

TNO Space & Scientific Instrumentation

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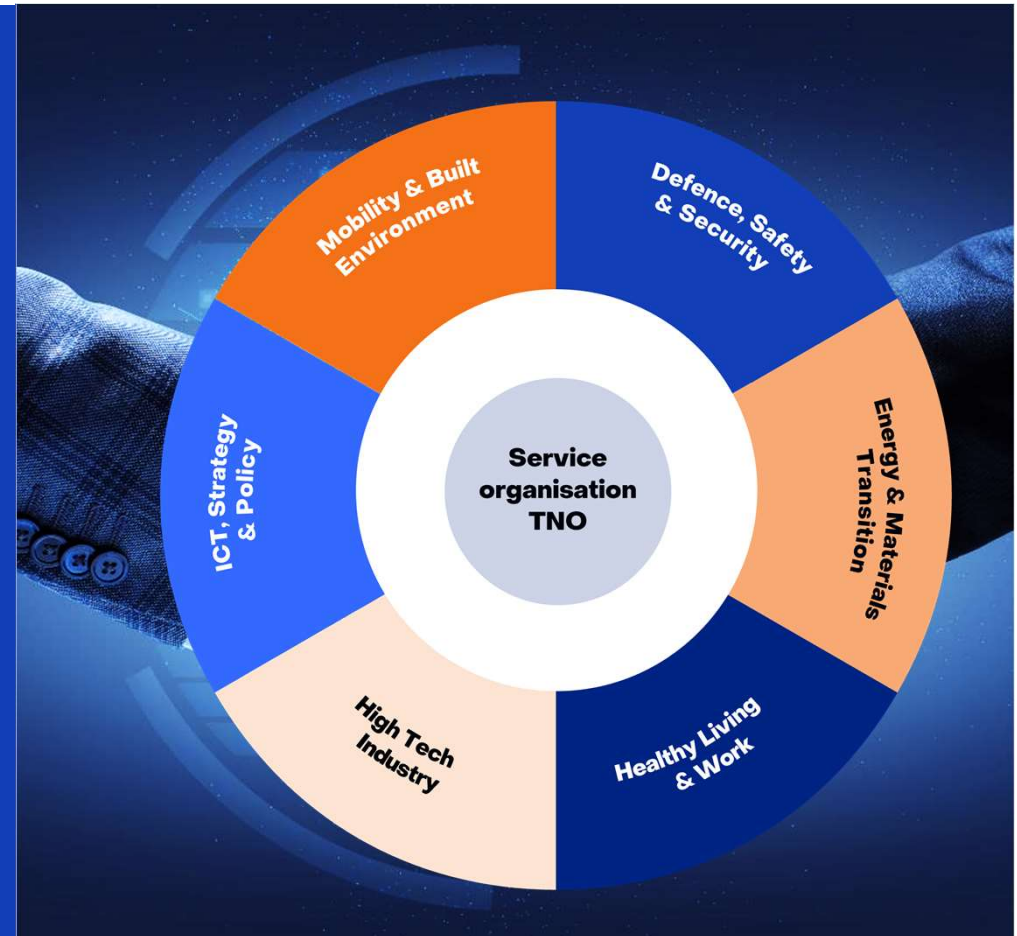


We are TNO

TNO connects people and knowledge to create innovations that

- 1/ boost companies' competitiveness and
- 2/ sustainably increase well-being across society.

90 years of innovation



TNO Unit High Tech Industry

- TNO's unit High Tech Industry realizes groundbreaking technological and systemic innovations in high-tech industrial value chains in order to safeguard and improve societal well-being and strengthen our national earning capacity.
- We believe the Dutch high-tech industry holds and will continue to hold a leading position in both new and existing markets, powered by TNO technologies.
- 4 innovative roadmaps combining market demands and technology based solutions:



Space & scientific instrumentation



Smart Industry



Semicon & Quantum



Flexible electronics

Why TNO Space & Scientific Instrumentation?

<p>13 CLIMATE ACTION</p>  <p>3 GOOD HEALTH AND WELL-BEING</p> 	<h3>Prevent climate change & air pollution</h3>  <p>2000 Aug 23, 2000 Jul 01 Dec 31</p> <p>2017 Aug 23, 2017 Jul 01 Sep 04</p> <p>Credits: NASA</p>	<p>15 LIFE ON LAND</p>  <p>14 LIFE BELOW WATER</p>  <p>11 SUSTAINABLE CITIES AND COMMUNITIES</p> 	<h3>Enable secure broadband connectivity</h3>  <p>Credits: ESA</p>	<p>9 INDUSTRY, INNOVATION AND INFRASTRUCTURE</p> 
<p>4 QUALITY EDUCATION</p>  <p>7 AFFORDABLE AND CLEAN ENERGY</p> 	<h3>Help understand the universe</h3>  <p>Credits: ESA</p>	<p>8 DECENT WORK AND ECONOMIC GROWTH</p> 	<h3>Safety and security in and from Space</h3>  <p>Credits: Northrop Grumman</p>	<p>16 PEACE, JUSTICE AND STRONG INSTITUTIONS</p> 

Economic growth in the Netherlands and Europe

Why TNO Space & Scientific instrumentation?

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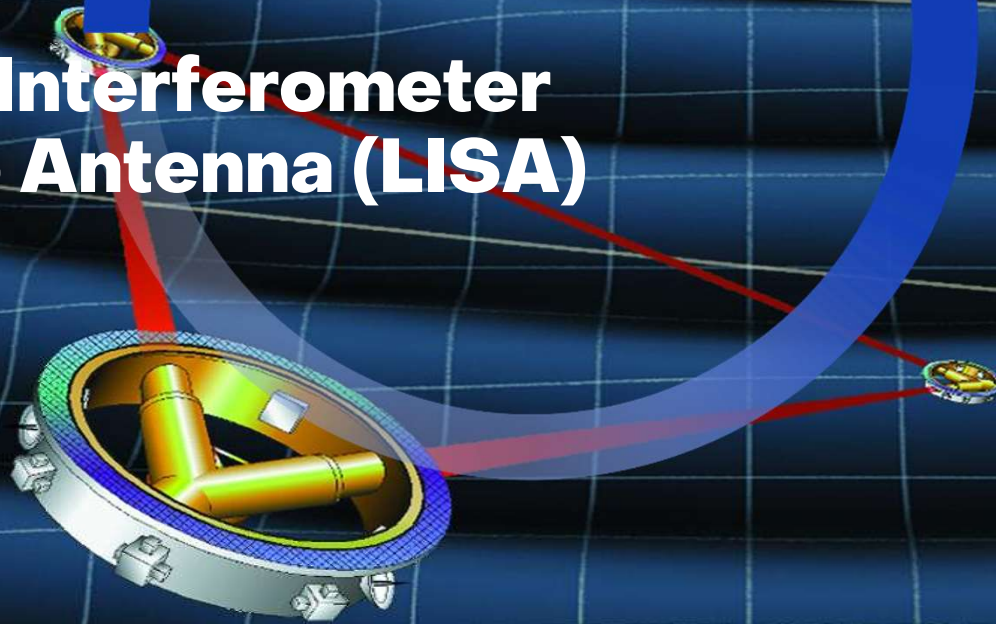
Economic growth in the Netherlands and Europe

Space & Scientific instrumentation

Instruments for Space based Astronomy

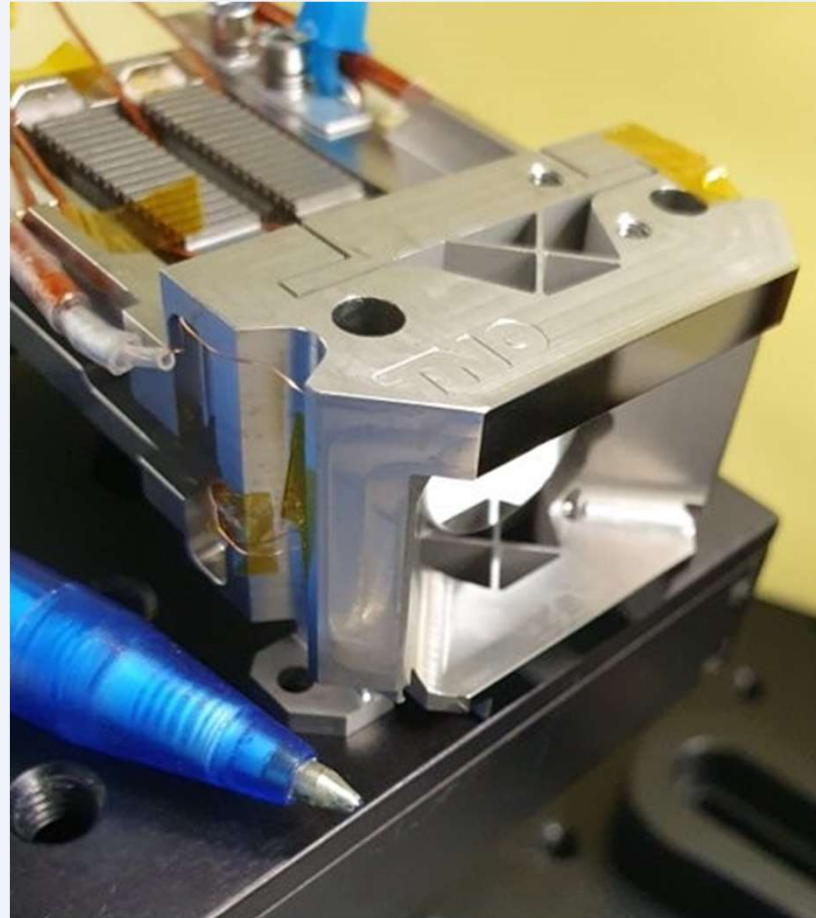


Laser Interferometer Space Antenna (LISA)



LISA

- Detection of Gravitational Waves
- TNO is working on Pointing Mechanisms
Focus on Point Ahead Angle Mechanism
- Measure distance changes with picometer accuracy over 2.5 million km
- Measurement band:
30 micro Hz to 1 Hz



Space & Scientific instrumentation

Instruments for ground-based astronomy

Ground-based astronomy at TNO



Answering the Big Questions:

Understanding the universe and our place in it, the hunt for exoplanets, international collaboration and the advancement of human knowledge



Potential for series production allows to involve industry, boosting their expertise, international visibility and business. Spin-off to aerospace, medical and ICT.

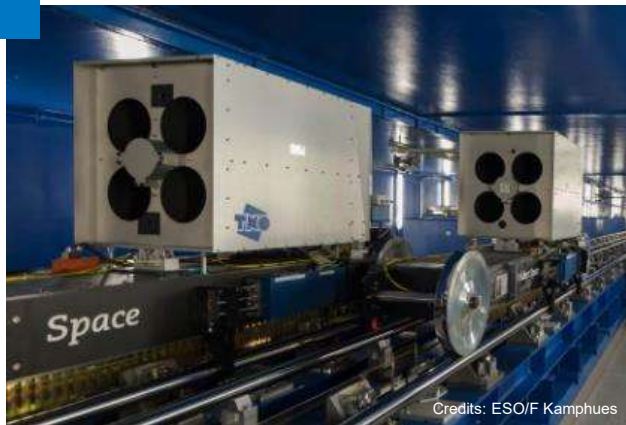


The Netherlands has a strong and long standing position in astronomy



TNO has a 100% success rate of delivering complex instruments for space and science, and a world class knowledge position: optics, optomechanics, (space) systems engineering

GROUND BASED ASTRONOMY - HERITAGE



VLTi Delay Lines



PRIMA Star Separators



Laser Launch Telescopes for 4LGS Facility

Ground-based astronomy



Support structures



Laser Guide stars



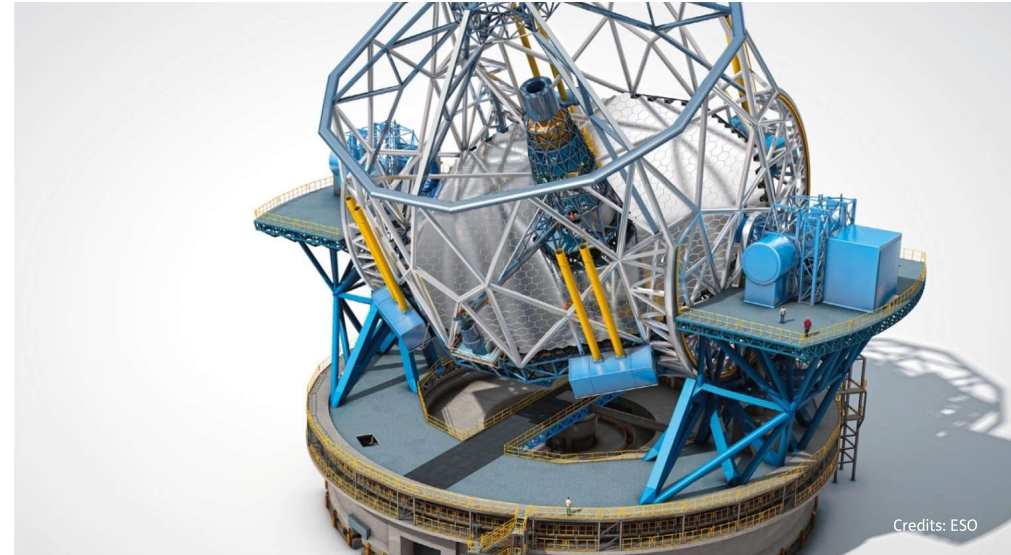
Adaptive Mirrors



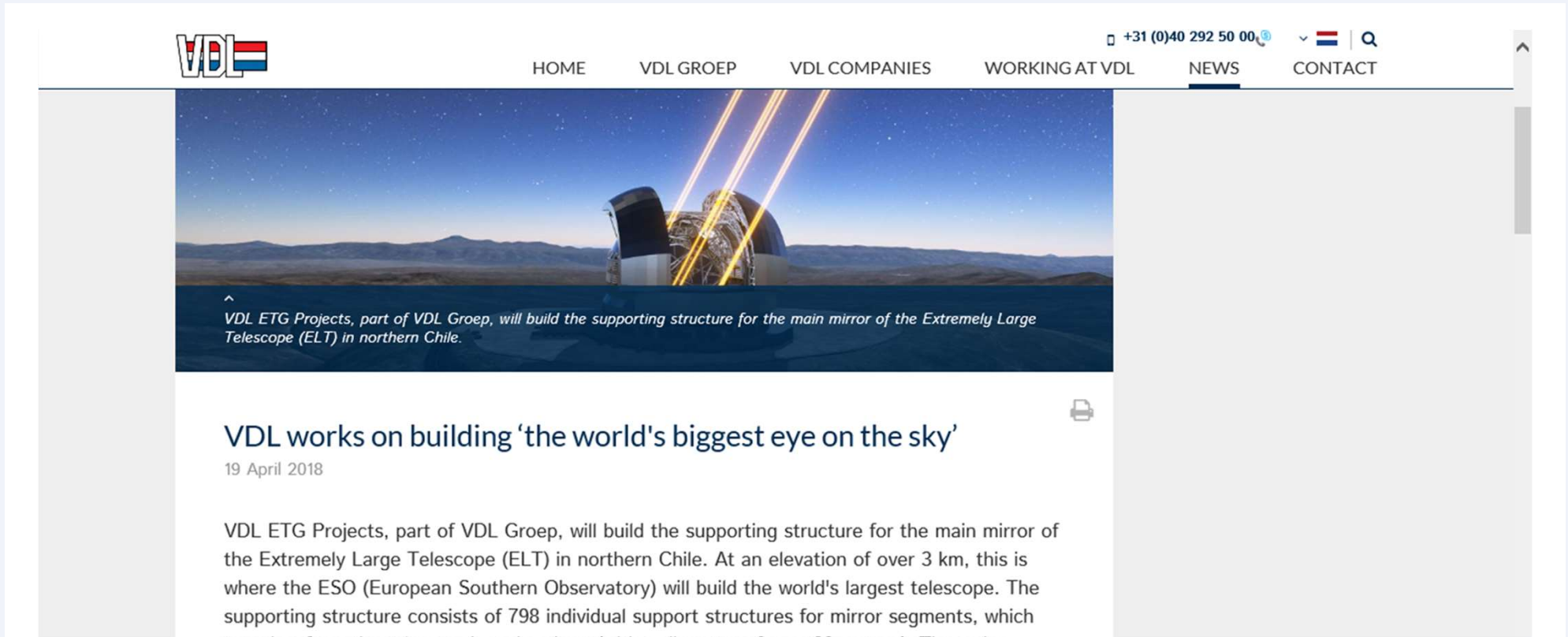
Targeting large adaptive optics systems with potential for series production for Dutch industry

ELT M1 support structure

- ESO's Extremely Large Telescope has a 39m diameter primary mirror, consisting of 798 hexagonal 1.4m segments
- The M1 support structure keeps each segment of each shape within 22nm surface form error, regardless of segment shape and gravity vector
- TNO together with VDL developed 6 prototypes meeting all specs
- Goal of prototype phase: qualify NL for > 30MEUR volume manufacturing contract from ESO for VDL



VDL ETG wins ESO M1 project



The screenshot shows a website header with the VDL logo on the left and navigation links: HOME, VDL GROEP, VDL COMPANIES, WORKING AT VDL, NEWS, and CONTACT. On the right, there is a phone number +31 (0)40 292 50 00, a dropdown menu with a flag icon, and a search icon. Below the header is a large banner image of a telescope dome at night with two bright yellow laser beams extending upwards. A text overlay on the banner reads: "VDL ETG Projects, part of VDL Groep, will build the supporting structure for the main mirror of the Extremely Large Telescope (ELT) in northern Chile." Below the banner is the article title "VDL works on building 'the world's biggest eye on the sky'" with a print icon to its right. The date "19 April 2018" is displayed below the title. The main text of the article begins: "VDL ETG Projects, part of VDL Groep, will build the supporting structure for the main mirror of the Extremely Large Telescope (ELT) in northern Chile. At an elevation of over 3 km, this is where the ESO (European Southern Observatory) will build the world's largest telescope. The supporting structure consists of 798 individual support structures for mirror segments, which together form the 40m diameter primary mirror (with diameter of over 20m)." The article text is partially cut off at the bottom.

VLT laser launch telescope

- Laser launch telescopes project an artificial 'star' by exciting sodium atoms on the upper atmosphere.
- Observation of this star allows for the characterization of atmospheric turbulence, which can then be compensated for using an adaptive deformable mirror.
- This allows ground-based telescopes to have the clear vision of space telescopes like Hubble
- TNO delivered the laser launch telescopes for ESO's VLT observatory



Credits: ESO/F Kamphues

VLT laser launch telescopes

TNO delivered 4 Laser Launch Telescopes for ESO's 4LGSF in 2012

- Large, highly aspheric optics with 17nm transmitted wavefront error
- Fully a-thermal for temperatures (0-150C) & all gradients (0.70C/hr) with <math><0.2</math> waves defocus
- Custom in-field pointing with Field Selector Mechanism: 4.8' radius with <math><0.1''</math> accuracy (3σ)
- In-house (with TU Eindhoven & VSL) developed freeform optics metrology system is now a commercial product (DUI, Dutch sme)



Demcon & TNO win ELT laser guide star project

careers | news | Search

 DEMCON

FOCAL

MARKETS

TECHNOLOGY

HOW WE WORK

SHOWCASES

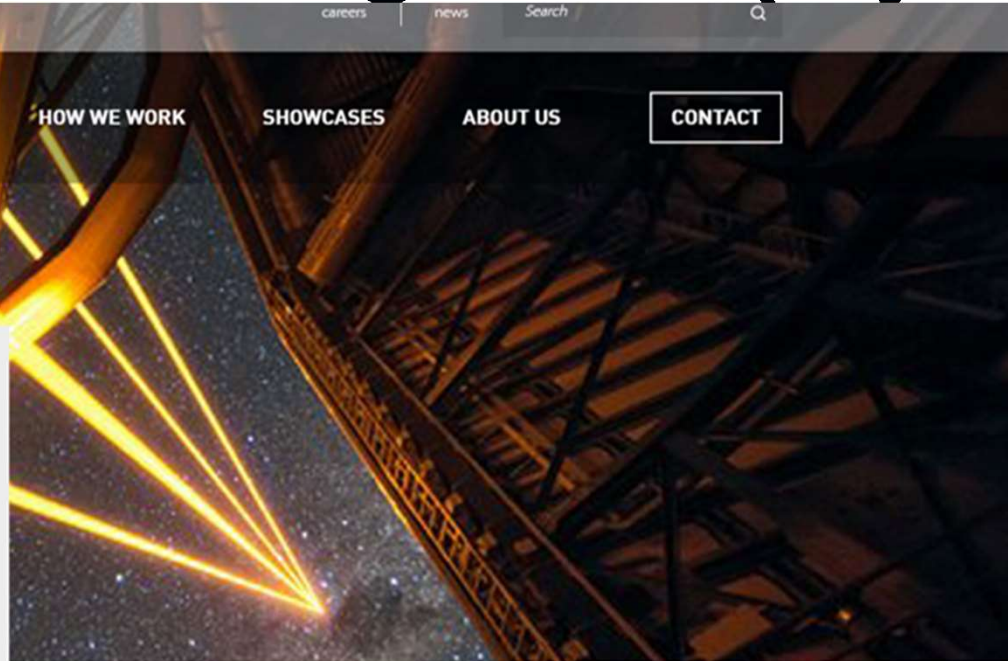
ABOUT US

CONTACT

Home > Showcases > laser guide star.

laser guide star.

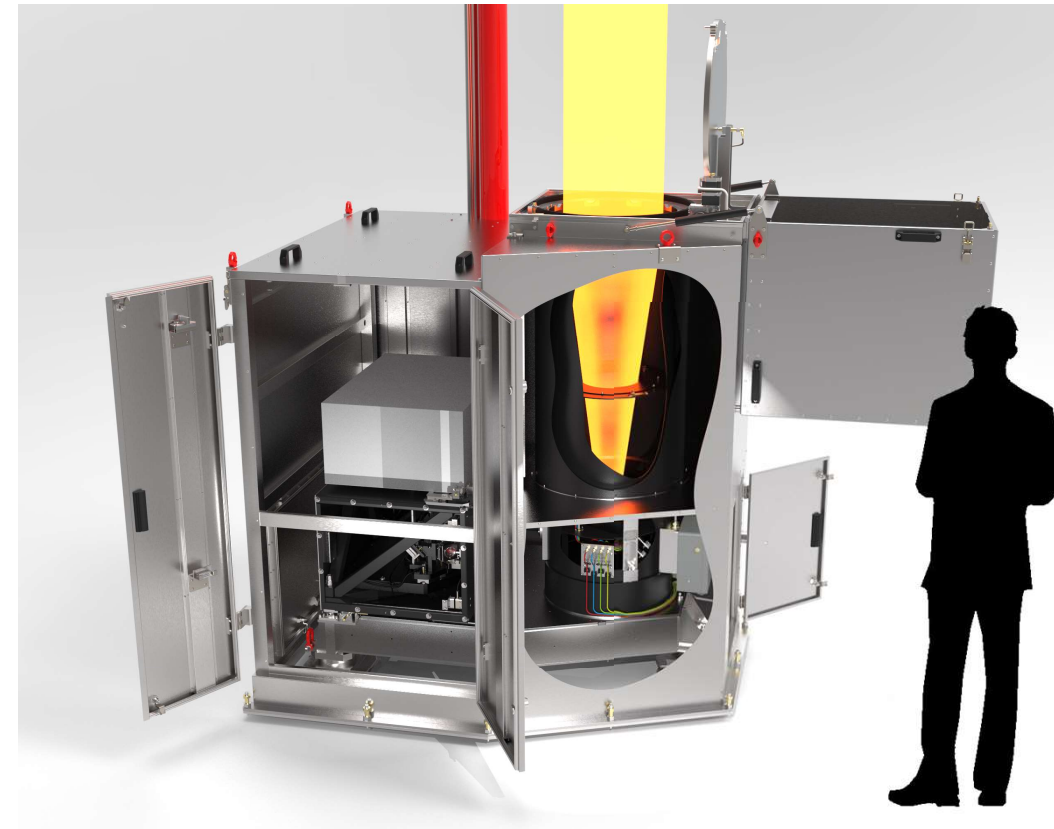
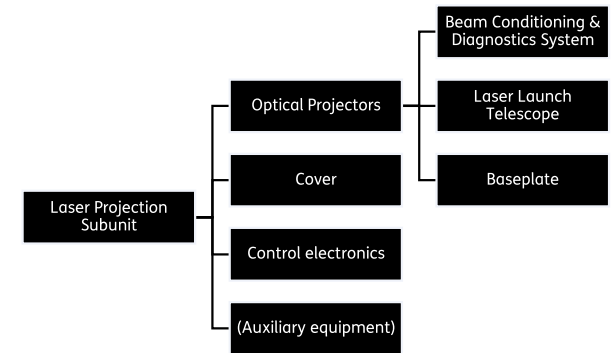
The European Southern Observatory (ESO) is creating the world's largest telescope. It has selected TNO to provide a key enabling technology that will allow the telescope to produce better views of the universe than have ever been possible. In the project, TNO will collaborate with Demcon focal as a major sub-contractor. With the help of TNO's laser guide star launch telescope technology, the Extremely Large Telescope (ELT) will provide insight into some of the greatest astronomical questions of our time, from the birth of stars to the search for signs of life on exoplanets in other star



Space & Scientific instrumentation

Laser projection system – 9 units for ELT and VLT Gravity+

- Laser Launch Telescope is passive a-thermal across operational temperature range including gradients
- Variable beam expander controls focus and corrects non-thermal error sources
- Building 9 Laser Projection Subunits (include 3 for VLT upgrade)
- With Dutch company Demcon – took over new BCDS from ESO
- Spare parts, documentation & models
- Future training for observatory personnel



Space & Scientific instrumentation

ELT laser projection system – current status

- The first of 9 systems is fully integrated at Demcon HQ.
 - After Test Readiness Review on January 11, the system will be shipped to ESO HQ where TNO will perform verification testing.
- Formal delivery to ESO is scheduled for June 2024.
 - The first 3 units will go to the VLT Gravity+ instrument, the next 6 are for ELT itself.



Above right: ELT OTA1 subsystem integration ready at TNO
Below right: The complete first LPS – prior to EMC testing at Demcon



TNO - DEFORMABLE MIRROR TECHNOLOGY

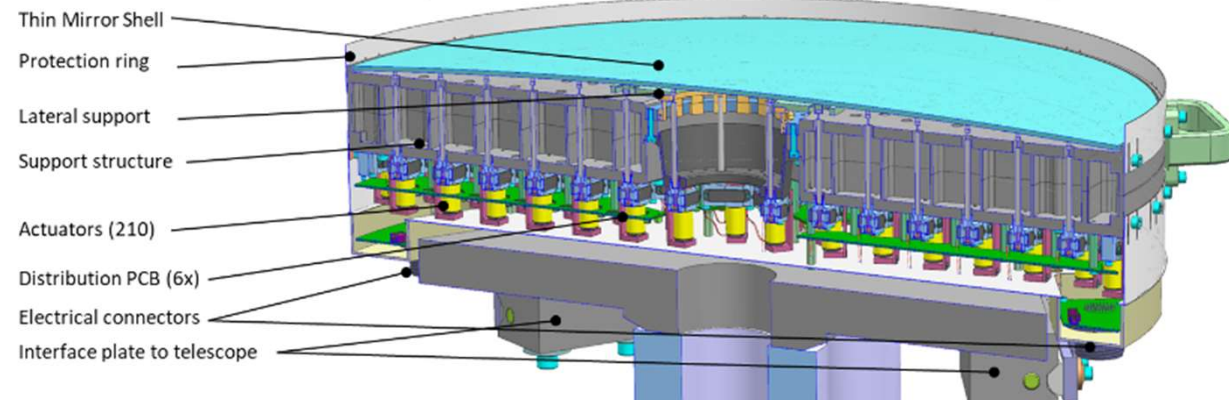
Space & Scientific instrumentation

Adaptive M2 for University of Hawai 'i 88-inch Telescope

- TNO concept offers far higher reliability at lower cost to user
- Funding: 1,5MEUR including partner investments
- Status: finalizing, on-sky demonstration by 2024

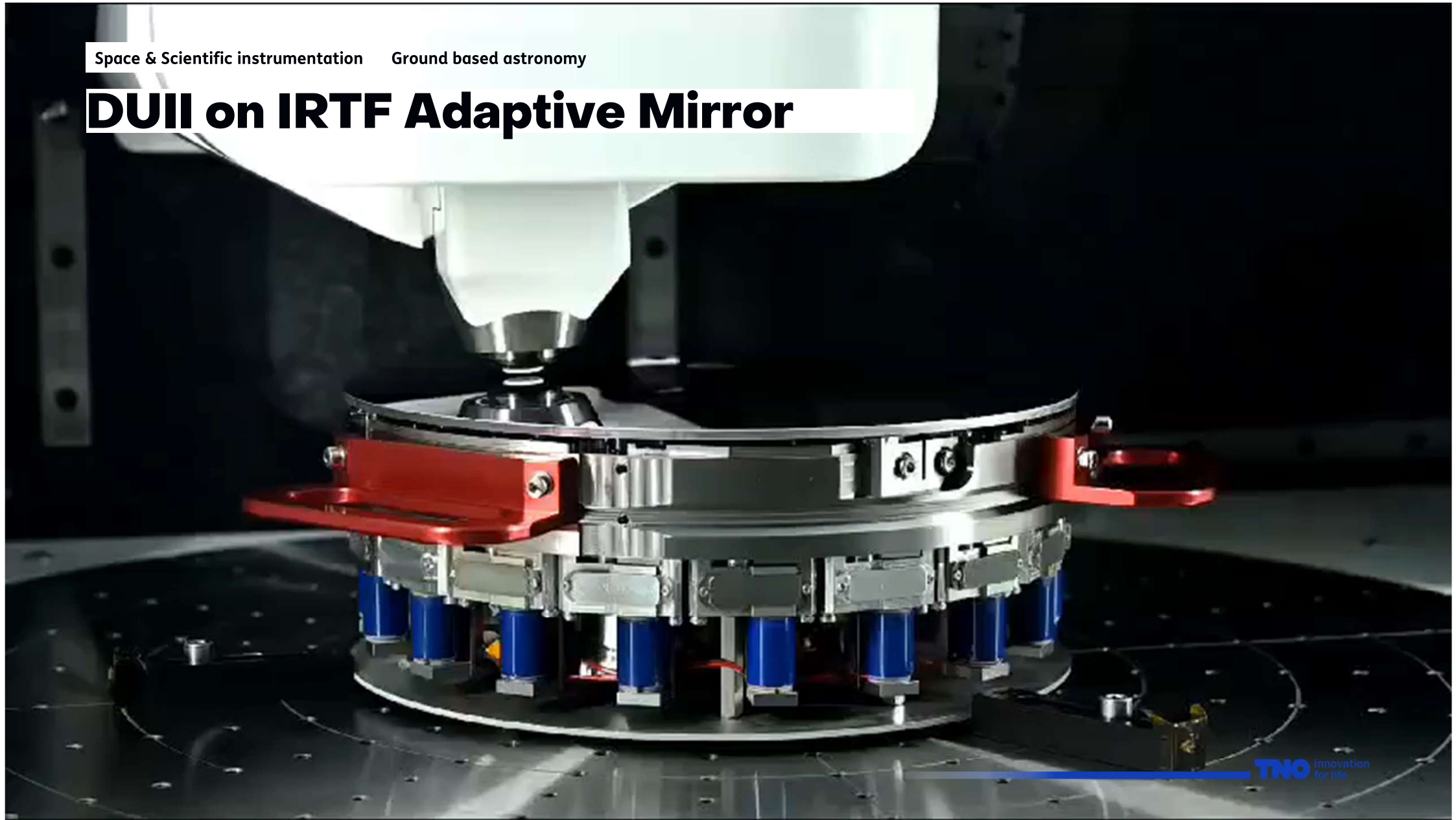
Consortium partners

- University of Hawaii (US): advisor and launching customer
- University of California (US): test and research partner
- TNO (NL): development and performance testing
- VDL (NL): actuators & support structure manufacturing
- AAC Clyde Space (NL): electronics development
- Fraunhofer (DE): facesheet pre-forming
- NOVA (NL): facesheet finishing



Space & Scientific instrumentation Ground based astronomy

DUII on IRTF Adaptive Mirror



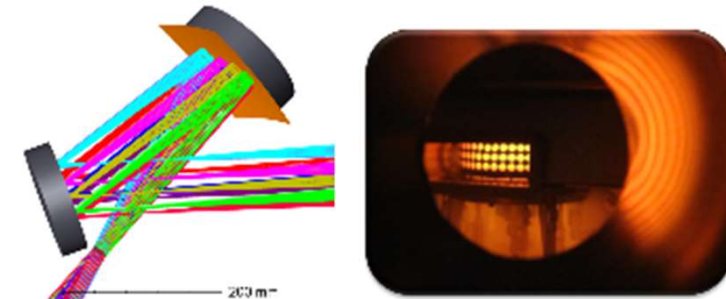
> TNO - FUSION TECHNOLOGIES

TNO innovation
for life

OVERVIEW OF FUSION ACTIVITIES

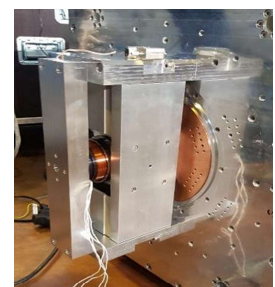
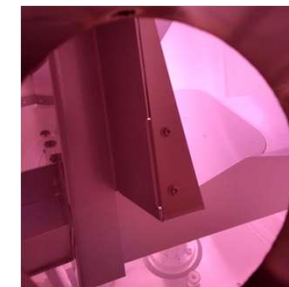
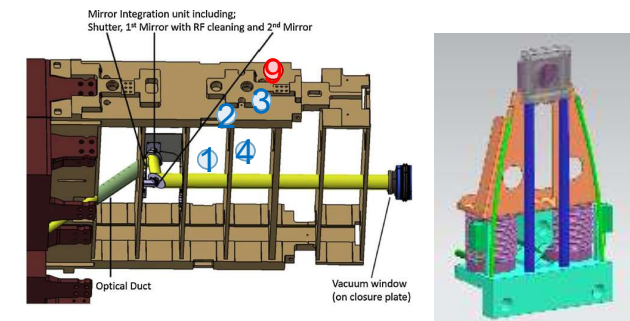
Key Product Market Combinations (PMCs)

- › Diagnostic System Design and Engineering
- › Plasma Cleaning Systems



Co-operations

- › ITER-IO, ITER-NL, ITER-Japan
- › DIFFER, AST-NL, ChromoDynamics
- › General Atomics, Princeton Plasma Physics Lab
- › IDOM



Space & Scientific instrumentation

Questions?

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