



RIT2021

SPACE INNOVATION GROWTH COOPERATION

SPACE INNOVATION FORUM

October 12-13, 2022

A space-themed background featuring the Earth's horizon at the bottom, a bright orange and yellow arc on the left side, and a starry sky with a faint galaxy. The text is centered in white.

R&D PROJECTS

Marta-Lena Antti, LTU, Eng. Materials
Anna Öhrwall Rönnbäck, LTU, Product Innovation
Erik Nyberg, LTU, Machine Elements

October 12-13, 2022



BACKGROUND

INNOVATION PHD-STUDENTS AND THE GRADUATE SCHOOL
OF SPACE TECHNOLOGY

ROUND 1 (2002) → 27 PhDs



ROUND 2 (2008)



12 PhDs



ROUND 3 (2014) → 14 PhDs



IDEA PITCH

FOR MORE INNOVATION PHD-STUDENTS AND A NATIONAL
GRADUATE SCHOOL OF SPACE TECHNOLOGY



*National Graduate
School of Space
Technology*

Launch...



Mars and beyond...



Satellites...

Atmosphere and up...





<https://youtu.be/fAAXsER57h8>

SUMMARY

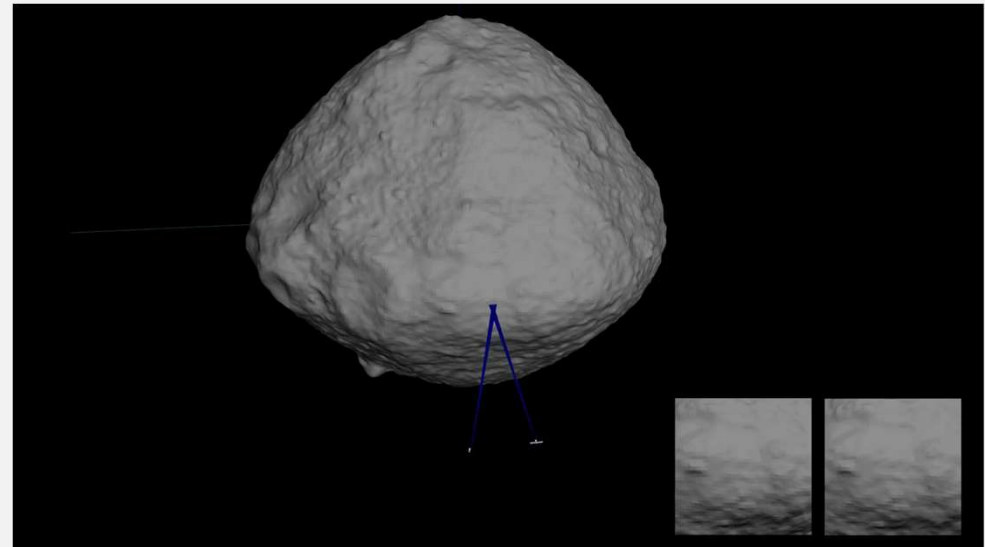
WHAT HAVE WE ACHIEVED SO FAR?

- ✓ Technical solutions and increased knowledge
- ✓ Educated persons
- ✓ Increased collaboration with industry and between research subjects
- ✓ Innovation capability and Sustainability awareness

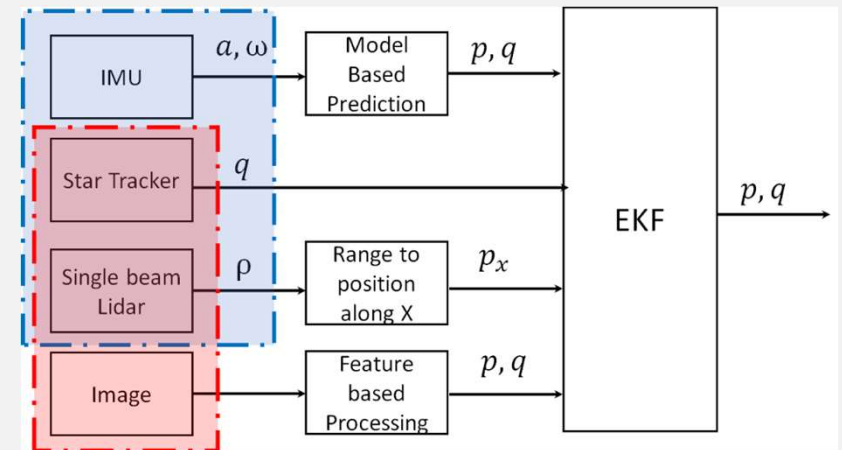
- ✓ Ongoing work together with our partner companies, OHB Sweden, Isar Aerospace, GKN Aerospace Engine Systems, SSC



Autonomous Visual Navigation around Small Celestial Bodies: NRFP-4

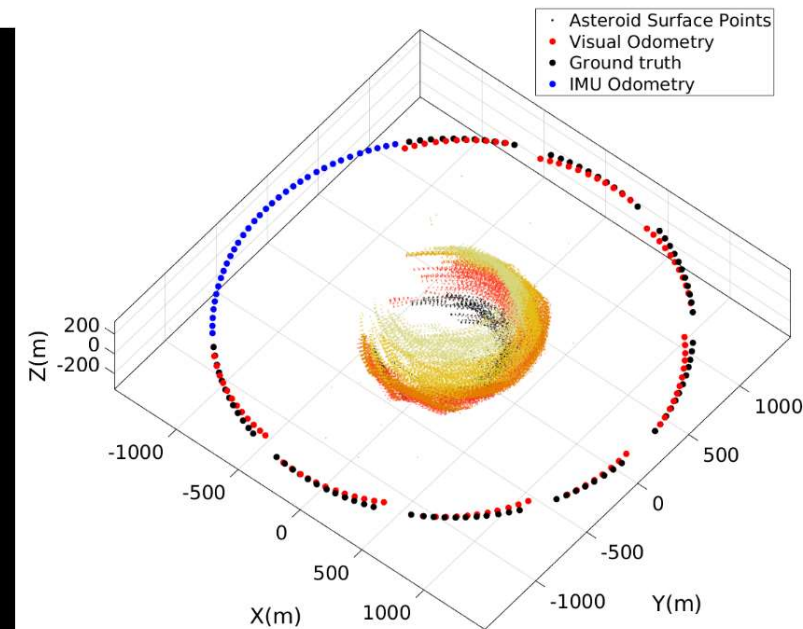
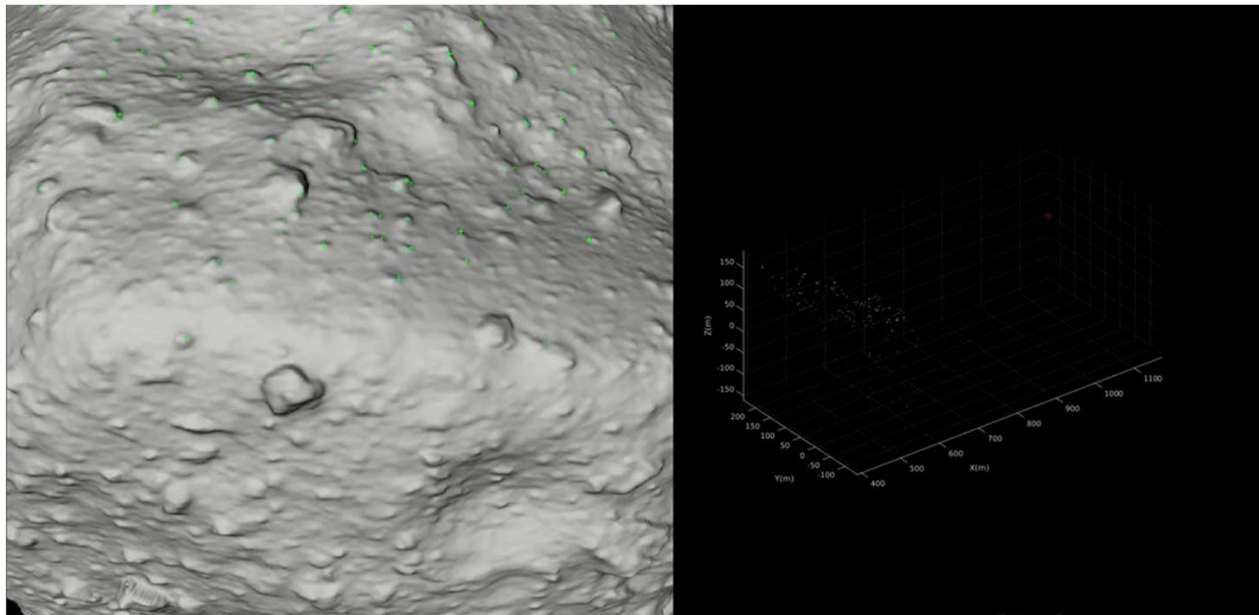


High-fidelity simulation framework capturing realistic image



Multi-sensor fusion based pose estimation

LiDAR-Visual Fusion based Simultaneous Localization and Mapping: NRFP-4

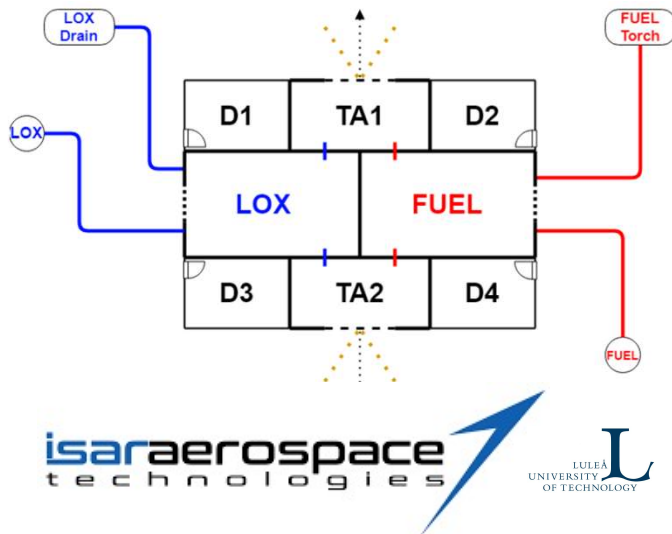


Estimated satellite trajectory based on autonomous relative navigation

Visual SLAM algorithm: (a) Detects feature points in each frame, (b) Associates Lidar point clouds with detected features, (c) Correlate between two successive frames, (d) Localize satellite in relative frame, (e) while enable provision for reinitialization for repetitive correction

Green Corridor to Space

an optimal test facility for modern rocketry



Isar Aerospace Test Center at Esrange

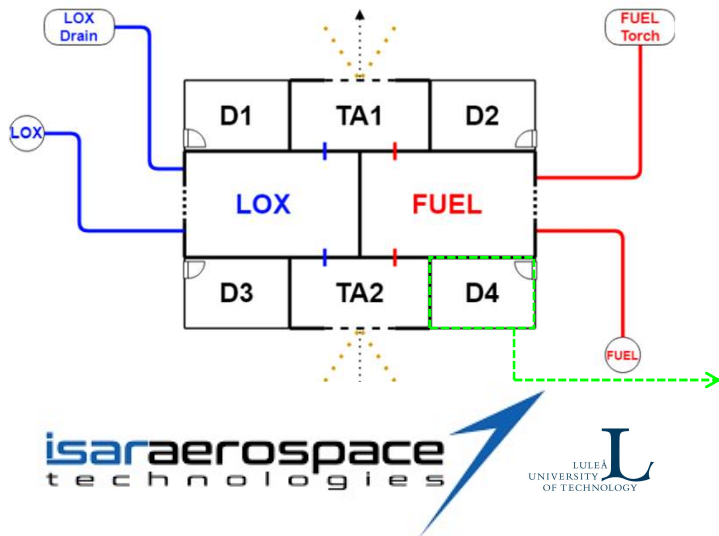
Improved materials, cooling-, injection- and ignition systems, fluid-structure interaction, combustion instabilities, nozzle design (de Laval type), 3D printed technologies – injector, combustion chamber, and nozzle, sustainable rocket fuels – with low carbon-to-hydrogen ratio (e.g., hydrogen, methane, propane, and metals).

LTU: Jihyoung Cha, Murugesan Ramakrishnan, Olle Persson, Alexis Bohlin

ISAR: Josef Fleischmann, Felix Kühne + LTU MSc thesis students



Ultrafast Laser Diagnostics used at tests/research of rockets, can it be done?



- Special challenges for practical/industrial applications of laser diagnostics, e.g.
 1. high-pressure, 2. perturbations of the platform, 3. limited optical access
- No standard exists for such advanced measurement capacity performed in-situ

In-Situ Ultrafast Laser Diagnostics vs. Inspection Methods

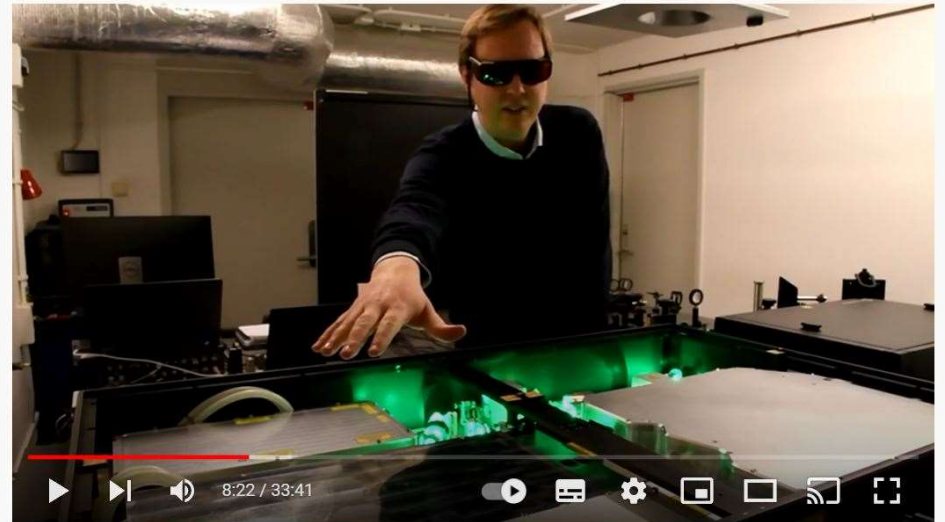
YouTube^{SE}



Technology Insights: Infrared Thermography

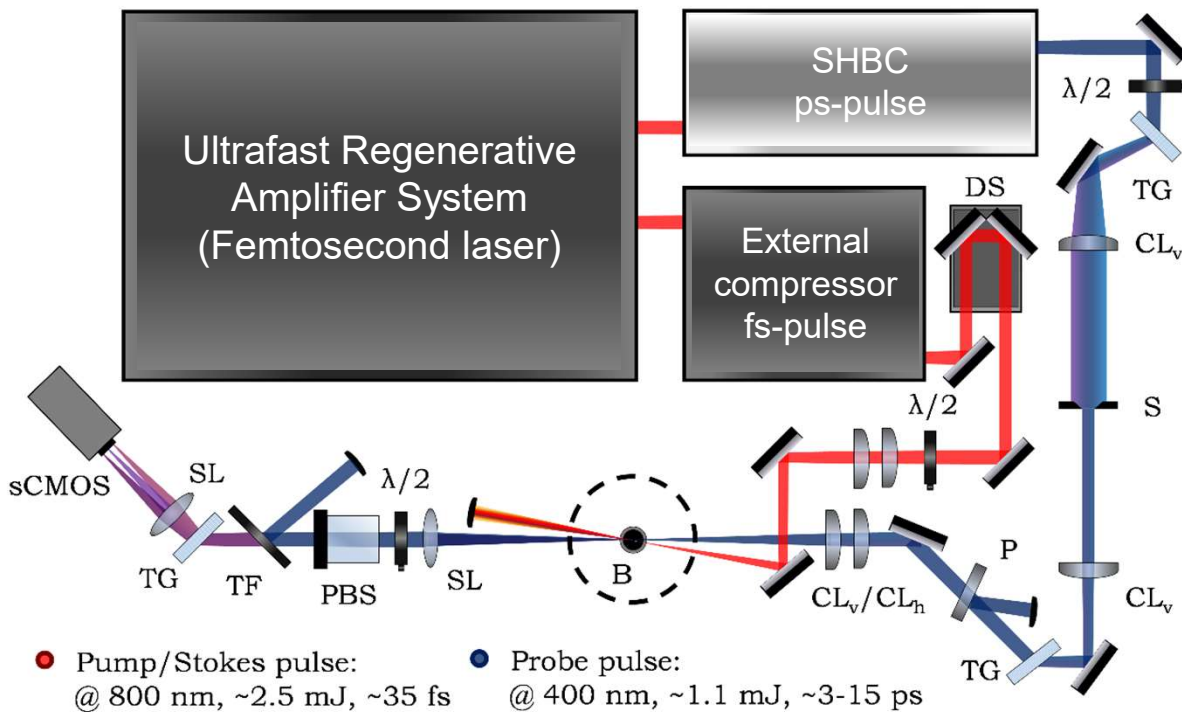


YouTube^{SE}



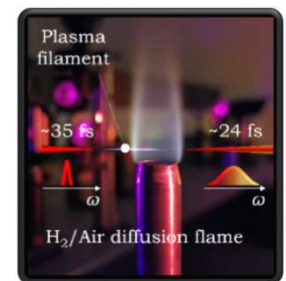
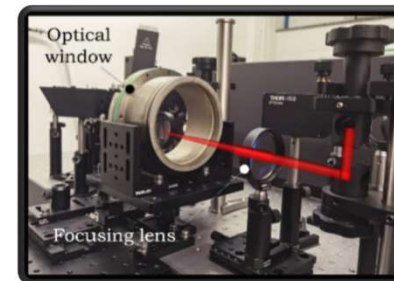
Ultrafast CARS Thermometry Tutorial

Making a portable CARS imaging system a reality



White Paper with Coherent Corp.

“Combustion analysis with CARS – It Really is Rocket Science”



Talks citing RIT 2021:

ESULaB 2022 COMBURA 2022
ECONOS 2022 ERCOFTAC 2022
Int. Symposium on Combustion 2022

Publications citing RIT 2021:

Combustion and Flame (2022)
Optics Express (2022) [Optica News]
Proceedings of the Combustion Institute (2022)

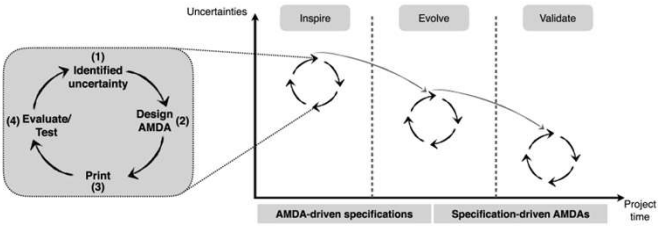
Design Uncertainties in Additive Manufacturing



- RIT PhD student 2015-2020
- Design for AM process with design artefacts
- Reduce uncertainties and learn about AM

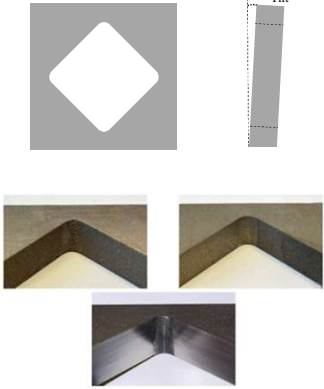
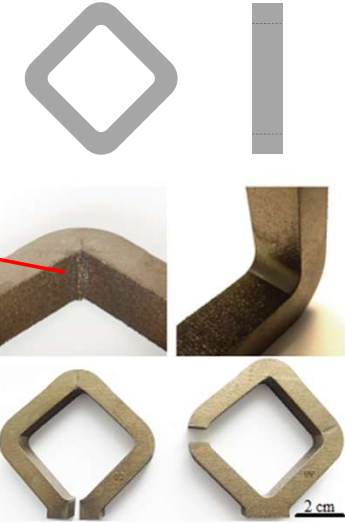


- RIT PhD student start 2020
- Continuation of research on design artefacts
- In-depth study on impact of surface roughness in AM designs
- Implementation and validation!



1st iteration

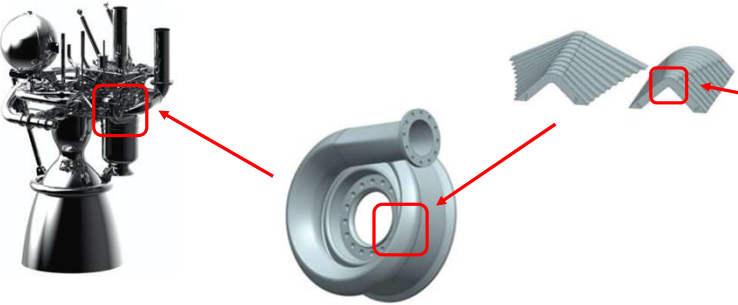
2nd iteration



Fatigue testing results at same testing condition



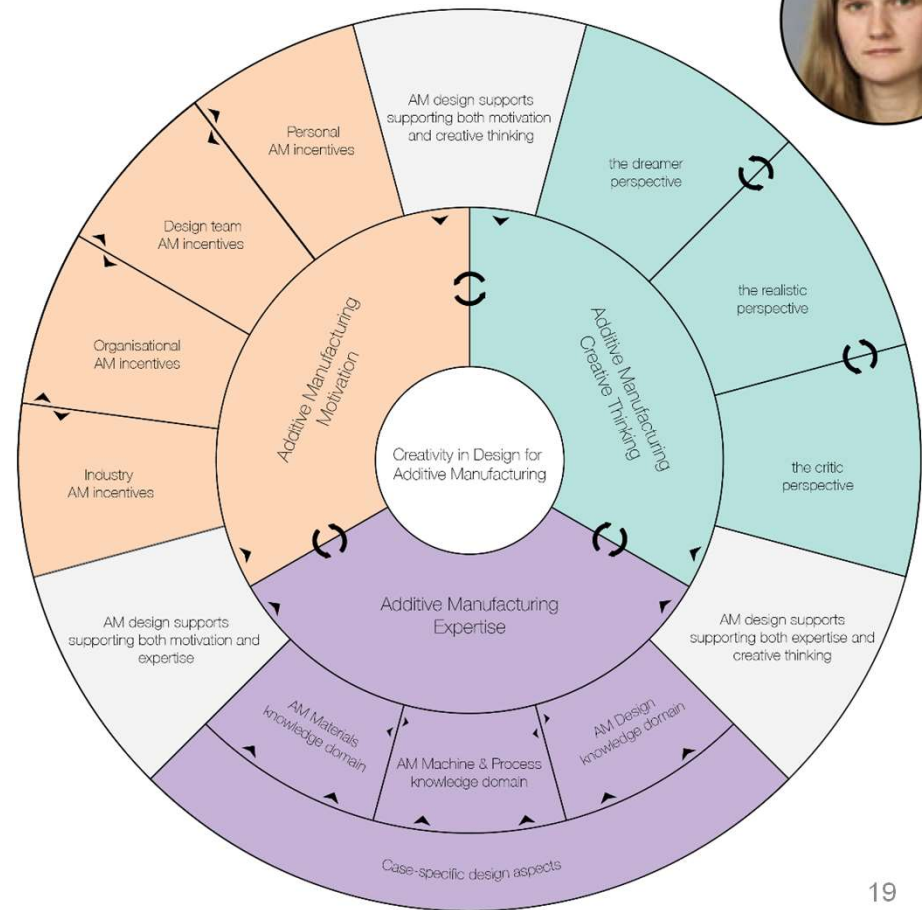
Picture from Ariane Group





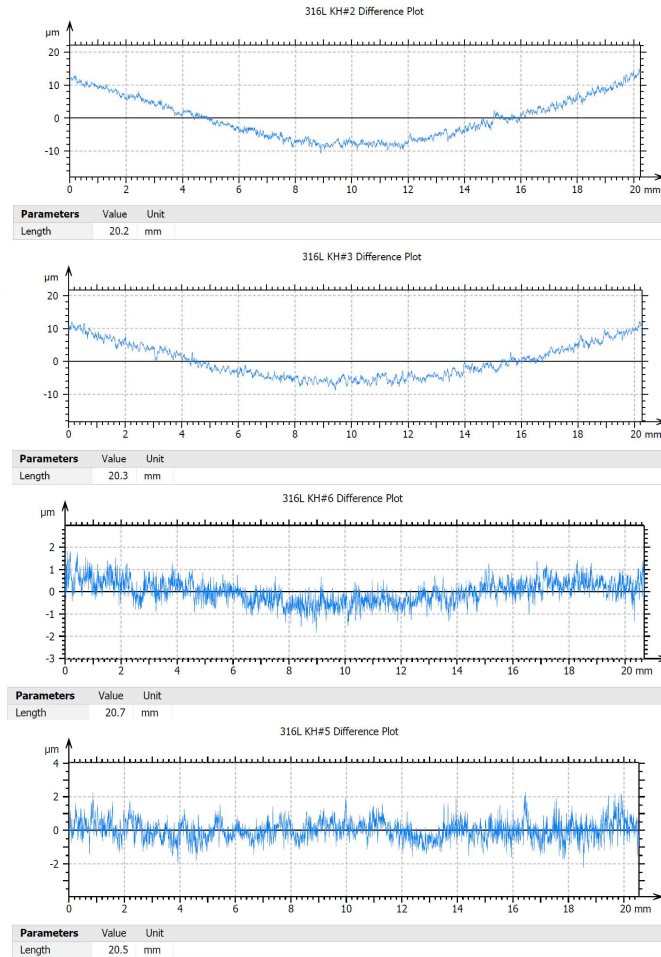
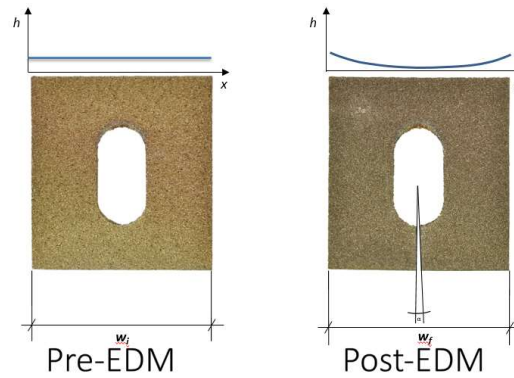
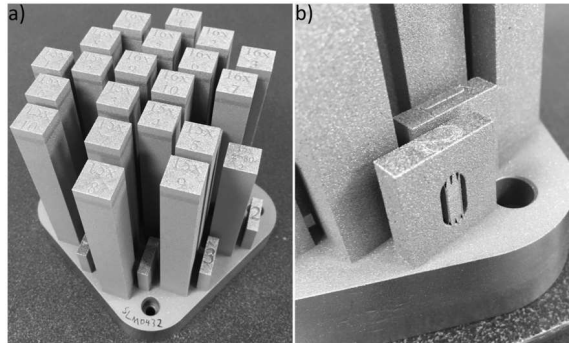
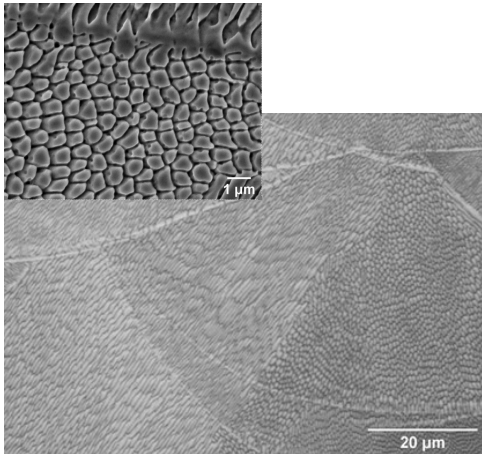
A Framework for Creativity in Design for Additive Manufacturing

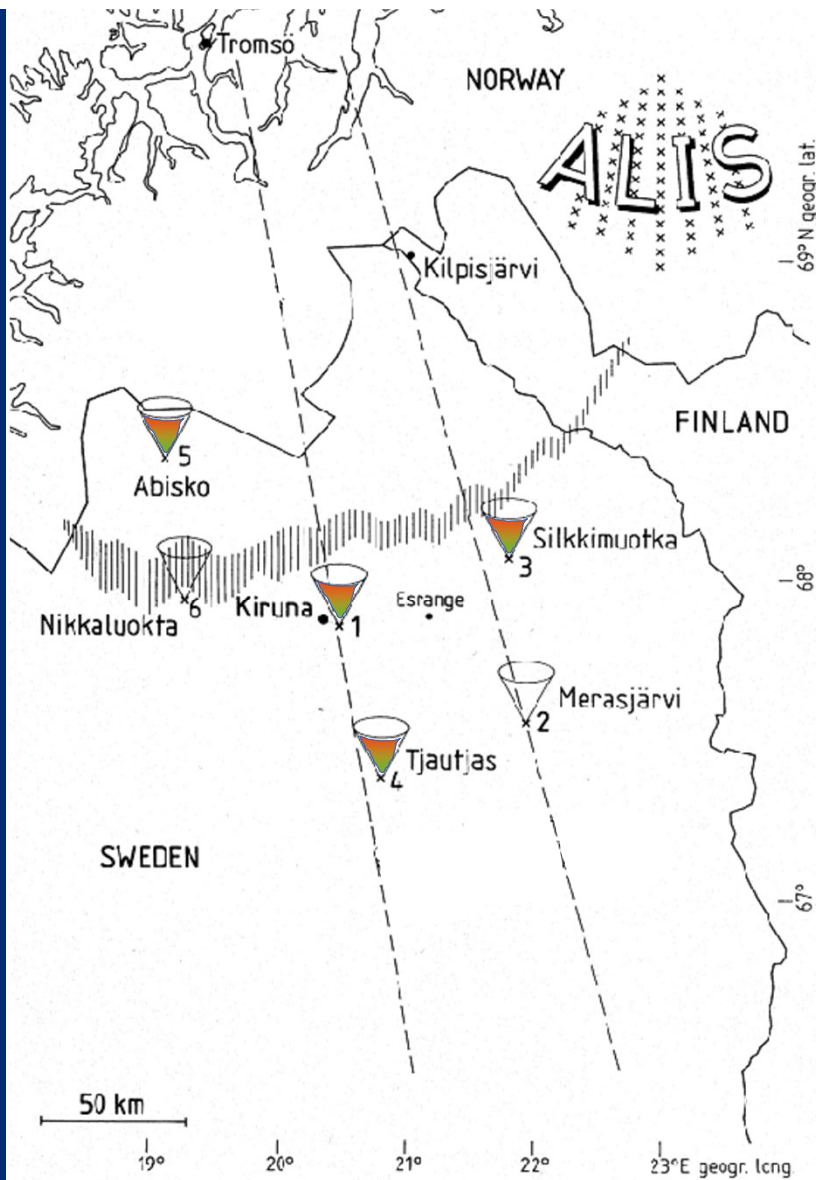
- A sneak peak of the framework presented in the thesis
- A "creativity wheel" for adopting AM in design
- Support engineers to make full use of their creative abilities while introducing AM in design



Stainless steels for rocket engines

- Extreme environment, from -196°C to $+750^{\circ}\text{C}$
- Laser and powder bed manufacturing (AM)
- 3 alloys, 316L, 21-6-9 and 316GAS
- Residual stresses from AM
- Industrially adapted method for measurements of residual stresses





TRACKING OF SPACE OBJECTS USING AURORAL IMAGES

IRF and SSC develop automated image analysis and space object orbit determination using ALIS_4D

- Project postdoc: Gabriel Borderes Motta
- SSC principal investigator: Hanna Sundberg
- IRF principal investigator: Johan Kero

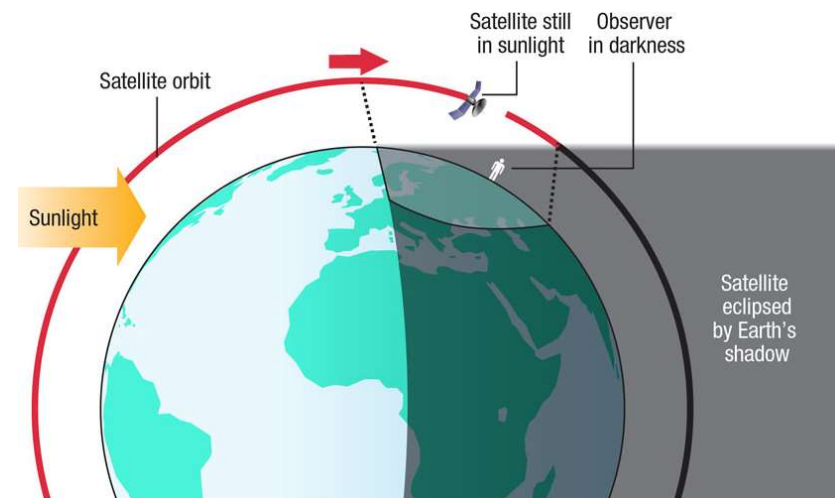
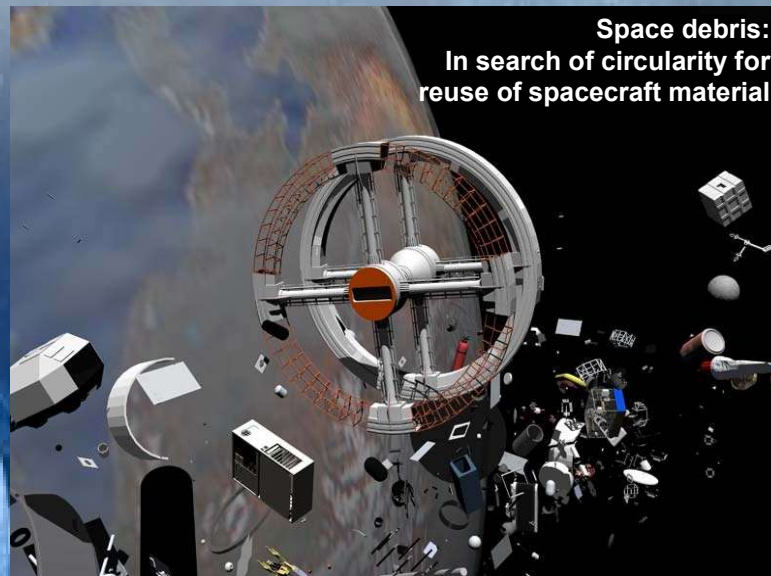


image credit: Gary Meader; from the book "Night Sky With The Naked Eye" by Bob King

Recycling at the highest level



Space debris:
In search of circularity for
reuse of spacecraft material



PhD candidates:
Margot Clauss, Space Systems
Bernd Weiss, Product Innovation

Supervisors:
René Laufer, *professor (chair) Space Systems*
Anna Öhrwall Rönnbäck, *professor (chair) Product Innovation*



**We help
Earth benefit
from space**

Innovation capabilities study – INNOCAP

William Johansson (SSC) & Lisa Larsson (LTU)

Karin Holmqvist (SSC) & Anna Öhrwall Rönnbäck (LTU)

Linda Lyckman (SSC) & Margareta Groth (LTU)





FUTURE

WHAT IS OUR NEXT STEP?

PhD level courses

Graduate School in Space Technology

- ✓ Product Innovation for Aerospace Applications: 7.5 HEC
 - ✓ Oct 2022 (initiated)

- ✓ Cross-disciplinary projects with Aerospace Application: 4–8 HEC
 - ✓ PhD Resource Pool
 - ✓ Spring 2023



SARC

Product Innovation for Aerospace Applications

Aeronautics Airplane

Space

7,5 credits
Start date: 4 October 2022
University: Linköping University,
Luleå University of Technology
Target group: PhD Student,
Industry
Academy: Product Development
Academy (PDA)

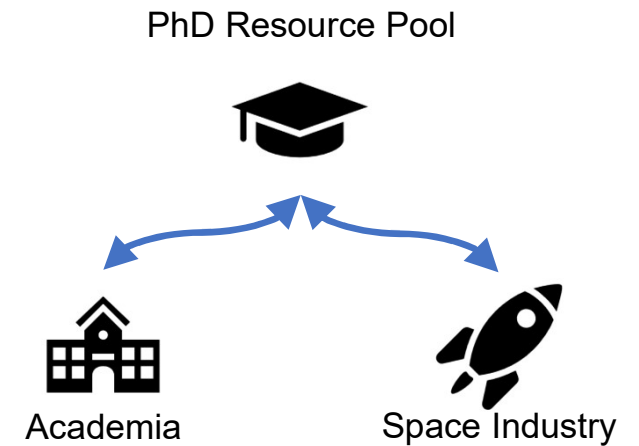
<https://kunskapsformedlingen.se/>

PhD Resource Pool




Collaborative innovation tool

✓ **Collaboration incentives for PhD candidates**

- ✓ Education: Cross-disciplinary projects
- ✓ Publications: Co-authorship matching
- ✓ Outreach: Academia industry network



Expected outcomes

		
<ul style="list-style-type: none"> ✓ PhD-tailored education ✓ Demonstrate skills ✓ Potential employer network 	<ul style="list-style-type: none"> ✓ Find needed competence ✓ Perform pre-studies ✓ Demo capabilities ✓ Outreach 	<ul style="list-style-type: none"> ✓ Find needed competence ✓ Perform pre-studies ✓ Screening of research potential



THANK YOU

SPACE

INNOVATION

GROWTH

COOPERATION