



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

Federico Ustolin (NTNU) et al

1<sup>st</sup> Stakeholders' workshop

Paris, France, 21.06.2023



Co-funded by  
the European Union



UK Research  
and Innovation

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

# Instructions for participants

- Microphone and video camera options will be deactivated by the hosts at the start of the workshop, given exception for questions. However, please ensure at any time that your microphone and video are off.
- Presentations will allow 5 minutes for questions. Please ask your questions to presenters by using the chat option. If this is not possible (e.g. short available time to write up a question) please use the option “raise hand” in the webinar controls. The hosts and chairs will be notified and you will be prompted to unmute yourself and verbally ask your question.
- The online event will be video recorded and by attending the meeting the participant agrees to the recording

# Agenda

Time	Presentation title
09:30-09:35	Welcome (F. Ustolin, NTNU; L. Bernard, AL)
09:35-10:00	ELVHYS project overview (F. Ustolin, NTNU)
10:00-10:25	Suiso Frontier: bunkering and transfer operations for the world's first ocean LH <sub>2</sub> carrier (S. Kamiya, Kawasaki Heavy Industries)
10:25-10:50	MF Hydra: storage and refuelling of the world's first LH <sub>2</sub> powered ferry (I. Østvik, Norled)
10:50-11:10	Coffee break
11:10-11:35	Industrial practices for cryogenic hydrogen transfer operations (Y. Pennec, Air Liquide)
11:35-12:00	Storage and handling of LH <sub>2</sub> at DLR Institute of Space Propulsion (B. Gobereit, DLR)
12:00-12:30	Intermediate round table discussion (F. Ustolin, NTNU; All)
12:30-13:50	Lunch break
13:50-14:15	ZEROe: towards the world's first zero-emission commercial aircraft (C. Louriou, Airbus)
14:15-14:40	Refuelling of LH <sub>2</sub> heavy duty vehicles: Daimler Trucks (J. Franzen, Daimler)
14:40-15:05	ESKHIMO project overview (B. Truchot, Ineris)
15:05-15:25	Coffee break
15:25-15:50	STACY - Towards safe storage and transportation of cryogenic hydrogen (E. Reinecke, Forschungszentrum Jülich GmbH)
15:50-16:20	Final round table discussion (F. Ustolin, NTNU; All)
16:20-16:30	Closure of the workshop (F. Ustolin, NTNU; L. Bernard, AL)

Time is CET

# 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
- ✓  $\sigma$ ,  $\sigma_{crit}$  and run-up distance for DDT determined at cryogenic conditions
- ✓ ...



# Scientific Data Published



**DOI:** <https://doi.org/105445/IR/> + "KITOpen ID Nr"

Participant: KIT	KIT Open ID Nr.	Participant: KIT WP 4.4	KIT Open ID Nr.	Participant: HSE	KIT Open ID Nr.
WP3.1.b	1000145859	Material: sand	1000145886	WP3	1000136281
WP3.4	1000145885	Material: concrete	1000145887	WP4	1000136330
WP5.1	1000147745	Material: water	1000145888	WP5	1000136285
WP5.5	1000136188	Material: gravel	1000145889		
Participant: KIT WP 5.3 warm	KIT Open ID Nr.	Participant: KIT WP 5.3 cold	KIT Open ID Nr.		
BR ratio: 0%	1000145890	BR ratio: 0%	1000145893		
BR ratio: 30%	1000145891	BR ratio: 30%	1000145895		
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Pre - ELVHYS

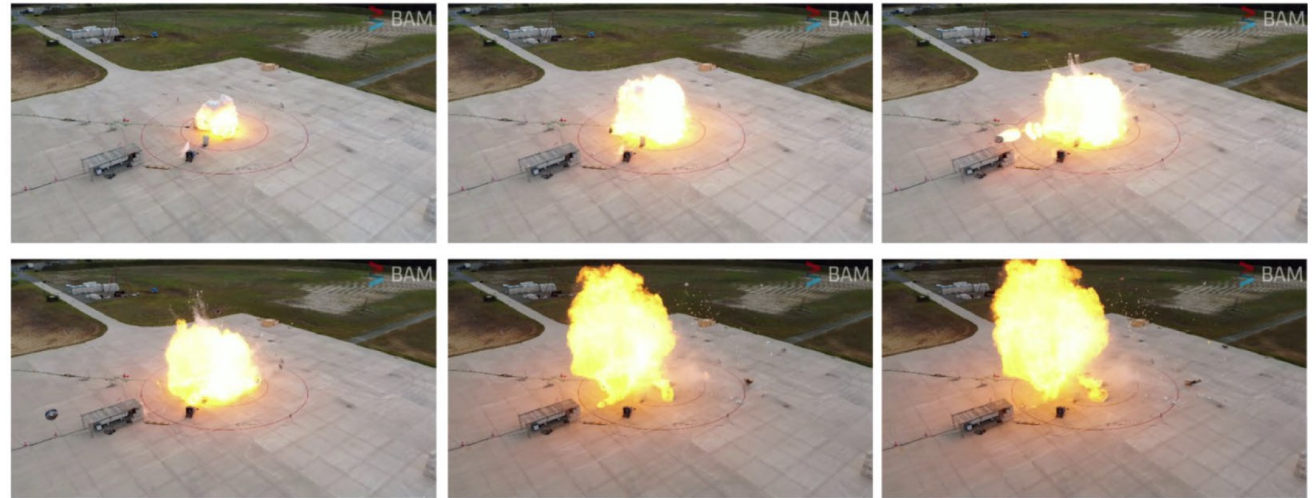
# SH2IFT Project Findings



## 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))



# ELVHYS

Follow-up of



## About

**Funding programme:** Horizon Europe

**Budget:** 2.0 M€

**Duration:** 2023-2026 (36 months)

**Type:** Research & Innovation Action

**Objective:** provide indications on inherently safer and efficient cryogenic hydrogen transfer 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.



Horizon Europe  
2021-2027



# ELVHYS

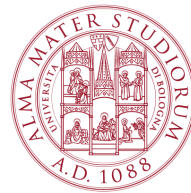
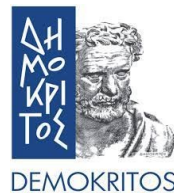
## Expected outcomes

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 **SimOps**
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

 **NTNU** (Coordinator)



# ELVHYS – Stakeholder Advisory Board

- At the moment 26 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, USA)
- Type of organizations: industries and companies (8), research centres (6), universities (5), national public institutes (3), association (HySafe), intergovernmental org. (IEA), industry org. (Hydrogen Council), rail operator (SNCF)

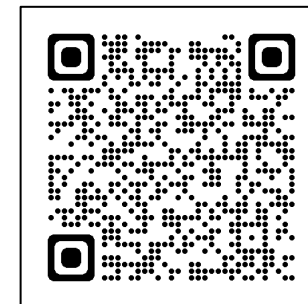
# ELVHYS – Stakeholder Advisory Board

No	Organization	Type	Country
1	International Association for Hydrogen Safety (HySafe)	Association	Belgium
2	IEA	Intergovernmental org.	---
3	Hydrogen Council	Industry organization	---
4	Sandia National Laboratory	Research center	USA
5	Kawasaki Heavy Industries	Industry	Japan
6	Daimler	Industry	Germany
7	Airbus	Industry	France
8	DNV	Certification body	Norway/UK
9	HYEX	Company	Norway
10	Norled (MF Hydra – LH2 ferry project)	Company	Norway
11	University of Salerno	University	Italy
12	ISPRA - Italian National Institute for Environmental Protection and Research	Public body	Italy
13	PPG	Company	UK
14	RIVM - the Netherlands National Institute for Public Health and the Environment, Centre for Environmental Safety and Security	Public body	The Netherlands
15	SNCF - DIRECTION TECHNOLOGIES, INNOVATION ET PROJETS GROUPE (rail operator)	Operator	France
16	RISE	Research Centre	Sweden

# ELVHYS – Stakeholder Advisory Board

No	Organization	Type	Country
17	SINTEF industry	Research Centre	Norway
18	SINTEF Energy	Research Centre	Norway
19	Fellow, Royal Society for the Encouragement of Arts, Manufactures and Commerce (FRSA)	Global network of changemakers	USA
20	CEA (ESKHYMO project)	Research Centre	France
21	Forschungszentrum Jülich (STACY project)	Research Centre	Germany
22	Politecnico di Milano (e-SHyIPS project)	University	Italy
23	Shandong University (SDU)	University	China
24	University of Trieste	University	Italy
25	NavalProgetti srl (sHYpS project)	Company	Italy
26	University of Bergen	University	Norway

The SAB list can be found on the project website



# ELVHYS – Collaboration with other projects

Intention to establish collaborations with other projects related to LH2 and cryogenic hydrogen transfer and storage

- **STACY** - Towards Safe Storage and Transportation of Cryogenic Hydrogen (EIG Concert Japan, 2022-2026, coordinator: Ernst-Arndt Reinecke, Julich, Germany)
- **MF Hydra** (LH2 ferry, Norway, Norled)
- **ESKHYMO** - Enhance Safety Knowledge for Hydrogen Measurements/Modelling in cryogenic phase (France, 2022-2026, coordinator: Etienne Havret, CEA, France)



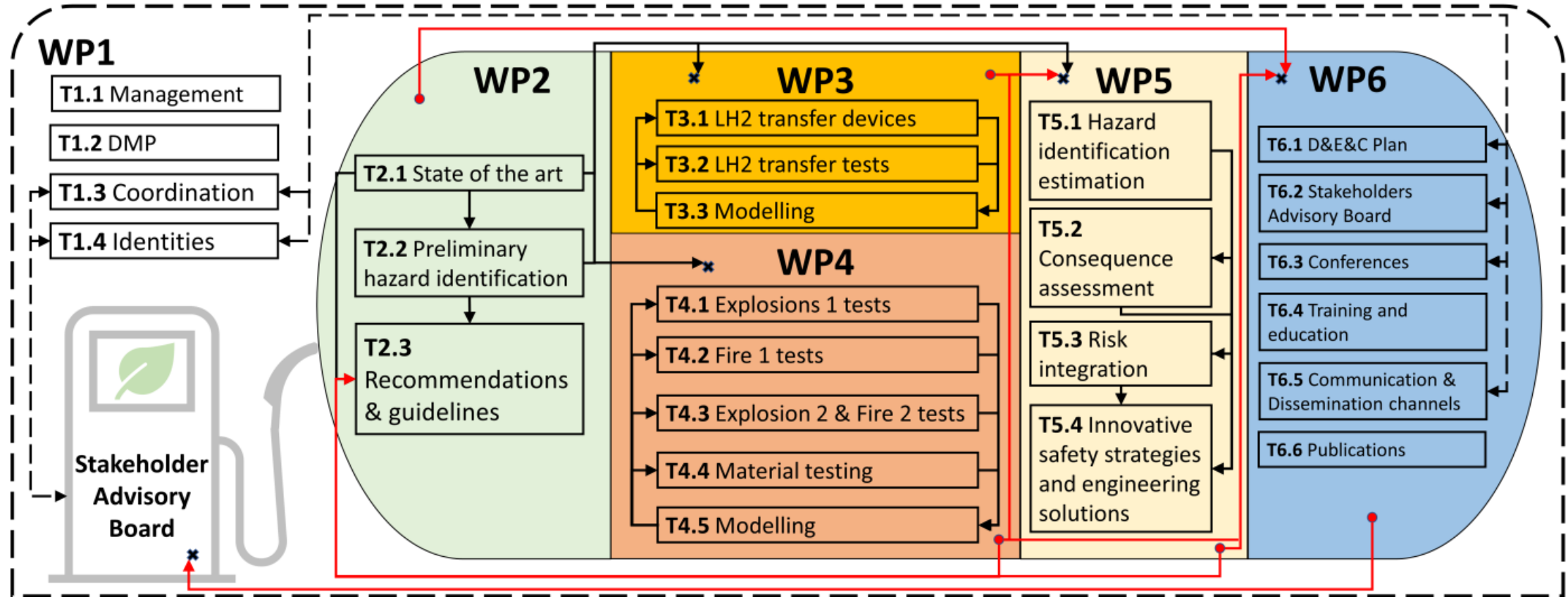
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- **e-SHyIPS** - Define the new guidelines for an effective introduction of hydrogen in maritime passenger transport sector (Horizon Europe, coordinator: Brendan Patrick Sullivan, Politecnico of Milano, Italy)
- **sHYpS** - Sustainable Hydrogen Powered Shipping (EU, coordinator (Horizon Europe, 2022-26, coordinator: Pierluigi Busetto, NAVAL PROGETTI, Italy)



# ELVHYS – Work Plan



# ELVHYS – Work Plan

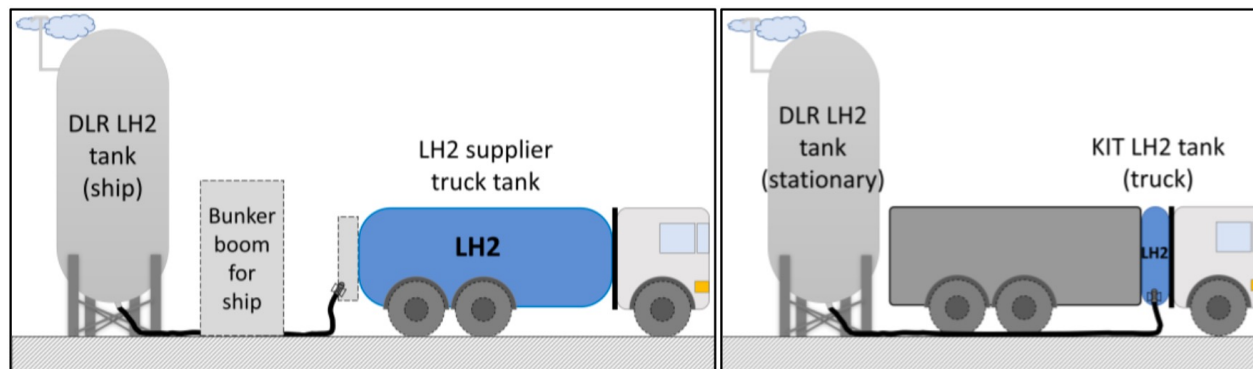
## Work Packages

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

# ELVHYS – Tasks

## WP3 - Cryogenic hydrogen transfer facilities performance

- **Task 3.1** - LH2 transfer devices definition
- **Task 3.2** - LH2 transfer tests: bunkering, fuelling, refuelling, defueling
- **Task 3.3** - Support by theoretical and numerical studies for experimental setup, and numerical experiments to formulate cryogenic hydrogen transfer protocols



**Tests will be  
carried out by  
DLR**

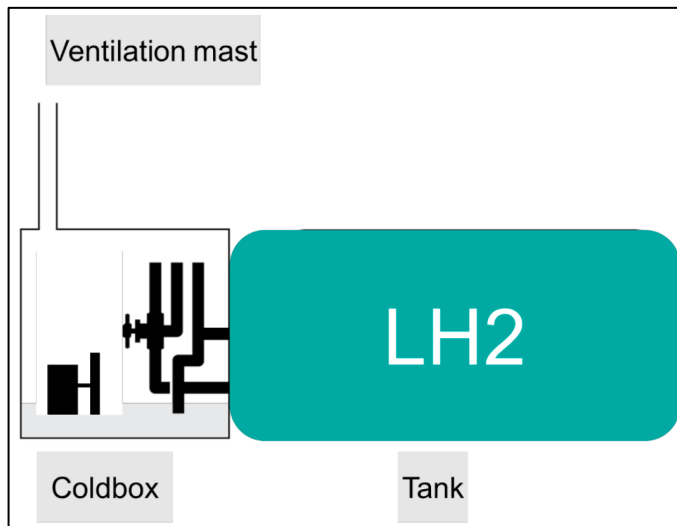
# ELVHYS – Tasks

## WP4 - Fires and explosions from cryogenic hydrogen transfer facilities

- **Task 4.1** – Oxygen enrichment and condensed phase explosions
- **Task 4.2** – Leakage into cold room/tank connection space considering barriers and obstacles



HSE test (Hooker et al., 2012)



DNV test (Aaneby et al., 2021)

**Tests will be  
carried out by  
HSE**

# ELVHYS – Tasks

## WP4 - Fires and explosions from cryogenic hydrogen transfer facilities

- **Task 4.3** – Performance of LH2 components and explosion consequences
- **Task 4.4** – Material testing against unignited and ignited jets (MLI, glass spheres, perlite layers and fire protecting wall) according to ISO 20088
- **Task 4.5** – Modelling in support of and utilising WP4 experimental activities



SH2IFT test (Ødegård et al., 2022)

**Tests will be carried out by KIT**



# ELVHYS – Tasks

## WP5 - Risk Analysis for selected cryogenic hydrogen transferring operations

- **Task 5.1** – Hazard identification and damage state estimation
  - Sub-Task: 5.1.1 Hazard identification
  - Sub-Task: 5.1.2 Damage state of the installation resulting in the release of hydrogen
- **Task 5.2** – Consequence assessment
  - Sub-Task: 5.2.1 Modelling of accidental phenomena
  - Sub-Task 5.2.2: Vulnerability assessment
- **Task 5.3** – Frequency assessment and risk integration
  - Sub-Task: 5.3.1 Frequency of incident occurrence
  - Sub-Task: 5.3.2 Risk integration
- **Task 5.4** – Innovative safety strategies and engineering solutions
  - Sub-Task: 5.4.1 Safety barriers
  - Sub-Task: 5.4.2 Safety zoning strategies





# Thank you for your attention

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**Disclaimer:** Despite the care that was taken while preparing this document the following disclaimer applies: Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Clean Hydrogen JU. Neither the European Union nor the granting authority can be held responsible for them.

# Final remarks

## 1<sup>st</sup> ELVHYS stakeholders' workshop

- Excellent presentations from industries, government agency and other research project
- Collaboration between different groups is critical for the safe and efficient deployment of LH2 technologies
- Next stakeholders' workshop will be organized at the end of 2023
- Thank you all for joining and discussing
- Special thanks to the workshop organizers!
- Stay tuned, subscribe to the ELVHYS newsletter

QR code to ELVHYS website

