



ELVHYS project overview

5th ELVHYS Stakeholders' Workshop

Federico Ustolin

05.06.2025



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Towards RCS for cryogenic and LH2 transferring operations and facilities



Programme	
Time (CEST)	Presentation title
09:00-09:05	Welcome (F. Ustolin, NTNU; A. Friedrich & E. Torres de Ritter, KIT)
09:05-09:30	ELVHYS project overview (F. Ustolin, NTNU)
09:30-09:55	KIT-ITEP activities towards RCS - Standardisation roadmap for LH2 (H. Neumann, KIT)
09:55-10:20	Australian standards on storage and handling of hydrogen, and future directions (P. Medwell, University of Adelaide)
10:20-10:40	Coffee break
10:40-11:05	Advancements of the ISO TC197/SC1/WG2 “Aerial vehicle liquid hydrogen fuel storage system” (Y.N. Choi, KAERI)
11:05-11:30	IEA Task 43 activities on “Safety and RCS of large-scale hydrogen energy applications” (E. Vyazmina, AL)
11:30-11:55	Supporting the European H2 industries via standardisation (CEN/CENELEC CoG H2) (H. Tlatlik, IMS, S. Jenkel, DIN)
11:55-13:00	Lunch break
13:00-13:25	Revision of basic considerations for the safety of hydrogen systems within ISO/TC 197/WG 29 (N. Hart, ITM Power)
13:25-14:15	From PRESLHY to ELVHYS and beyond... (M. Kuznetsov, KIT; D. Houssin, AL; F. Ustolin, NTNU)
14:15-14:35	Coffee break
14:35-15:00	DLR activities within the national standardisation roadmap for hydrogen technologies (B. Linseisen, DLR)
15:00-15:25	Scientific justification for separation distances in NFPA 2 Hydrogen Technologies Code (E. Hecht, SNL)
15:25-15:50	Final round table discussion (F. Ustolin, NTNU; All)
15:50-16:00	Closure of the workshop (F. Ustolin, NTNU; A. Friedrich & E. Torres de Ritter, KIT, D. Cirrone, UU)



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Progress / Closed gaps

Fundamental/Modelling “Release”:

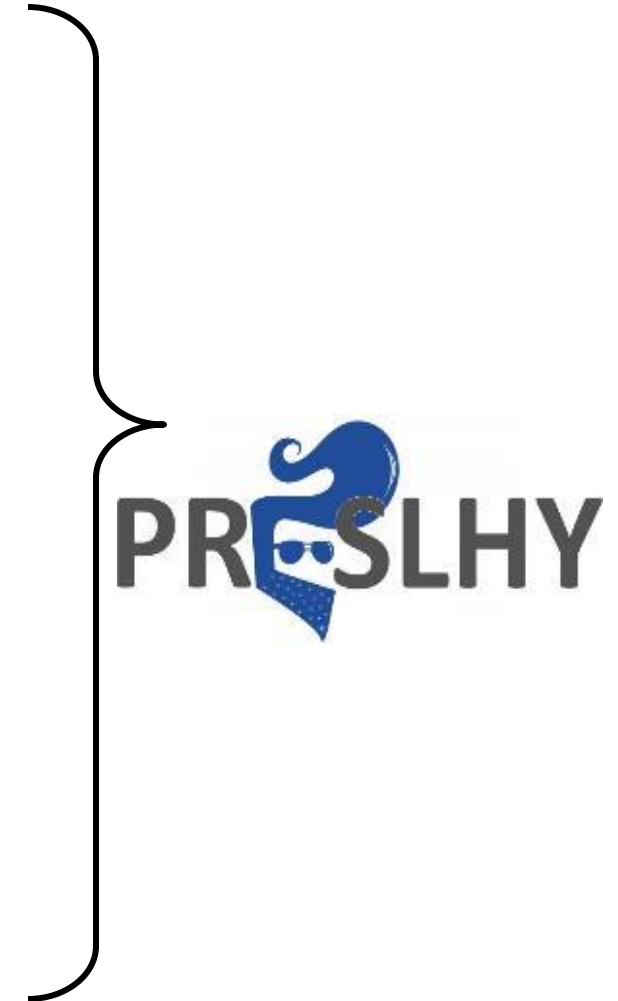
- ✓ Discharge coefficients for cryo- and cryocompressed releases
- ✓ Rainout phenomena better understood
- ✓ Fundamental data for mixing of large scale releases

Fundamental/Modelling “Ignition”:

- ✓ MIE and hot surface T determined for cryogenic conditions
- ✓ Empirical tests for RPT without fast reaction
- ✓ Electrostatics of cryogenic releases
- ✓ Worst case effects for small cryogenic inventories determined via variation of ignition time and position

Fundamental/Modelling “Combustion”:

- ✓ Flame length correlations validated
- ✓ σ , σ_{crit} and run-up distance for DDT determined at cryogenic conditions
- ✓ ...



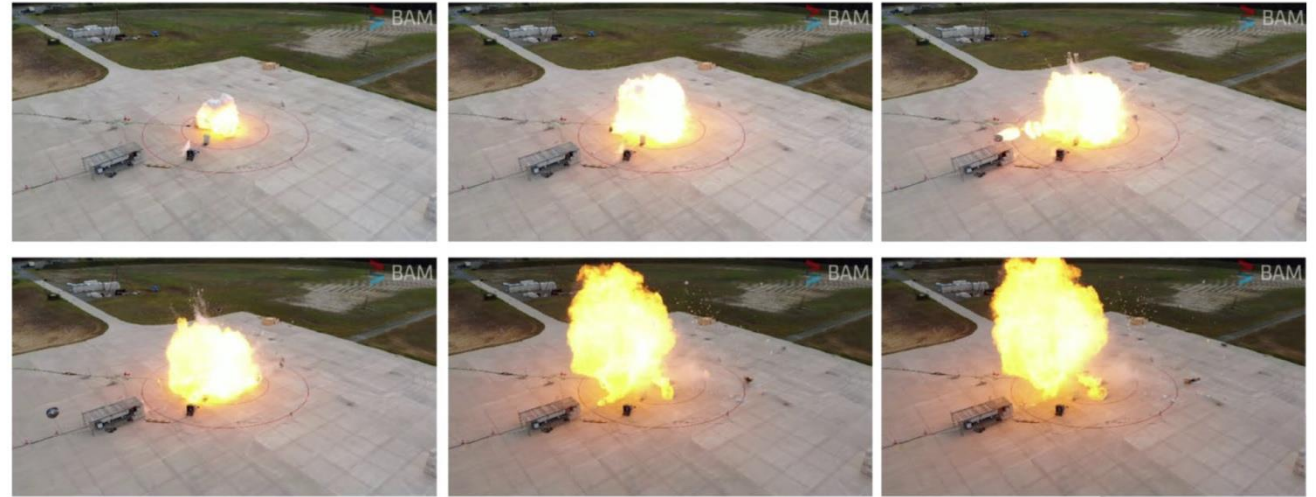
SH2IFT Project Findings



Fundamental/Modelling “BLEVE”:

- ✓ Experiments performed and BLEVE observed at BAM

(see van Wingerden, Kees, et al.
Chemical Engineering Transactions,
2022, 90. Jg., S. 547-552)



Fundamental/Modelling “RPT”:

- ✓ RPT observed in BAM tests spilling LH2 on water

(see van Wingerden, Kees, et al.
"Experimental Investigation into
the Consequences of Release
of Liquefied Hydrogen onto and under Water." (2022))



ELVHYS



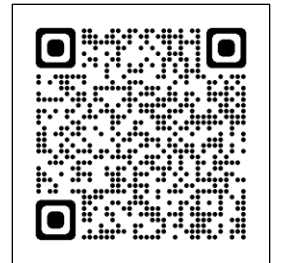
Enhancing safety of liquid and vaporised hydrogen transfer technologies in public areas for mobile applications

Funding: 2.0 M€

Duration: 2023-2026

Coordinator: NTNU

Partners:



Project
website

Objective: provide indications on inherently safer and efficient cryogenic hydrogen technologies and protocols in mobile applications by proposing innovative safety strategies including selection of effective safety barriers and hazard zoning strategies, which are the results of a detailed risk analysis.

NTNU role: coordinator, consequence analysis, risk analysis

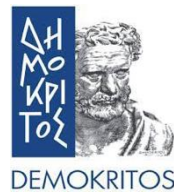


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Expected outcomes & objectives

1. Detailed **risk analysis** for LH2 transferring operations for mobile applications (ships, trucks, stationary tanks) fillings
2. **Generic hazard distances** for LH2 transferring operations in the different applications, also addressing **Simultaneous Operations**
3. **Guidelines for design** of LH2 transferring facilities
4. **Consensual loading procedures** for LH2 transferring operations
5. Provide inputs for developing **Standards, Technical Specifications, or Technical Reports** at the international level

ELVHYS – Consortium



ELVHYS – Stakeholder Advisory Board

- At the moment **33 organizations** are included in the SAB
- The organizations are based in **8 European** (Belgium, France, Germany, Italy, Norway, Sweden, The Netherlands, UK) and **4 non-European countries** (Canada, China, Japan, South Korea, USA)
- Type of organizations: industries and companies (10), research centres (5), universities (11), national public institutes (3), association (HySafe), intergovernmental org. (IEA), industry org. (Hydrogen Council), rail operator (SNCF)

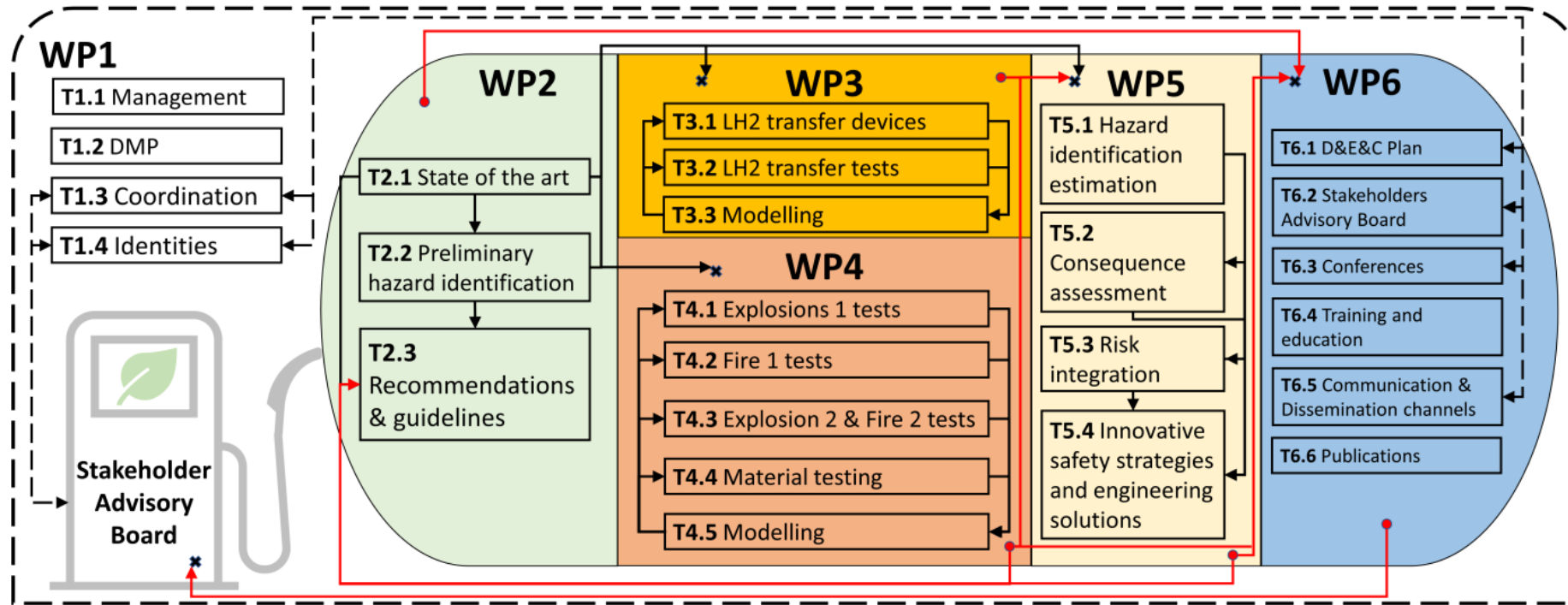
ELVHYS – Collaboration with other projects



Collaborations with other projects related to LH2 and cryogenic hydrogen transfer and storage were established:

1. **ALRIGH2T** (Horizon Europe, 2024-27 coordinator: ENEA, Italy)
2. **e-SHyIPS** (Horizon Europe, 2021-24 coordinator: Politecnico of Milano, Italy)
3. **EPSRC UK-MaRes Hub** (UK, 2023-27, Coordinator: Durham University, UK)
4. **ESKHYMO** (France, 2022-2026, coordinator: CEA, France)
5. **DelHyVEHR** (Horizon Europe, 2024-26, coordinator: Engie, France)
6. **HEAVEN** (Horizon Europe, 2023-26, coordinator: Rolls-Royce, Germany)
7. **LH2 Pioneer** (NFR, 2021-25, coordinator: SINTEF Energy)
8. **MF Hydra** (LH2 ferry, Norway, Norled)
9. **NICOLHy** (Horizon Europe, 2024-26, coordinator: BAM, Germany)
10. **sHYpS** (EU, coordinator (Horizon Europe, 2022-26, coordinator: NavalProgetti S.r.l., Italy)
11. **STACY** (EIG Concert Japan, 2022-2026, coordinator: Julich, Germany)

ELVHYS – Work Plan



- WP1 (NTNU) - Project Management & Coordination
- WP2 (AL) - From industrial background and strategy to findings application
- WP3 (DLR) - Cryogenic hydrogen transfer facilities performance
- WP4 (HSE) - Fires & explosions from cryogenic hydrogen transfer facilities
- WP5 (NCSRD) - Risk Analysis for selected cryogenic hydrogen transferring operations
- WP6 (UU) - Dissemination, exploitation, communication

ELVHYS – State of the art on LH2 transfer and preliminary analysis



The main activities in WP2 in the first half of the project were:

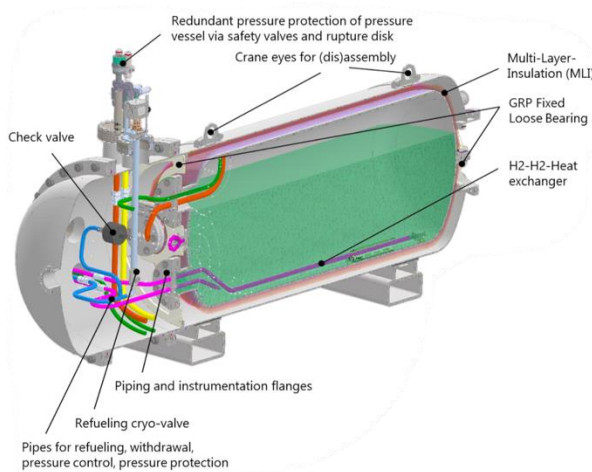
- **Task 2.1 - LH2 transfer ecosystem, infrastructure description and regulatory challenges**
 - **Sub-Task 2.1.1** LH2 transferring applications and associated feared events
 - **Sub-Task 2.1.2** Description of LH2 transfer equipment and protocols for LH2 transfer operations
 - **Sub-Task 2.1.3** Overview of existing RCS and identification of gaps
- **Task 2.2 - Preliminary major accident hazard identification for LH2 transfer operations**
 - **Sub-Task 2.2.1** Overview of risk analysis methodologies
 - **Sub-Task 2.2.2** Preliminary major accident hazard identification and severity assessment
 - **Sub-Task 2.2.3** Research programme and expected results
- **Task 2.3 - Valorisation of the findings for safe LH2-based operation and use**
 - **Sub-task 2.3.1** Guidelines for inherently safer design of LH2 transferring facilities
 - **Sub-task 2.3.2** RCS for cryogenic and LH2 transferring operations and facilities

ELVHYS – Experimental activities

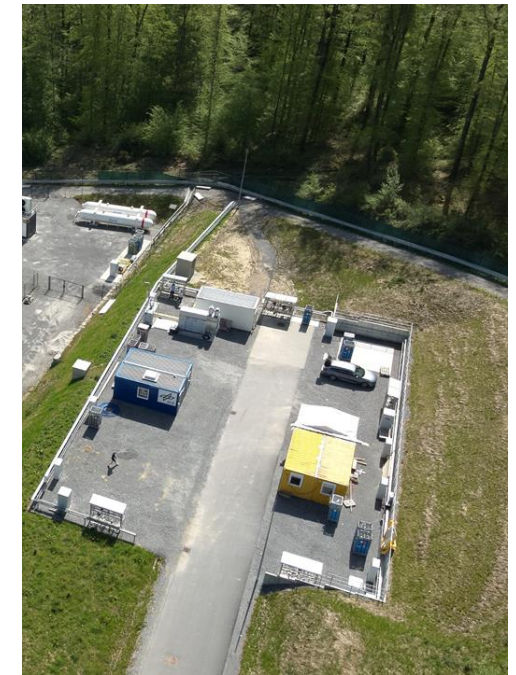
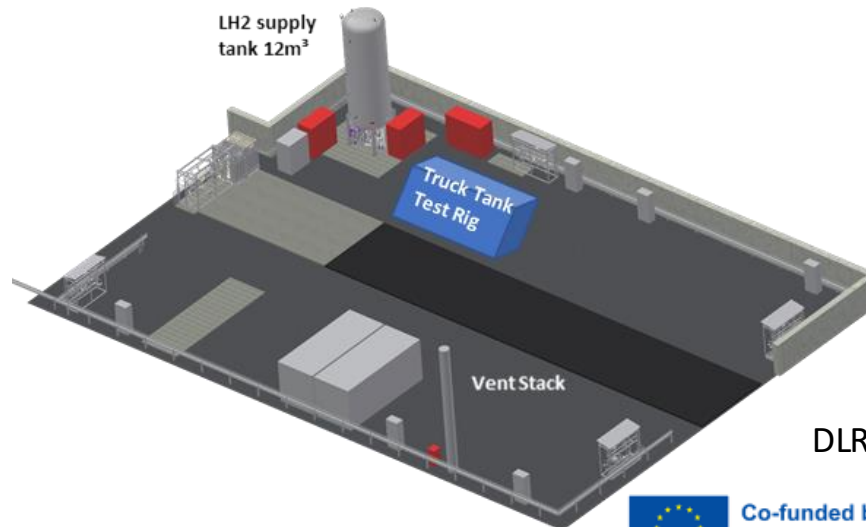
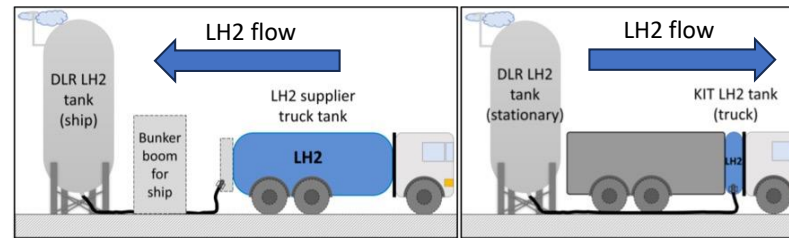
Nr.	Phenomenon investigated	WP	Location	Performed by	Status
1	LH2 transfer operations from a giving to a receiving tank	3	Lampoldshausen (Germany)	DLR	In progress
2	Oxygen enrichment and condensed phase explosions	4	Buxton (UK)	HSE	Completed
3	LH2 Leakage into cold room/tank connection space considering barriers and obstacles	4	Buxton (UK)	HSE	Completed
4	Boiling Liquid Expanding Vapour Explosion (BLEVE) tests with a shock tube	4	Karlsruhe (Germany)	KIT	In progress
5	Fire tests of short LH2 transfer line elements	4	Karlsruhe (Germany)	KIT	In progress
6	Material testing against unignited and ignited LH2 jets	4	Karlsruhe (Germany)	KIT	In progress

ELVHYS – Experimental activities (1/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
1	LH2 transfer operations from a giving to a receiving tank	3	Lampoldshausen (Germany)	DLR	In progress



LH2 tank (images courtesy of KIT)



DLR test facility (images courtesy of DLR)

ELVHYS – Experimental activities (2/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
2	Oxygen enrichment and condensed phase explosions	4	Buxton (UK)	HSE	Completed



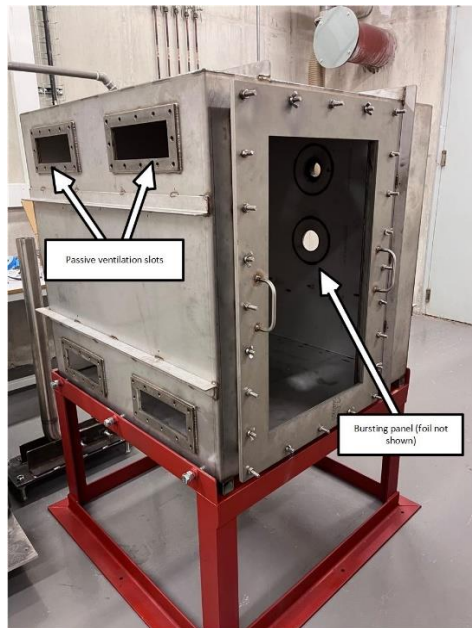
Experimental release of LH2
previously performed at HSE
(Hooker et al., 2012)



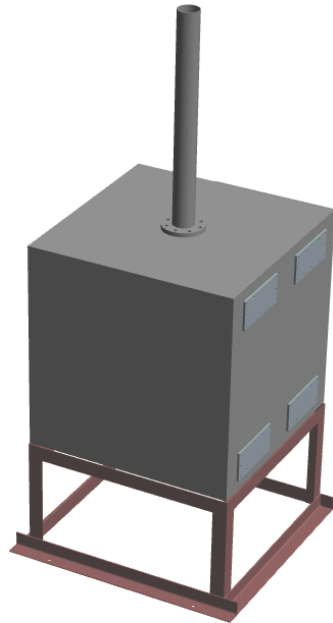
Aerial view of HSE test pad during the tests(images courtesy of HSE)

ELVHYS – Experimental activities (3/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
3	LH2 Leakage into cold room/tank connection space considering barriers and obstacles	4	Buxton (UK)	HSE	Completed



HSE experimental setup (images courtesy of HSE)



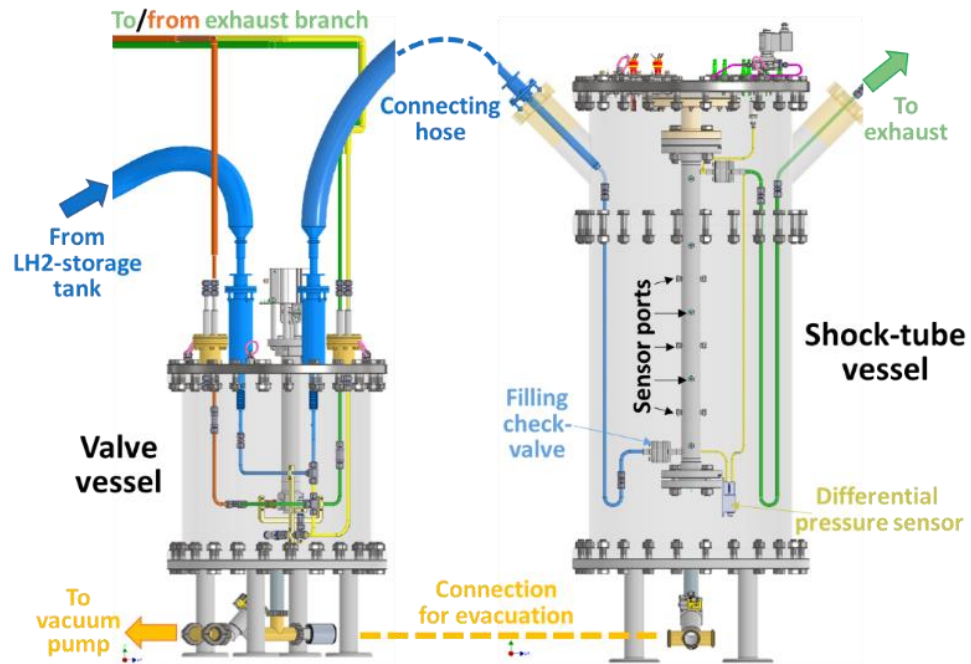
LH2 indoor testing at HSE (images courtesy of HSE)

ELVHYS – Experimental activities (4/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
4	Boiling Liquid Expanding Vapour Explosion (BLEVE) tests with a shock tube	4	Karlsruhe (Germany)	KIT	In progress



HYKA safety vessel V220 at KIT
(images courtesy of KIT)



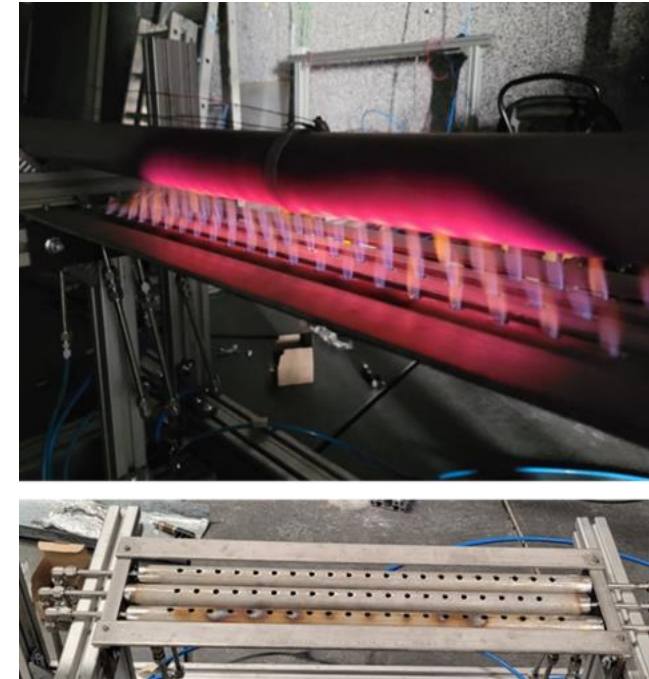
ELVHYS experimental setup (images courtesy of KIT)

ELVHYS – Experimental activities (5/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
5	Fire tests of short LH2 transfer line elements	4	Karlsruhe (Germany)	KIT	In progress



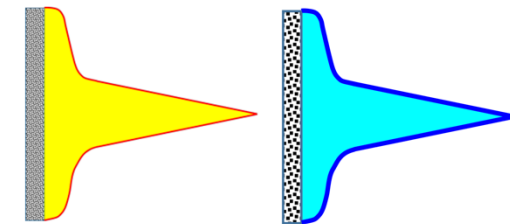
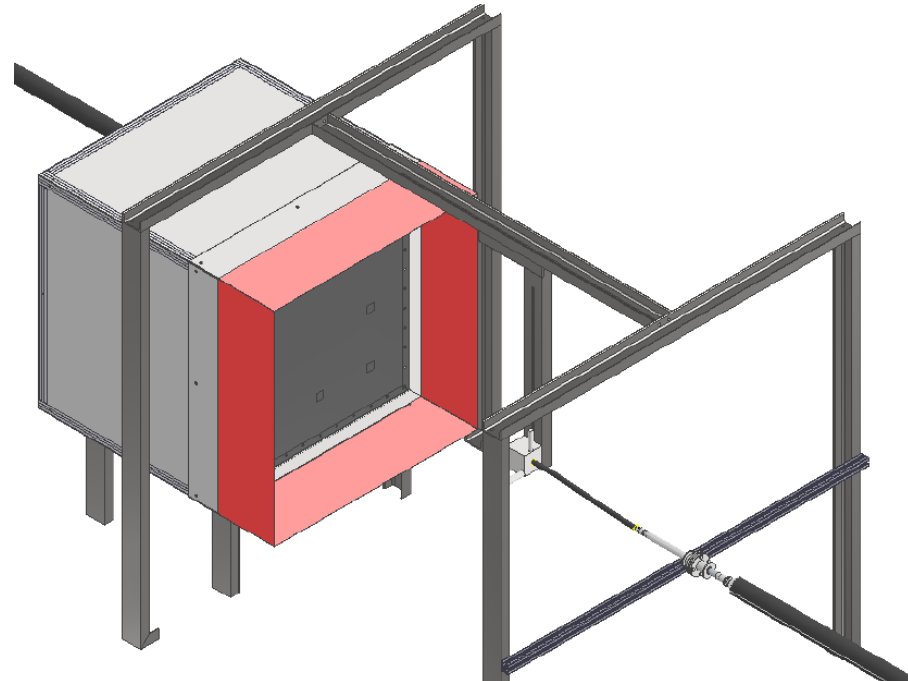
Inside HYKA H110 safety vessel A1 at KIT



ELVHYS experimental setup (images courtesy of KIT)

ELVHYS – Experimental activities (6/6)

Nr.	Phenomenon investigated	WP	Location	Performed by	Status
6	Material testing against unignited and ignited LH2 jets	4	Karlsruhe (Germany)	KIT	In progress



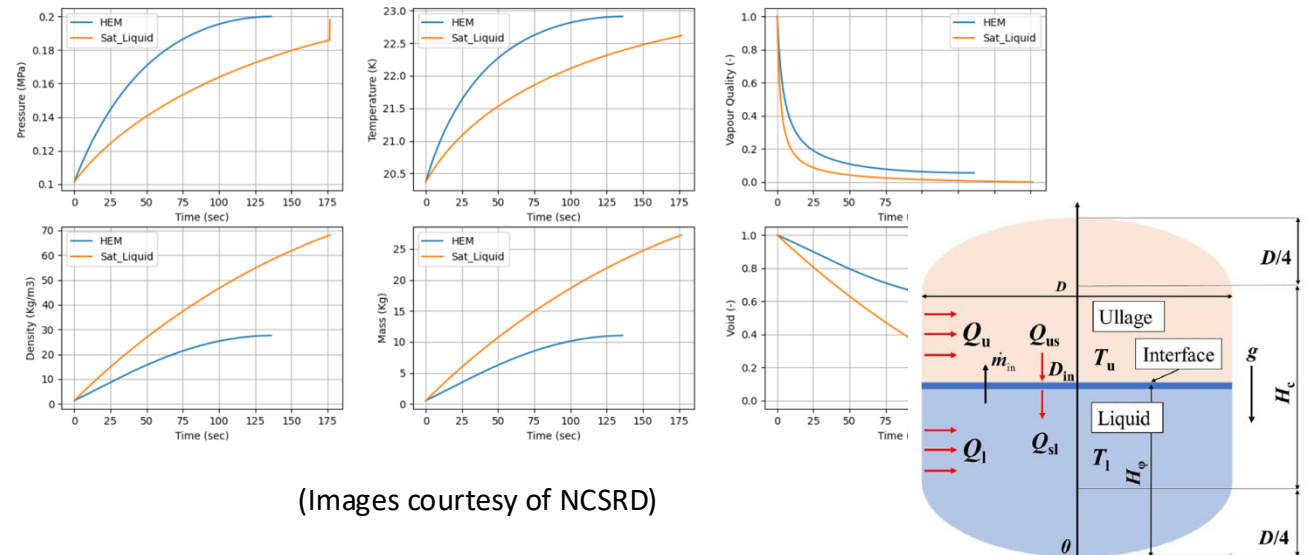
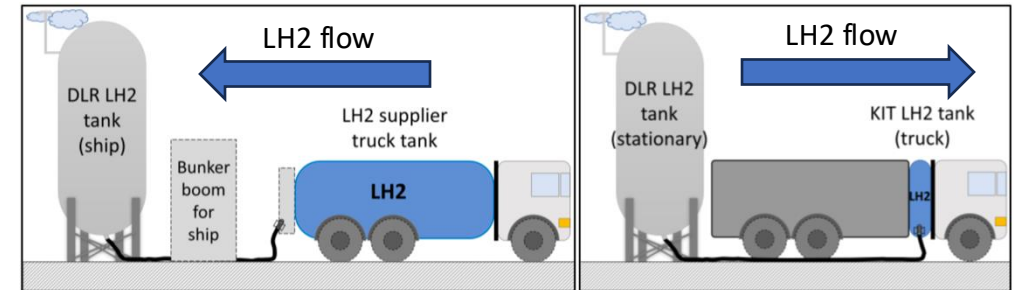
Animation of ignited and unignited LH2 jets

Free field test site of ITES-KIT (campus south) with installed experimental rig for impingement and its 3D model (images courtesy of KIT)

ELVHYS – Modelling activities (1/2)

Cryogenic hydrogen transfer facilities performance

- NCSR “Demokritos” partner is leading this activity.
- Modelling is carried out in parallel with the tests to first support the experiments and then validate the models.
- NCSR aims to further develop DISCHA engineering tool previously developed to simulate LH2 releases.
- KIT and NTNU are also involved in the modelling activity of LH2 transfer operations.



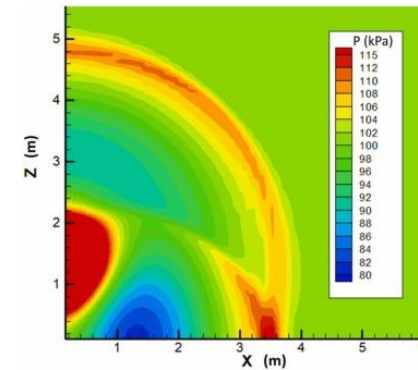
(Images courtesy of NCSR)

(Wang H.R. et al., 2022)

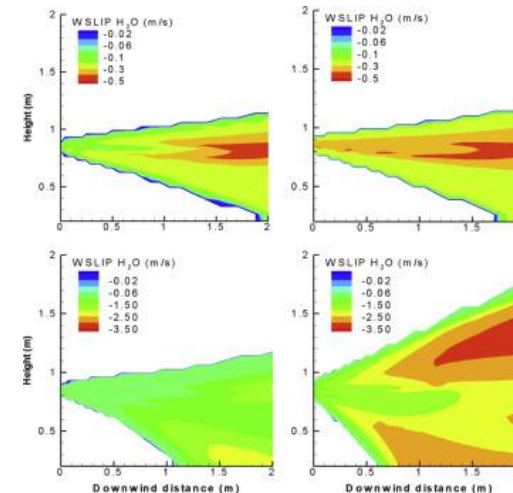
ELVHYS – Modelling activities (2/2)

Fires and explosions from cryogenic hydrogen transfer facilities

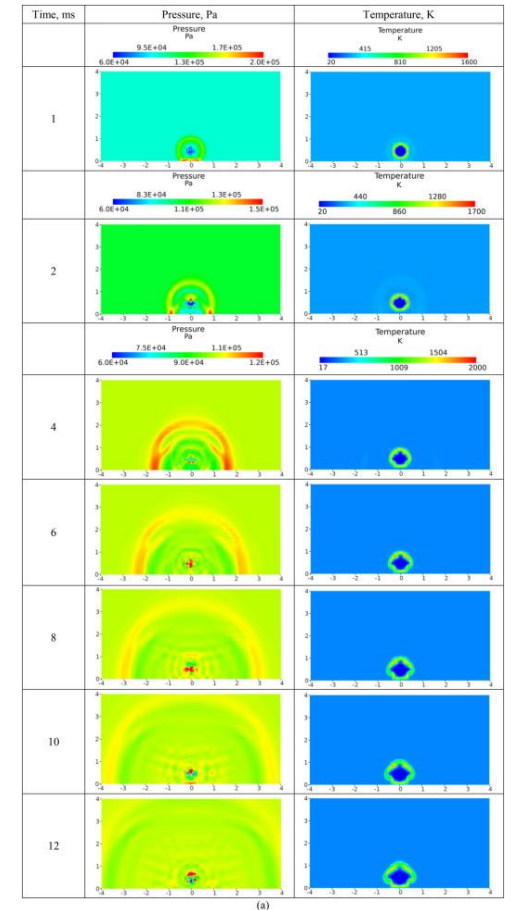
- NCSRD partner is leading.
- Partners involved in modelling of WP4 physical phenomena: HSE, KIT, NTNU, UNIBO, UU.
- Physical phenomena that will be modelled are:
 1. BLEVE
 2. Unignited and ignited LH2 releases
 3. Fire resistance of LH2 components
 4. Jet fires
 5. Pressure Peaking Phenomenon (PPP)



(Ustolin et al., 2021)



(Giannissi and Venetsanos, 2018)

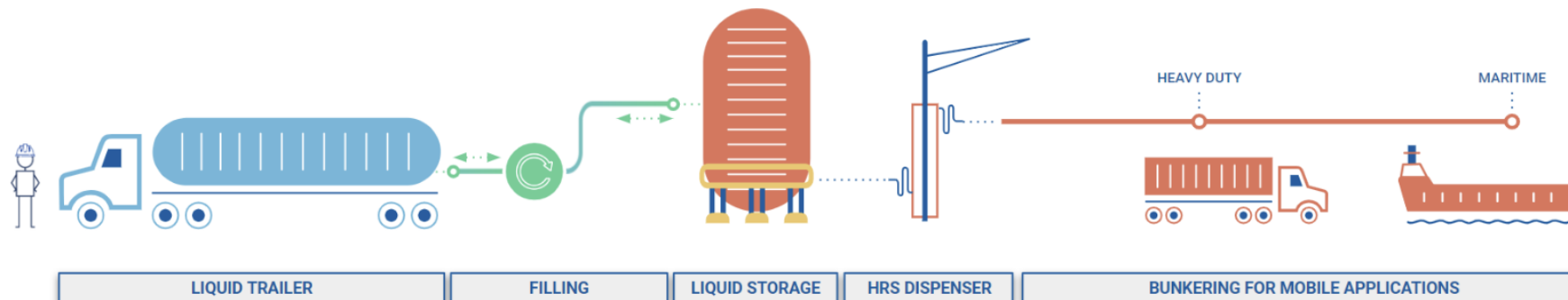


(Cirrone et al., 2023)

ELVHYS – Risk Analysis

Risk Analysis for selected cryogenic hydrogen transferring operations (WP5)

- NCSRD partner is leading this activity supported by AL, DLR, KIT, NTNU, UNIBO, UU.
The tasks of this risk analysis are:
 - **Task 5.1** – Hazard identification and damage state estimation
 - **Task 5.2** – Consequence assessment
 - **Task 5.3** – Frequency assessment and risk integration
 - **Task 5.4** – Innovative safety strategies and engineering solutions

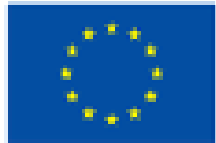


(Image courtesy of Air Liquide)



Thank you for your attention

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