ELT Status

Roberto Tamai
ELT Programme Manager

ELT Roofing Ceremony
16th April 2025

Programme

Time	Item	Location
10:00	Registration Welcome coffee	Registration Desk Eridanus Foyer
10:30	Welcome note	Auditorium Eridanus
11:00	ELT status incl. contractors' presentation	Auditorium Eridanus
13:00	Q & A	Auditorium Eridanus
13:30	Lunch buffet	Eridanus Foyer
14:00	Networking, poster session	Eridanus Foyer
15:00	Group photo	In the garden outside the building
15:30	Connection to the ELT site	Auditorium Eridanus
16:00	Closing note	Auditorium Eridanus
16:30	Adjourn	

ESO’s Mission

We design, build, and operate advanced ground-based observatories

We foster international collaboration for astronomy

ESO’s Vision

To **advance humanity’s understanding of the Universe** by working with and for the astronomy community, providing it with **world-leading facilities**

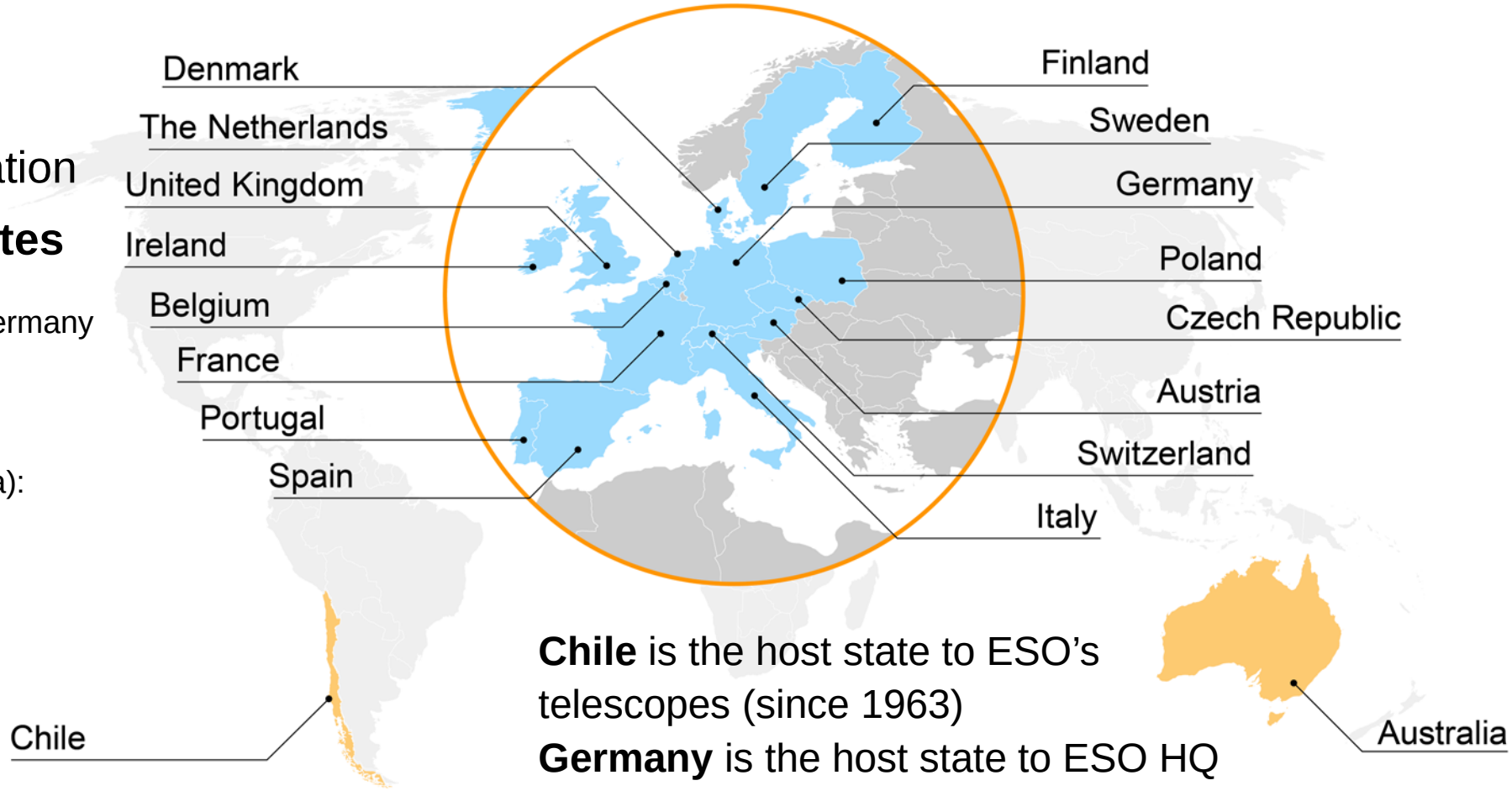
Credit: ESO/G. Beccari

Member States and Partners

Intergovernmental Organisation (1962) with **16 Member States**

750 staff of 30 nationalities: 450 in Germany and 300 in Chile

Yearly income
(from Member States and Australia):
228 MEUR (in 2024)
In proportion to GDP



Chile is the host state to ESO's telescopes (since 1963)
Germany is the host state to ESO HQ
Australia is a strategic partner (2017-2027)

ESO telescope portfolio

Paranal

VLT
VLTI

VISTA

CTA
South*

Chajnantor

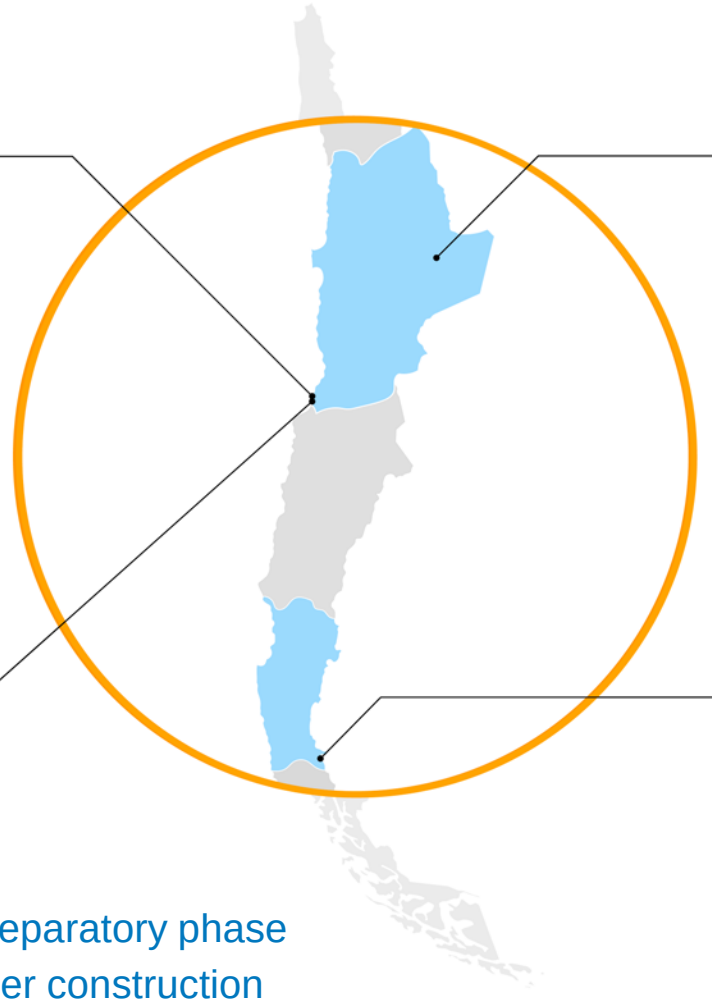
ALMA

Armazones

ELT**

La Silla

ESO 3,6m and NTT

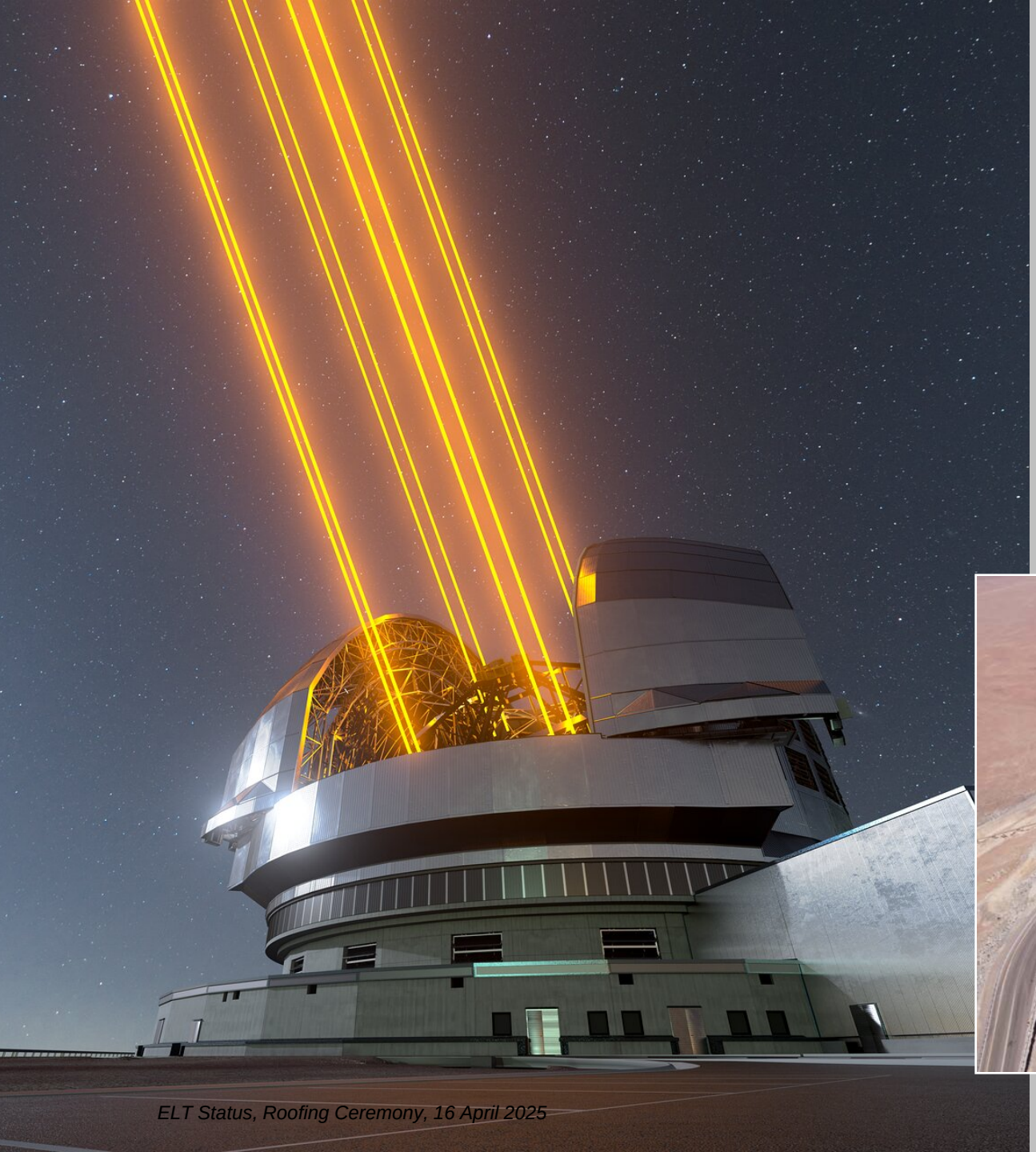


* In preparatory phase
** under construction

The ELT

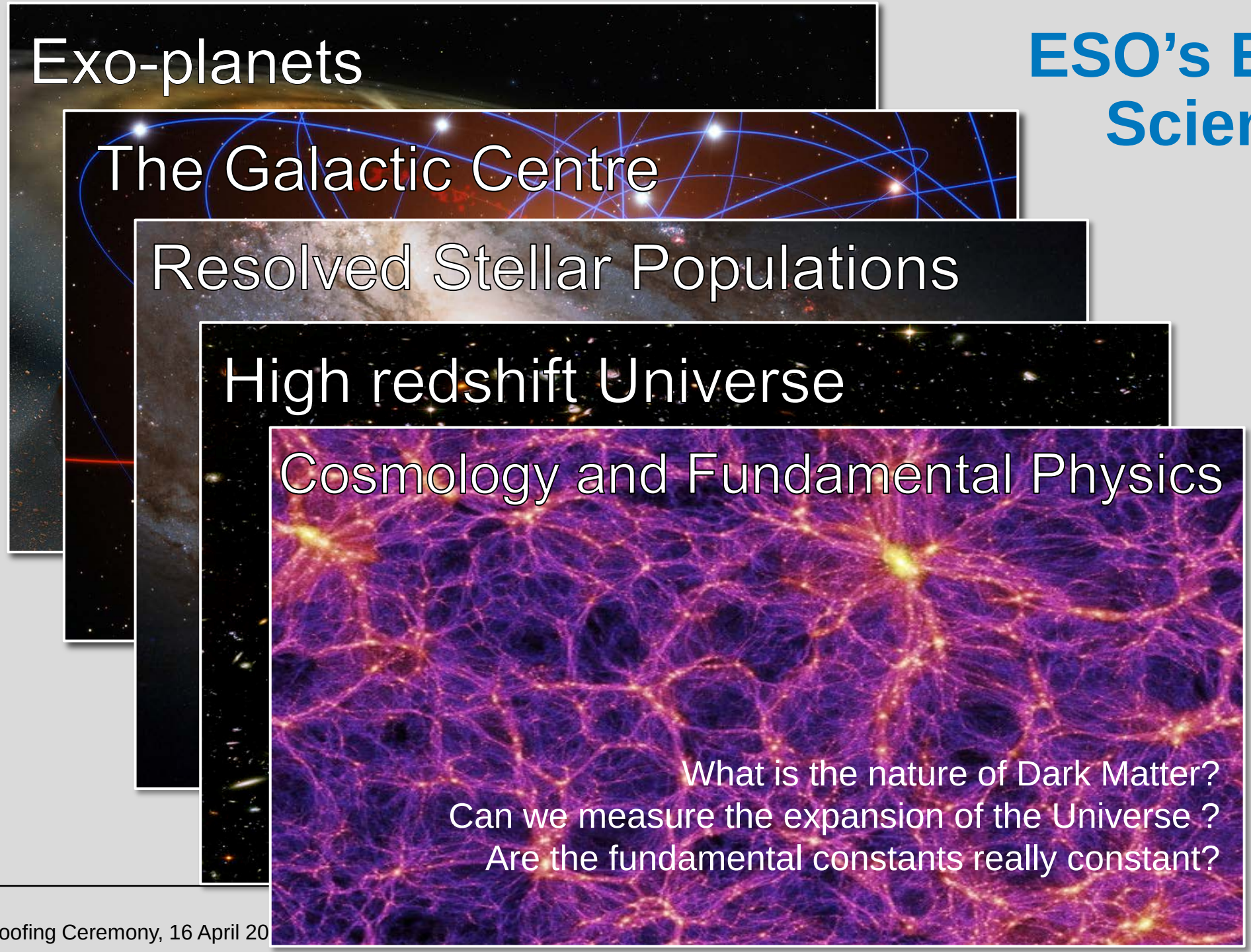
Will be the **largest optical/infrared telescope** ever built or planned

The most powerful telescope of the new generation, the only one with secured funding, and the most advanced in its construction

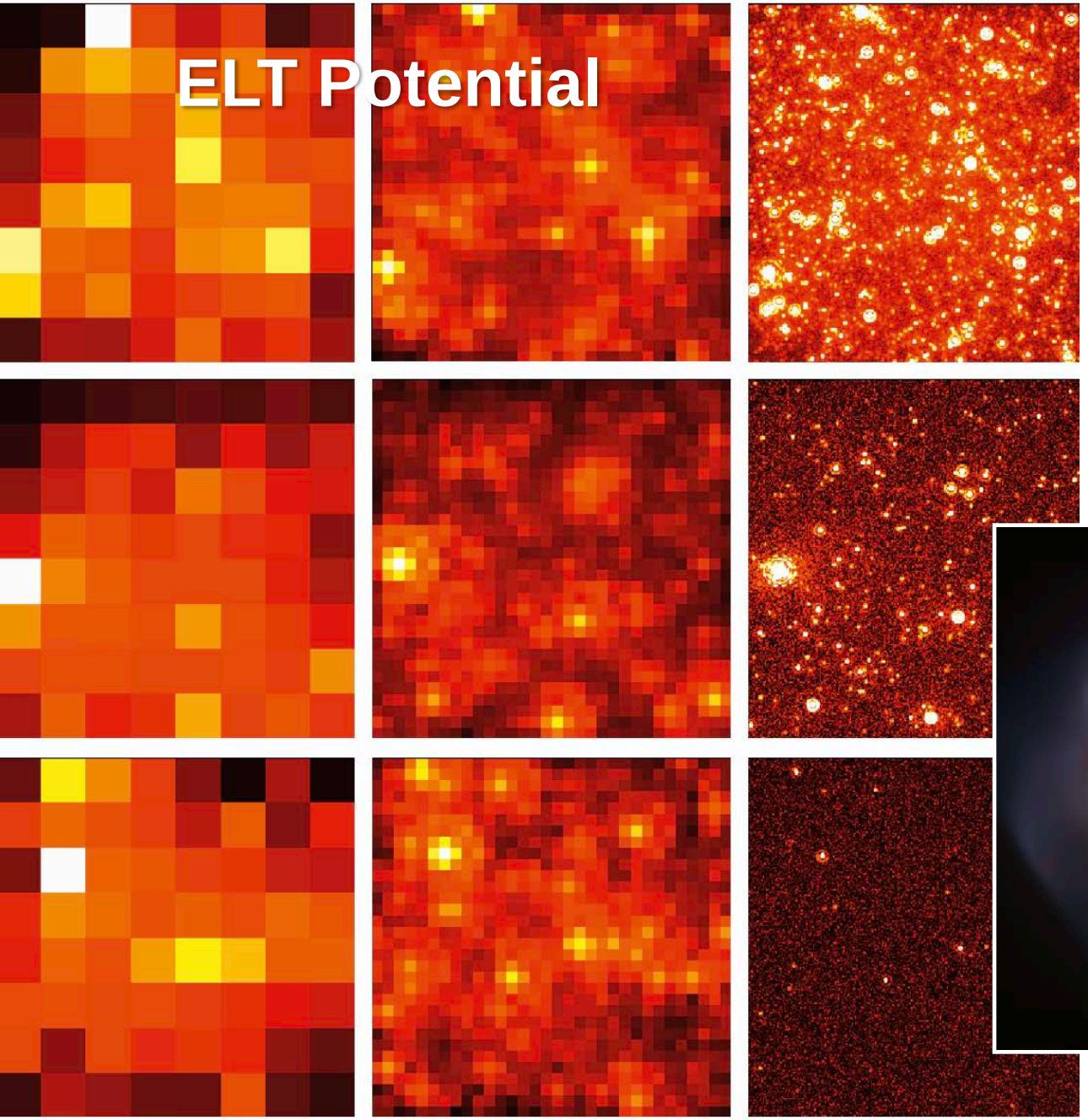


ELT Status, Roofing Ceremony, 16 April 2025

ESO's ELT Science



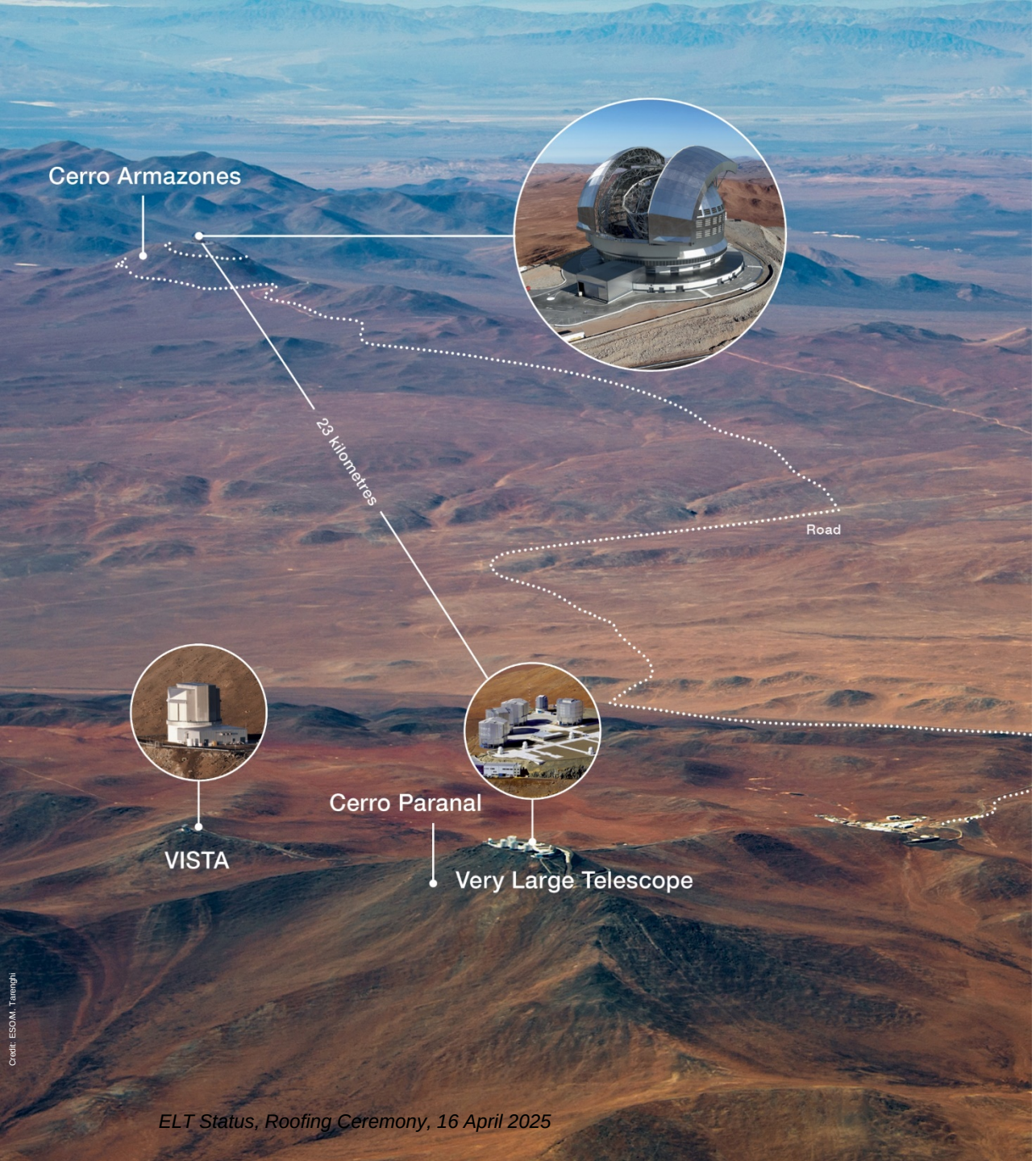
ELT Potential



20x more light gathering ability than a VLT Unit Telescope; 100 million more than the human eye

15x sharper than Hubble (HST)

6x sharper than JWST



ELT Status, Roofing Ceremony, 16 April 2025

The ELT

Is being built on Cerro Armazones in the Chilean Atacama Desert, at 3046 metres altitude and just 23 kilometres from the site of ESO's Very Large Telescope (VLT) at Paranal

Construction 2014-2030 (~**1500 MEUR)**

First scientific light by the end of 2030

How extremely large is the ELT?

120 m

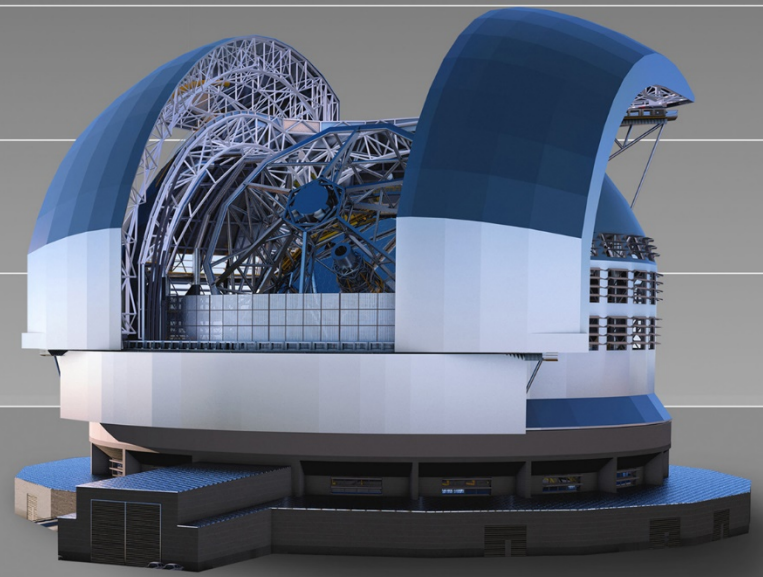
100 m

80 m

60 m

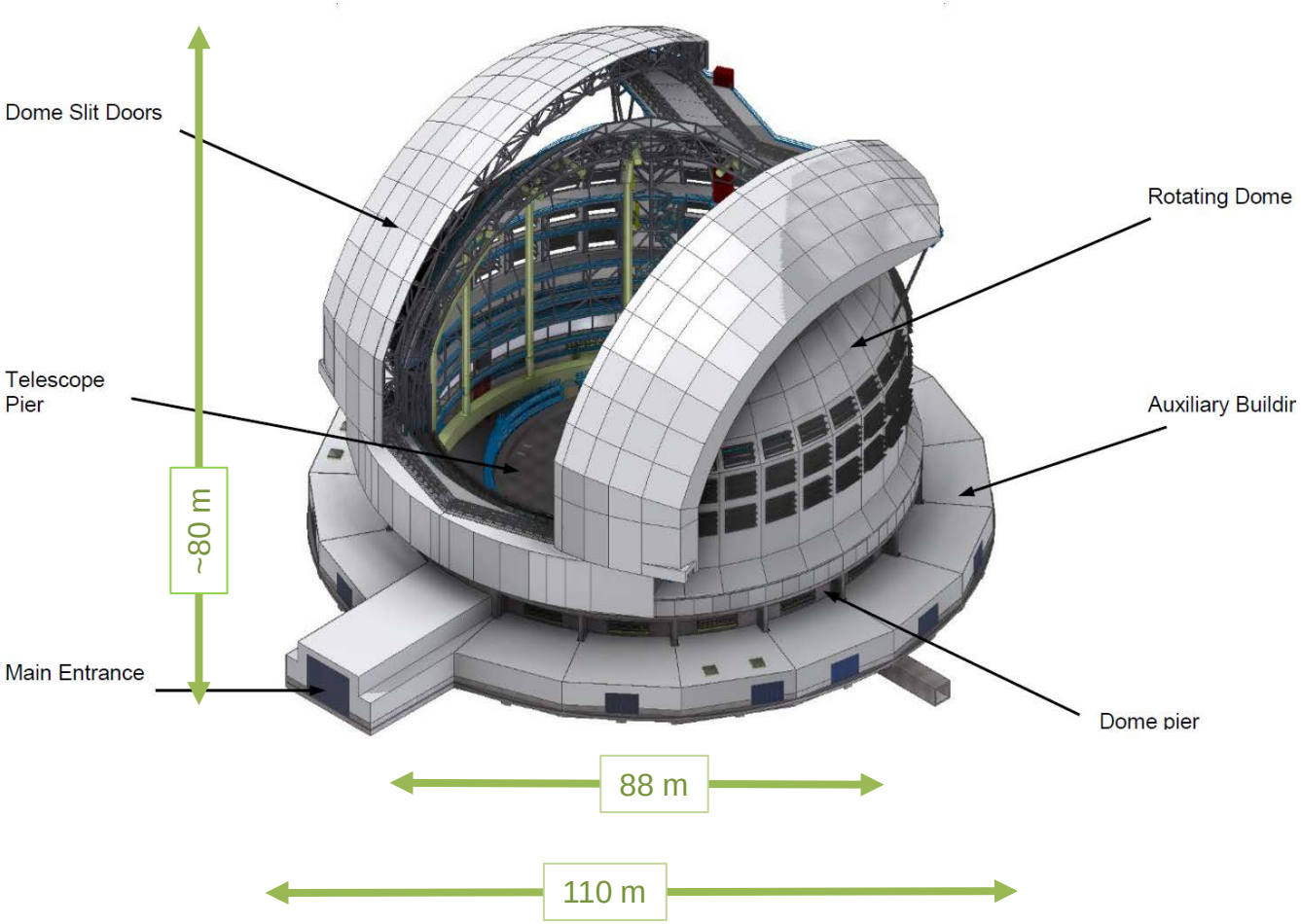
40 m

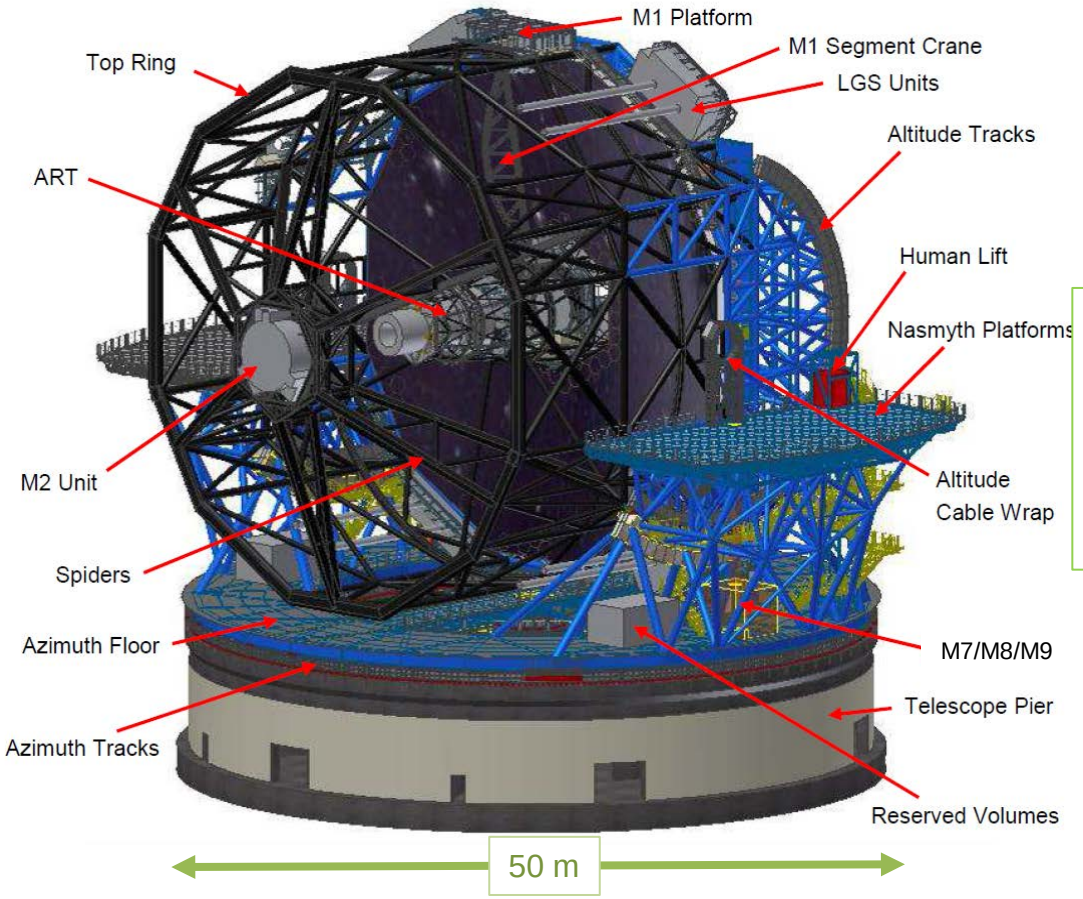
20 m



Credit: ESO/L. Calçada

Dome & Main Structure (DMS)

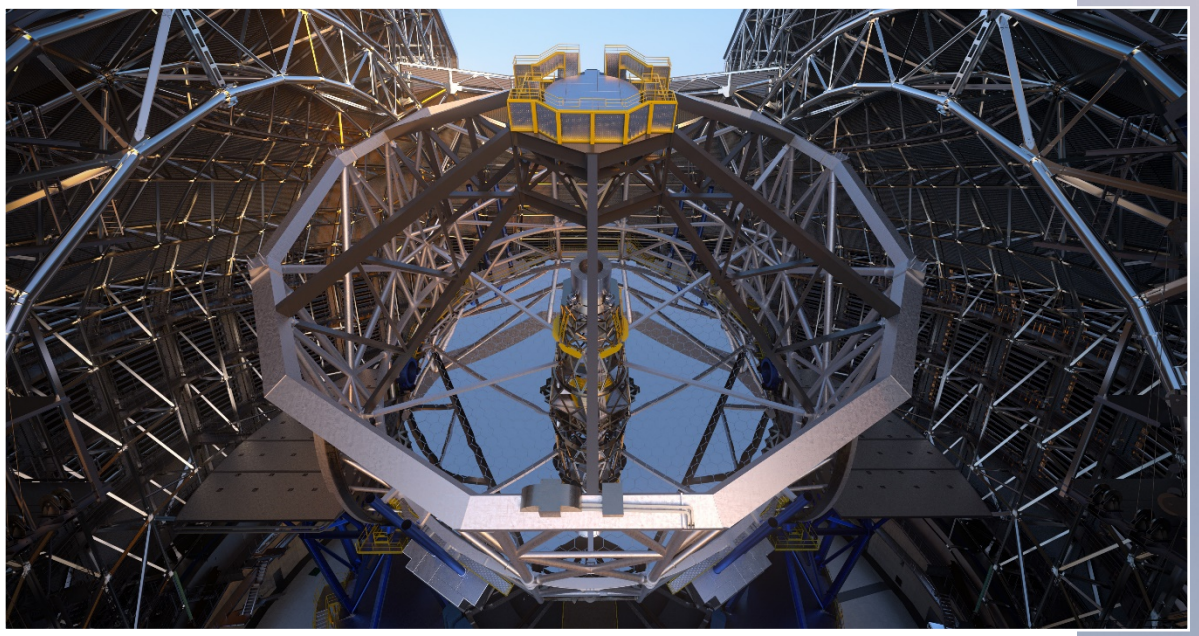




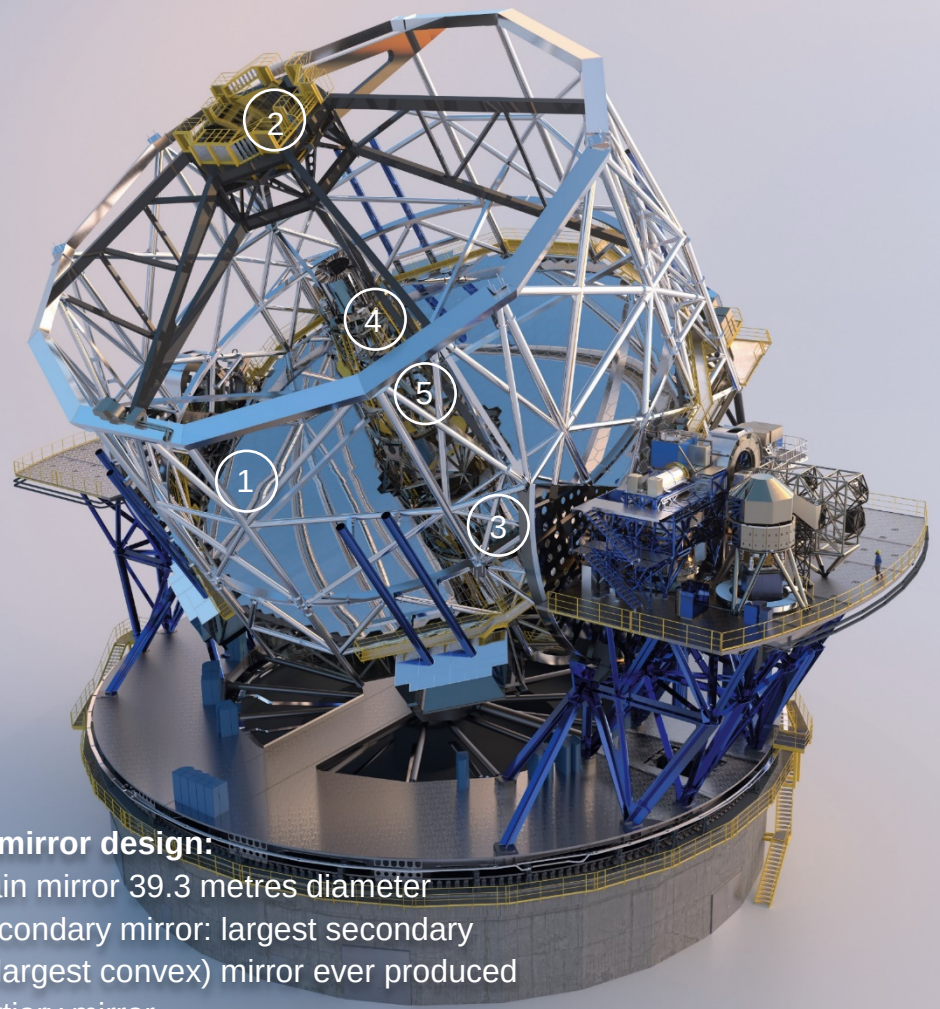
The ELT

Has a 39m segmented primary mirror, M1, made of 798 hexagonal segments (+extras)

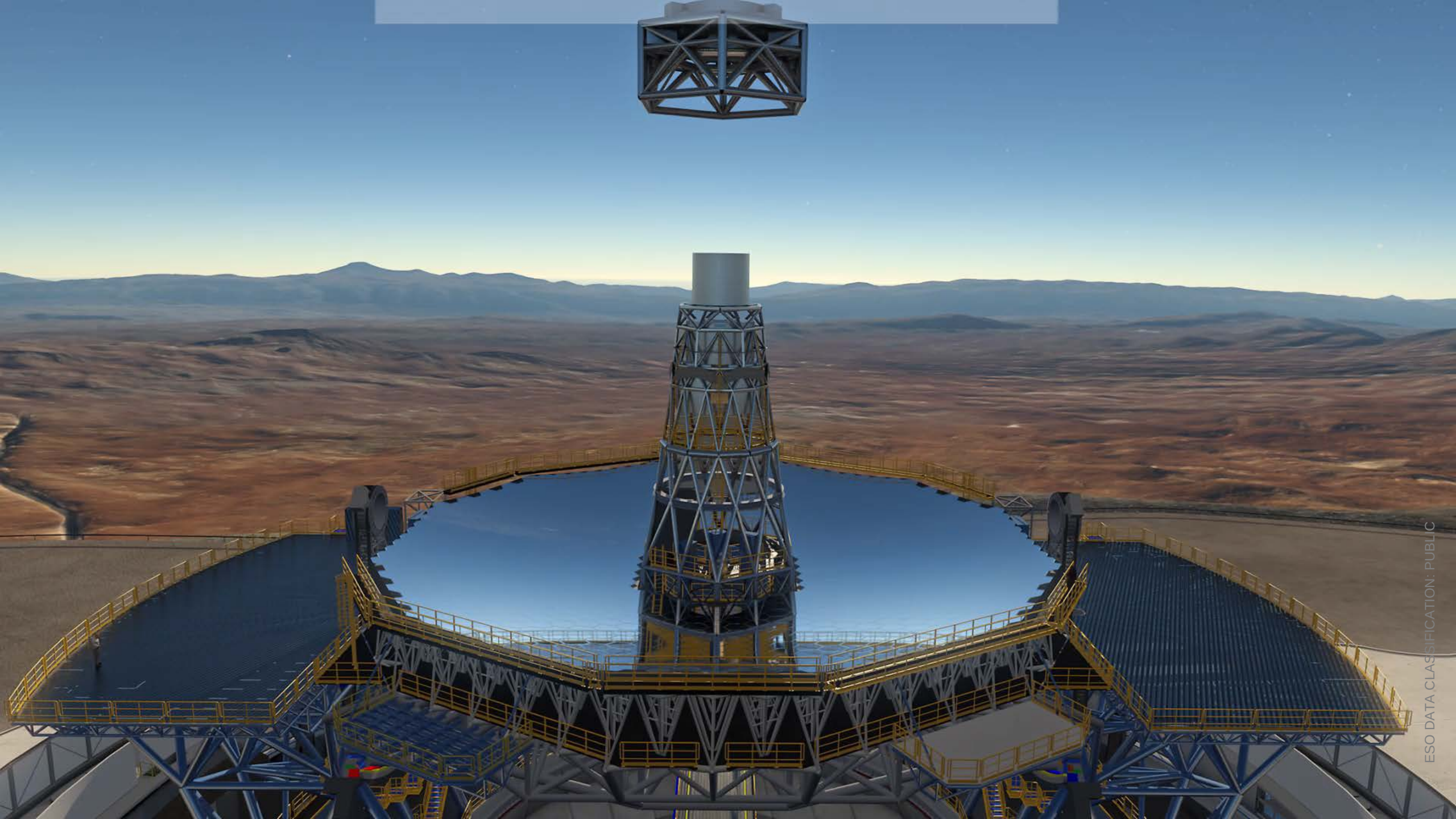
Five-mirror design with adaptive optics, to correct for effects of turbulence in Earth's atmosphere

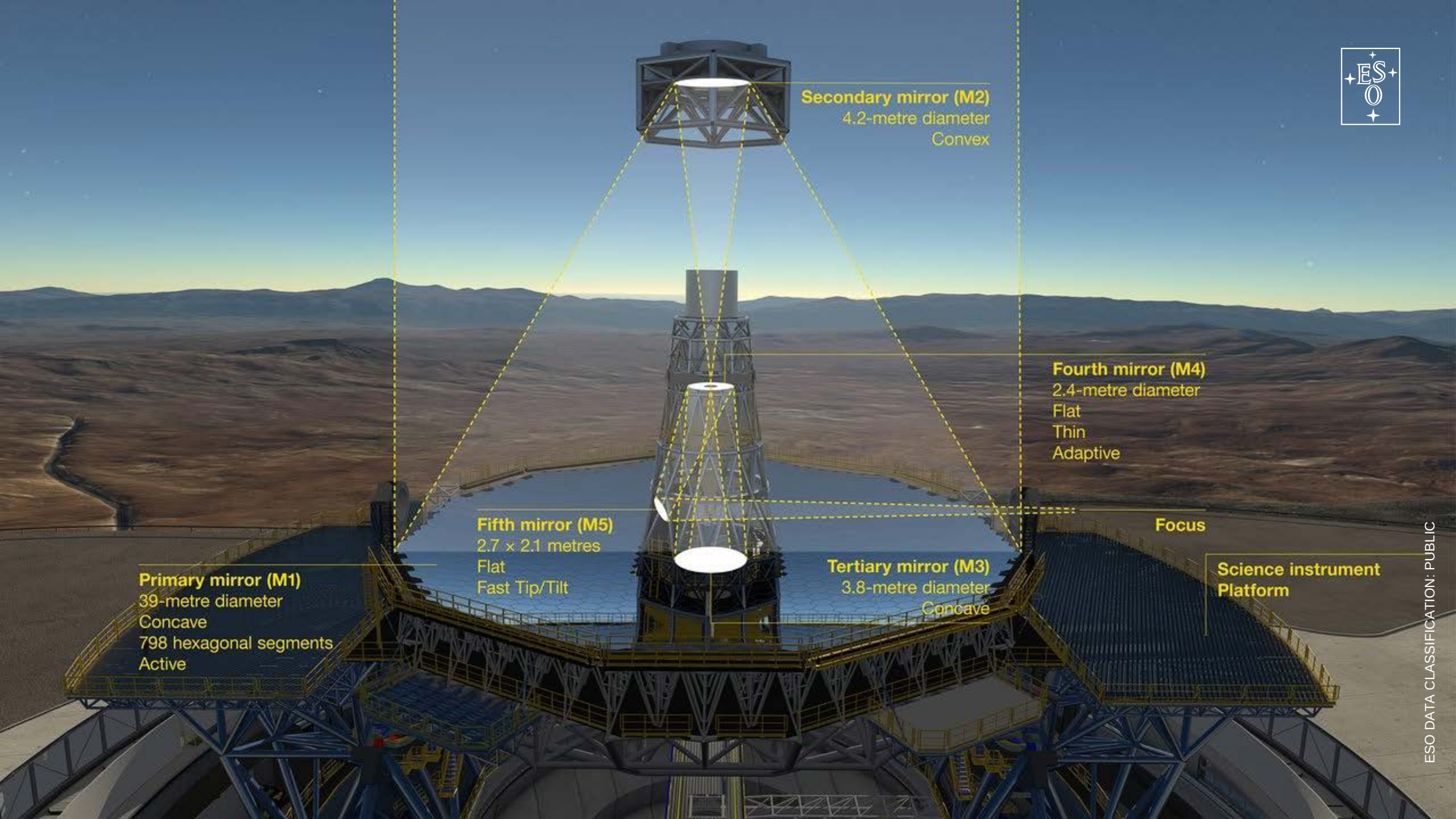


ELT Status, Roofing Ceremony, 16 April 2025



Five-mirror design:
1. Main mirror 39.3 metres diameter
2. Secondary mirror: largest secondary (and largest convex) mirror ever produced
3. Tertiary mirror
4. Adaptive fourth mirror
5. Rapid tip-tilt fifth mirror





ESO and its Partners

ESO and the Industry

Quotes from ESO Director General Blog post 2017 (https://www.eso.org/public/blog/eso-collaboration-with-industry/)

- **Astronomy is a driving force for humanity …**
- **It's an inherently innovative discipline, using some of the most advanced technologies and sophisticated techniques available to scientists and engineers**
- **Creating infrastructures of this size and complexity requires a massive collaborative effort between scientists, engineers and industry partners across the world.**
- **In total, over 330 M€ were spent in the ESO Member States for the construction of the VLT […] 150 M€ contract for ALMA antennas, […] 400 M€ contract for ELT DMS**
  - The latter was the largest contract ever awarded by ESO and also in ground-based astronomy
- **Over the last 10 years, ESO has spent 1.3 billion euros on industry contracts, with two-thirds of that value spent directly in ESO Member States**

ESO and the Scientific Institutes

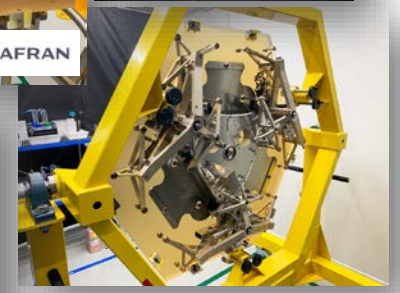
- **ESO cooperates with scientific institutes** for projects with direct **scientific scope** (e.g. instruments)
- **Manpower cost** is covered by the scientific institute (or consortium of institutes)
  - Compensated by nights of **Guaranteed Time Observations** (GTO)
- **Hardware cost** is usually reimbursed by ESO or shared with the institute/consortium
- **Selection process** includes typically:
  - Request for ideas
  - Call for proposals
- Institutes selected **within the Member States** (only exceptionally outside)

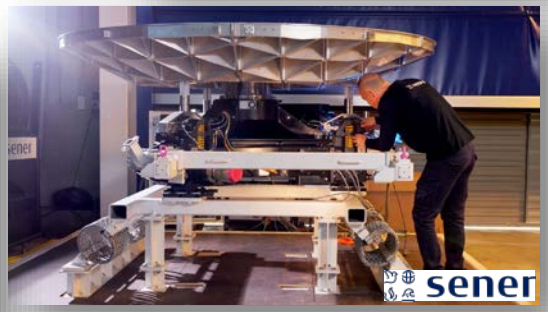
Overall Status

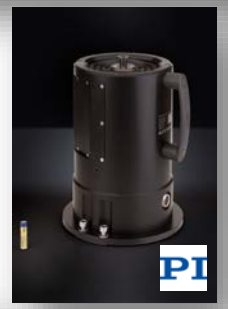
ELT Overall Status

Overall ELT **construction progress beyond 60%**

- Basic **Infrastructure** completed (Road & Platform, ETF, electricity supply, …)
- Dome and Main Structure **erection on site** progressing fast
- Several items already **accepted/delivered:**
  - First 180 M1 Segment Assemblies (polished segments)
    - All Blanks, Supports, Position Actuators, Edge Sensors
  - M5 Cell
  - Supporting Equipment
    - M1 Coating Plants (2x)
    - Power Substation
  - Photovoltaic Plant
  - Detectors, Laser Sources and Projectors, etc.

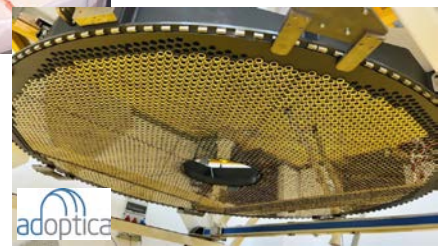


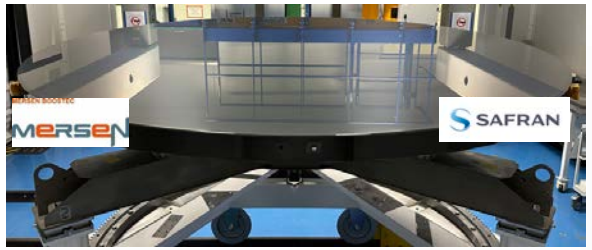


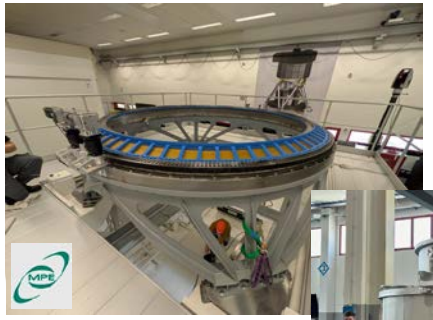


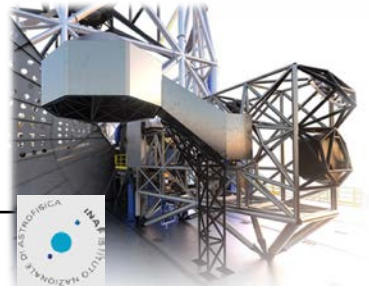
ELT Overall Status

- Most items in **manufacturing/assembly/test phase**
  - M2 mirror and Cell
  - M3, M4, M5 units
  - Pre-Focal Stations
  - MICADO & METIS instruments
  - Control System, coating plants, handling equipment, AIV tools, power conditioning system, etc.
- Only 4 items still in **design phase**
  - 2 recently signed contracts
    - LN2 Infrastructure, M5 commissioning mirror
  - 2 of the 4 science instruments
    - MORFEO and HARMONI









ELT Overall Status

… and many **consulting service contracts** running throughout the years:

- PA/QA Consultancy Services
- Independent SW Verification Consultancy Services
- Consultancy Support for DMS follow-up (Civil, Specialties, inspections, etc.)
- Construction All Risk Insurance
- Freight Forwarding Services
- Control SW Outsourcing Contract
- Dataflow Software Components for ELT
- Chilean Electricity Consultancy Services

ELT Overall Status

The overall ELT **System Assembly, Integration and Verification (AIV)** is under ESO responsibility.

- Experience from La Silla, Paranal, ALMA and other ESO projects
- Its preparation is well advanced (Workflows/procedures, Tools and handling equipment, configuration processes, Team management structure, System Engineering and Safety organization, etc.)
- Its core activities have started with the coating of M1 Segments

Large Contracts Status

95-100%

50-95%

<50%

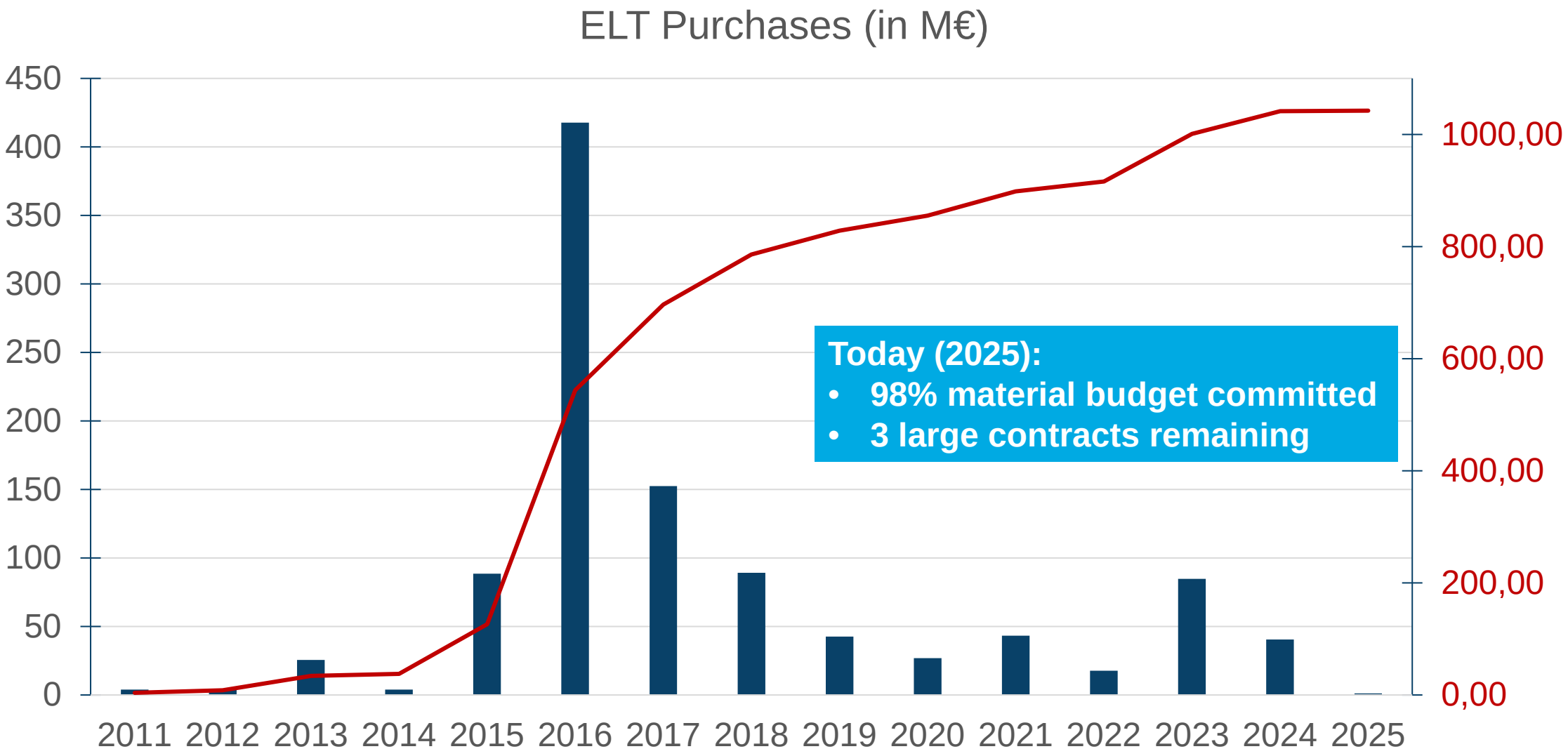
April '25

Closed or under warranty

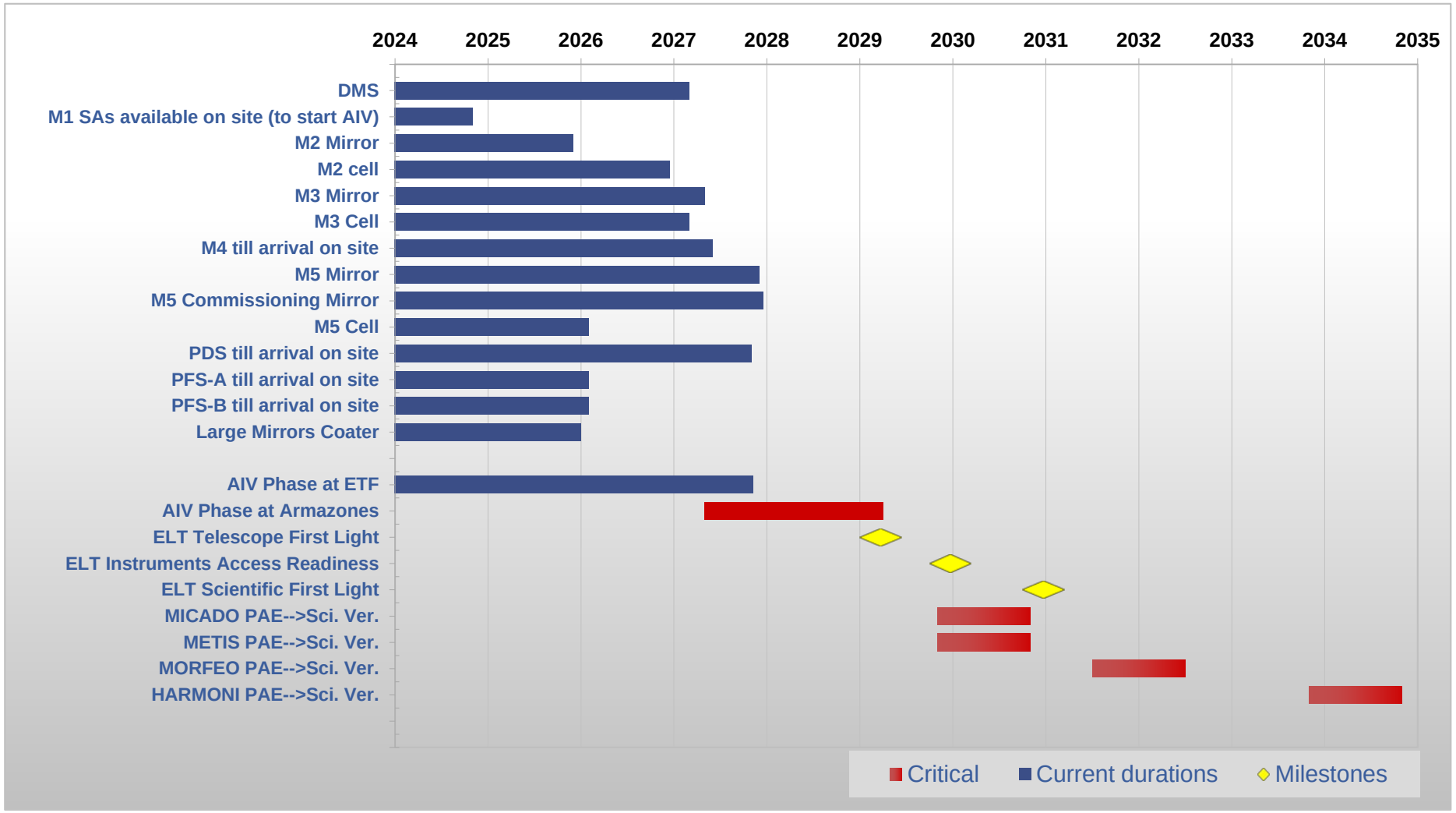
- Design : only 2 instruments and 2 recently started contracts still in design phase
- Manufacturing: majority very close to completion (>80%)
- Integration: about 1/3rd completed

Description of Work	Start	Contractor	Status	Design	Manuf.	Integr.
PA Consultancy Services	Jan-16	ISQ	On-going	N/A	N/A	N/A
ISVV Consultancy Services	Jan-16	Critical Software	On-going	N/A	N/A	N/A
Construction All Risks Insurance	Mar-18	SCOR	On-going	N/A	N/A	N/A
Freight Forwarding Services	Oct-20	DSV	On-going	N/A	N/A	N/A
Consultancy Support	Jun-13	Ramboll	On-going	N/A	N/A	N/A
Consultancy Support - On site activities	May-23	CyD	On-going	N/A	N/A	N/A
DM&S Design and Construction Contract	May-16	ACe Consortium	On-going	100%	97%	63%
M4 Phase 1 Preliminary Design	May-12	AdOptica	Closed	100%	100%	100%
M4 Unit Final Design and Manufacturing	Jun-15	AdOptica	On-going	100%	100%	89%
M1 Segment Supports - Qual. Units	Jan-15	VDL	Closed	100%	100%	100%
M1 Segment supports - Qual. Units	Feb-15	CESA	Closed	100%	100%	100%
M4 Mirror Shells Supply	Jul-15	Safran Reosc	Under warranty	100%	100%	N/A
M2 Mirror and Auxiliary Equipment Supply	Jul-16	Safran Reosc	On-going	100%	99%	N/A
M2 Blank Supply	Jan-17	Schott	Closed	100%	100%	100%
M3 Blank Supply	Jan-17	Schott	Closed	100%	100%	100%
M3 Mirror and Auxiliary Equipment Supply	Feb-17	Safran Reosc	On-going	100%	50%	N/A
M2 and M3 Cell Design and Manufacturing	Jan-17	Sener	On-going	100%	100%	94%
M1 Edge Sensors Design and Manufacturing	Jan-17	FAMES	Under warranty	100%	100%	N/A
M1 Mirrors Polishing	May-17	Safran Reosc	On-going	100%	42%	19%
M1 Blanks Supply	May-17	Schott	Under warranty	100%	100%	N/A
M1 Position Actuators	Jun-17	PI	Under warranty	100%	100%	100%
M1 Segment supports - Production	Apr-18	VDL	On-going	100%	98%	NA
M5 Blank Supply + Polishing	Mar-19	Safran Reosc	On-going	100%	80%	30%
M5 Cell Design and Manufacturing	Nov-19	Sener	Under warranty	100%	100%	100%
M5 Commissioning Mirror - Blank	Mar-24	Schott	On-going	N/A	30%	0%
M5 Commissioning Mirror - Polishing	Jun-24	Glyndŵr Innovations	On-going	2%	0%	0%
M1 Segment Assemblies Manipulator	Jan-21	Sener	On-going	100%	95%	50%
M1 Segment Assemblies Local Coherencer	May-21	IDOM	On-going	100%	35%	0%
Core Integration Infrastructure	Jul-17	Cosylab AB	Closed	100%	100%	100%
M1LCS Cabinets Procurement and AIV	Dec-20	PROCON	Under warranty	100%	100%	100%
M1LCS Cabinets Heat Exchangers	Nov-20	AAVID Thermalloy	Under warranty	100%	100%	100%
CSW Outsourcing Contract	Mar-23	N7 SPACE Sp. z o.o.	On-going	N/A	N/A	N/A
Road and Platform	Dec-13	ICAFAL	Closed	100%	100%	100%
Paranal ELT Technical Facility Design and Construction	Mar-18	Abengoa	Closed	100%	100%	100%
Supply, and installation of ABC Power Substations (23kV + 0.4 kV)	Oct-16	SIEMENS	Closed	100%	100%	100%
M1 Coating Plants Supply	Jun-18	AGC	Under warranty	100%	100%	100%
Large Mirrors Coating Plant Supply	May-21	AGC	On-going	100%	100%	0%
M1 Mirror Washing & Stripping plant Supply	Jan-20	Fagerström Industrikonsult	On-going	100%	98%	0%
Power Conditioning System	Nov-19	SAESA	On-going	N/A	N/A	N/A
ELT LN2 Infrastructure	Nov-23	AS Scientific Products Ltd.	On-going	75%	20%	0%
Dataflow Software Components for ELT	Nov-18	Etamax	On-going	N/A	N/A	N/A
MICADO Construction	Oct-15	MPE	On-going	100%	40%	0%
HARMONI Construction	Oct-15	STFC	On-going	75%	0%	0%
METIS Construction	Oct-15	NOVA	On-going	100%	50%	0%
MORFEO Construction	Feb-16	INAF	On-going	90%	10%	0%
IR Detectors for HARMONI, MICADO, METIS	Jul-18	Teledyne	On-going	100%	85%	N/A
C-RED Cameras for MAORY	Jul-18	FLI	Under warranty	100%	100%	100%
CCD-220 Detectors for MAORY, MICADO, HARMONI, PFS-A, PDS	May-19	Teledyne	Under warranty	100%	100%	100%
MUSE type detectors	Sep-19	Teledyne	Under warranty	100%	100%	N/A
AOWFS Cameras Production	Dec-22	TAS-E	On-going	100%	30%	0%
PFS-A Main system Design and Manufacture	Apr-18	IDOM	On-going	100%	100%	15%
Laser Sources	Dec-17	Toptica	On-going	100%	100%	100%
Laser Projection Subunits	Dec-20	TNO	On-going	100%	75%	20%
PDS Powered Optics	Feb-23	Bertin	On-going	100%	50%	N/A
Laser Trackers	Oct-21	Hexagon Wetzar	On-going	N/A	100%	NA

ELT Purchases over the years



Overall ELT Schedule

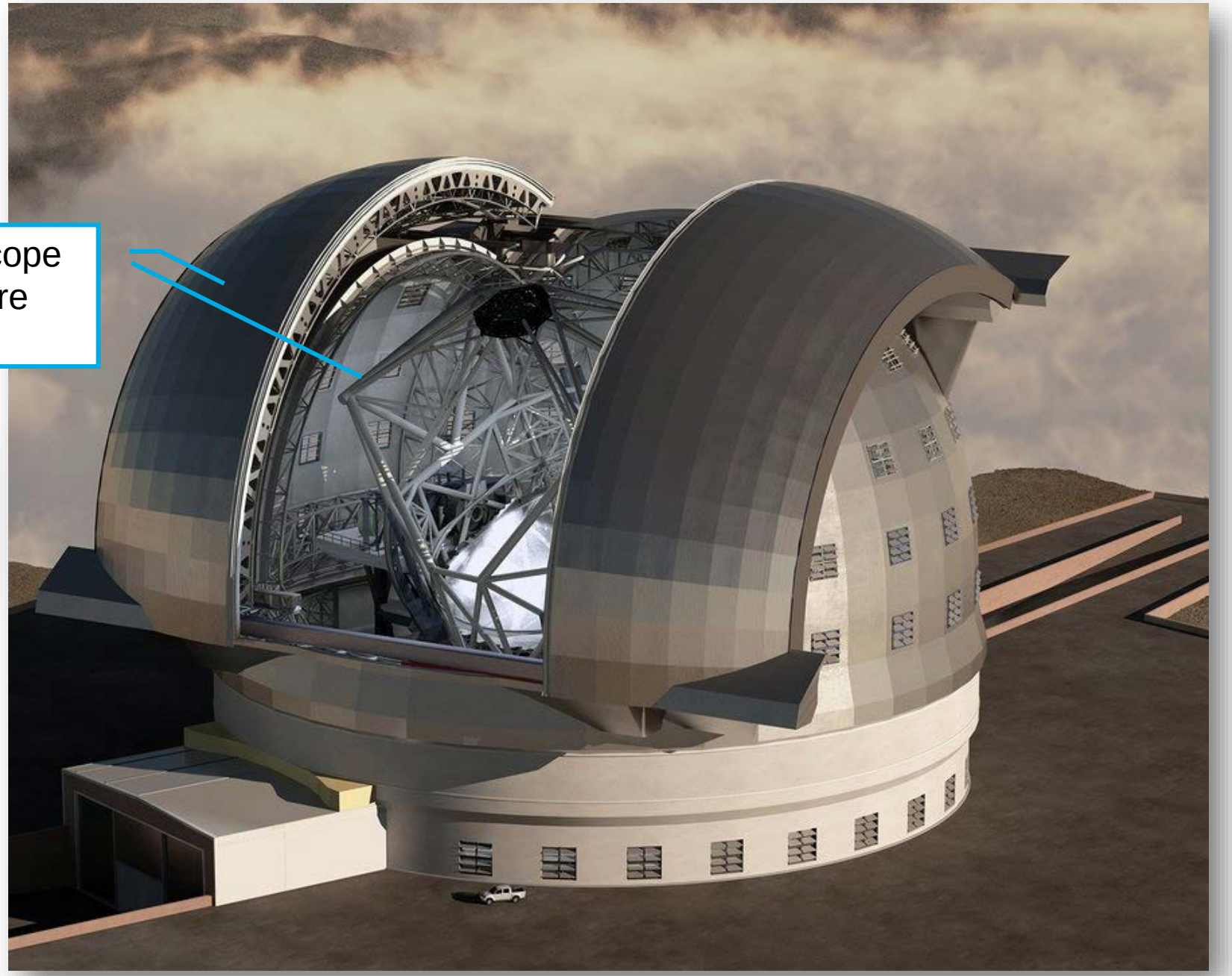


Your Contributions !

CIMOLAI

webuild

Dome & Telescope Main Structure (DMS)



CIMOLAI

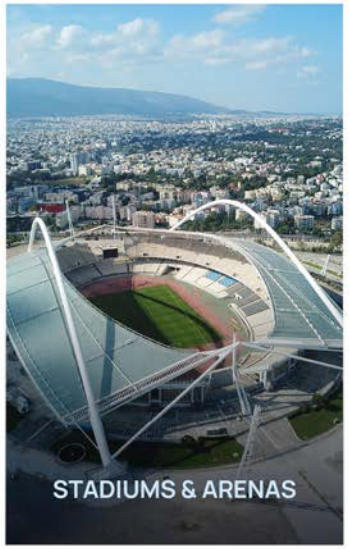
Cimolai operates worldwide in the design,
supply and assembly of complex steel structures, diversifying its activities in the fields of Civil, Industrial, Military and Aerospace Engineering,
as well as in the Oil&Gas and Naval sector.

59
countries

160,000 tons
production capacity per year

1,065,000 m^2
of industrial areas

258,000 m^2
of covered industrial areas



Cimolai S.p.A.

ON SITE

14
cranes

13
forklifts

24
aerial
platforms

approx.
250
people

31,000 m³
concrete

14,000 tons
steel

25,000 m²
cladding

36
dome trolleys

128
hydrostatic bearings

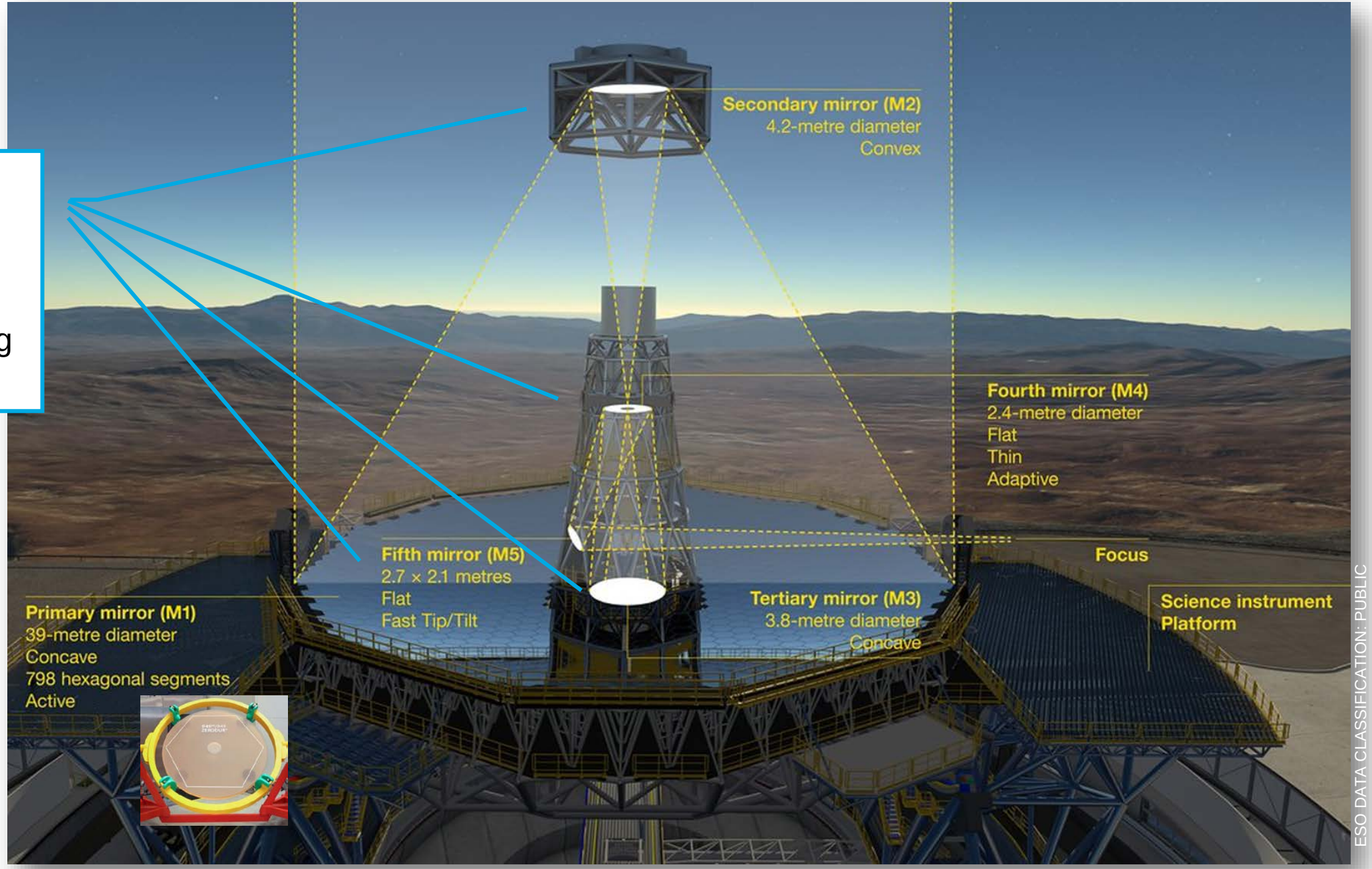
to date

+900
containers

3
Ships with approx.
2,200 tons of
oversized parts

SCHOTT
glass made of ideas

M1 mirror blank
M2 mirror blank
M3 mirror blank
M4 mirror blank
M5-Commissioning blank



SCHOTT‘s low thermal expansion glass-ceramic ZERODUR® is equipping ESO’s telescopes and high-tech applications

Astronomy


Material of choice for monolithic & segm. astronomical & solar telescope mirrors

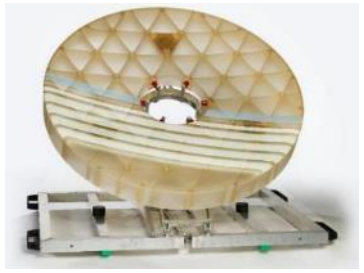
IC Lithography


ZERODUR® components enable wafer steppers to produce adv. microchips

Aviation


ZERODUR® is designed into Ring Laser Gyroscopes in Inertial Navigation Systems

Space

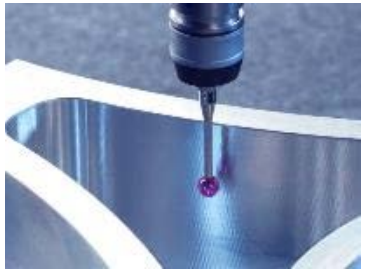
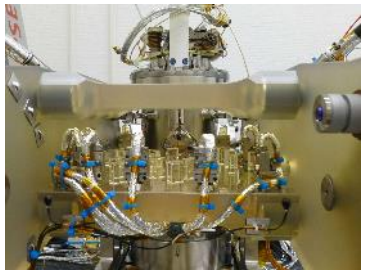



Light-weighted mirror substrates for excellent imaging in space

FPD Lithography


>75 % of Flat Panel Displays are produced with ZERODUR® as essential optical component

Metrology

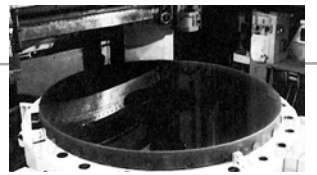



ZERODUR® enables highest precision and accuracy for high-tech instruments

SCHOTT

Thanks to ESO for challenging SCHOTT ZERODUR®'s capabilities for decades pushing our boundaries to benefit high tech industry.

1986



New Technology Telescope

1989

Very Large Telescope

1995

2003

VISTA Telescope

2016

Contracts ELT M2,M3,M1

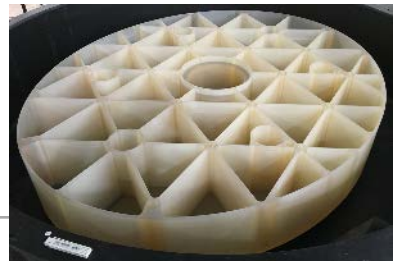
2017

ELT M4 blanks

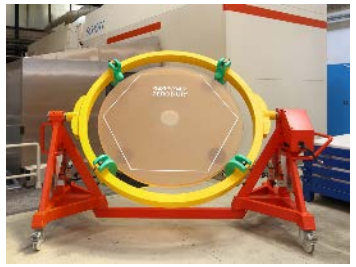
2019

ELT M3 blank

ELT M2 blank



ELT M5 com. blank



ELT M1 blank

2024

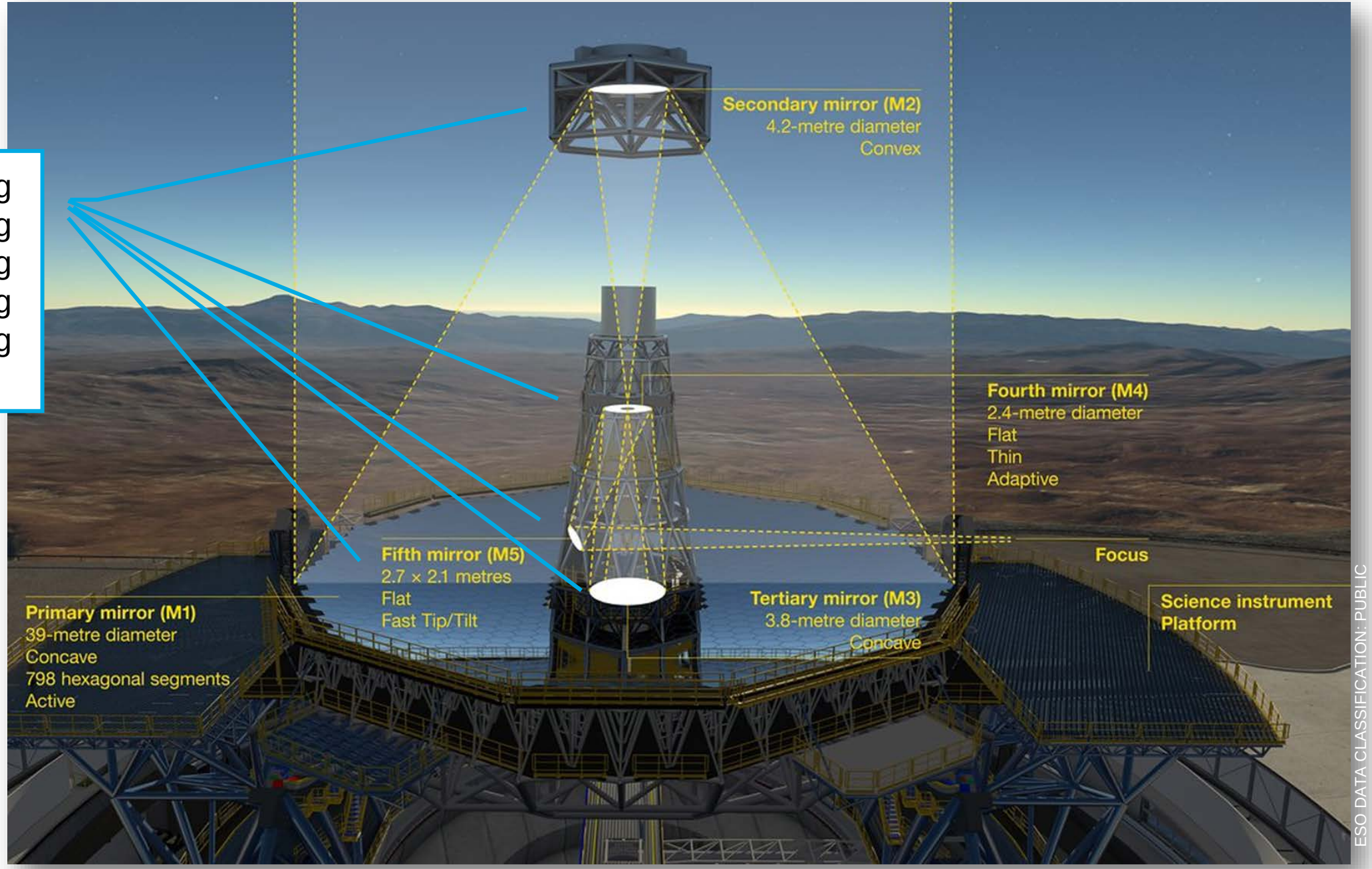
What's next ESO?

We are ready!

SCHOTT

SAFRAN

M1 mirror polishing
M2 mirror polishing
M3 mirror polishing
M4 mirror polishing
M5 mirror polishing

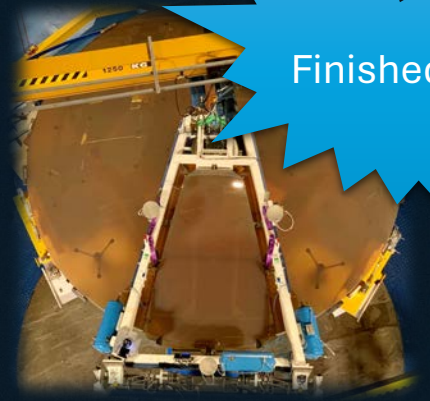


SAFRAN Reosc : The ELT Mirror maker

Completed
12 shells
delivered

ELT M4 : meter size thin shell mirrors (thickness < 2mm)

Finished !

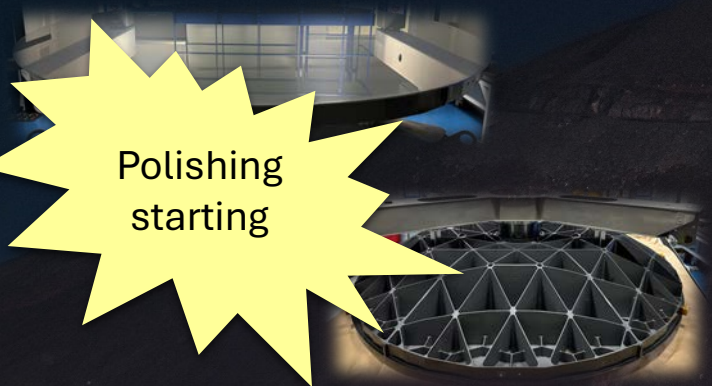


ELT M2 : The world biggest convex mirror (∅ 4.25 m)

Production
in progress

ELT M1 : 931 10 nm RMS class hexagonal segments to be produced in a smart dedicated plant

Polishing
starting



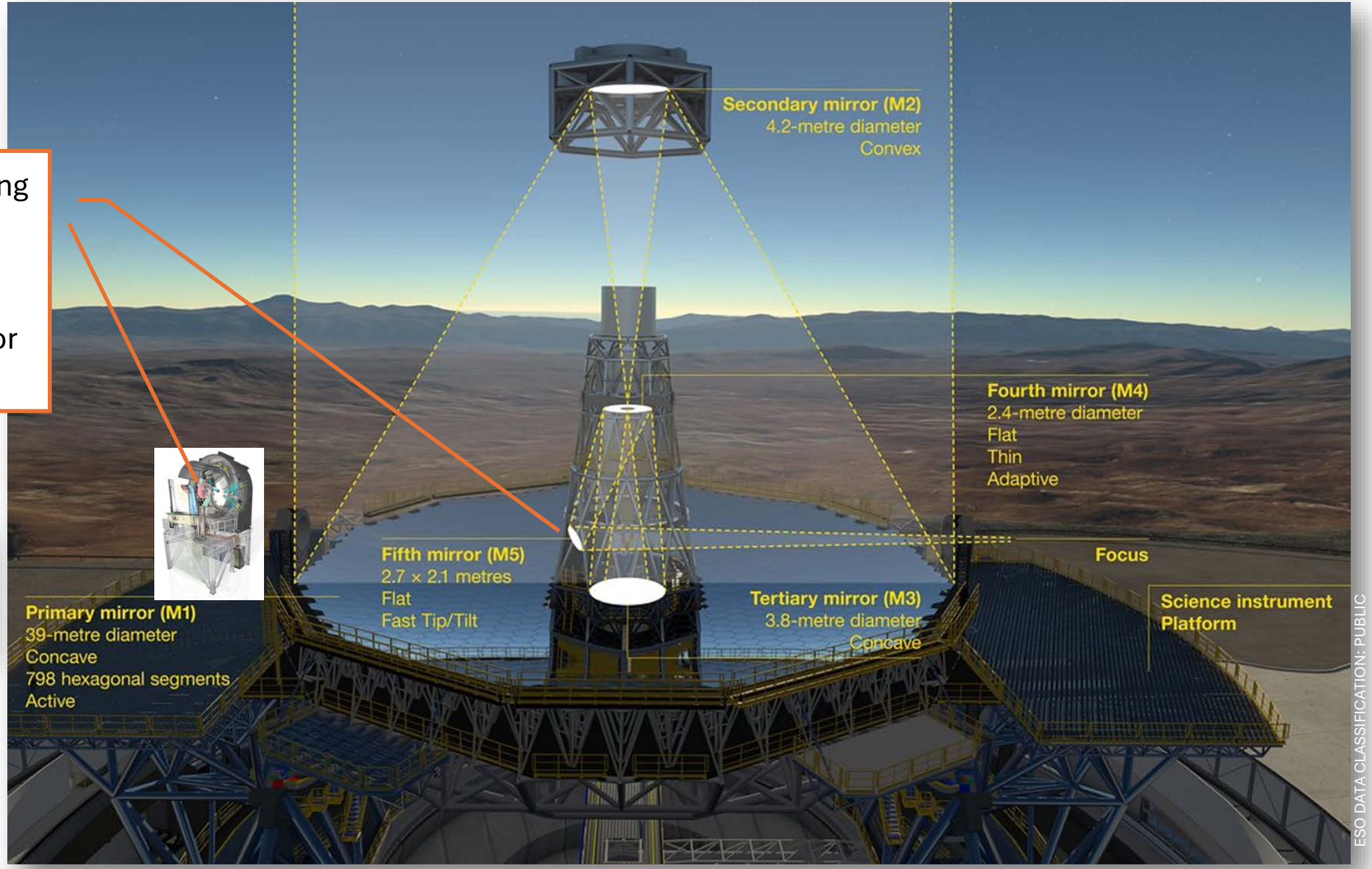
ELT M5 : one of the largest SiC brazed mirror ever made

Polishing
in progress

ELT M3 : concave cousin of ELT M2 (∅ 4.00 m)

Credit : J. Beltrán/ESO

- M5 Commissioning mirror polishing
- Subco of IDOM (PFS) for M6 mirror polishing



Glyndwr Innovations Ltd (GIL)

(Adobe Stock)

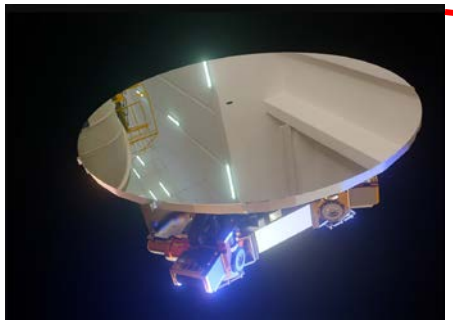
Glyndwr Innovations Limited (GIL) will manufacture and test the M5 Commissioning mirror and, design, manufacture & supply the equipment needed to handle, store and transport the mirror, as well as develop a test bench to measure the mirror during manufacture

The M5 Mirror is a crucial part of the ELT's Adaptive-Optics System Design

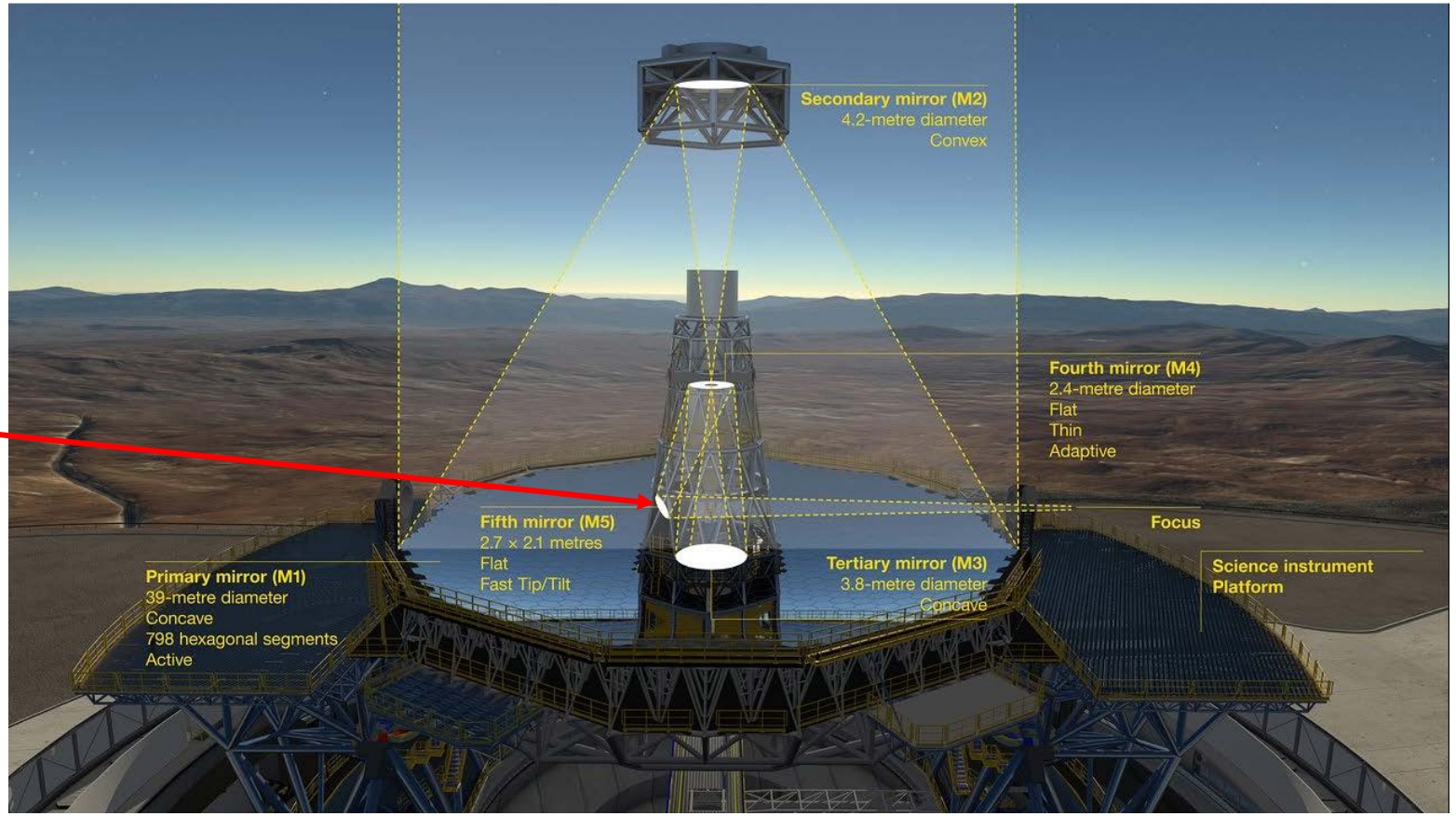
The 2.2m x 1.8m M5 Commissioning Mirror, made from Glass (Zerodur), will be used to commission the telescope

GIL is the only manufacturer of complex large optical components up to 2.2m diameter in the UK.

The lightweighted M5 Zerodur blank being packaged for transportation from SCHOTT to GIL



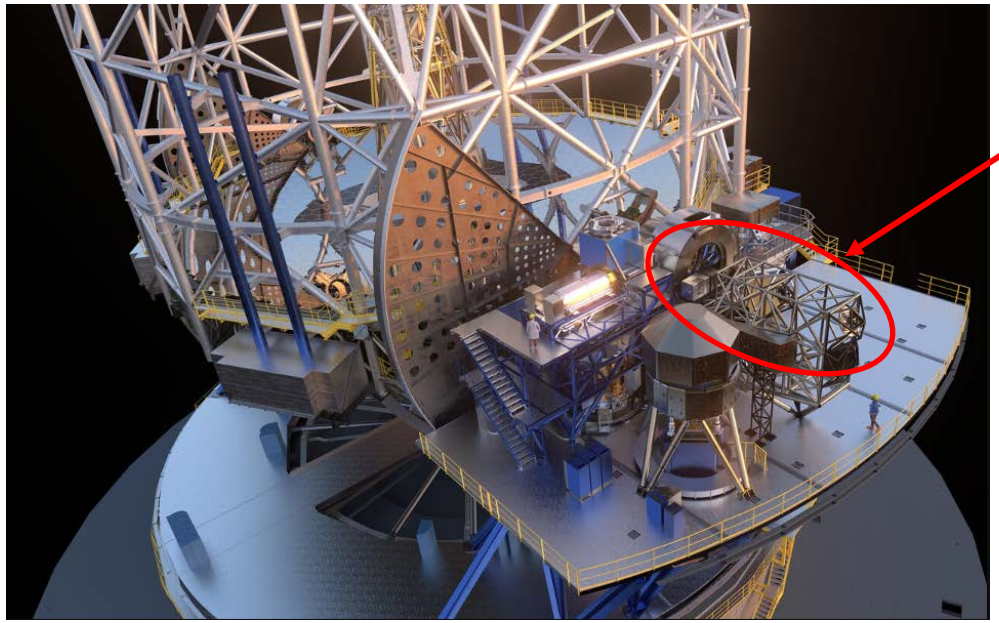
M5 Mirror
Artists impression



https://www.eso.org/public/images/0919-e-elt-big-cc/

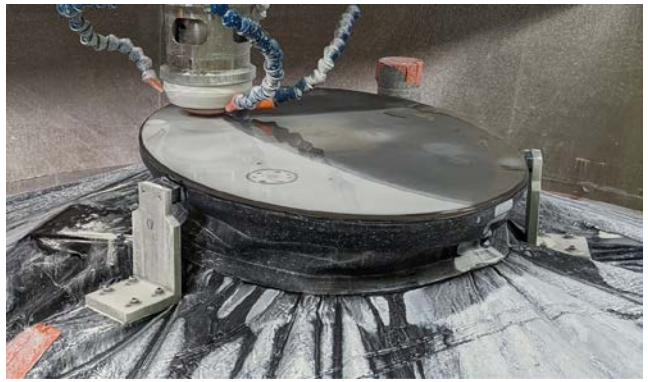
arloesiadau cyf Glyndŵr innovations ltd

Located on both sides of ELT's tube structure are the two Prefocal Stations

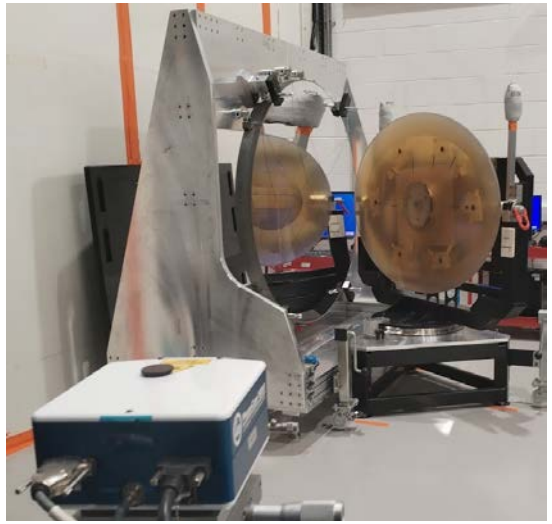


- The Prefocal Station is a critical ELT subsystem – containing 2 high precision mirrors

- GIL is manufacturing both these critical high-precision mirrors
- A flatness of <15nm RMS has been achieved on the M6C Mirrors



M6C Mirror Polishing at GIL



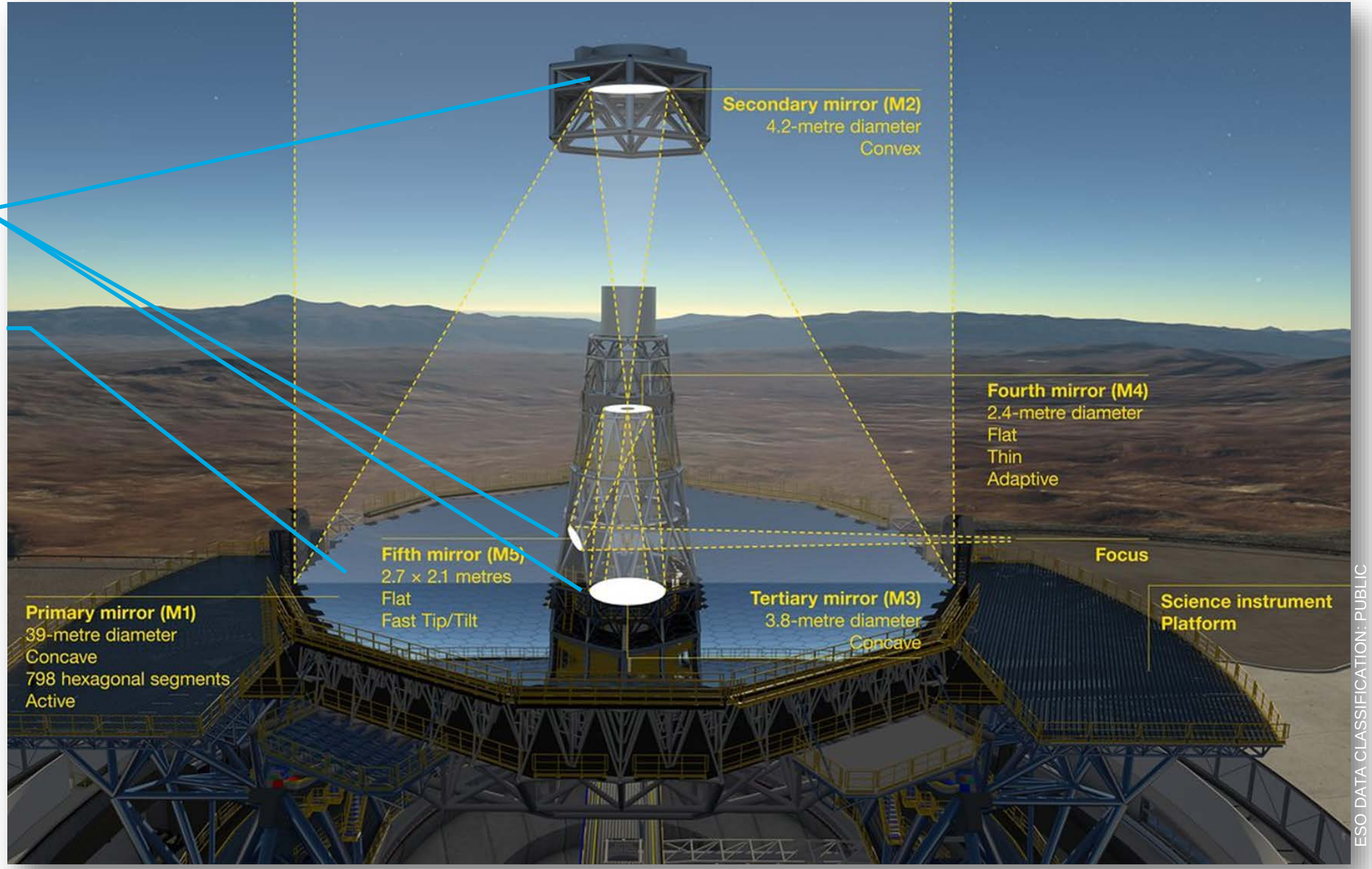
M6N mirror under test during manufacture at GIL

arloesiadau cyf Glyndŵr innovations ltd

sener

M2 mirror cell
M3 mirror cell
M5 mirror cell

M1 segment
Manipulator



ELT M2 & M3 Cells

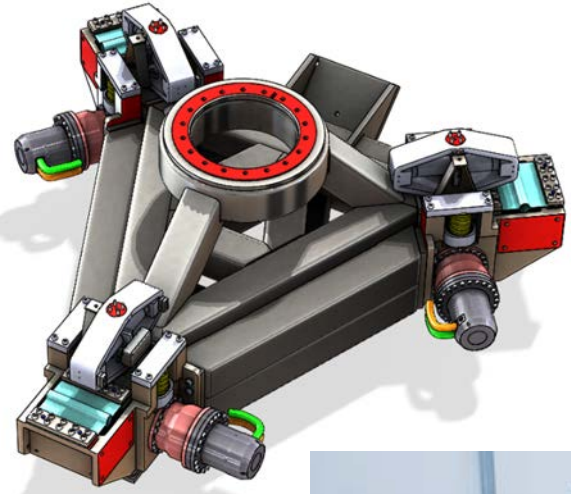
Large monolithic mirror precision support

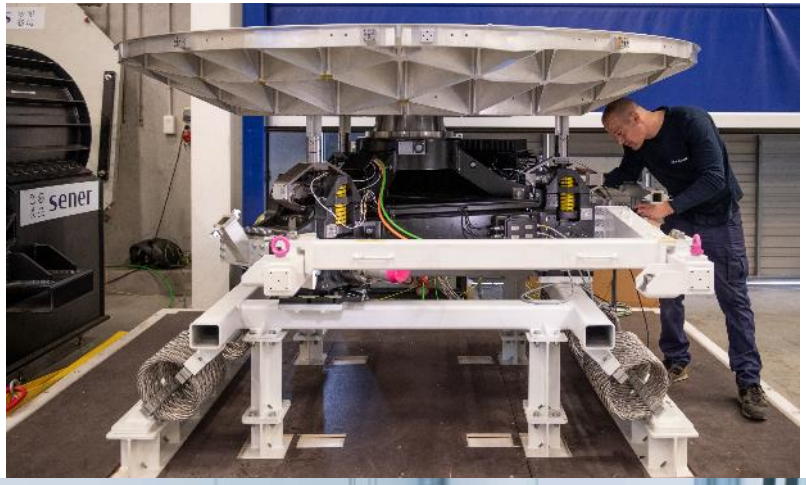
www.aerospace.sener

sener

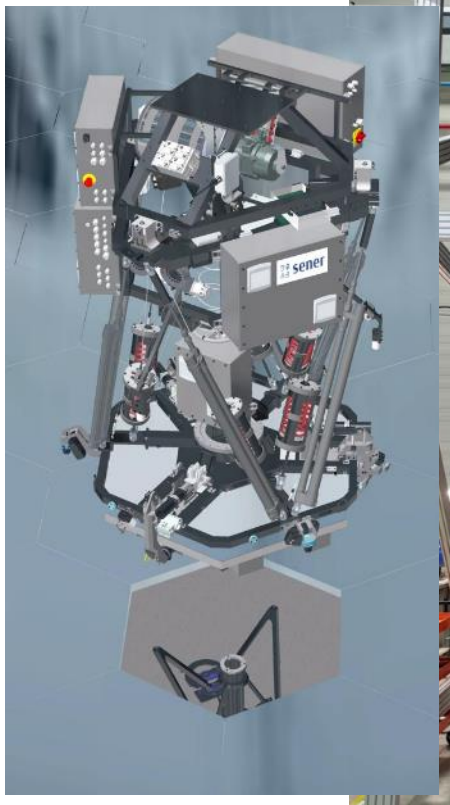
ELT M5 Cell & M1 Manipulator

Largest tip-tilt mechanism





Mirror segments manipulation

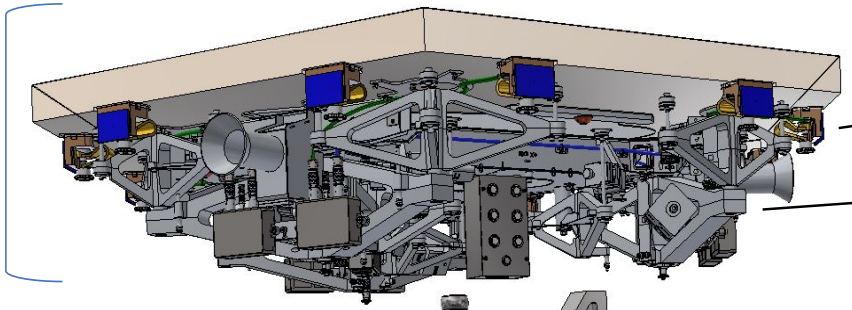


www.aerospace.sener

sener

Segment Assembly

Subcell



Segment

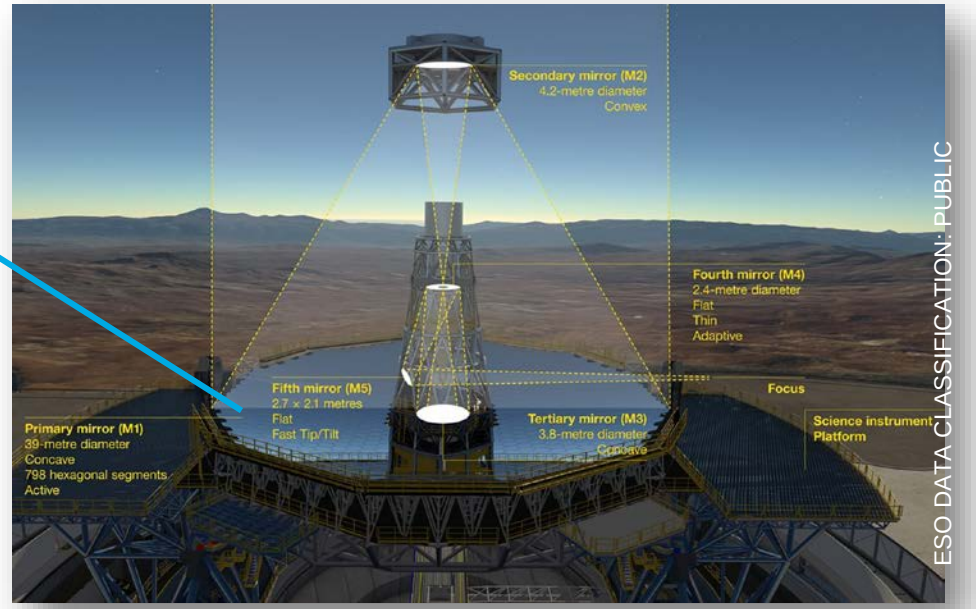
Edge Sensors

Segment Support

Fixed Frame Assembly

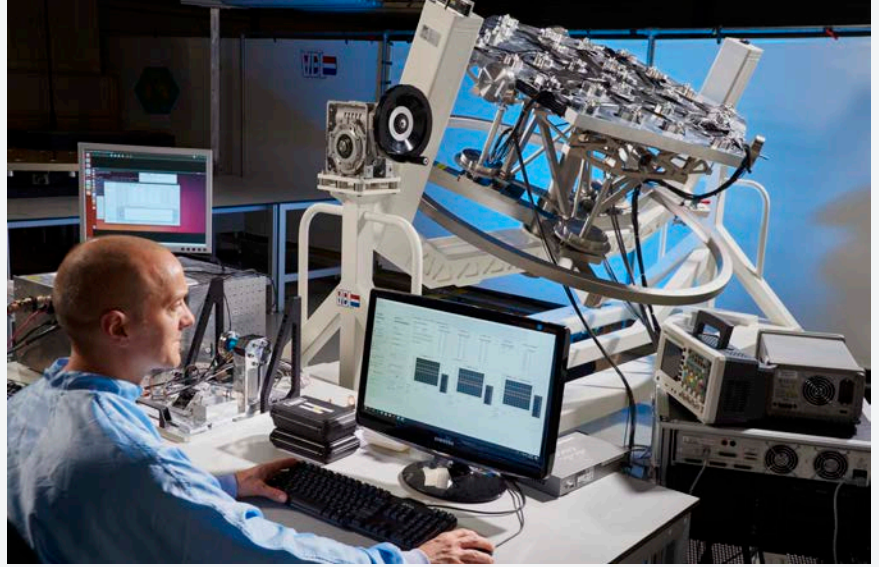
Position Actuators

M1 segment support (cell)



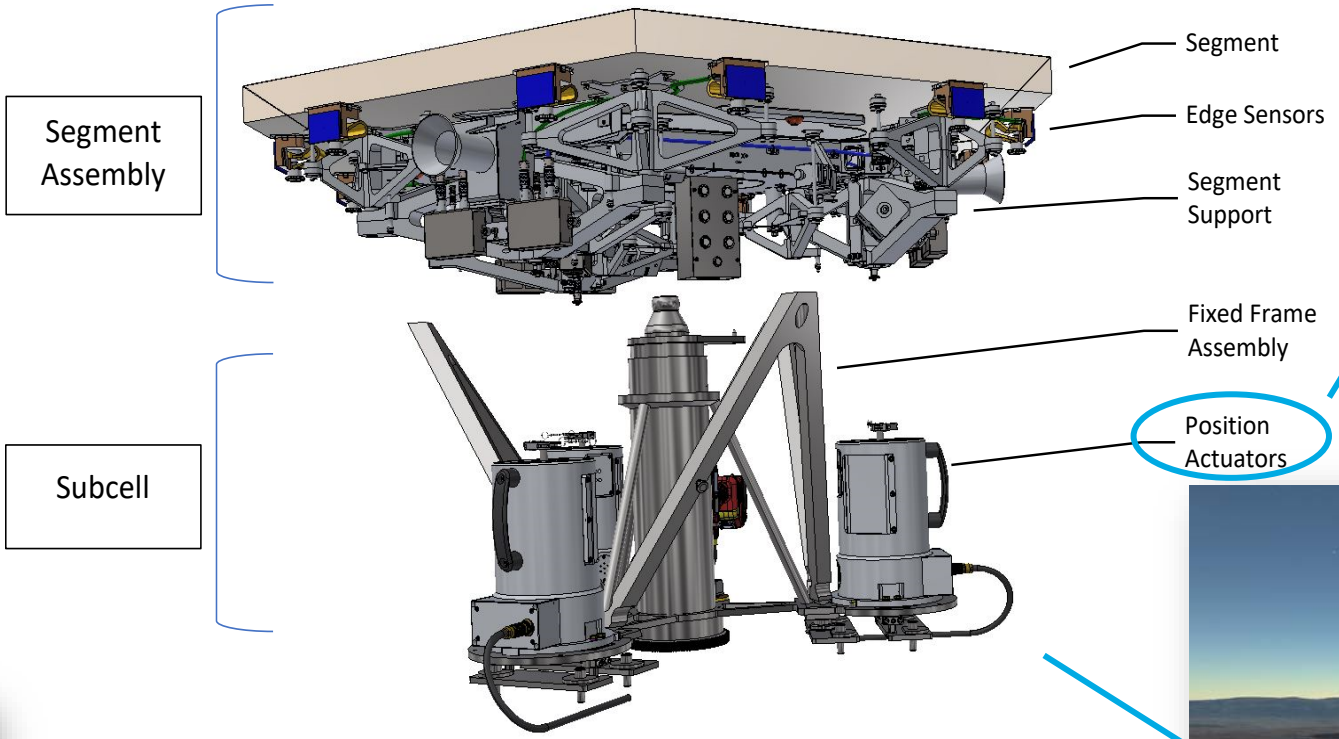
VDL GROEP, NETHERLANDS , 14.250 FTE, 1 TIER CONTRACT MANUFACTURER

ELT SEGMENT SUPPORT M1

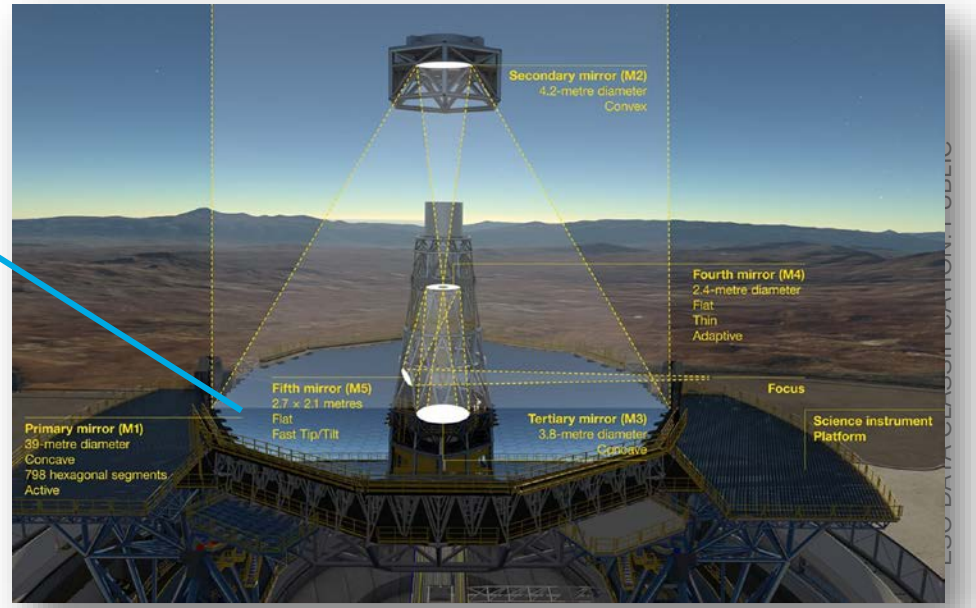


- 936-segment support produced at VDL.
- TNO and NOVA are strategic partners.
- The VDL supply chain is committed to performing.
- LCIA serves as the basis for the assembly approach.
- The Smart Qualification Tool: the Force Field Test have proven decisive.
- The consequences of the Coronavirus were mitigated.

Even in the face of headwinds, we always experienced a constructive collaboration.



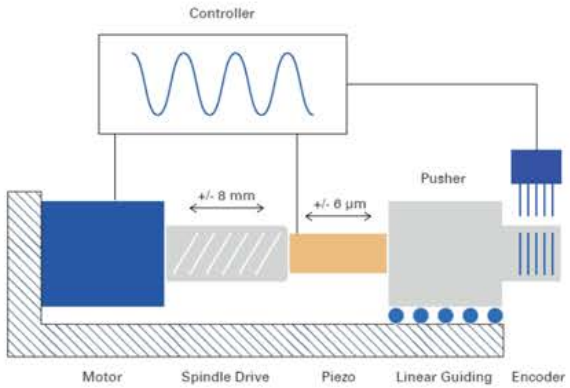
M1 segment position actuators (PACT's)



PI's contribution to the ELT-Project

Hybrid Actuator with Electric Motor and Piezo Drive to position the M1 mirror segments

Concept



Hybrid-Drive concept to achieve an extremely constant velocity with high positioning accuracy (Image: PI)

Product

Hybrid linear actuator with up to 1050 N push forces, travel range of ±5 mm, and a maximum position deviation of 3 nm (rms) over the full travel range (Image: PI)

Application

Conceptual design of the M1 Segment Subunit (Image: ESO)

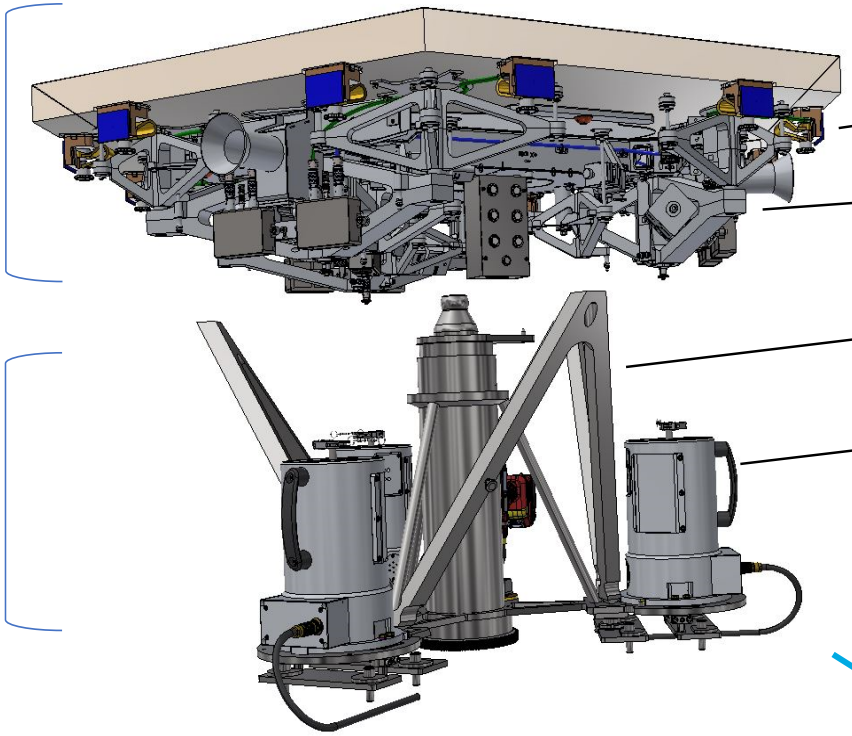
FAMES

FOGALE

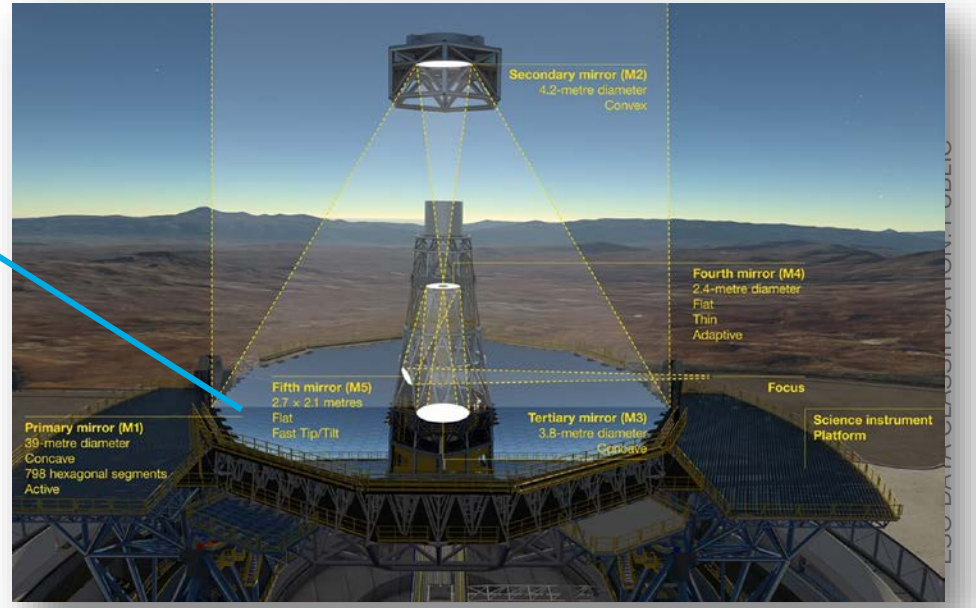
Micro-Epsilon

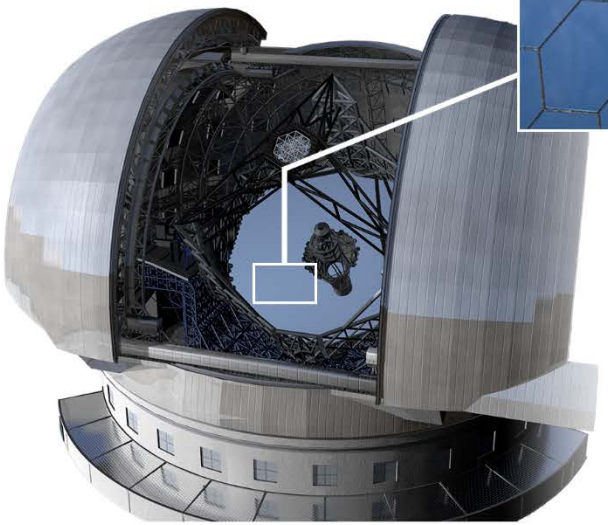
Segment Assembly

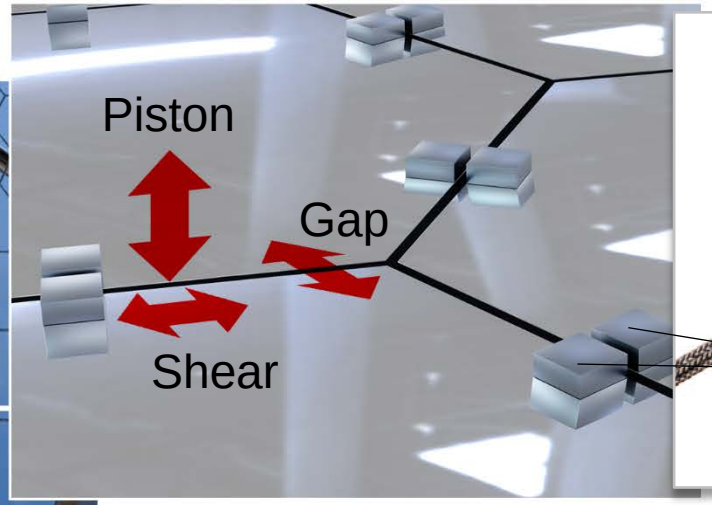
Subcell

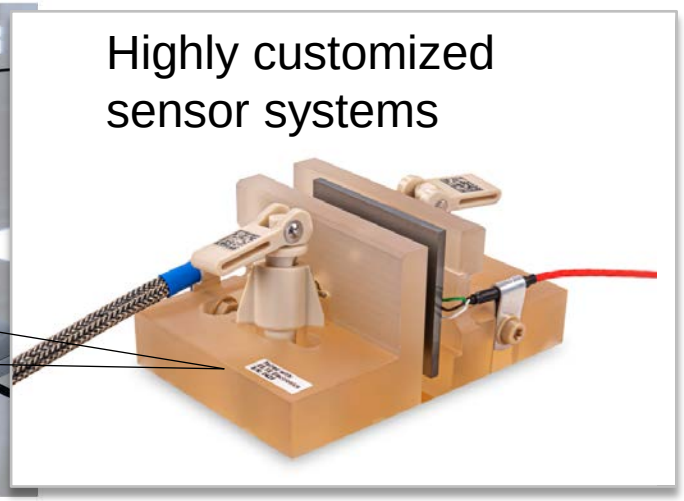


M1 segment edge sensors









Edge sensors for position measurement of the M1 mirror segments

- Ultra performance: nano resolution <1 nm,
  extreme temperature stability ≤ 10 nm/K, zero thermal expansion
- Highly customized sensor systems
- High quality serial production of more than 4600 sensor pairs

---

MICRO-EPSILON

Shaping the future with high precision sensor technology

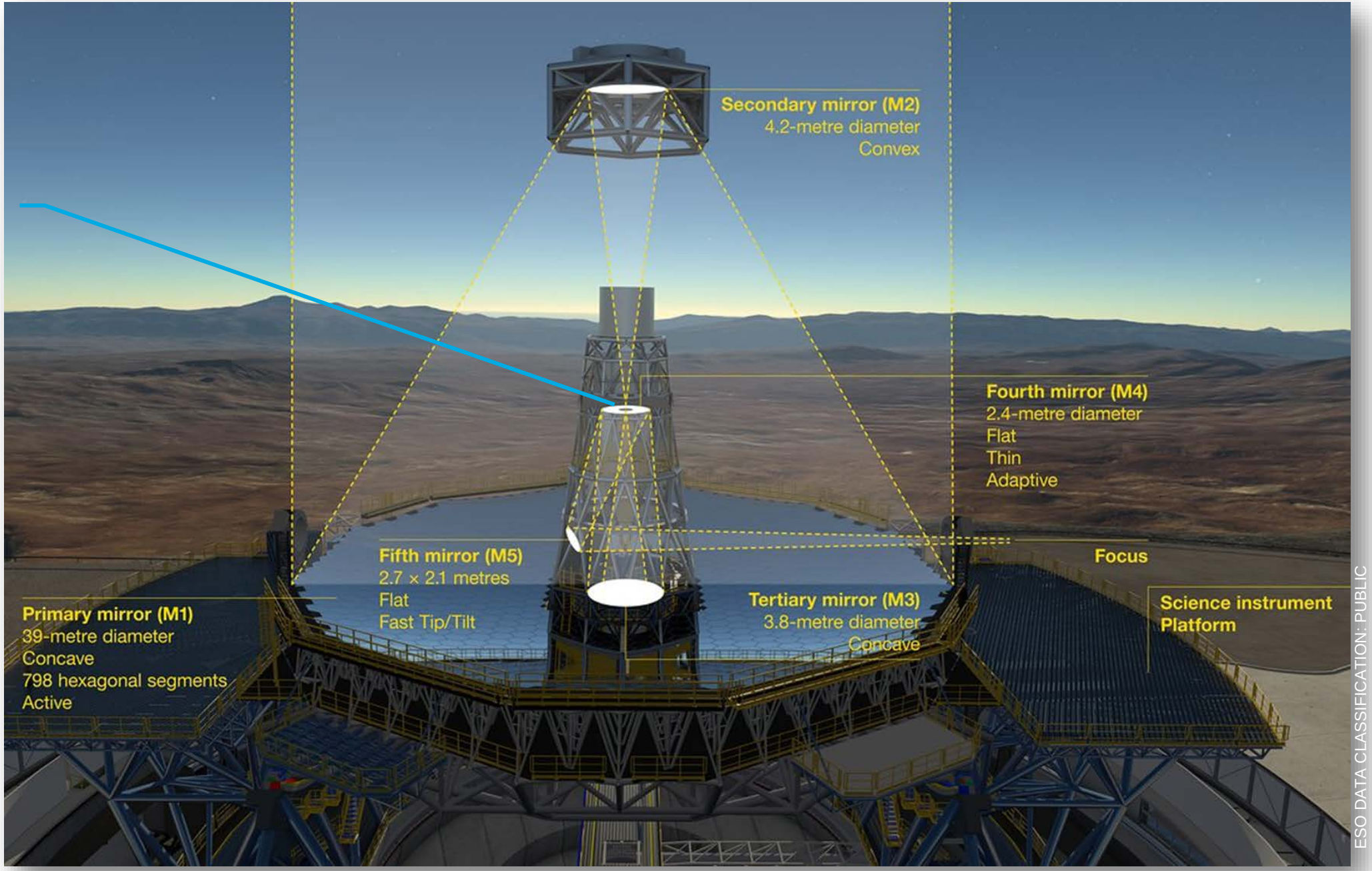
- Leading supplier for precise sensor systems for machine building, advanced automation, aerospace, precision optics & semiconductor industry
- Large portfolio from catalogue sensors up to customized OEM solutions

Micro-Epsilon is part of the FAMES Consortium (EEIG), together with SAS FOGALE Sensors

FAMES

adoptica

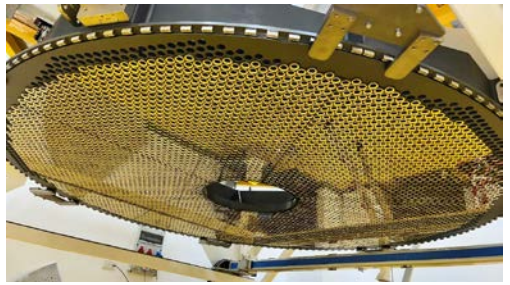
M4 Adaptive Optics Unit

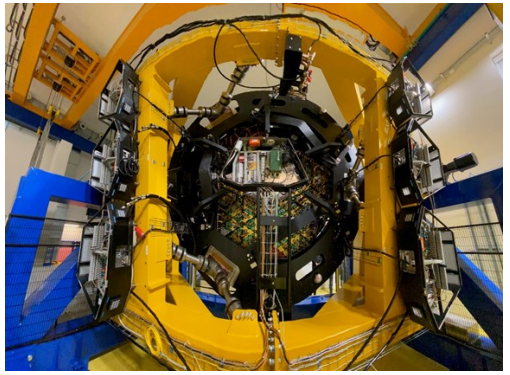


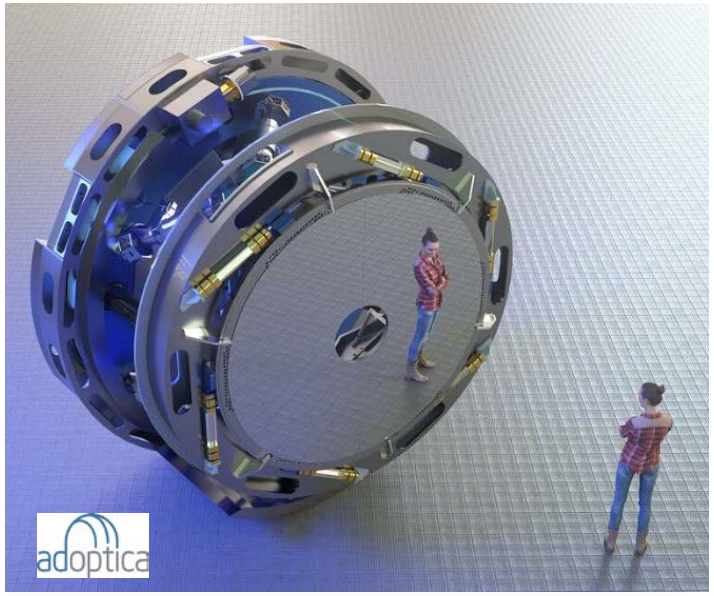
adoptica MICROGATE + A.D.S. International

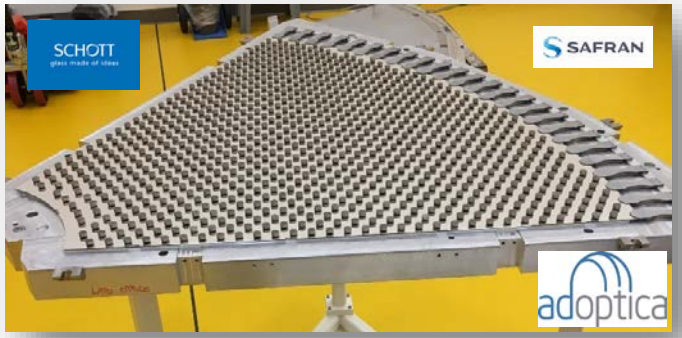
The world largest Adaptive Optics Mirror

- Thin mirror shell: Φ2.4m diameter (6 sectors),1.95mm thick only!
- >5000 voice coil actuators & capacitive sensors; 1kHz control; SiC Reference Body
- M4 integration proceeding at full speed:
  - All 6 shells ready for imminent integration
  - Reference Body equipped with thousands of components (inserts, local electronics, etc.)
  - Cell completed
  - Large Optical Test Tower ready
  - Full-scale tests on-going with complete control electronics







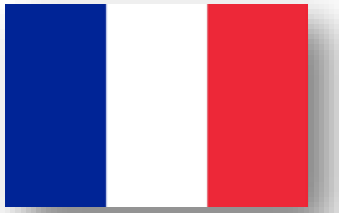


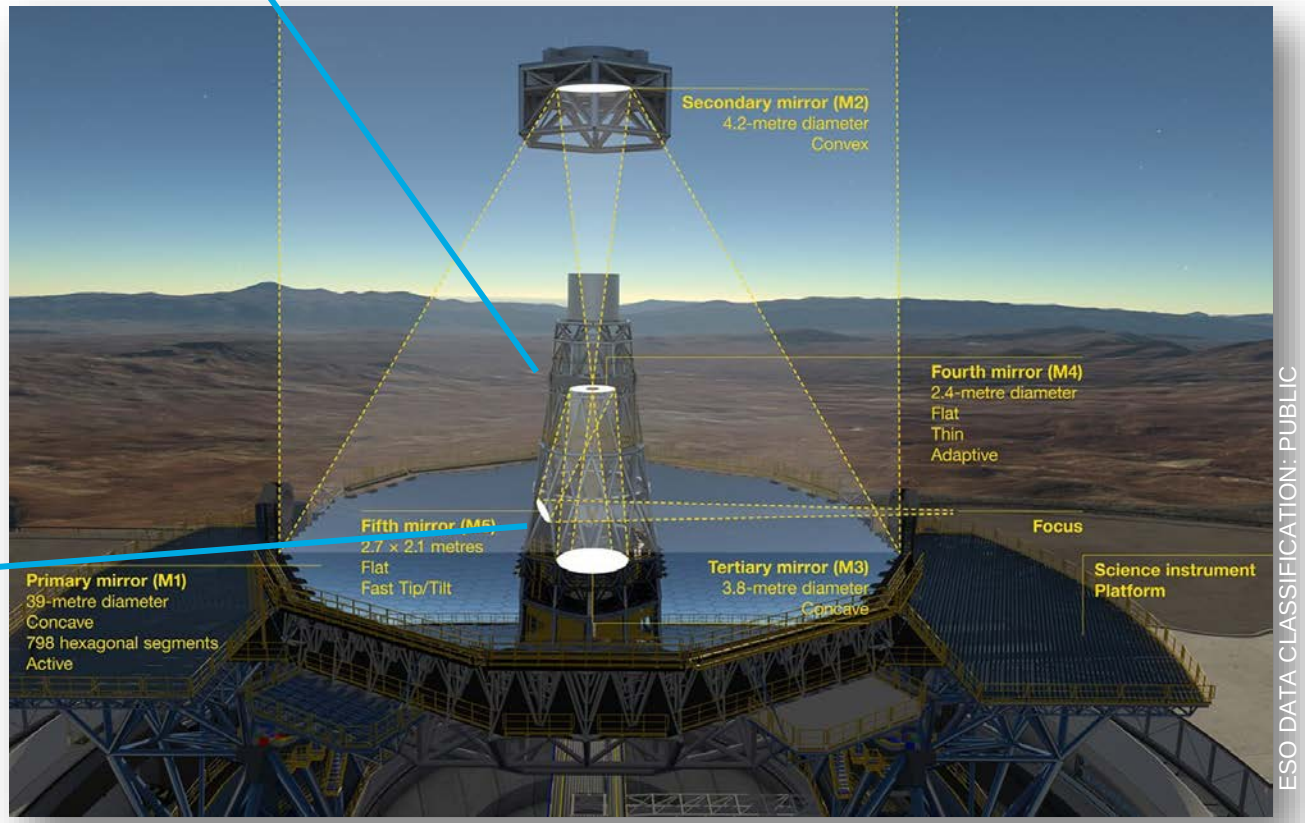
MERSEN BOOSTEC

MERSEN
Expertise, our source of energy

SiC Technology for:

- M4 Reference Body
- M5 mirror blank





MERSEN BOOSTEC

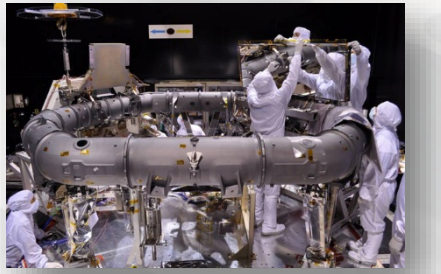
Producing large SiC telescopes for 25 years

Manufacturing SiC parts from Ø1mm to Ø3.5m

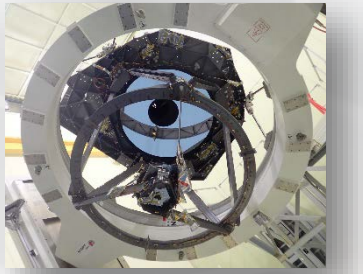
2003 - Herschel

2007 - NIRSpec on JWST

2009 - Gaïa



2018 - Euclid



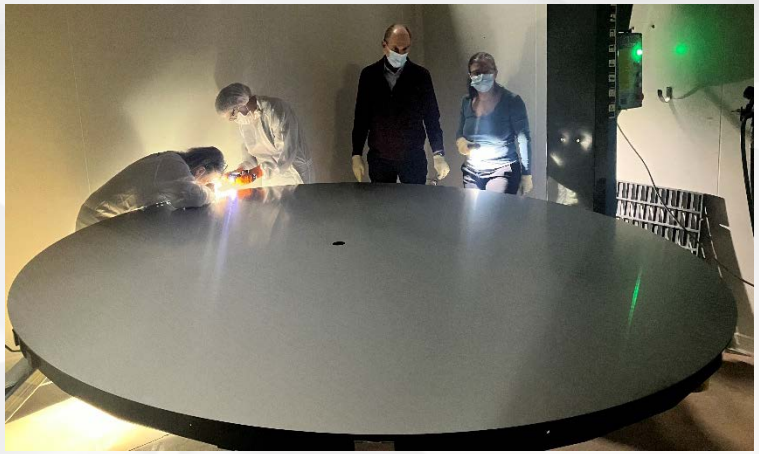
Participation in the ELT

M4 Reference Body

Ø 2.7m brazed structure
5000+ actuators bores

M5 Blank Mirror

2.2 x 2.7 m^2 brazed mirror
SiC CVD coating



Boostec® SiC

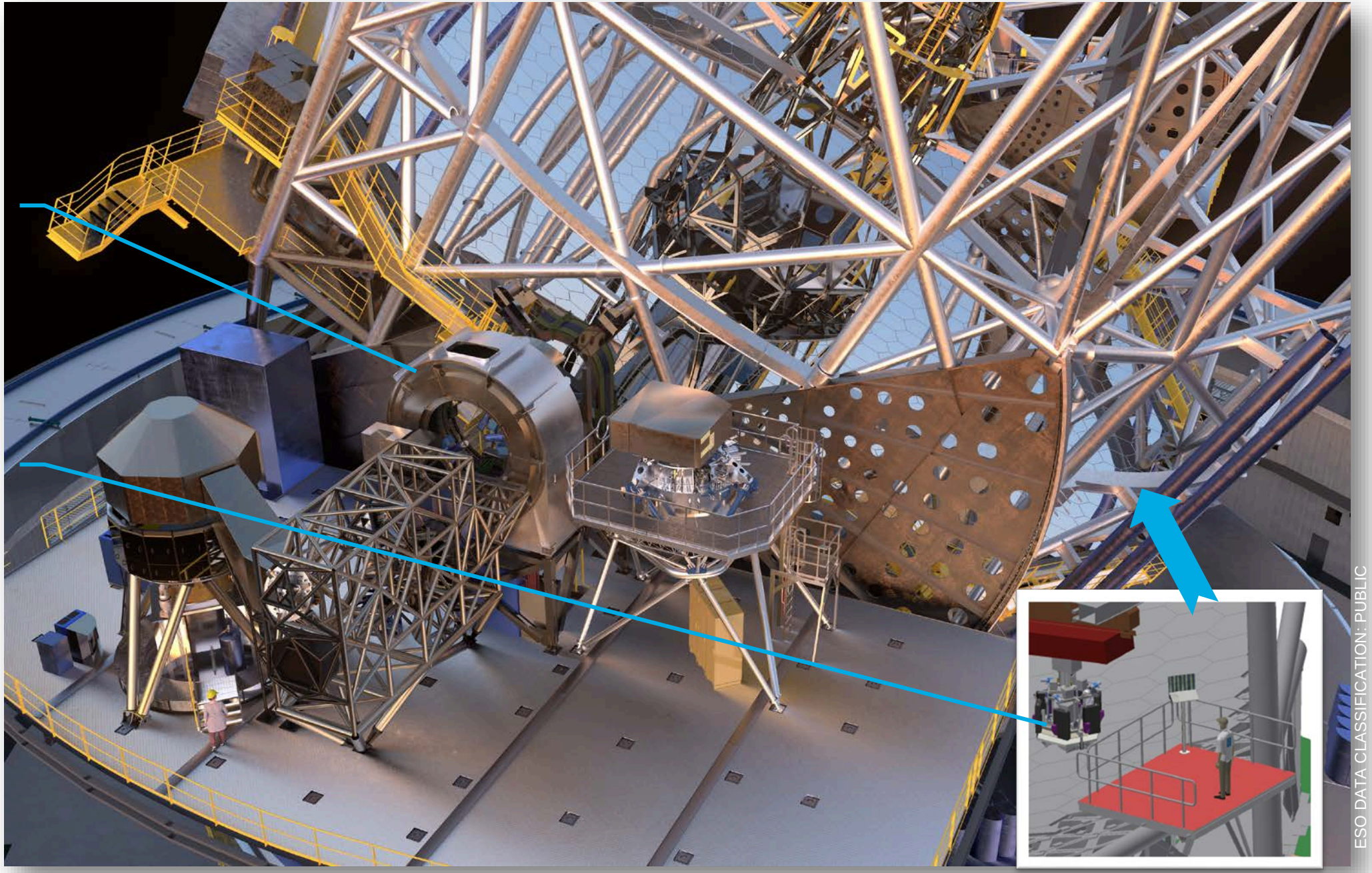
adoptica

SAFRAN

IDOM

Pre-focal Stations
(PFS-A & B)

M1 Local
Coherencer
(Tool to phase the
M1 segments)

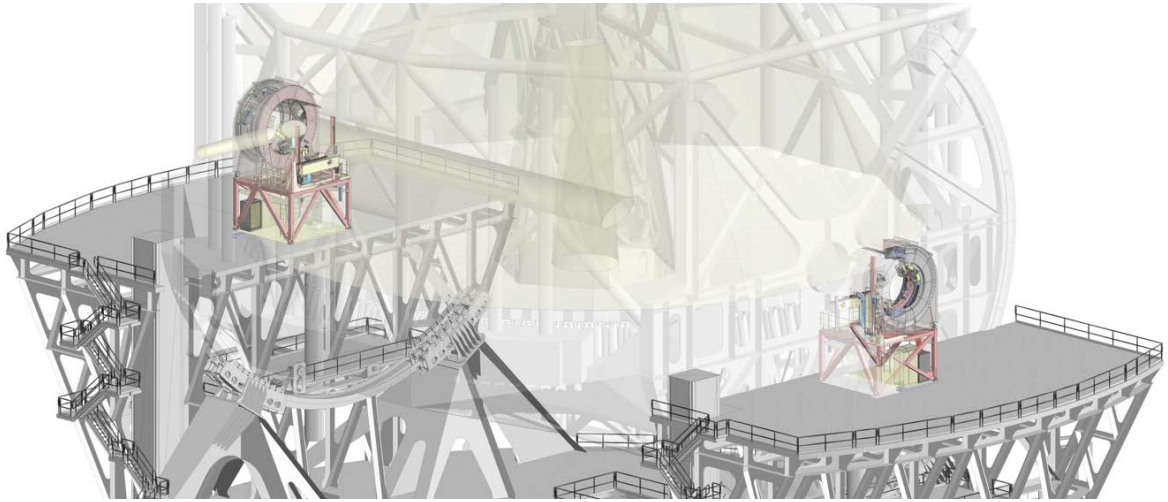


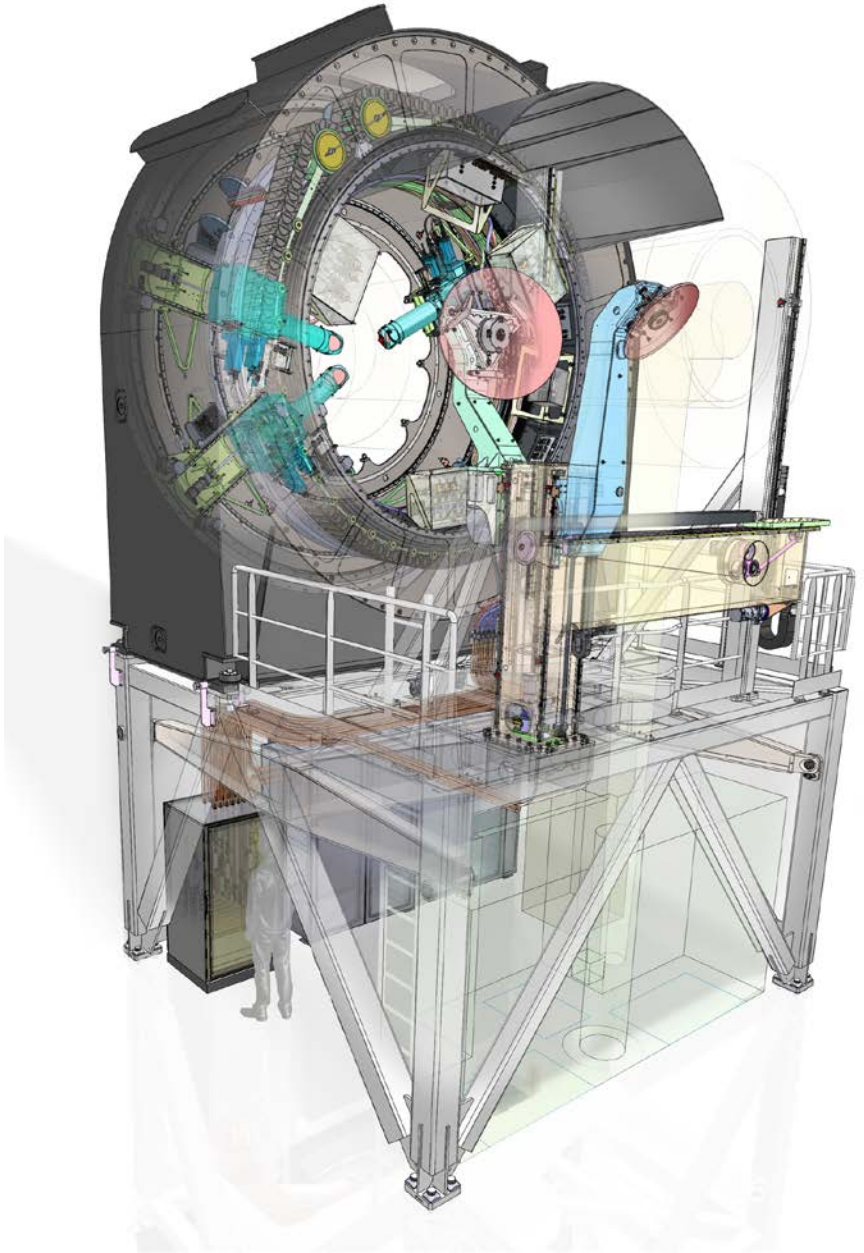
ELT PREFOCAL STATIONS

MISSION:

- To propagate the light towards the science instruments and other test equipment by means of the deployable M6N and M6C mirrors.
- By means of three (3) Sensor Arms, pick and adapt the light from up to three guide stars for its use in the Acquisition, Guiding & Wavefront Sensing.
- To provide optical sensing to support phasing of the ELT primary mirrors, diagnostics, and maintenance of the optics.

Critical for the commissioning and operation of the ELT telescope.





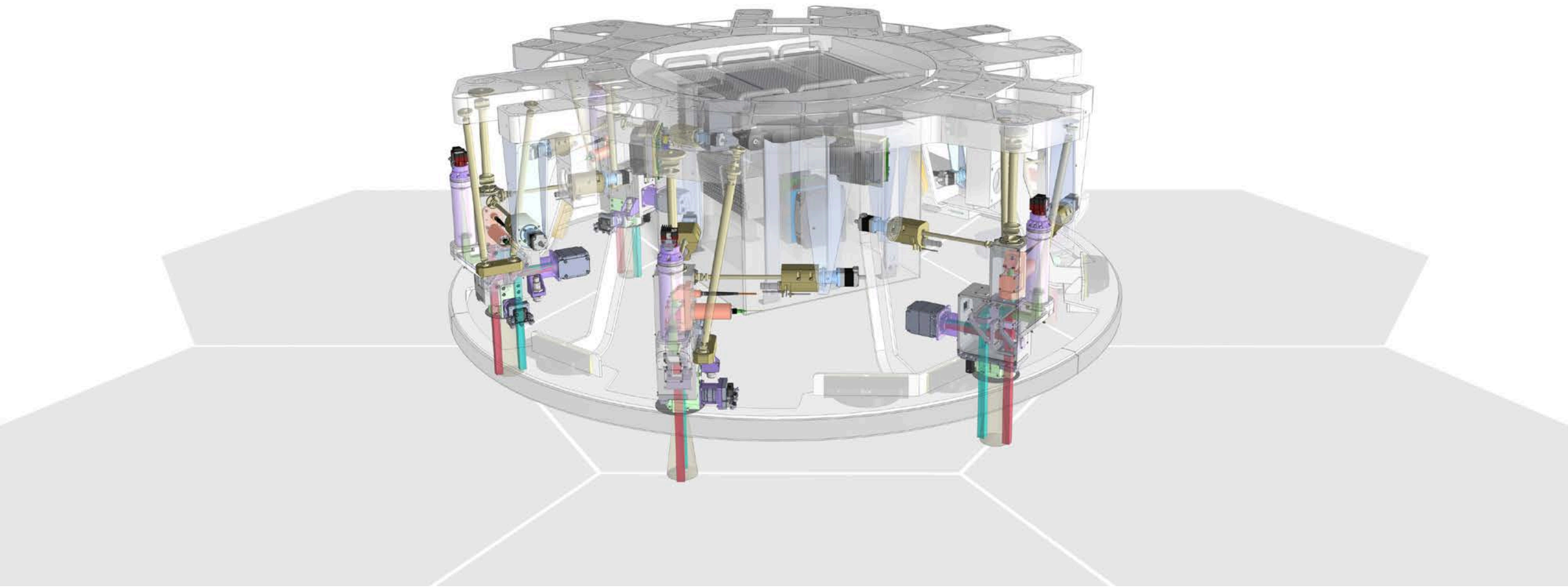
IDOM

ELT PREFOCAL STATIONS

IDOM

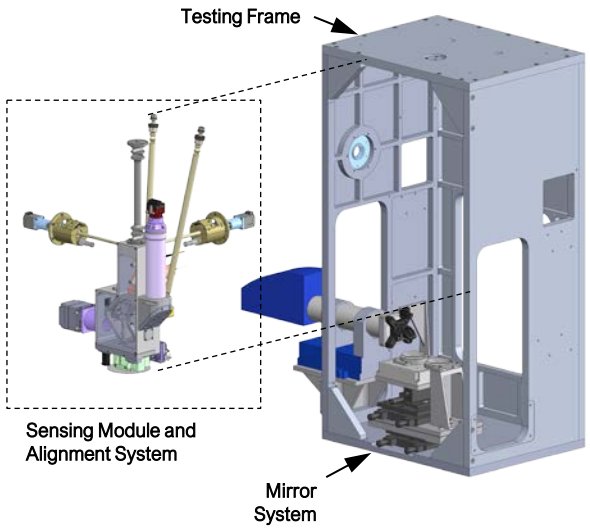
ELT M1 LOCAL COHERENCER

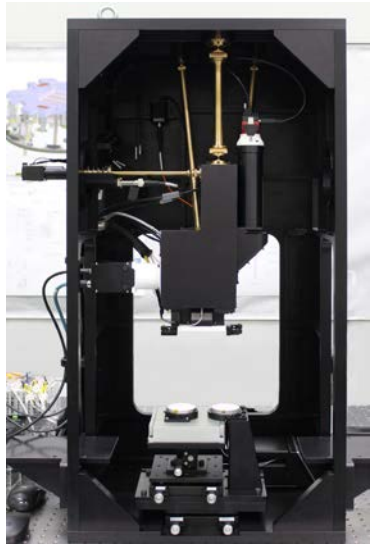
The ELT M1 Local Coherencer is an optical **non-contact metrology system** aimed to simultaneously measure the relative pistons on the six sides of a target M1 segment with respect to neighboring ones (reference segments) with an **accuracy below 150nm (RMS) in a range of 0.5mm**. This measurement shall be performed while the Local Coherencer is supported by the M1 Segment Manipulator hanging from the M1 Segment Crane.

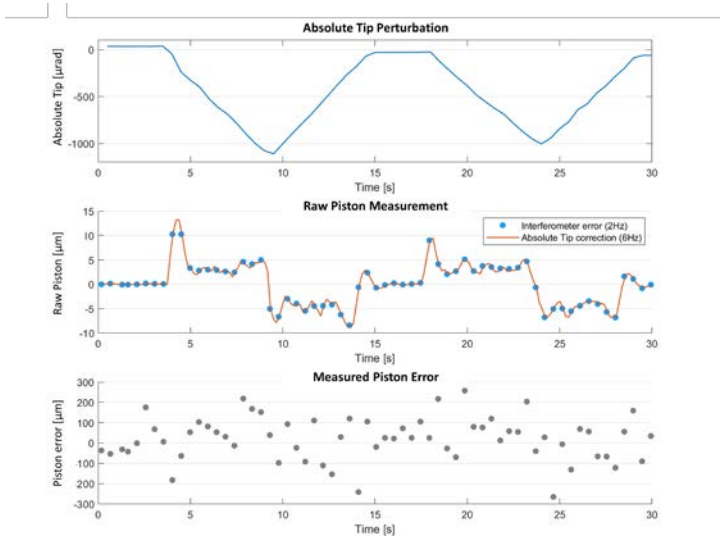


IDOM

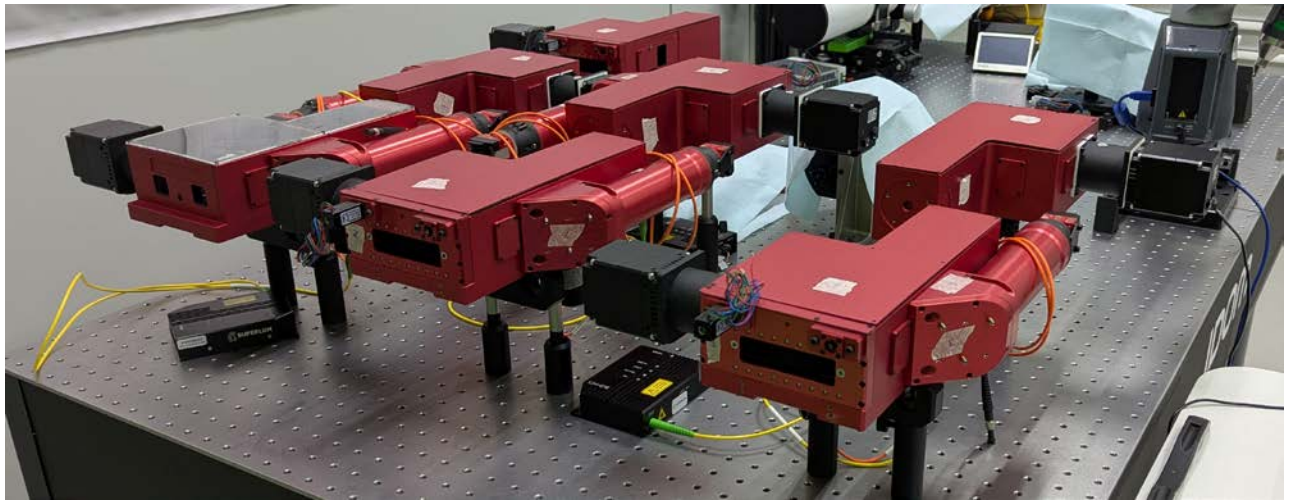
ELT M1 LOCAL COHERENCER







The Project completed the Final Design Phase as of May 2024. The compliance with key performance requirements was Validated with a completely functional early unit of one of the Sensing Modules.
Picture above: Validation model overview and results.

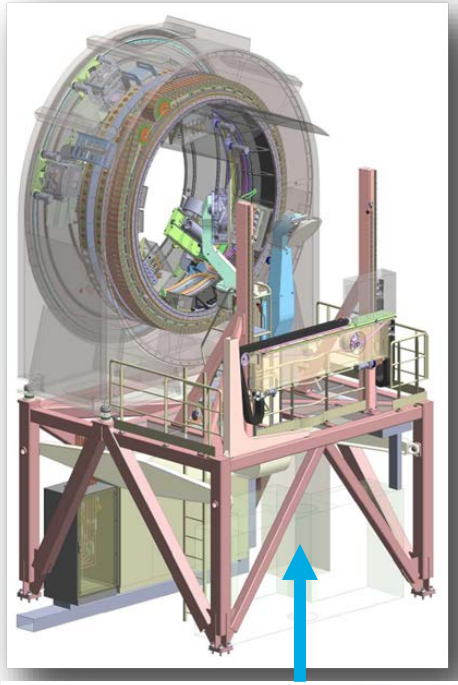


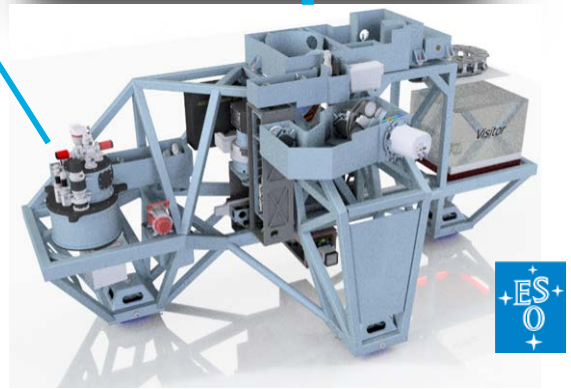
The manufacturing of the system is almost complete, and the integration is ongoing with most of the advances centred around the Sensing Modules.

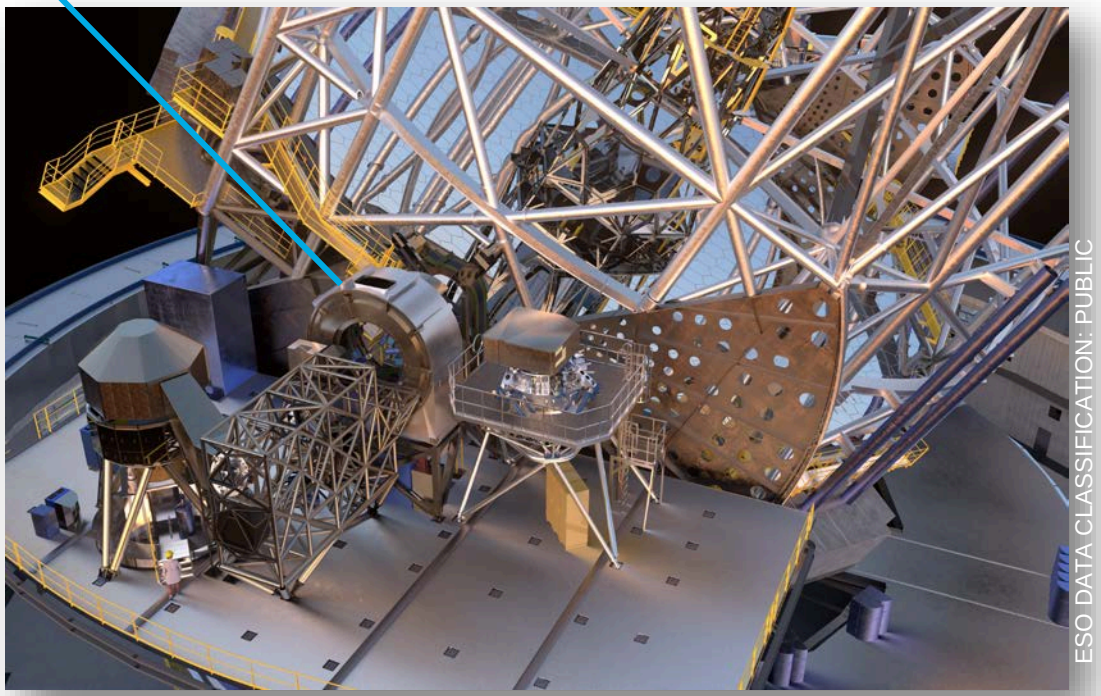
IDOM

bertin winlight

PDS Optics





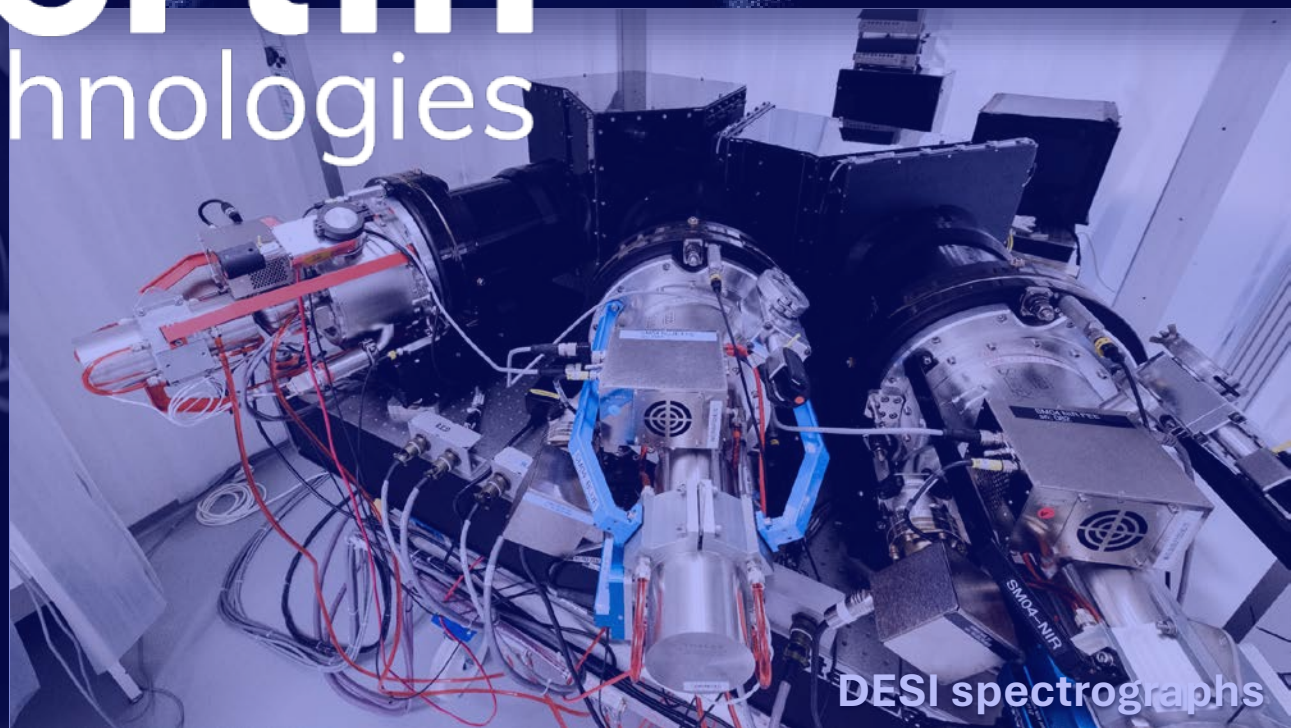


PFS

MUSE field splitter

bertin technologies

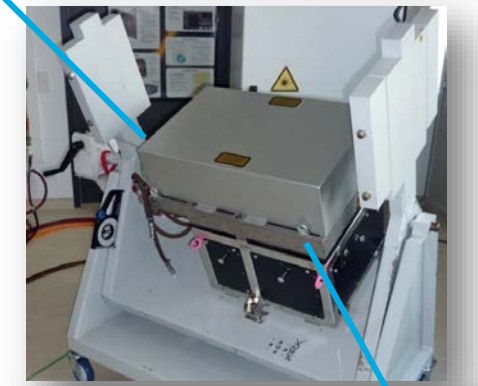
Deformable mirrors

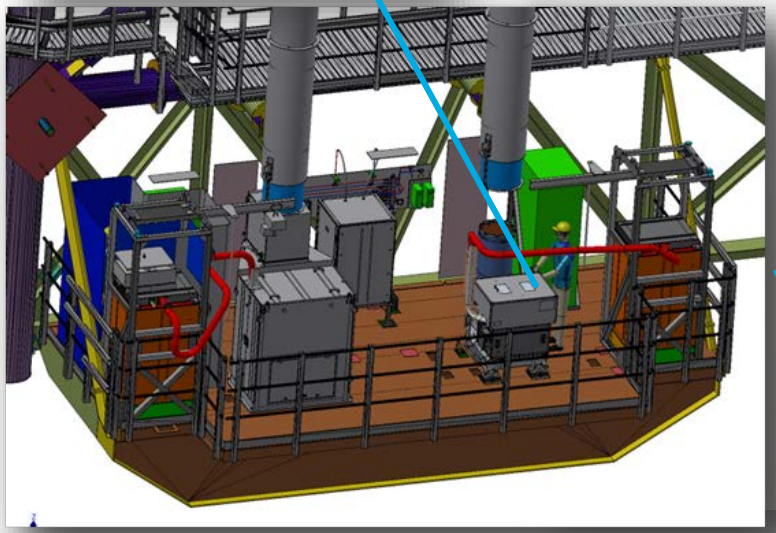


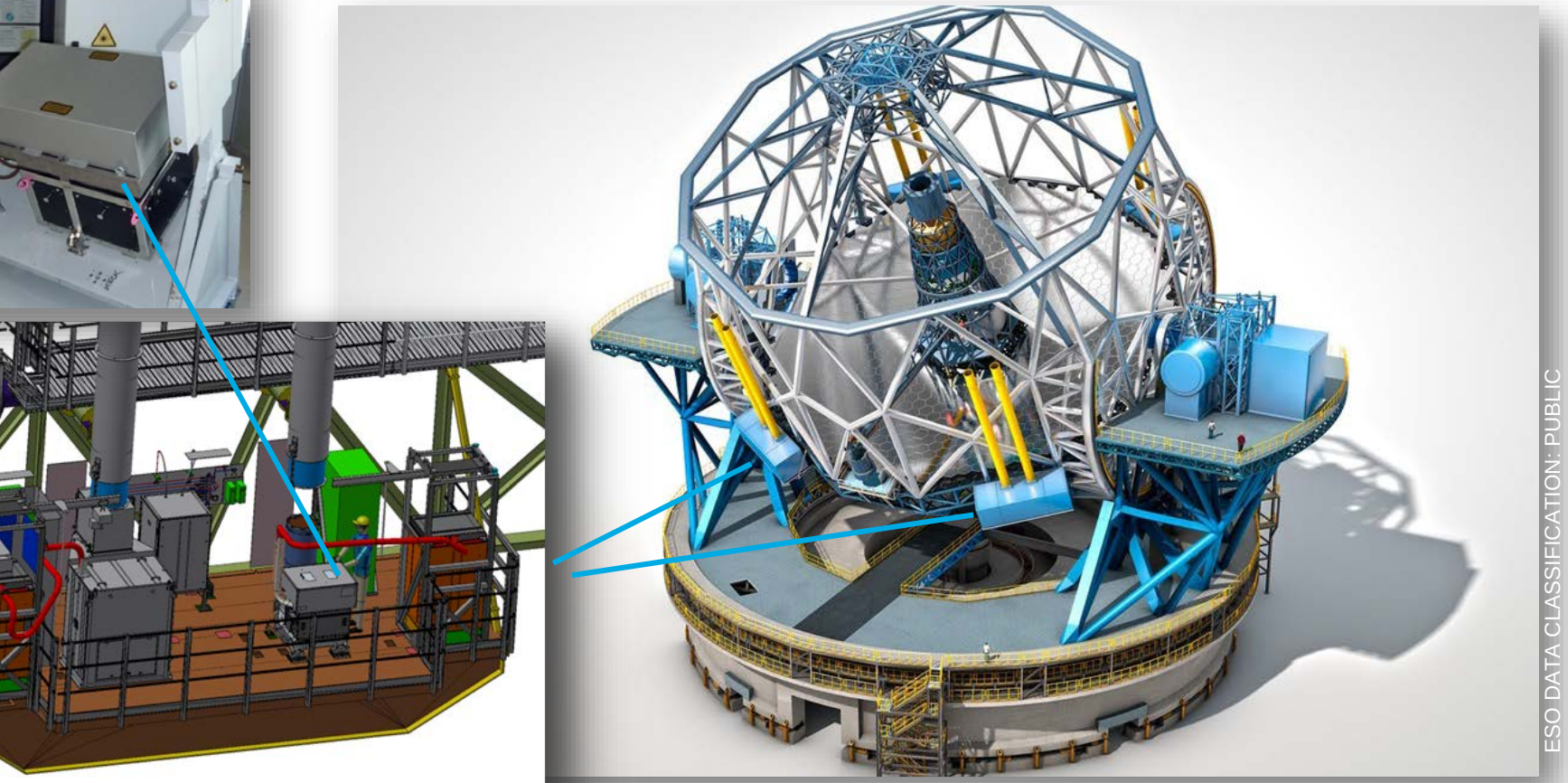
DESI spectrographs

TOPTICA PHOTONICS

LGS
Laser Source







Sodium Guidestar Lasers – SodiumStar 20/2
ESO & TOPTICA: 2002 .. today

TOPTICA Projects

TOPTICA PROJECTS

TOPTICA Projects GmbH

- Spin-off from TOPTICA Photonics AG in 2016
- 25 people
- Guide star lasers for astronomy,
  Fiber amplifiers for laser communications,
  Specialty laser systems

- Mother company
  - TOPTICA Photonics AG
  - 600 people, 150 M€ revenue
  - Diode and fiber lasers for
    quantum technology, biophotonics & materials

TOPTICA PROJECTS

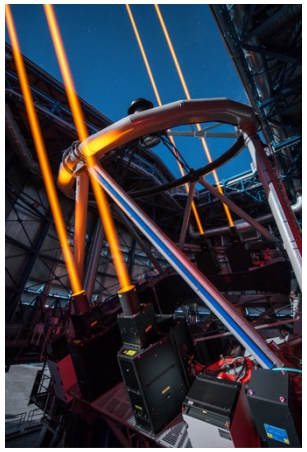
Sodium Guide Star Laser – ESO & TOPTICA

2010
Contract
Guide Star Laser
for 4LGS

2014
4LGS
development
accepted by ESO

2016
4 LGS installed at
VLT

Berthold
Leibinger
Innovation Award
(TOPTICA, MPB,
ESO)



2017
Order for
LU6..LU9 (ELT)

2021
Order for
LU10..LU14
(Gravity+)

2024
Delivery of LU 14
SodiumStar

Ongoing R&D activities with ESO –> higher efficiency

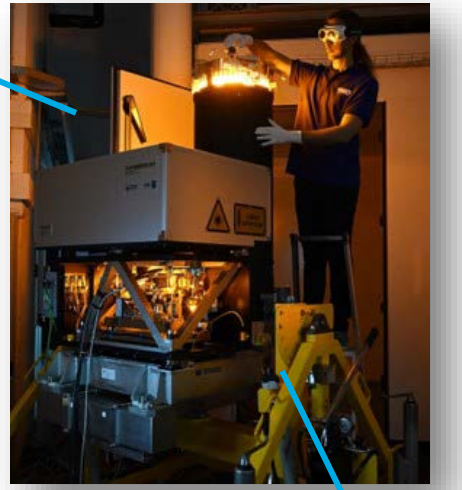
TOPTICA PROJECTS

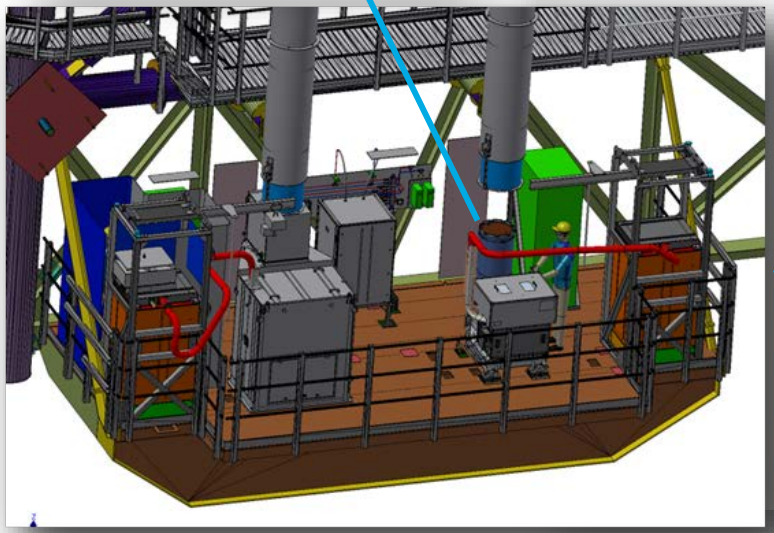
Thanks!

TOPTICA PROJECTS

TNO

LGS
Laser Projection
Subunit
(launch telescope)





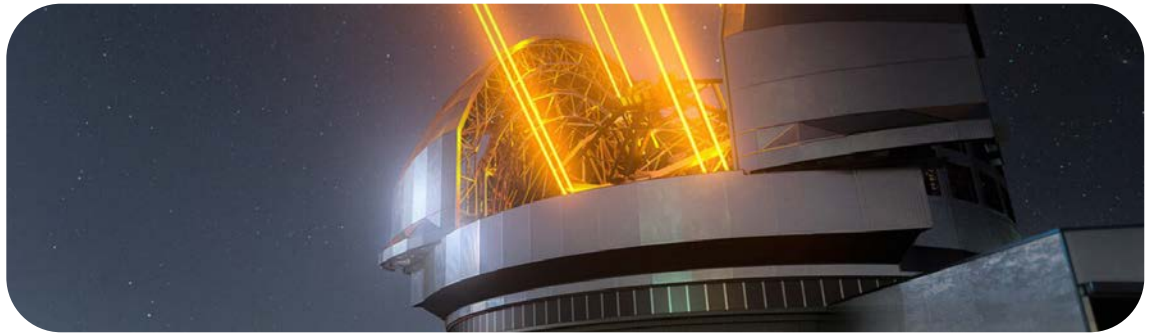
Laser Projection System (LPS)

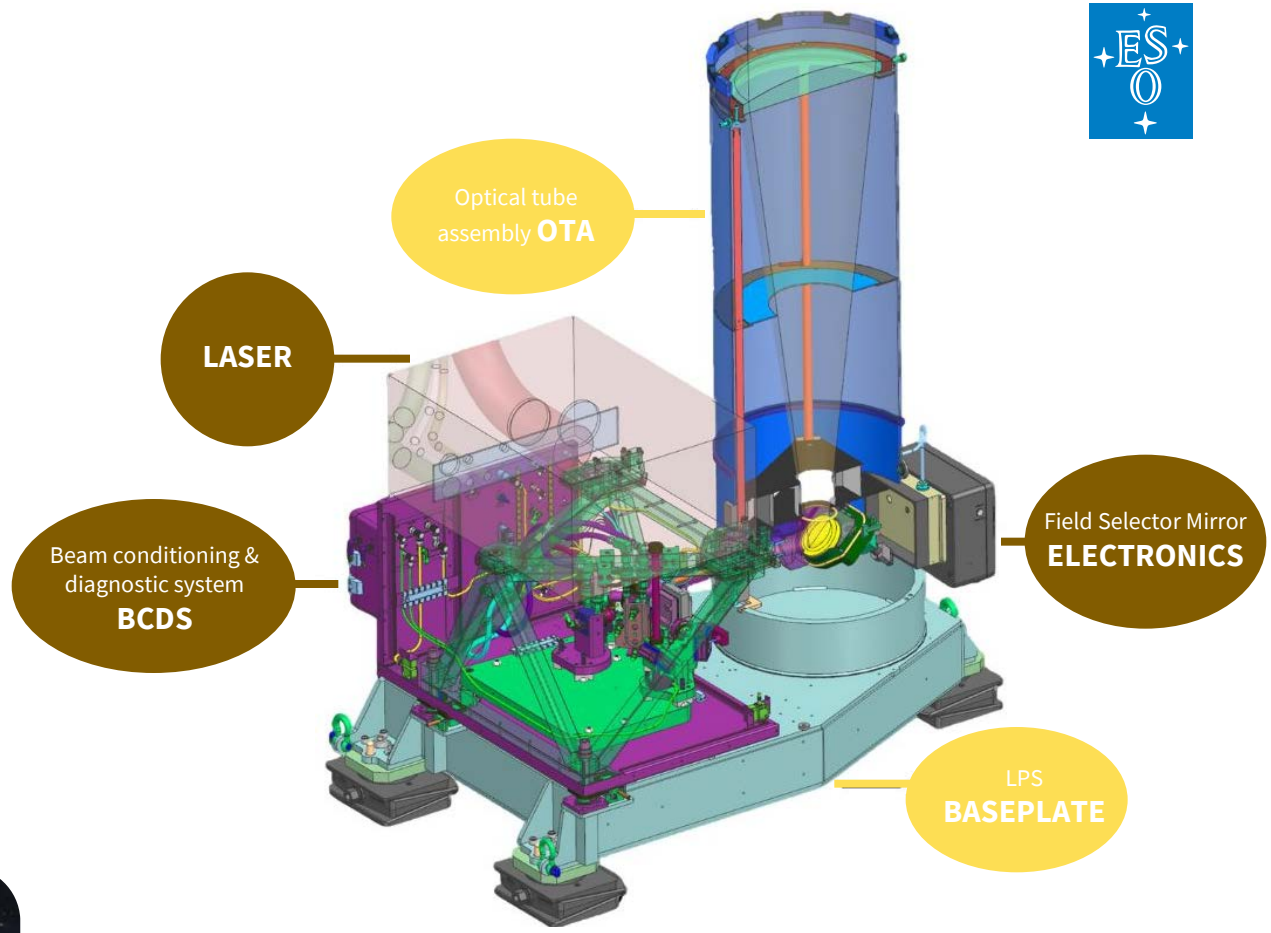
Main Characteristics

Projects artificial ‘star’ by exciting sodium atoms in upper atmosphere – used for AO correction

TNO-Demcon consortium delivers 3 systems for VLT Gravity+ and 6 systems for ELT

Mature product: improved opto-mechanical and electronics design for high performance, long lifetime & better serviceability





TNO

The Netherlands Organization for Applied Technical Sciences, with 60 years of 100% success in Space & Scientific Instrumentation. TNO is the innovation engine of the Netherlands.

Demcon Focal

Demcon Focal specializes in the design, engineering and assembly of custom optomechatronic and vision systems. Demcon Focal serves a variety of high-tech markets.

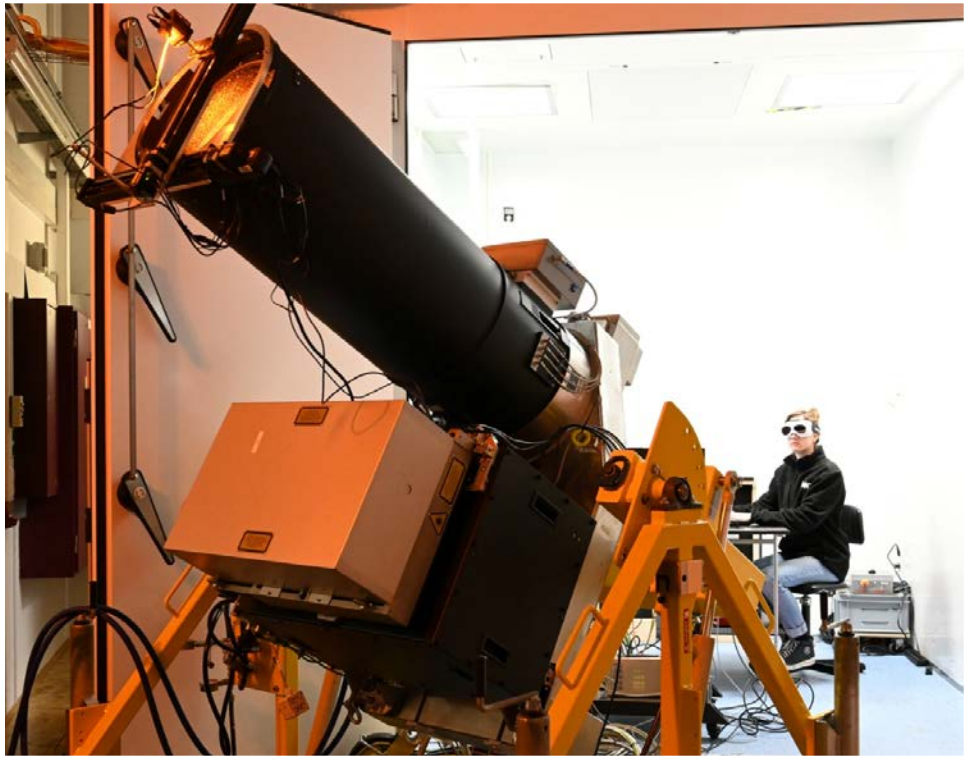
TNO innovation for life

DEMCON

Laser Projection System (LPS)

Project status

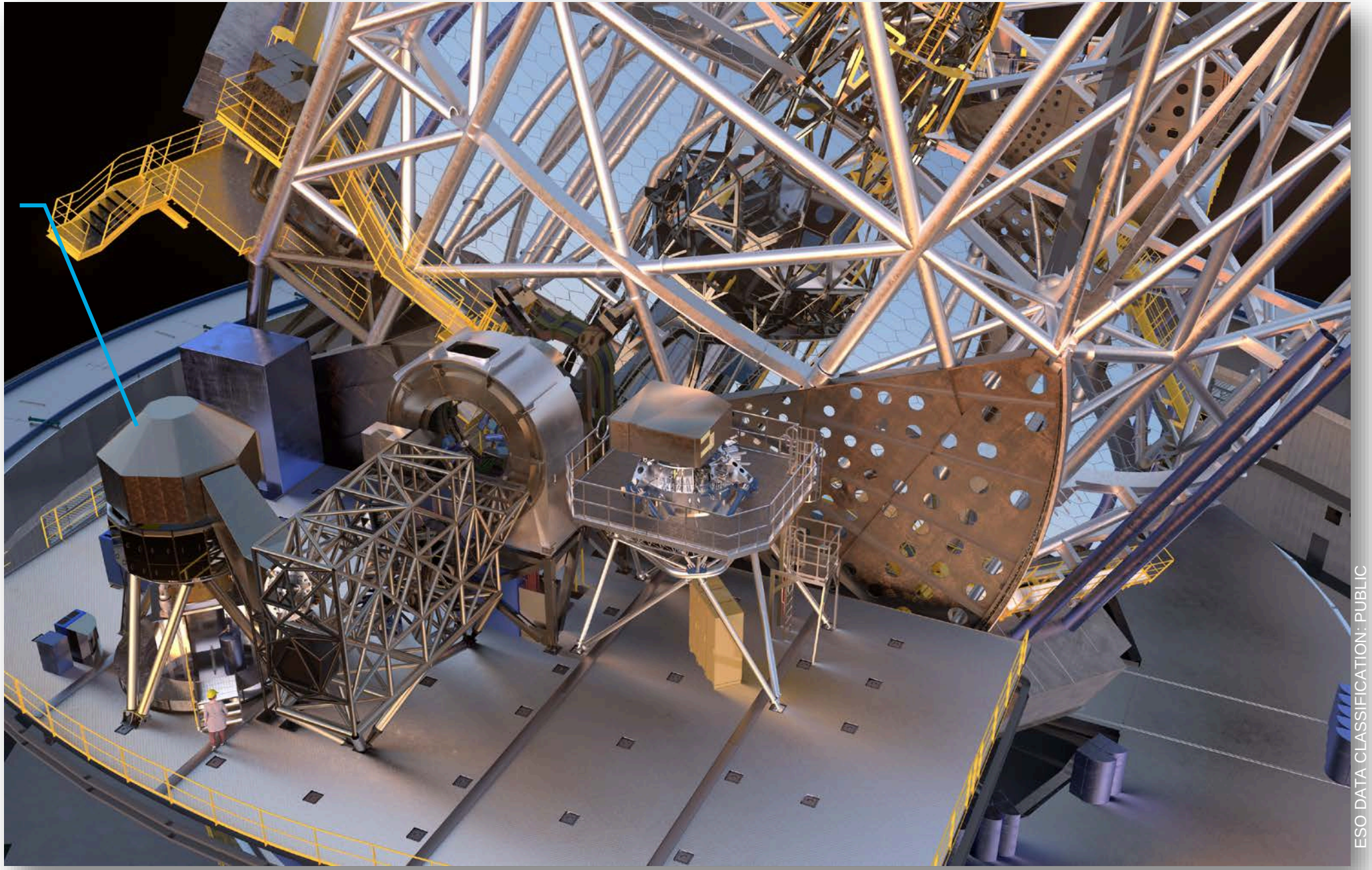
- High power testing of LPS1&2 at ESO HQ completed successfully. LPS3 testing actively ongoing!
- Integration & FAT of LPS4-9 over the coming year



Specification	ELT Requirement
Design power	50W
Optical throughput @ 589nm	Spec: 88% Achieved: 98,9%
Total transmitted WFE, excluding TTF	Spec: 65 nm Achieved: 11.6nm
PER (|S3 / S0|)	Spec: 0.82 Achieved: 0.986
Defocus	±0.2 waves
Field selector	
Pointing range	7.0' radius on-sky
Steering speed	2"/s
Slewing speed	25"/s
Accuracy	2.5"
Pointing resolution	0.2"
Jitter control	
Pointing range	8.0" radius
Accuracy	5 mas
Pointing resolution	1 mas
BEU focus range	±5 waves
Total Mass	~750kg
Envelope (L x W x H)	Length 1.7m Width 1.4m Height 2.4m

Scientific Instrumentation

MICADO
Instrument



MAX-PLANCK-INSTITUT
FÜR EXTRATERRESTRISCHE PHYSIK

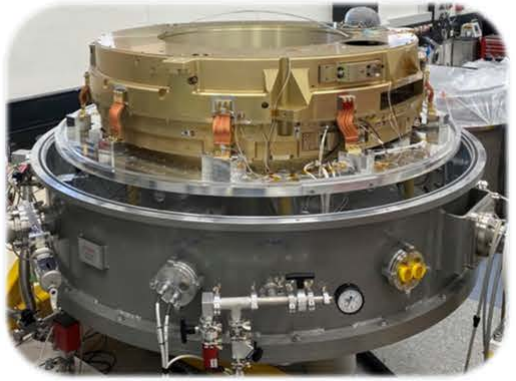
MPE:

- 350 staff + 75 guest scientists.
- Building & using world class astronomical satellites & instruments.
- Nobel Prize in 2020 for research on Black Holes.
- Leading the MICADO consortium.

MICADO:

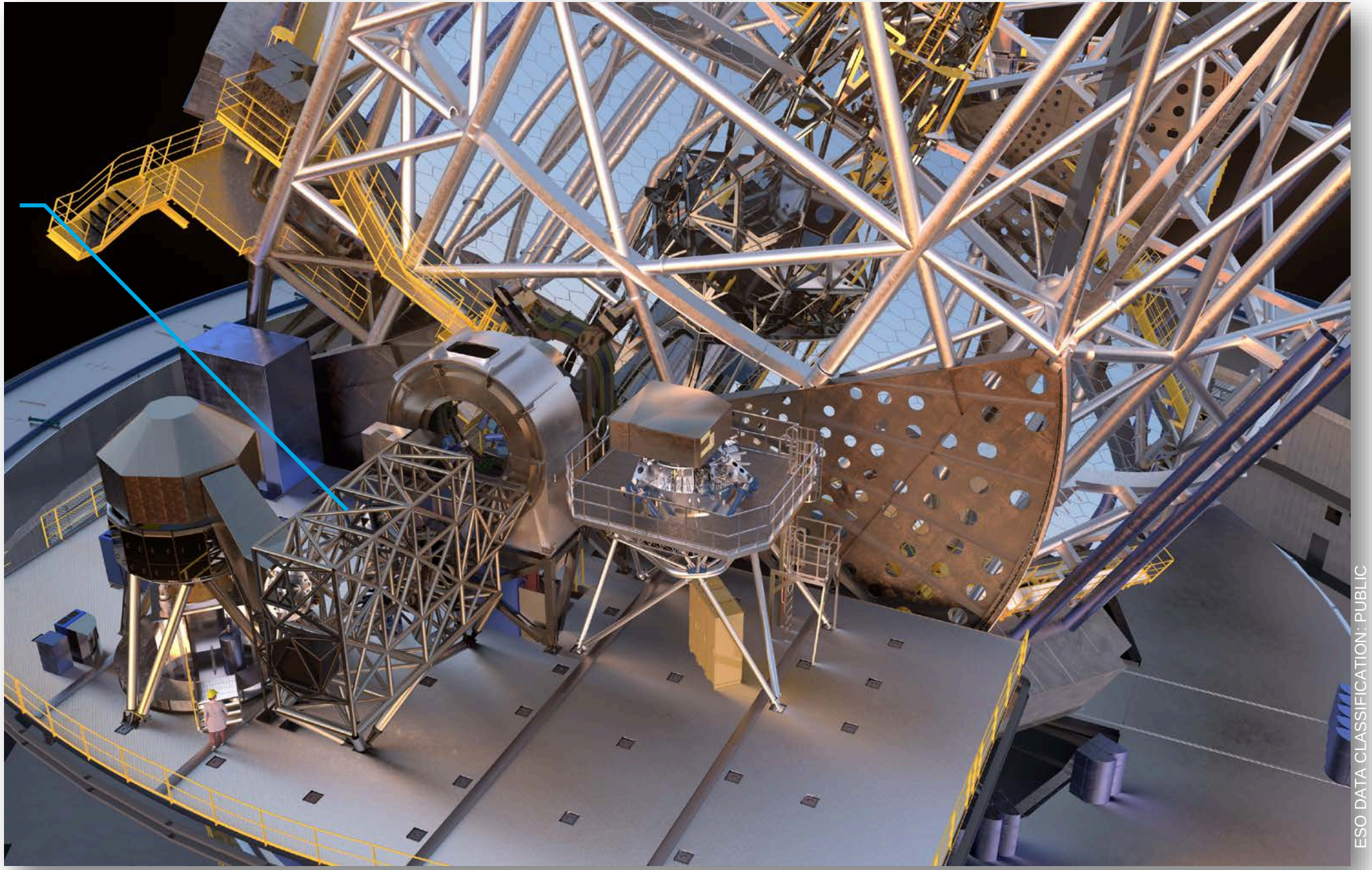
- 9 partners in 6 countries + ESO.
- A first light instrument for the ELT.
- Cryogenic mechanisms under test.

MICADO

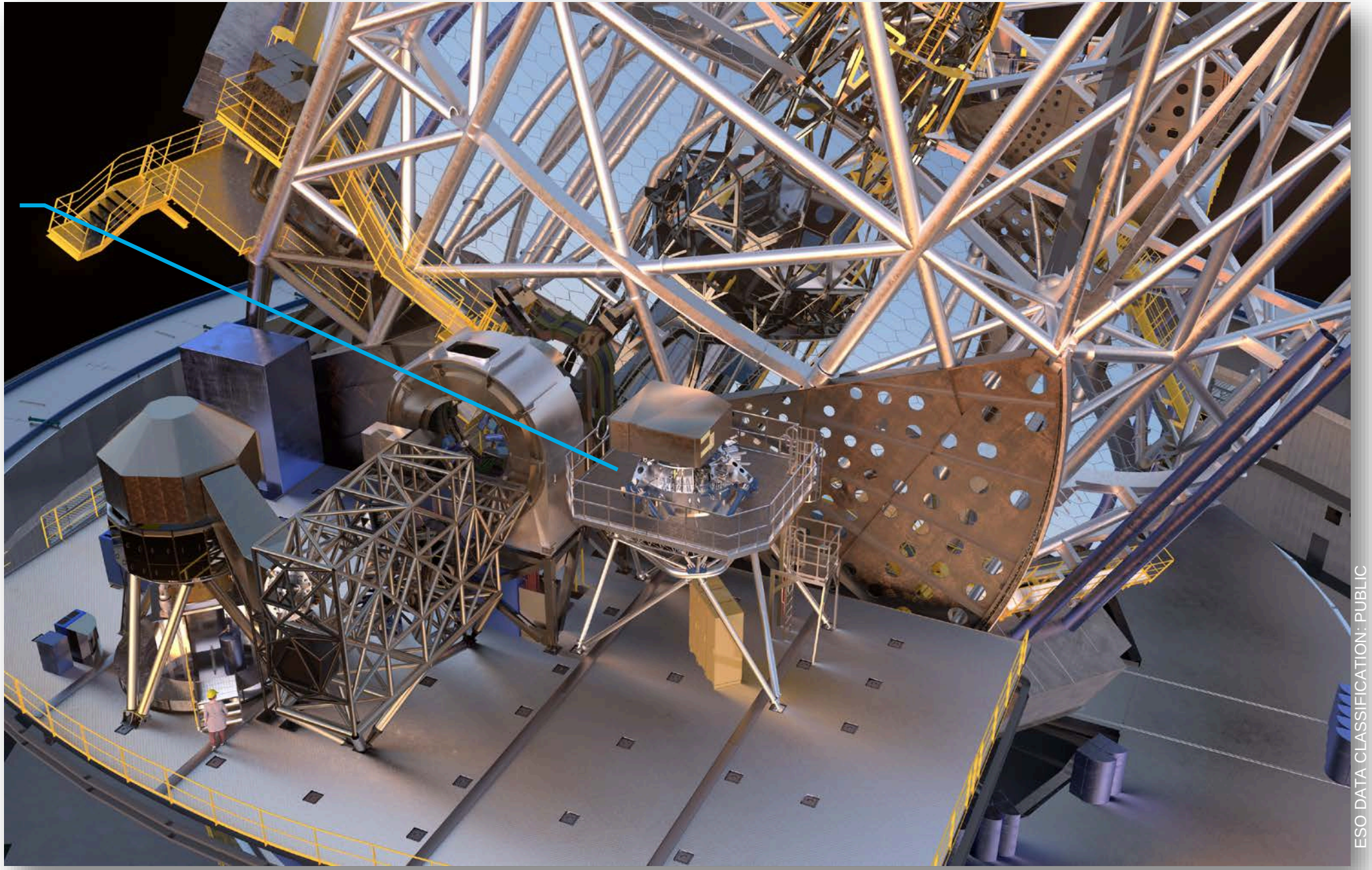


INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

MORFEO Instrument



METIS Instrument

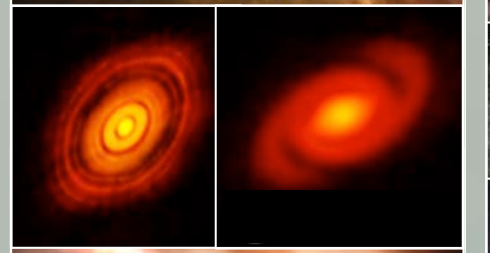


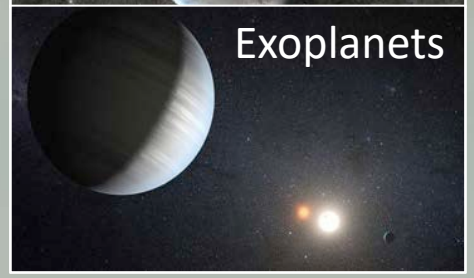
METIS – *the* 1st Generation Instrument for compact Sources in a cool and dusty Universe

Mid-infrared ELT Imager and Spectrograph

PI: Bernhard Brandl; PM: Felix Bettonvil

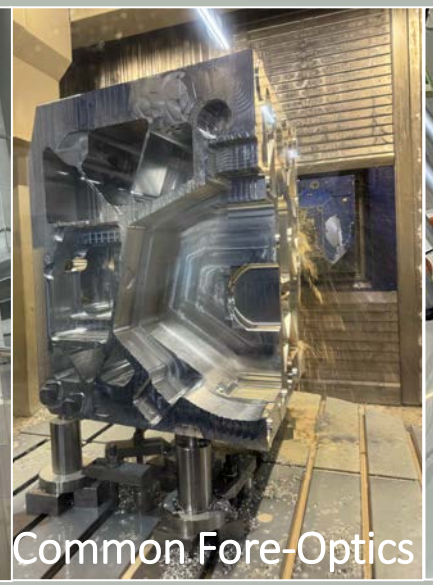
Main science drivers: the study of…





…and much more!

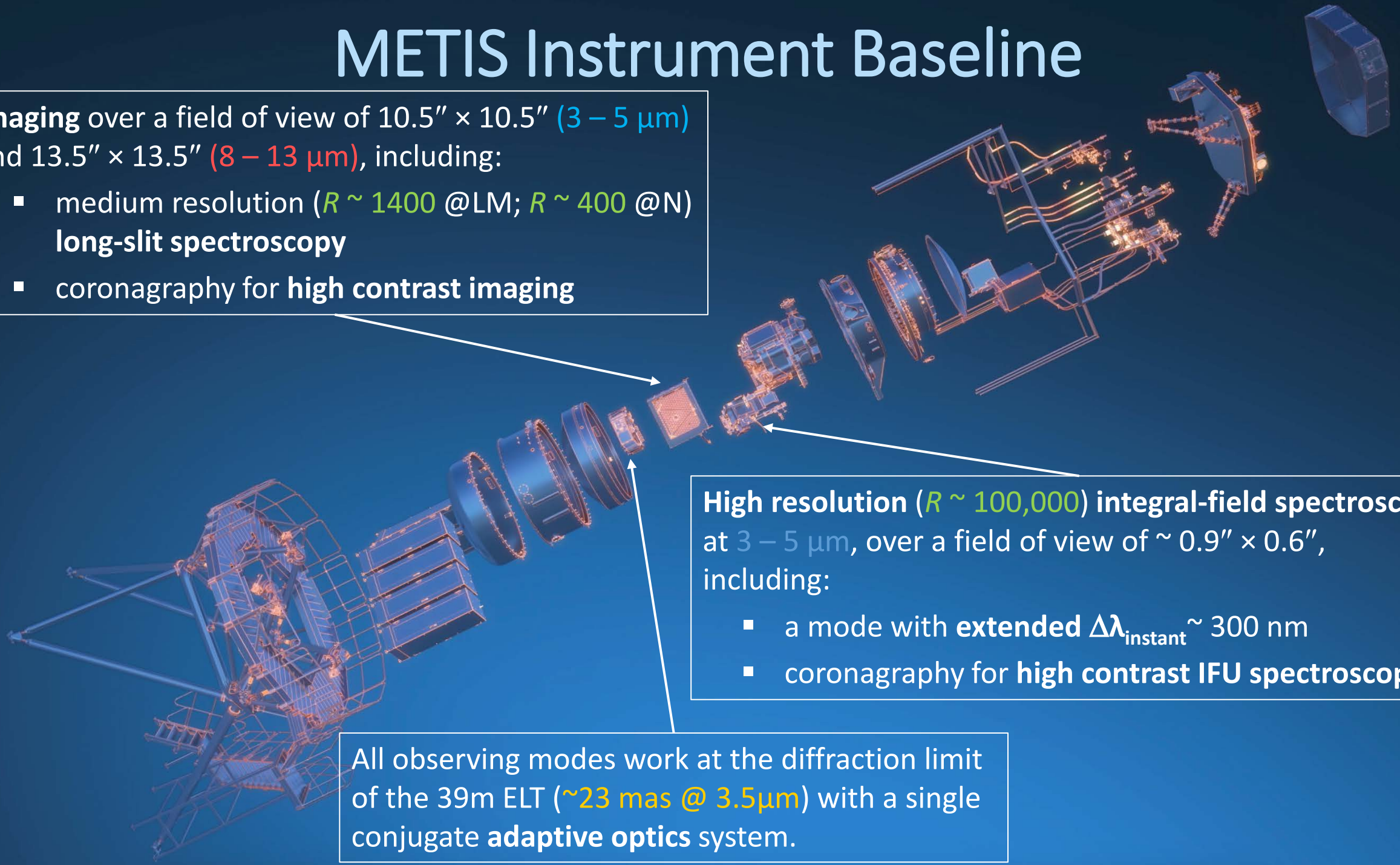
Hardware procurement is in full swing:



METIS Instrument Baseline

Imaging over a field of view of 10.5″ × 10.5″ (3 – 5 µm) and 13.5″ × 13.5″ (8 – 13 µm), including:

- medium resolution (*R* ~ 1400 @LM; *R* ~ 400 @N) **long-slit spectroscopy**
- coronagraphy for **high contrast imaging**



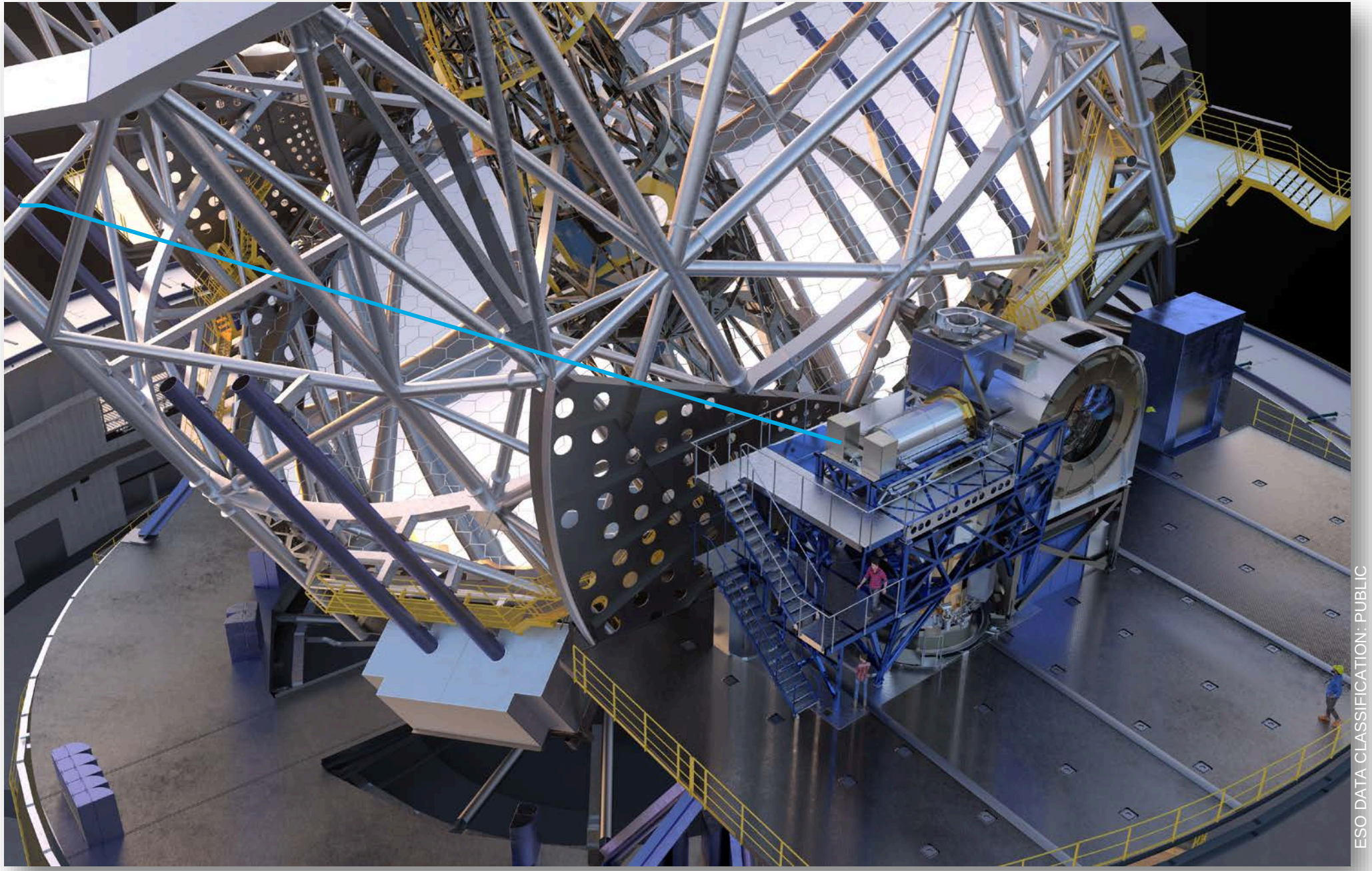
High resolution (*R* ~ 100,000) **integral-field spectroscopy** at 3 – 5 µm, over a field of view of ~ 0.9″ × 0.6″, including:

- a mode with **extended** $\Delta\lambda_{instant}$ ~ 300 nm
- coronagraphy for **high contrast IFU spectroscopy**

All observing modes work at the diffraction limit of the 39m ELT (~23 mas @ 3.5µm) with a single conjugate **adaptive optics** system.

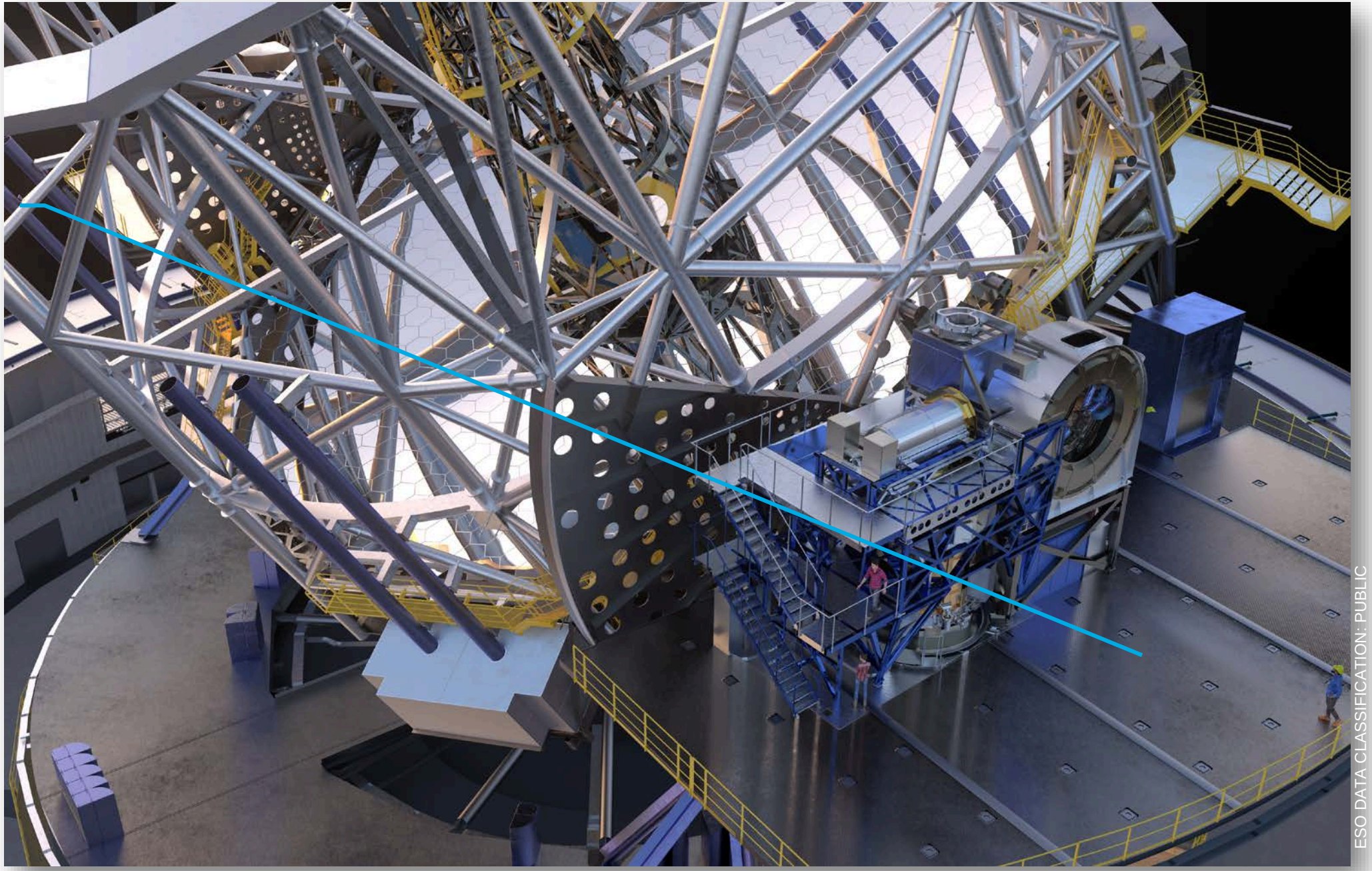
Science & Technology Facilities Council

HARMONI Instrument

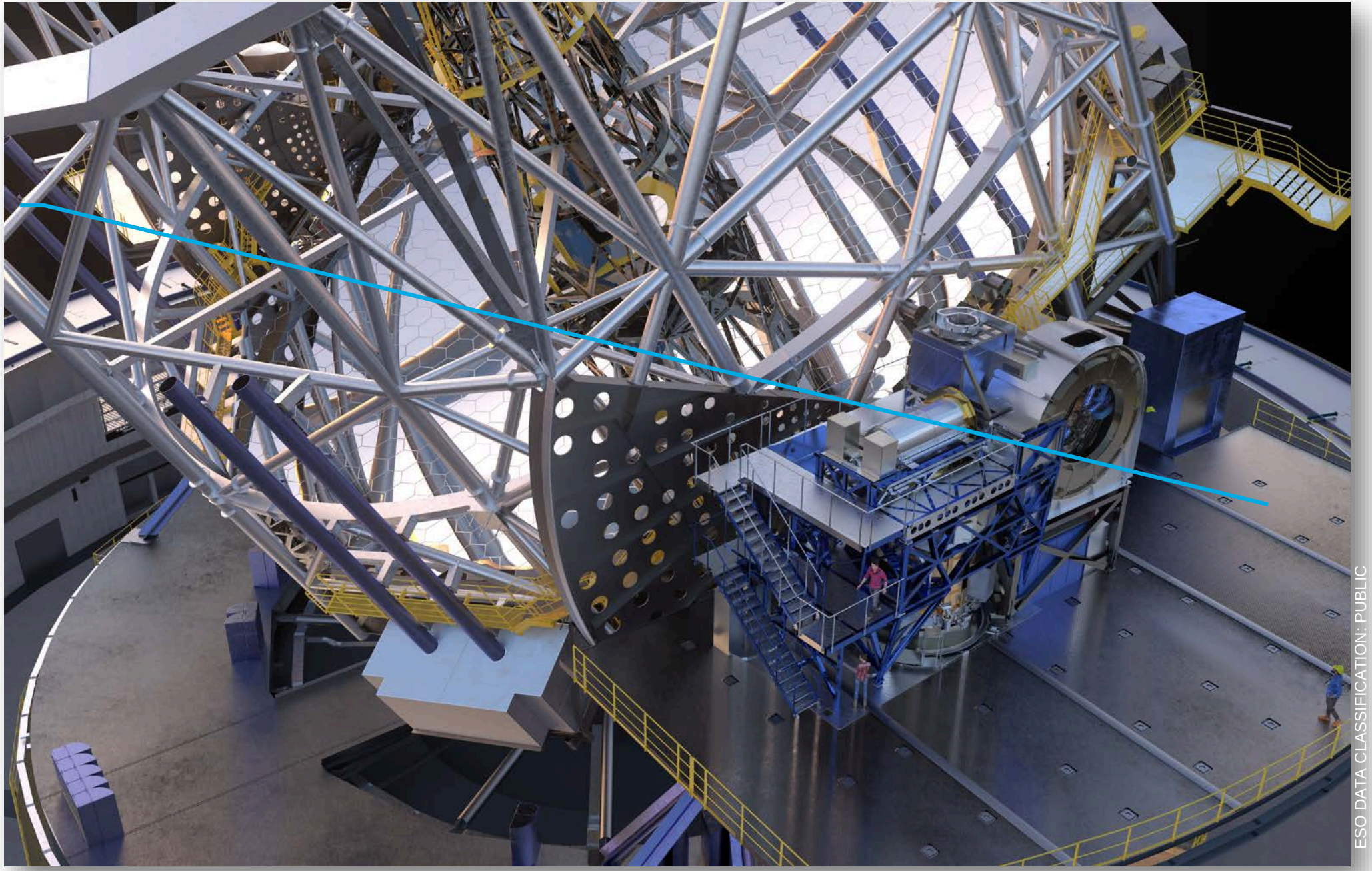


INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

ANDES Instrument



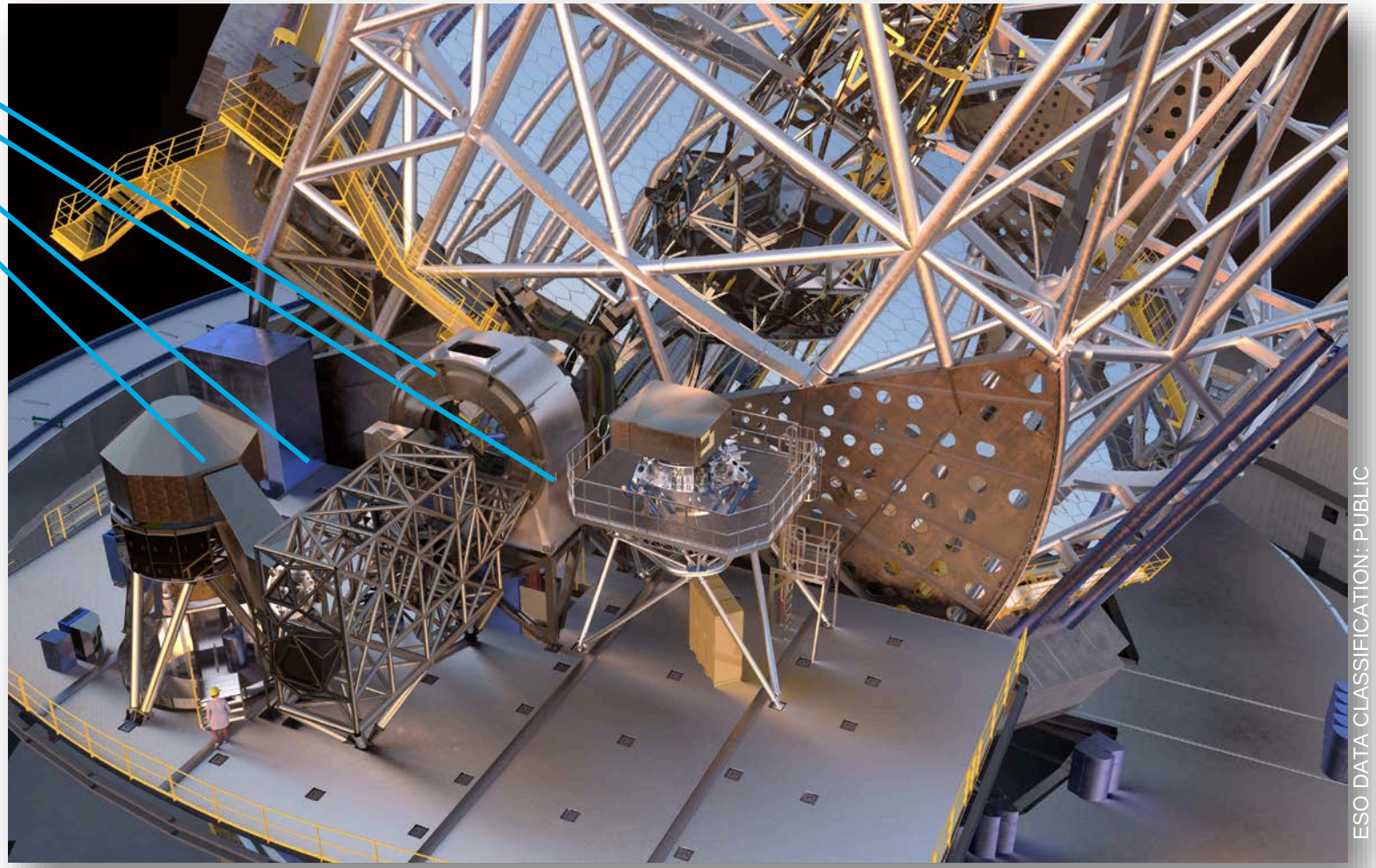
MOSAIC
Instrument



Detectors
&
Wave Front Sensing Cameras

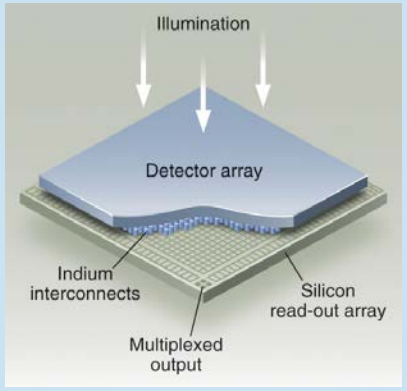
TELEDYNE e2v
Everywhereyoulook™

Detectors for:
- Instruments
- Wave Front Sensors

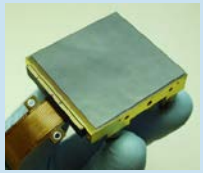


Teledyne Space Imaging is proud to support the First Light Instrumentation of ESO's Extremely Large Telescope - CCD, CMOS and Infrared Focal Plane Arrays

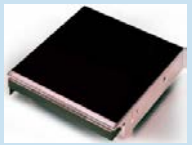
IR FPAs have a readout integrated circuit (ROIC) hybridized to HgCdTe detector material that is grown and processed for the wavelengths of interest.



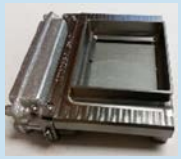
Hybrid CMOS FPA



H2RG
2048×2048 pixels
18 µm pixel pitch



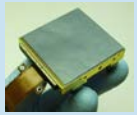
H4RG-15
4096×4096 pixels
15 µm pixel pitch



GeoSnap-18 2K×2K
2048×2048 pixels
18 µm pixel pitch

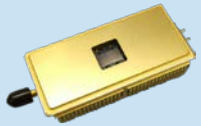
METIS
Imager and Spectrograph

1x GeoSnap-18
VLWIR HgCdTe

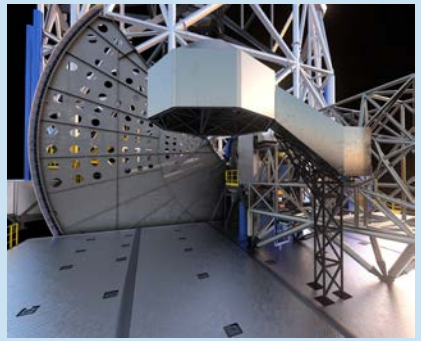


4x H2RG MWIR
HgCdTe

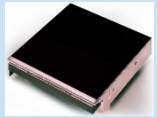
MORFEO
Adaptive Optics System



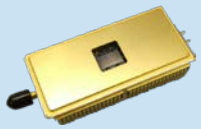
CCD220 in
4x ALICE cameras



MICADO
Adaptive Optics Imaging Camera

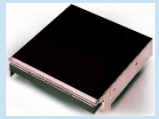


9x H4RG-15 SWIR
HgCdTe arrays

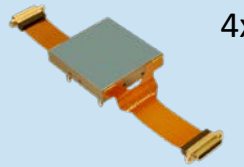


CCD220 in
1x ALICE camera

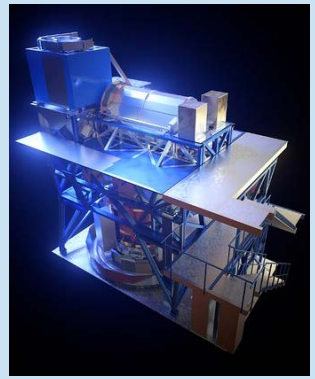
HARMONI
Near infrared integral field spectrograph



8x H4RG-15 SWIR
HgCdTe arrays



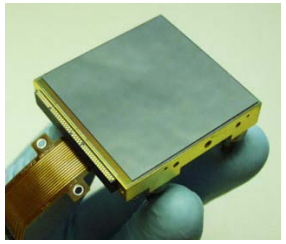
4x CCD231-84



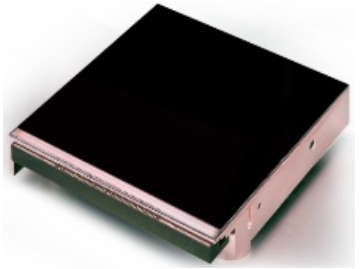
TELEDYNE | Space Imaging

H2RG and H4RG-15 Infrared Focal Plane Arrays

H: HAWAII: HgCdTe Astronomical Wide Area Infrared Imager
x: Number of 1024 (or 1K) pixel blocks in x and y-dimensions
R: Reference pixels
G: Guide window capability



H2RG
2K×2K, 18 µm pitch



H4RG-15
4K×4K, 15 µm pitch

ROIC	Pixel Pitch µm	Pixel amplifier	Full Well* ke-	# of Outputs	Readout Noise (e-)	Rows #	Columns #	Shutter Type	Input	Output	TRL	Space Telescope	λ_c (µm)
H2RG	18	Source Follower	80 - 120	1, 4, 32	10 - 18	2040	2040	Rolling	Analog	Analog	9	JWST +	2.5 & 5.3
H4RG-15	15		80 - 120	1, 4, 16, 32, 64	12 - 20	4096	4096				9	ISS / PIANO	2.5

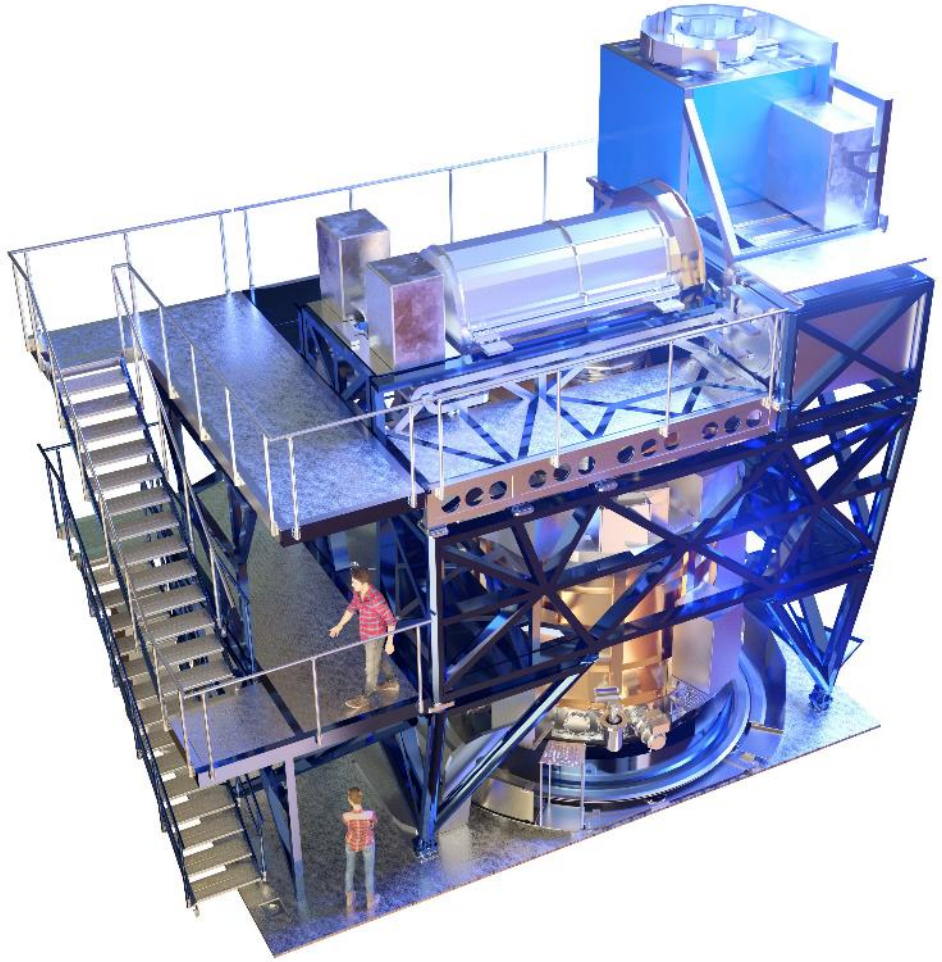
- Readout noise of HxRG (source follower) ROICs stated for single correlated double sampling.
  - Noise can be reduced by multiple sampling.
- HxRG full well and readout noise depend on cutoff wavelength and operating conditions (e.g. detector bias).
- Technology Readiness Level (TRL)
  - TRL-9 denotes that the FPA is operating in space.

CCD sensors on the HARMONI instrument

CCD231-84

- 4x science grade CCD sensors supplied
- 4096 x 4112, 15 µm square pixels
- Back illuminated for high quantum efficiency
- Custom graded anti-reflection coating
- 2e readout noise
- Peak signal of 350 ke−/pixel
- Deep depletion options for Red/NIR

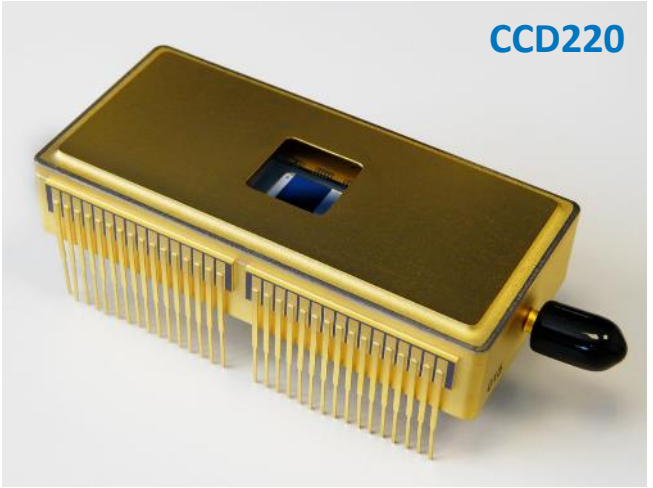
CCD231-84



Teledyne Space Imaging sensors for Adaptive Optics

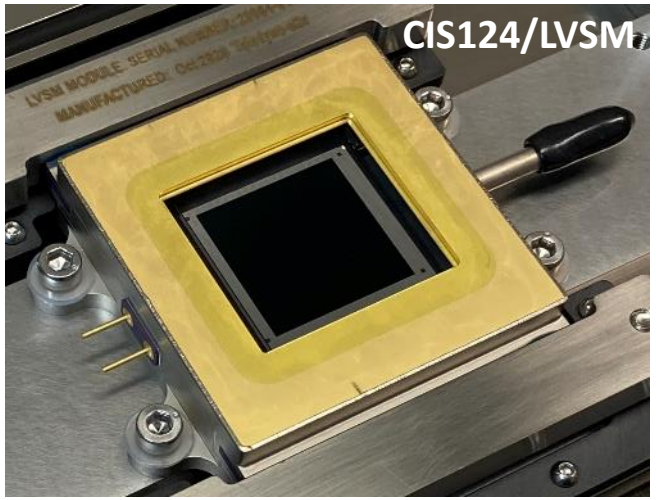
CCD220

- 19x science grade CCD sensors delivered
- The CCD220 is an **EMCCD** specifically designed for Adaptive Optics (AO) Wavefront Sensing (WFS) for ESO
- 240 x 240, 24 µm square pixels
- >1500 fps
- 8 outputs
- Sub electron read noise (using EM gain)
- Deep-depleted silicon for better red response



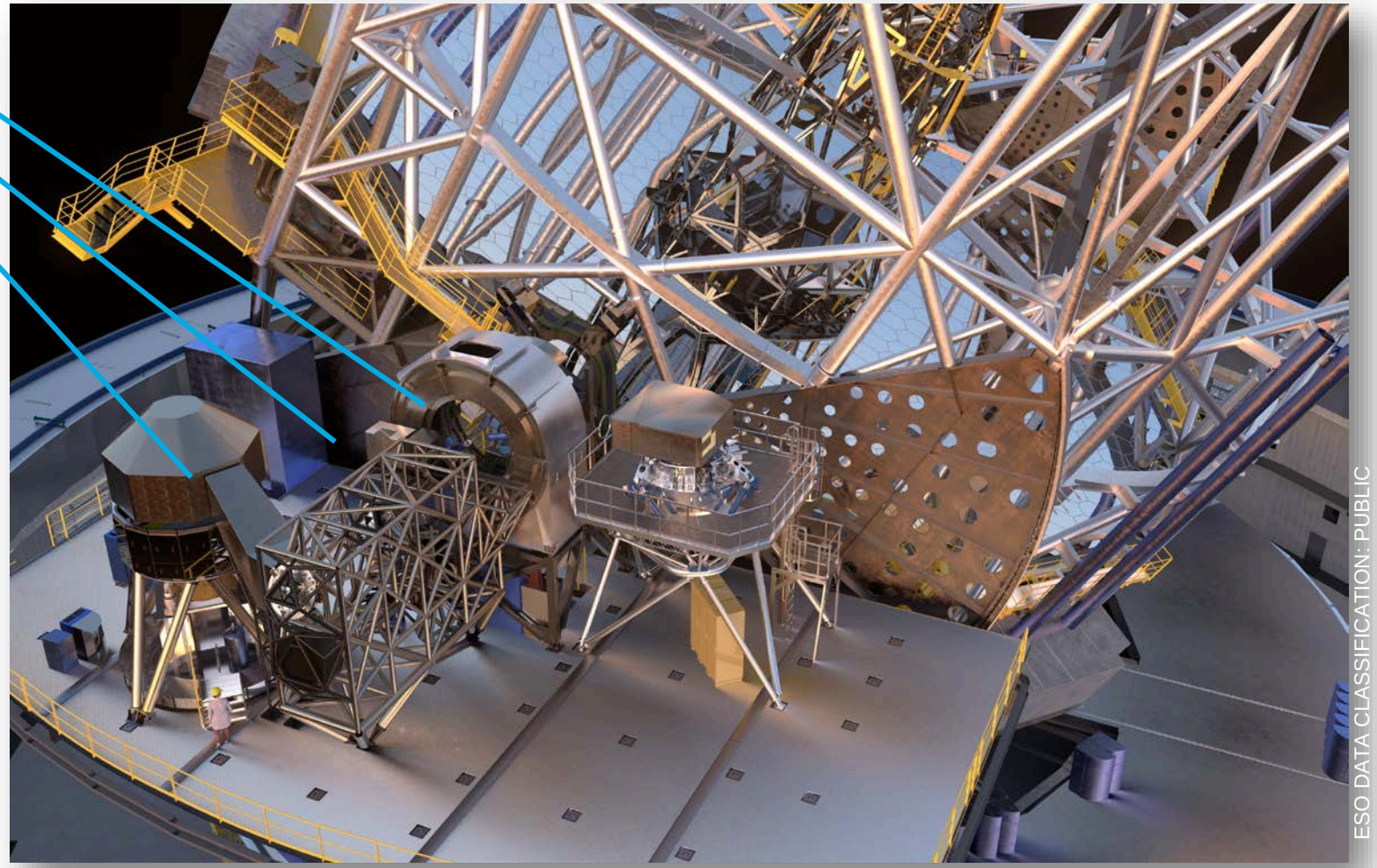
CIS124 / LVSM

- 28x science grade CMOS sensors delivered
- The CIS124 is a **CMOS** imager specifically designed for Adaptive Optics (AO) Wavefront Sensing (WFS) for ESO
- 800 x 800, 24 µm square pixels
- ~720 fps, with 9/10 bits digital output, 24x LVDS channels
- 400 regions, 40 x 40 pixels in size with independent pre-amp gain settings
- Back illuminated for highest QE and best intra-pixel uniformity



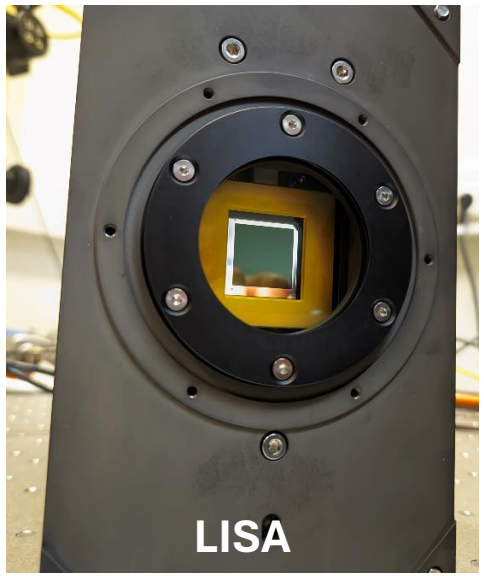
ThalesAlenia Space
a Thales / Leonardo company

Wave Front Sensing Cameras



Wavefront Sensing Cameras for the ELT

- Two types of wavefront sensing cameras, based on two detectors
  - 21x **ALICE** (CCD220)
  - 9x **LISA** (CIS124/LVSM), more expected
- Designed and prototyped by ESO
- Common platform with 85% shared components
- Built to print contract
- Production split in two phases:
  - **Validation model phase**, almost concluded
  - **Mass production phase**, delivery in batches
- Installed at:
  - **ELT Telescope:** Pre-Focal Stations, Phase and Diagnostic Station
  - **ELT Instruments:** MORFEO, MICADO, (MOSAIC)
  - ***VLT Instrument:*** *MAVIS*



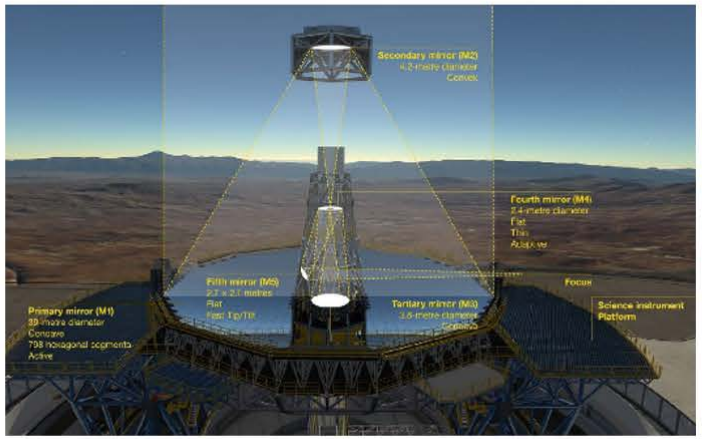
Supporting Infrastructure

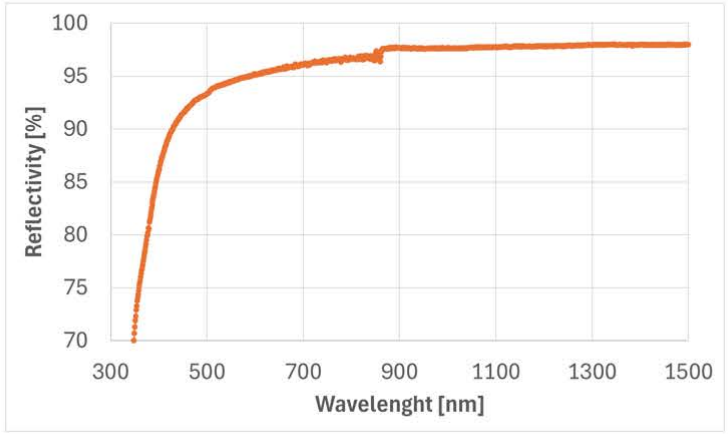
AGC
Your Dreams, Our Challenge

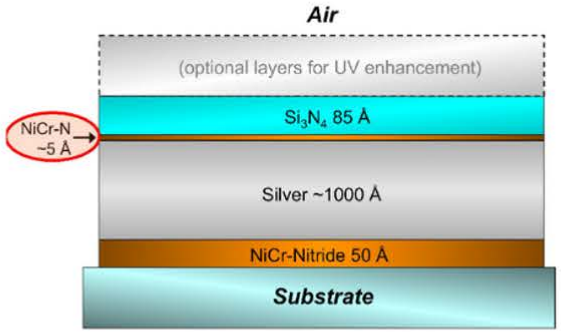
M1 Coating Plant

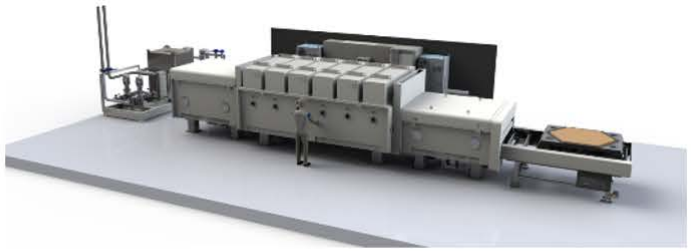
Large Mirrors
Coating Plant

AGC Plasma Technology Solutions supplies 3 coating systems for initial coating and maintenance of all large area mirrors of the ELT (M1 - M5).









Mirror Coating plants for M1 segments

Contract signature: June 2018

Acceptance: April & June 2022

Large Coating Plant for M2 – M5

Contract signature: May 2021

Acceptance : December 2025

FAGERSTRÖM
INDUSTRIKONSULT AB

M1 Washing and Stripping Plant

FAGERSTRÖM
INDUSTRIKONSULT AB

M1WS

Washing and stripping plant

Application unit

Main process steps

1 Detergent

2 Etchant

3 Acidic rinse

4 Water rinse

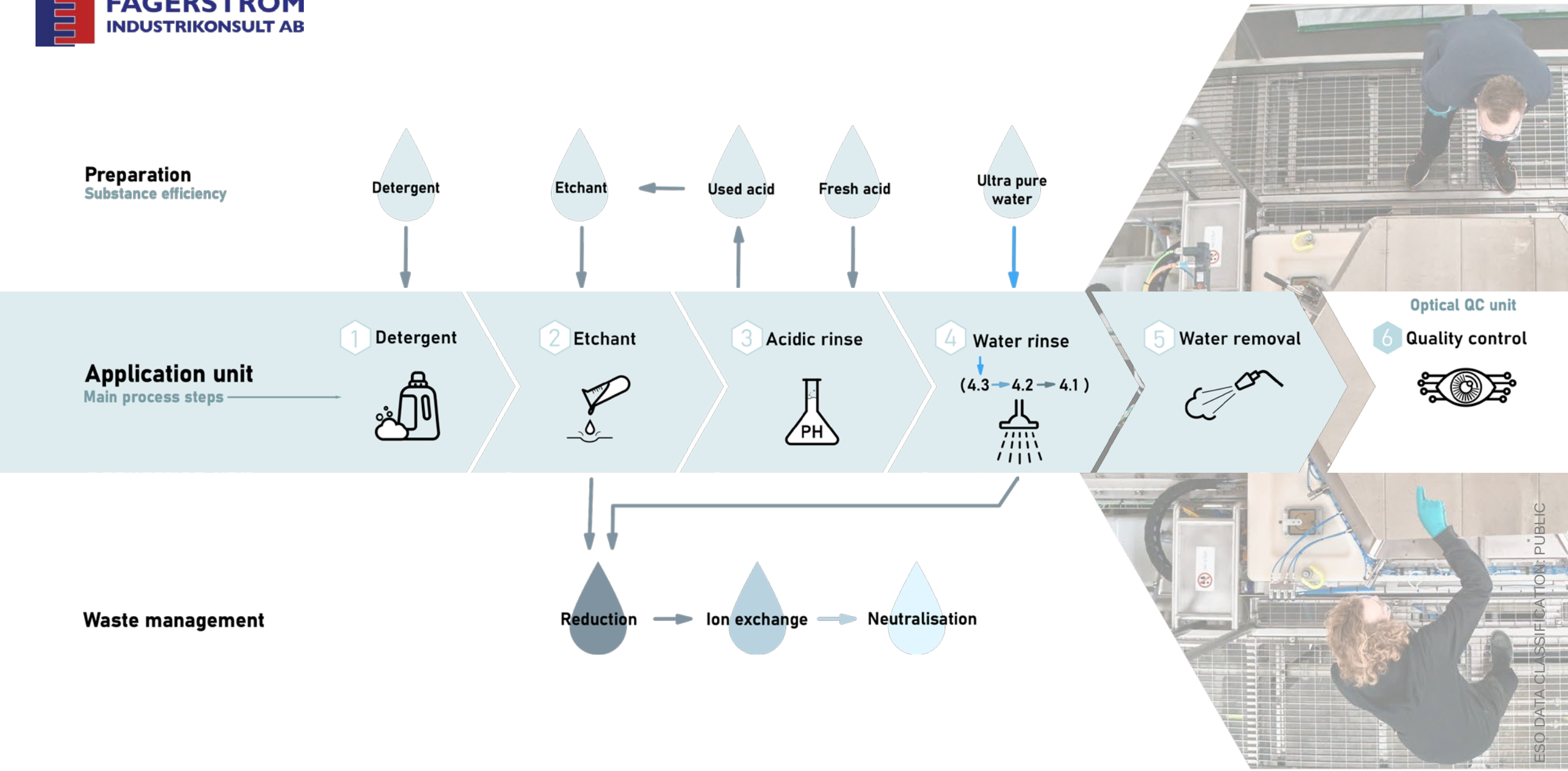
(4.3 → 4.2 → 4.1)

5 Water removal

Optical QC unit

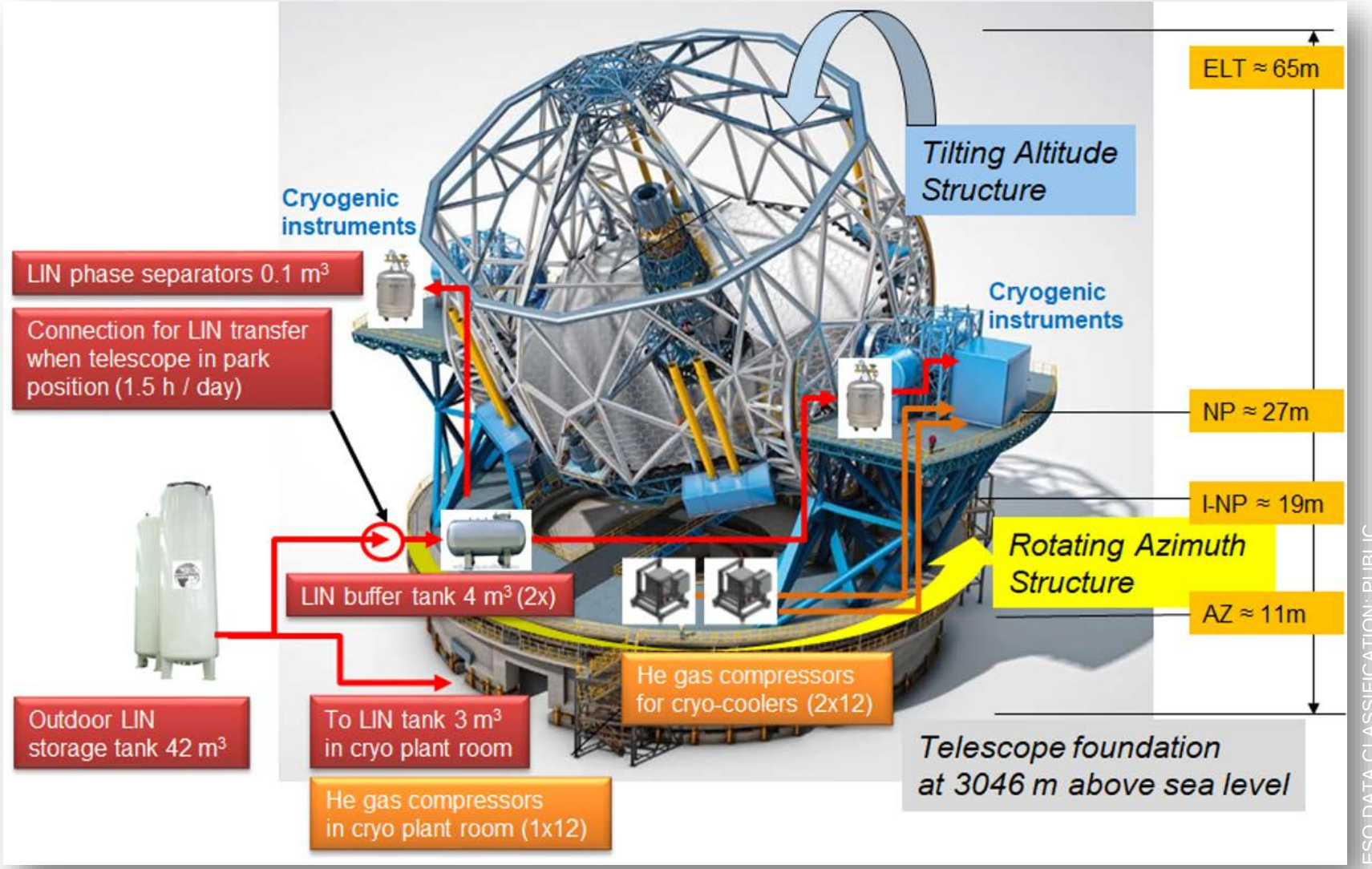
6 Quality control

FAGERSTRÖM
INDUSTRIKONSULT AB



Scientific Products Ltd

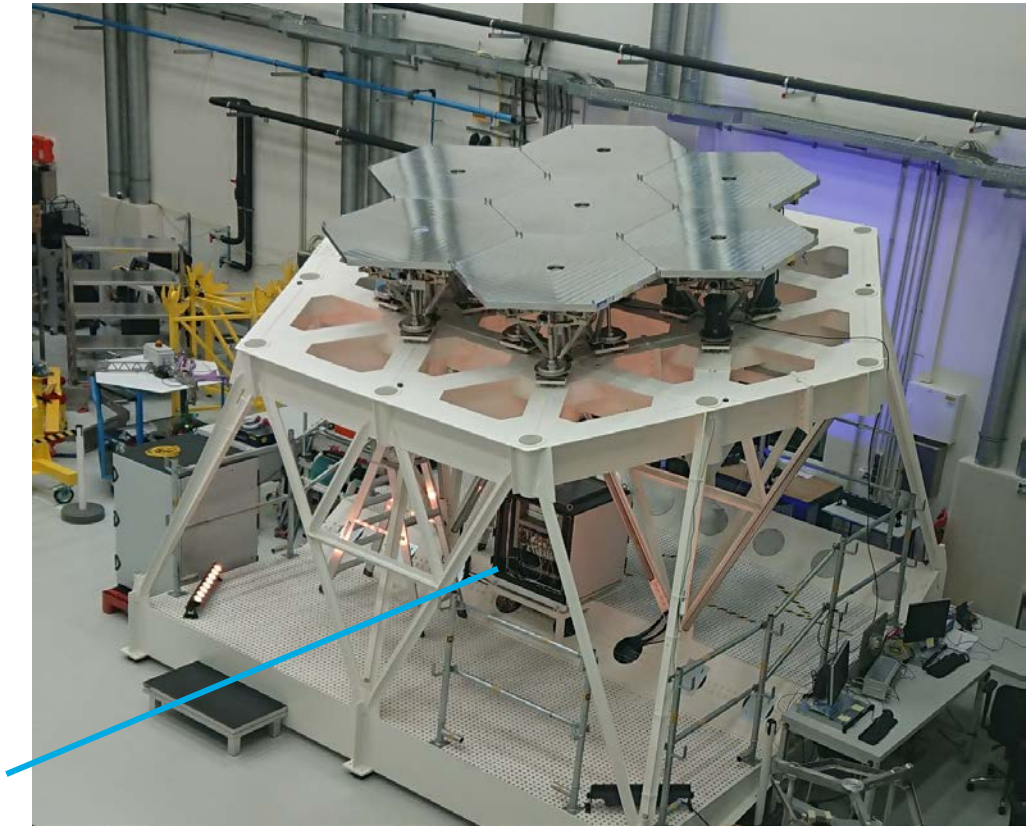
- Liquid Nitrogen (LIN) Infrastructure



- Grid connection
- Photo Voltaic Plant
- Power Conditioning System
- Electricity supplier

PROCON SYSTEMS

M1 Electronic Cabinets (132)



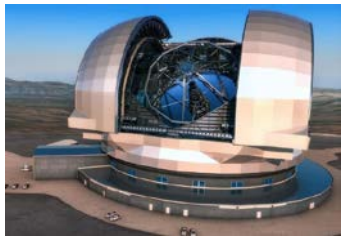
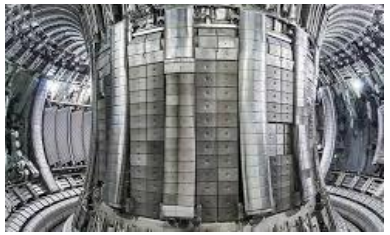
PROCON SYSTEMS AT A GLANCE..

Who we are..

- Engineering Contractor specialized in Advanced Process Automation and Digital Transformation
- Founded in 1995
- Headquartered in Barcelona (Spain)
- Primary contractor for the largest European automotive industry and large scientific facilities
- A highly skilled technical team of 70 people
- Collaboration culture to meet customers' requirements and needs.

Where to find us..

Particle accelerators / Large telescopes / Fusion reactors

Whom we have collaborated..

CERN

ESO

ALBA

FUSION FOR ENERGY

iter
china eu india japan korea russia usa

ess EUROPEAN SPALLATION SOURCE

MANUFACTURING AND VERIFICATION OF 132 ELECTRONICS CABINETS FOR THE ELT M1 CELL

- Procurement of parts, Assembly, Integration and Verification of Electronics Cabinets for the ELT M1 Cell control.
- Schedule: December 2020 – July 2022.
- Customer and location: ESO (European Southern Observatory), Cerro Armazones (Chile).

TECHNICAL HIGHLIGHTS

- 132 I&C Cabinets were produced to be used to house control, communication and power electronic components for the primary mirror of the Extremely Large Telescope (ELT).
- Each cabinet could control up to 7 segments.
- Phase 1 is the production of the Engineering Model, which allowed the validation of an example product.
- Phase 2 was the serial assembly, integration and packaging of the remaining 131 cabinets following the process established in Phase 1 and after a Production Readiness Review approval by ESO.

Consultancy and Service contracts (no hardware delivery)

Consultancy and Service contracts

Throughout the years; No hardware delivery

Pres.	Company	Scope	Country
*	**Ramboll**	Consultancy Support for DMS contract (managerial, civil engineering, architectural, fire safety, etc.)	Denmark / UK
*	**N7 SPACE Sp. z o.o. / iTTi**	Control Software Outsourcing Contract	Poland / Czech Republic
*	**FEV.io (formerly Etamax)**	Dataflow Software Components for ELT	Germany
*	**ISQ**	PA Consultancy Services	Portugal
	CyD	Consultancy Support - On site activities	Chile
*	**Critical Software**	ISVV Consultancy Services	Portugal
	SCOR	Construction All Risks Insurance	Chile
*	**DSV**	Freight Forwarding Services	Germany / Chile
	MegaRed	- Consultancy Chilean electrical systems Chile (technical & legal) - Technical know how - Legal know how	Chile

Technical Consulting

European Southern Observatory

Extremely Large Telescope (ELT)
Roofing Ceremony

RAMBØLL

Bright ideas.
Sustainable change.

ESO’s Technical Advisor

Ramboll is a global architecture, engineering and consultancy company delivering expertise and sustainable solutions to clients and partners.

We provided expert review of the ELT’s engineering design to ensure its successful delivery and long-term performance as a cutting-edge astronomical facility.

Credit: ESO/Guido Vecchia

Credit: ESO

ELT Status, Roofing Ceremony, 16 April 2025

David Grove Ramboll

Ramboll’s contributions to ESO’s Extremely Large Telescope

Trusted Technical Advisor since 2013

Providing continuous technical oversight and assurance to ensure the ELT is structurally and functionally ready for groundbreaking discoveries.

Subject Matter Experts from across Ramboll

Our specialists worldwide have thoroughly reviewed and assessed ELT’s design meeting the highest standards and best industry practices. Their extensive input ensures that the telescope's infrastructure is robust, efficient and ready for cutting-edge astronomical exploration.

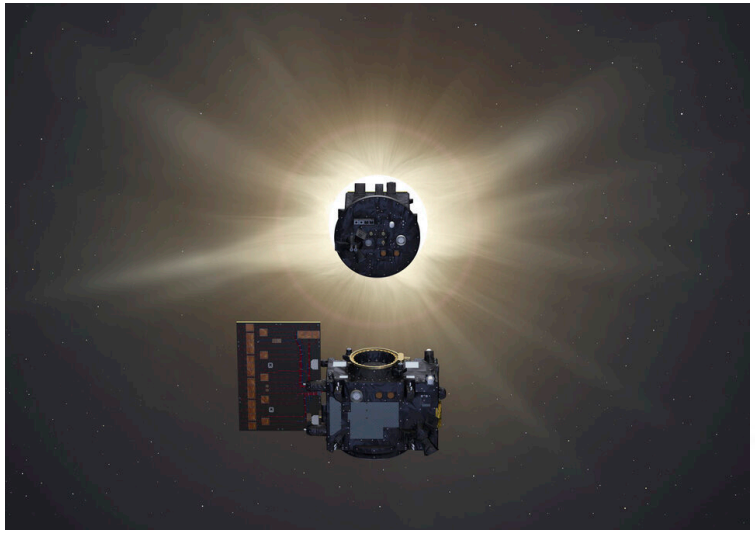
Ongoing technical advice and assurance during construction

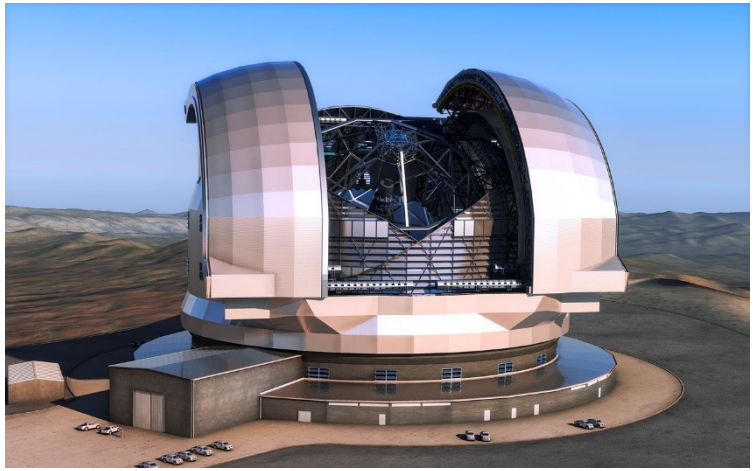
Our engineering expertise supports the ESO site team with monitoring and inspections to secure world-class construction, delivered according to ESO specifications for optimal astronomical observations.

Control System Service Contracts

N7 Space

- Company devoted to space systems software development
- Key activities:
  - Critical software development for real-time embedded systems
    - LEON and ARM based systems
    - Software qualification based on ECSS standards
  - Development and applications of MBSE tools
    - Formal architecture and data modelling for flight software
    - Model checking
    - Rich experience in TASTE and Capella ecosystems
  - Software for telescope systems
- Engineering team more than 10 years of experience in space engineering





N7 Space - ELT Activities

- Development of ELT Control System Software
  - Joint N7 Space and ITTI contract in Poland
  - Development of Telescope Real-Time Executor (TREx) application
  - Maintenance and development of Miniature ELT Control Software
  - Development support for Common Integration Infrastructure (CII)
  - Development of Local Supervisors (LSVs) for Main Structure, Pre-focal Station and Dome
  - Support and maintenance of the Data Display Tool (DDT)
  - Support for DevEnv environment for ESO software projects
- NGCII Firmware Development
  - Contribution to the software design, development and testing for the next generation of detector control systems (NGCII) for ELT and VLT

The company

About iTTi

- SME from **Poland** – ca. 75 persons
- For **more than 29 years** we support companies and institutions using innovative IT solutions.
- Main activities
  - **Custom software solutions** development
  - **Space sector development** in areas of EGSE (Electrical Ground Support Equipment), SSA (Space Situational Awareness)
  - **Applied R&D activities** in the area of ICT and security

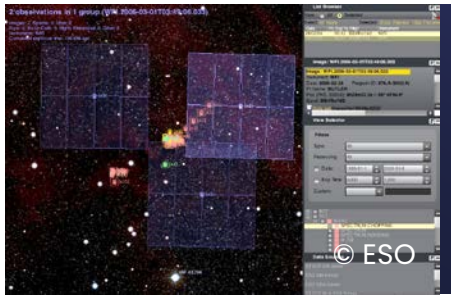
iTTi & ESO ELT

- **Our Key Responsibilities:**
  - **CUT (Control UI Toolkit):** Developing libraries and tools for building GUI applications for ELT systems (Qt + Taurus).
  - **HLCC (High Level Coordination and Control):** Integrating and coordinating ELT telescope subsystems, developing supervisory applications.
  - **RTCTk (Real Time Control Toolkit):** Creating tools for adaptive optics systems.
  - **LSV (Local Supervisor Software):** Controlling and monitoring ELT telescope mirrors (M2/M3/M4/M5) using OPC UA, DDS, and ZeroMQ + Protobuf.
  - **Diagnostics & Optimization:** Identifying and resolving software defects, developing inspection tools.

Science Data Flow

FEV.io

Dataflow Software for VLT/ELT & ALMA



Frontend - Client-side/UI – Focus Angular

- Develop frontend software functions for observation scheduling of the telescopes
- Focus on user experience

Backend - Server-side – Focus Java

- REST and GraphQL APIs
- Business logic and Persistence toSQL/noSQL DBs

Automated Software Testing

- Software Test specification, implementation and execution
- Test result evaluation, reporting and issue tracking

European Southern Observatory

Collaboration since July 2018

Dr. Pascal Ballester
Head of Science Operation
Software Department
European Southern Observatory

"With FEV we found a reliable partner who understands the various software demands from ESO's projects and provides first-class agile software engineering and testing services."

From your idea to the final product, we support and consult you in all phases shaping your custom-tailored software application.

Our Industries

- Astronomy
- Space
- Defence
- Railway
- Aviation

Our Promise

- Living the whole software engineering life cycle
- Secure software by design
- Proven full-stack software expertise
- Test Automation to ensure software quality
- Pragmatic approach with an agile mindset

Your Business Impact

- Close and trustworthy collaboration to fulfil your needs
- State-of-art technology to reduce maintenance cost
- High level of software quality and safeguards
- Open feedback and communication of risks and challenges
- Maximum flexibility in an organised environment

PA/QA on Hardware

DELIVERING TRUST

CONSULTANCY SERVICES FOR QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) FOR THE ELT PROGRAMME

ELT Status, Roofing Ceremony, 16 April 2025

DOME AND MAIN STRUCTURE, MIRRORS & CELLS, POSITION ACTUATORS, SENSORS, PDS, COARSE ALIGNMENT METROLOGY, AOWFS CAMERAS, ELT & ESO LIQUID NITROGEN INFRASTRUCTURE, LARGE COATING PLANT, QA SUPPLIERS

MORE THAN 100 MISSIONS IN 7 COUNTRIES

Inspection

Welding

Tests

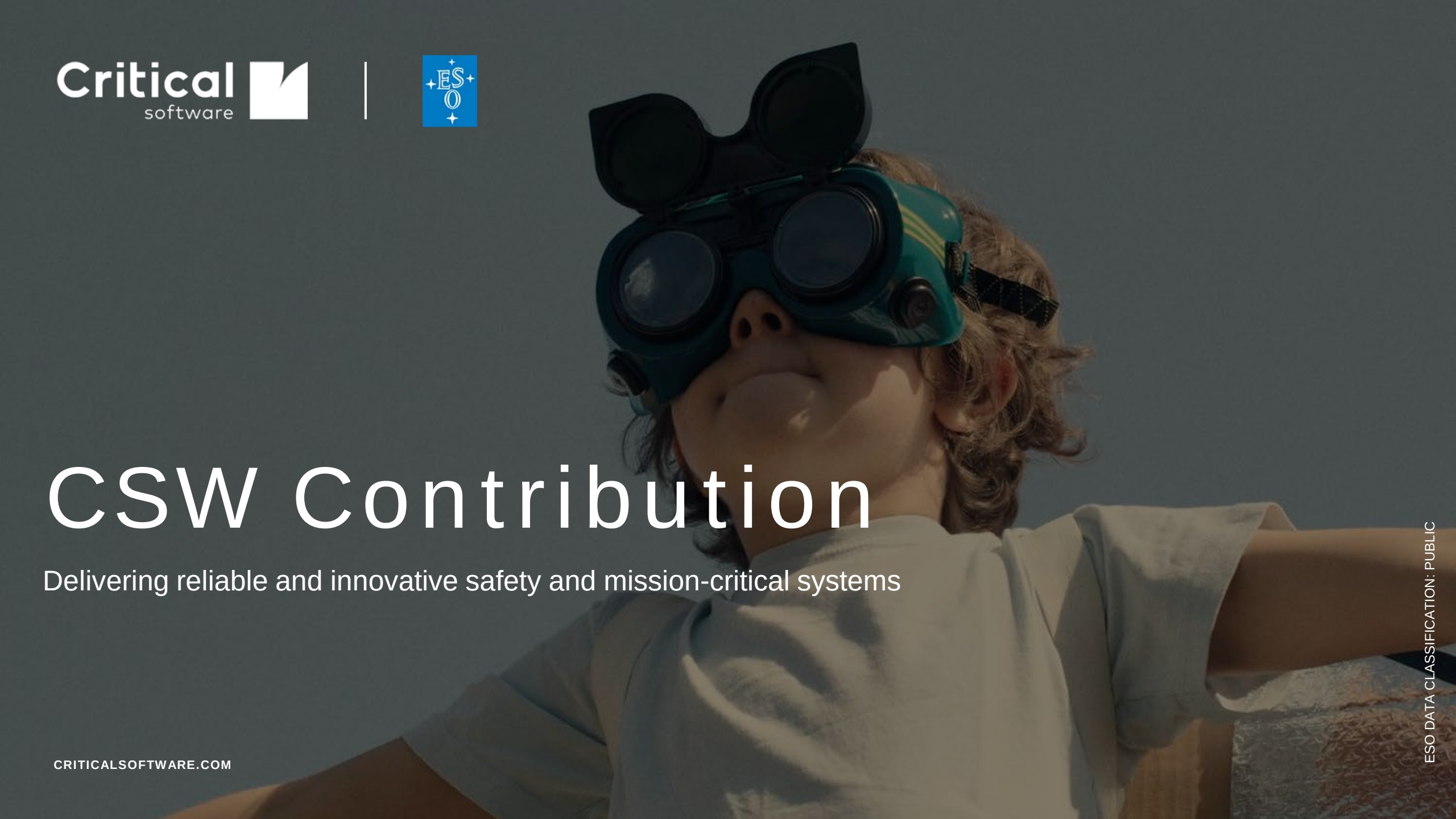
RAMS

QA/QC

ISQ TEAM INVOLVED

Alícia Alvarez, Ana Margarida, Andreia Centeio, António Sequeira, Carlos Barbio, David Jusdado, Elói Trindade, Jorge Pereira, Luis Martins, Luis Pires, Mário Ribeiro, Mónica Reis, Nelson Mónica, Nuno Pereira, Nuno Rente, Paula Branco, Paulo Chaves, Pedro Conceição, Pedro Pinto, Pierre Luten, Ricardo Felix, Roberto Garcia, Rodrigo Cunha, Rogério Rebelo

PA/QA on Software



CSW Contribution

Delivering reliable and innovative safety and mission-critical systems

CRITICALSOFTWARE.COM

Critical Software

Founded in 1998 with NASA as the first client

Pioneers in safety-critical embedded software development and testing

Systems and software engineering company

Our Divisions

ARMS: Automotive, Railway and Medical Devices Systems

DES: Digital Engineering Services (Finance, Manufacturing)

SRS: Smart & Reliable Systems (Aviation, Space & Science, Defence, Energy)

1600 +
employees
4000 +
Critical Group

Global
vision

Growth
& reinvestement

Independent
private company

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1600 +
employees
4000 +
Critical Group

Global
vision

Growth
& reinvestement

Independent
private company

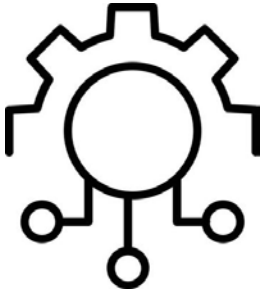
Critical Software contribution

Control system

- Development, testing and integration for all mirrors;
- Simulator development for sensors and actuators to mimic final system behavior.

Central system support

- Independent test analysis and specifications;
- Control deterministic and Non-deterministic tests;
- Test campaigns at the contractors' facilities including
- SW and HW integration.



Core Integration Infrastructure

- Online Database Benchmark;
- Service DB manipulation;
- Client Configuration Dev;
- Unit/Integration Tests.

Critical Software contribution

MAL Dev & Maintenance

- Dev. activities and corrections during code generation;
- Functional Tests;
- Compiling resources/time investigation, and correspondent corrections.

HLCC User Interface

- UI features for telescope positioning;
- Interface between the CII and HLCC.
- Generic Multi stream viewer.

Independent V&V

- ELT Requirements, architecture and code baselines analysis;
- Subsystems and components RAMS assessment;
- Test analysis and new test specifications.

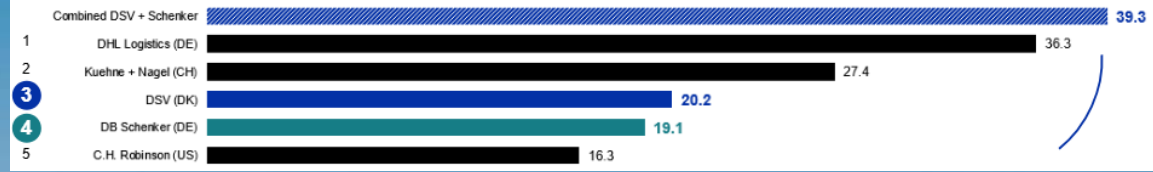
Transportation

DSV and Schenker

DSV x Schenker – creating a world-leading player

Combining DSV and Schenker to create a world leading player

Third-party logistics providers by 2023 revenue in EUR billion



An excellent match – to the benefit of all customers

Asset-light business models and corporate cultures with focus on customer service, entrepreneurship and corporate responsibility

Customers first

Combining the best of both worlds with customers at the centre and a shared commitment to a responsible way forward

Global network

A significant expansion of our global logistics network and an even stronger range of service offerings that meet our customers' transportation and logistics needs

Digitalisation

Continued focus on supporting supply chain management and visibility through joint IT infrastructure

Local ownership

A shared culture of local ownership and entrepreneurship supported by global processes and systems

ESO and DSV

Transport Services for M1 mirror segments:

full Transport management
Carrier capacity management
Tracking, Tracing, online Monitoring
Container planning
Customs clearance
Risk management
Independent marine cargo survey
Lashing and cargo securing concept
Port operations
Pre- and oncarriages to site

First container loading in December 2023

DSV Global Transport and Logistics

Global Transport & Logistics

2025-04

2023-08

Credit: J. Beltrán/ESO

Credit: E. Garcés/ESO (top) & B. Häußler/ESO (bottom)

Thank you!

Roberto Tamai

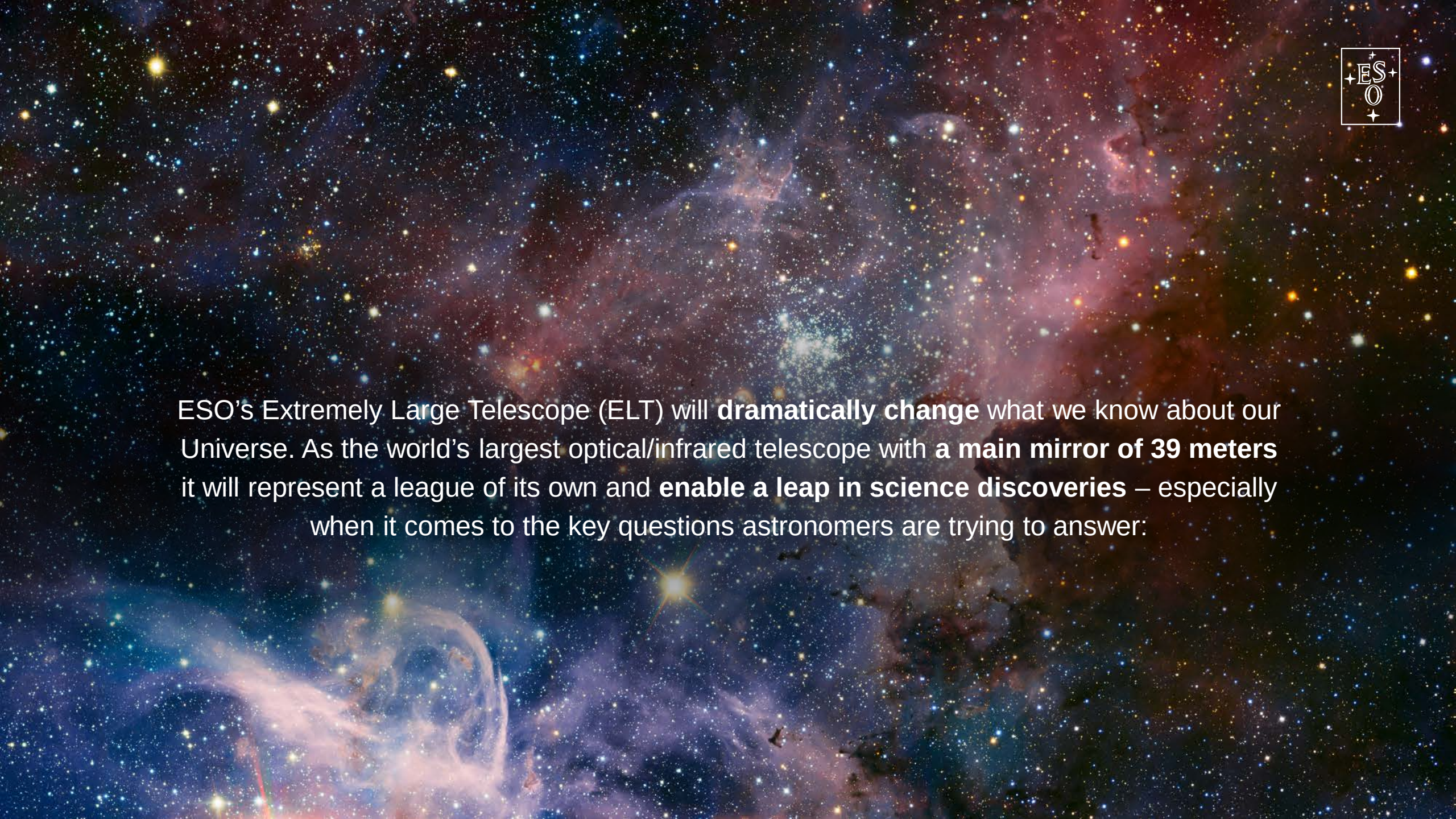
ELT Construction Programme Manager

rtamai@eso.org

ESO Communication Department Presentation

Martin Wallner

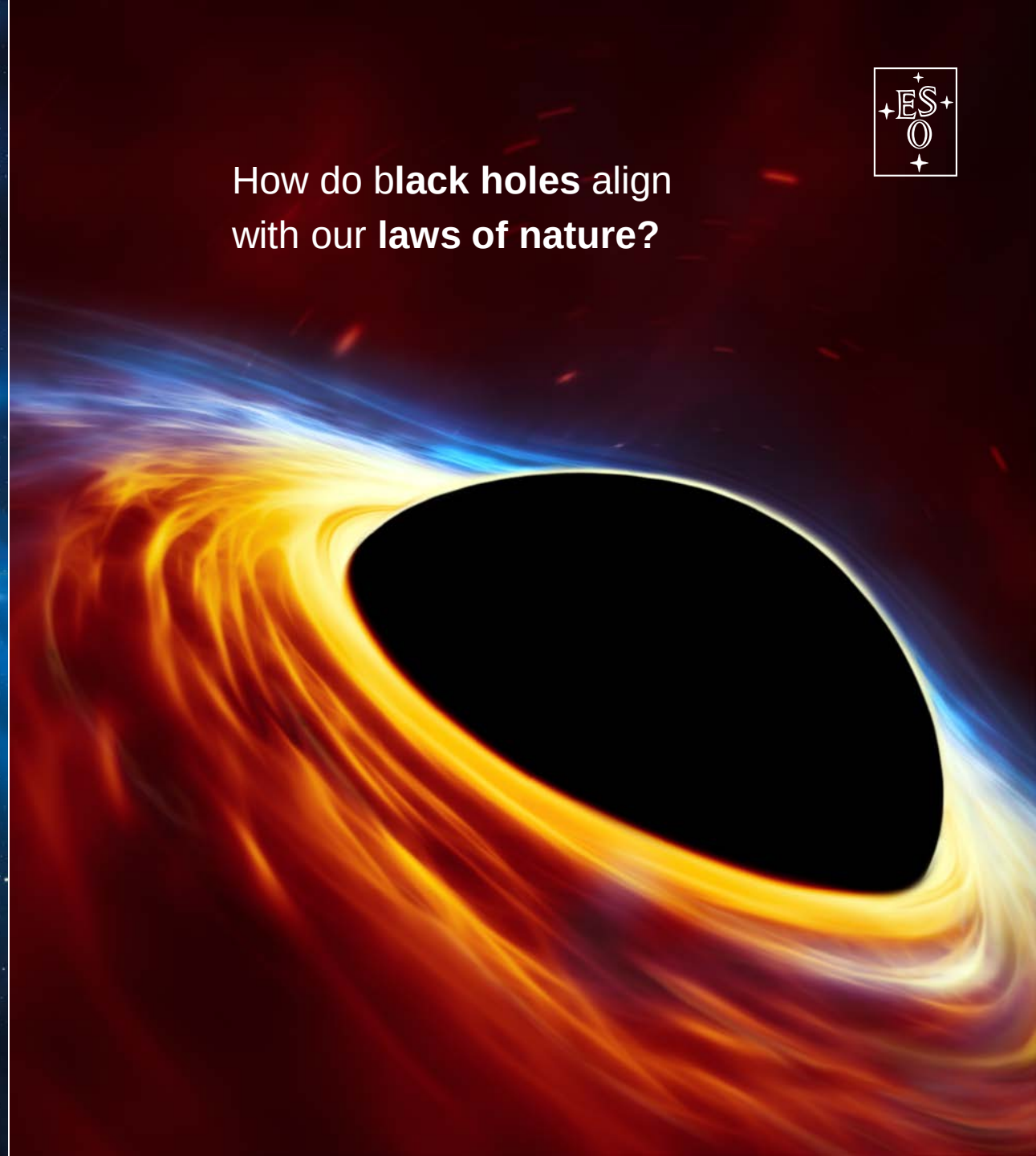
ELT Documentary



ESO’s Extremely Large Telescope (ELT) will **dramatically change** what we know about our Universe. As the world’s largest optical/infrared telescope with **a main mirror of 39 meters** it will represent a league of its own and **enable a leap in science discoveries** – especially when it comes to the key questions astronomers are trying to answer:

How did the **Universe come to be?**

How do b**lack holes** align with our **laws of nature?**




Are we alone in the Universe?

“With the ELT we’re going to see things that were impossible to see before – and we’re going to be surprised!”

Didier Queloz

Nobel Prize Laureate

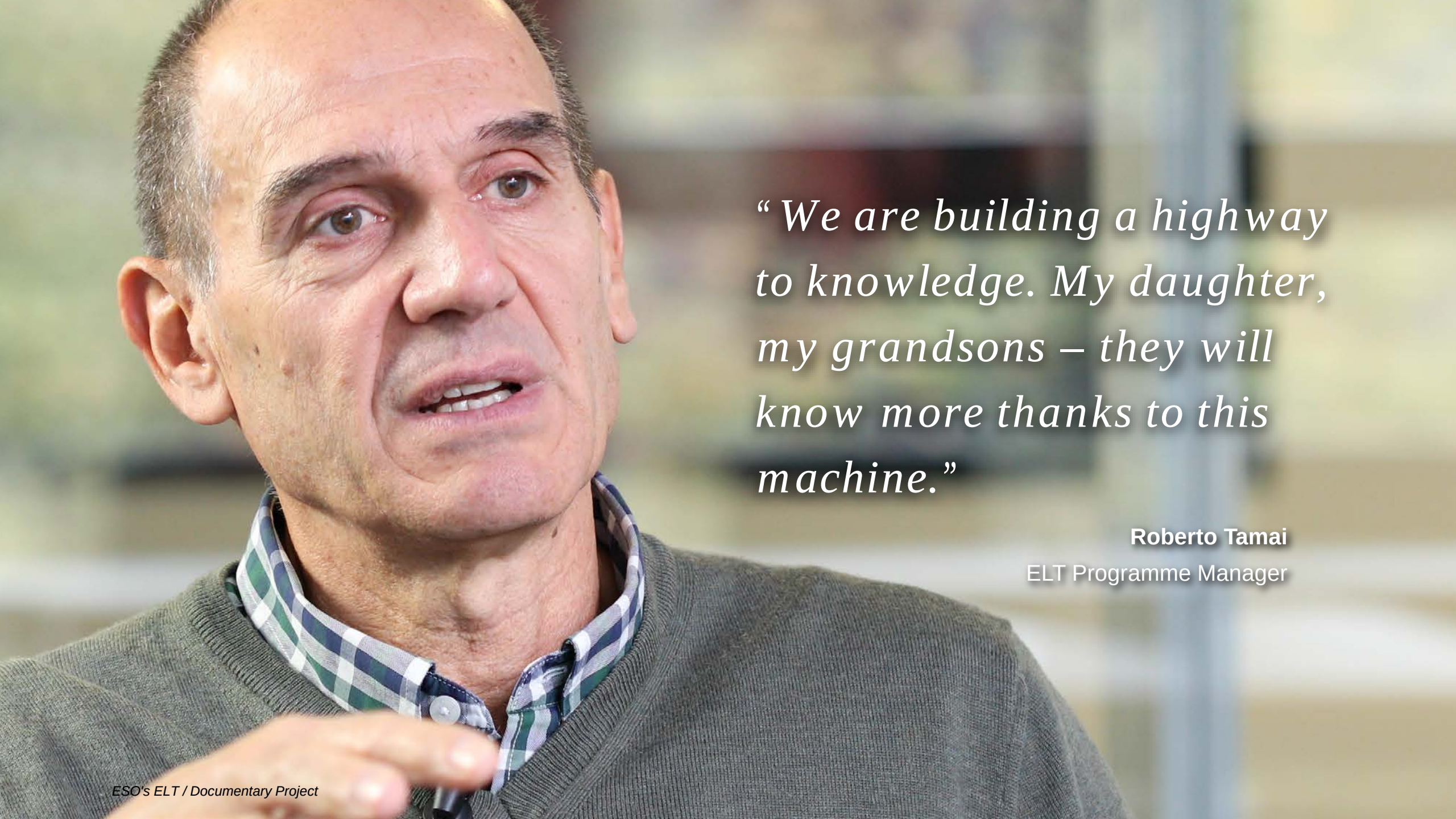
The construction itself is a **pan-European and Chilean endeavor** and involves **thousands of people** and many partner companies, organizations and institutes.

We’re building a one-of-a-kind facility! The engineering requirements reach from **“never attempted before on such a scale”** to **“never attempted before”.**

The construction of the ELT is a story of many challenges, of **collaboration** and **joint achievement** – **no single country** could realise a project of this scale **on its own**.

It requires **very unique and specific expertise**
in many fields of science and engineering, experience, perseverance,
and a cast of dedicated people, **driven** by the idea
of creating **something larger than themselves**.

We would like to tell the story of these people.


“We are building a highway to knowledge. My daughter, my grandsons – they will know more thanks to this machine.”
Roberto Tamai
ELT Programme Manager
ESO's ELT / Documentary Project

“This project is a monster!
Deep down you know,
you will never get to see
another project like this
in your lifetime.”

Guido Vecchia
Armazones Site Manager



CIMOLAI



Dear partners:

Without you, this would not be possible.
Please share your stories with us.

Q & A

ELT Construction Timelapse 2020 - 2025