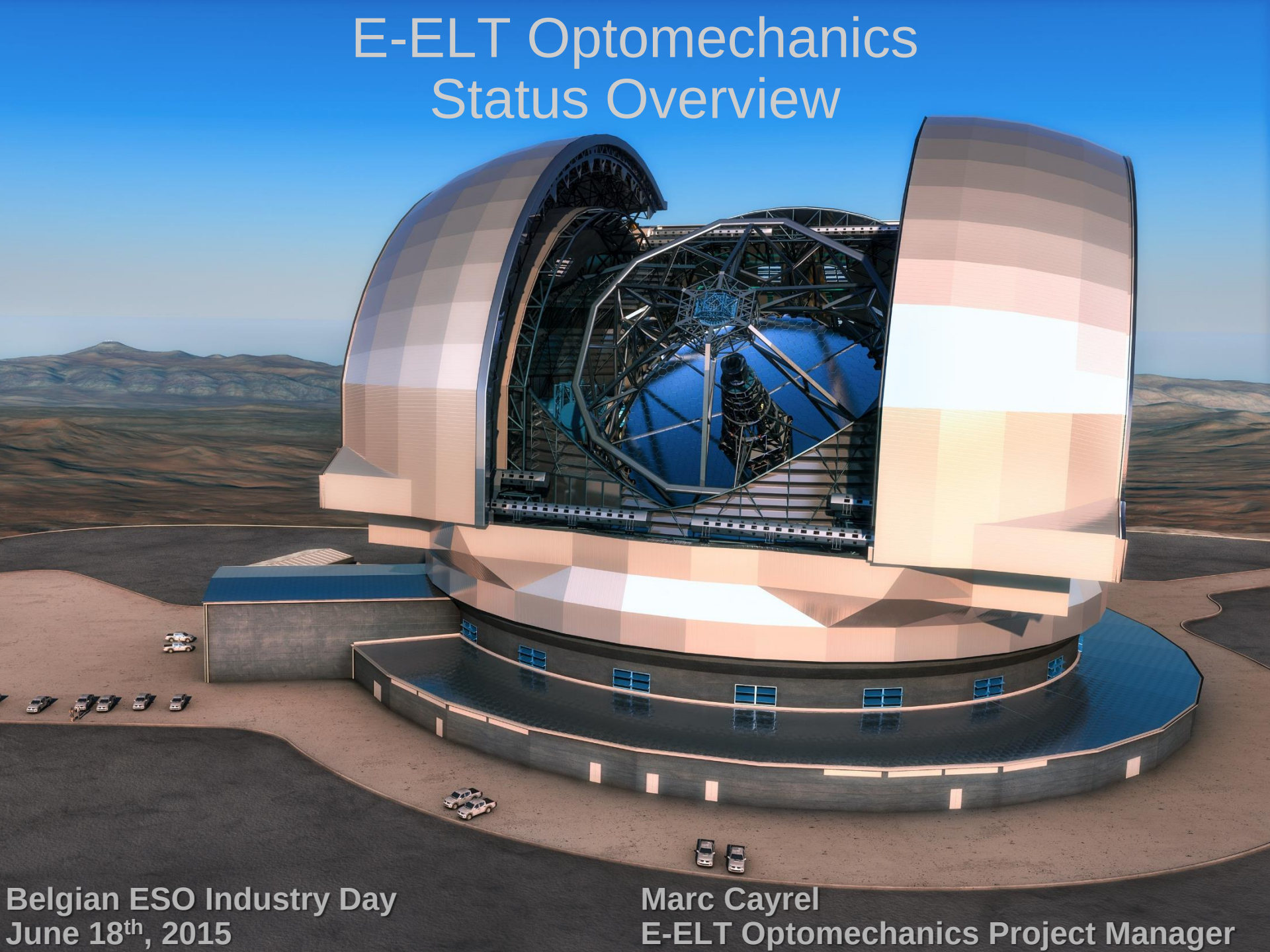
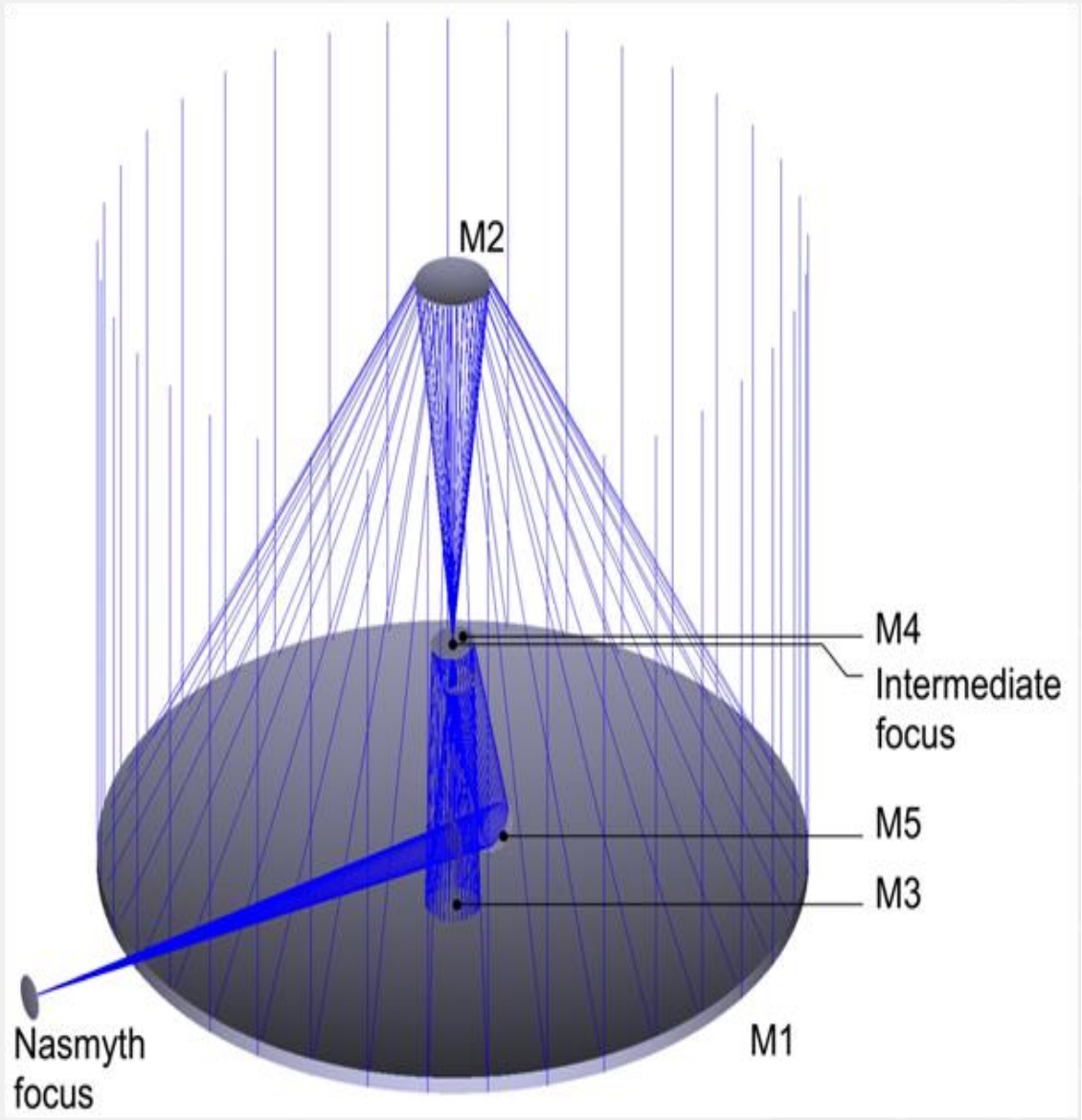
E-ELT Optomechanics Status Overview

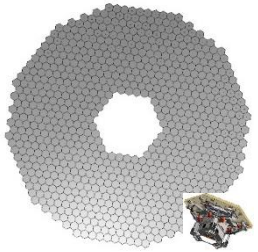


Belgian ESO Industry Day
June 18th, 2015

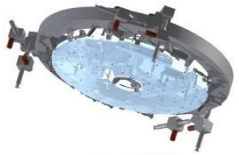
Marc Cayrel
E-ELT Optomechanics Project Manager

E-ELT Optomechanics



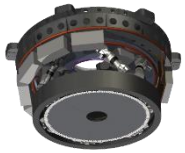


M1 Unit
39-m
Concave – Aspheric f/0.9
Segmented (798 Segments)
Active + Segment shape Control



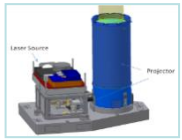
M2 Unit
4-m
Convex Aspheric f/1.1
Passive + Position Control

M3 Unit
4-m – Concave – Aspheric f/2.6
Active + Position Control



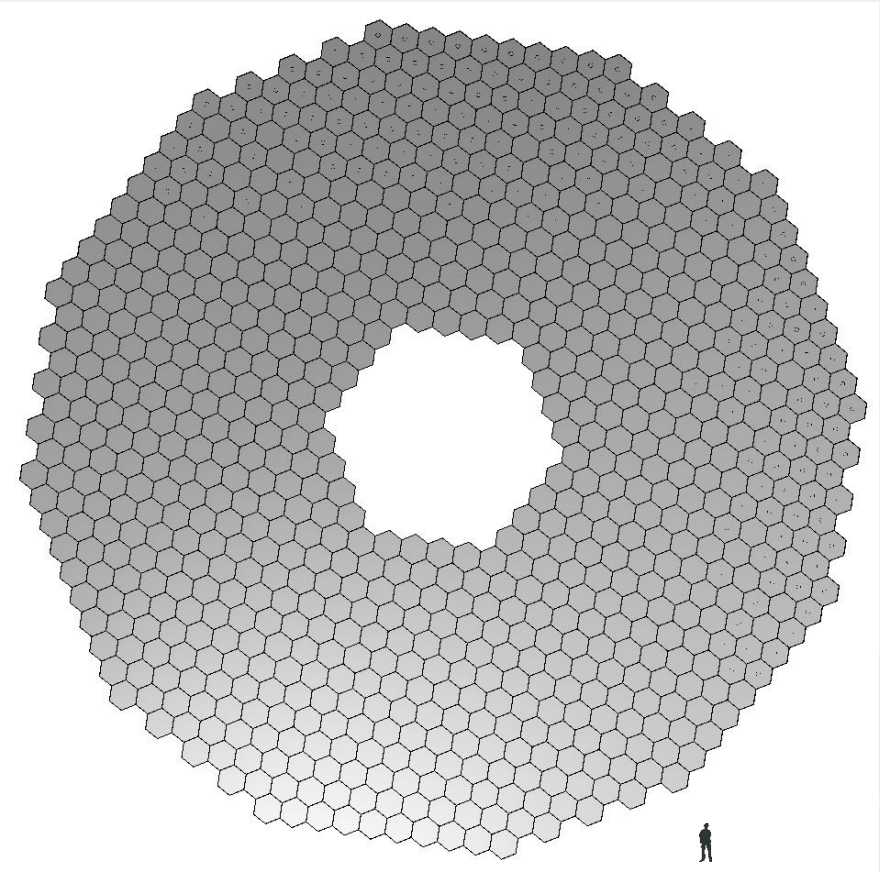
M4 Unit
2.4-m
Flat
Segmented (6 petals)
Adaptive + Position Control

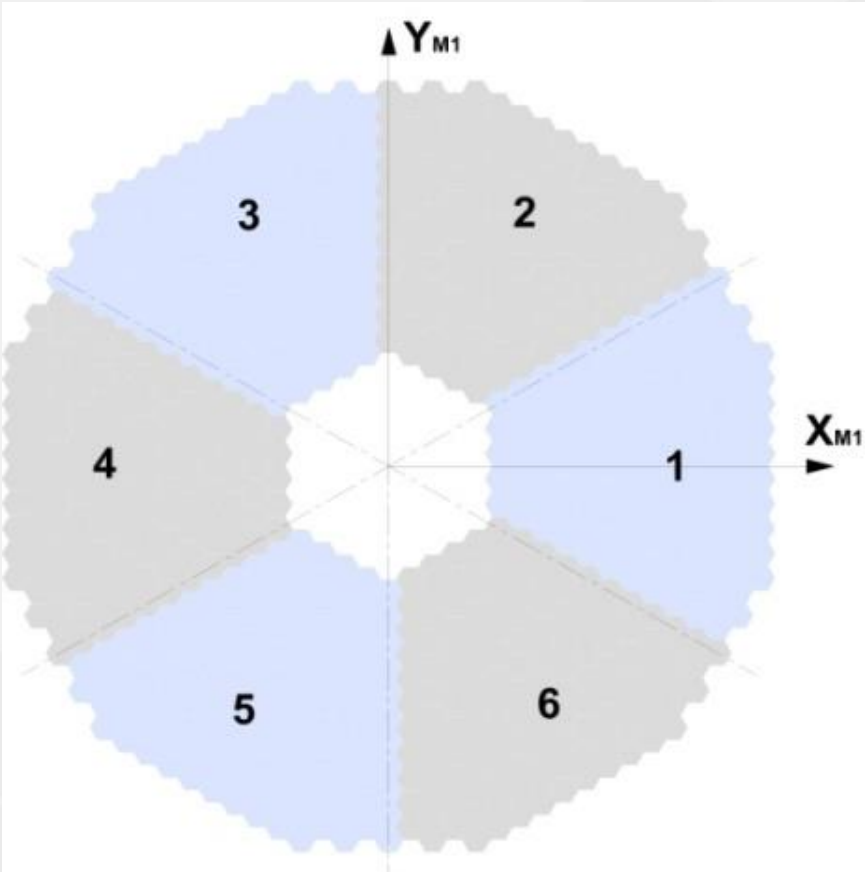
M5 Unit
2.7x2.1-m
Flat
Passive + Fast Tip/Tilt



LGSU
(Laser Guide Star Units)
Laser Sources + Laser Beacons
shaping and emitting

M1 Unit

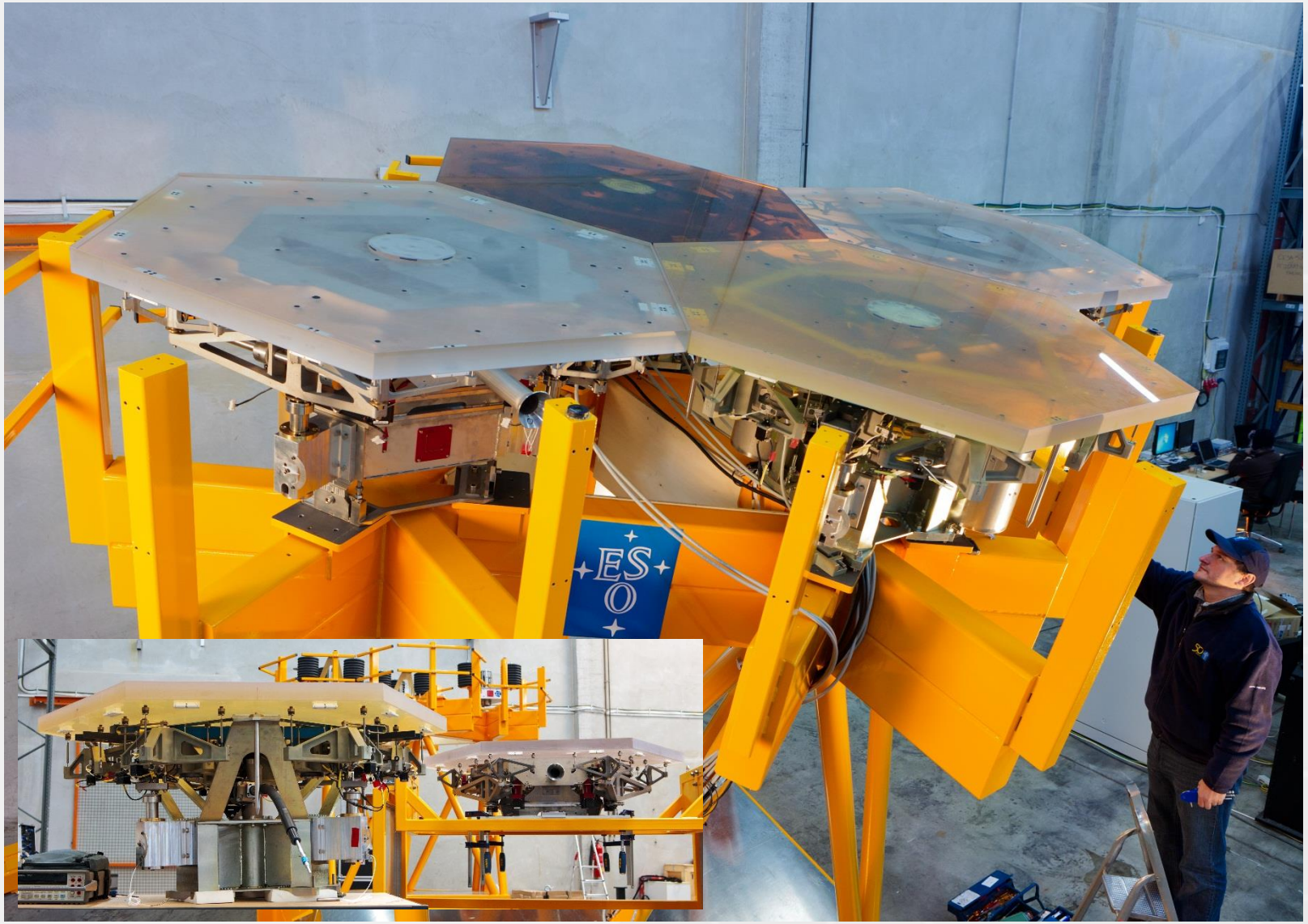




39-m diameter
6 x 133 segments (1.4-m)
1 x 133 spare segments
Total: 931 segments

M1 Mirror	
Outer diameter (mm)	39146.0
Inner diameter (mm)	9418.4
M1 Optical Prescription	
Radius of curvature (mm)	68685
Conic constant	-0.9964064

M1 Unit



M1 Unit

931 x M1 Segments

931 x Blanks + 19 x Spare Blanks
931 x Segments Polishing

4530 x M1 Edge Sensors

4530 x Sensors +813 x Electronics + Spares
(100 sensors – 15 x controllers)

931 x M1 Segment Supports

& SA Auxiliary Equipment

[SA Handling Tools, SA Transport Containers, SA AIV Tools]

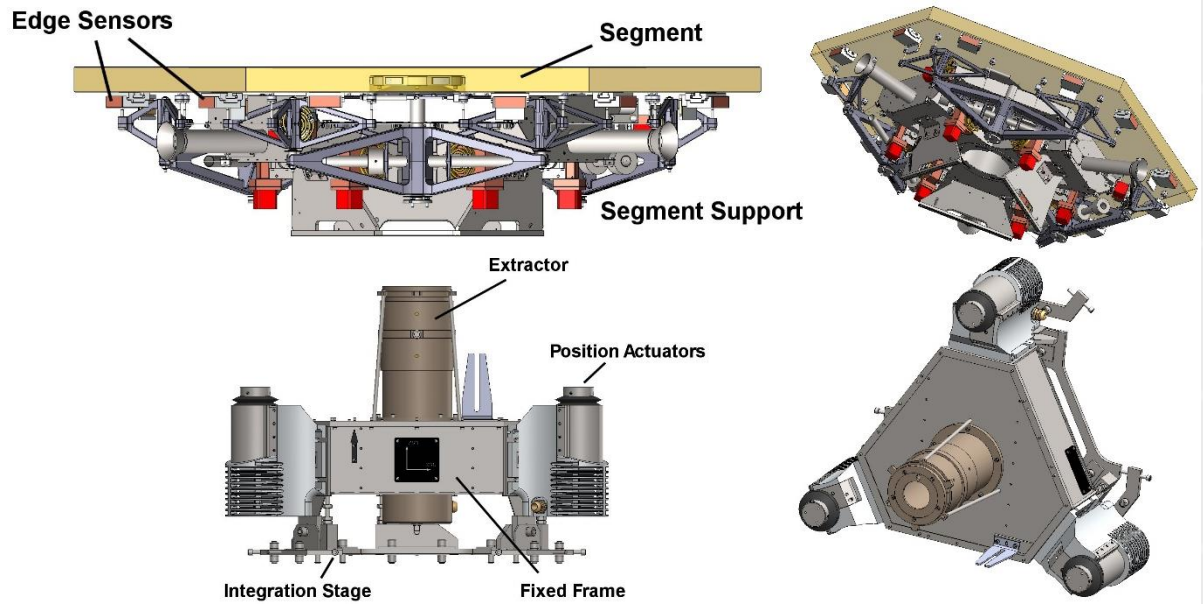
2394 x M1 Position Actuators

2394 x Actuators + 798 x Electronics + Spares (16 x PACT – 6 x Controllers)

M1 Auxiliary Equipment

Aux. Sensors, Mass Dummies. Carts, Stands, Manipulator, Phasing Gun, Alignment Tools

Segment Assembly



Subcell

Including glass, mechanics, electronics:

⇒ more than 10 000 components

M1 Unit – Segment Supports

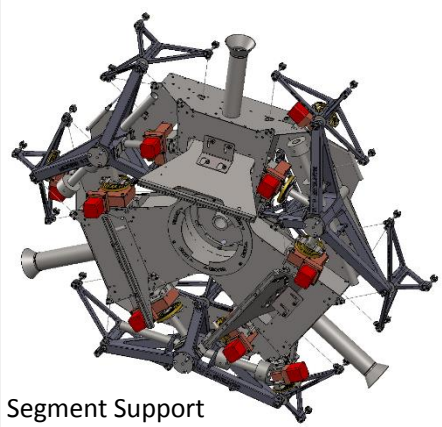
931 x M1 Segment Supports

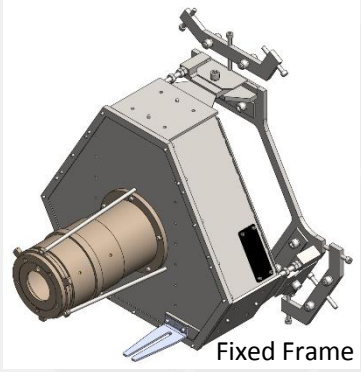
798 x M1 Fixed Frames

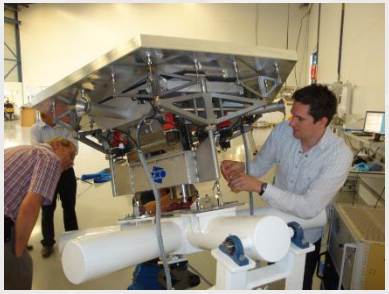
3 x M1 SA Handling Tools

798 x M1 SA Transport Containers

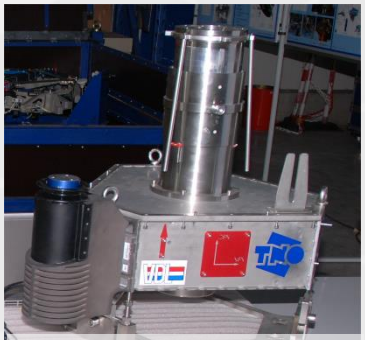
1 x M1 SA AIV Tools


Segment Support

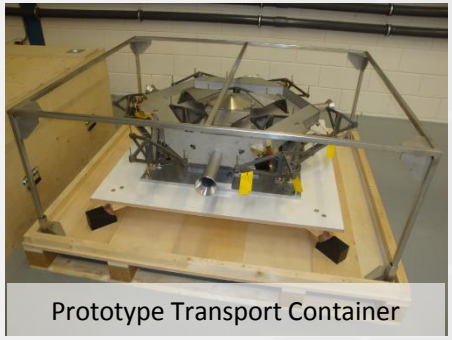

Fixed Frame




Prototype Segment Support


Prototype Fixed Frame


Extraction & Handling

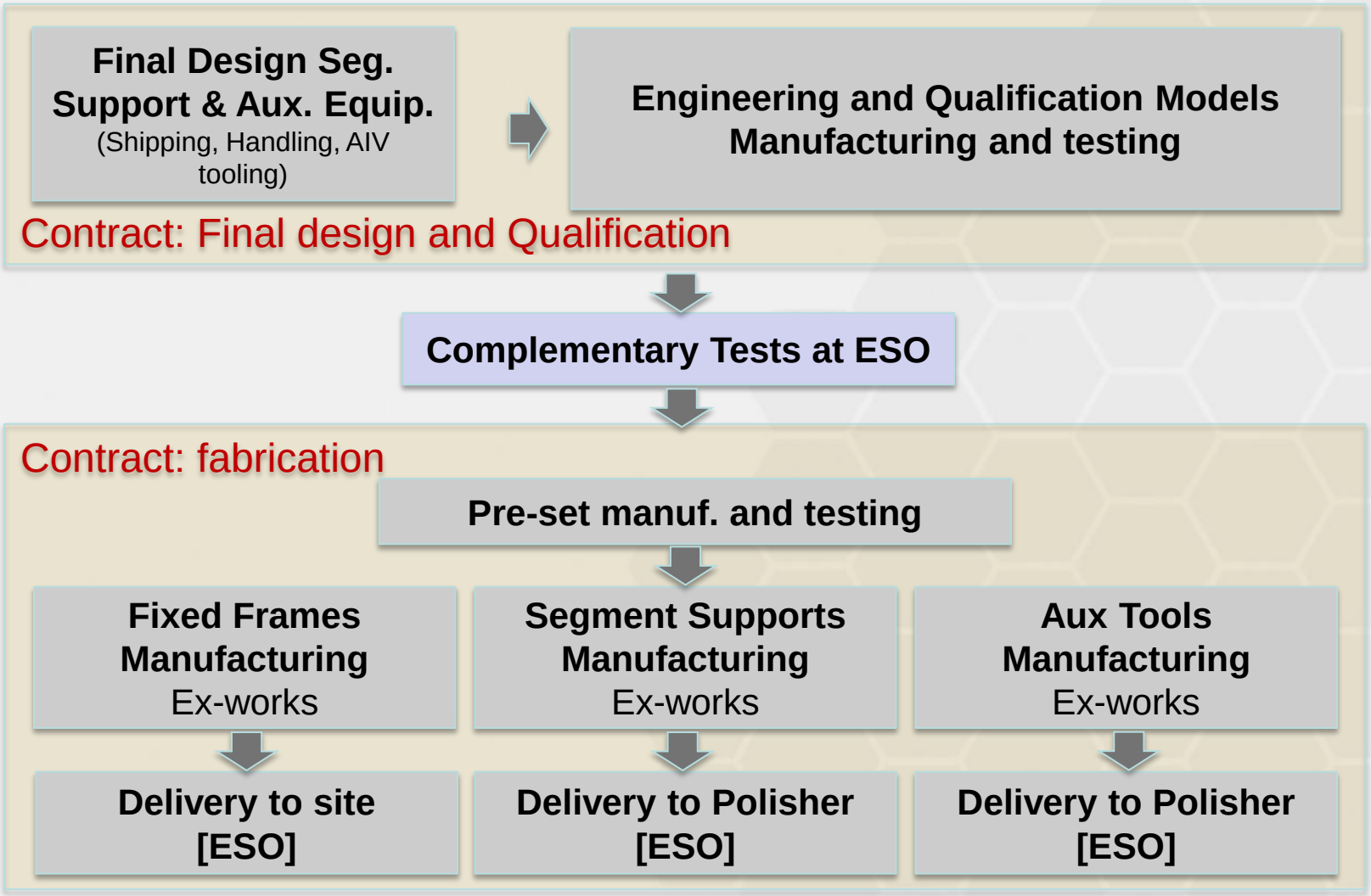

Prototype Transport Container


AIV Tooling

Handling Tool

M1 Unit - Segment Supports

M1 Segment Support – Procurement



M1 Unit - Segment Supports

M1 Segment Support – Procurement

Final Design and qualification: awarded, 2 contracts ongoing.

VDL/TNO Eindhoven/Delft (The Netherlands)

- Kick Off: 26.01.15

CESA Madrid (Spain)

- Kick Off: 10.02.15

M1 Unit - Segment Supports

M1 Segment Support – Procurement

Final Production:

CfT: planned in May 2017

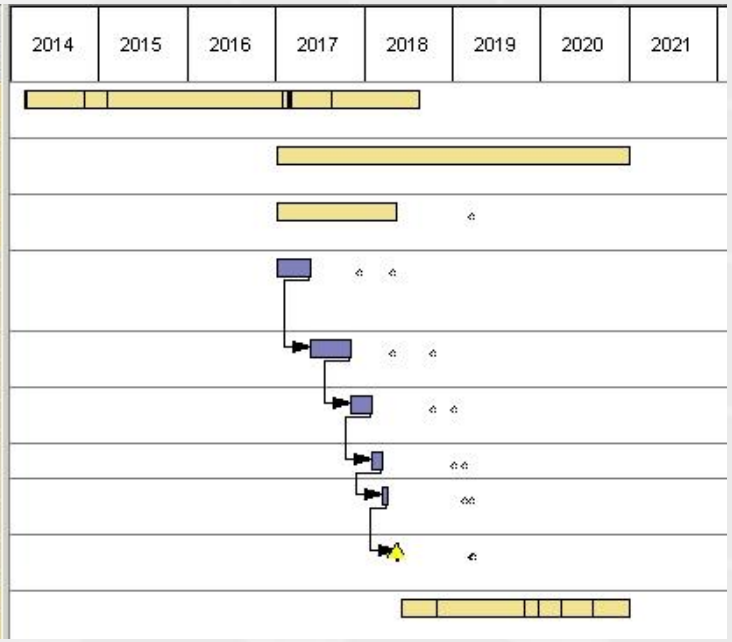
Contract start: June 2018

Production plan: 2.5 years

Required Skills:

- Precision Mechanical Manufacturing and Integration
- Mass Production

Activity Desc.	Duration	Early Start	Early Finish
M1 Segment Support Qualification Units	1163d	03Mar2014	20Aug2018
M1 Segment Support Production Units	1036d	05Jan2017	30Dec2020
M1 Segment Support Prod. Units - Procurement	351d	05Jan2017	11May2018
M1 Segment Supports - Tech. and Managerial Reqs.(CfT Package) - Production	100d	05Jan2017	24May2017
M1 Segment Supports - Tendering	120d	25May2017	08Nov2017
M1 Segment Support Prod-Units - Selection	60d	09Nov2017	31Jan2018
Contract award comittee	30d	01Feb2018	14Mar2018
Preparation of FC Documentation	20d	15Mar2018	11Apr2018
M1 Segment Supports - FC Approval	0	11May2018	11May2018
M1 Segment Supports - Manufacture Contact	665d	07Jun2018	30Dec2020



M1 Unit – Blanks and Polishing

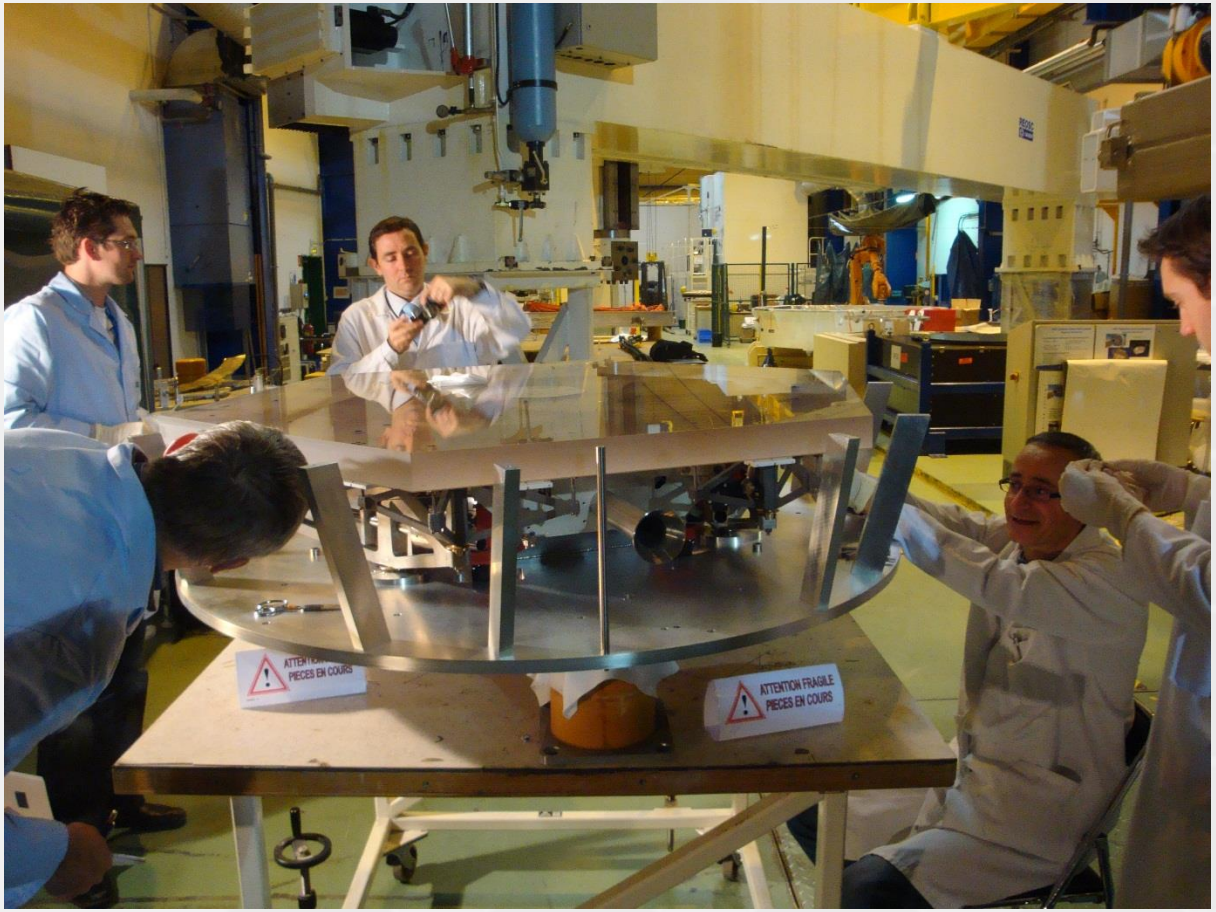
931 x Grind & Pre-Polish Segment Roundels

931 x Bound interfaces

931 x Cut to hexagonal shape

931 x Integrate with Segment Support

931 x Finish figure and Test Segment Assemblies

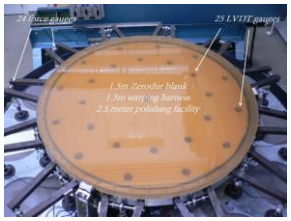


M1 Unit - Blanks and Polishing

- RFI for blanks procurement: ongoing.
- RFI for Polishing: completed.
- PI for Polishing: July 2015.
- CfT for Polishing: planned Nov 2015

Blanks

High Precision grinding

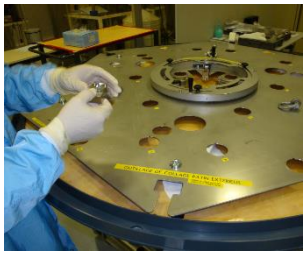


Stressed Mirror Polishing

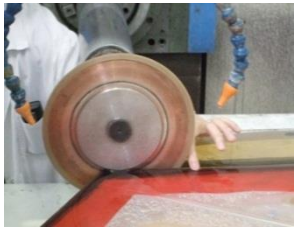
Bonnet Polishing and Lapping

Pre-Polished Roundel

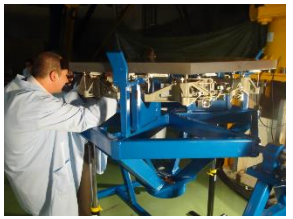
Polishing #1



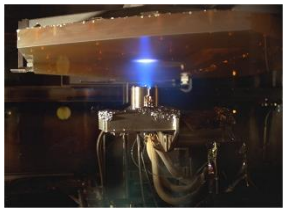
Pads Bonding



CNC - Cutting



Support integration



Ion Figuring

Polishing #2

M1 Unit – Blanks and Polishing

M1 Segments Polishing – Procurement

CfT: planned in Nov 2015

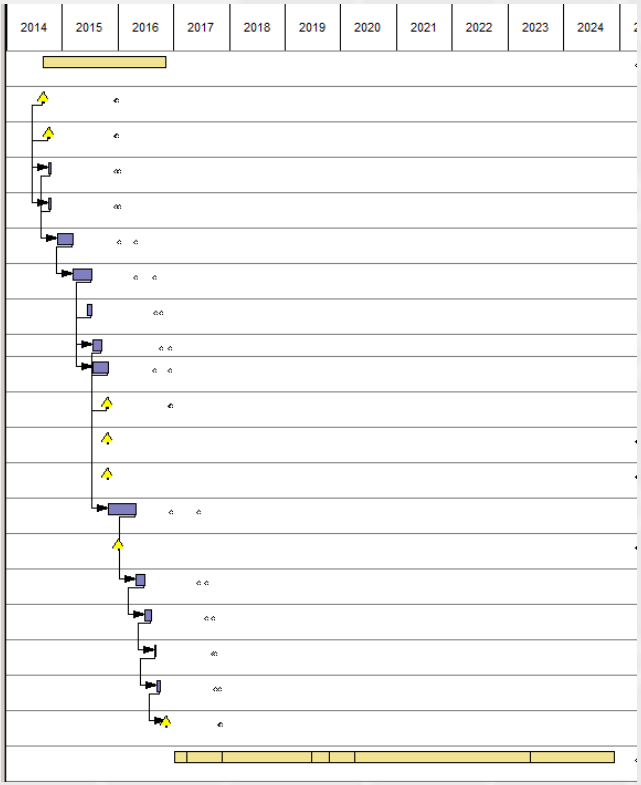
Contract start: Jan 2017

Contract plan: 7 years

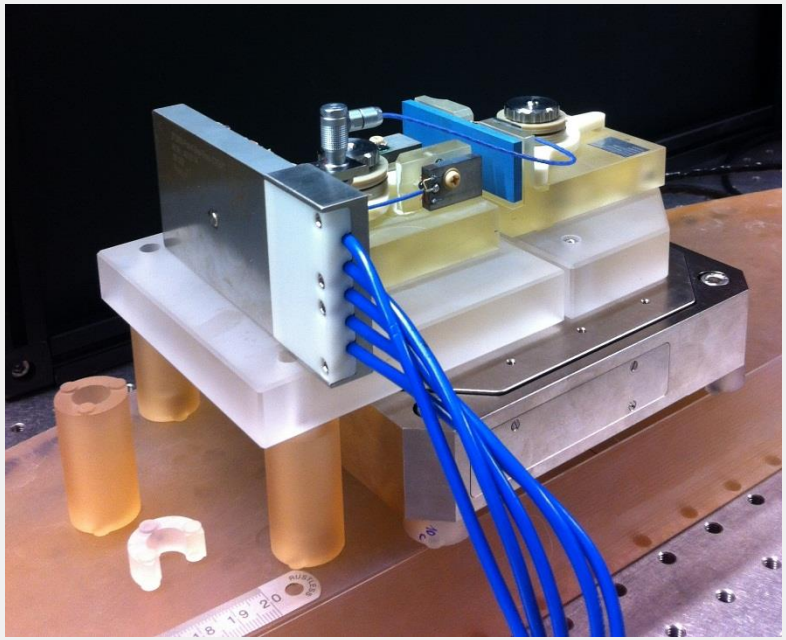
Required Skills:

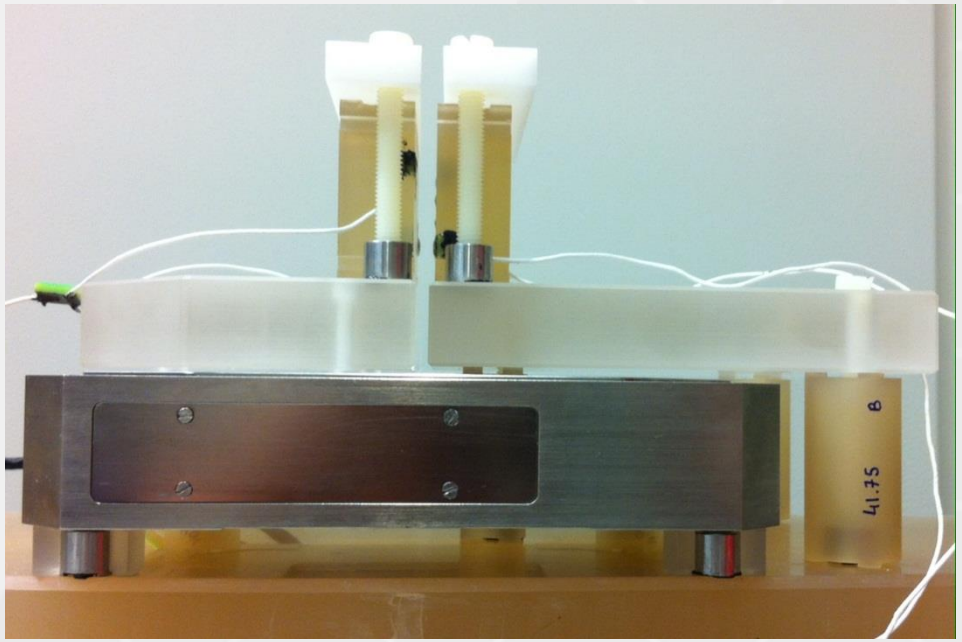
- High Performance optomechanical components manufacturing, integration, and testing
- Mass Production

Activity Desc.	Duration	Early Start	Early Finish
M1 Segment Polishing - Procurement	573d	29Aug2014	11Nov2016
M1 Segments Polishing - RFI - Advance Info	0	29Aug2014	29Aug2014
M1 Segments Polishing - Synopsis	0	01Oct2014	01Oct2014
M1 Segments Polishing - RFI - ILOs	15d	01Oct2014	21Oct2014
M1 Segments Polishing - Synopsis and Draft SPE	15d	01Oct2014	21Oct2014
M1 Segments Polishing - RFI - Industry	75d	28Nov2014	13Mar2015
M1 Segments Polishing - RFI - Clarifications	90d	16Mar2015	17Jul2015
M1 Segments Polishing - PI Documentation	25d	15Jun2015	17Jul2015
M1 Segments Polishing - PI	45d	20Jul2015	18Sep2015
M1 Segments Polishing - Finalize CfT Package	75d	20Jul2015	30Oct2015
M1 Segments Polishing - M1 Blanks SPE & SOW version 0	0	26Oct2015	26Oct2015
M1 Segments Polishing - Tech Specs Version 1	0	23Oct2015	23Oct2015
M1 Segments Polishing - SOW Version 1	0	23Oct2015	23Oct2015
M1 Segments Polishing - Tendering	129d	02Nov2015	29Apr2016
M1 Segments Polishing - CfT - M1 Blanks - SPE & SOW v1	0	05Jan2016	05Jan2016
M1 Segments Polishing - Bids Clarifications and Evaluation	40d	02May2016	24Jun2016
M1 Segments Polishing - Buffer for Clarifications/Evaluation/Nego	30d	27Jun2016	05Aug2016
M1 Segments Polishing - Selection - CaC	10d	29Aug2016	09Sep2016
M1 Segments Polishing - FC documentation	20d	12Sep2016	07Oct2016
M1 Segments Polishing - FC Approval	0	11Nov2016	11Nov2016
M1 Segments Polishing - Manufacture Contract	2053d	04Jan2017	25Nov2024



M1 Unit – Edge Sensors





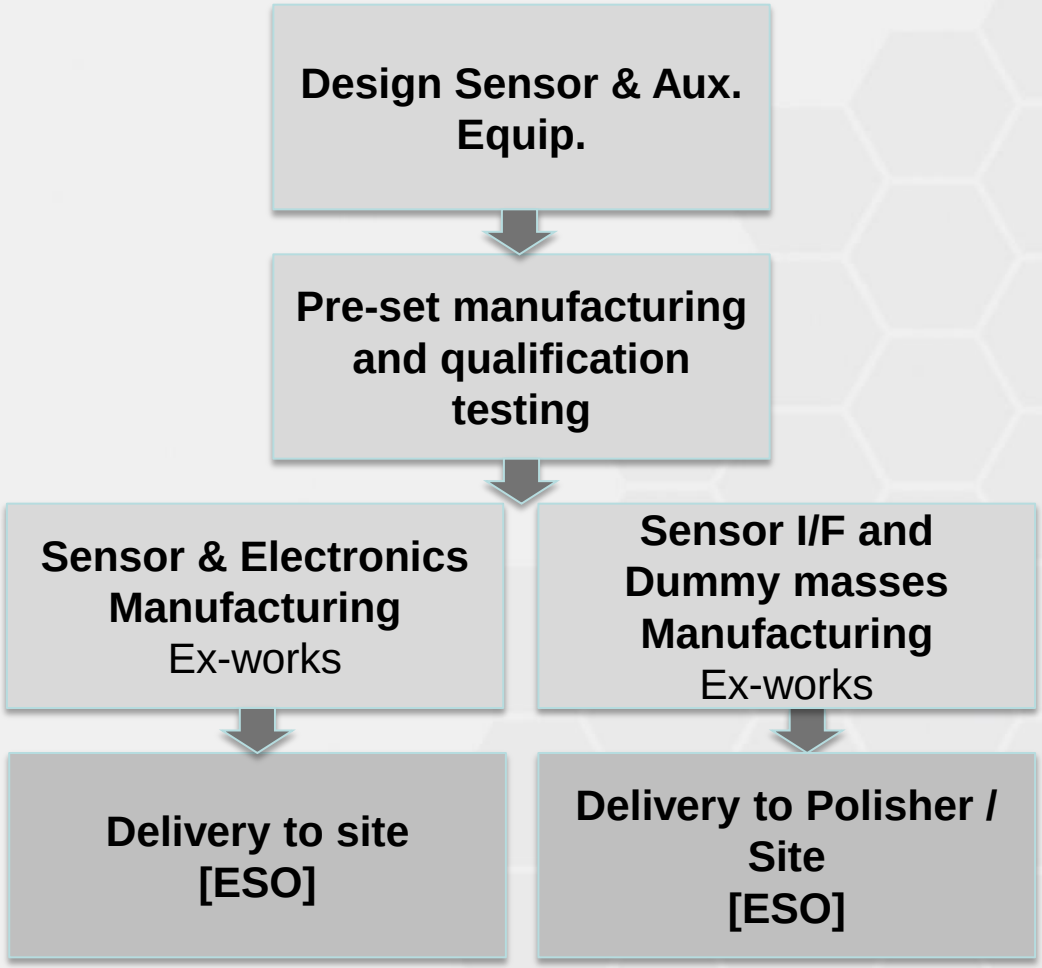
4630 x M1 Edge Sensors
(Including 100 Spares)

813 x Controllers & Electronics
(Including 15 Spares) – One for 6 Sensors

Dummy Masses
To equip M1 free edges
For figuring

M1 Unit – Edge Sensors

M1 Edge Sensors – Procurement



M1 Unit – Edge Sensors

M1 Edge Sensors – Procurement

CfT: planned in Jan 2016

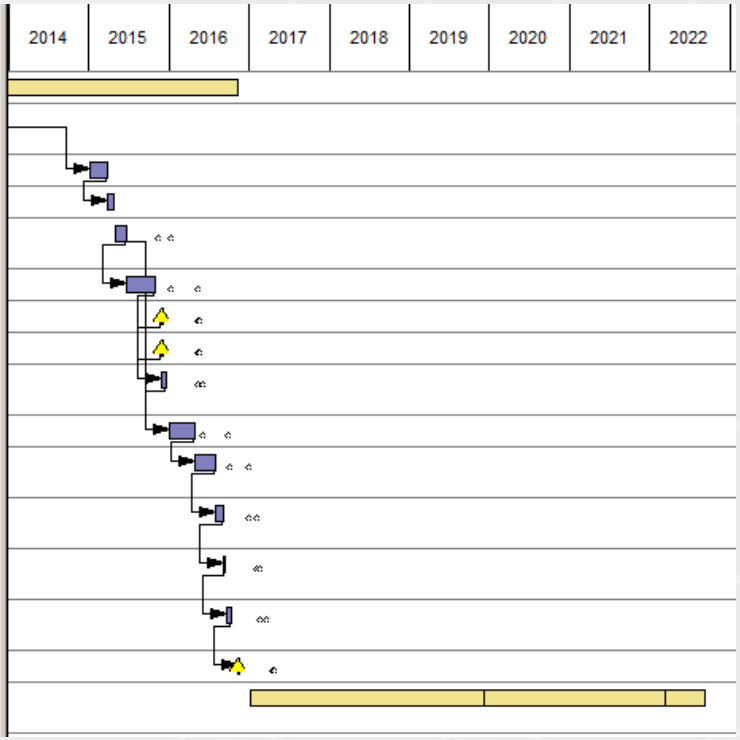
Contract start: Jan 2017

Production plan: 5 years

Required Skills:

- Precision non-contact sensors (inductive, nm precision)
- A/D electronics, mechanics
- Control
- Mass Production

Activity Desc.	Duration	Early Start	Early Finish
M1 Edge Sensors - Procurement	1206d	26Mar2012	11Nov2016
M1 Edge Sensors - Advance Info	0	26Mar2012	26Mar2012
M1 Edge Sensors - Synopsis	58d	05Jan2015	25Mar2015
M1 Edge Sensors - PI - ILOs	23d	27Mar2015	28Apr2015
M1 Edger Sensors - Preliminary Inquiry	38d	04May2015	24Jun2015
M1 Edge Sensors - CfT Package	90d	25Jun2015	28Oct2015
M1 Edge Sensors - SPE	0	30Nov2015	30Nov2015
M1 Edge Sensors - SOW	0	30Nov2015	30Nov2015
M1 Edge Sensors - Finalize CfT Package	15d	30Nov2015	18Dec2015
M1 Edge Sensors - Tendering	85d	04Jan2016	29Apr2016
M1 Edge Sensors - Clarifications and Evaluation	65d	02May2016	29Jul2016
M1 Edge Sensors - Buffer - Single Source Procurement	25d	01Aug2016	02Sep2016
M1 Edge Sensors - Selection - CaC	10d	05Sep2016	16Sep2016
M1 Edge Sensors - FC Documentation	20d	19Sep2016	14Oct2016
M1 Edge Sensors - FC Approval	0	11Nov2016	11Nov2016
M1 Edge Sensors - Design and Manufacture Contract	1475d	09Jan2017	12Sep2022

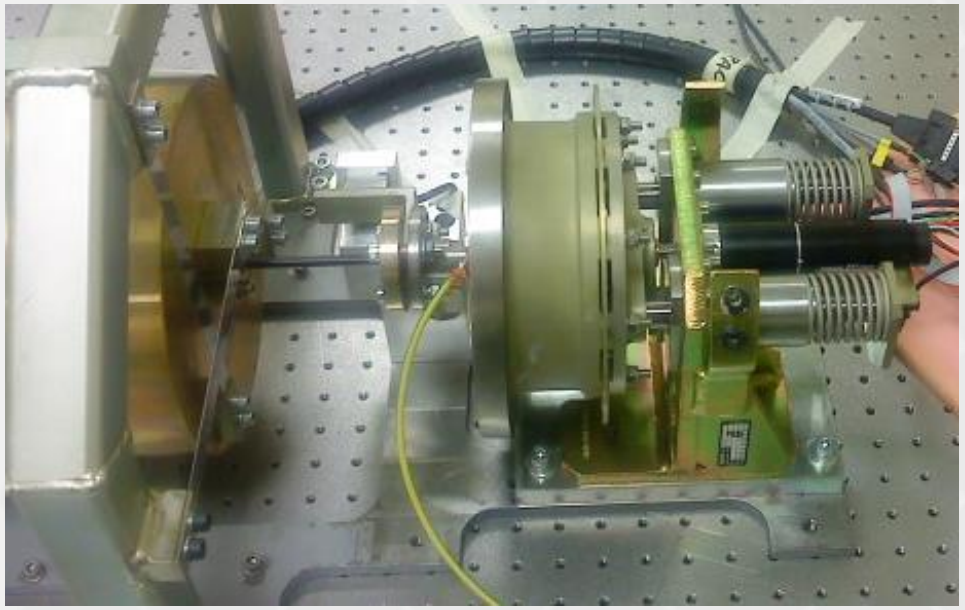


M1 Unit – Position Actuators

2 Stage actuators – nm precision along 15 mm stroke.

2 Technologies still competing:

Hard PACTs (Piezzo) / Soft PACTs (voice coil)

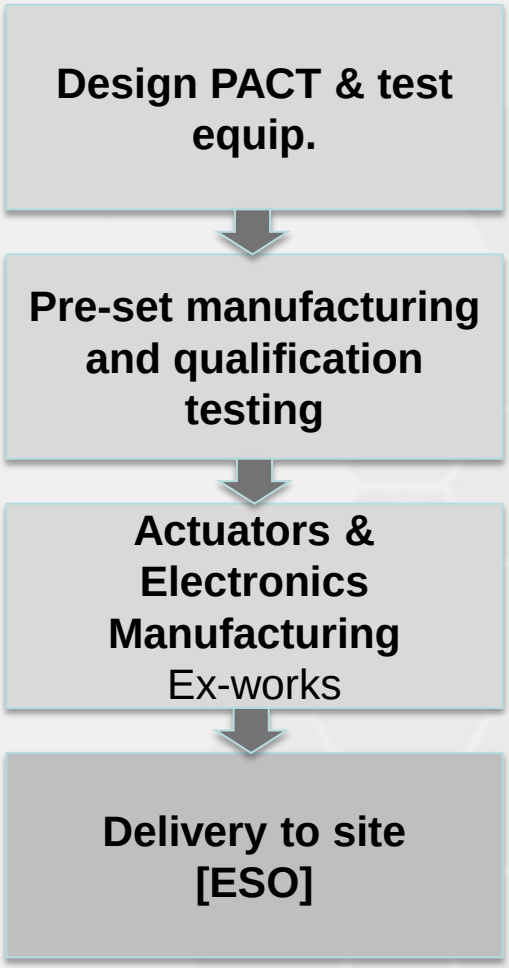


2410 x Position Actuators
(Including 16 Spares)

804 x Controllers & Electronics
(Including 6 Spares)
3 Channels

M1 Unit – Position Actuators

M1 Position Actuators – Procurement



M1 Unit – Position Actuators

M1 PACTs – Procurement

CfT: planned in Apr 2016

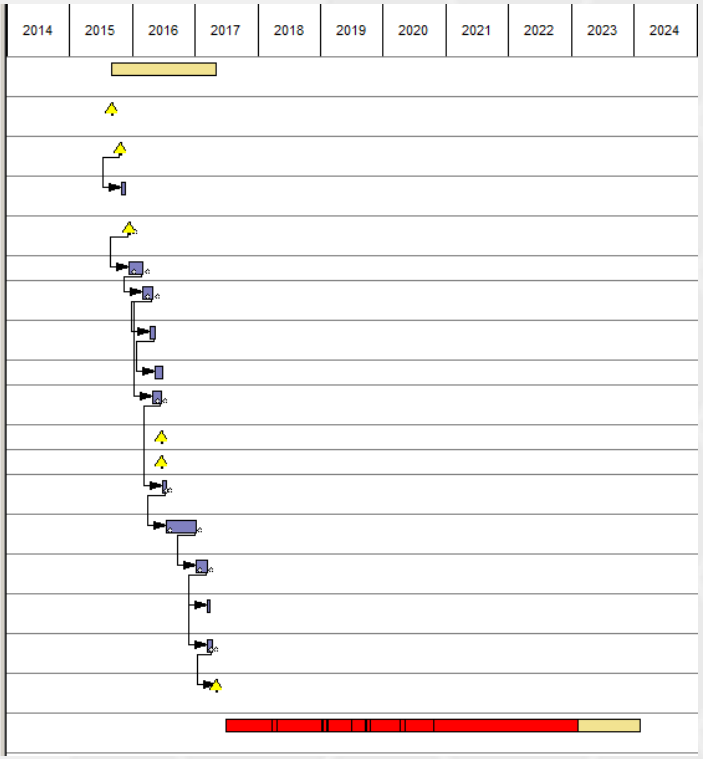
Contract start: Jun 2017

Production plan: 6.5 years

Required Skills:

- High precision actuators (nm)
- Electro-Mechanics, Electronics
- Control
- Mass Production

Activity Desc.	Duration	Early Start	Early Finish
M1 Position Actuators - Procurement	433d	04Sep2015	05May2017
M1 Position Actuators - Advance Info	0	04Sep2015	04Sep2015
M1 Position Actuators - Synopsis	0	26Oct2015	26Oct2015
M1 Position Actuators - RFI - ILOs	20d	27Oct2015	23Nov2015
M1 Position Actuators - Draft SPE for Synopsis	0	15Dec2015	15Dec2015
M1 Position Actuators - RFI	55d	16Dec2015	02Mar2016
M1 Position Actuators - RFI - Clarifications	40d	03Mar2016	27Apr2016
M1 Position Actuators - PI Documentation	20d	14Apr2016	11May2016
M1 Position Actuators - PI	30d	12May2016	22Jun2016
M1 Position Actuators - CfT Package v0	35d	28Apr2016	15Jun2016
M1 Position Actuators - SPE	0	21Jun2016	21Jun2016
M1 Position Actuators - SOW	0	20Jun2016	20Jun2016
M1 Position Actuators - Finalize CfT Package	20d	22Jun2016	19Jul2016
M1 Position Actuators - Tendering	120d	20Jul2016	04Jan2017
M1 Position Actuators - Clarifications and Evaluation	50d	05Jan2017	15Mar2017
M1 Position Actuators - Selection - CaC	10d	16Mar2017	29Mar2017
M1 Position Actuators - FC Documentation	20d	16Mar2017	12Apr2017
M1 Position Actuators - FC Approval	0	05May2017	05May2017
M1 Position Actuators - Design and Manufacturing Contract	1720d	29Jun2017	08Feb2024



M2 Unit

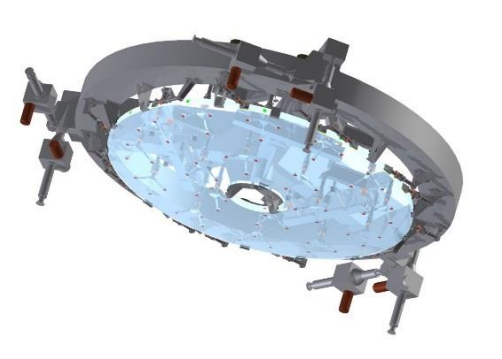
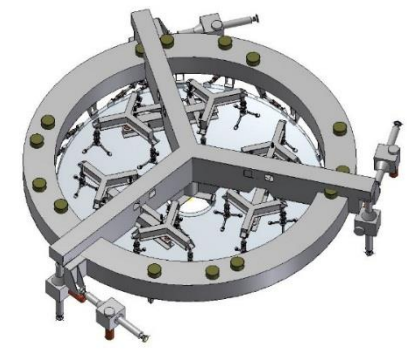
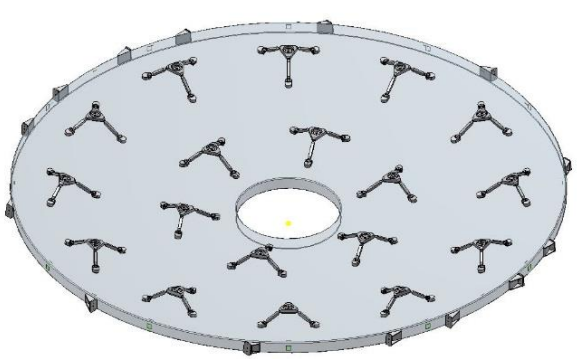
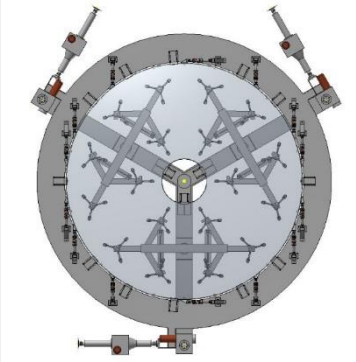
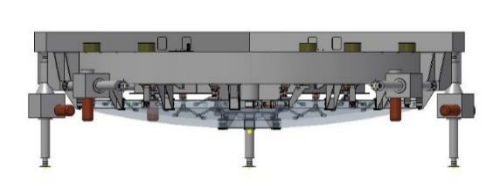
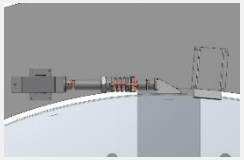
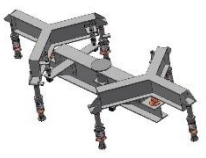
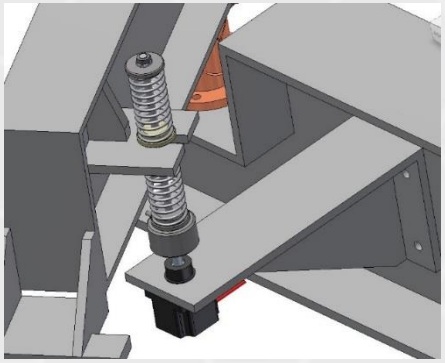
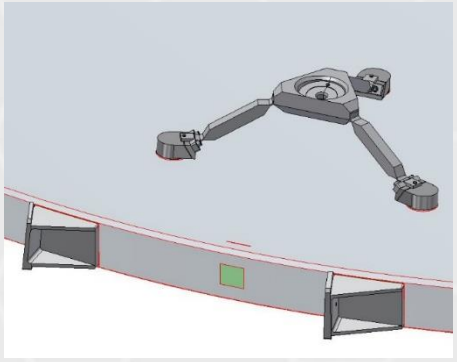
Passive 4-m f/1.1 convex mirror, highly aspheric (+ warping harness provision)

Axial support: 18 points whiffletree + tripods

Lateral support: 12 tangential struts + fixed lateral and clocking

Positioning system: hexapod with sub-micron accuracy

Earthquake protection: mirror restrainers + load limiters

M3 Unit

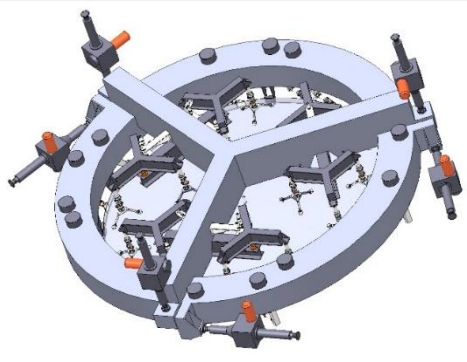
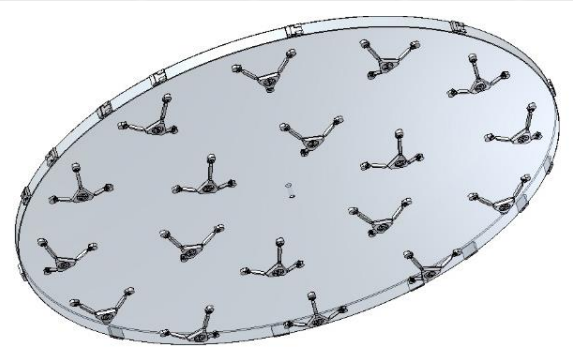
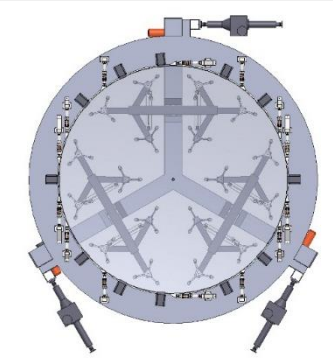
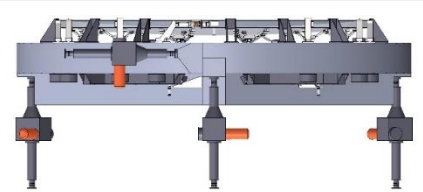
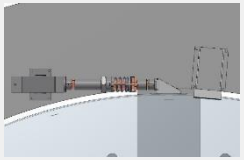
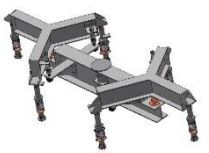
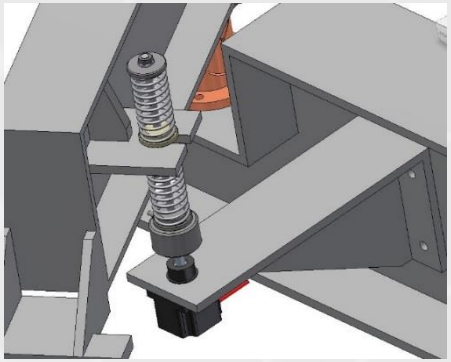
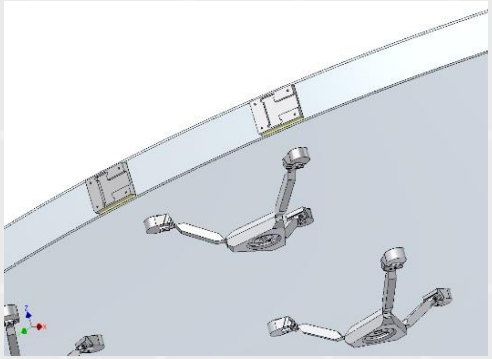
Active 4-m f/2.6 concave mirror, mild aspheric (warping harness shape control)

Axial support: 18 points whiffletree + tripods

Lateral support: 12 tangential struts + fixed lateral and clocking

Positioning system: hexapod with sub-micron accuracy

Earthquake protection: mirror restrainers + load limiters

M2 & M3 Units

M2 and M3 /Units are very similar ones !

⇒ Same size, same support concept

⇒ Same mass, same stiffness

⇒ Same shaping system (warping harness: provision on M2, required on M3)

⇒ Same positioning system

⇒ Common auxiliary equipment (handling, transport, …)

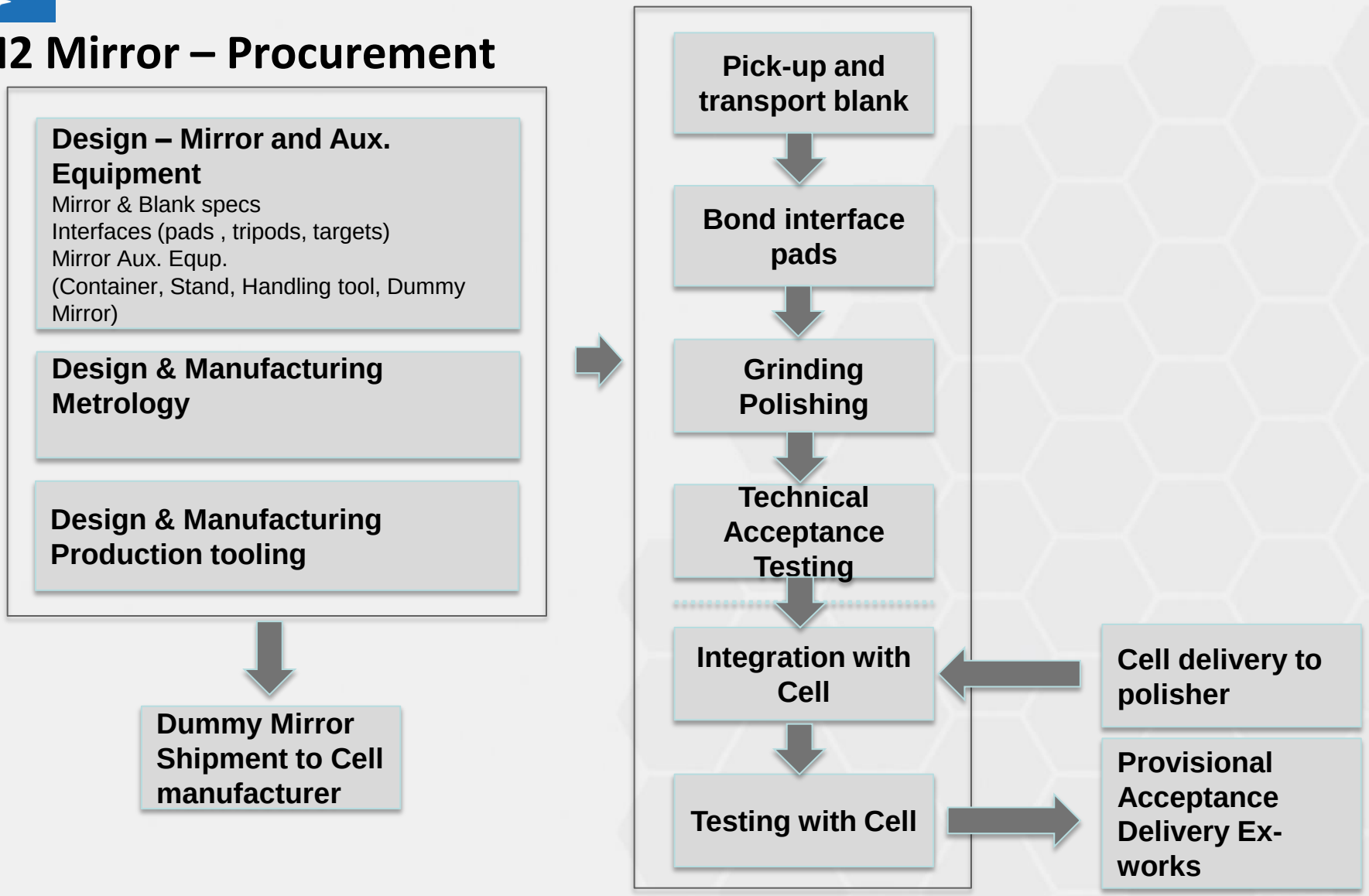
Main difference: the mirrors.

Hence, ESO is willing to contract:

- The M2 Mirror
- The M3 Mirror
- The M2+M3 Cells

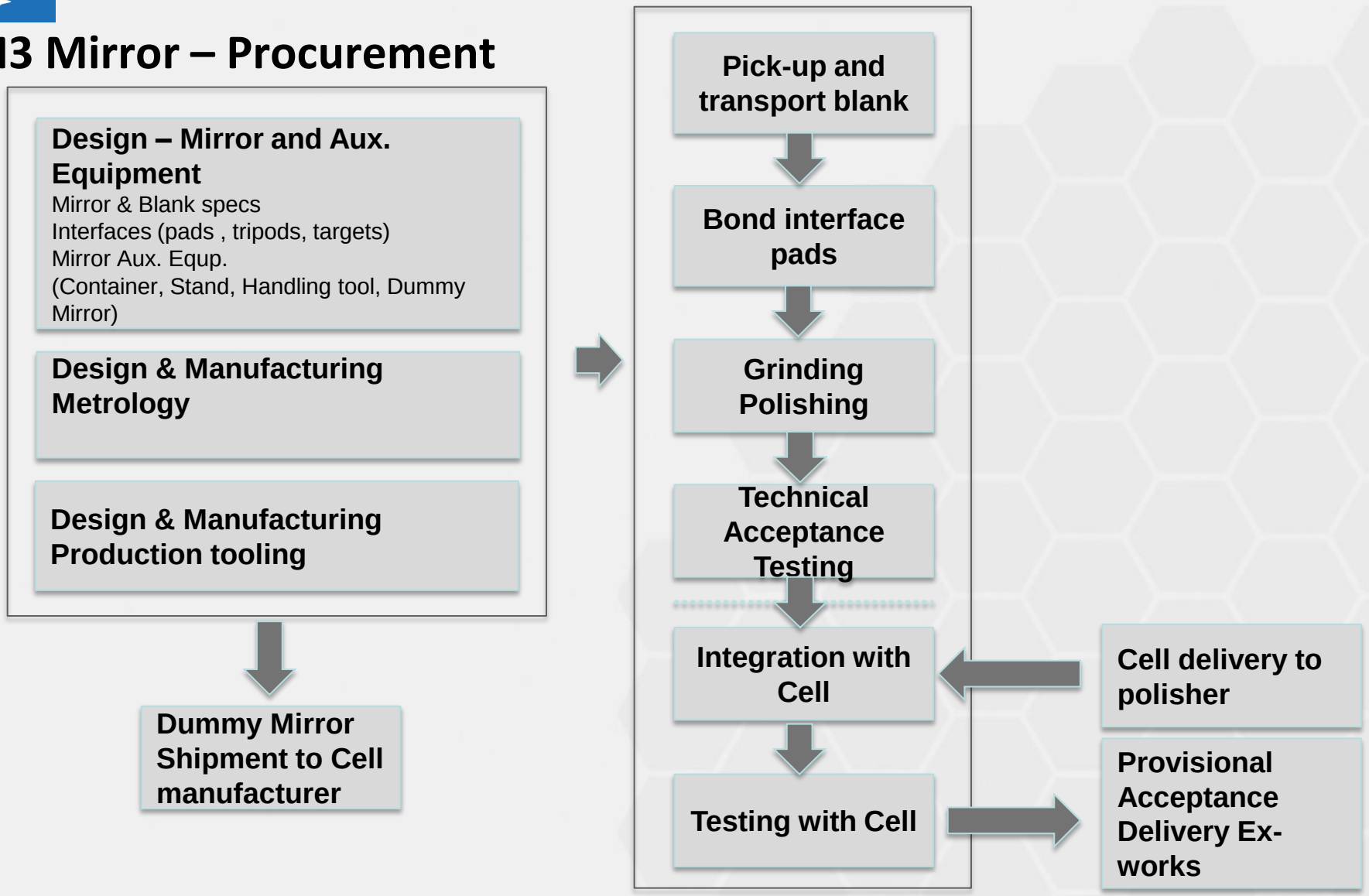
M2 Mirror

M2 Mirror – Procurement

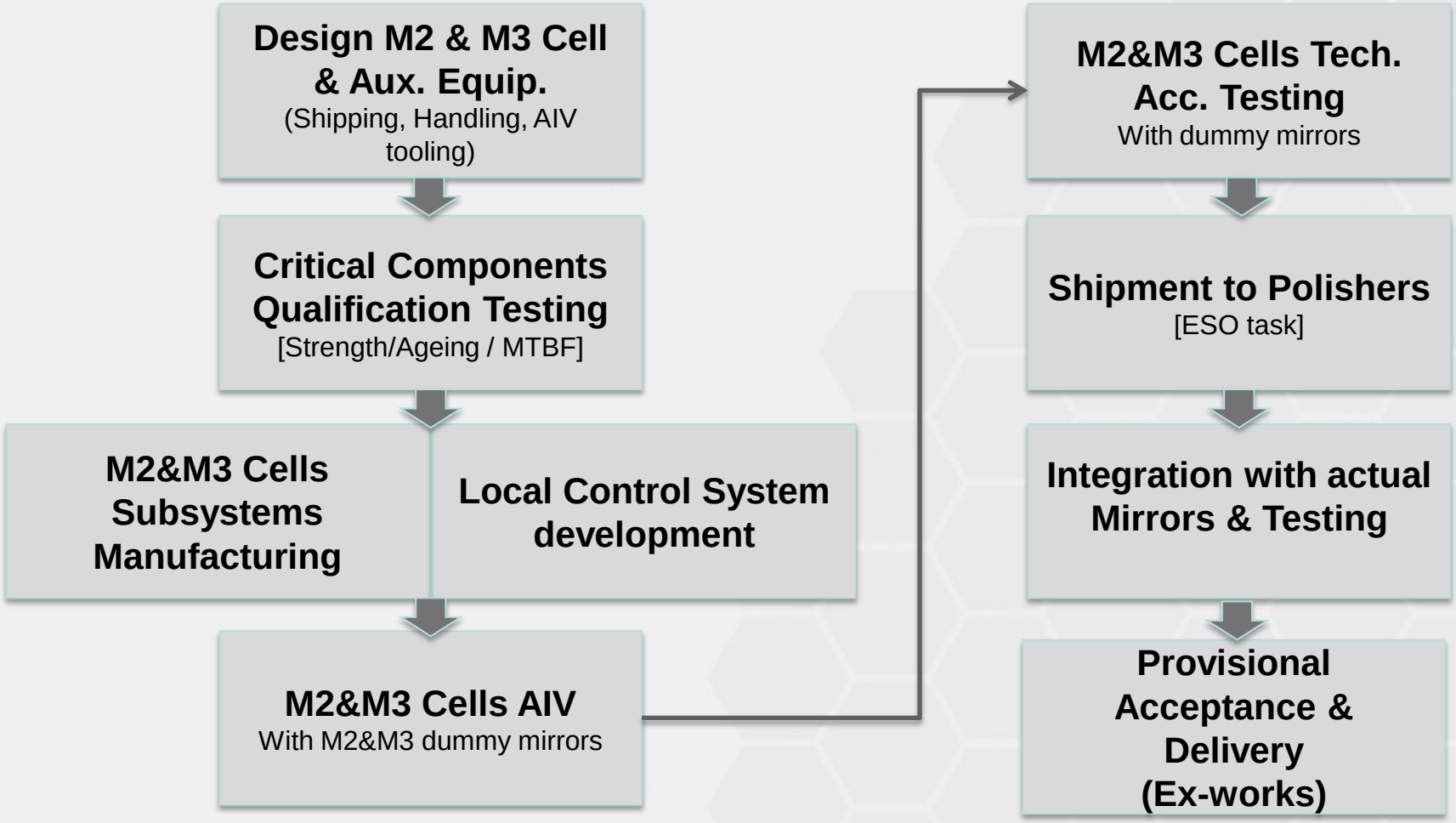


M3 Mirror

M3 Mirror – Procurement



M2 & M3 Cells – Procurement



M2 Mirror

M2 Mirror – Procurement

CfT: planned in Oct 2015

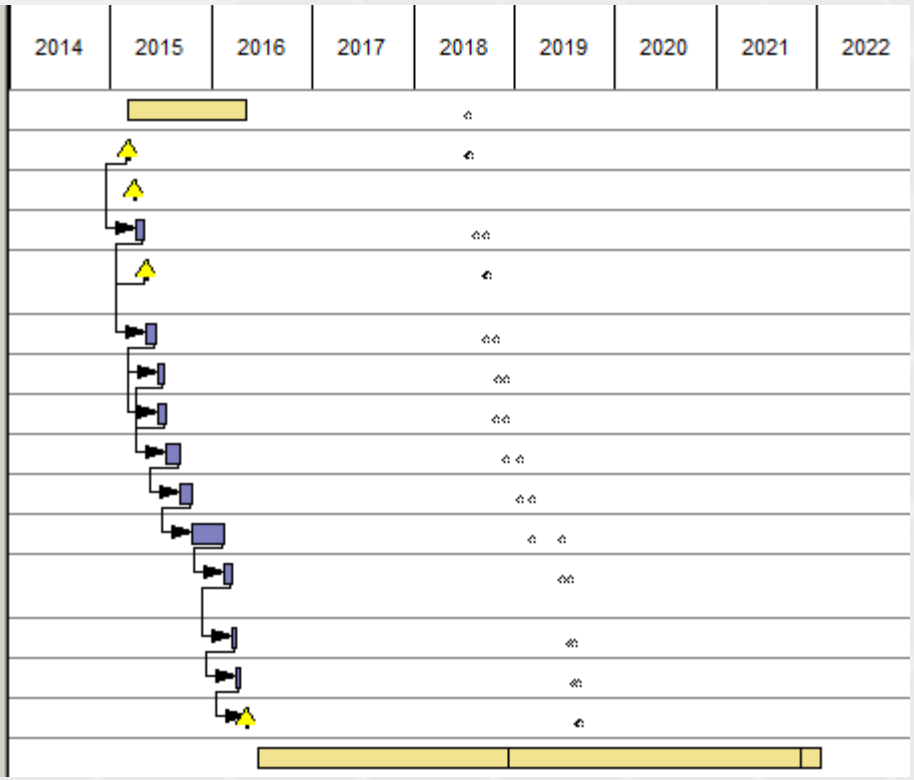
Contract start: Jun 2016

Production plan: 5.5 years

Required Skills:

- High performance large optics manuf. & testing
- Optics, Mechanics, Metrology, Adhesive bonding, …

Activity Desc.	Duration	Early Start	Early Finish
M2 Mirror - Procurement	307d	03Mar2015	06May2016
M2 Mirror - RFI - Advance Info	0	03Mar2015	03Mar2015
M2 Mirror - Synopsis	0	26Mar2015	26Mar2015
M2 Mirror - RFI - ILOs	25d	31Mar2015	04May2015
M2 Mirror - Synopsis and Draft SPE	0	08May2015	08May2015
M2 Mirror - RFI - Industry	28d	12May2015	18Jun2015
M2 Mirror - RFI - Clarifications	20d	19Jun2015	16Jul2015
M2 Mirror - PI Documentation	24d	19Jun2015	22Jul2015
M2 Mirror - PI	35d	24Jul2015	10Sep2015
M2 Mirror - Finalize CfT Package	30d	11Sep2015	22Oct2015
M2 Mirror - Tendering	81d	23Oct2015	15Feb2016
M2 Mirror - Bids Clarifications and Evaluation	20d	16Feb2016	14Mar2016
M2 Mirror - Selection - CAC	10d	15Mar2016	28Mar2016
M2 Mirror - FC Documentation	10d	29Mar2016	11Apr2016
M2 Mirror - FC Approval	0	06May2016	06May2016
M2 Mirror - Manufacturing Contract	1450d	17Jun2016	14Jan2022



M3 Mirror

M3 Mirror – Procurement

CfT: planned in Feb 2016

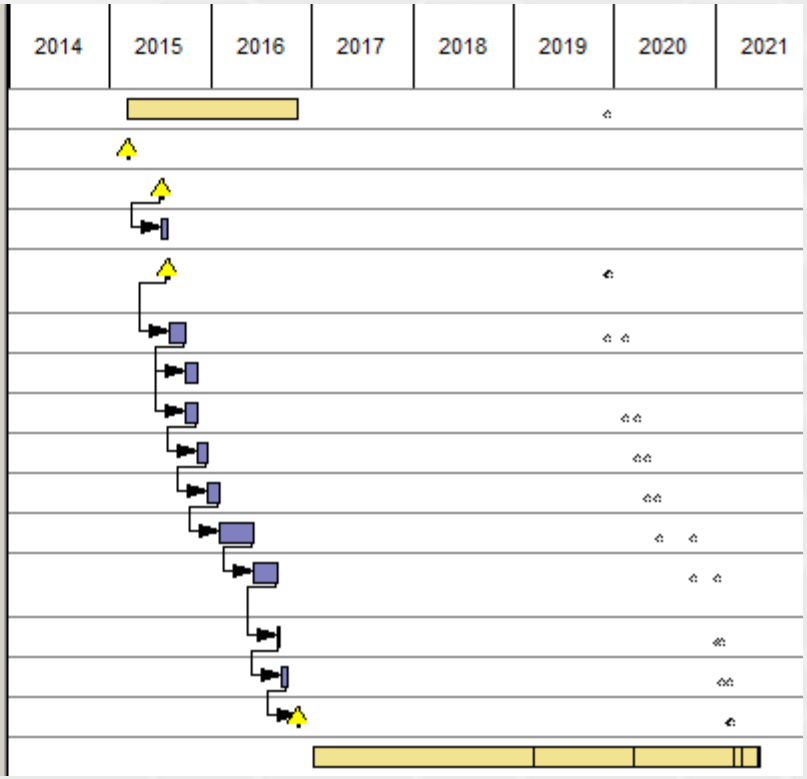
Contract start: Jan 2017

Production plan: 4.5 years

Required Skills:

- High performance large optics manuf. & testing
- Optics, Mechanics, Metrology, Adhesive bonding, …

Activity Desc.	Duration	Early Start	Early Finish
M3 Mirror - Procurement	442d	03Mar2015	11Nov2016
M3 Mirror - RFI - Advance Info	0	03Mar2015	03Mar2015
M3 Mirror - Synopsis	0	03Jul2015	03Jul2015
M3 Mirror - RFI - ILOs	20d	03Jul2015	30Jul2015
M3 Mirror - Synopsis and Draft SPE	0	31Jul2015	31Jul2015
M3 Mirror - RFI - Industry	45d	03Aug2015	02Oct2015
M3 Mirror - RFI - Clarifications	30d	05Oct2015	13Nov2015
M3 Mirror - PI Documentation	30d	05Oct2015	13Nov2015
M3 Mirror - PI	25d	16Nov2015	18Dec2015
M3 Mirror - Finalize CfT Package	29d	21Dec2015	29Jan2016
M3 Mirror - Tendering	90d	01Feb2016	03Jun2016
M3 Mirror - Bids Clarifications and Evaluation	60d	06Jun2016	26Aug2016
M3 Mirror - Selection - CAC	10d	29Aug2016	09Sep2016
M3 Mirror - FC Documentation	20d	12Sep2016	07Oct2016
ESO FC Approval - M3 Mirror	0	11Nov2016	11Nov2016
M3 Mirror - Manufacturing Contract	1149d	06Jan2017	09Jun2021



M2&M3 Cells

M2&M3 Cells – Procurement

CfT: planned in Feb 2016

Contract start: Jan 2017

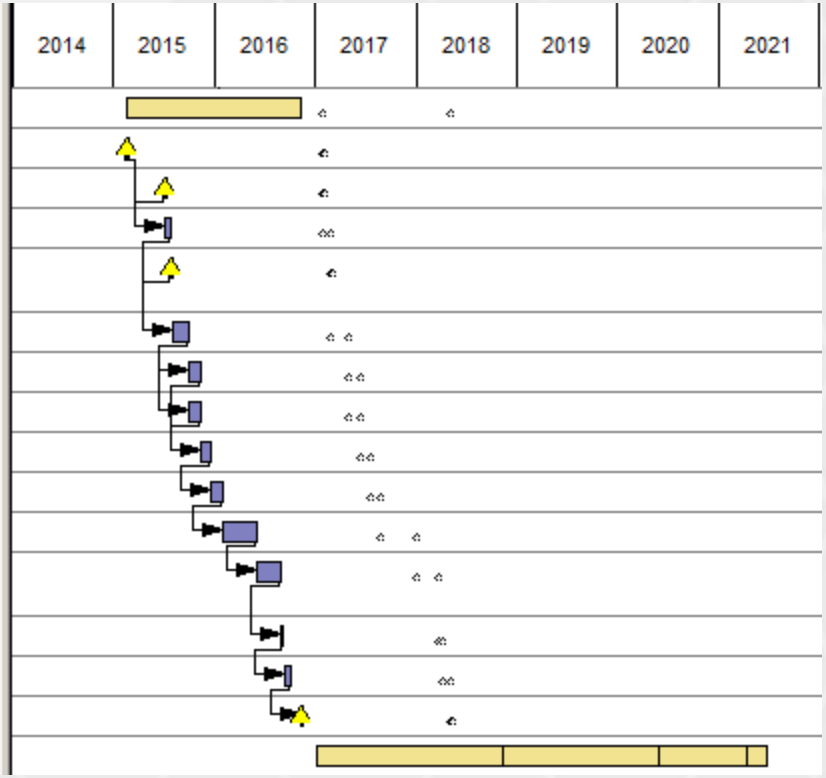
Production plan: 4.5 years

(schedule shall read M2 and/or M3)

Required Skills:

- Optomechanics, Mechanics (for large high performance optics)
- Electromechanics (warping harness)
- Mechanical & optomechanics integration and testing

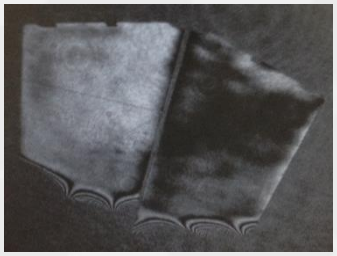
Activity Desc.	Duration	Early Start	Early Finish
M2 Cell - Procurement	450d	19Feb2015	11Nov2016
M2 Cell - RFI - Advance Info	0	19Feb2015	19Feb2015
M2 Cell - RFI - Synopsis	0	03Jul2015	03Jul2015
M2 Cell - RFI - ILOs	20d	06Jul2015	31Jul2015
M2 Cell - Synopsis and Draft SPE	0	31Jul2015	31Jul2015
M2 Cell - RFI - Industry	45d	03Aug2015	02Oct2015
M2 Cell - RFI - Clarifications	30d	05Oct2015	13Nov2015
M2 Cell - PI Documentation	30d	05Oct2015	13Nov2015
M2 Cell - PI	25d	16Nov2015	18Dec2015
M2 Cell - Finalize CfT Package	29d	21Dec2015	29Jan2016
M2 Cell - Tendering	90d	01Feb2016	03Jun2016
M2 Cell - Bids Clarifications and Evaluation	60d	06Jun2016	26Aug2016
M2 Cell - Selection - CAC	10d	29Aug2016	09Sep2016
M2 Cell - FC Documentation	20d	12Sep2016	07Oct2016
ESO FC Approval - M2 Cell	0	11Nov2016	11Nov2016
M2 Cell - Manufacturing Contract	1160d	09Jan2017	24Jun2021

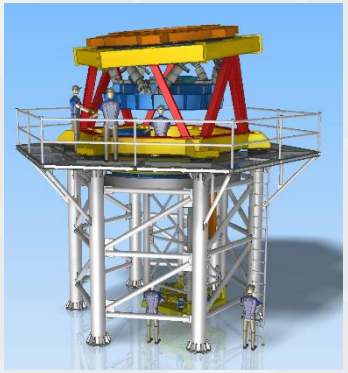


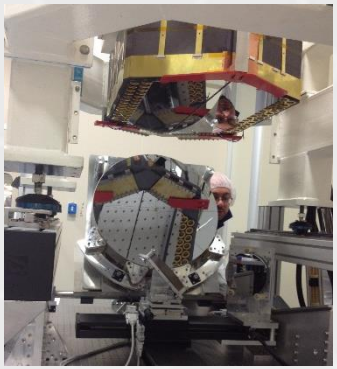
M4 Unit

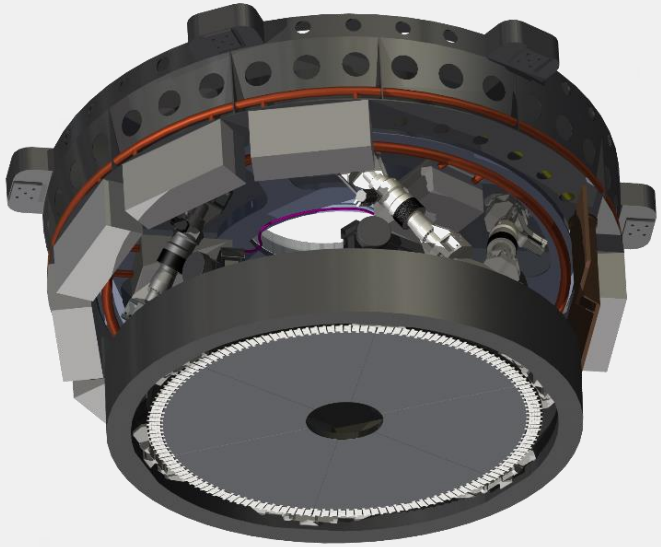
- 2.4-m flat adaptive mirror – 6 petals
- Preliminary Design Study contract completed
- Contract for Final Design and Manufacturing being awarded
- Contract for Optics being awarded
- Contracts start: July 2015

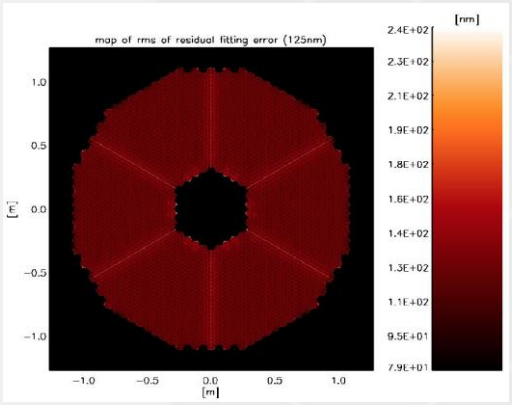
⇒ Check ESO Web site to know contractors



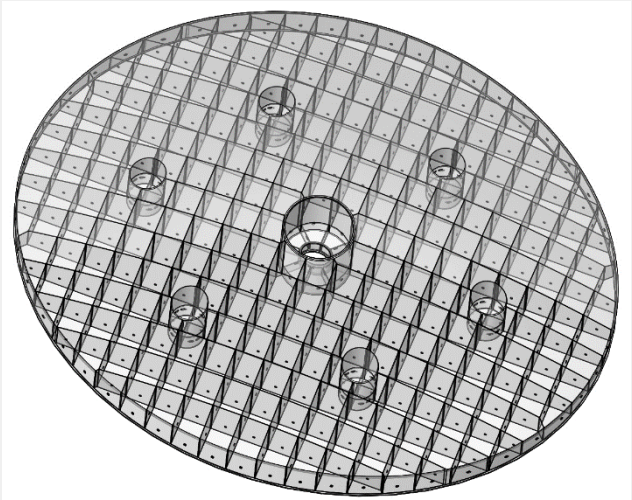




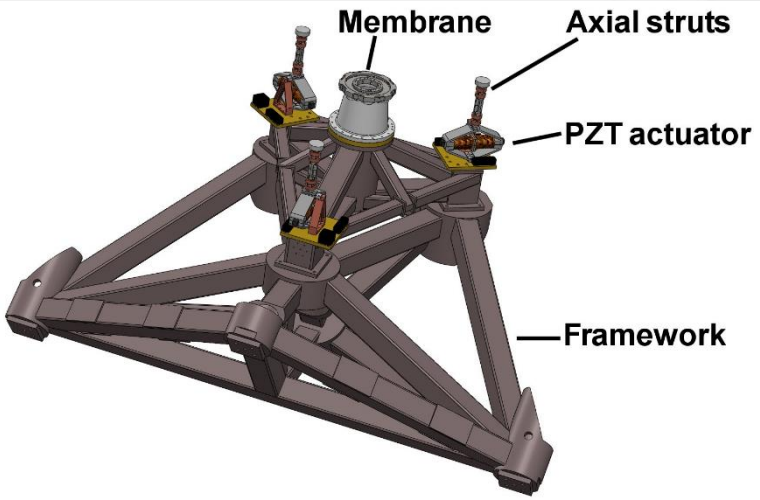




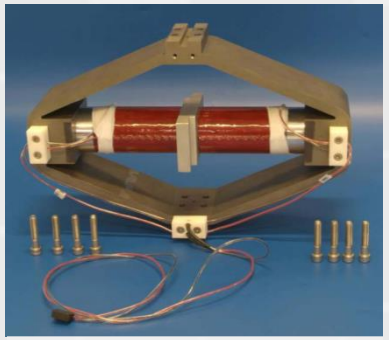
M5 Unit



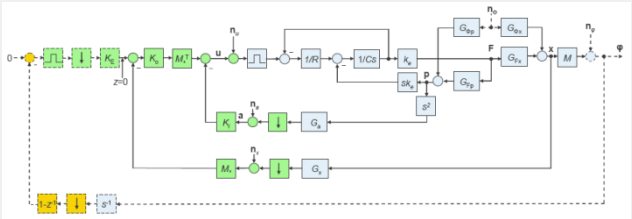
M5 Mirror



M5 Electromechanical Subunit



Prototype Actuator



M5 Local Control System

M5 Auxiliary Equipment [Shipping, Handling, AIV]

Spare Parts

Scale 1 Prototype Unit

M5 Unit

M5 Mirror – Procurement

Design – Mirror and Aux. Equipment
Mirror & Blank specs
Interfaces (pads , targets)
Mirror Aux. Equp.
(Container, Stand, Handling tool)

Design & Manufacturing Metrology
Variable gravity orientation. Compatible with integrated M5 Unit

Design & Manufacturing Production tooling

Blank fabrication
Technology: tbd

Interface bonding
Grinding
Polishing

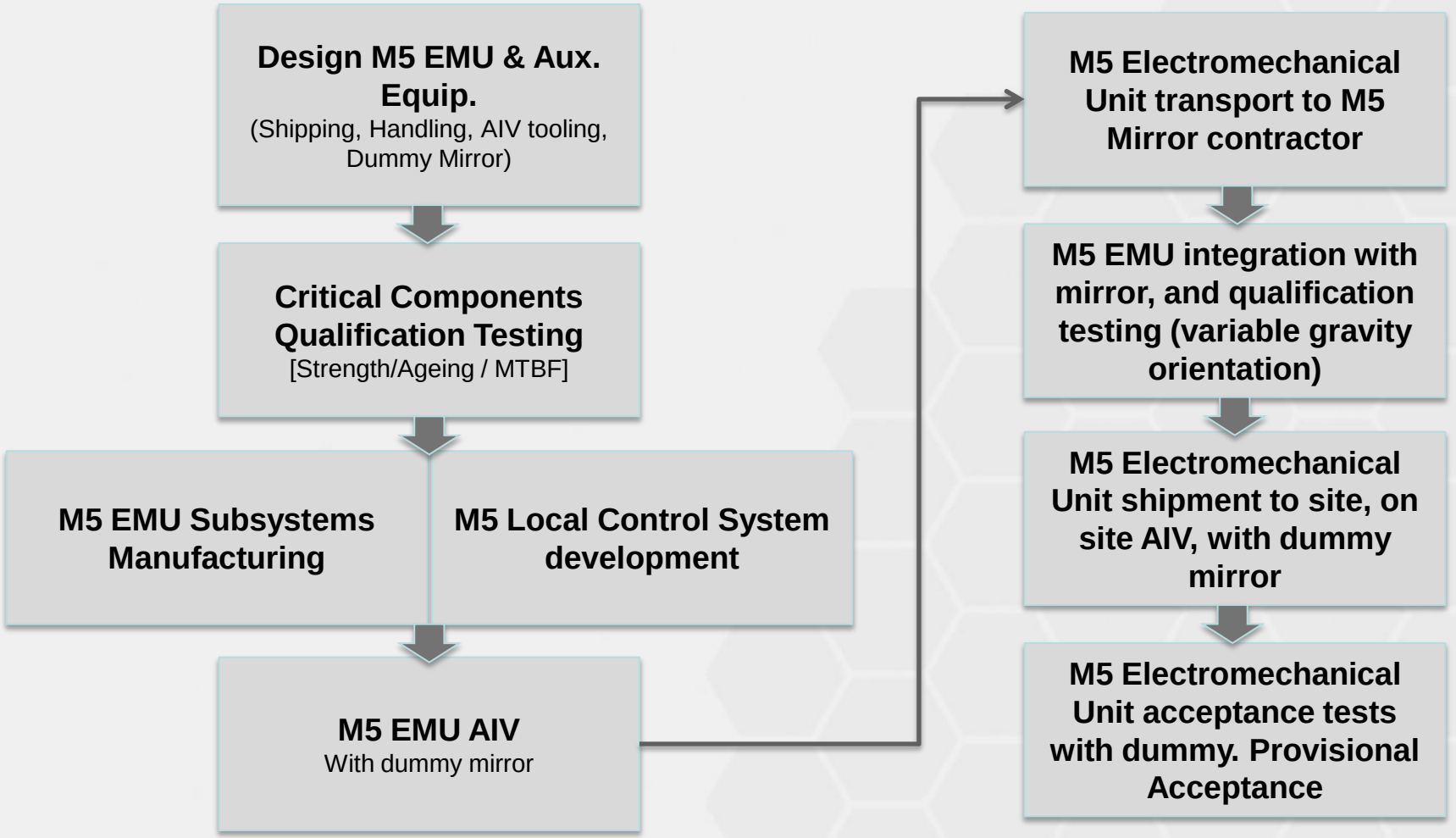
Mirror acceptance testing with metrology support

Mirror Tests & Qualification integrated M5 Unit

Mirror and Aux. shipment to site

Mirror site inspection and acceptance

M5 EMU – Procurement



M5 Mirror – Procurement

CfT: planned in July 2017

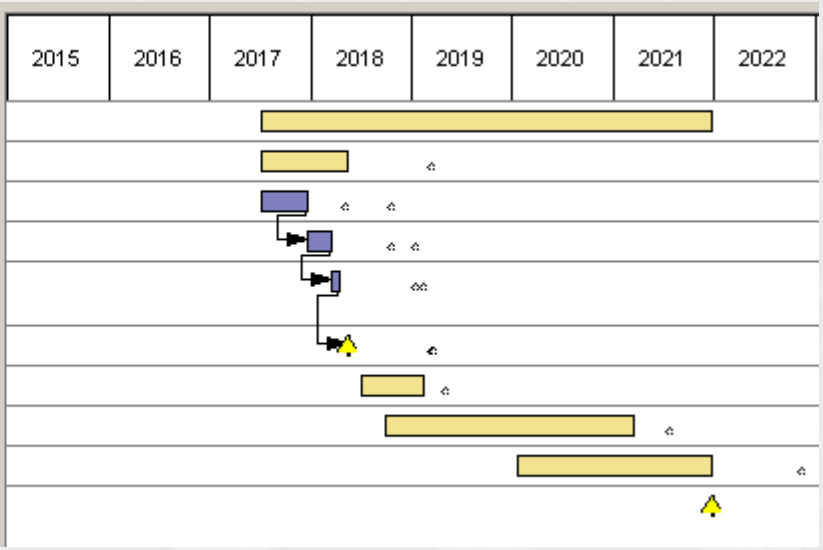
Contract start: July 2018

Production plan: 4 years

Required Skills:

- High performance large optics manuf. & testing
- Optics, Mechanics, Metrology, Adhesive bonding, …

Activity Desc.	Duration	Early Start	Early Finish
M5 Mirror	1160d	07Jul2017	22Dec2021
M5 Mirror - Procurement	220d	07Jul2017	11May2018
M5 Mirror - Tendering	120d	07Jul2017	21Dec2017
M5 Mirror - Selection	60d	22Dec2017	15Mar2018
M5 Mirror - Prepare FC Documentation	20d	16Mar2018	12Apr2018
M5 Mirror - FC Approval	0	11May2018	11May2018
Phase 1 - Design M5 Mirror	160d	05Jul2018	15Feb2019
Phase 2 - Manufacture M5 Blank	640d	27Sep2018	17Mar2021
Phase 3 - Mirror Finishing	500d	21Jan2020	22Dec2021
M5 Delivery (Stays at polisher facilities)	0	22Dec2021	22Dec2021



M5 Unit

M5 EMU – Procurement

CfT: planned in Jan 2018

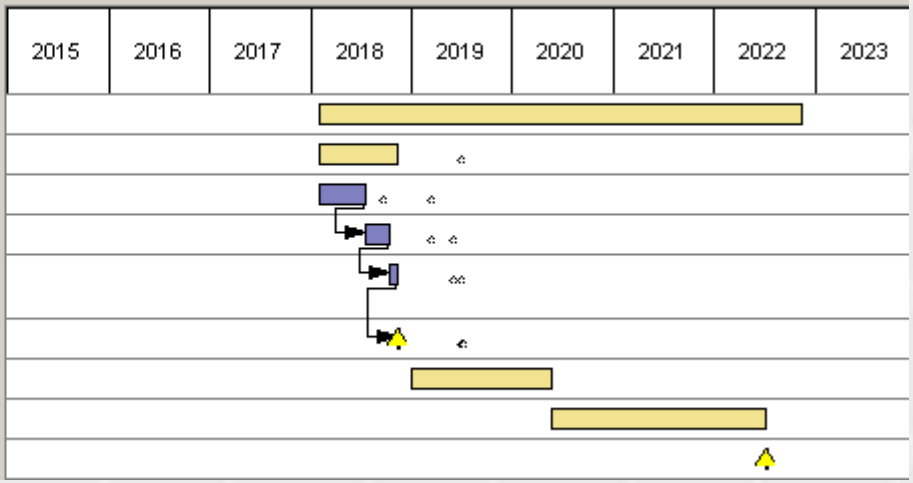
Contract start: Jan 2019

Production plan: 3.5 years

Required Skills:

- Optomechanics, Mechanics (for large high performance optics)
- Electromechanics
- Mechanical & optomechanics integration and testing
- Control

Activity Desc.	Duration	Early Start	Early Finish
M5 ElectroMechanical SubUnit	1245d	02Feb2018	17Nov2022
M5 EMU - Procurement	200d	02Feb2018	09Nov2018
M5 Electrom. Unit - Tendering	120d	02Feb2018	19Jul2018
M5 Electrom. Unit - Selection	60d	20Jul2018	11Oct2018
M5 Electrom. Unit - Prepare FC Documentation	20d	12Oct2018	08Nov2018
M5 Electrom. Unit - FC Approval	0	09Nov2018	09Nov2018
M5 EMU Design	360d	04Jan2019	25May2020
M5 EMU Procurements and MAIT	550d	26May2020	07Jul2022
M5 Available on Site	0	07Jul2022	07Jul2022

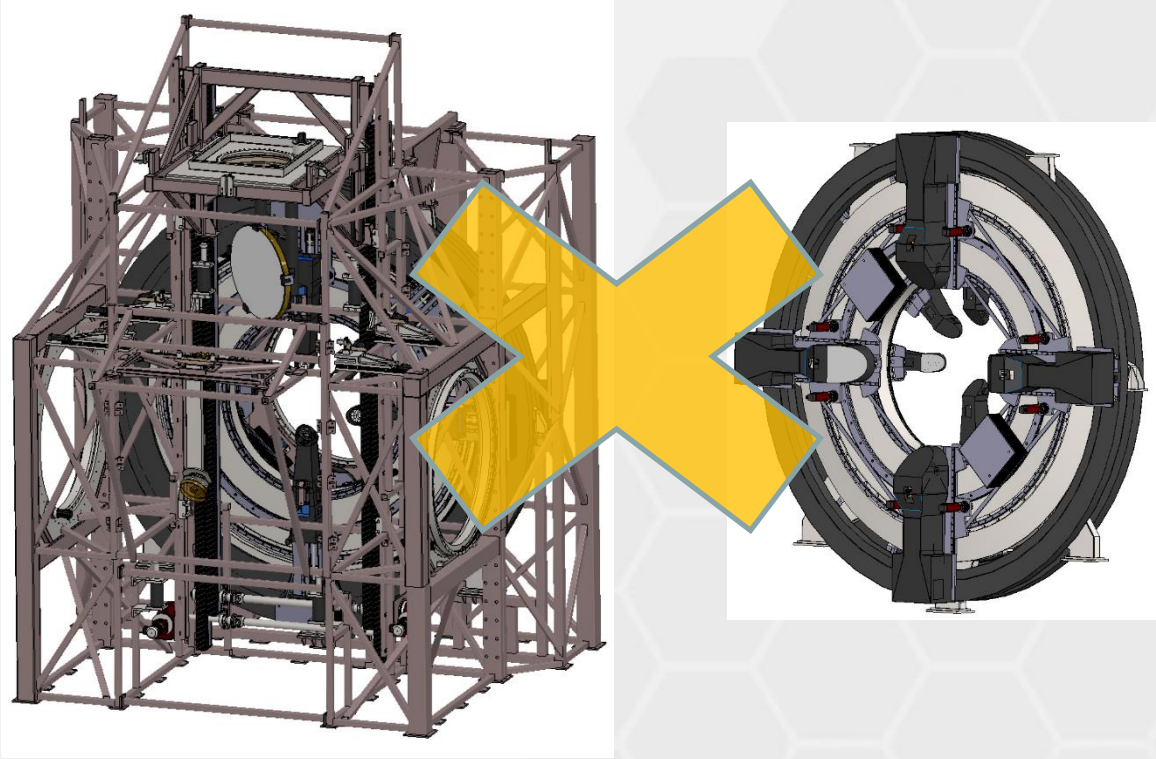


Prefocal Stations

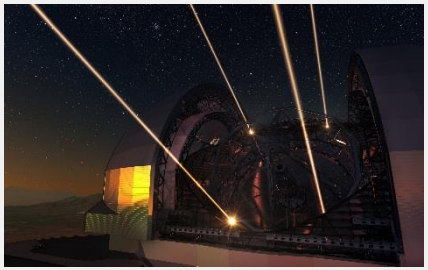
Interface with Telescope have changed.

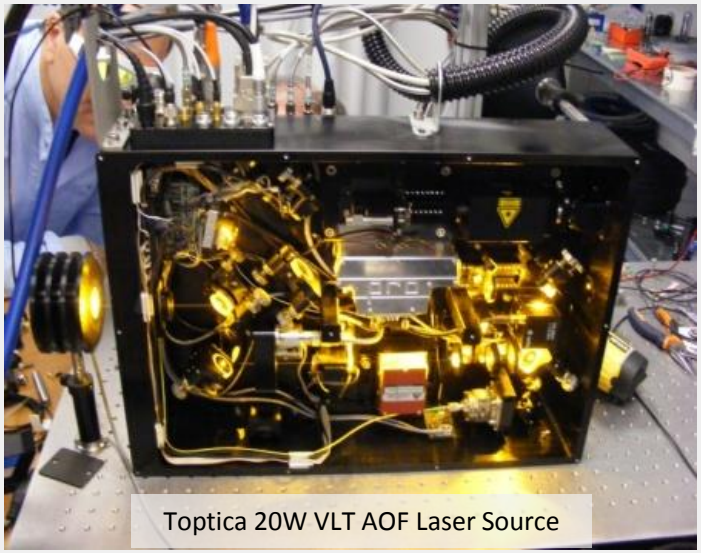
⇒Under development…

⇒See Roberto's presentation

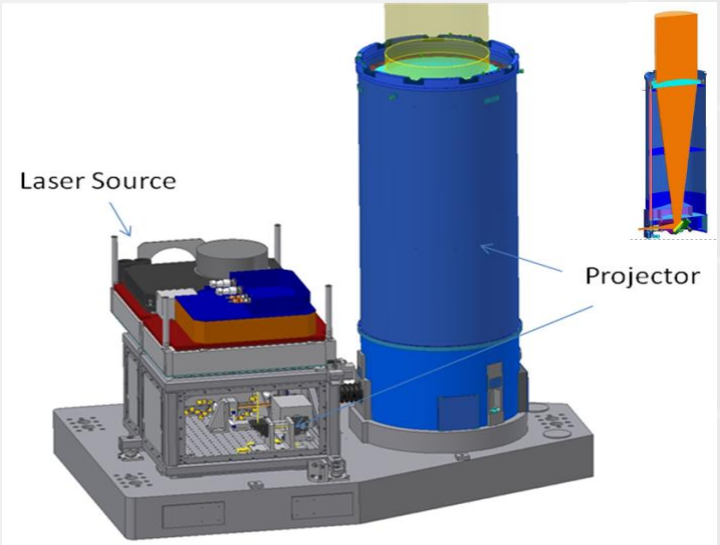


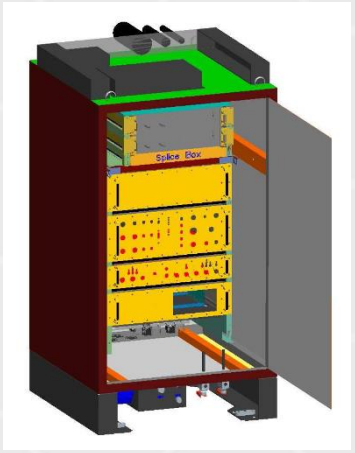
Laser Guide Star Units





Toptica 20W VLT AOF Laser Source





Laser Source Control Electronics

6 +1 Laser Sources
(Including 1 Spare)
20/25W Raman Fiber Amplifier

Local Electronics and Control System

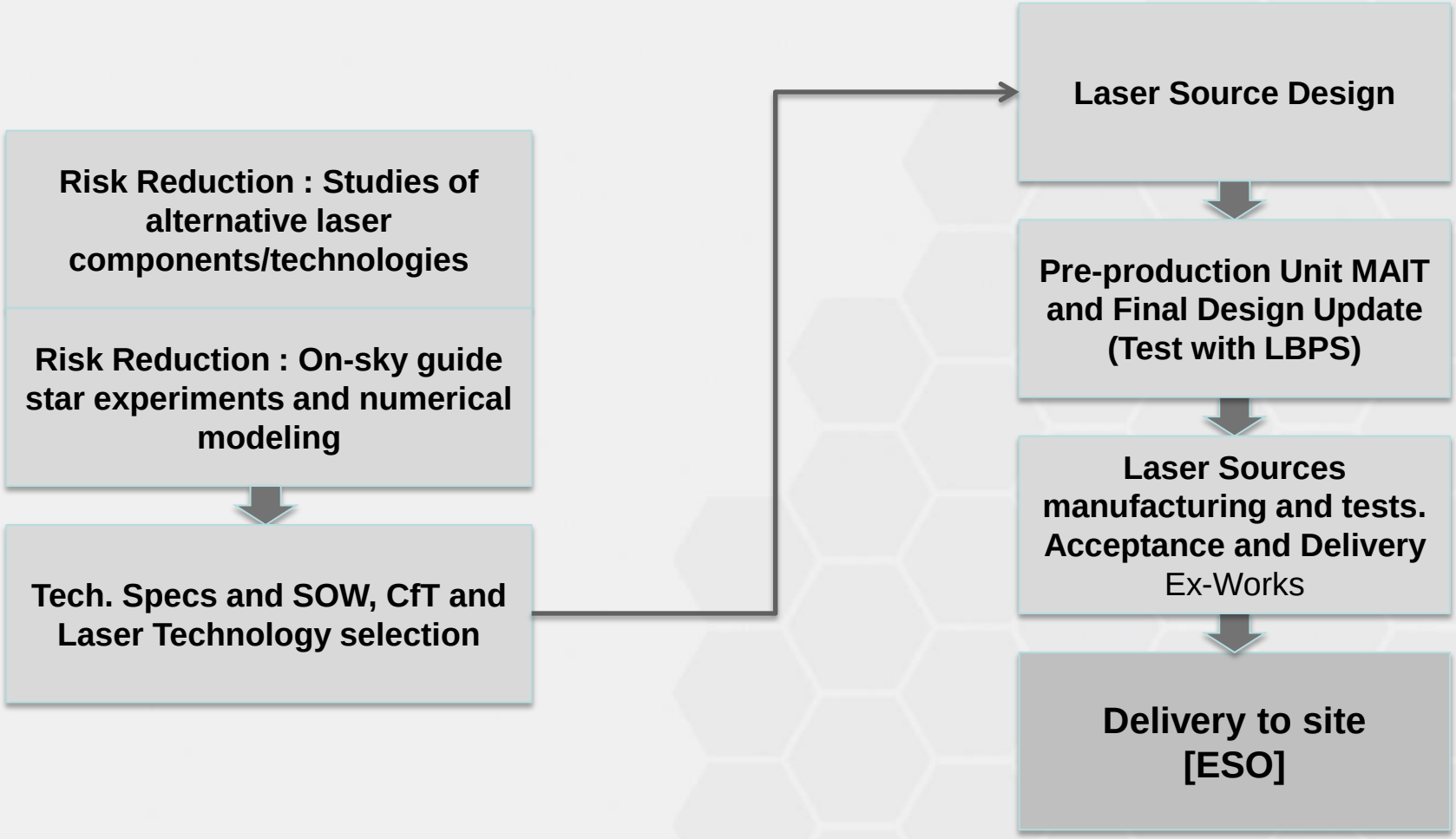
Auxiliary Equipment
(AIV, handling, shipping, testing)

6 Laser Beam Projection Subunits
- Mechanical Structure & enclosure
- Beam relay and diagnostics
- Launch Telescope
- Baffle towers
- Cooling
- Control Electronics

TNO 20W VLT AOF Launch Telescope

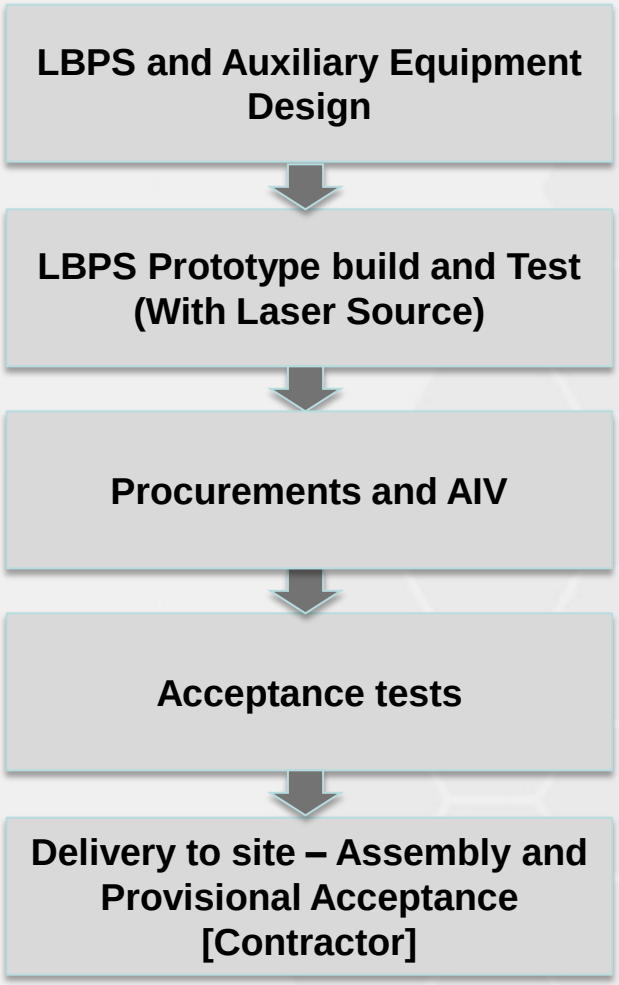
Laser Guide Star Units

Laser Sources – Procurement



Laser Guide Star Units

Laser Beam Projection Subunits – Procurement



Laser Guide Star Units

Lasers – Procurement

CfT: planned in Jan 2018

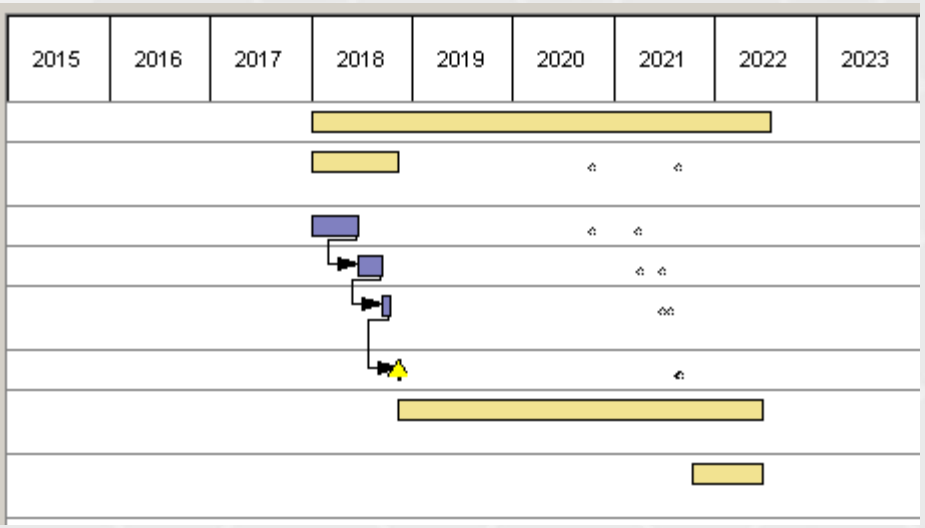
Contract start: Jan 2019

Production plan: 4 years

Required Skills:

- High power lasers 589 nm

Activity Desc.	Duration	Early Start	Early Finish
Laser Source Subunits	1180d	05Jan2018	21Jul2022
Laser Source subunits - Procurement	220d	05Jan2018	09Nov2018
Laser Sources - Tendering	120d	05Jan2018	21Jun2018
Laser Sources - Selection	60d	22Jun2018	13Sep2018
Laser Sources - Prepare FC Documentation	20d	14Sep2018	11Oct2018
Laser Sources - FC Approval	0	09Nov2018	09Nov2018
Laser Sources - Manufacture (phase 1)	940d	09Nov2018	23Jun2022
Laser Sources - Manufacture (phase 2)	180d	14Oct2021	23Jun2022



Laser Guide Star Units

LBPS – Procurement

CfT: planned in Jan 2018

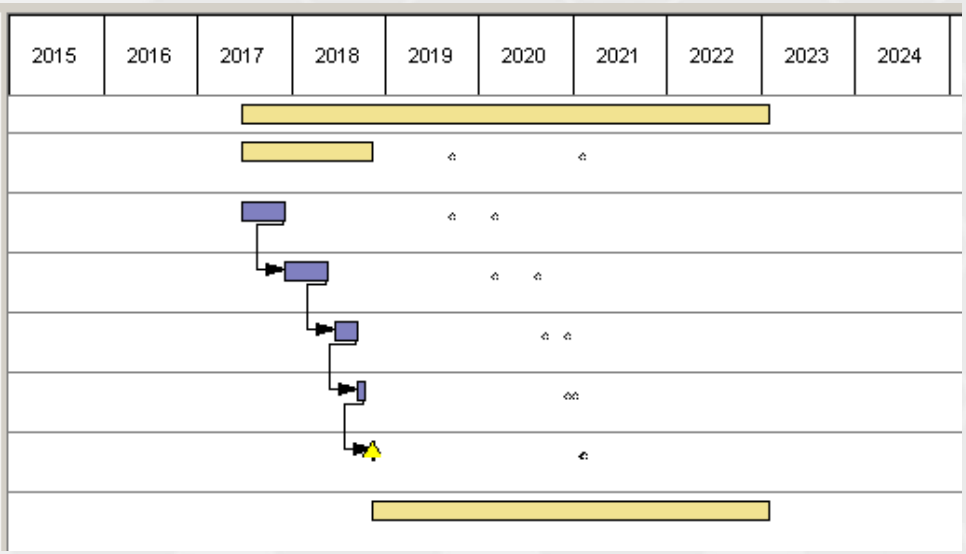
Contract start: Jan 2019

Production plan: 4 years

Required Skills:

- Optomechanics, Mechanics
- Electromechanics
- Mechanical & optomechanics integration and testing
- Control

Activity Desc.	Duration	Early Start	Early Finish
Laser Beam Projection Subunits	1460d	23Jun2017	02Feb2023
Laser Beam Projection Subunits - Procurement	360d	23Jun2017	09Nov2018
Laser Beam Projection Subunits - Technical and Managerial	120d	23Jun2017	07Dec2017
Laser Beam Projection SubUnits - Tendering	120d	08Dec2017	24May2018
Laser Beam Projection SubUnits - Selection	60d	22Jun2018	13Sep2018
Laser Beam Projection SubUnits - Prepare FC Documentation	20d	14Sep2018	11Oct2018
Laser Beam Projection SubUnits - FC Approval	0	09Nov2018	09Nov2018
Laser Beam Projection Subunits (LGSU) - Manufacture (Phase 1)	1100d	09Nov2018	02Feb2023



E-ELT Optomechanics - Conclusion

WE ARE DOING IT NOW !!!

PLEASE JOIN ☺ !!!