Impact for a better society

TU Delft wants to make a significant contribution to a sustainable society by

- conducting groundbreaking scientific **research**
- **education** and training scientists and engineers with a genuine commitment to society
- **translating** knowledge and know-how into technological innovations and activities with both economic and social value

Chiara (dr. Falsetti, assistant prof.)
Peter (dr. Lucas, business development manager energy)

Faculties

Mechanical, Maritime, Materials Engineering

Applied Sciences

Civil Engineering & Geosciences

Architecture and the built environment

Aerospace Engineering

Electrical Engineering, Mathematics, Computer Sciences

Industrial Design Engineering

Technology, Policy, Management

TU Delft

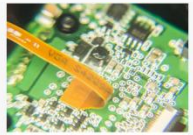
Delft Institutes for thematic collaboration

ONDERZOEKSINSTITUTEN
TU Delft | Bioengineering Institute

ONDERZOEKSINSTITUTEN
TU Delft | Climate Institute

ONDERZOEKSINSTITUTEN
TU Delft Institute for Computational Science and Engineering

ONDERZOEKSINSTITUTEN
TU Delft | Process Technology Institute

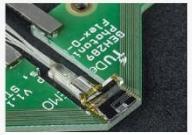


ONDERZOEKSINSTITUTEN
TU Delft | Robotics Institute

ONDERZOEKSINSTITUTEN
TU Delft | Safety & Security Institute

ONDERZOEKSINSTITUTEN
TU Delft | Wind Energy Institute

ONDERZOEKSINSTITUTEN
TU Delft | Design for Values Institute



ONDERZOEKSINSTITUTEN
TU Delft | Dutch Optics Centre

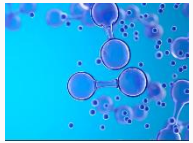
ONDERZOEKSINSTITUTEN
TU Delft | PowerWeb Institute

ONDERZOEKSINSTITUTEN
TU Delft | Space Institute

ONDERZOEKSINSTITUTEN
TU Delft Sport Engineering Institute

ONDERZOEKSINSTITUTEN
TU Delft | Transport Institute

ONDERZOEKSINSTITUTEN
TU Delft | Engineering in agri food

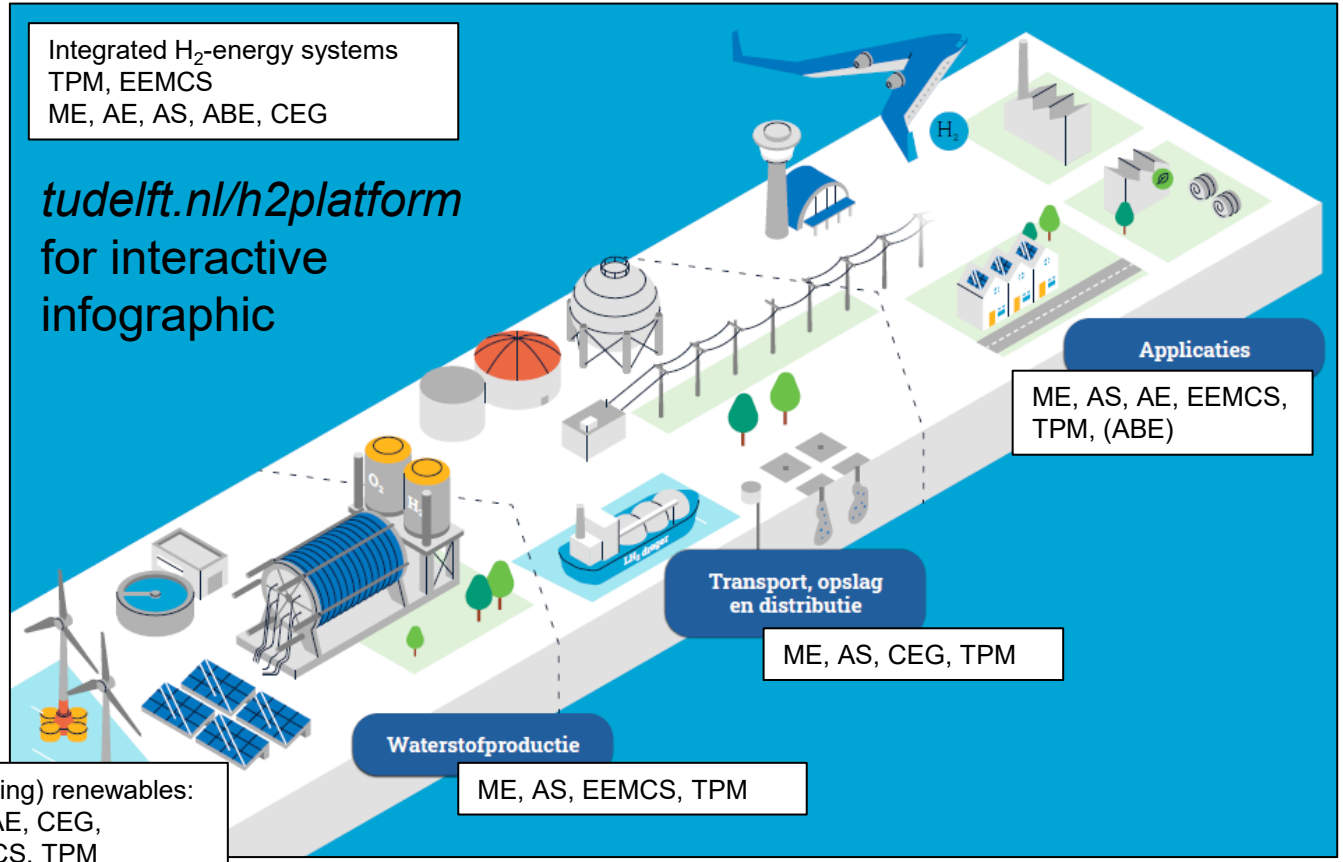


ONDERZOEKSINSTITUTEN
Hydrogen platform

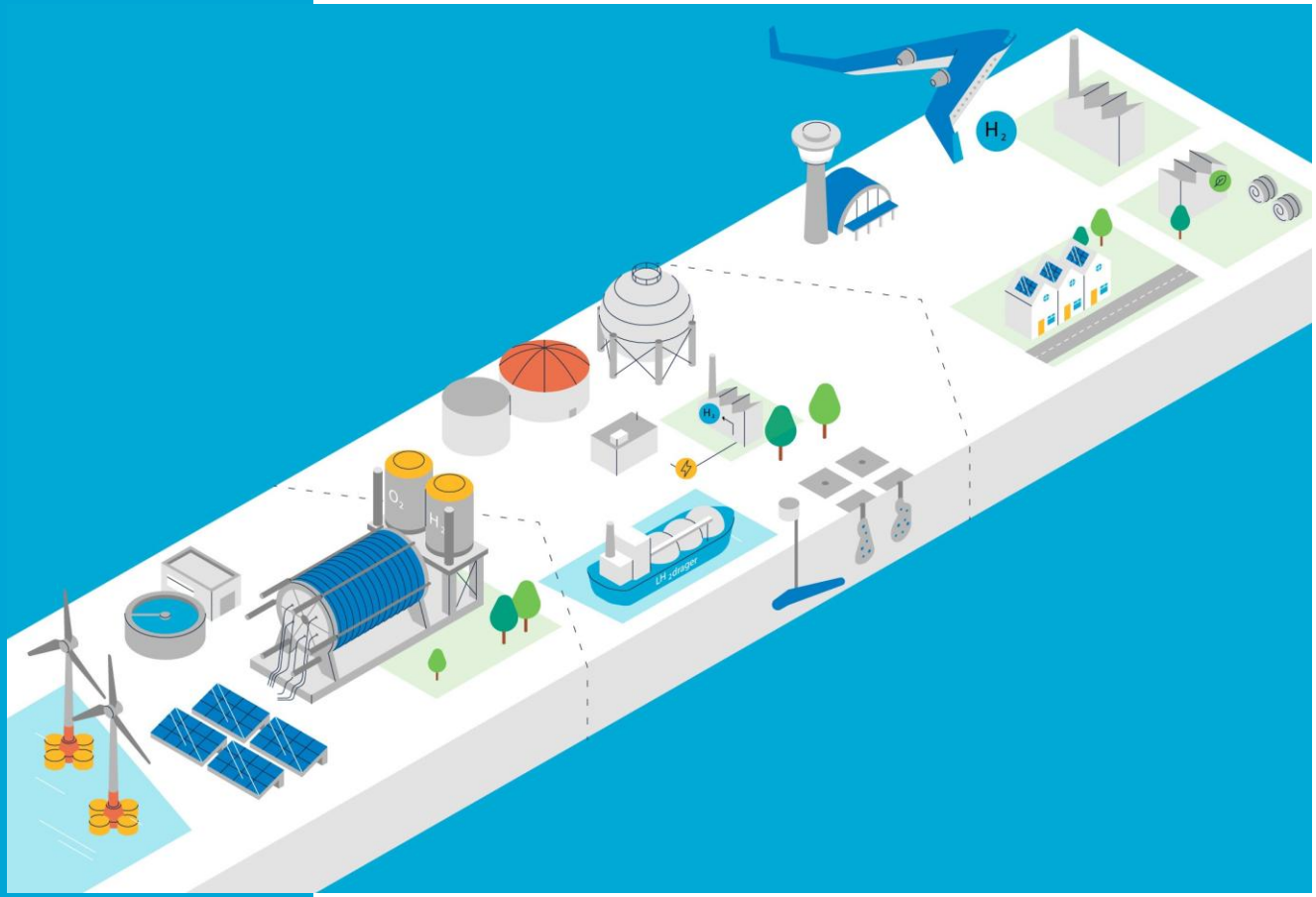
TU Delft

The Hydrogen chain at TU Delft

CEG: Civil Engineering and Geosciences
EEMCS: Electrical Engineering, Mathematics & Computer Science
AE: Aerospace Engineering
TPM: Technology, Policy and Management
AS: Applied Sciences
ME: Mechanical, Engineering
ABE: Architecture and the Built Environment



Liquid hydrogen at TU Delft

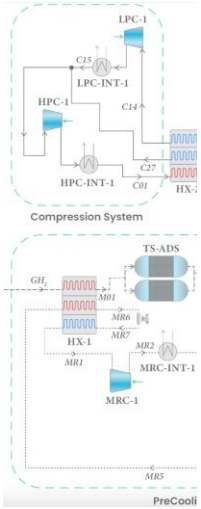


- Liquefaction, transport and distribution/ refueling
- Structures and materials for onboard storage
- Application in shipping and aviation

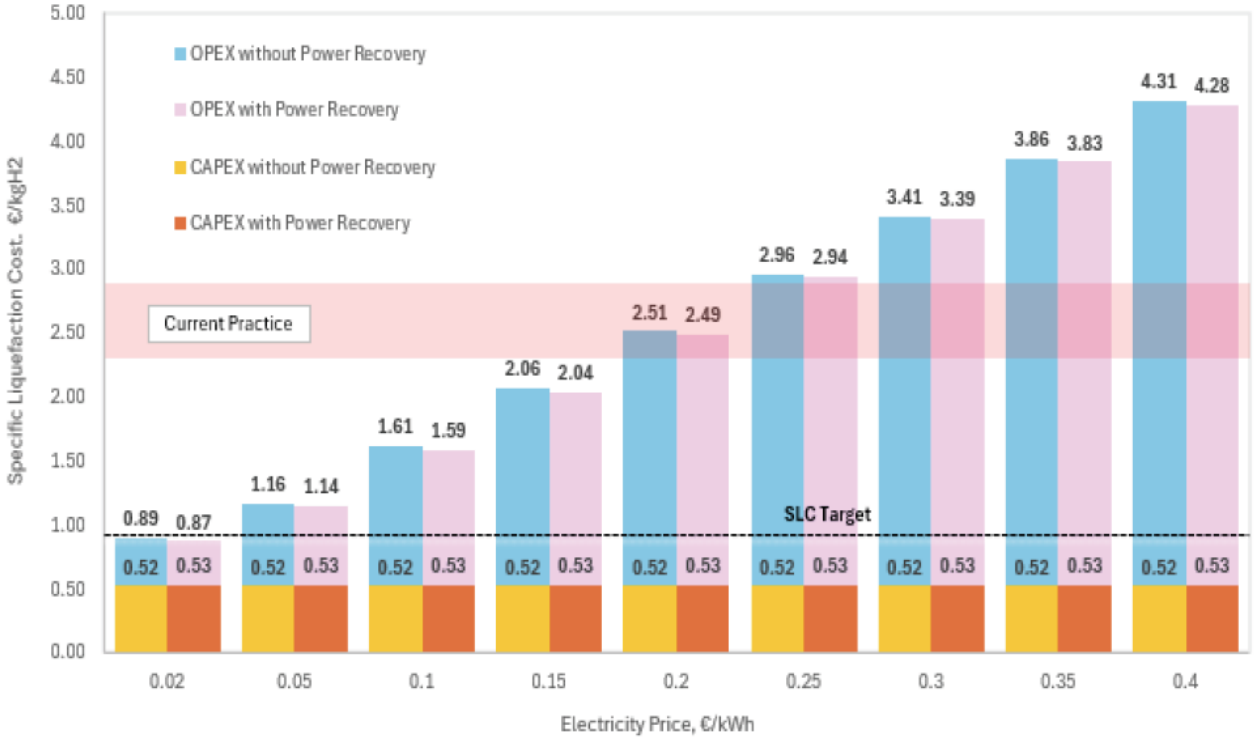
- Safety/ detection
- Fundamentals

Mahinder (dr. Ramdin, assistant prof.) Process design and economics of advanced refrigeration cycles for H_2 liquefaction

Liquefaction



Claude Cycle



Brayton Cycle

Bendiks Jan (prof.dr. Boersma), depart. chair MTT, scientific director H2 Platform

Alexei (dr. Sharpans'kykh assistant prof.) AI application to air transport operations

Pieter-Jan (dr. Proesmans assistant prof.) Operations & Environment

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LH2 transport, distribution and refueling

- Demonstrating liquid hydrogen refuelling technologies
- Demonstrating small-scale liquid hydrogen aircraft ground operations
- Standardisation and certification framework of future liquid hydrogen operations
- Economics of hydrogen value chains for airports

research.airbus.com/en/products-systems/goliat

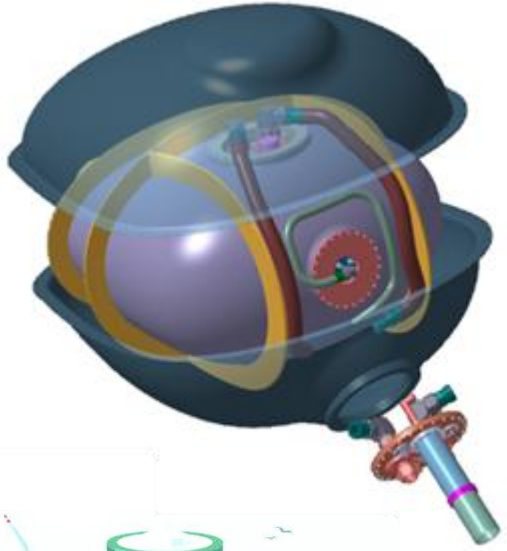
John-Alan (dr. Pascoe, associate prof.)
Certification of novel aerospace structures

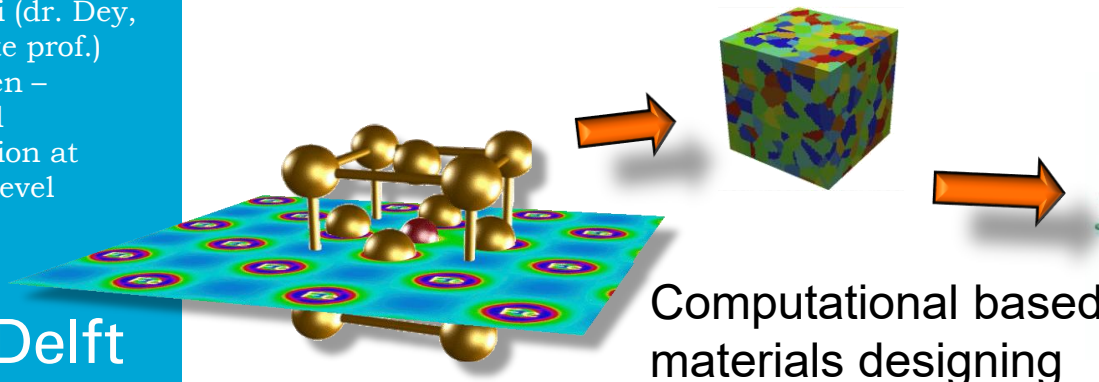
Poulumi (dr. Dey, associate prof.)
Hydrogen – material interaction at atomic level

On-board storage - structures and materials

cocolih2t.eu

- Safe composite and vacuum insulated conformal LH_2 tank
- Reduction 60% in production energy and 50% in manufacturing time
- Facilitate aircraft structural integration
- Demonstrated TRL4 at end of project

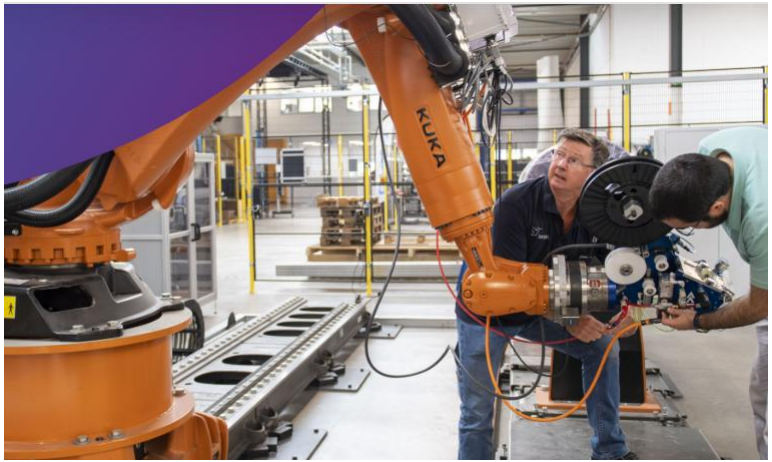




Computational based materials designing

Bram (dr. Jongbloed) Manufacturing & automation engineering lead at SAM-XL

On-board storage - structures



- Lightweight thermoplastic composite LH2 tank
- Develop knowledge and technology composite materials, design and manufacturing processes

samxl.tudelftcampus.nl/projects/lh2-tank

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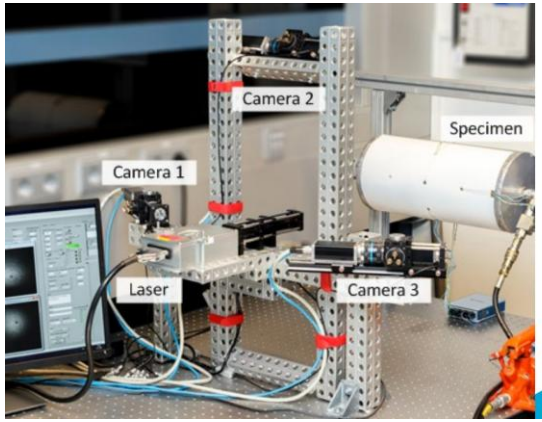
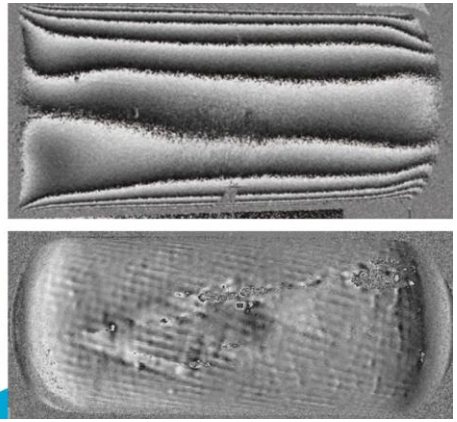
On-board storage – integrity and cryo-compressed

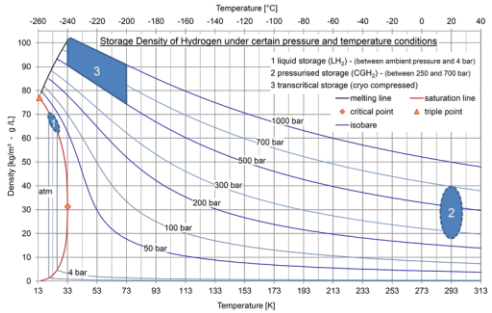
Nan (dr. Yue, assistant prof.)
Structural Health Monitoring

Julien (dr. Van Campen, assistant prof.)
Composite vessels for hydrogen storage

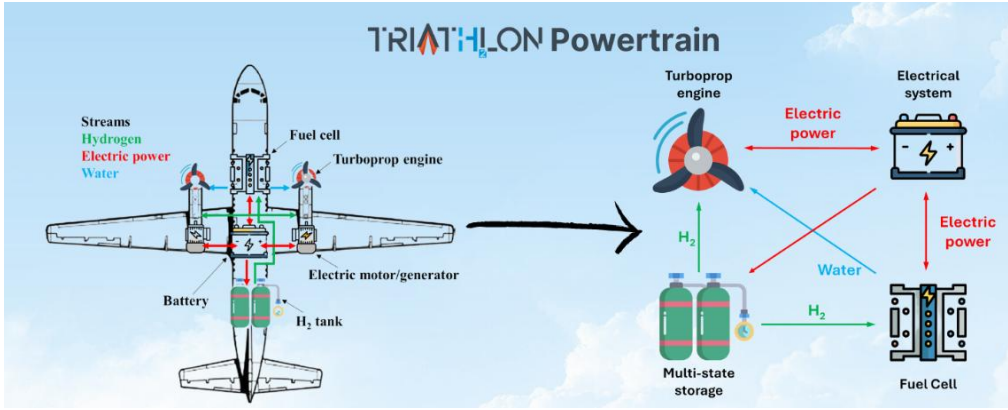




Non-destructive inspection:
Micro-crack sensing thru ultrasound, shearography,



triathlon-project.eu



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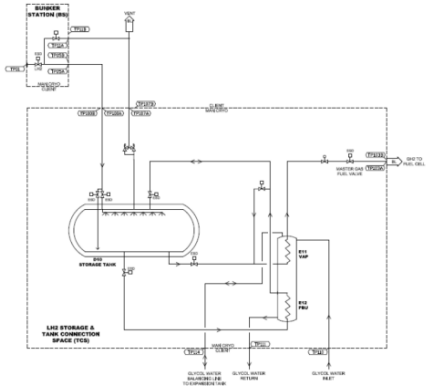
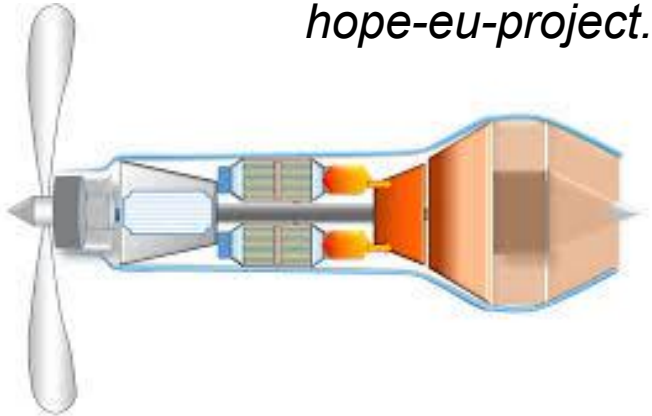
Lindert (dr. Van Biert, associate prof.)
Novel drive and energy systems based on fuel cells

Arvind (prof. dr. Rao)
Sustainable aircraft propulsion

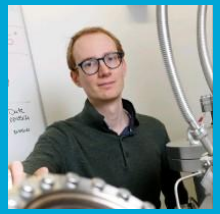
Shipping and aviation – LH2 as a fuel



research.airbus.com/en/products-systems/hylenash2ipdrive.com
hope-eu-project.eu



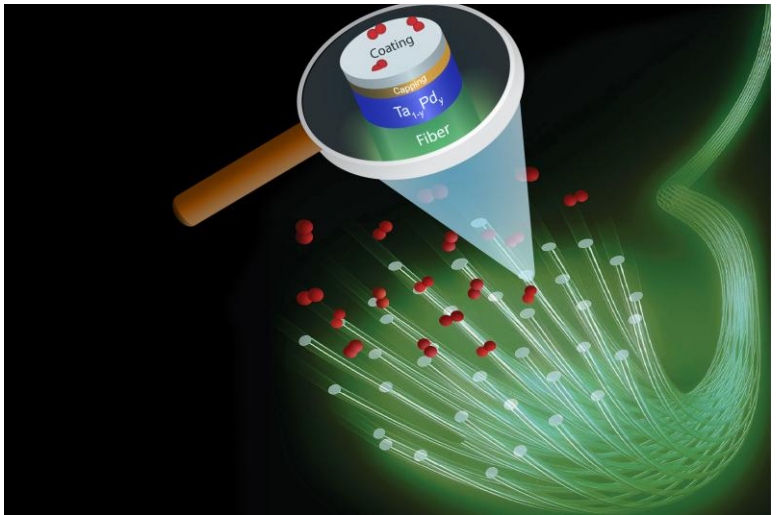
Quantative risk assessment LH2 and CH2 for inland shipping



Lars (dr. Bannenberg, associate prof.) Hydrogen sensors and other applications of thin film metal hydrides

Safety and detection

- Hydrogen sensors based on thin film metal hydrides
- Working principle: optical properties change when metal hydrides partly hydrogenate
- Inherently safe, small, inexpensive.



hydrogensensing.nl

TU Delft

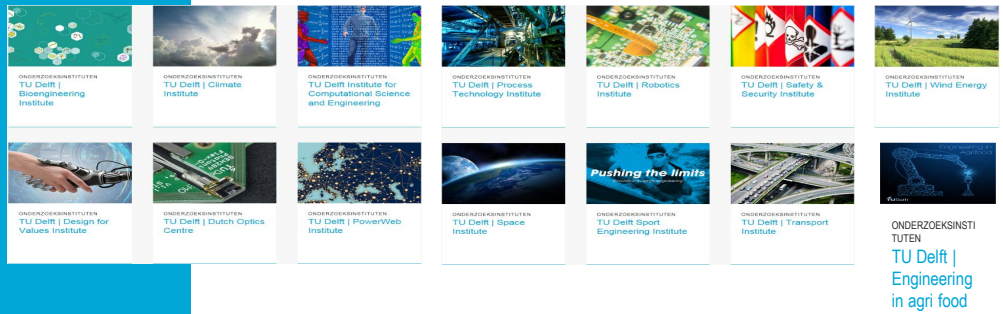
AeroDelft and HydroMotion

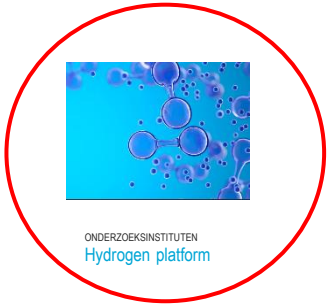
aerodelft.nl

hydromotionteam.nl

TU Delft

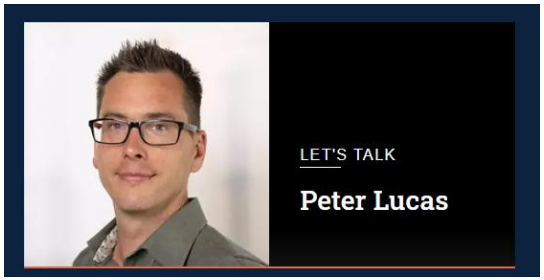
Collaboration – get in touch





H2 Platform

tudelft.nl/h2platform



Business collaboration

tudelft.nl/en/innovation-impact/business-collaboration

Clean Tech Event March 17
Liquid Hydrogen meet up January 30

March 17

- Inspiring talks
  - Keynote IEA
  - Breakouts H2, Green Chemistry, H2-integrated energy system
- Interactive collaboration sessions on project and start-up development
- Networking with researchers, industry experts, policy makers and many more

January 30

- LH2 meet-up Friday

aanmelder.nl/cleantech

Understanding hydrogen two-phase flow

On-going projects: *COOLPIPE (LIT RVO)* and THRIVE *(NOW VIDI)*

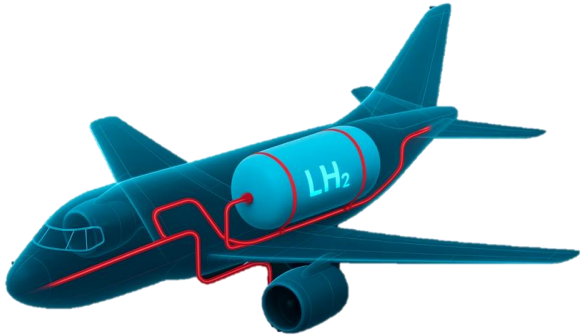
Dr. Chiara Falsetti,
Faculty of Aerospace Engineering, TU Delft

TU Delft

Coolpipe & THRIVE

Source: NASA

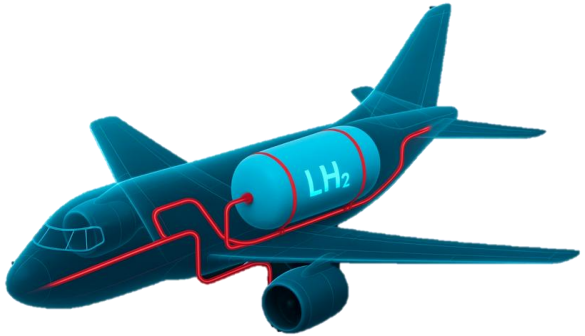
Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!



Coolpipe & THRIVE

Source: NASA

Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!



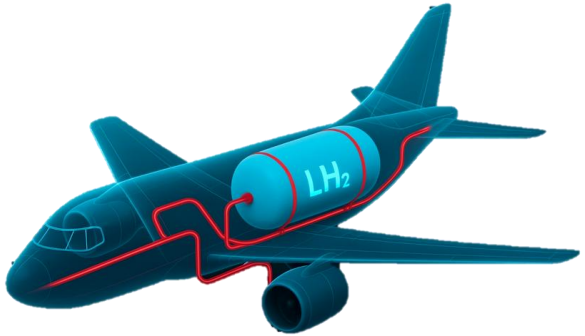
What we know NOW - Rockets:

- Hydrogen at cryogenic T
- Extreme $\Delta T \rightarrow$ Chaotic Two-phase flow

Coolpipe & THRIVE

Source: NASA

Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!



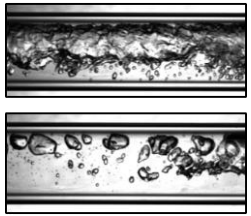
What we don't - Aviation & Maritime:

- Very different operating conditions
- How does hydrogen reach the engine?

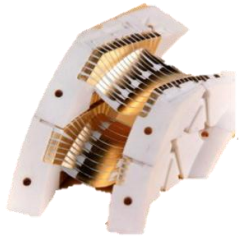
Coolpipe & THRIVE

Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!

Overall Objectives:



1. Understanding physics of cryogenic phase-change under transient/dynamic conditions

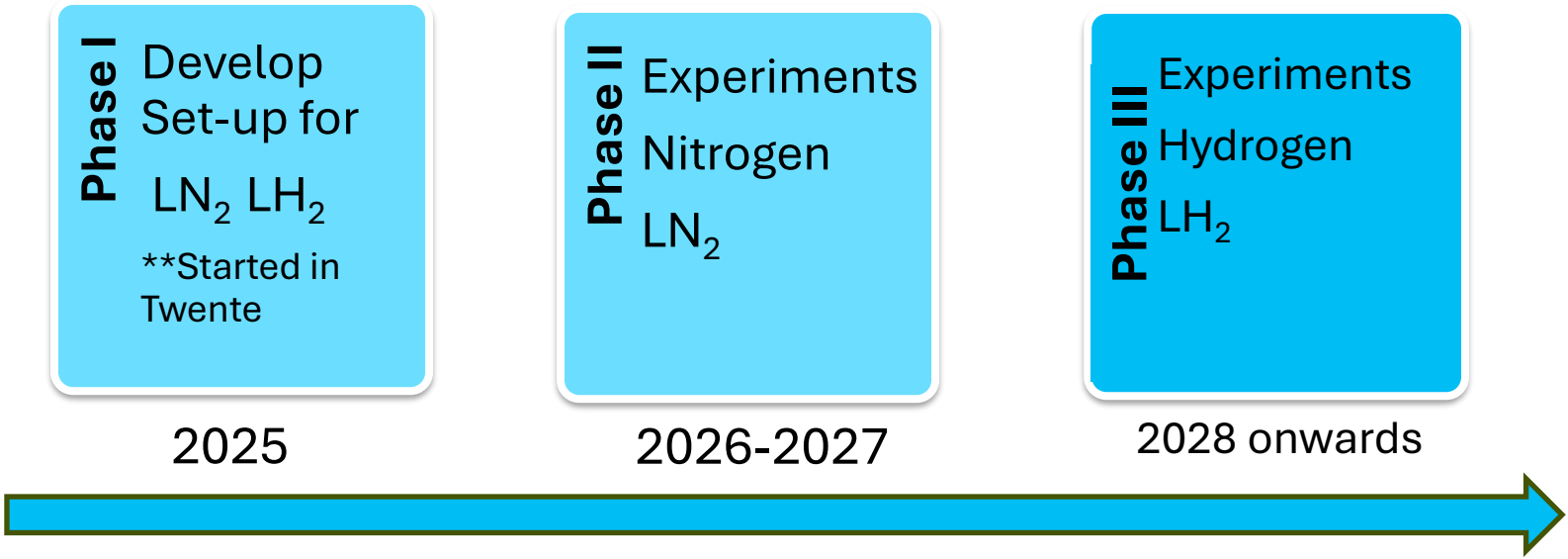


2. Developing advanced diagnostics to study cryogenics two-phase flow and heat transfer

Coolpipe & THRIVE

Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!

Timeline:



Coolpipe & THRIVE

Problem:Hydrogen stored in liquid state (LH_2) ~$-250℃$ → evaporate!

Project partners: