MARKET SURVEY THERMAL VACUUM CHAMBER

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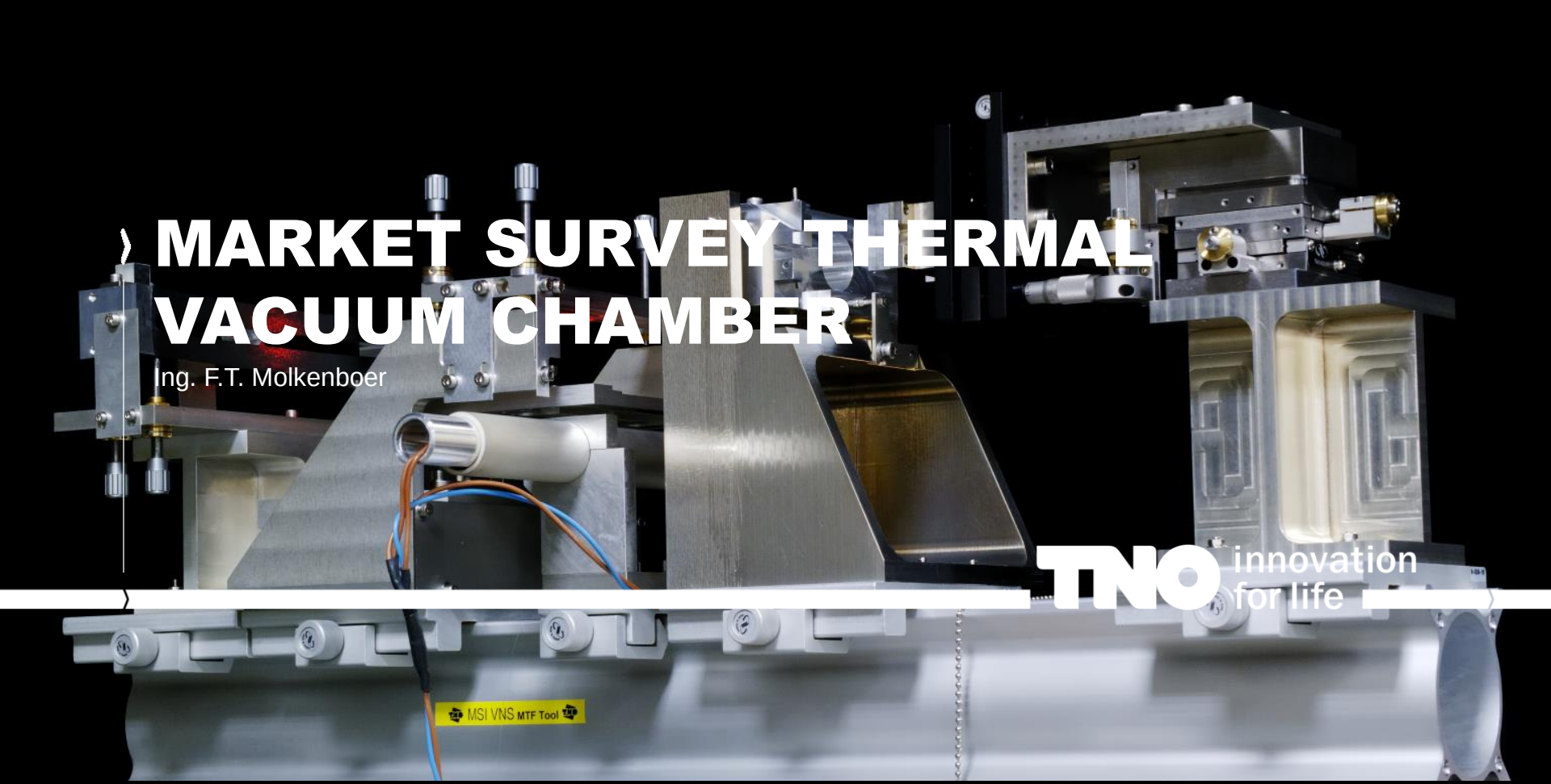


TNO innovation for life

OUTLINE

- Introduction TNO
- Introduction CSI
- High level requirements
  - Vacuum
  - Temperature
  - ..
- TVC design ideas (for discussion)

INTRODUCTION TNO

Article 4 TNO Act

The Organisation aims to ensure that applied engineering and scientific research and other associated social scientific and applied research is made suitably serviceable for the general good and the distinctive interests contained therein.

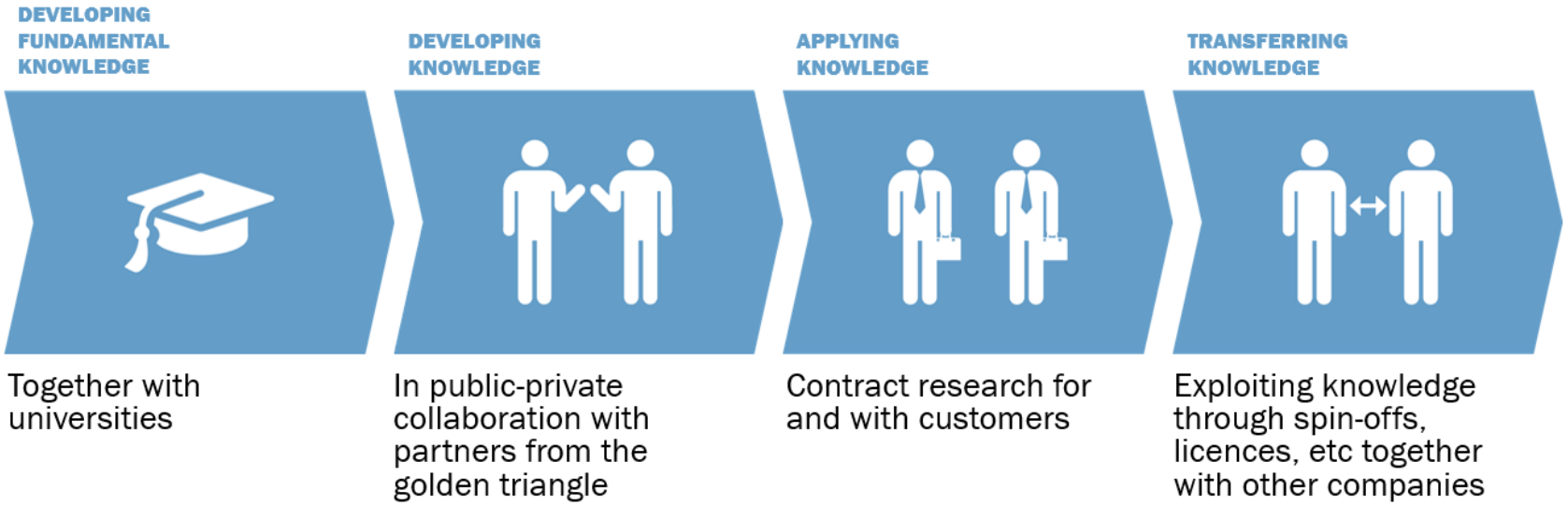
TNO Mission:

- TNO connects people and knowledge to create innovations that boost the competitive strength of industry and the wellbeing of society in a sustainable way.

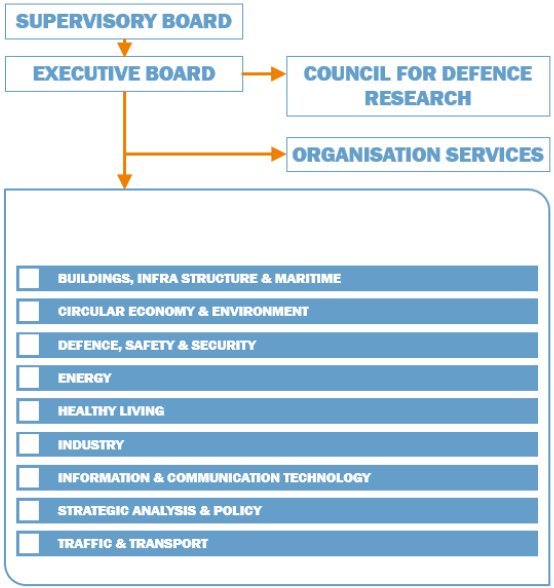
Although TNO is mentioned in the constitution of the Netherlands.
TNO is independent

INTRODUCTION TNO

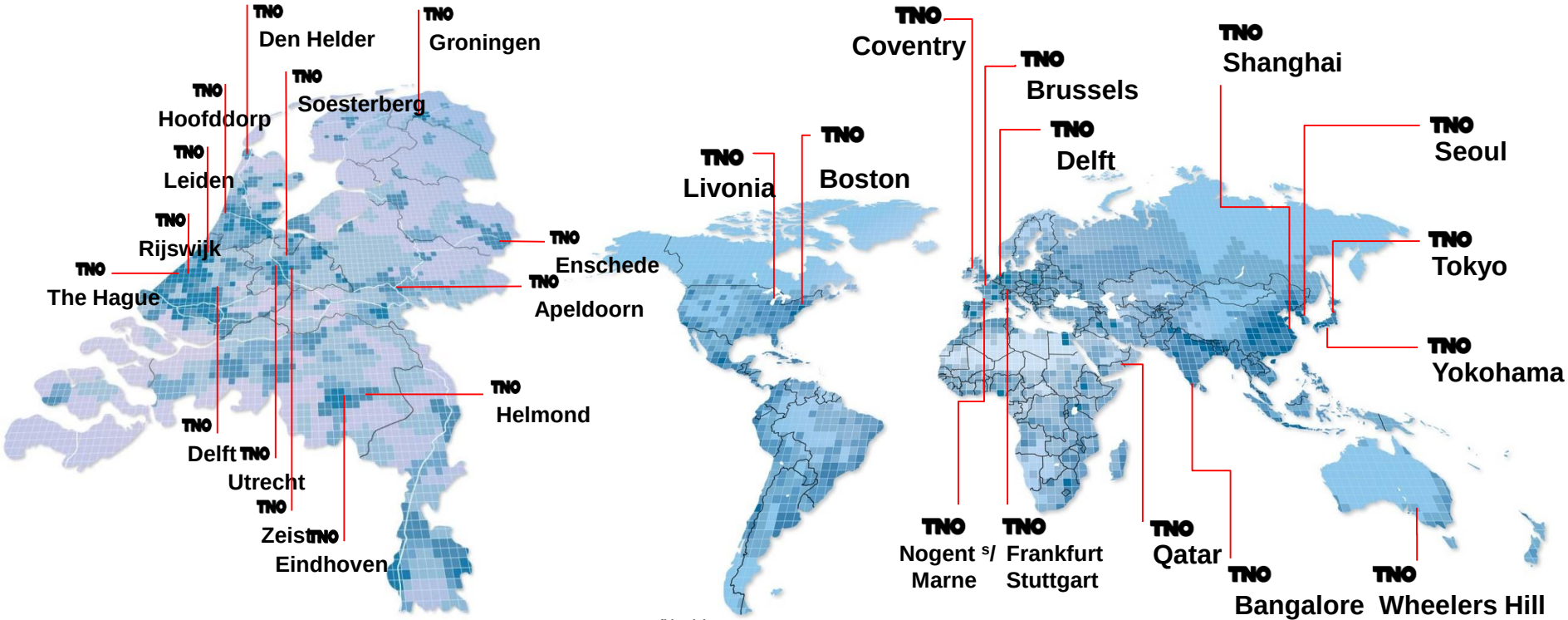
- The power of TNO
  From idea to innovation



INTRODUCTION TNO



INTRODUCTION TNO



INDUSTRY

TROPOMI WILL ANSWER PRESSING QUESTIONS ABOUT CLIMATE CHANGE

CHALLENGE

- Even more specific measurements from space of the air quality and distribution of greenhouse gases worldwide

APPROACH

- Collaboration with Airbus Defence & Space Nederland, KNMI and SRON, funded by the ministries of Economic Affairs, Education, Culture & Science, and Infrastructure & Water Management
- Innovative optics allows high resolution in a compact unit

RESULT

- Within one second pinpoint clearly a strip of 2600 m by 3.5 km and thereby assess the air quality at urban level
- Help answer pressing questions on climate change
- Strengthening the position of the Netherlands as space instrumentation supplier

INTRODUCTION CSI

- TNO is investing in a new facility for Calibrating Space Instruments (CSI)
- This new facility should be larger than the current calibration facility of TNO which is a 1.5 meter diameter horizontal cylinder vessel of 2 meter length
- The new investment also includes Optical, Mechanical and Electrical Ground Support Equipment (OGSE, MGSE, EGSE) but that is no part of this market survey and the foreseen European tender
- Facility must be operational on January 1st, 2021

- Market survey is for the Thermal Vacuum Chamber (TVC) and includes at least the following modules;
  - Vacuum vessel, thermal system (including shroud), vacuum system (including pumps), cleanliness monitoring system, sensors, switching cabinet (including PLC).

PRELIMINARY TIME PLANNING

- Start European tender: May 2018
- Contract: September 2018
- FAT: November 2019
- SAT: July 2020
- Operational: January 2021

PRODUCT BREAK DOWN

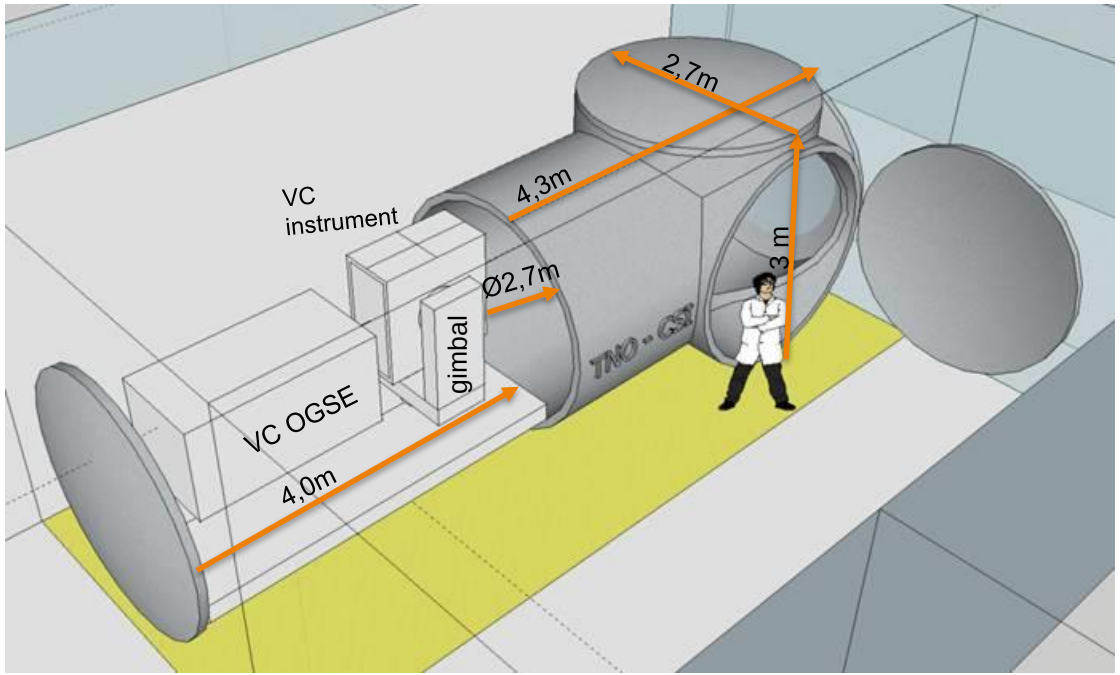
- Latest version of product break down will be discussed during visit

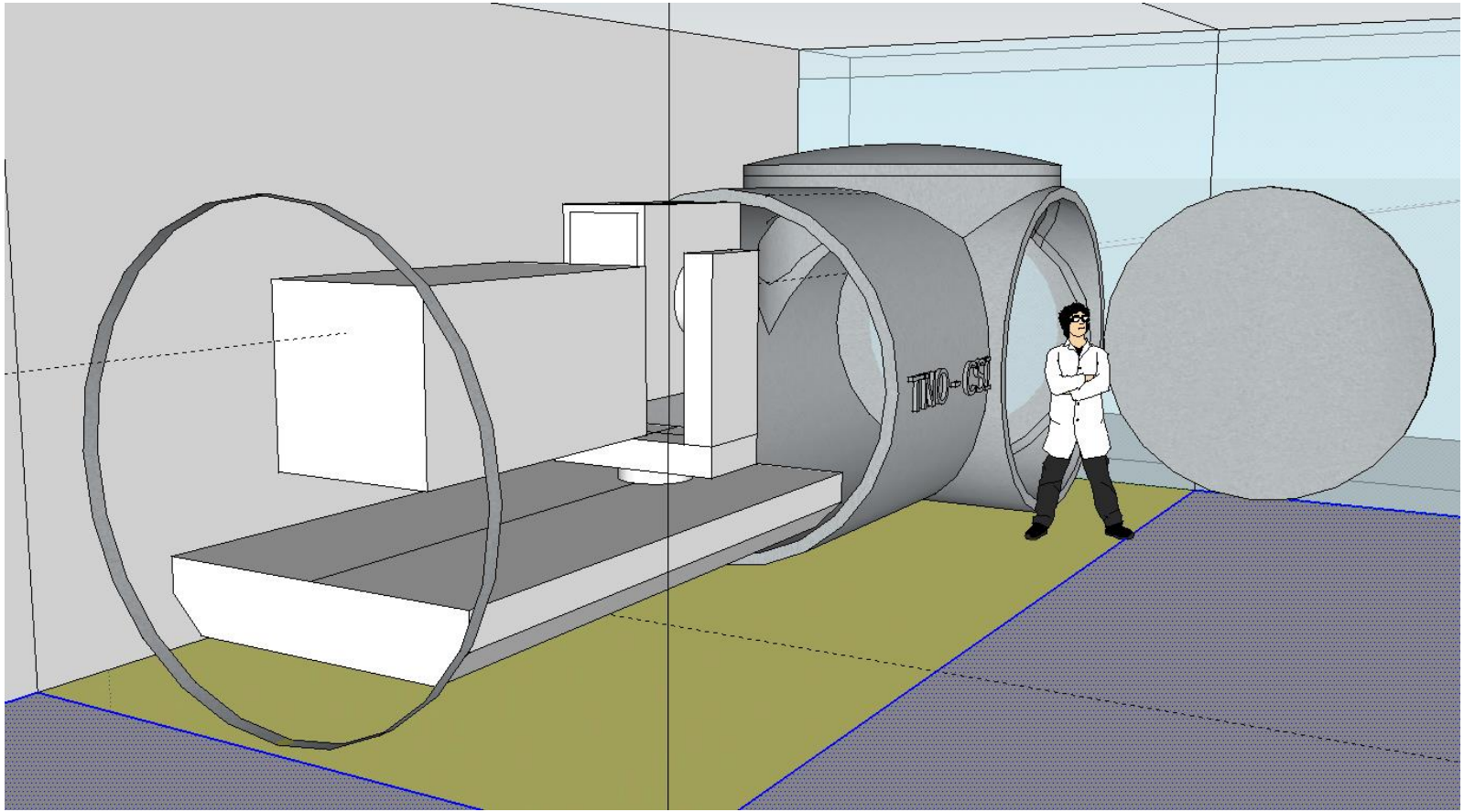
HIGH LEVEL REQUIREMENT TVC (PRELIMINARY)

- Vacuum level during calibration (including instrument) better than 1e-5 mbar
- Designed to be compatible with ISO 6 cleanroom
- A controlled temperature around the instrument with an accuracy of 0.5 °C between +60 °C and -120 °C (TBD)
- House an instrument to be calibrated with a volume claim of 1.2 (L) X 1.2 (W) X 0.6 (H) meter
- Current idea is to mount the instrument on a “2 axes gimbal” kind design
- TVC should also house Optical Ground Support Equipment, current volume claim is 2 (L) X1 (W) X 1 (H) meter

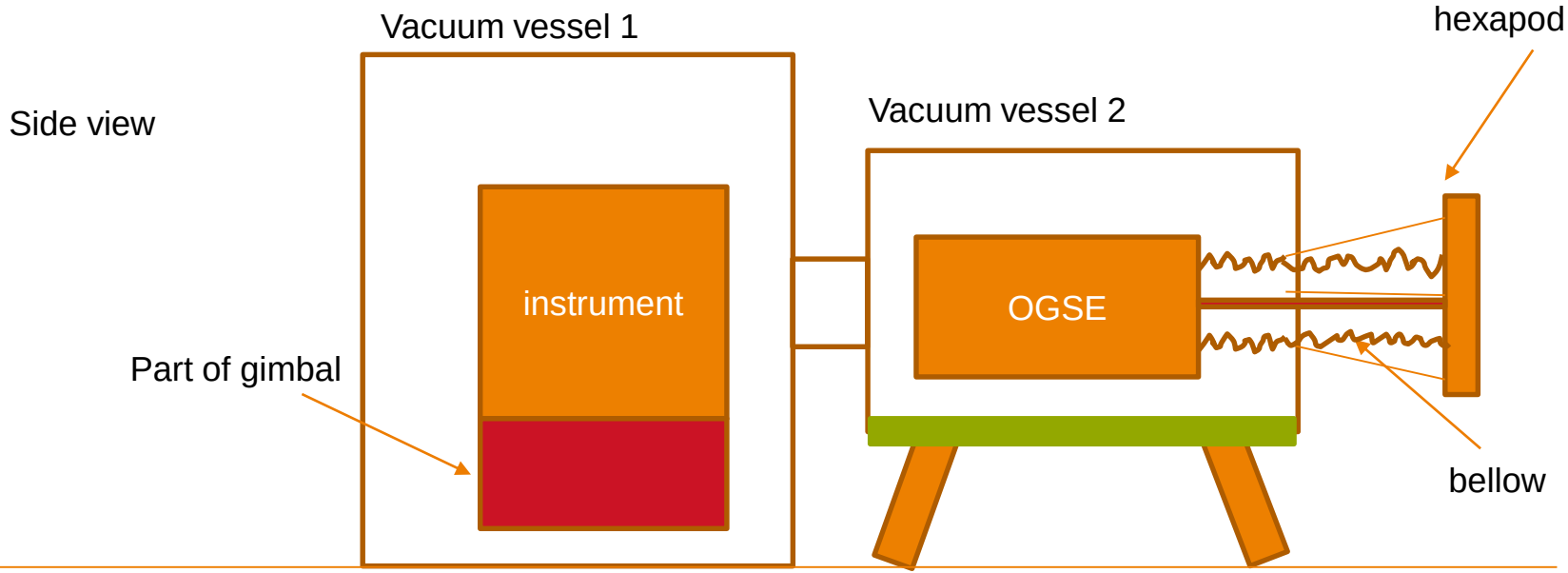
- Note that instrument, gimbal, and OGSE are not part of this market survey

CURRENT DESIGN IDEA OPTION 1 (FOR DISCUSSION)




TNO-CSI

CURRENT DESIGN IDEA OPTION 2 (FOR DISCUSSION)



VACUUM (PRELIMINARY)

- End pressure including instrument and shroud shall better than 1e-5 mbar, this within 24 hours after starting pump down
- FAT and SAT end pressure shall be better than 1e-7 mbar (bake-out is allowed and expected)
- Two roughing pumps: a main roughing pump and a smaller roughing pump used to maintain vacuum
- Roughing pumps shall be dry roughing pumps, preferably COTS
- X amount of magnetically levitated TMP's (X to be determined by the supplier)
- X amount of cryogenic pumps (X to be determined by the supplier)
- We expect that seals of doors have a "guard vacuum"
- The combination of pumping speed and diameter of roughing pump line shall result in a laminar flow regime in the chamber, an option is to have a butterfly valve to control this
- Goal is to limit the amount of fan cooled equipment (heat to lab, and particles)→ water cooling of TMP's
- Vacuum chamber shall have an automated bake-out system (e.g. removable), outer touchable TVC surfaces shall be between 15° C and 45° C
- Cleanliness measurement of chamber required

HIGH LEVEL REQUIREMENT TVC (SHROUD) (PRELIMINARY)

- Shroud should enclose instrument, not OGSE
- Temperature range -120 °C (TBD) to 60 °C
- Cooling to -120 °C (TBD) with profitably a closed loop cryogenic refrigeration system
- Shroud should have an optical absorbing coating TBD
- Shroud temperature homogeneity 5 °C TBD
- Time to reach minimum temperature from room temperature to setpoint is 12 hours TBD

EGSE/ CONTROL SYSTEM (PRELIMINARY)

- The control system of the TVC shall control the entire operation of the TVC, this includes
  - Pump down, venting, thermal control of shroud and possible a cold plate connected to the instrument
  - The control shall ensure safe error handling
  - Excluded is control of OGSE and MGSE, however interface to overall control system (remote control, monitoring, logging) is required
- The operation of the control shall be user friendly and shall have a mode that allows all operation. The default operation shall ensure human, instrument and machine safety. Obtaining this safe operation can be a combination of sensors and software
- Review/ FMEA of entire system will be required and needs approval from TNO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