LH_2CRAFT Project - Safe and Efficient Marine Transportation of Liquid Hydrogen

Project developments and overview of present and future of H_2 in waterborne transportation

Towards Zero emissions Synergies Workshop
Lisbon, 10/12/2024

UK Research and Innovation
Clean Hydrogen Partnership
Co-funded by the European Union
UK participation in LH2CRAFT Project is funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe guarantee [grant numbers 10070575 and 10082044].

LH_2CRAFT Project - Safe and Efficient Marine Transportation of Liquid Hydrogen

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LH_2CRAFT Project

Presentation Outline

- Introduction to University of Strathclyde
- Project Overview
- Safety and Risk Assessment work

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University of Strathclyde

Department of Naval Architecture, Ocean and Marine engineering

- Research excellence, effective industrial partnerships and creative engineering education
- Rated 1st in the UK & Europe, 3rd in the world for Marine/Ocean Engineering by ShanghaiRanking 2022
- 141 years' history
- First world Naval Architecture Chair was established in the Department in 1883

29 Members of Staff	Student numbers
9 Professors	350 Undergraduates
8 Readers/Senior Lecturers	62 MSc
12 Lecturers	Over 140 PhD

- Students come from over 40 countries

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University of Strathclyde

Department of Naval Architecture, Ocean and Marine engineering

Research Units

Marine Transportation Research Unit	Ocean Energy Research Unit
the stability and survivability of ships	experimental hydrodynamics
human factors and navigational safety	marine computational fluid dynamics
energy-efficient ship design	ship stability and safety
marine engineering	structural integrity management
alternative fuels and emissions	offshore renewable energy devices/systems
lifecycle risk management	offshore/subsea infrastructure
	offshore decommissioning

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University of Strathclyde

Department of Naval Architecture, Ocean and Marine engineering

Alternative Fuels and Emissions Team

- Prof Peilin Zhou
- Dr Byongug Jeong
- Dr Haibin Wang
- Dr Ana Mesbahi
- Dr Hayoung Jang
- Dr Mujeeb Mughadar Palliparambil
- Dr InjunYang
- Dr Lin Yang
- Mr Insik Hwang
- Mr Binteng Gu
- Mr Panagiotis Gialelis

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Project Overview

Key Facts

Project dates:

01/06/2023– 31/05/2027

Total project budget:

7.664.269,67 €

14 partners

11 beneficiaries
3 associated partners

9 countries

Clean Hydrogen JU contribution:
5.627.595,94 €

Other financial contribution:
806.348,75 € UKRI
1.230.325,00 € HD KSOE

Expected TRL: TRL5 by the end of the project

***TRL5 refers to technology validated in relevant environment*

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Project Overview

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Horizon Europe
GA 101111972

Consortium

HYDRUS - *Project Coord.*	**NTUA**
HD KSOE	**TUD**
ABS	**UPATRAS**
RINA	**UoS**
BV	**GABADI**
WEGEMT	**ACTEMIUM**
EASN	**TWI**

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Project Overview

Main Objectives

LH_2CRAFT aims at developing next generation, sustainable, commercially attractive, and **safe long-term storage and long-distance transportation of large amounts of Liquid Hydrogen (LH_2)** for commercial vessels.

The project focuses on developing an **innovative containment system of membrane-type for large capacity storage (e.g. 160k-200k m^3) at a temperature of -253 °C,** demonstrating and validating it on a **10 ton (180 m^3) prototype**.

The **CCS** will achieve **AiP and General Approval** by ABS Classification Society, whereas **AiP** will be also issued for the concept design of the **auxiliary systems (HDMSS)**.

LH_2CRAFT will also develop a **preliminary integrated LH_2 carrier ship design**, while **alternative conceptual designs of CCS and LH_2 carrier vessels**, including detailed safety and risk assessment, will be examined.

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Work Packages

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Work Breakdown

WP	LEADING PARTNER
WP1 - Project Management	HYDRUS
WP2 – LH_2 Containment Implementation Plan and Evaluation Criteria Completed	RINA
WP3 – Conceptual Engineering Design for the LH_2 Tank Storage & Scalability Scenarios	HD KSOE
WP4 – Preliminary Integrated Ship Design for an Innovative LH_2 Carrier	HYDRUS
WP5 – Engineering Design Process for Handling, Distribution & Monitoring Subsystems (HDMSS)	NTUA
WP6 – Subsystems testing for thermo-mechanical validation Not Started	TUD
WP7 – Assembly, Manufacturing, Demonstration and Functionality Testing of the Prototype Not Started	GABADI
WP8 – Safety and Risk Assessment of the LH_2 CCS	UoS
WP9 – Approval-in-Principle and General Approval of the LH_2 CCS and HDMSS	ABS
WP10 – Technical Assessment KPIs and LCA	TWI
WP11 – Dissemination, Exploitation and Communication	HYDRUS

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Project Overview

Core Technologies

Core technology	Way towards materialization	Goal TRL
Design of insulation system to accommodate LH_2 temperatures (-253 °C) and minimizing boil-off rate	Expand the corresponding existing LNG containment system technology to meet the new stringent requirements	5 by M48
Modular and adaptable CCS design, to fit in cargo holds of various shapes and sizes	CCS comprised of modular, repeatable unit modules. Standardized connecting modules for joints with specific angle values.	5 by M48
Technology for integrating the proposed CCS into the hull structure	Expand the corresponding existing LNG containment system technology	5 by M48
Technology for manufacturing the CCS and erecting it inside a vessel cargo hold	Expand the corresponding existing LNG containment system technology	5 by M48

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Project Timeline

Key Milestones / Checkpoints

Year 1 (June '23 – May '24)

- June '23 — **Project Start**
- Analysis of H_2 Trade & Demonstration Requirements **(WP2)**
- May '24 — Definition of Testing Reqs. for the CCS **(WP2)**; Detailed benchmark of alt. CCSs **(WP2)**

Year 2 (June '24 – May '25)

- June '24 — HAZID Workshop **(WP8)**
- Conceptual CCS design **(WP3)**
- HAZOP Workshop **(WP8)**

Year 3 (June '25 – May '26)

- June '25 — FMEA Workshop **(WP8)**
- Issuance of AiP for the LH_2 CCS **(WP9)**
- Detailed Eng. Design of the Prototype Tank Completed **(WP7)**
- Preliminary LH_2 carrier design **(WP4)**

Year 4 (June '26 – May '27)

- Integration solutions for alternative CCSs **(WP4)**
- Prototype Tank Manufacturing **(WP7)**
- Prototype Tank Testing **(WP7)**
- May '27 — General Approval for the LH_2 CCS **(WP9)**; **Project End**

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WP8 - Safety and Risk Assessment of the LH_2 CCS

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This WP will ensure and enhance the safety of the engineering and detailed LH_2 storage design (WP2 to 6) and prototype testing (WP7) while proposing optimal design solutions for minimizing potential risks so as to achieve **Approval in Principle (AiP) and general Class Approvals**.

WP Objectives:

- Safety evaluation of conceptual/detailed designs of the demonstrator conducted.
- Optimal solutions for risks associated with designing testing of the demonstrator.
- Qualitative and quantitative consideration of key potential hazard elements
- Control of identified risks and implementation of safety solutions to the demonstrator.
- Design guidelines for general applicability and demonstration of scalability
- Comparison with other types of storage systems and highlighting of safety differences and similarities

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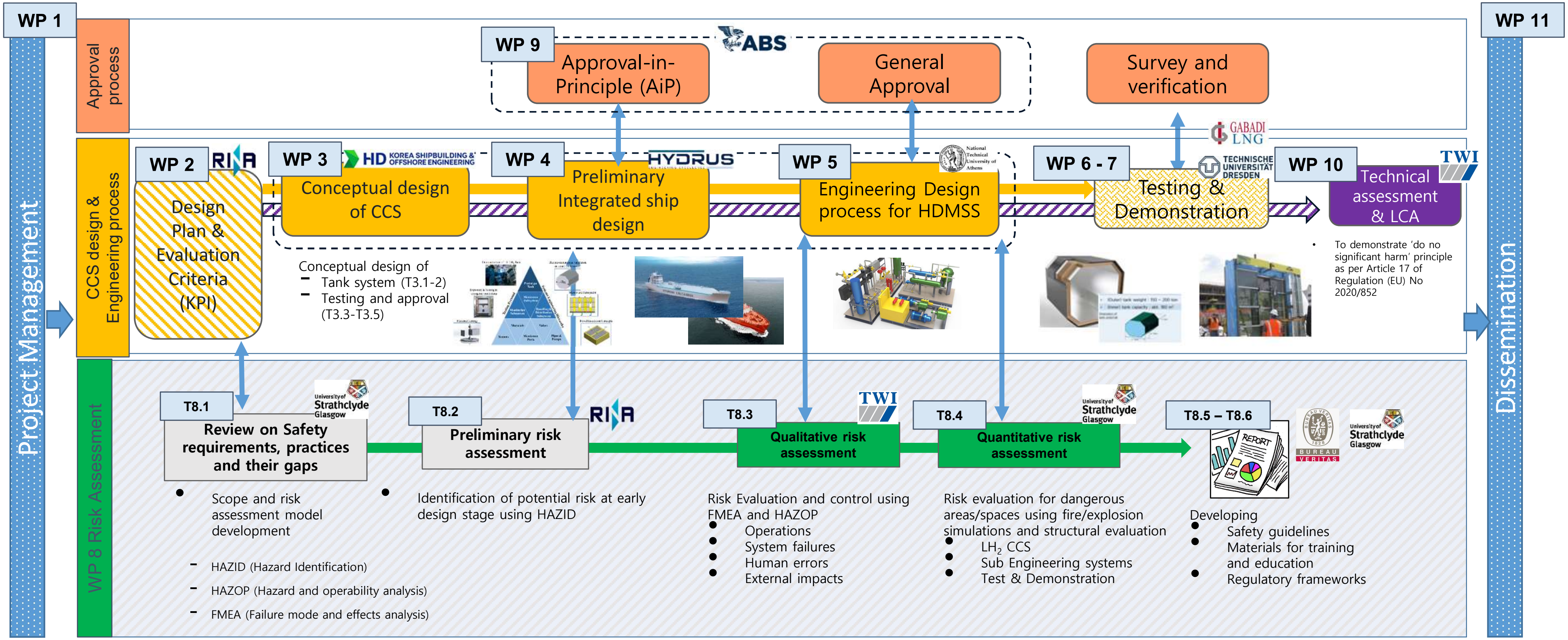
WP8 Workflow



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Quantitative Risk Assessment

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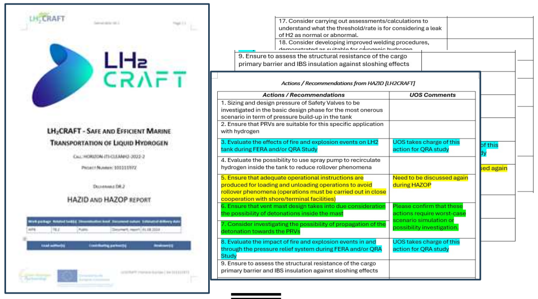
List of hazard scenarios identified from the HAZID workshop



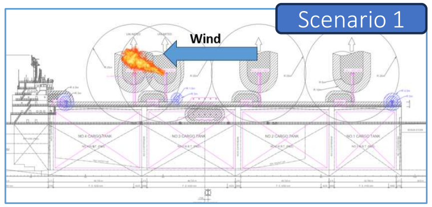
Preparation of the scope of each scenario to be evaluated

Literature review and validation studies relevant to each scenario

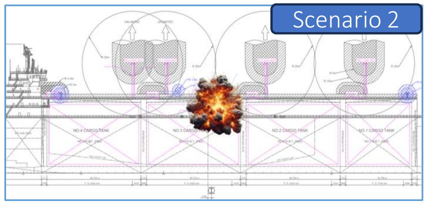
Scenarios simulations

QRA Scenarios 1 - 8

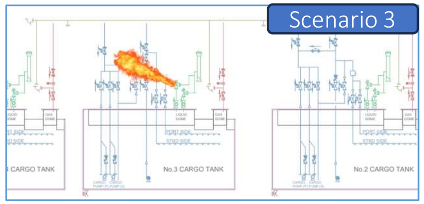
Scenario 1



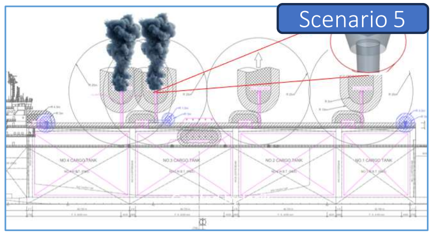
Scenario 2



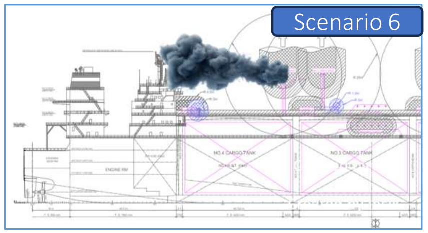
Scenario 3



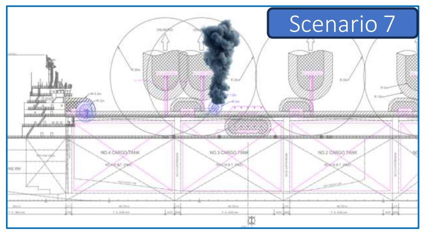
Scenario 5



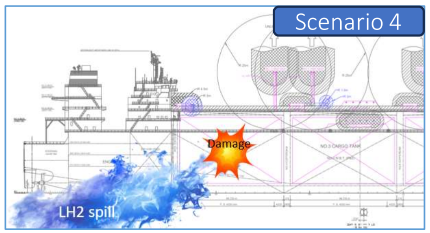
Scenario 6



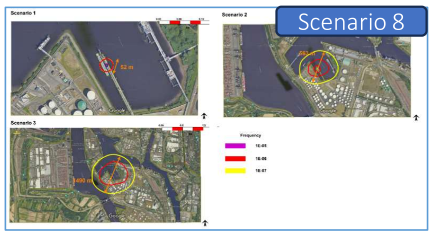
Scenario 7



Scenario 4



Scenario 8



WP3
CCS design

WP4
Integrated ship design

WP5
HDMSS

AiP report for LH_2 CCS and HDMSS

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Next Steps

WP8:

- Completion of QRA studies
- HAZOP and FMEA Workshops

Overall:

- Completion of CCS design and materials selection
- Update of HDMSS drawings based on HAZID outcomes
- Further design analysis of LH_2 carrier
- Completion of materials testing list and procedures

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https://www.linkedin.com/showcase/lh2craft/

Thank you!

https://lh2craft.eu/

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