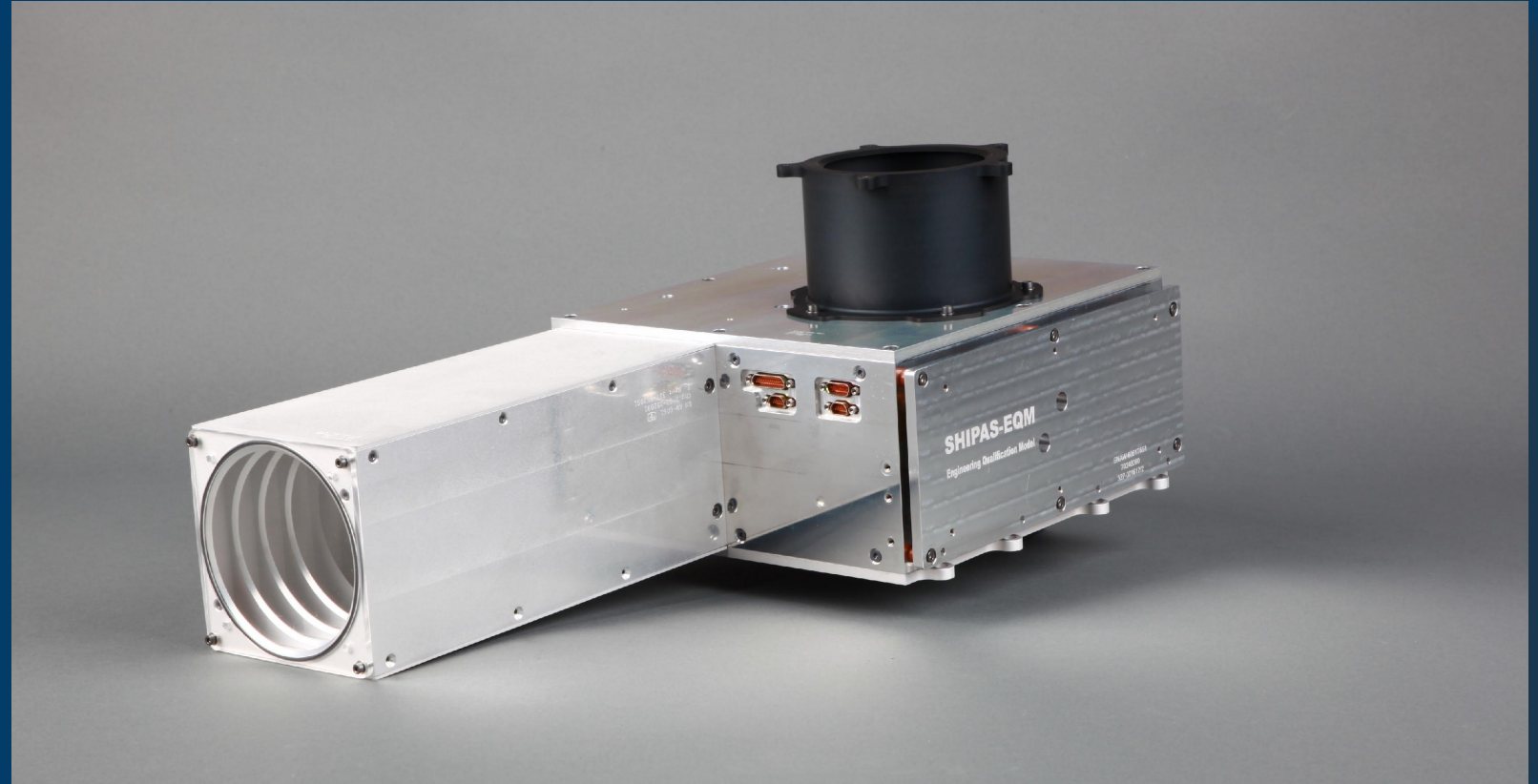


MINIMIZATION OF THERMO-MECHANICAL INFLUENCES ON THE IMAGE QUALITY OF OPTICAL SYSTEMS

13.09.2024 GIORGI KAKABADZE, ZEA-1/ITE

CONTENT

- Institute Overview
- Project outline
 - Project stages
 - Significance of the research
 - Research questions
- Research methods
 - Thermal modelling
 - Optics
- Final goal
- Research progress
- Conclusion



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INSTITUTE OF TECHNOLOGY AND ENGINEERING

New name of the institute from January 2025

ZEA – Central Institute of Engineering, Electronics and Analytics

ZEA-1 – Engineering
and Technology

ZEA-2 – Electronic
Systems

Measurement Systems

ITE

PGI-
4

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ZEA-1 FACTS AND FIGURES

ZEA-1

9 PhDs, 5 Master- and
4 Bachelor students,
2 Trainees and 6 Colleagues
in Administration

Active in four HGF research fields:
Energy, Information, Matter, Earth and
Environment

Within all research programmes, in every
scientific priority of the FZJ

200 on-going
FZJ-cooperation

30 on-going
industrial
cooperation

10 funded projects
with external
partners

Approx. 160 Employees

100 in the Department Engineering and
New Technologies

50 in the Department
Fabrication Techniques and Assembly



Management
System
ISO 9001:2015

www.tuv.com
ID 9108620945



Prof. G. Natour
Director of ZEA-1
and
Professor at
RWTH Aachen University

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ZEA-1 TEAM



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ZEA-1 MISSION STATEMENT

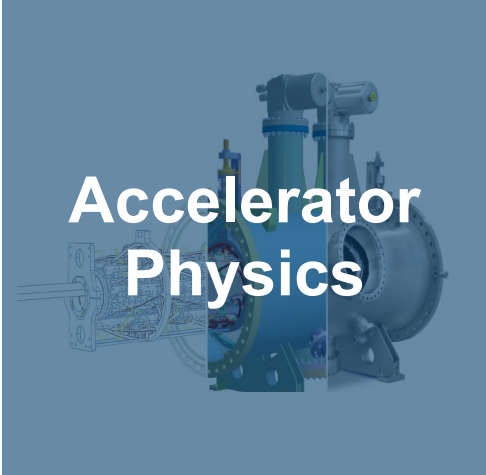
- We make our capacities, competences and technologies available to the institutes of the research centre and third parties and transfer the results to society.
- We research comprehensive solutions for the major societal challenges of the future in the areas of information, matter, earth & environment and energy and create the foundations for future key technologies for this purpose.
- We provide impulses and are partners in the value creation process of research from basic research to transfer to society.
- We strengthen our acquisition of third-party funding and establish our R&D activities in alliances, research consortia and strategic partnerships.
- We are joining forces in line with the goals of the BMBF, HGF and FZJ.
- We are breaking new ground in strategic partnerships with universities, research institutions and industry.
- We want to be demonstrably among the best in the world with our research results and our management services, the operation and use of complex infrastructures.
- We value the creativity and motivation of our employees as the most valuable asset of our research centre, offer equal opportunities and promote education and training.

OUR FIELDS OF RESEARCH

RESEAR
CH



Neutron Science



Accelerator
Physics



Energy



Climate Research



Bio-Geo
Science



Information



Manufacturing
Technology

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PARTNERS IN RESEARCH

Cooperat
ions



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GGSB COLLABORATION HISTORY

Students at ZEA-1

Lasha Lomsadze (AUG)

Aleksandre Kobeshavidze (AUG)

Giorgi Gvasalia (AUG)

Davit Togonidze (AUG)

Nika Sharmazanashvili (GTU)

Sergo Samkharadze (GTU)

MOTIVATION AND RATIONALE OF THE RESEARCH

Climate change challenge

Understanding of processes in the atmosphere

Monitoring and measurement

Obtaining accurate data

PROJECT PARTNERSHIP

Project supervisor – Prof. Dr. Ghaleb Natour



**BERGISCHE
UNIVERSITÄT
WUPPERTAL**

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PROJECT OUTLINE

Research subject

- Micro Satellite
- SHIPAS optical instrumentation
- Atmosphere monitoring
- Climate research
- 500 km orbital altitude
- 90 min orbital period
- Extreme thermal loads
- Image quality at risk



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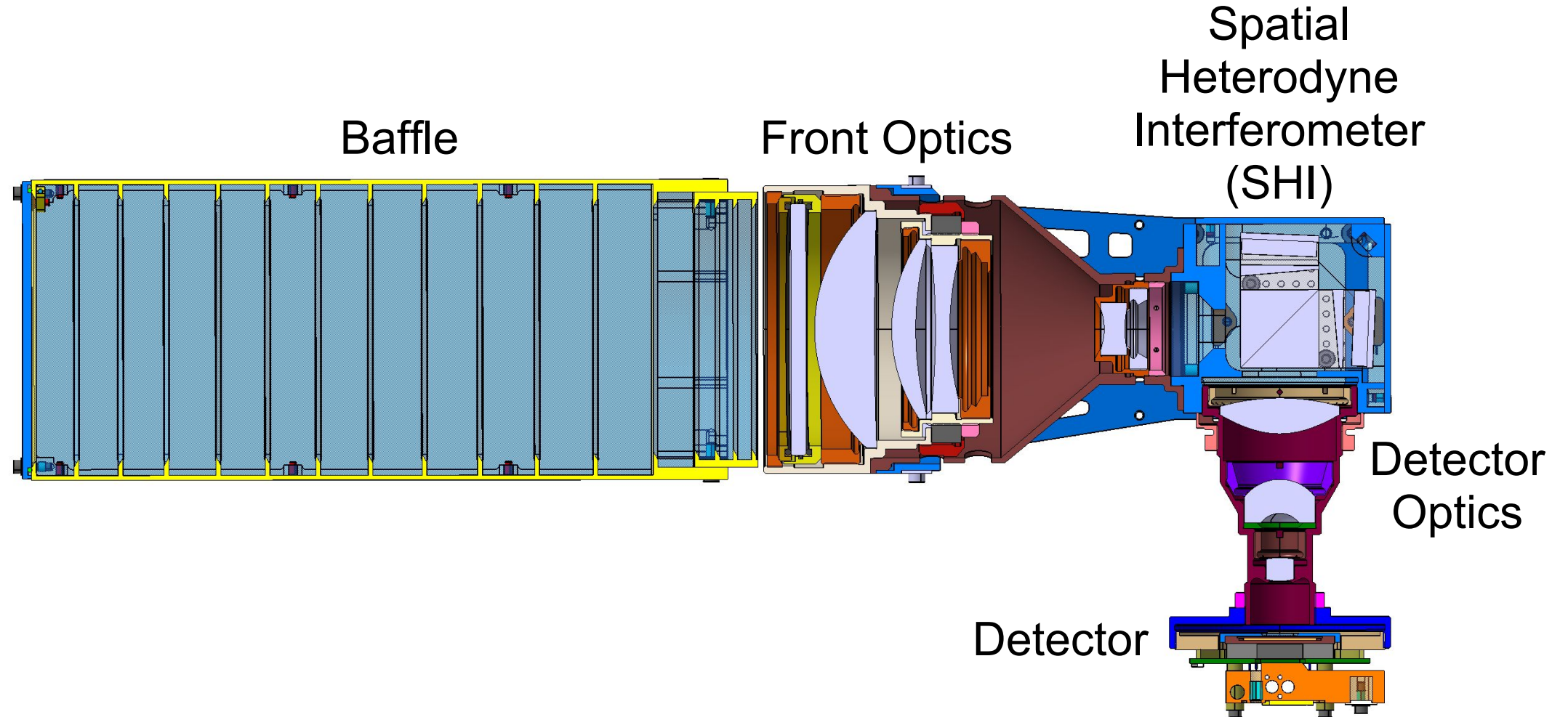
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SYSTEM ARCHITECTURE

Optics



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PROJECT STAGES

State of the art

Subsystems thermo-mechanical analysis

Thermal loads modelling during orbital movement

Thermo-mechanical coupling

Structural-Thermal-Optical-Performance (STOP) analysis

Optimization of the design

Validation

SIGNIFICANCE OF THE RESEARCH

Contribution to global science

Realistic orbital thermal loads modelling

Full STOP analysis for Micro satellite

STOP analysis for system with optical interference

Contribute to satellite cluster technology

Earth environmental monitoring technology

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RESEARCH QUESTIONS

How to address the problem?

What thermal loads are met on orbit?

How thermal loads affect satellite structure?

What are weak points in satellite structure?

How structural deformation affects image quality?

What are the critical deformations?

How to minimize critical deformations?

How to optimize whole system?

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RESEARCH METHODS

How to answer research questions?

Numerical simulations

Thermo-mechanical analysis

Optical ray tracing

STOP analysis

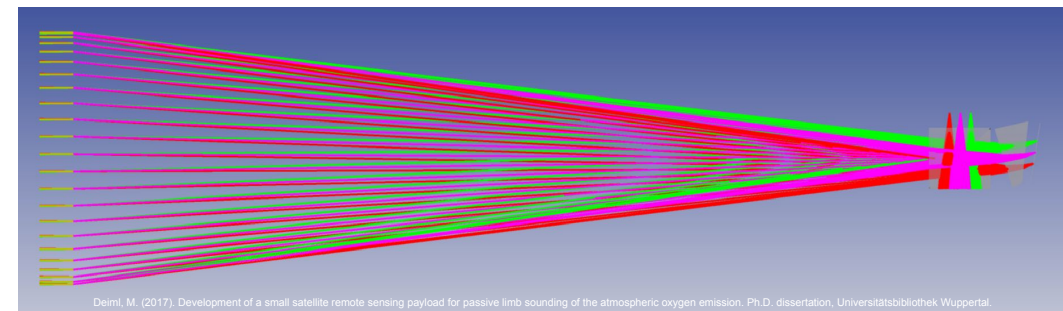
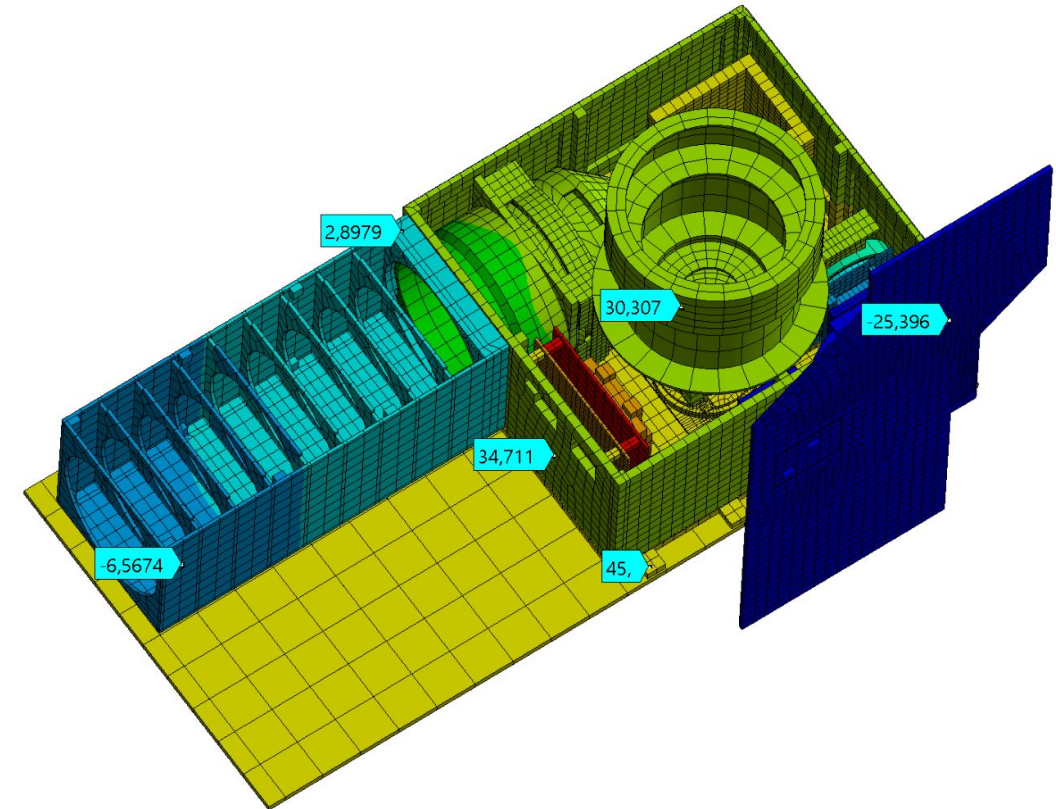
Multidisciplinary optimization

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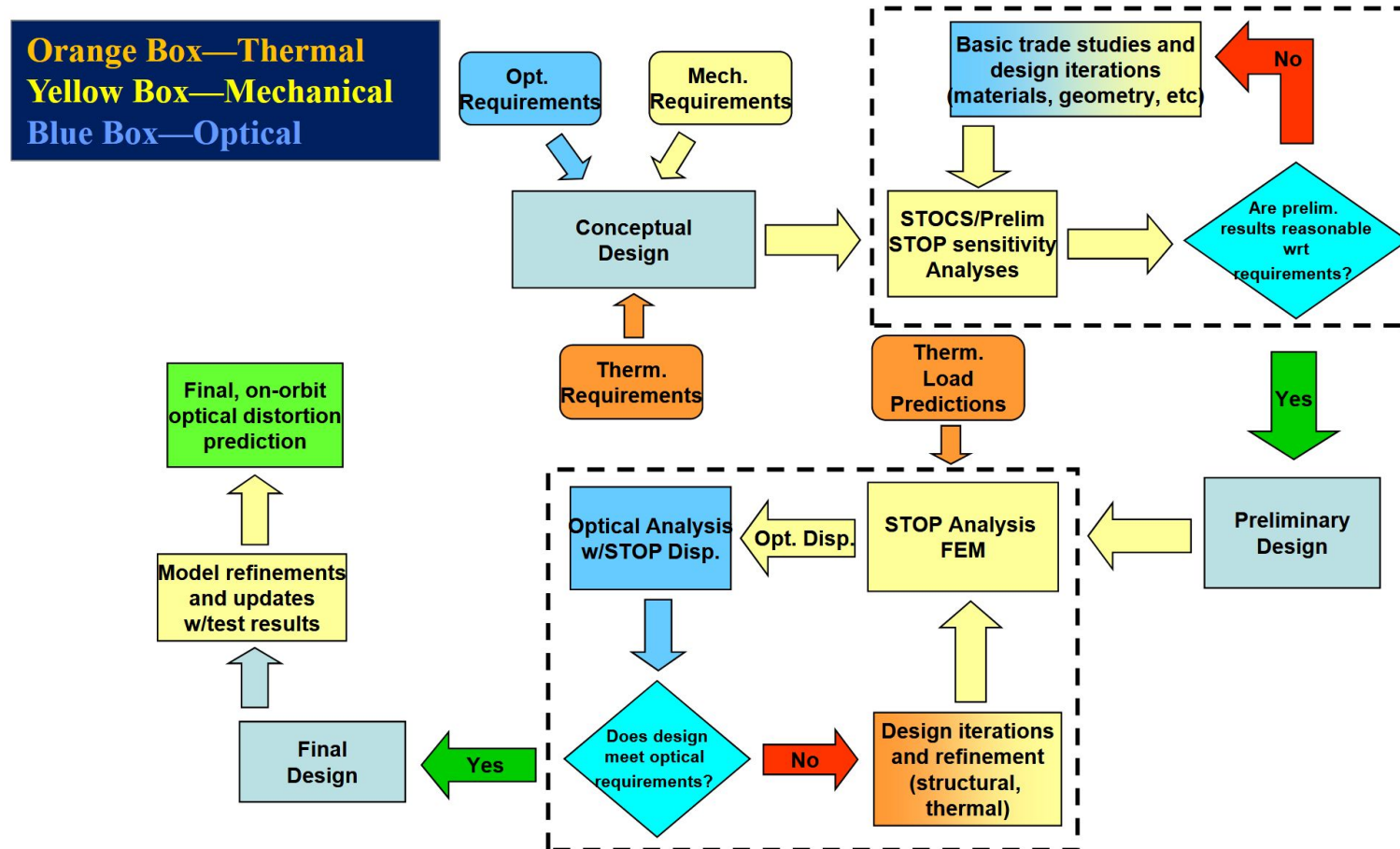
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STRUCTURAL-THERMAL-OPTICAL-PERFORMANCE (STOP) ANALYSIS



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SOFTWARE PACKAGES

Tools used during research



Thermo-mechanical coupling



Optical ray tracing

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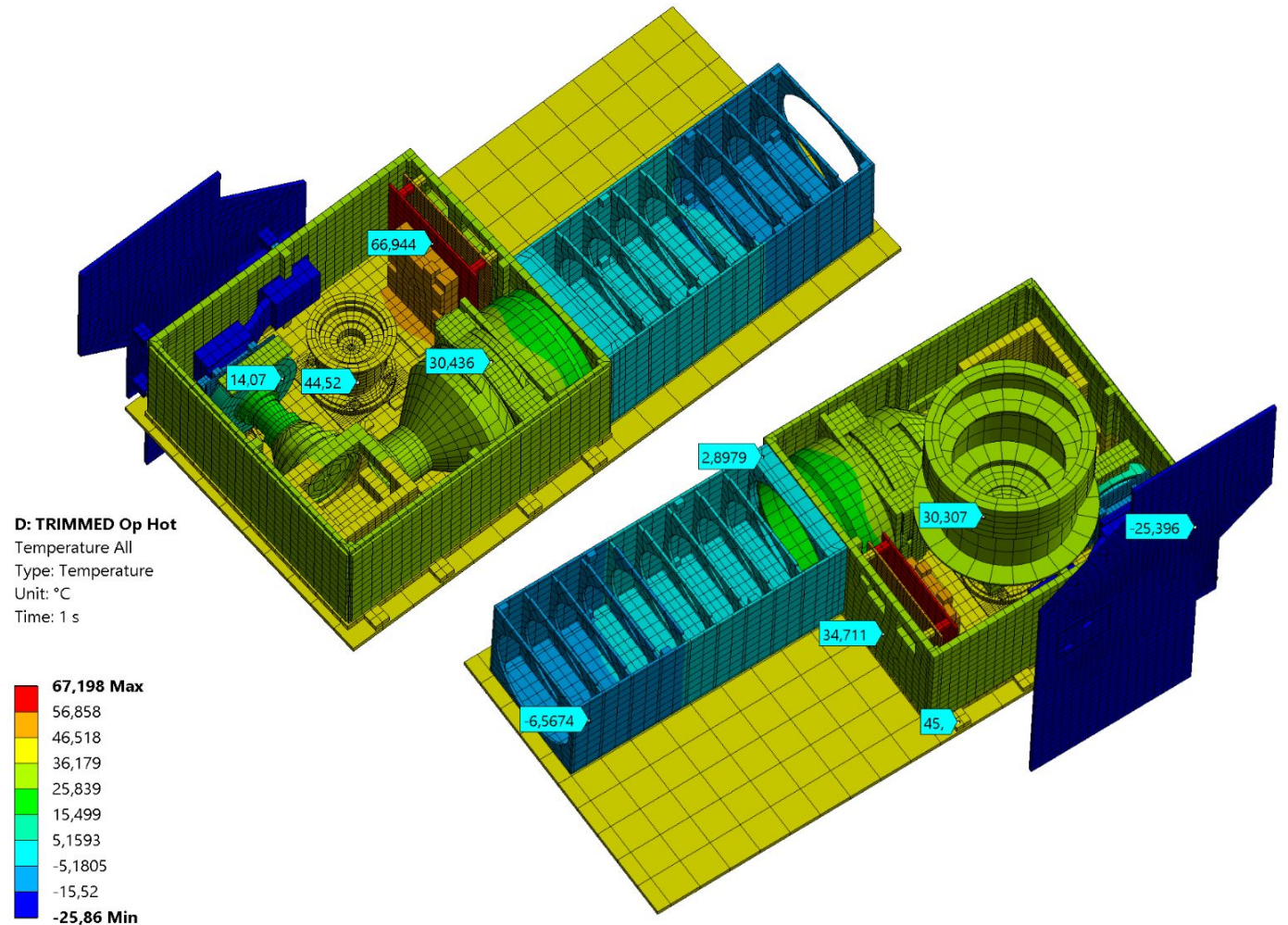
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THERMAL MODELLING

- Isothermal
 - Analyze subsystems
 - Hot case +70°C
 - Cold case −40°C
- Steady-State Thermal
 - Introduction of radiation
- Transient Thermal
 - Modelling realistic thermal loads during orbital movement



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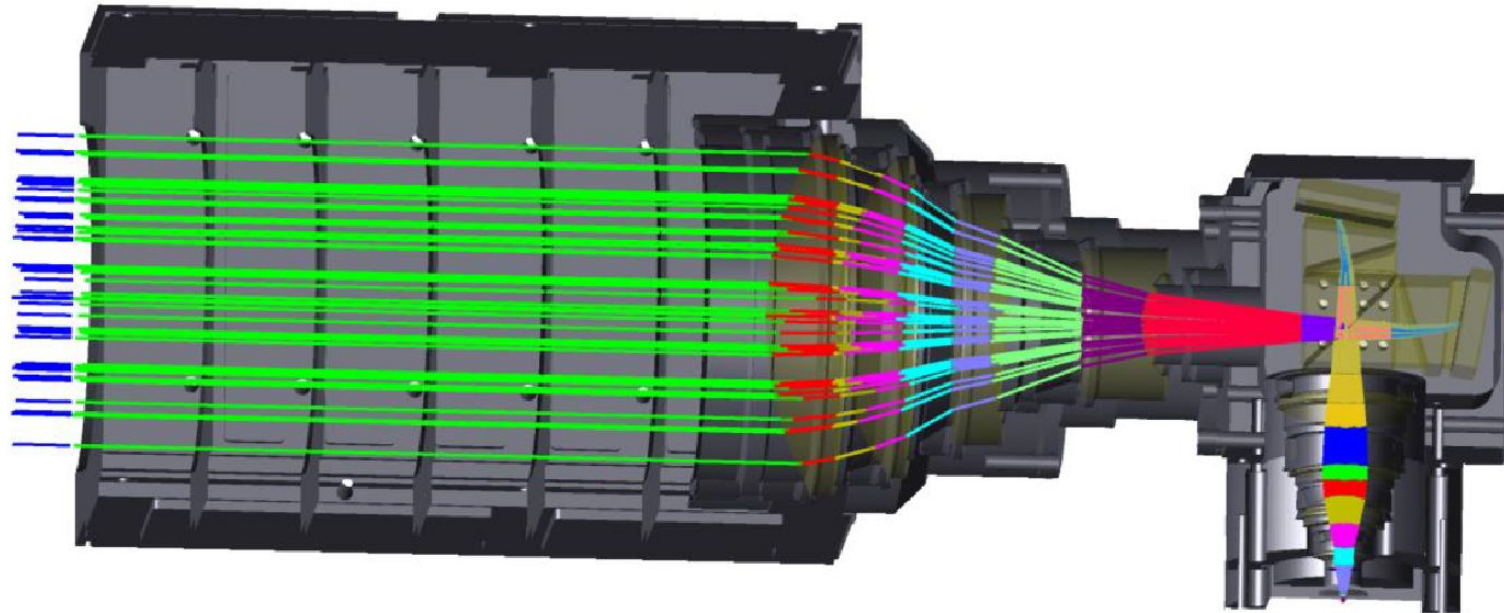
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FINAL GOAL

- Obtain structural stability against thermal loads
- Guarantee acceptable image quality



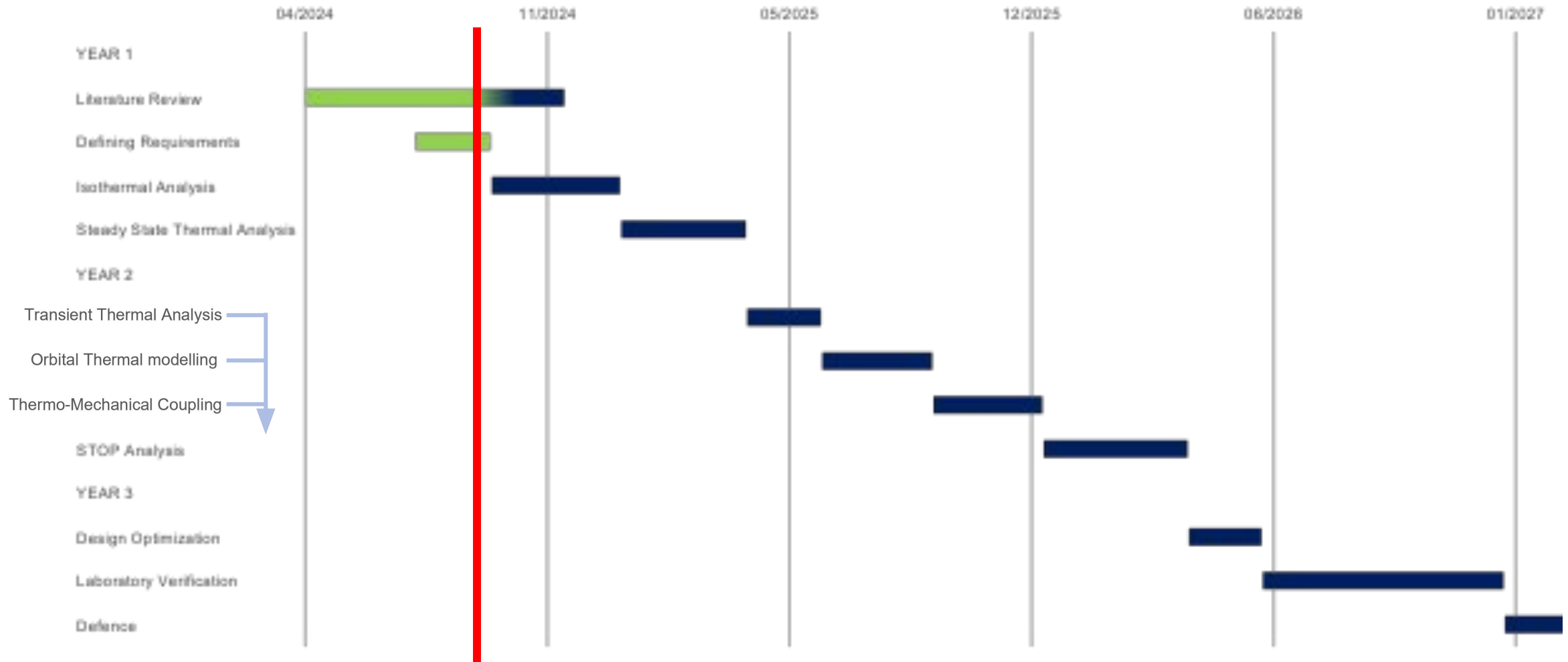
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RESEARCH PROGRESS



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CONCLUSION



https://www.esa.int/Applications/Satellite_navigation/ESA_plans_for_low-orbiting_navigation_satellites

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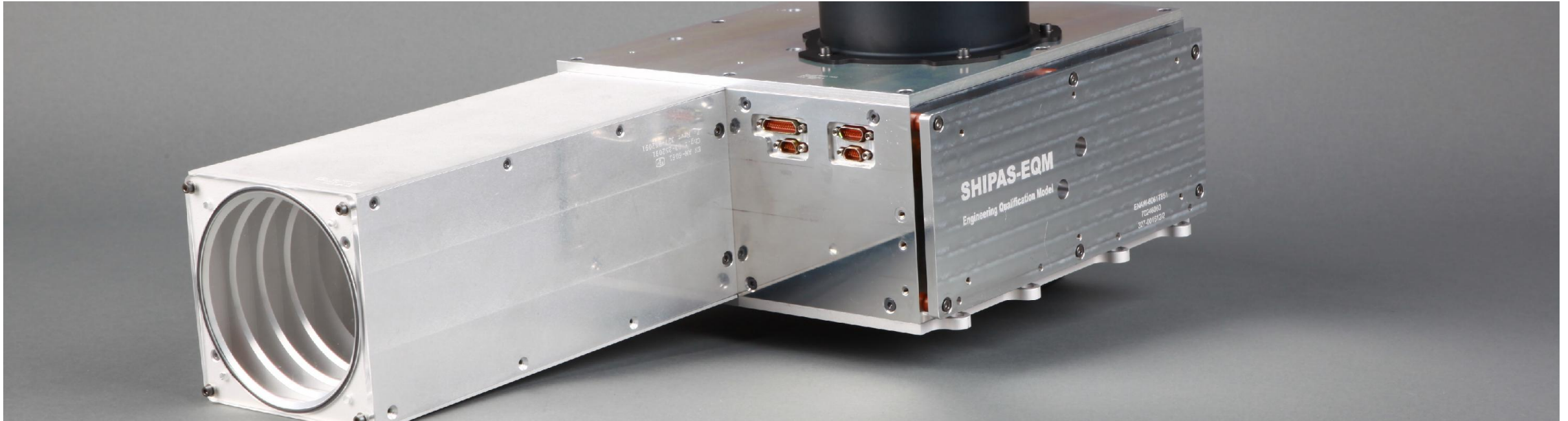
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Global challenges require global solutions

Accessible satellite constellation technology

Accurate environmental data collection

Better future for our home



THANK YOU FOR YOUR ATTENTION