parts:
      i. Name and address of manufacturer
      ii. Part number / Serial number
      iii. Manufacturing month and year

g) All name plates and indication labels shall be permanently marked, made of metal or laminated plastic, and be attached to the 4LGSF by means of screws or rivets.

h) All the cables, connectors and electrical equipment shall be marked following the recommendations: Each PPT should be labeled like LST1-PPT1 or MST4-PPT1 and so on. Ports on the PPTs should be labeled easy with 1 to 12 or 24. LST1-PPT1-11

is the 11th Port on the PPT in the LST1.

Cables should be labeled like:
Source Host / Source Port – Destination Rack/ Destination Host / Destination Port
In case of the Array Topology the recommendation is the following:

Patchpanel x Port X – Patchpanel y Port Y

- ➔ Example:
- ➔ LST1-PPT1-7 – PPTDC1-7
- ➔ MST1-PPT1-8 – PPTDC5-8

The marking requirements of the relevant harmonized standards shall be fulfilled.

3.3.4 Workmanship

Only methods and procedures which are state-of-the-art in high precision mechanics, hydraulics and pneumatics, optical, electrical and electronics engineering, design and fabrication shall be used for the design, construction and test of the CTA Instrument. These methods and procedures shall be appropriate for the applicable extreme environmental conditions and the long life time of the instrument. Preferable are those technologies which have been proven to lead to high reliable equipment for application at remote astronomical observatories at an altitude of >2400m above sea level.

TBD for cables

3.3.5 Interchangeability

The design shall consider interchangeability requirements related to the long lifetime of the instrument. In particular the probable non-availability / -procurability of electronic components over the long instrument lifetime shall be taken into account.

For the cables and patch panels, the use of standards as identified in section 3.2.2 “Characteristics” shall be mandatory.

3.3.6 Safety

All CTA Subsystem shall comply with the European Union (EU) product safety related legislation. The relevant EU Directives and the harmonized European standards are listed at https://ec.europa.eu/growth/single-market/ce-marking/manufacturers_en.

The applicability of various additional EU Directives - and the associated Harmonized Standards - depends on the subsystem design concept.

A Declaration of Conformity as defined in the Directive 2006/42/EC on Machinery and other relevant Directives shall be supplied. TBD for cables

3.3.7 Human Performance, Human Engineering

The requirements of the relevant harmonized standards - see Section 3.3.6 - shall be fulfilled.

3.4 Documentation

3.4.1 General Requirements

All documentation shall comply with applicable DIN or similar standards and with the EC Product Safety Legislation requirements.
All documentation necessary for the operation and maintenance of the On-Site Networking Infrastructure shall additionally be prepared in Spanish.

3.4.2 Instructions and CE Declaration

Not applicable

3.4.3 Operation and Maintenance documentation

In addition to the documentation required by an EU Directive, the following documents shall be supplied:

1. Logbook(DRD TBD)
2. A complete set of as-build construction and verification documents, including all specifications, drawings, ordering instructions, plans, procedures, manuals, hand-books etc. This documentation shall allow long term maintenance and logistic support activities. (delivery form and detailed contents are TBD.

3.5 Maintenance

CTA-North: CTA-O personnel will do the maintenance.

3.5.1 Use of multipurpose test equipment

For maintenance and repair only standard tools available at the observatory shall be used. In case special tools are unavoidable, these tools shall be provided by the equipment supplier.

3.5.2 Parts replacement

Only exchange of Line Replaceable Units (LRUS) is foreseen as in-situ repair method.

3.5.3 Maintenance and Repair Times

Only daytime maintenance and repair shall be foreseen.
For maintenance, spare ducts shall be laid during the installation in case a new fiber needs to be laid. The empty pipes of the ductwork shall be provided with taut wires during the construction for easy cable pulling later. Cable pits (manholes) must be provided in narrow bends, junctions as well as in straight sections within a suitable distance of 50 meters or less.

3.5.4 Definition of Serviceability Limit State

Not applicable

3.5.5 Definition Collapse Prevention Limit

Not applicable

3.5.6 Accessibility

The cabling in the Array shall be accessible through cable pits as described in Section 3.2.2 “Physical Characteristics”, and at the interface points in the patch panels described also in Section 3.2.2.

3.6 Personnel and Training

For CTA-N special operation processes and procedure will be defined by the Detailed designer. In particular if there are special tools and a special training, this needs to be part of the detailed design.

3.7 Major Component Characteristics

For patch panels, the characteristics are the ones defined in Section 3.1.3.

3.8 Precedence

No special precedence requirement has been identified.

4 Product Assurance Provisions

4.1 General

The verification shall follow a systematic verification approach*:*

4.1.1 Conceptual Design Phase

Not applicable

4.1.2 Detailed / Final Design Phase

The detailed design for the On-site Networking Infrastructure shall be subject to design reviews. The successful passing of these reviews is mandatory for the release of the subsequent project phase.

4.1.3 MAIV Phase

Not applicable

4.2 Quality Conformance Verifications

(this section does not consider the QA activities required by the applicable EU product safety directives)

4.2.1 Subsystem Verification Plan

The analyses, tests and inspection requirements necessary to demonstrate that all requirements of Section 3 of the specification have been achieved shall be included in the detailed

design.

4.2.2 Preliminary Acceptance Supplier

Not applicable

4.2.3 Preliminary Acceptance Observatory PAO

Not applicable

4.2.4 Final Acceptance Observatory, FAO

At the end of the guarantee period, CTAO performs an official Final Acceptance at the Observatory FAO.

5 Preparation for Delivery

Not applicable

6 Notes

No notes are included.

7 Appendixes

7.1 Appendix 1 Network Array Topology for the Short Project

In a separate document

7.2 Appendix 2 List of Standards included in IAC-CTAO Hosting Agreement (IAC-CTA Hosting Agreement, 09/09/2016)

Reference to Standards (electrical / mechanical / safety / environmental) required for components to be installed at ORM

• Reglamento Electrotécnico para Baja Tensión e Instrucciones Técnicas Complementarias, aprobado por el R.D. 842/2002 de 2 de agosto de 2002.
• Decreto 141/2009, 10 noviembre, por el que se aprueba el Reglamento por el que se regulan los procedimientos administrativos relativos a la ejecución y puesta en servicio de las instalaciones eléctricas en Canarias.
• R.D. 2267/2004, de 3 de septiembre por el que se aprueba el Reglamento de seguridad contra incendios en los establecimientos industriales.
• Ley 34/2007, de 15 de noviembre, de calidad del aire y protección de la atmósfera.
• R.D. 1627/1997, de 24 de octubre, por el que se establecen disposiciones mínimas de seguridad y salud en las obras de construcción.
• R.D. 614/2001, de 8 de junio, sobre disposiciones mínimas para la protección de la salud y seguridad de los trabajadores frente al riesgo eléctrico.
• Norma UNE-EN 60617: Símbolos gráficos para esquemas.
• Norma UNE 21144-3-2: Cables eléctricos. Cálculo de la intensidad admisible. Parte 3: Secciones sobre condiciones de funcionamiento.
• Sección 2: Optimización económica de las secciones de los cables eléctricos de potencia.
• Norma UNE 12464.I: Norma Europea sobre iluminación para interiores.
• Guía Técnica para la evaluación y prevención de los riesgos relativos a la utilización de lugares de trabajo, que adopta la norma UNE 12464 y ha sido elaborada en virtud de lo dispuesto en el artículo 5 del R.D. 39/1997, de 1 de enero y en la disposición final primera del R.D. 486/1997, de 14 de abril, que desarrollan la Ley 31/1995, de 8 de noviembre, de Prevención de Riesgos Laborales.
• Real Decreto 1215/1997 Disposiciones mínimas de seguridad y salud para la utilización por los trabajadores de los equipos de trabajo.
• Real Decreto 485/1.997, sobre Señalización de Seguridad y Salud en los centros de trabajo.
• Real Decreto 486/1.997, sobre disposiciones mínimas de Seguridad y Salud en los centros de trabajo.
• RAEE (Directiva 2002/96/CE): R.D. 208/2005, de 25 de febrero, sobre aparatos eléctricos y electrónicos y la gestión de sus residuos. Version 22-06-2016 18
• ROHS Directiva 2002/95CE: Restricciones de la utilización de determinadas sustancias peligrosas en aparatos eléctricos y electrónicos.
• R.D. 2135/1980 de 26 de Septiembre sobre liberalización industrial.
• RD 2060/2008, de 12 de diciembre por lo que se aprueba el Reglamento de equipos de presión y sus instrucciones técnicas complementarias modificado por el RD 560/2012, de 7 mayo.
• R.D. 838/2002. Requisitos de eficiencia energética de los balastos de lámparas fluorescentes.
• Real Decreto 1435/1992 de 27 de noviembre que traspuso la Directiva 89/392/CEE relativa a la aproximación de las legislaciones de los estados miembros sobre máquinas, modificada por la Directiva 91/368/CEE del Consejo, 20 junio, y se fijan los requisitos esenciales correspondientes de seguridad y salud. • Real Decreto 1367/2007, de 19 de octubre, por el que se desarrolla la Ley 37/2003, de 17 de noviembre, del Ruido, en lo referente a zonificación acústica, objetivos de calidad y emisiones acústicas.

• ♦REAL DECRETO LEGISLATIVO 2/2008, de 20 de junio, por el que se aprueba el texto refundido de la Ley de suelo.
• Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación. • D.L.1/2000, de 8 de mayo, TR Leyes de Ordenación del Territorio de Canarias y de Espacios Naturales de Canarias.
• Reglamentos de desarrollo de la Ley 1/2000, de/ 8 de mayo, por el que se aprueba el TRLOTCENC.
• Código Técnico de la Edificación (RD 314/2006, de 17 de marzo y RD 1371/2007, de 19 de Octubre) Version 22-06-2016 19

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9. Data cabling concept

Due to the large amount of data exchanged between the telescope and the data center, each telescope needs a dedicated fiber optic cable with 24 fibres and should be spliced in between as less as possible.

9.1 Expansion stage 1

In expansion stage 1 the data center is located near LST1. Figure 3.1.1-2 shows a possibility for the radial connection of the telescopes (blue lines). The auxiliary system like LIDAR, Weather station and ceilometers have an additional FO cable.
The thin lines represent always one cable, the thicker line the parallel route of the cables.
The cables are routed as far as possible along existing or planned roads.

9.2 Expansion stage 2

In expansion stage 2 the data center will be moved to the Operation Building. As the cables should be spliced as less as possible only one splice box shall be used for the extension to the new location.
This concept is shown in Figure 3.1.1-3. The cabling used in Stage 1 is shown in blue color. The additional cabling is shown in red color. The cable packages from the south eastern area and from the south western area will be laid until the old location of the data center and then, without splicing, together with the extended old cabling in the same trench to the Operation Building. The red numbers along the lines give the figures of parallel cables in each part of the routes.
In the trenches which will be used during Stage 1 and Stage 2 the appropriate number of empty pipes shall be laid in Stage 1 to be used in Stage 2.

10. Power and data cable routing

The existing electrical infrastructure of the ORM area, consisting of 20 kV cabling, 400 V cabling and data cabling is laid, as far as possible, along the roads.
The planned cable routing of the new telescope array is also orientated along existing and new roads.
During construction of the new roads to the individual telescope sites, ductwork can be implemented to one or both shoulders of the road. This will avoid extra digging of trenches across the whole area.
The empty pipes of the ductwork shall be provided with taut wires during the construction for easy cable pulling later. Cable pits (manholes) must be provided in narrow bends, junctions as well as in straight sections within a suitable distance of 50 meters or less.
Within the existing ORM infrastructure cable pits as shown in **Annex 3.3** with pipes of 200 mm diameter are used. If possible, the same diameter and similar cable pits shall be used for the new ductwork.
Near the 400 V substations a lot of cables will be necessary. Within this narrow area parallel pipes shall be used. In the first pipe all power cables of the first expansion stage shall be placed. The second and may be third parallel pipe shall be foreseen for the second expansion stage of the telescope array.
In the peripheral zone of the telescope array, where only few cables are necessary, a smaller pipe diameter can be used. It shall be avoided to pull additional cables in a partly filled pipe. All planned cables should be pulled at one time through the empty pipe.

The dimensions of the proposed cables shown in Table 25 shall be considered during the cable routing:

Table 25

As far as possible the data cables (optic fibres) shall be laid separately from the power cables, maybe in the other shoulder of the road or, if only a few cables are needed, at least in a separate pipe.

Special intention has to be paid when laying cables along the main road from the entrance of the Astrophysical Park to the summit of the Roque de los Muchachos. Several high voltage, low voltage and data cables are laid along this road. Between the planned positions of MST3 and MST10 new power and data cables have to be added on this route, mainly near the position of the new Substation 1.

Another critical point is the route along the public road LP-4. Due to higher traffic volume as on the other roads, only one trench on the southern shoulder of the road should be used for data and for power cabling.

In the section from the Operation Building to the first bend near the planned position of LST4 the maximum number of data cables is needed. Therefore at least 3 empty pipes for data cabling and 3 pipes (in Variant 1 and 2) for power cabling shall be foreseen. In Variant 3 one pipe for power cabling is sufficient.

7.4 Appendix 4 (Internal version)

Requirements in Jama for the bandwidth definition between Telescopes and datacentre

B-INFRA-0730 Network Data Link LST	Network links must be provided between each LST Camera and corresponding Camera Server within the on-site Data Centre, allowing data transfer with a speed of at least 48 Gb/s, facilitating the transfer of data at the required event rate.
B-INFRA-0740 Network Data Link MST	Network links must be provided between each MST Camera and corresponding Camera Server within the on-site Data Centre, allowing data transfer with a speed of at least 32 Gb/s, facilitating the transfer of data at the required event rate.
B-INFRA-0750 Network Data Link SST	Network links must be provided between each SST Camera and corresponding Camera Server within the on-site Data Centre, allowing data transfer with a speed of at least 8 Gb/s, facilitating the transfer of data at the required event rate.
B-INFRA-0760 Network Data Link Control room	Network links must be provided between the control room and the relevant monitoring and control Servers within the on-site Data Centre.
B-INFRA-0780 Trigger Information Transfer Latency	The time taken for the network transfer of Trigger Timestamp information between individual Cameras and the OES must not exceed 0.1 seconds in either direction.
B-INFRA-0980 Clock Distribution	Appropriate network infrastructure must be provided for the distribution of the Master Clock to all Cherenkov Cameras and other Controllable Systems requiring precision synchronisation.

B-INFRA-0720 Network Connection	Provision must be made for network connections to all Telescopes and Controllable Systems from the on-site Data Centre for control and monitoring purposes, plus data capture excluding Cherenkov Camera data, with a speed of at least 1 Gb/s and a latency of at most 0.1 seconds.

Requirements in Jama for Interfaces to Telescopes and Common Array Elements

B-INFRA-0060 Telescope Infrastructure Access	There must be a clear physical interface provided at the location of each Telescope to enable access and integration into central infrastructure systems including: communications network; power network and the Safety & Alarm System. Local maintenance work must be supported.
B-INFRA-0080 Controllable System Infrastructure Access	There must be a clear interface provided at the location of each non-Telescope Controllable System to enable integration into central infrastructure systems including: communications network; power network and the Safety & Alarm System. Local maintenance work must be supported.
B-TEL-0510 Interface Cabinet	Telescopes must connect to all of the on-site infrastructure systems using the Interface Cabinet provided as part of the on-site infrastructure.

B-INFRA-0710 Network Cable	Telescopes and other Controllable Systems must be provided with a cable network connection from the on-site Data Centre, which must be protected against damage for the entire cable length (between the System and the on-site Data Centre) without impeding access to the System.