

LST System Engineering and participation to LST South construction.



**UNIVERSITÉ
DE GENÈVE**

FACULTÉ DES SCIENCES

*Domenico della Volpe
CTAO Swiss Day, 13-14 December 2023*



Outlook



- ▶ LST project status
- ▶ SE Team and its activities
 - CDR
 - LST-1 commissioning status
 - ACADA-LST1 integration
 - LST Southern array & Swiss contribution



- ▶ LST project status
- ▶ SE Team and its activities
 - ~~QTR~~ Acceptance
 - LST-1 commissioning status
 - ACADA-LST1 integration
 - LST Southern array & Swiss contribution



Team and activities



▶ Main focus on CDR closure

■ Principal deliverables

- FMEA and reliability analysis with report
- Verification & Validation (Verification Plan and Compliance Matrix)
- Software hazard analysis – not included in the initial CDR closure plan

■ ACADA-LST Integration

■ Following up on Commissioning issues

- Foundations repair
- Emergency system
- Fiber Ropes damages

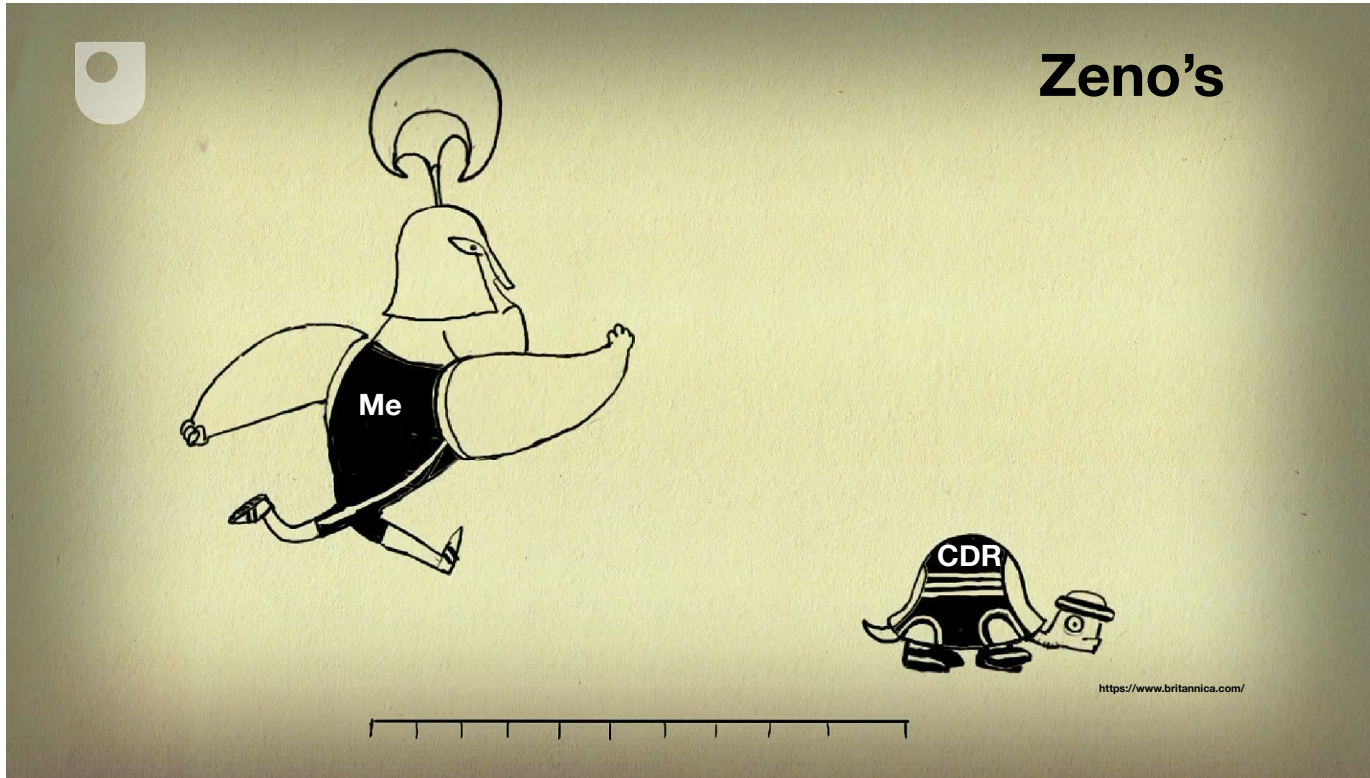
■ CTAO Point of contact for all Technical Issues

- Interface Control Documents - ICD
- Change request
- Request of informations

cta		LST		cta		LST		Ref: EDMS 280813	
LST Compliance Matrix CDR		LST Verification Plan		Version: 0.6		Date: 26.10.2023		Page: 1/2	
Prepared by Magdalena Stodulska		Prepared by Magdalena Stodulska		Checked by		Released by		Version	
Checked by		Checked by		Released by		Released by		0.1	
Released by		Released by		Released by		Released by		0.2	
Version		Date		Version		Date		0.3	
0.1		09.12.2022		0.4		21.12.2022		0.5	
0.2		21.12.2022		0.6		07.07.2023		0.6	
0.3		25.05.2023		Version		Date		0.1	
0.4		07.07.2023		0.1		09.12.2022		0.2	
Safety Hazard Analysis for LST control software		Version n: 2		09/10/2023		Version		0.1	
Hazard List (at Phase A review)		Problem Hazard Analysis		Hazard Analysis		Version		0.2	
Nr.		Hazard List (at Phase A review)		Problem Hazard Analysis		Hazard Analysis		0.3	
		Hazard origin		S P R R		Relevant Provision		0.4	
		Hazard origin		S P R R		Relevant Provision		0.5	
		Hazard origin		S P R R		Relevant Provision		0.6	
S-1-1		Due to data corruption, and/or a loss at time of preparing the setup parameters (coordinates, time, ...) by TC2, an Scheduling block is prohibited with coordinates that point to the field motor during night-time, putting the servopilot camera (photo) modules at risk of damage.		H N V E		0		The hardware limitation on maximum rotations per minute (RPM) is not exceeded. In case of high speed a recent accident in which the camera...	
S-1-2		Due to a security breach (non-authorized access), TC2 is unable to control cameras to use during day-time, putting the equipment at risk of damage.		H N V E		0		It is assumed that cybersecurity network TC2 has high security which on a day time. A modification of the software to control the feature. Also, the hardware limitation on maximum rotations per minute (RPM) is not exceeded. In case of high speed a recent accident in which the camera...	
S-1-2a		Due to a security breach (non-authorized access), TC2 is unable to control cameras to use during night-time, putting the equipment at risk of damage.		H N V E		0		Safety measures as for S-1-1. In addition, the drive system is protected by a software measure to prevent...	

cta		CTA		Ref: EDMS 2754819	
LST Reliability Analysis		LST Reliability Analysis		Version: 1.1	
Author		Institution		Date: 17/02/2023	
Magdalena Stodulska		UNIGE		Page: 1/148	
Enrico Giro		INFN		To be approved by	
		D. della Volpe		UNIGE	
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Carlos Diaz		CIEMAT		Koji Noda	
Armand Fiasson		LAPP		Takayuki Saito	
Satoshi Fukami		ICRR		Holger Wetteskind	
		ICRR		MPI	
List of Abbreviations					
2.		Failure rate		PMH	
AMC		Active Mirror Control		Per Million Hours	
CAT		Camera Access Tower		POE	
CCA		Common Cause Analysis		Power over Ethernet	
CDM		Camera Displacement Monitoring		PSF	
CSS		Camera Support Structure		Point Spread Function	
CTA		Cherenkov Telescope Array		RAM	
DoF		Degree of Freedom		Reliability, Availability, Maintainability	
DEM		Finite Element Method		RPN	
FMEA		Failure Mode and Effects Analysis		Risk Priority Number	
FLCM		First Level Corrective Maintenance		SPF	
FR		Failure Rate		Single Point Failure	
ICD		Interface Control Document		TAT	
LRU(s)		Line Replaceable Unit(s)		Turn Around Time	
LST		Large Sized Telescope for CTA			
LUT		Look up tables			
MAIT		Manufacturing, Assembly, Integration, Test			
MDT		Mean Down Time			
MTBF		Mean Time Between Failure			
MTTR		Mean Time To Replace			
OARL		Optical Axis Reference Laser			

CDR Status - Before CTAO GM in Berlin



CDR Status - After CTAO GM in Berlin



A perfect
Xmas gift



Towards acceptance

DRAFT



'Technical acceptance'
IS NOT the Handover to CTAO

1) Def: bri lator
2) OARL off when opening inter l

Pre-Requisite to start technical Acceptance:

- CDR closure
- * Finishing Commissioning
- * List of Open Items/ Works → CIDL (config item data list)
- Hardware Configuration (Version/PA document)
- Software Configuration
- * List of NCR 1 FTE
- Updated/Valid Hazard Analysis
- TESTING PROCEDURES (FOR LEVEL B) using LST shw
- VERIFICATION PLAN (incl. ICA's)
- Safety Inspection Procedure
- MAINTENANCE:
 - MANUALS → TRR
 - TOOLING
- TA:
 - Workmanship Inspection
 - Safety Inspection
 - Execute TEST PROCEDURES (selective)
- DATA DLO ✓
- CLOCK
- MONITORING ✓
- POWER
- NETWORK ✓
- ACADA ✓

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11-11
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- A. Donini
- A. Paredes
- D. della Volpe
- D. Mazin
- S. Stanghellini
- M. Will

- ▶ Brainstorming in CC with CTAO on Acceptance
- ▶ Draft the list of pre-requisite and documentation to go to Technical acceptance
- ▶ A dedicated discussion will happen Q1-2024
- ▶ Finalise the list
- ▶ Define a plan



Towards acceptance

DRAFT



'Technical acceptance'
IS NOT the Handover to CTAO

1) Def: bri lator
2) CARL off when opening inter l

Pre-Requisite to start technical Acceptance:

Def: bri lator

Not a pre-requite.... I hope!

- List of NCR
- Updated/Valid Hazard Analysis
- TESTING PROCEDURES (FOR LEVEL B) using LST shw
- VERIFICATION PLAN (INC. ICA's)
- Safety Inspection Procedure
- DATA DLO ✓
- CLOCK
- MONITORING ✓
- POWER
- NETWORK ✓
- ACADA ✓

MAINTENANCE:

- MANUALS
- TOOLING

TRR

TA:

- Workmanship Inspection
- Safety Inspection
- Execute TEST PROCEDURES (selective)

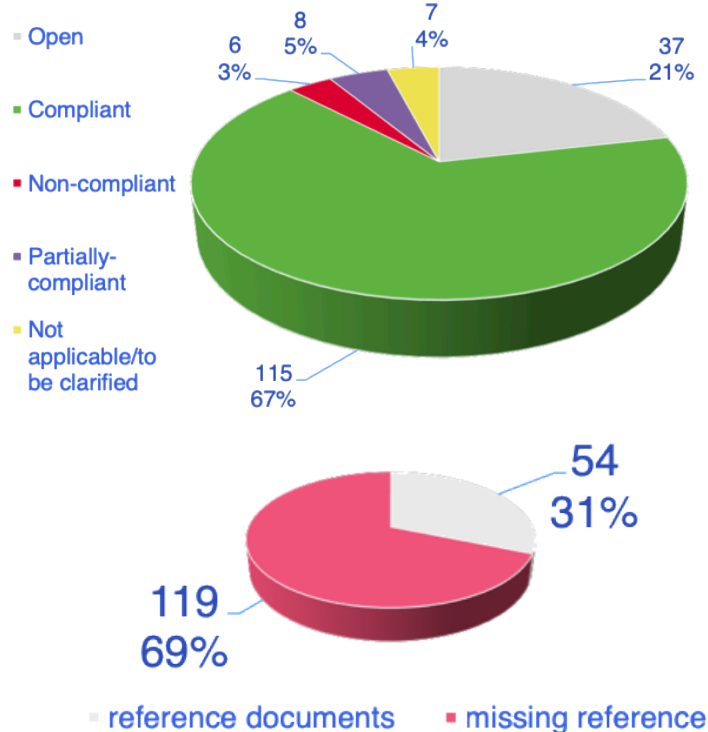
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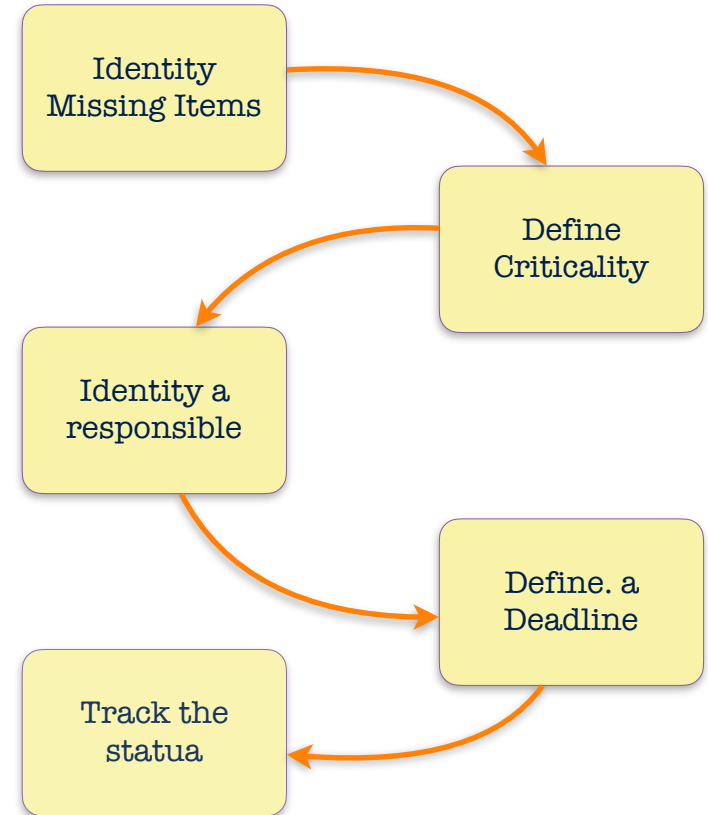


LST compliance status @CDR



- ▶ A long work for CDR but also for next steps
- ▶ Compliance status here is for CDR only
 - Many Open or Partially compliant would now be compliant
- ▶ Yet a lot of work
 - missing documentation,
 - sparse information,
 - not properly organised (tagged)
- ▶ A very useful work to assess the level of commissioning
 - See the [Verification Session at LST GM](#)

- ▶ Missing items list defined to smooth the process
 - A bit less than 100 entries
 - About 10% related to the identified missing person-power
 - Mixture of:
 - Issues occurring during the operation (fine-tuning, pending corrective maintenance)
 - Development of missing items for acceptance & requirements compliance
 - 10 tasks already closed, 10 showing good progress
- ▶ A living document, updated when needed





Building the LST array

- ▶ LST1 Commissioning & Operations
- ▶ LST2-4 Construction & Commissioning
- ▶ Towards Acceptance

A huge burden on a small group of persons (~20).

Help needed to bring this process to completion

LST introduced Tasks (~100)

LST-SE 3 tasks assigned

▶ LST-SE a main actor in this process

■ Regular biweekly meeting with Computing management

- Define plans & action items
- Coordinate with LST group
- Report on progress and sort issues

▶ Test preparation & early test

- Test procedures defined in advance in Redmine
- Off-site tests using software emulators
- Remote on-site tests to check the interfaces and their logic before the final integration test (due to missing fully developed emulators for all LST sub-systems)

▶ Integration tests

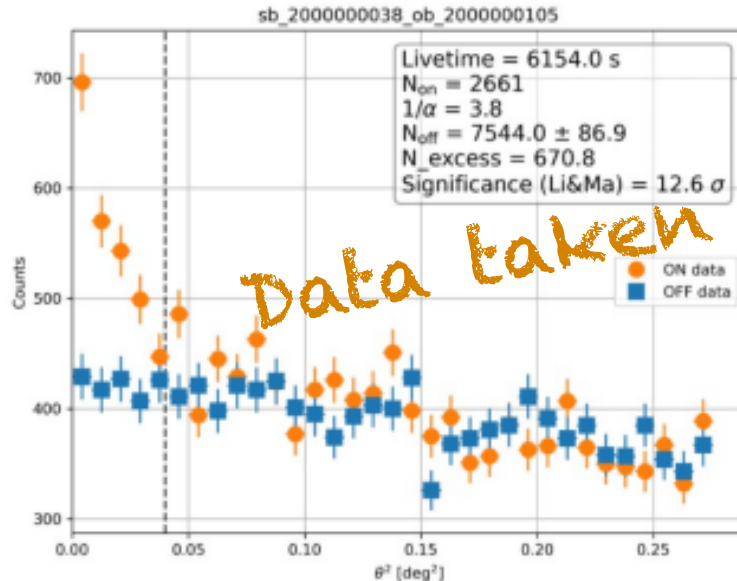
- Two on-site test campaigns – 2 weeks with ~1-week break in between for possible bug fixing
- 1st campaign 28th September to October 3rd, 2023, ~28 people involved
- 2nd campaign 13th to 17th October, 2023, ~24 people involved



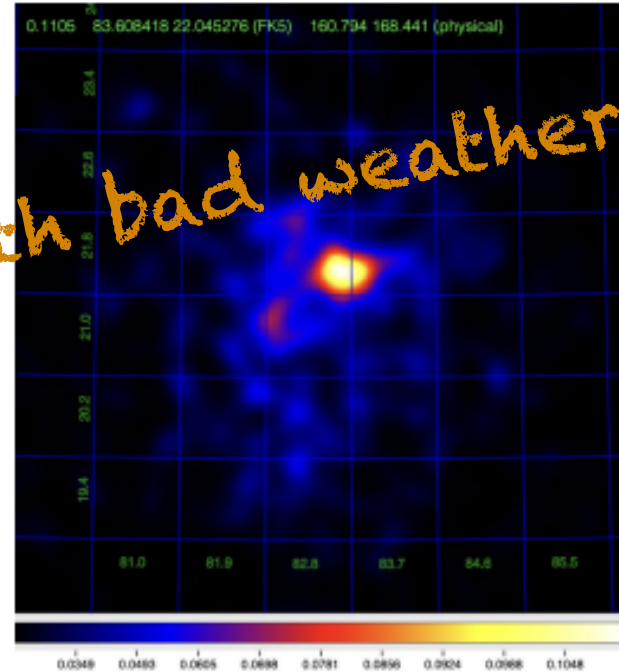


ACADA-LST Integration

During tests, a clear detection of a gamma-ray signal from the direction of the Crab Nebula was obtained in the ACADA online Science Alert Generation analysis



Data taken with bad weather



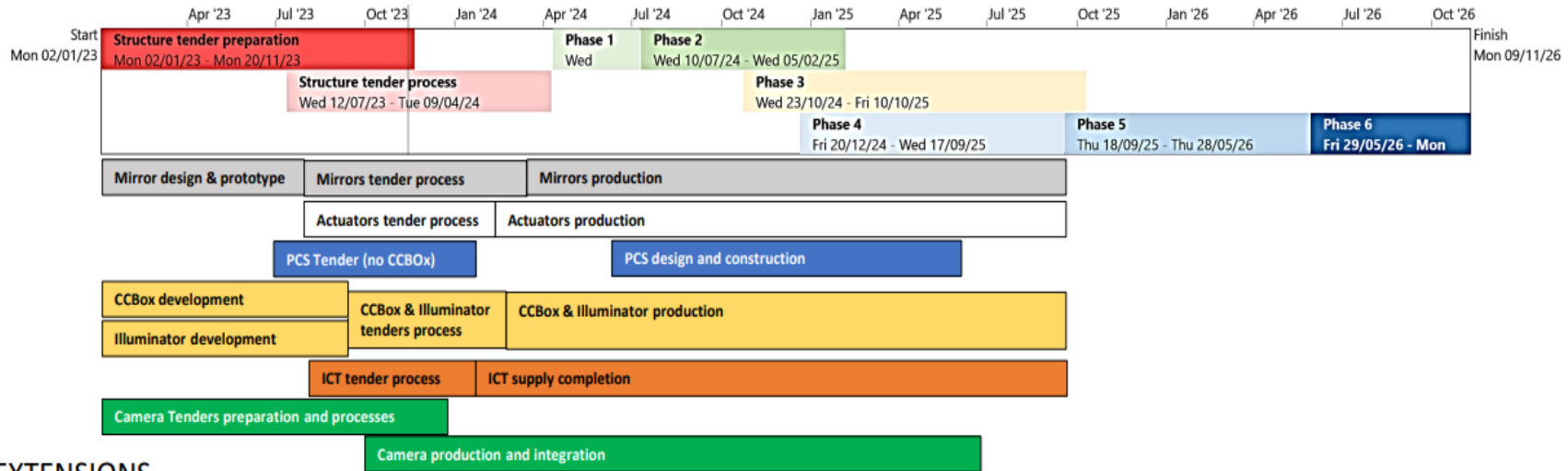


LST Southern array



Overall schedule

A. Busatta LSR GM 13-17 November 2023



EXTENSIONS

- 6 months seems already feasible (end of 2025)
- Further 12 months (end of 2026) are not defined yet, but still not impossible



- ▶ Structure tender published on 22.11.2023, deadline for application 22.12.2023 [link](#)
- ▶ Mirror tender published on 29.11.2023, deadline for application 08.01.2024 [link](#)
- ▶ Actuators' tender is under finalisation. Publication foreseen within week 50.
 - ▶ License Agreements between DESY and INAF for use under license of their design, shareable with UNIGE
 - ▶ Agreement between UNIGE and INAF for the recognition of the In-Kind



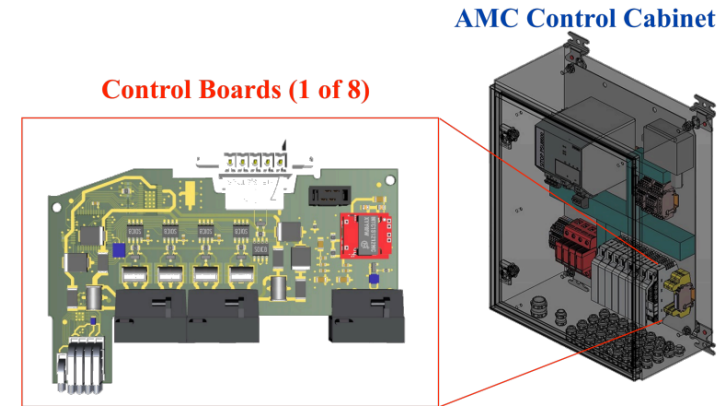
Contribution to AMC

- ▶ Initially the idea was to contribute with the actuators, but the cost increase didn't allow us
- ▶ We decided to go for the new AMC boxes and Fix points only
- ▶ It will involve more companies
 - Diener for Mirror Fix points production
 - AMC box assembly - Control Automation Company
 - Control electronics for RS485 control of actuators (Electronics production company)



AMC Box

- ▶ For LST South, it was decided to go for wired actuators based on DESY design of electronics.
- ▶ Their control electronics is designed by DESY as well
- ▶ Money available in Switzerland since January
 - Agreement with INAF to formalize the recognition of this money as IKC (as requested by SERI) for South in preparation
- ▶ Consultations with UNIGE legal service is on going, we will submit a new version to INAF next week.





Swiss contribution to LST Project



Time Frame 2024-2028

- ▶ We have also submitted a proposal for the next funding period for LST south
 - ▶ Two energy storage system for ~ 1.2 MCHF + 1 FTE
- ▶ But much more
 - SE manpower (Magda!)
 - Advanced camera
 - ACADA
 - DATA Center
 - DPPS
- ▶ Decision should arrive in 2024
- ▶ IKC recognition to be better understood with CTAO

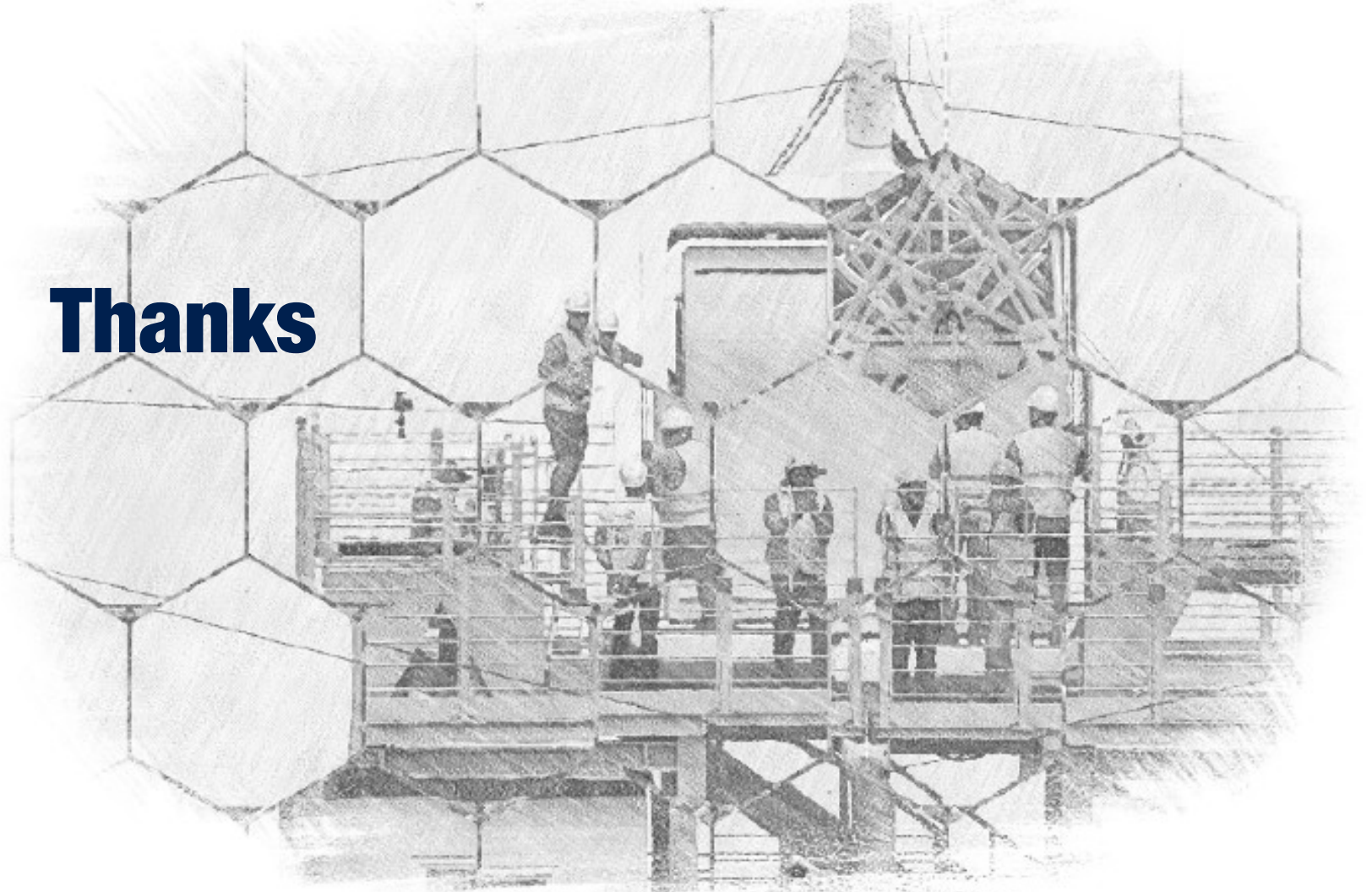
LST related



Conclusion

- CDR closed – a big milestone achieved but...
- a new activity starts: Acceptance
 - More challenging task than CDR
 - Lacking man-power
 - Many the activities going in parallel
 - LST1 commissioning
 - LST1 operation & maintenance
 - LST2-4 construction
 - LST South

Thanks





Fiber Inspection by Future Fibres

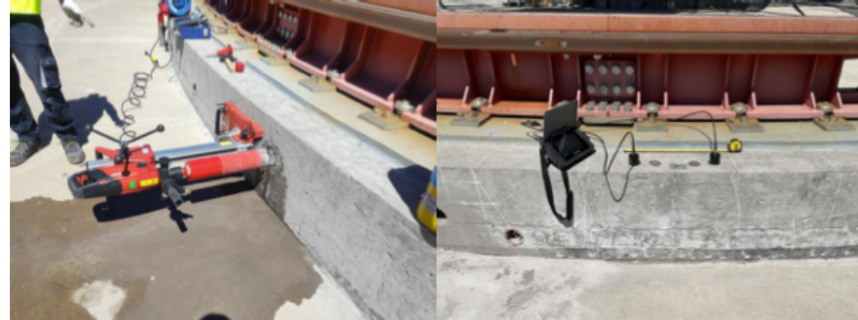
- ▶ Visit on August 2023 by FF with visual inspection - report delivered on October 2023
- ▶ Findings
 - Some twisting of the ropes during installation
 - Some turnbuckle locking wires broken
- ▶ Analysis
 - No clear cause for the breakage,
 - Excluded icefall
 - Some delamination see exclude overloading
 - In cable specs, no requirement for high solar concentration
 - Water penetration between fibres to be taken in consideration, even if
 - Some delimitation seems not to favour it,
 - Fibres have enough length to absorb this small local





Foundation repair

- ▶ Trigger by the CTAO report from visit on
- ▶ September 2021
- ▶ Grout removal for inspection ~ 12 k€
- ▶ ISQ inspection and analysis of cracks ~ 20k€
 - No structural damage, no corrosion but needs repairing
- ▶ Repair finally started ~ 90k€
 - One company (MRES) performs the crack repair
 - A different one (APPLUS) QC/QA of the repair working
- ▶ In 1 year another inspection
 - If everything fine, cover with grout



ISQ inspection July 2022



Repairing November 2023

- ▶ Emergency parking system allowing parking of the telescope in case the drive system is not operational being installed.
- ▶ 3 components:
 - Fixed cabinet to switch from drive control to alternative power source
 - Mobile cabinet to host control electronics to move telescope
 - External generator to provide power
- ▶ Fixed cabinet installed and tested 5 weeks ago
- ▶ Mobile one still not provided
- ▶ =>Generator to be purchased (specs to be provided)

A. Fiasson LSR GM 13-17 November 2023

