
PRECISION TECHNOLOGY IN
OPTICAL SPACE INSTRUMENTS
Now and in the future | Ir. B.T.G. de Goeij (TNO Space Systems Engineering)
TNO innovation for life

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INTRODUCTION
TNO AND MYSELF

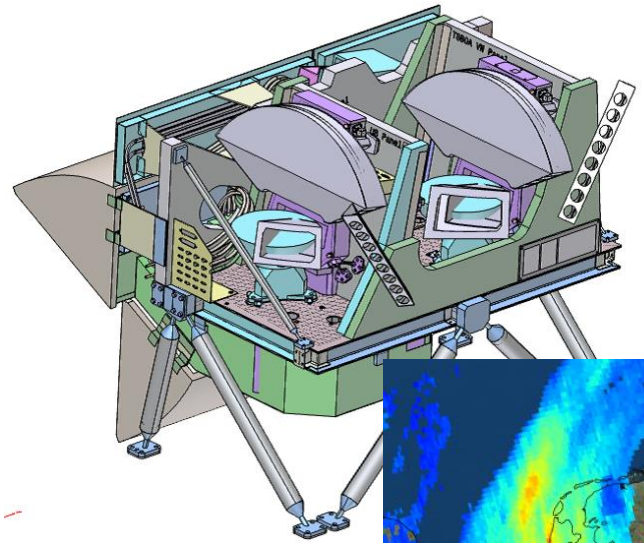
TNO

- Over 50 years of heritage of working on space projects
- Focus on opto-mechatronical systems for space and high tech industry
  - Scientific optical instruments
  - Laser communication terminals
  - Sun Sensors

- Senior Space Systems Engineer
- Just over 12 years of experience in developing:
  - Sun Sensors
  - Scientific optical instruments
- Involved in setting development priorities

INTRODUCTION
SENTINEL 5

- The Sentinel-5 mission focuses on monitoring of trace gas concentrations and aerosols in the atmosphere to support operational services covering air-quality near-real time applications, air-quality protocol monitoring and climate protocol monitoring.
- The Sentinel-5 instrument is a high resolution spectrometer system operating in 5 different spectral bands:
  - UV-1 (270-300nm)
  - UV2VIS (300-500nm)
  - NIR (685-773nm)
  - SWIR-1 (1590-1675nm)
  - SWIR-3 (2305-2385nm).
- Spatial resolution is below 8km (>300nm); below 50km (<300nm)



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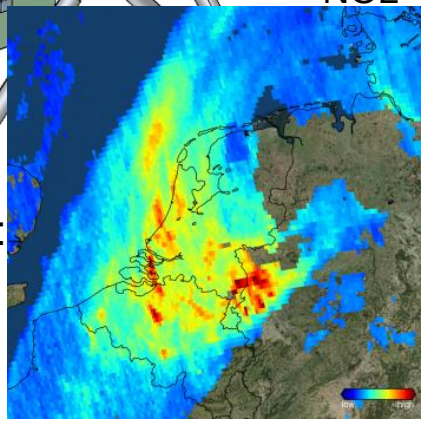
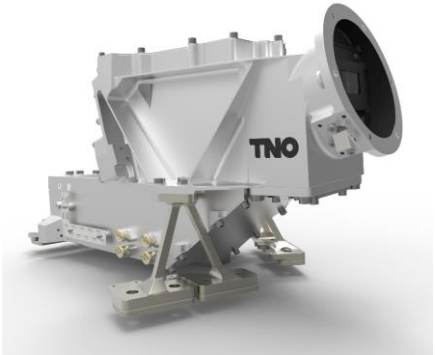


TNO Contributions:

- ❑ **TSBOA H/W**
- ❑ **UV1 H/W**

CHALLENGES FOR OPTO-MECHANICAL SPACE INSTRUMENTS AND INDUSTRY

- Sentinel 5 requirements lead to state of the art (ideally even better) production technology:
  - Freeform mirrors with high accuracy and low roughness
  - Complex mechanical structures with high precision and accuracy



20 mechanical interface planes
Tolerance 10µm (typical)

Complex shape with tolerances 50-100nm

$$z = \frac{x^2/R_x + (y-150{,}5)^2/R_y}{1 + \sqrt{1 - (1+k_x)x^2/R_x^2 - (1+k_y)(y-150{,}5)^2/R_y^2}} + a_6x^6 + a_8x^8 + a_{10}x^{10} + b_6(y-150{,}5)^6 + b_8(y-150{,}5)^8 + 30{,}896153$$

CHALLENGES FOR OPTO-MECHANICAL SPACE INSTRUMENTS AND INDUSTRY

CHALLENGES FOR OPTO-MECHANICAL SPACE INSTRUMENTS AND INDUSTRY

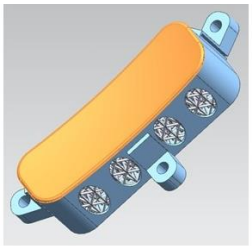
- Besides the required technical state-of-the art there are other challenges.

- Right to play
  - Heritage
  - Certification and process control
  - Cleanliness

- Difficult industry (at the moment):
  - Opto-mechatronical instruments for space are single offs
  - Firm Fixed Prices
  - High Risk and low profit
  - No / limited recurring products

5 YEARS FROM NOW

- Commercial space application (incl laser comm.) will also reach opto-mech space applications.
  - More recurring product
    - Opportunity to maintain knowledge and processes
    - Opportunity to increase margins
  - Synergy between commercial applications and scientific missions
- Technology
  - Even tighter tolerances to reach “plug and play” instruments
  - Imbedding of new technologies in space
    Example: 3D printing




THANK YOU FOR YOUR ATTENTION
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