

# Safe, Secure & Reliable with Hydrogen

Davide Mores – LH2-Kenniscommunity – 02-2026



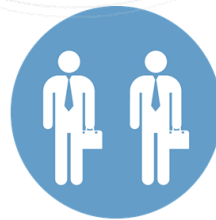
# TNO IN A NUTSHELL

**TNO CONNECTS PEOPLE AND KNOWLEDGE TO CREATE INNOVATIONS THAT BOOST THE COMPETITIVE STRENGTH OF INDUSTRY AND THE WELL-BEING OF SOCIETY IN A SUSTAINABLE WAY.**

- **INDEPENDENT RTO**
- **SINCE 1932**
- **MULTIDISCIPLINARY**
- **~ 550 MEUR/YR**
- **~ 4500 FTE**



TNO AS CATALYST IN PUBLIC-PRIVATE PARTNERSHIPS



TNO AS EXECUTOR OF CONTRACT RESEARCH FOR CUSTOMERS

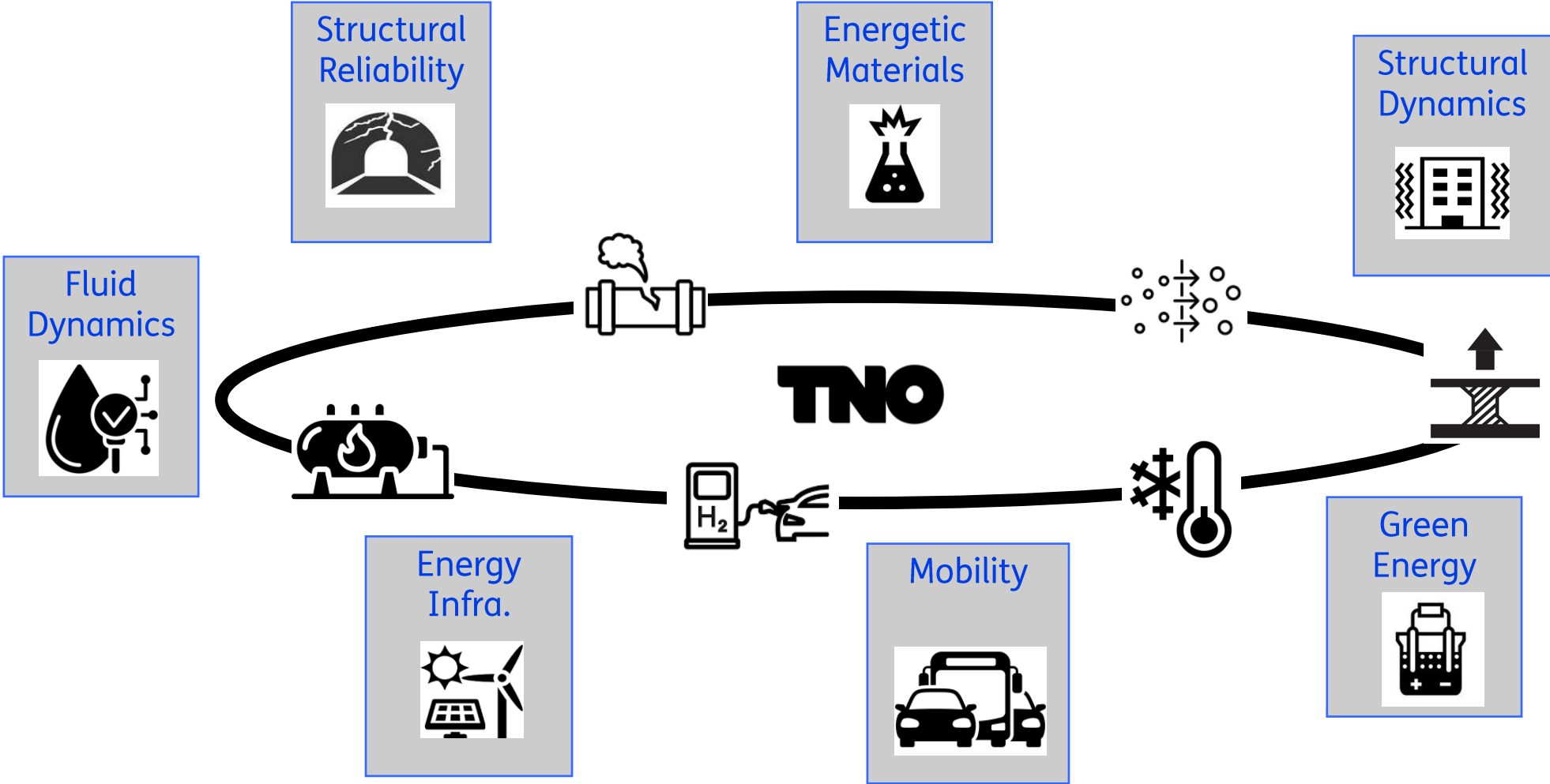


TNO AS EXECUTOR OF ASSIGNED TASKS



# MULTIDISCIPLINARY APPROACH

Complementary Expertise & Capabilities are our value add



# TNO Hydrogen fields of work

- Hydrogen Production *electrolysis , offshore wind , critical raw materials ...*
- Hydrogen Infrastructure *integration energy systems , sensors , underground storage ...*
- Hydrogen Usage *ICE , synthetic fuels ...*
- Enabling Expertise *safety testing , MW test centre , Field lab ...*



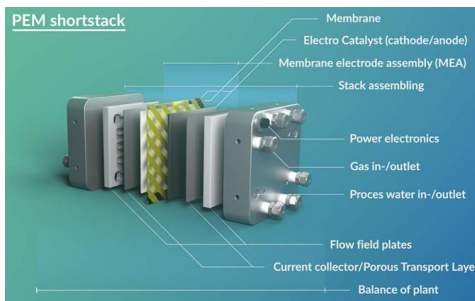
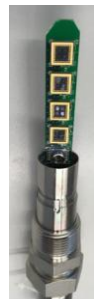
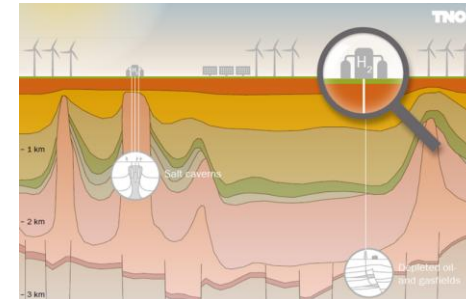
**Innovation Across the Chain**  
 Green & blue hydrogen production  
 Offshore hydrogen infrastructure  
 Storage, transport & system integration

**Mobility Solutions**  
 Fuel cell systems for heavy-duty transport  
 Hydrogen combustion engines  
 Mobile refueling stations & test sites

**Industrial Applications**  
 Power2Heat, Power2Fuels, Power2Chemicals  
 Hydrogen as feedstock for chemicals & refining

**Flagship Projects**  
 HyPRO: Cutting costs with 50+ partners  
 Faraday Lab: Scaling up electrolysis  
 Hydrohub: MegaWatt Test Centre

**Policy & Market Insights**  
 Feasibility studies & energy system modeling  
 Breakthroughs in electrolyser efficiency  
 Strategic foresight on hydrogen trade routes



# TNO Hydrogen Safety Testing

Historical perspective (overview is not exhaustive)

WATERSTOF ALS ENERGIEDRAGER

OVERGANG DEFLAGRATIE IN DETONATIE  
IN BUISLEIDINGEN

(TNO PML, 1974)

Simulatie van de ontsteking van een mengsel van waterstof en zuurstof.

(TNO PML, 1983)

**Bepaling van de invloed op de minimale ontstekingsenergie door toevoegen van waterstof aan aardgas**

(TNO PML, 2002)

Explosie veiligheidsstudie stolpgloeien met waterstof

(TNO PML, 2010)

**Conventionele trekproeven en breukmechanisch onderzoek aan oppervlaktescheuren in het kader van het waterstofverbrossingsonderzoek**

(TNO Ind, 1999)

**Externe Veiligheid  
Waterstoftankstation Arnhem**

(TNO ML, 2009)

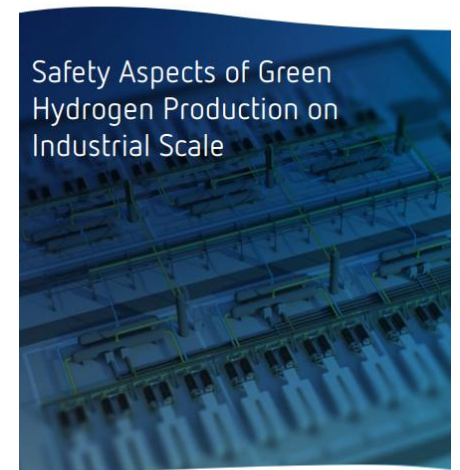
**Tunnel safety and Quantitative Risk Analysis of gas explosions**

(TNO PML, 2016)

**Behoeftte aan infrastructuur voor alternatieve energiedragers voor mobiliteit in Nederland**

(TNO TT, 2019)

Public report



(TNO DSS, 2023)

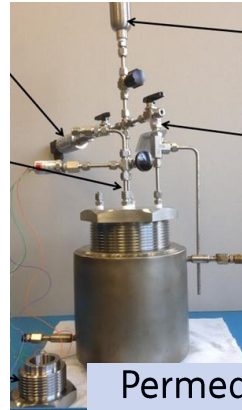
# TNO Hydrogen Safety Testing

## H2 Testing Facilities & Expertise

### Material Safety Testing



Liquid Hydrogen  
Experimental Facility



Permeability Testing  
(e.g. hydrogen)



Tensile/Fatigue Testing

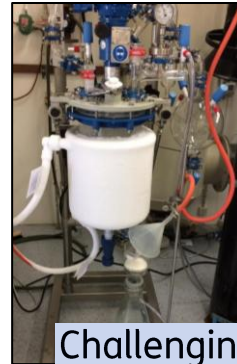


Cryogenic Testing

### Dangerous Chemistry Testing



Testing with explosive &  
toxicity risks



Challenging Synthesis  
(e.g.  $\text{AlH}_3$ )



Gas Explosion  
Testing Facility

# Liquid Hydrogen Infrastructure

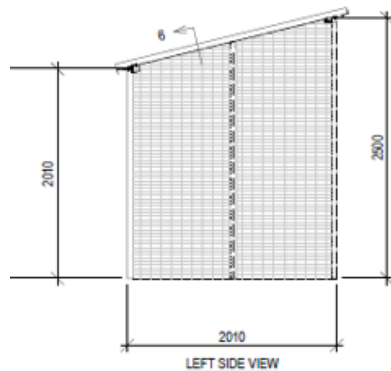
From concept to realisation

Concept start ~2019

Permit ~ 3 year

First Fill ~ 2024

- Goal: enable entities to test anything in or with LH2
- Liquid hydrogen infrastructure based on:
  - Replenishment from a tanker truck via a filling point
  - LH2 stored in Dewar (125 L ~ 10 Kg) and withdrawal LH2 for test
  - Dedicated vent stack to release hydrogen in atmosphere (boil-off, 8 meters above ground level)
  - Sheltered, naturally ventilated enclosure to protect against rain, wind, sunlight ...
  - and PGS35 permit ... a concrete floor etc.
- Research in a small-scale test setup.
  - In case of more LH2 need, a coupling for a cryocooler (to produce 3 kg LH2 pd) is reserved.



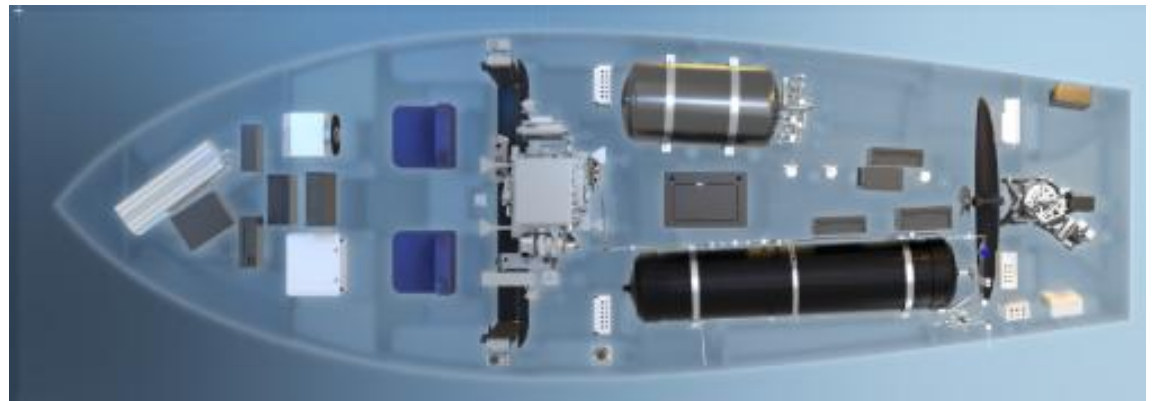
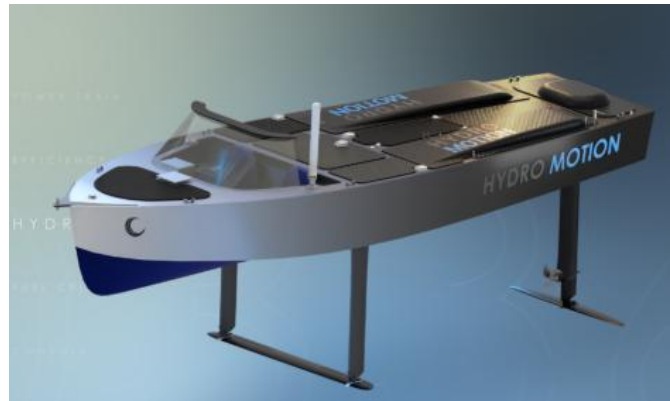
# Project – AeroDelft

- AeroDelft is a TU Delft student team, intending to have a small plane ('Phoenix') powered by liquid hydrogen
- A demo model of the liquid hydrogen propulsion system needed to be validated.
- $\text{LH}_2 \rightarrow \text{GH}_2 \rightarrow \text{electricity} \rightarrow \text{rotate propellor}$
- Successful demonstration and with that the first student team in the world to have achieved this.



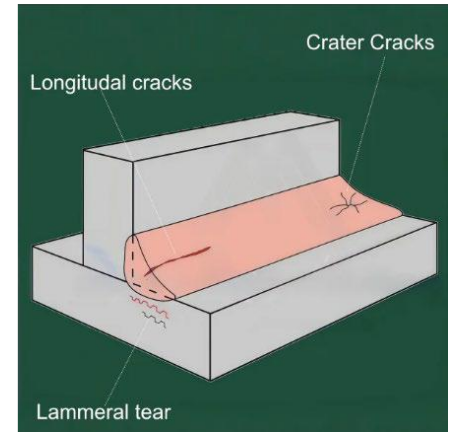
# Project – HydroMotion

- HydroMotion is a TU Delft student team, intending to become the first foiling boat powered by liquid hydrogen to participate in the Monaco Energy Boat Challenge.
- Major innovation is the design & integration of a liquid hydrogen storage system.
- TNO assists with validation and testing of storage tank plus power-train.



# Project – Others

- **SH2IPDRIVE**
  - EU project
  - assessment on potential of crack propagation in especially welds due to exposure to LH2
  - Thermal / chemical effect
- **INDY** (Energy Independent and Efficient Deployable Military Camps)
  - EDF project
  - desk study that benefited from LH2 (safety and permit) knowledge
- **CALIPSO**
  - EDF project
  - focus on reducing emissions and supporting the EU sustainability goals in land and maritime defense applications.



# Hydrogen Testing

## Future potentials

- › Liquid Hydrogen safety:
  - New systems, materials, processes & applications
  - Spills , Rapid Phase Transition , ...
  - Cryo-compressed
  
- › General Hydrogen (Explosion) safety:
  - Ignition probability , Influence of impurity , Domino-effects , Dispersion characteristics & safety distances
  
- › General Hydrogen (Material) safety
  - Compatibility , Fast pressure cycling testing , Tensile/fatigue/fracture testing

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# THANK YOU FOR YOUR ATTENTION

## Point of Contact:

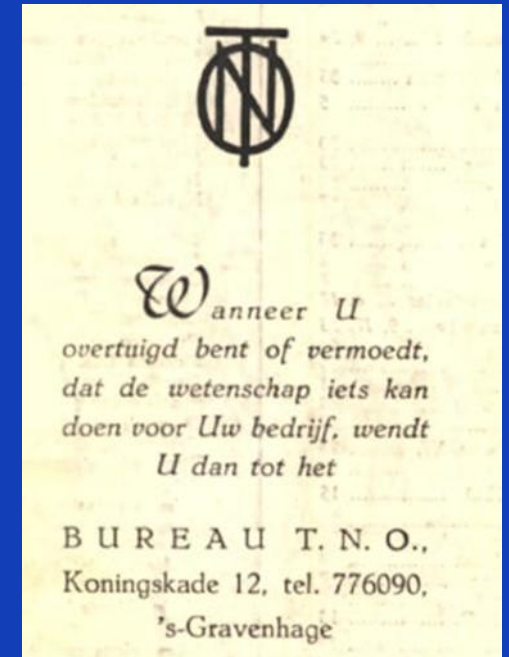
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[www.tno.nl/prosafe](http://www.tno.nl/prosafe)



## Testing in Practice – Considerations

- Purpose & clear research question
  - reason for practical assessment (5x why)
  - what do you want to achieve (SMART)
- Status and boundary conditions
  - what is already known & what is unknown
  - involve team with complementary expertise and experience
- Initial approach (high level)
  - Phased build-up (must have vs nice to have..)
  - Location (Indoor vs Outdoor, Permits & Logistics, SHEQ & EVD..)
  - Budget & Risks (ROM)
  - Envisioned outcome achievable? (SMART)
- Proceed with detailed approach
  - use of experienced partners (devil is in the details)
  - continuous & thorough evaluations with project team
  - robust with room for adjustment and delays
- Project & Test execution (safely etc.)