

TNO innovation
for life

CSI; THE NEW SPACE CALIBRATION FACILITY AT TNO
AVS 68; PITTSBURGH | ING. F.T. MOLKENBOER



**AVS 68th INTERNATIONAL
SYMPOSIUM & EXHIBITION**
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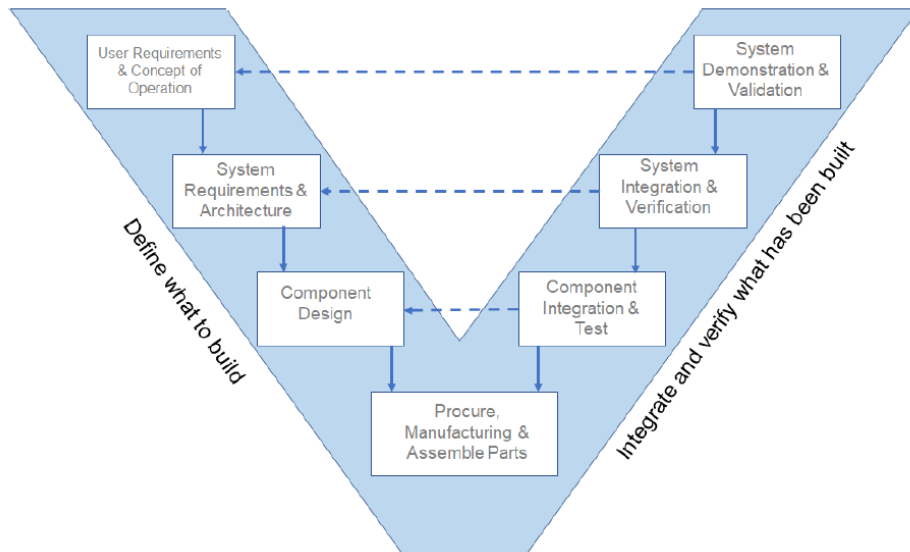
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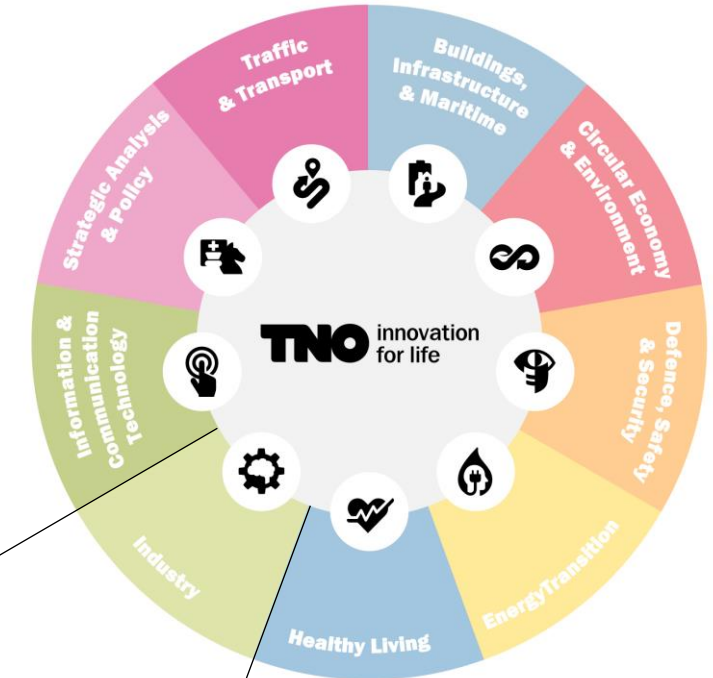
INTRODUCTION

FREEK MOLKENBOER

- › Senior systems engineer at TNO
- › TNO is an independent research organisation for applied scientific research in the Netherlands



- › Why, what, how, how well, and how to prove



- › Semiconductor & quantum
- › Space & Scientific instrumentation
- › Smart Industry
- › Flexible & Free-form products
- › Nano Instrumentation
- › Contamination control
- › Vacuum
- › Materials
- › Plasma

INTRODUCTIE SPACE @ TNO

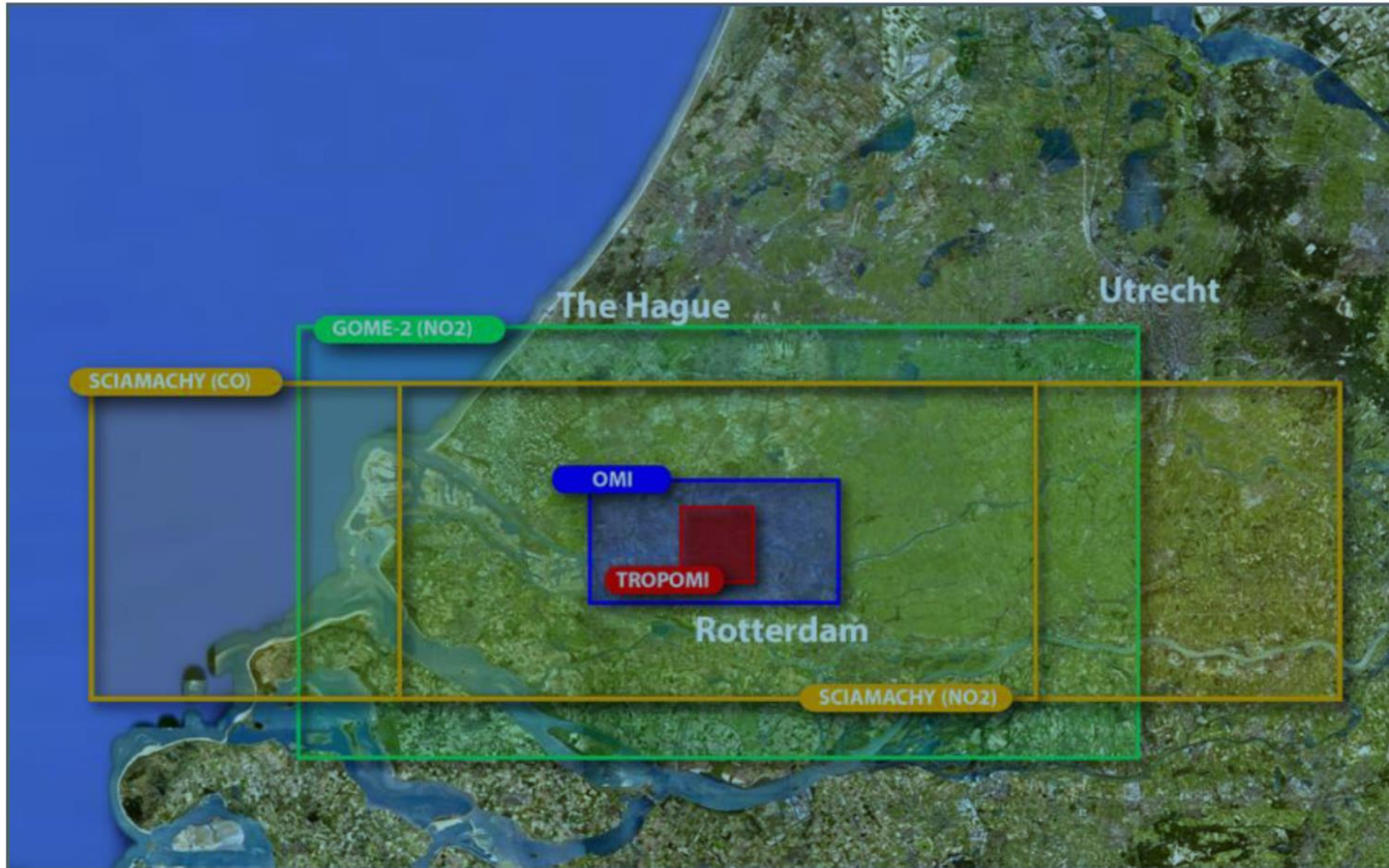
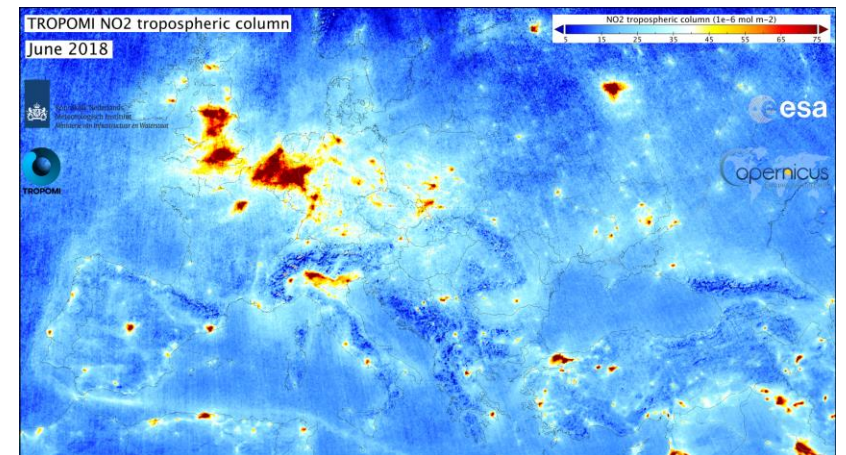


Image credit: Copernicus, Airbus Defense & Space

TROPOMI on Sentinel 5P



Launched in 2017



THE NEED FOR CALIBRATION

› Calibration is needed to know how you can interpret the measured data

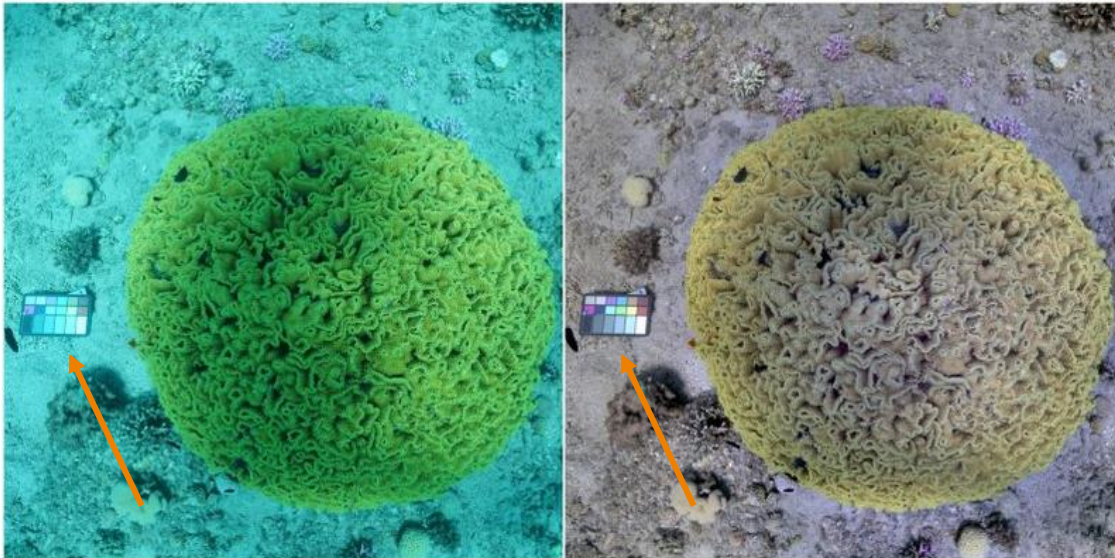


Foto: Color charts were placed next to underwater objects to test the algorithm. source Tom Shlesinger

Bron: <https://www.businessinsider.nl>



Kalibrierschein / Calibration Certificate

erstellt durch das Kalibrierlaboratorium
issued by the calibration laboratory

Technische Hochschule Mittelhessen
Labor für Vakuumtechnik
Wiesenstrasse 14
D-35390 Giessen



Deutscher Kalibrierdienst **DKD**

11102

D-K-
15173-01-00

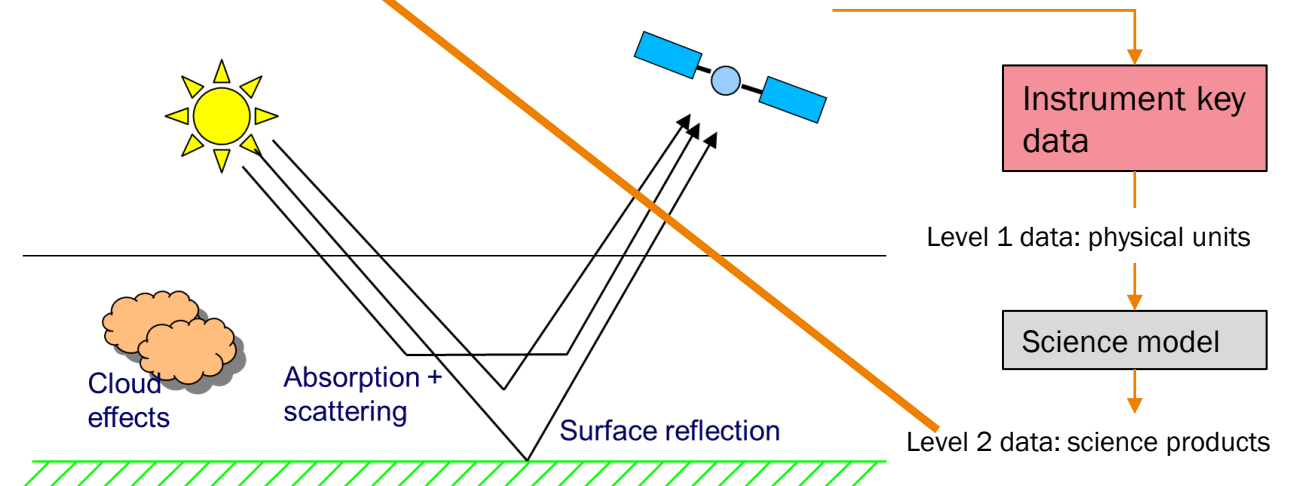
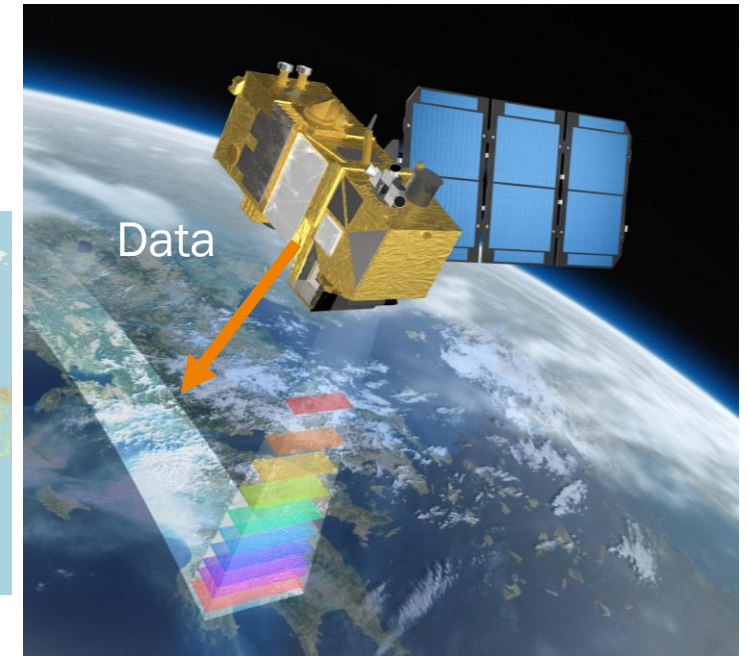
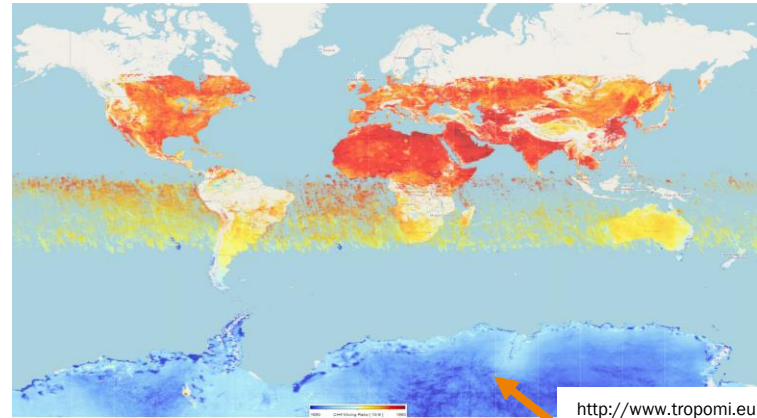
Kalibrierzeichen
Calibration mark

2021-09

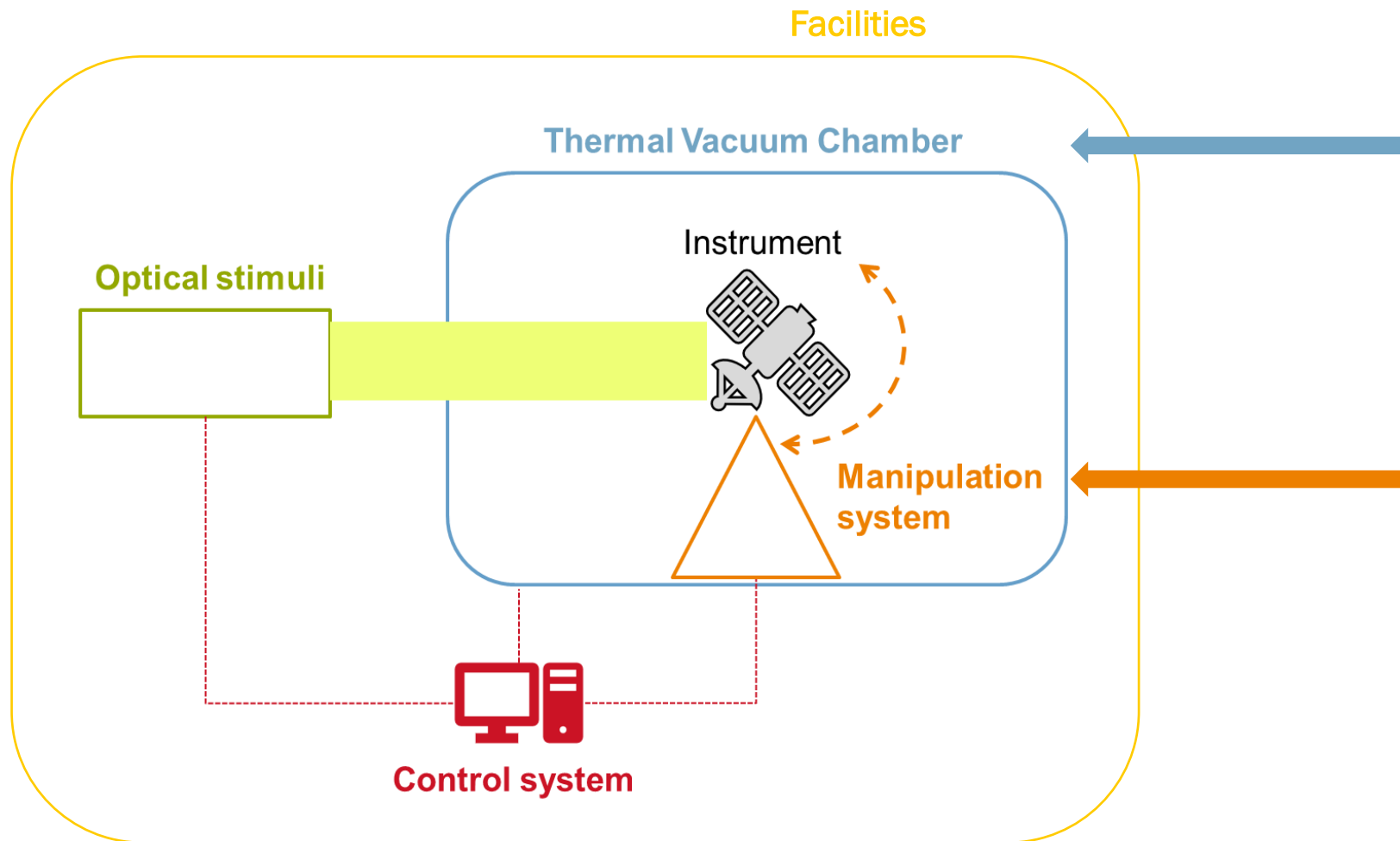
Gegenstand <i>Object</i>	Capacitive diaphragm gauge 1 mbar abs., with controller	Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich. <i>This calibration certificate documents the</i>
Hersteller <i>Manufacturer</i>	Pfeiffer Vacuum	
Typ <i>Type</i>	Transducer: CMR 364 Controller: TPG 366	
Fabrikat/Serien-Nr. <i>Serial number</i>	Transducer: 44264037 Controller: 44879072	
Messmittel-Nr.	Transducer: 94019569 (MC LO)	

CALIBRATION EARTH OBSERVATION INSTRUMENTS

- › Without calibration this measurement would have two unknowns;
 - › Earth
 - › Instrument
- › The **generated output** of the instrument must therefore be known, and this must be measured in a “as realistic as possible environment” w.r.t.:
 - › Temperature
 - › pressure
 - › Known (optical) input conditions
- › **Instrument key data**
- › Science model

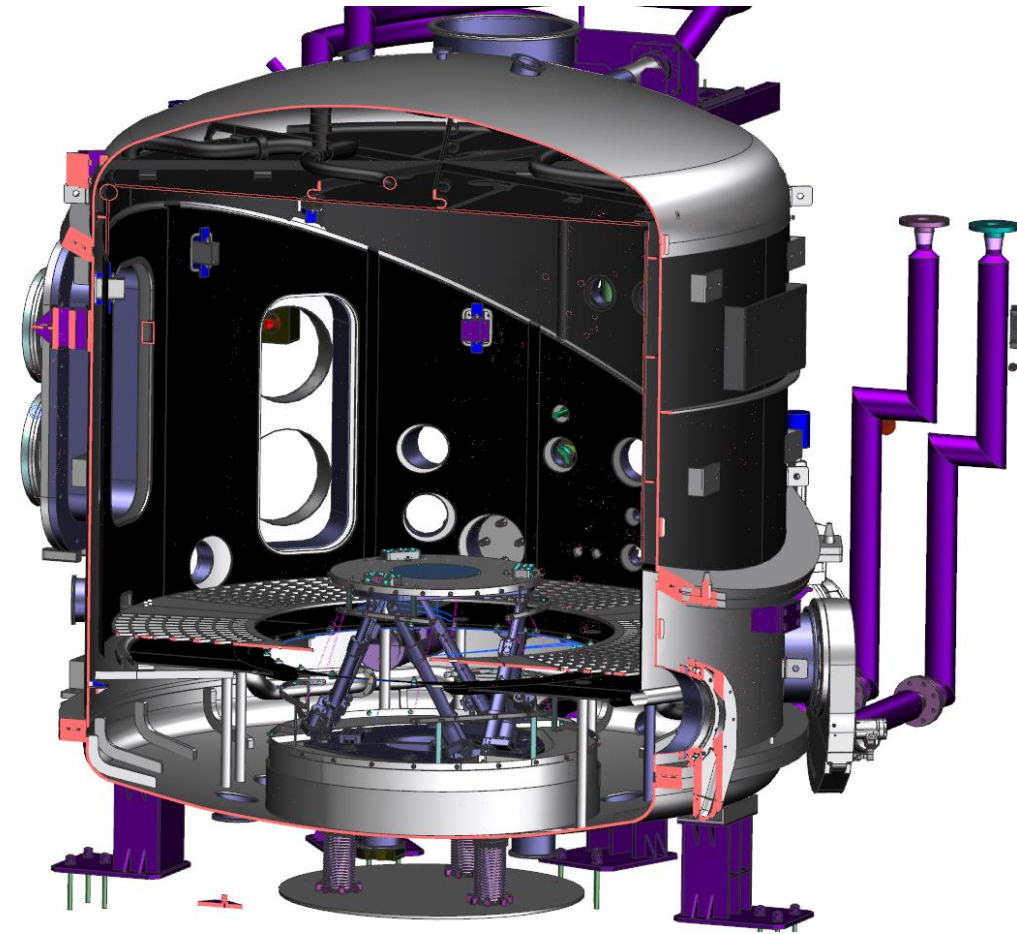


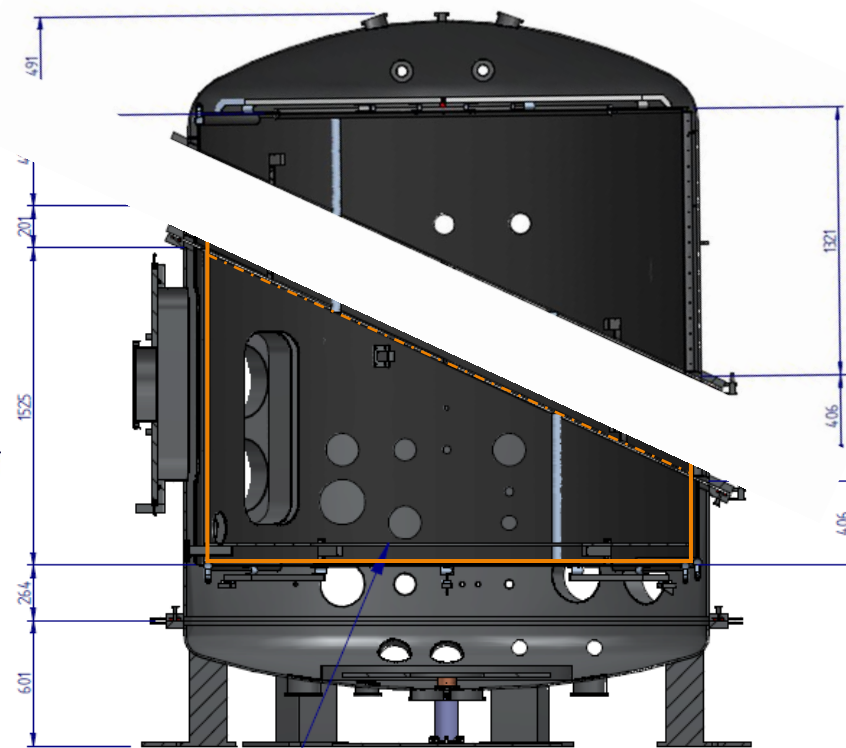
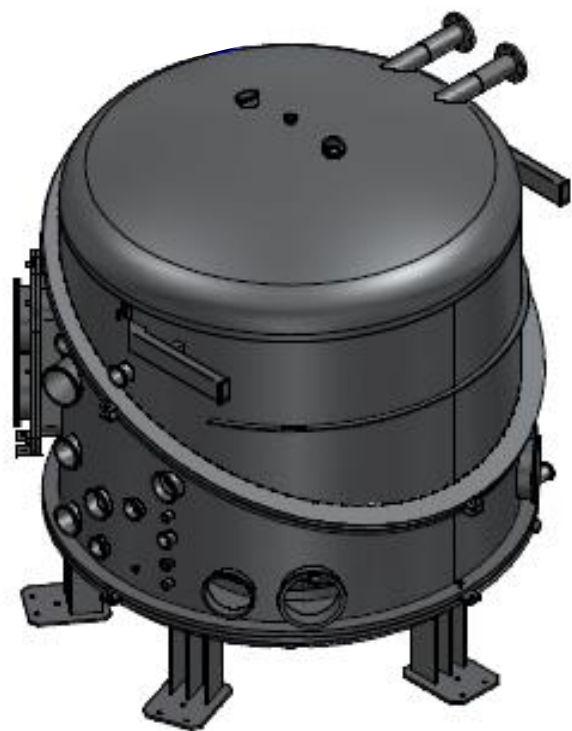
› ARCHITECTURE CSI REALISTIC CONDITIONS



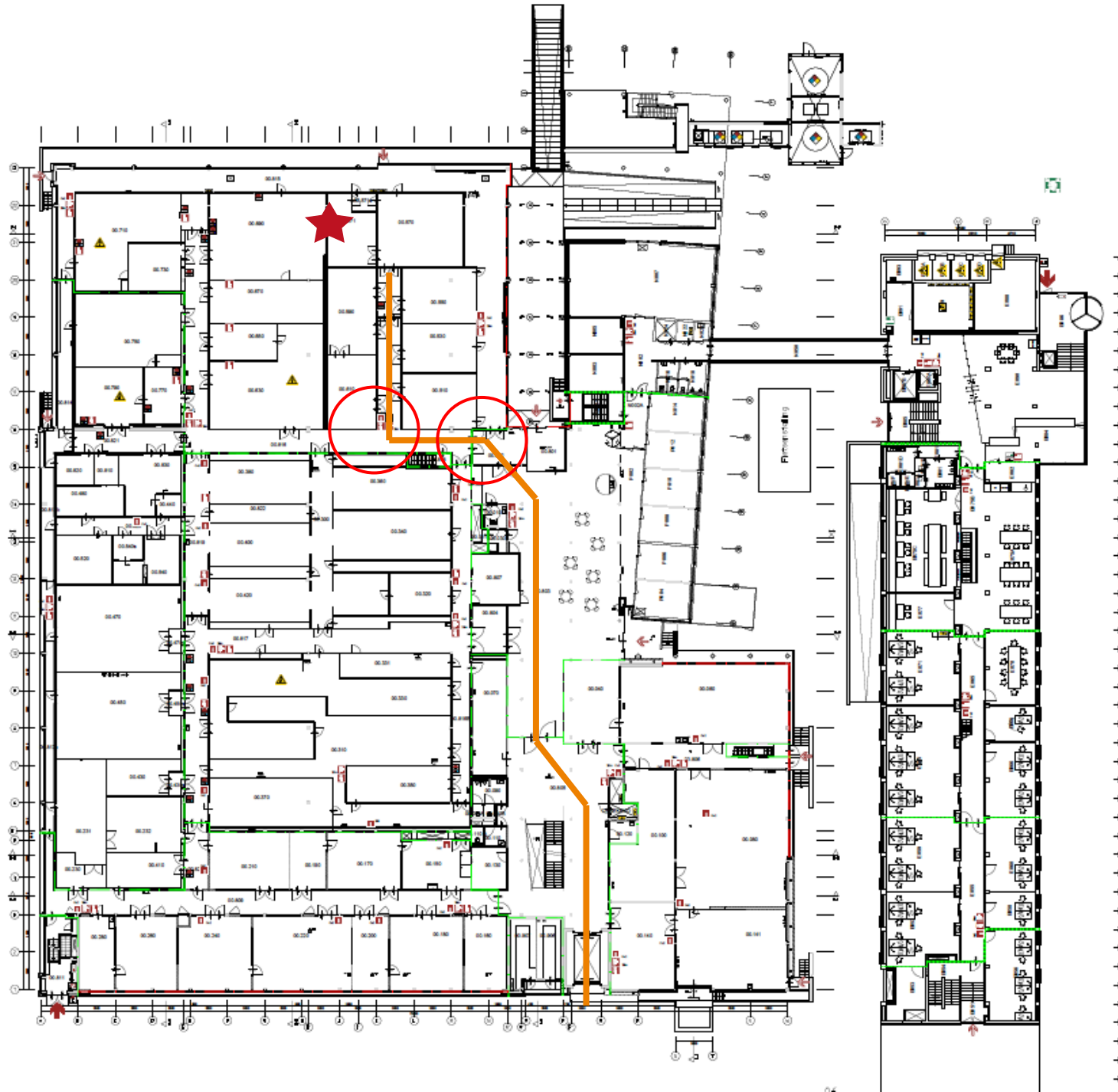
› TVC DESIGN SUPPLIER (FOLLOWING OUR PROPOSED DESIGN)

- › Slanted design
- › 2x 2700 l/sec TMP's & 2x 3000 l/sec cryo pumps
- › Two in-dependent thermal shrouds (193k \leftrightarrow 353k)
- › Two LN2 gas mixers for cold plates (100k \leftrightarrow 353k)
- › State-of-the-art cleanliness
 - › Design and production using semiconductor cleanliness protocols
 - › Cold trap to capture water and contamination
 - › QCM and RGA for cleanliness monitoring
 - › Thermal enclosure around hexapod
 - › Bake-out of TVC > 373 k





INTERNAL IT'S BIG...



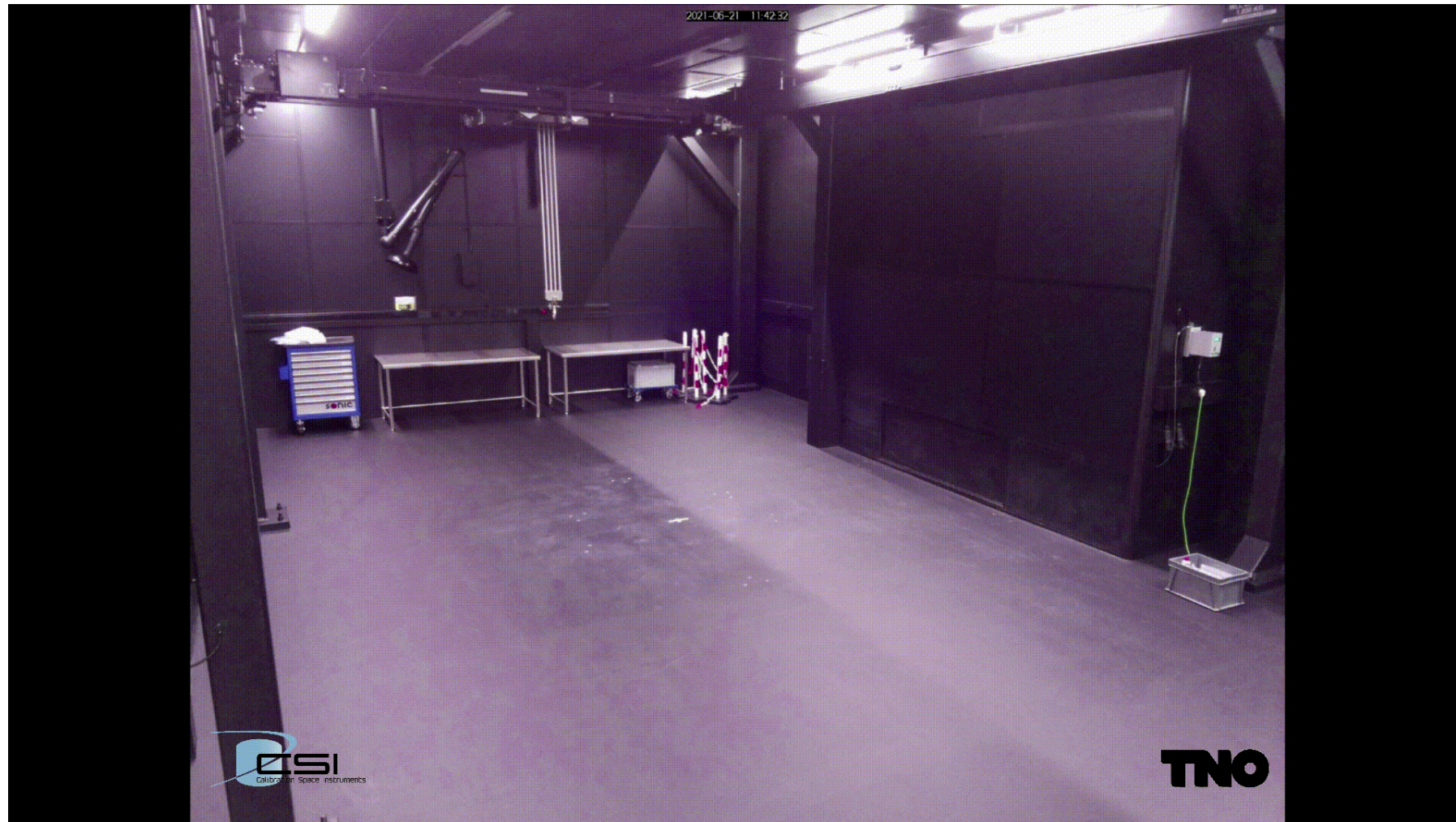


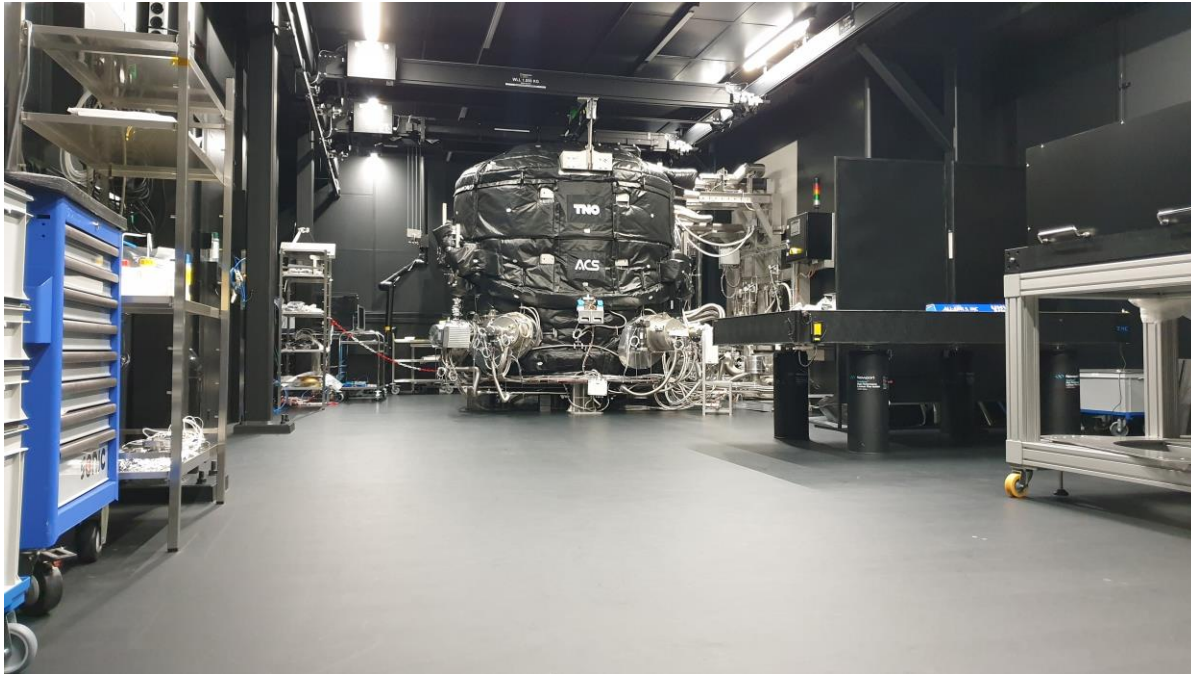


CSI
Calibration Space Instruments



ASSEMBLY OF TVC IN CLEAN ROOM





› TVC PERFORMANCE (VACUUM) CONTROLLED PUMP DOWN SPEED

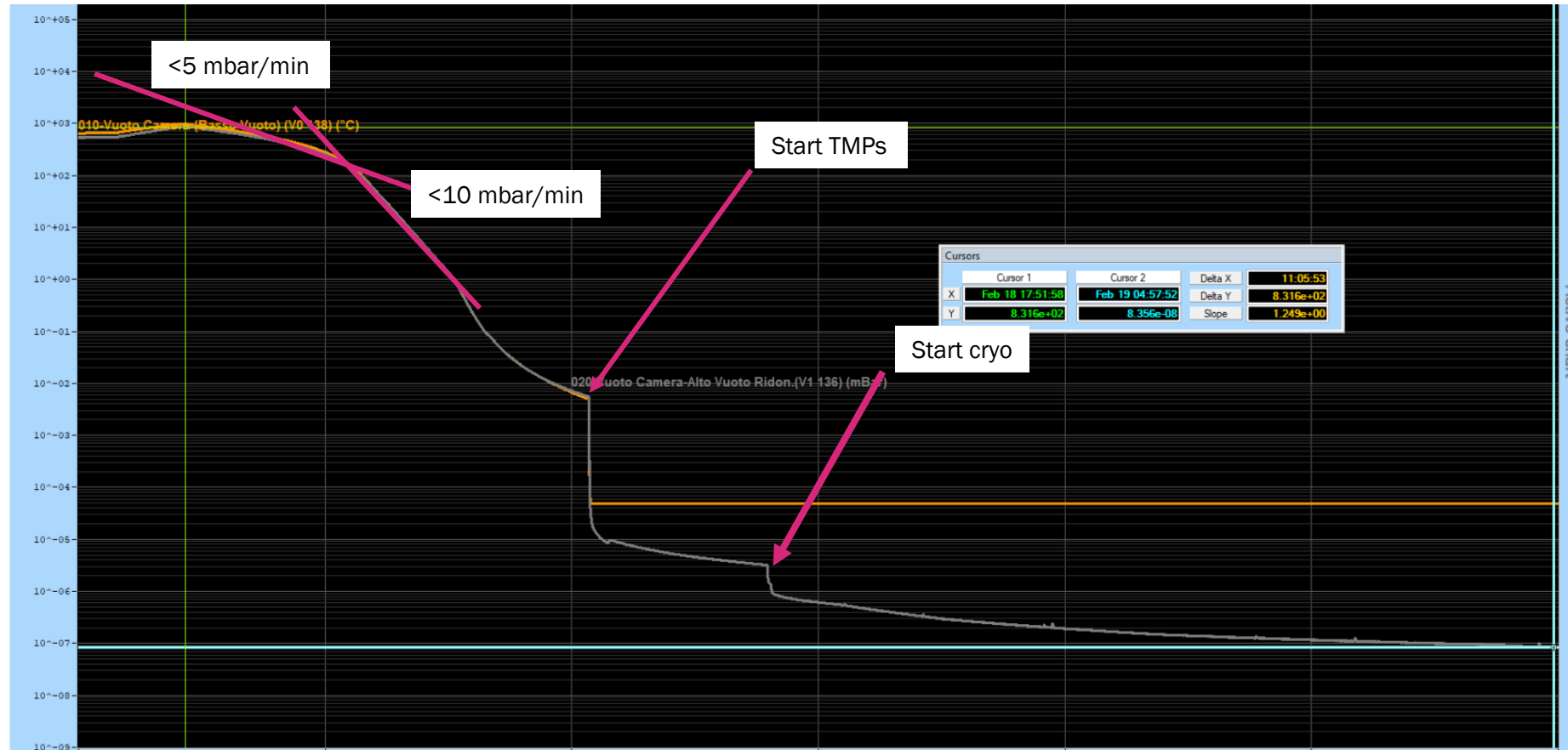
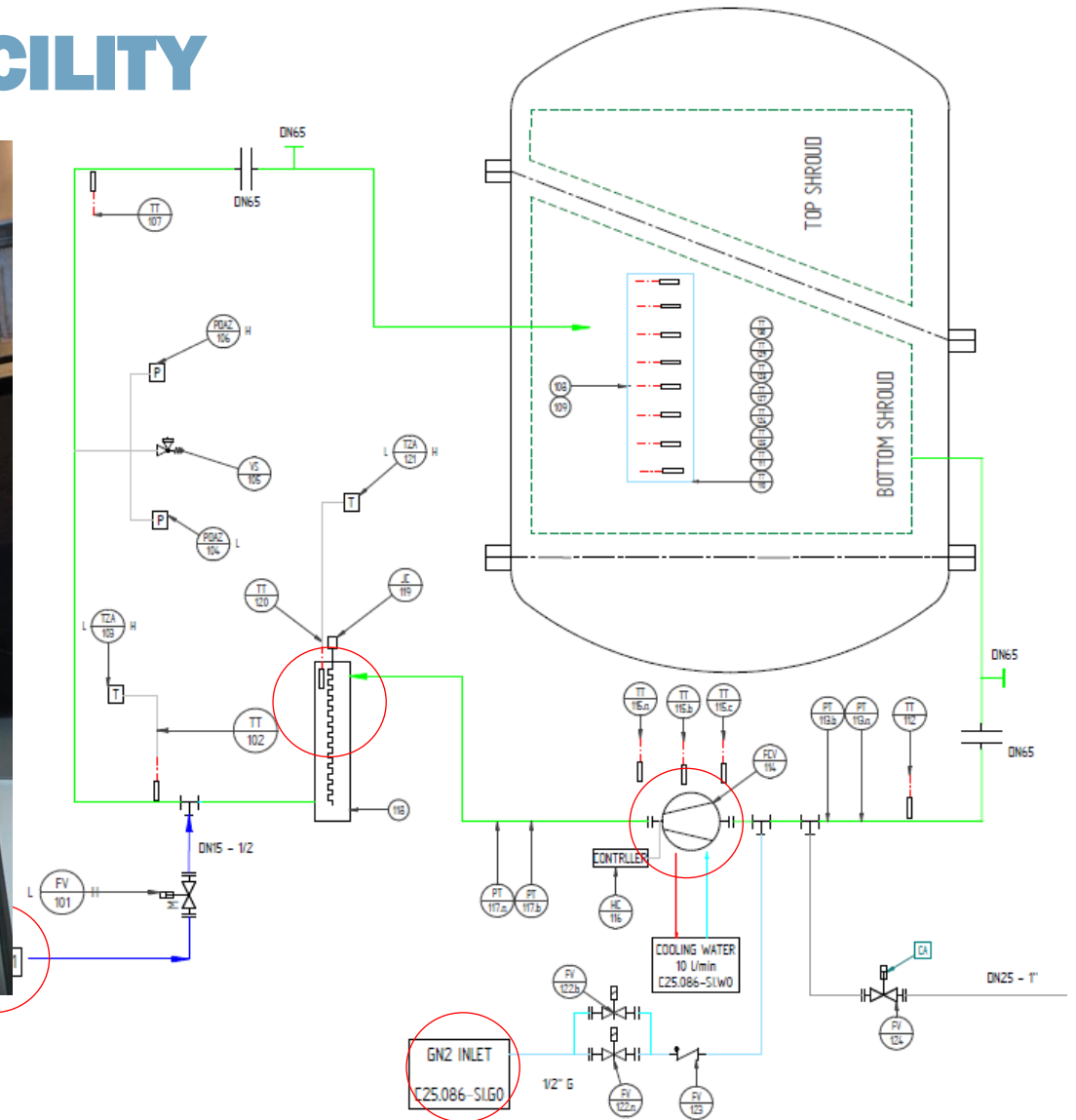


Figure 48: Reach 10⁻⁷ mbar

TVC PERFORMANCE THERMAL FACILITY



TVC PERFORMANCE THERMAL FACILITY

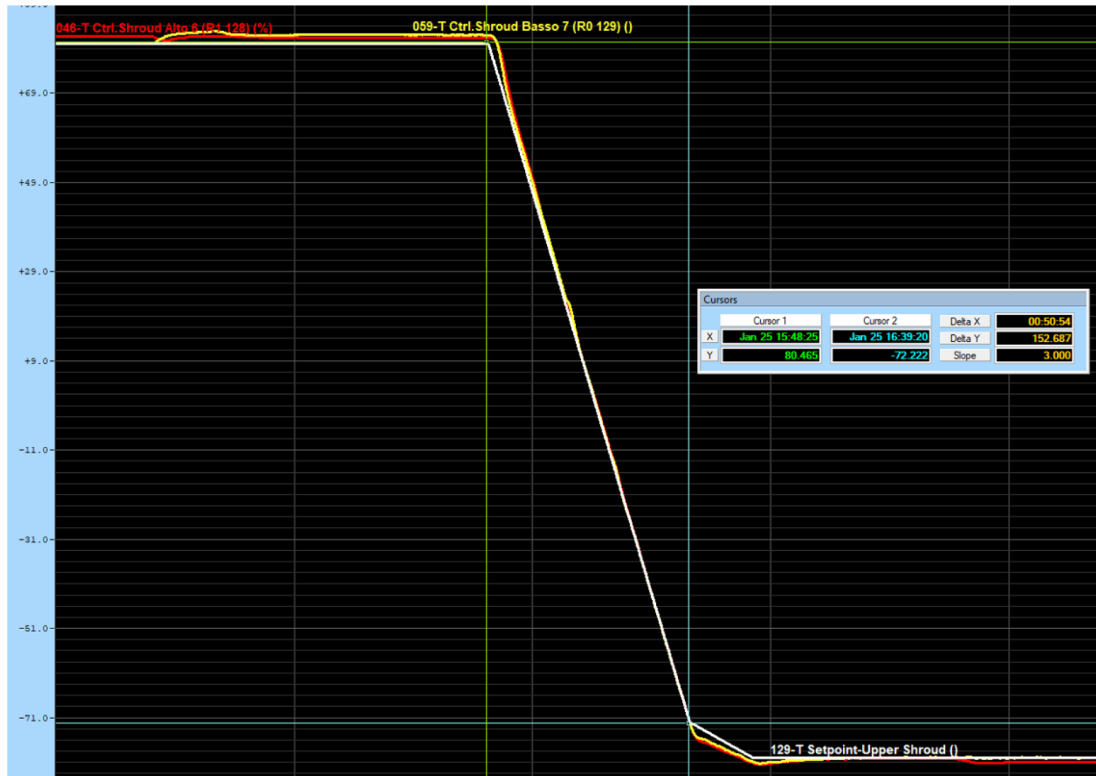


Figure 5: Shroud average temperature cooling rate down to -72°C

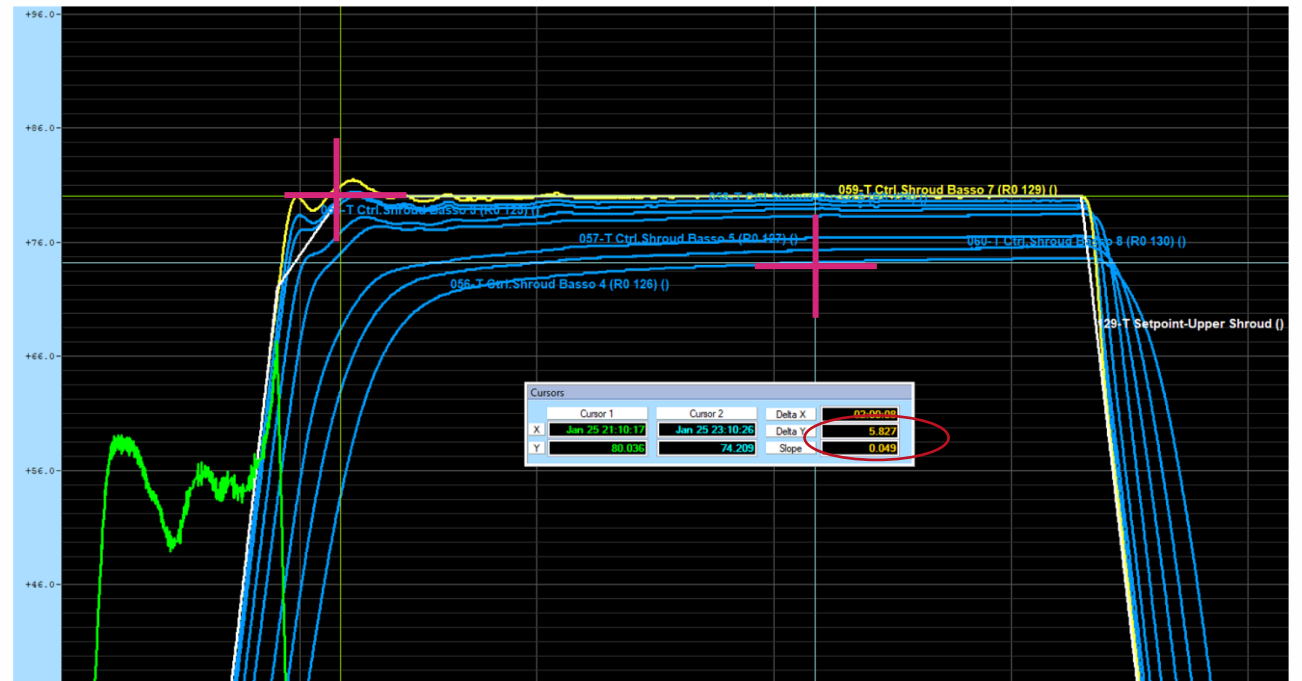
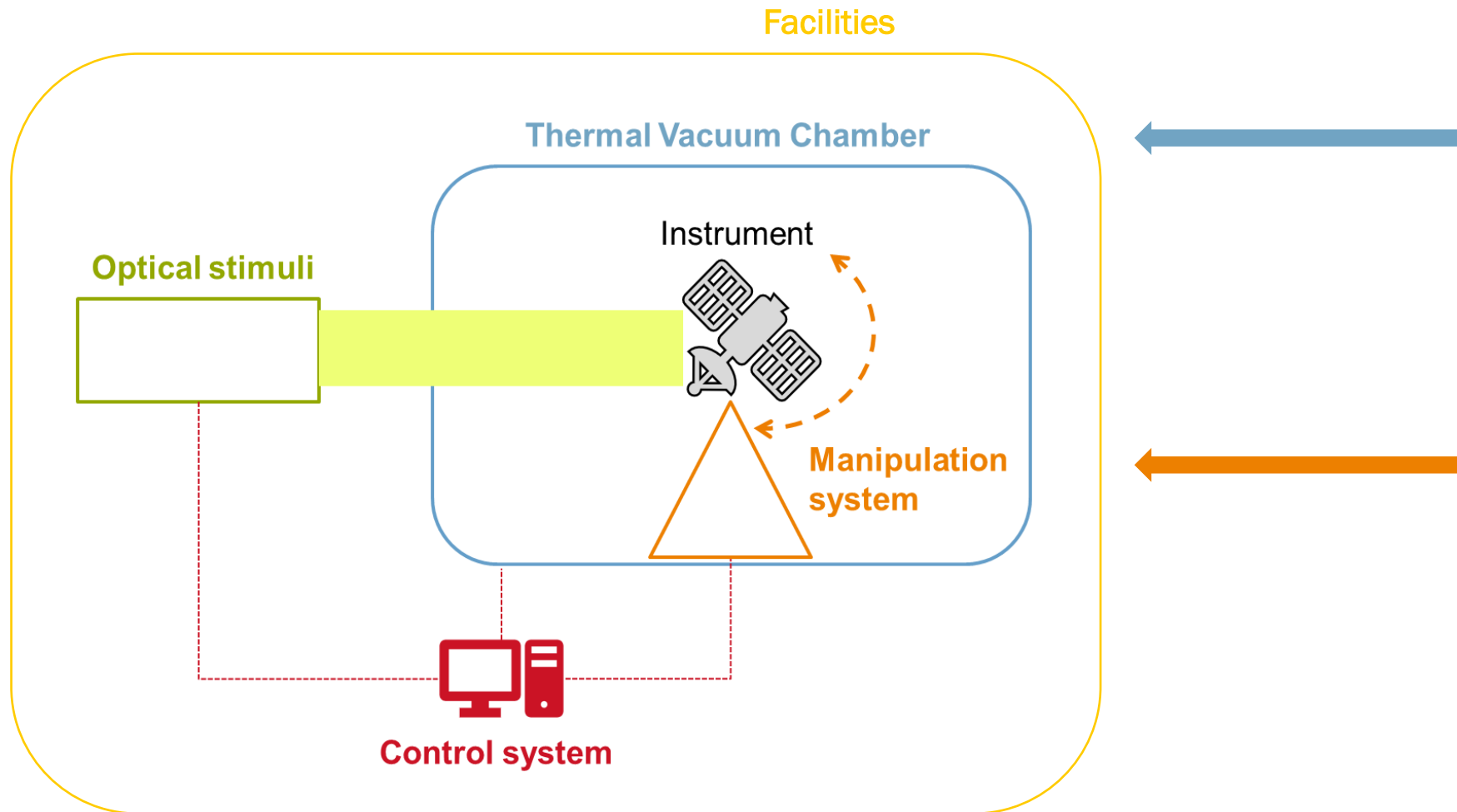


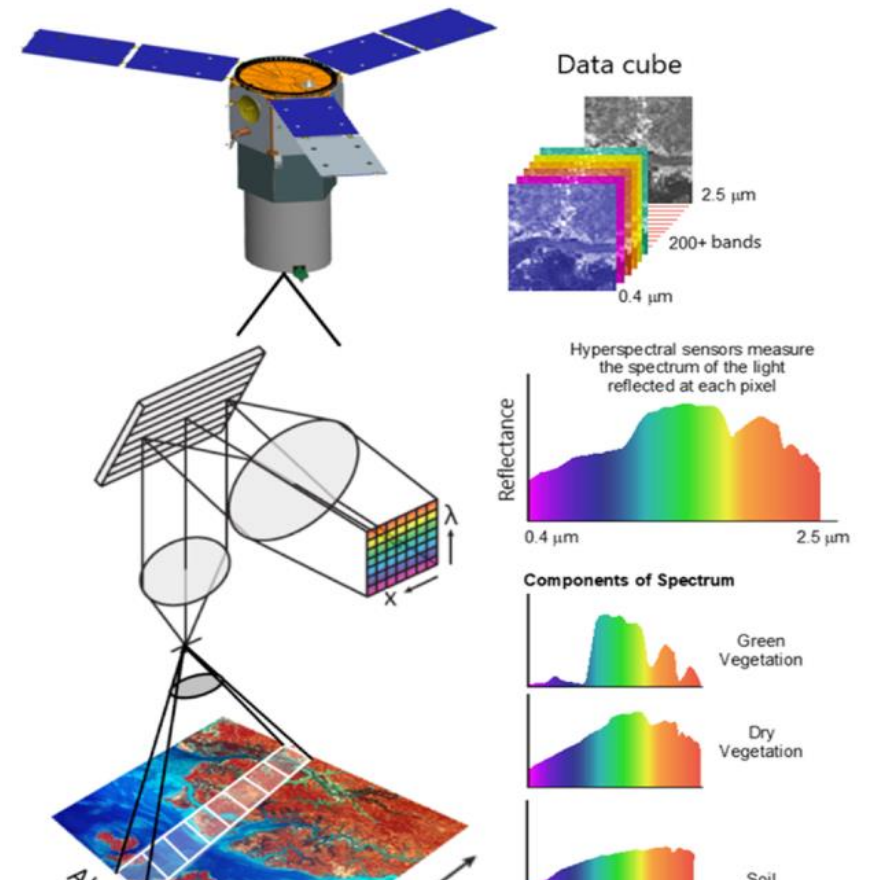
Figure 9: Bottom shroud homogeneity at +80 °C after 2h

› ARCHITECTURE CSI REALISTIC CONDITIONS




MECHANICAL MANIPULATION SYSTEM

- › An earth observation instrument looks both to the Earth, but also toward the sun
- › Both fields of view need to be calibrated
- › These fields of view can be rather large, and are expected to increase in size for newer missions
- › Architectural decision to position the instrument on a rotation table with a hexapod



IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 14, 2021

Hyperspectral Satellites, Evolution, and Development History

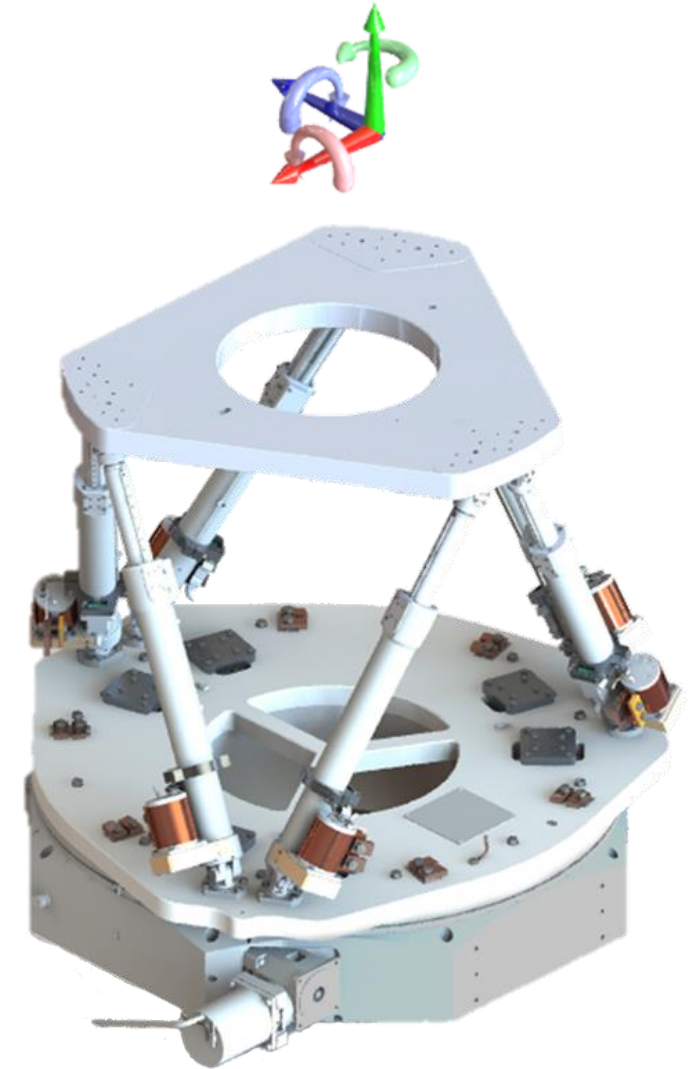
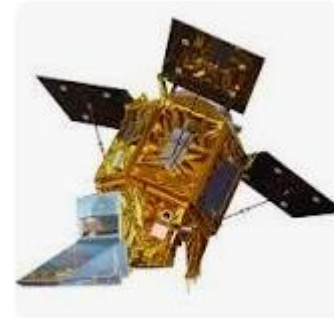
Shen-En Qian , Senior Member, IEEE

› MECHANICAL MANIPULATION SYSTEM ROTATION TABLE WITH HEXAPOD

- › Rotation table will be used for the larger, horizontal rotations
 - › +/- 175°
- › Hexapod:
 - › Translation and rotation (6 DOF)
 - › Maximum tilt up to 15°
- › Instrument pointing accuracy: < 0,001°
 - › Accuracy error:
 - › 14 meter (on Earth)
- › Allowed instrument mass: 300 kg
- › Special design with increased thermal stability

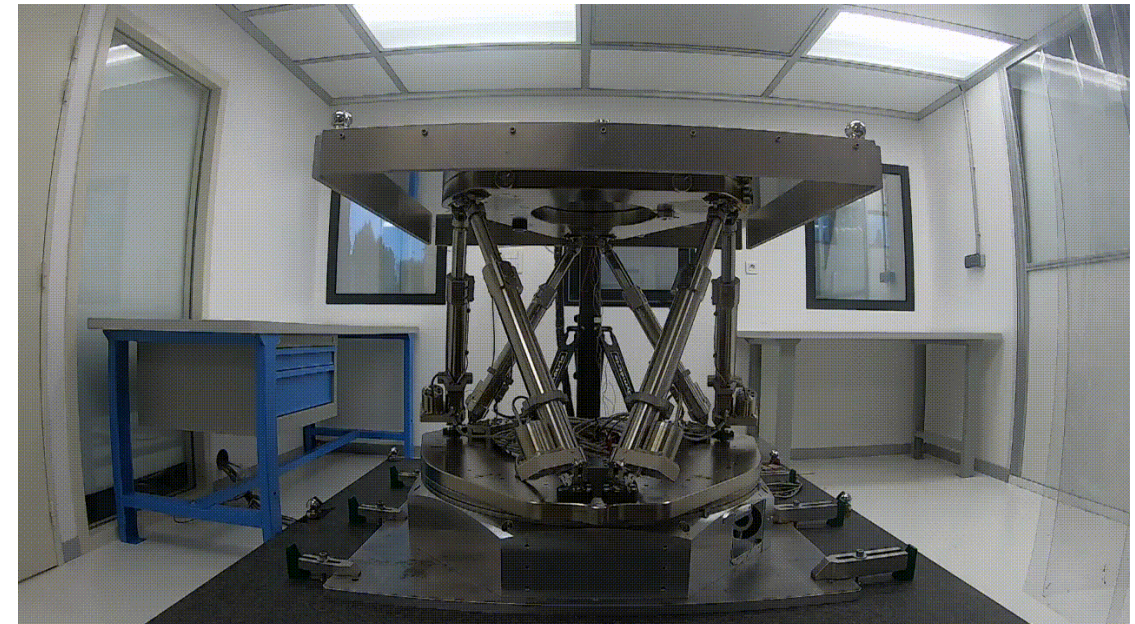
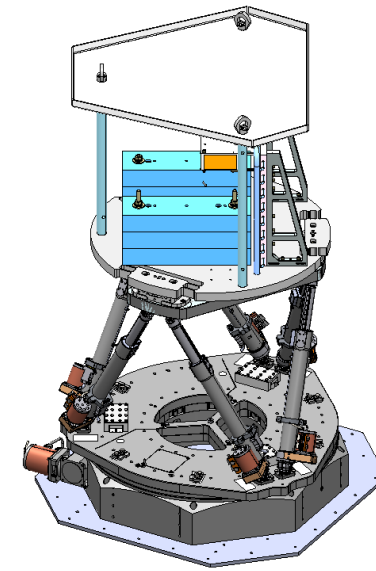
Sentinel-5 / Orbit height

824 km



› CONCLUSIONS

- › TVC and Hexapod in the clean room of TNO
- › Integration of total system (control, optical stimuli) is in the closing phase
- › CSI facilities will start extended testing campaign early next year
 - › With a test instrument



› **THANK YOU FOR
YOUR TIME**

TNO innovation
for life



Freek Molkenboer
Senior Systems Engineer bij TNO

