Welcome to the 6th ELVHYS Stakeholders' Workshop

Belfast, UK

Federico Ustolin

05.12.2025

ELVHYS project No. 101101381 is supported by the Clean Hydrogen Partnership and its members. UK participants in Horizon Europe Project ELVHYS are supported by UKRI grant numbers 10063519 (University of Ulster) and 10070592 (Health and Safety Executive)

Project achievements, remaining knowledge gaps and technological bottlenecks

Tentative programme	
Time (CET)	Presentation title (presenter)
10:15-10:20	Welcome (F. Ustolin, NTNU; V. Molkov, UU)
10:20-10:40	ELVHYS project brief and achievements (F. Ustolin, NTNU)
10:40-11:00	The large-scale loading/unloading arm for LH_2 carriers and expected research developments for high performance (S. Kamiya, Kawasaki Heavy Industries)
11:00-11:20	A novel platform for testing refuelling and transfer operations of a aircraft LH_2 system architecture (C. Lemaitre, Airbus)
11:20-11:40	Leakage and dispersion of LH_2 in confined spaces and the effect of forced ventilation (W. Rattigan, HSE)
11:40-12:00	Coffee break
12:00-12:20	Pressure peaking phenomenon for LH_2 releases in confined spaces (J. Vizma, HSE, D. Cirrone, UU)
12:20-12:40	Oxygen enrichment mechanisms of condensed phase air in LH_2 environments (J. Welch, HSE)
12:40-13:00	A multi-stage modelling approach for rainout, pool formation and dispersion of LH_2 releases (D. Rescigno, NTNU)
13:00-13:20	CFD model of liquefaction and solidification of air after full-bore rupture of LH_2 pipeline (D. Makarov, UU)
13:20-14:20	Lunch break
14:20-14:40	Consequence analysis by CFD model for LH_2 bunkering of a hydrogen powered ship (N. Koutsourakis, NCSRD)
14:40-15:00	The DISCHA integral tool for LH_2 tank to tank transfer operations (A. Venetsanos, NCSRD)
15:00-15:20	CFD model of pressure and temperature dynamics in LH_2 storage tank due to heat ingress (M. Kamboj, UU)
15:20-15:40	DELHYVHER project on delivery of liquid hydrogen for various environment at high rate (P. Bernard, Engie)
15:40-15:55	Coffee break
15:55-16:15	Quantitative risk assessment of hydrogen releases in a hydrogen fuelling station with LH_2 storage (K. Groth, University of Maryland)
16:15-16:35	Failure behaviour of a LH_2 tank under vacuum-loss conditions (M. Bragin, Air Products)
16:35-16:55	Round table discussion (F. Ustolin, NTNU; All)
16:55-17:00	Closure of the workshop (F. Ustolin, NTNU; D. Cirrone, UU)

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ELVHYS project brief and achievements

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Pre - ELVHYS

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, σcrit and run-up distance for DDT determined at cryogenic conditions
- ✓ …

PRESLHY

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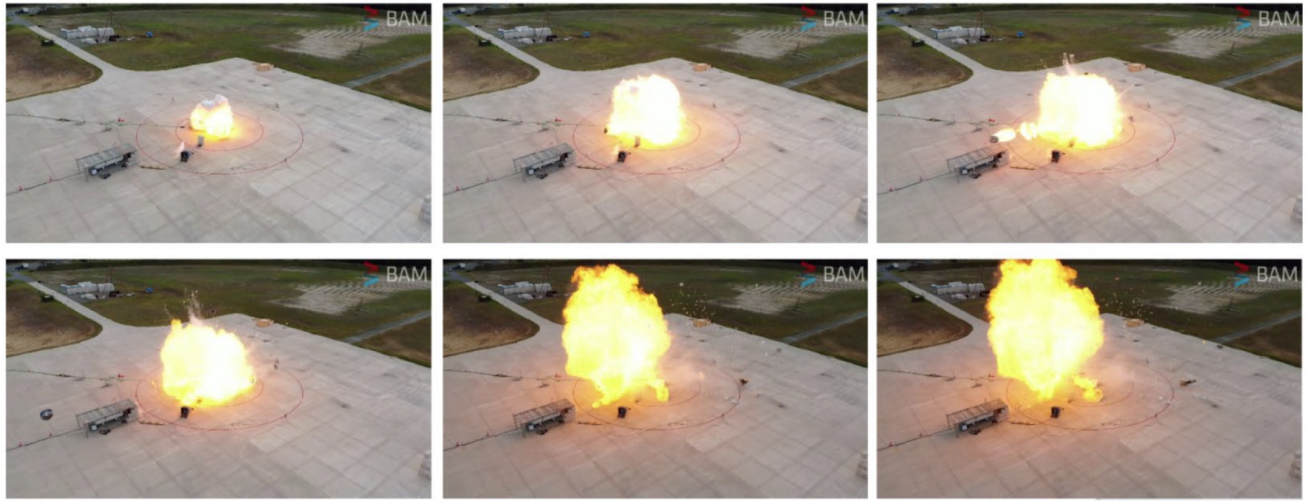
Pre - ELVHYS

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 Liquified Hydrogen onto and under Water." (2022))

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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.

Website: https://elvhys.eu/

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ELVHYS

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

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ELVHYS – Consortium

NTNU (Coordinator)

Ulster University

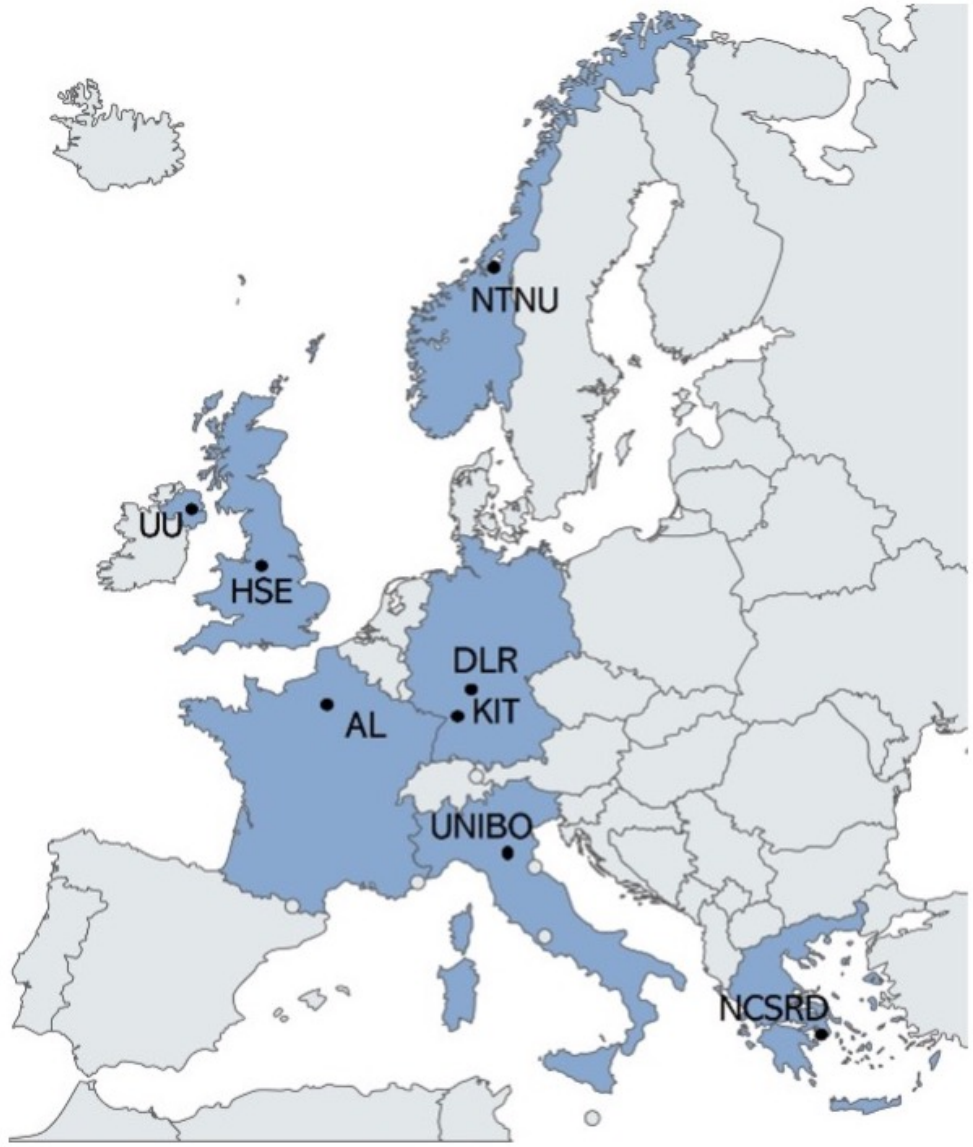
DEMOKRITOS

DLR

HSE

KIT
Karlsruher Institut für Technologie

Air Liquide



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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)

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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)

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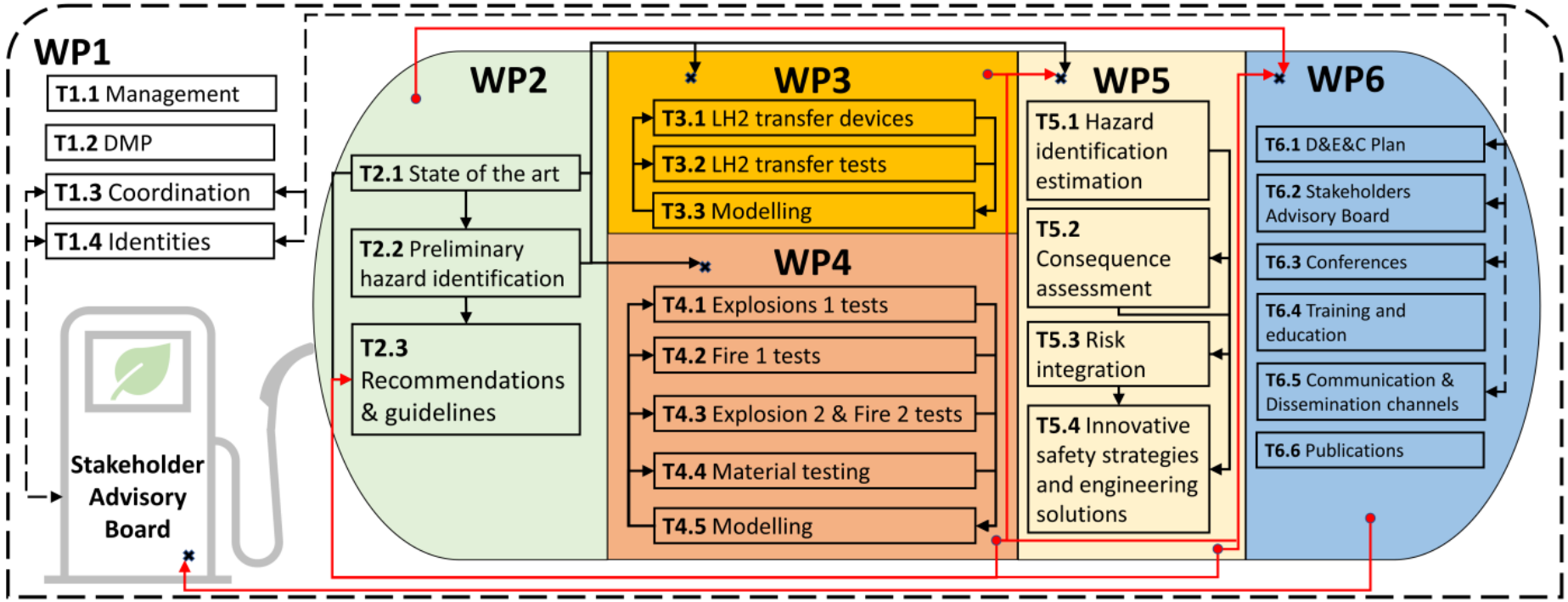
ELVHYS – Work Plan



- 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

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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

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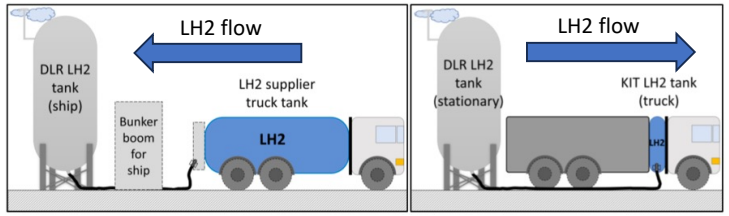
ELVHYS – Experimental activities

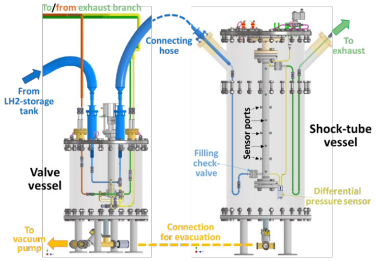
Nr.	Phenomenon investigated	WP	Location	Partner
1	LH2 transfer operations from a giving to a receiving tank	3	Lampoldshausen (Germany)	DLR
2	Oxygen enrichment and condensed phase explosions	4	Buxton (UK)	HSE
3	LH2 Leakage into cold room/tank connection space considering barriers and obstacles	4	Buxton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



DLR test facility

KIT LH2 tank

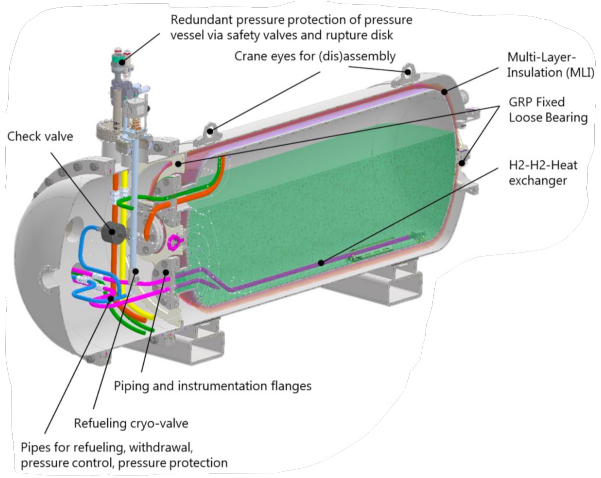
KIT free field test site



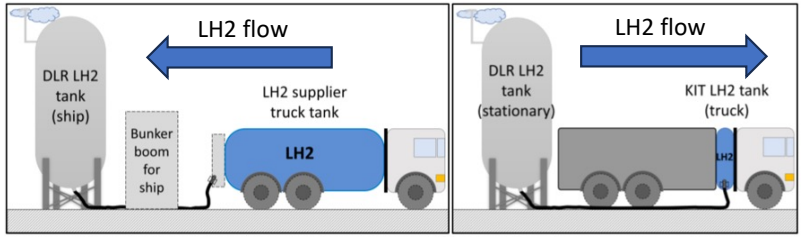
KIT shock tube

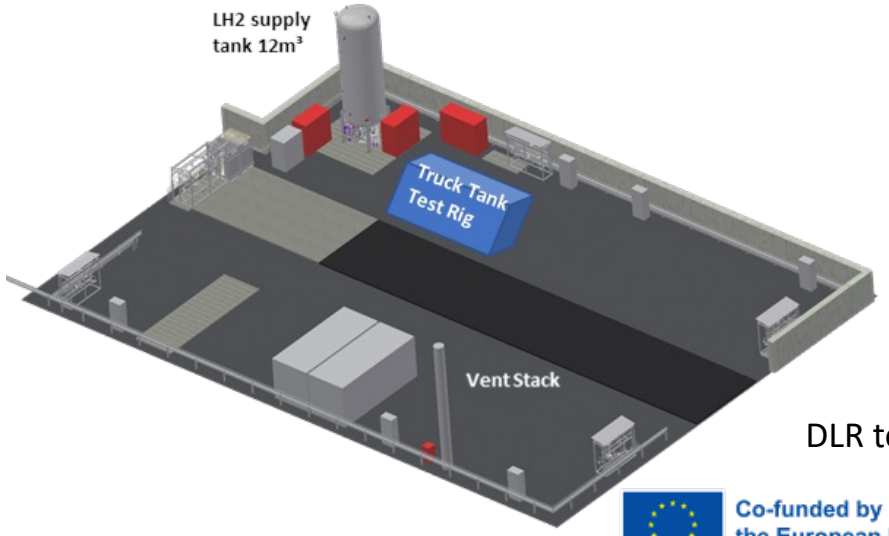
ELVHYS – Experimental activities (1/6)

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)

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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 (video courtesy of HSE)

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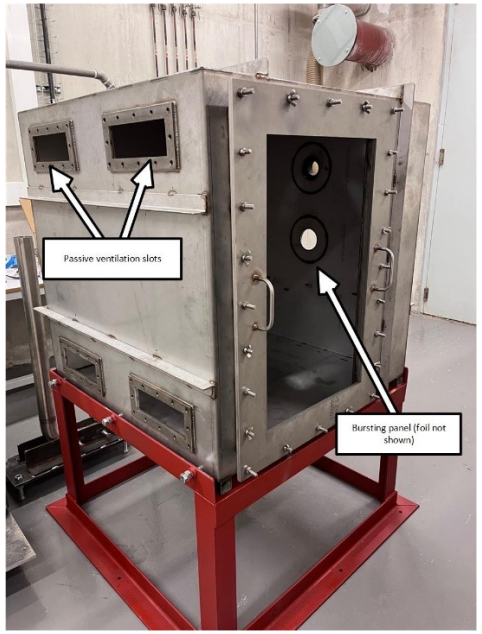
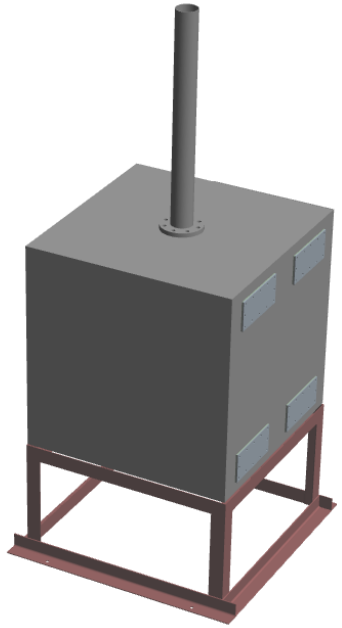
ELVHYS – Experimental activities (3/6)

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)

Test 39 - LH2 ignited release in cold box (video courtesy of HSE)

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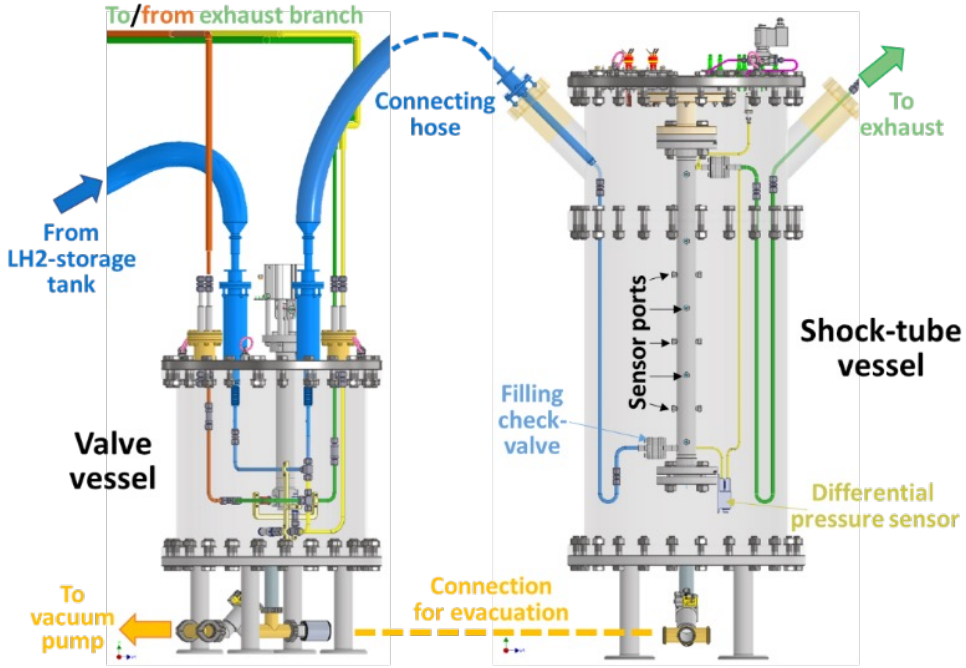
ELVHYS – Experimental activities (4/6)

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)

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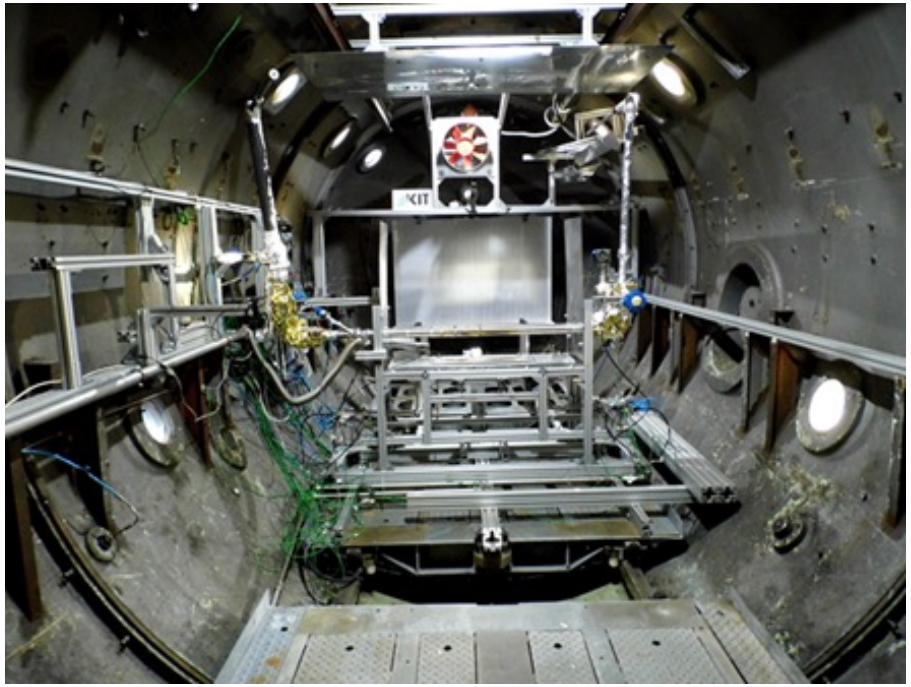
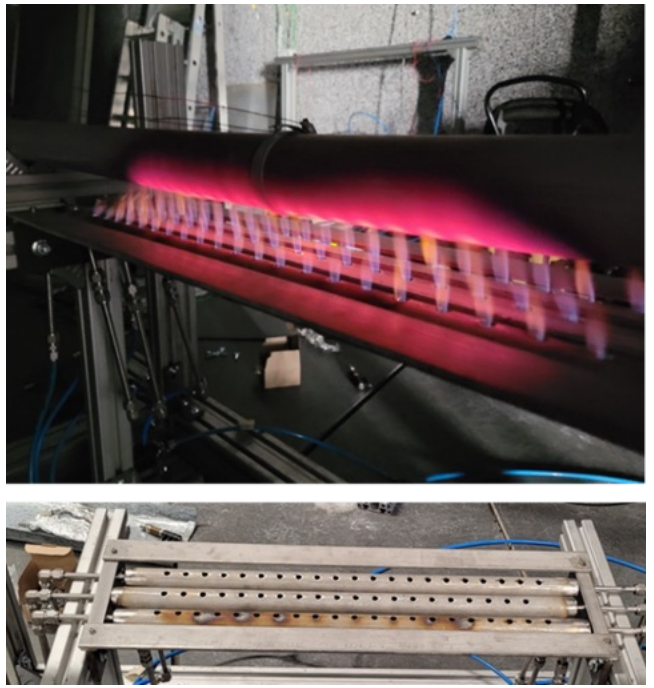
ELVHYS – Experimental activities (5/6)

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)

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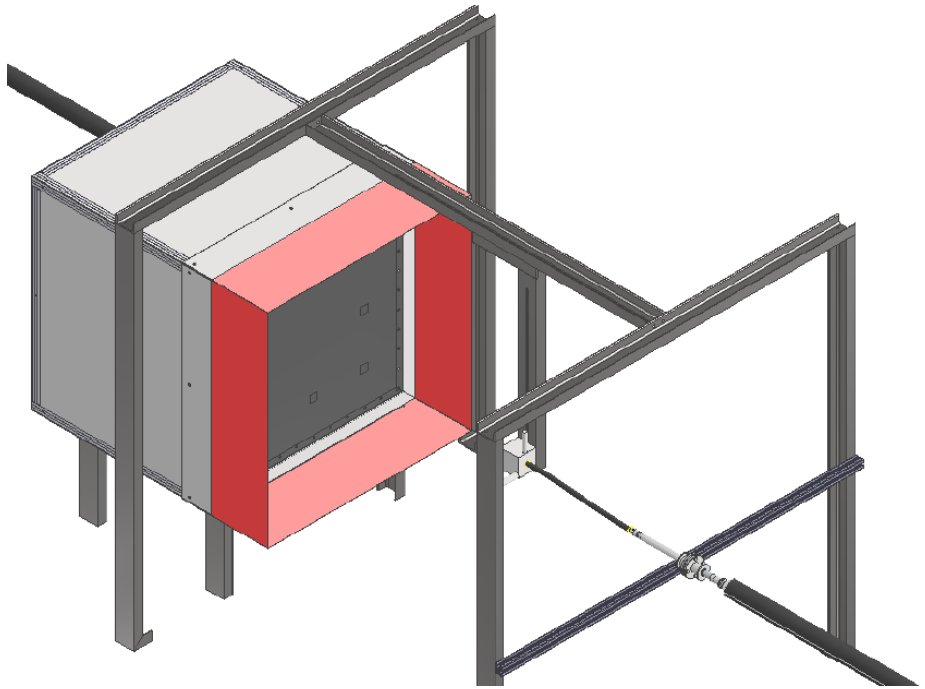
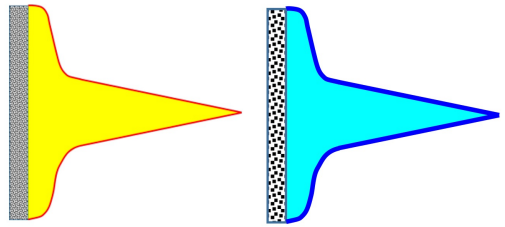
ELVHYS – Experimental activities (6/6)

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)

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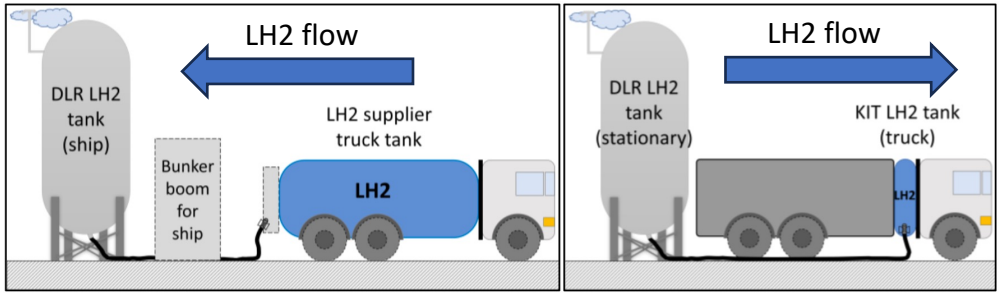
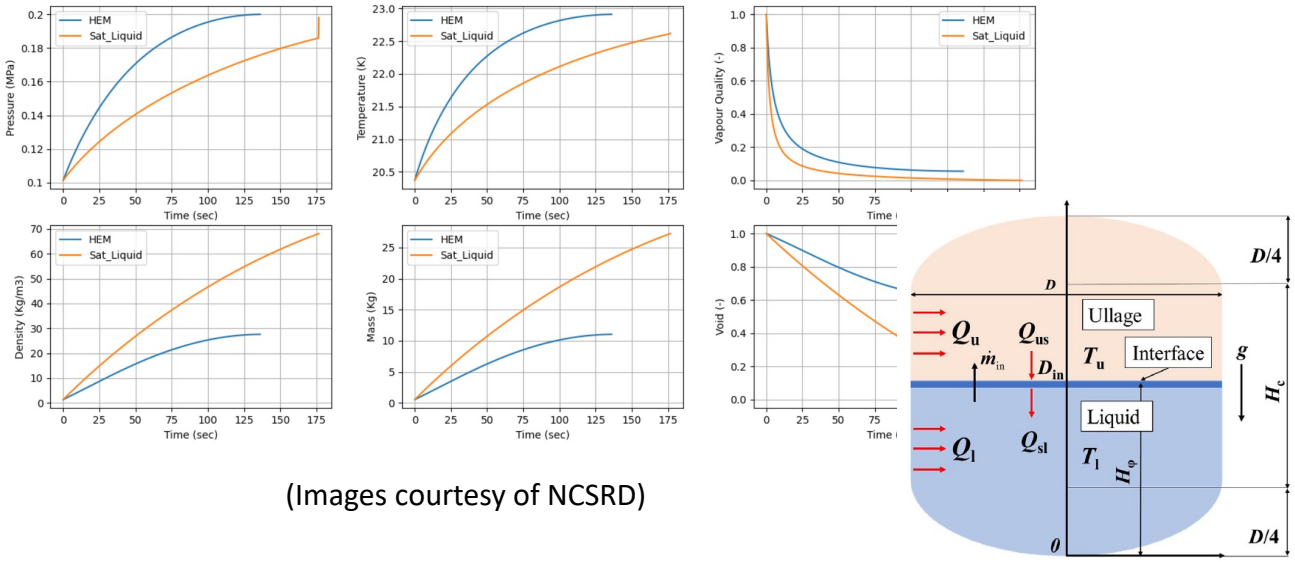
ELVHYS – Modelling activities (1/2)

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.
- NCSRD 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 NCSRD)

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

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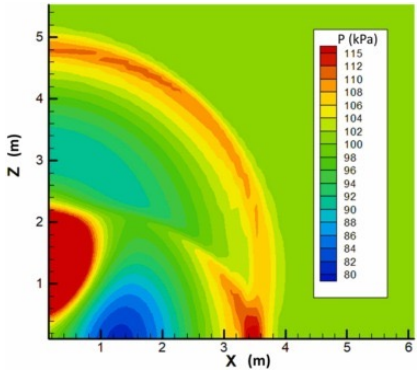
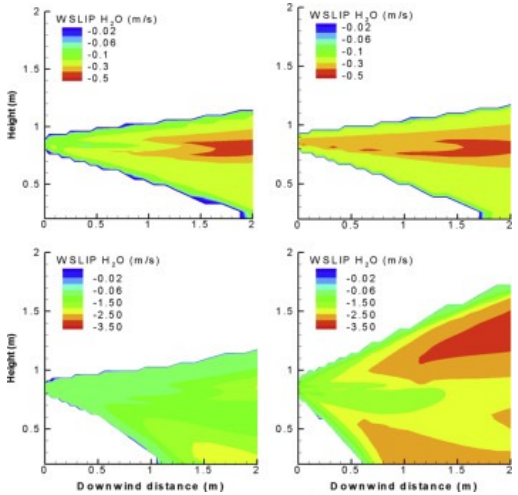
ELVHYS – Modelling activities (2/2)

Fires and explosions from cryogenic hydrogen transfer facilities

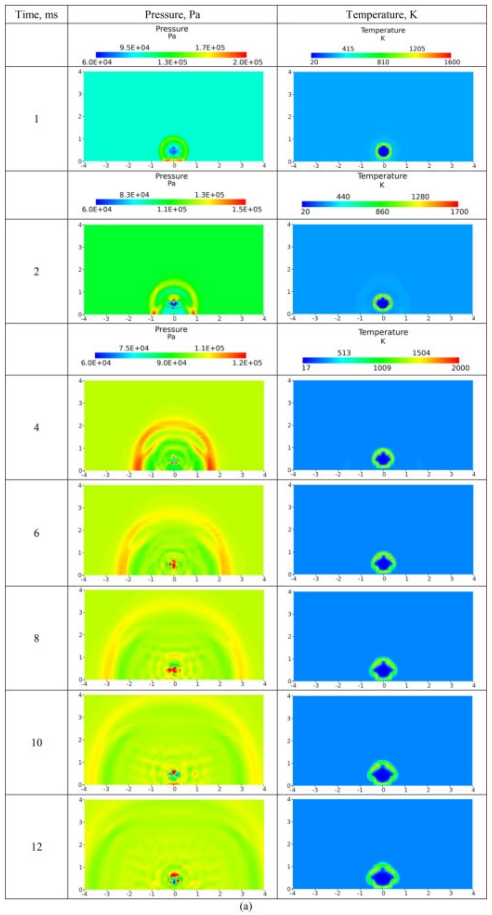
- NCSRD partner is leading.
- Partners involved in modelling of WP4 physical phenomena: HSE, KIT, NTNU, UNIBO, UU.
- Physical phenomena that will be modelled are:
    1. BLEVE
    2. Unignited and ignited LH2 releases
    3. Fire resistance of LH2 components
    4. Jet fires
    5. Pressure Peaking Phenomenon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



(Ustolin et al., 2021)



(Giannissi and Venetsanos, 2018)

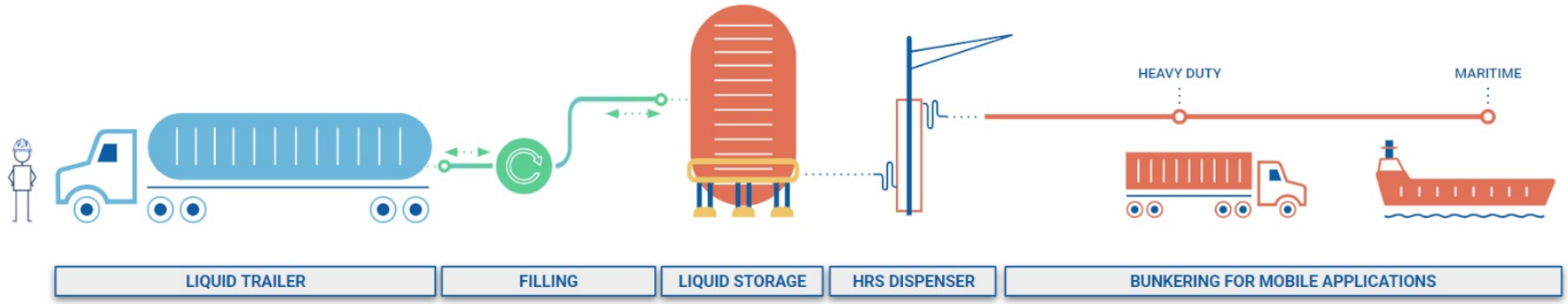


(Cirrone et al., 2023)

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)

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