Digital Stakeholders Workshop
HyTunnel-CS project
4-5 May 2020

Introduction to HyTunnel-CS project

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(on behalf of project partners)

Introduction

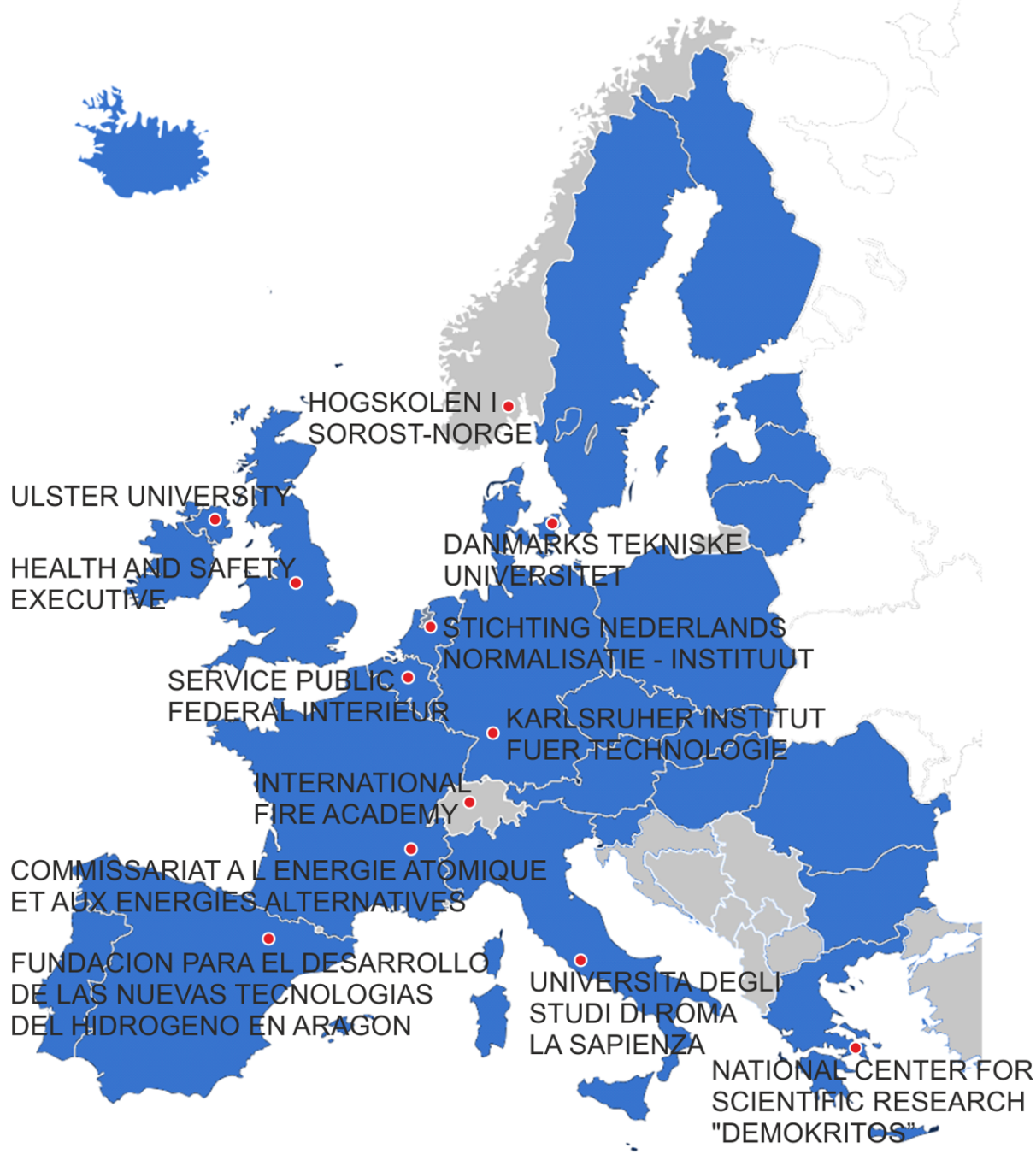
Project title, funding body, budget, duration

- **Title: "Pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces"** (Grant agreement No. 826193)
- **Funding body:** Fuel Cell and Hydrogen 2 Joint Undertaking (FCH2 JU) receiving funding from the European Union's Horizon 2020 research and innovation programme
- **Budget:** €2,500,000
- **Duration:** 3 years (01 March 2019 – 29 February 2022)

Partners: 13

Countries: 11

	UNIVERSITY OF ULSTER
	KARLSRUHER INSTITUT FUER TECHNOLOGIE
	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"
	HOGSKOLEN I SOROST-NORGE
	HEALTH AND SAFETY EXECUTIVE
	DANMARKS TEKNISKE UNIVERSITET
	FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON
	INTERNATIONAL FIRE ACADEMY
	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA
	STICHTING NEDERLANDS NORMALISATIE - INSTITUUT
	SERVICE PUBLIC FEDERAL INTERIEUR
	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES
	PRO-SCIENCE - GESELLSCHAFT FUR WISSENSCHAFTLICHE UND TECHNISCHE DIENSTLEISTUNGEN MBH



Aim and objectives

Aim

To perform pre-normative research for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces.

Objectives (1/2)

- Carry out critical analysis of conventional safety measures effectiveness in tunnels and underground infrastructure.
- Generate unique experimental data for interaction of hydrogen with tunnel safety equipment and systems.
- Create deeper knowledge of the relevant physics to underpin advanced hydrogen safety engineering and develop innovative prevention and mitigation strategies.
- Reduce over-conservatism and increase efficiency of installed safety equipment to save costs.

Aim and objectives

Objectives (2/2)

- Develop further existing and new contemporary CFD and FE models, engineering correlations, hazard and risk assessment tools; validate them against generated experimental data.
- Prepare harmonised recommendations for intervention strategies and tactics for first responders during accidents with hydrogen-powered vehicles in tunnels, underground parking, etc.
- Develop recommendations for inherently safer use of hydrogen vehicles in underground transportation systems.
- Produce commonly agreed, scientifically based recommendations for the update of relevant RCS
- Level up the safety culture of using hydrogen cars in general and especially in confined spaces.

Aim and objectives

The objectives are realistic and achievable

This follows from the international leadership and recognised standing of the consortium members in areas of hydrogen safety and tunnel safety, including their:

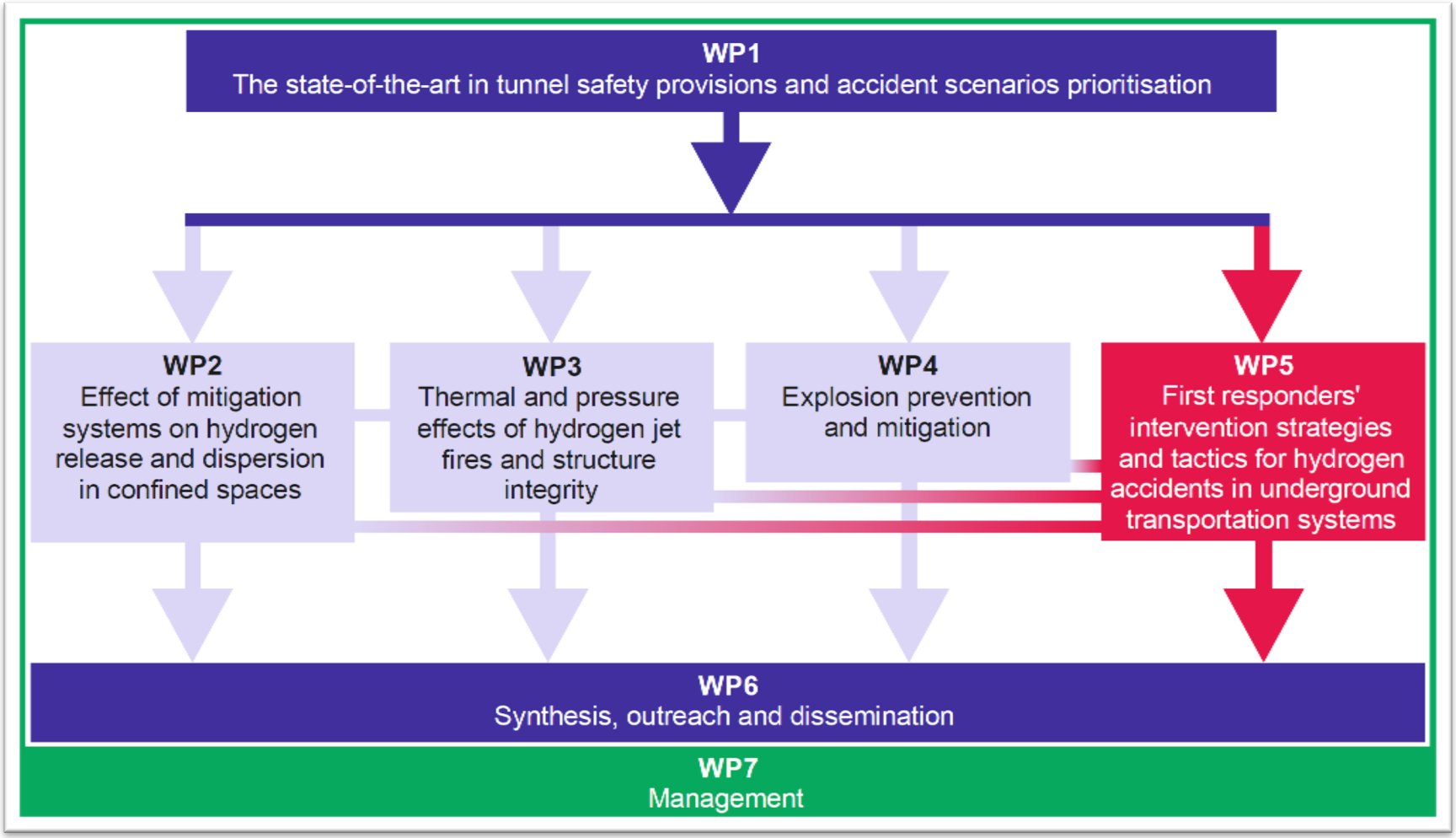
- Unique experimental facilities
- Strong legacy of publications in peer-reviewed journals
- Access to exclusive state of the art in-house modelling capabilities and numerical tools
- World leading experience in the development of engineering correlations, including for e-Laboratory of Hydrogen Safety
- Unique practical knowledge in accident scene intervention strategies and tactics
- Knowledge of procedures of standard development organisations (SDO), etc.

The concept

- Efforts to address safety of hydrogen vehicles in tunnels and confined spaces were at rudimental level (no one of previous EU studies on tunnel safety: FIT, DARTS, Safe Tunnel, Sirtaki, Virtual Fires, UPTUN, SafeT, EuroTAP, L-surf, addressed issues of hydrogen safety).
- The overall concept behind this project is to use inter-disciplinary and inter-sectoral pre-normative research by bringing together theoretical, modelling and experimental studies to maximise the impact.
- HyTunnel-CS addresses knowledge gaps and technological bottlenecks in inherently safer use of hydrogen vehicles in underground traffic infrastructure for both road and rail tunnels.
- The originality of the overall concept is consideration of hydrogen vehicle and underground traffic structure as a *single system* with *integrated safety approach*.

The methodology

Partners started working together in building collaboration from day one in WP1. The core of the project are three phenomena oriented WP2-4, and response oriented WP5.



HyTunnel-CS ambitions (1/3)

The main ambition: allow hydrogen-powered vehicles and transport enter underground traffic infrastructure with risks at least at the same level as today's fossil fuel transport or below.

The project is ambitious as it claims to:

- Provide new essential knowledge, close knowledge gaps and resolve technological bottlenecks in provision of safety of hydrogen transport in tunnels and similar confined spaces.
- Bring together different groups of stakeholders (SAB and NN role).
- Validate and disseminate novel safety strategies and engineering solutions for hydrogen safety engineering as well as first responders' intervention and tactics at the accident scene in the underground traffic systems.
- Perform for the first time large-scale and real scale experiments with hydrogen releases, fires and explosions in tunnels.
- Generate broad consensus about the research results and thus initiate amendments in relevant RCS already during the project.

HyTunnel-CS ambitions (2/3)

- The project ambition is to add consequences analysis of hydrogen fires and different types of explosions to the risk assessment in tunnels using contemporary methods.
- The tailored for underground traffic infrastructure QRA methodology will be informed by the Bayesian Belief Networks, and then expanded by innovative dynamic risk models, will include probit functions, etc.
- New validated tools for hydrogen safety engineering will be developed, e.g. considering “new hazards” like blast wave and fireball scenarios following the tank rupture in a fire.
- Two types of explosion are being investigated: (1) deflagration of flammable hydrogen-air cloud, and (2) tank rupture in a fire. The ambition is to close knowledge gaps for both scenarios using experiments in real tunnels.
- The ambition is to better understand the spalling of selected concretes and provide PNR results to the Eurocodes update.

HyTunnel-CS ambitions (3/3)

HyTunnel-CS ambitions include the safety underpinning of:

- Scaling up the usage of hydrogen as clean energy carrier in mobile applications and traffic infrastructure.
- Provision of safe traffic infrastructures throughout Europe adapted to prevent potential hydrogen accidents for a sustainable development of hydrogen energy for mobile applications.
- Novel prevention and mitigation measures against hydrogen fires and explosions.
- Intervention procedures preventing hydrogen release incidents and potential follow-up accidents in tunnels.
- National and international RCS in terms of hydrogen risk.
- Essential safety guidelines for the construction and/or upgrade of the confined traffic facilities like road/rail tunnels, underpasses and underground park houses, etc.

Beyond the state-of-the-art (1/2)

HyTunnel-CS will develop beyond the state-of-the-art contemporary CFD models, advanced engineering tools and correlations to assess hazards and define hazard distance in case of hydrogen release, fire or explosion event, etc.

Examples of beyond the state-of-the-art project products are:

- KIT will develop fast flame criteria and deflagration to detonation transition criteria tailored for tunnel systems.
- KIT will create theoretical models for mitigation systems in underground traffic infrastructure (ventilation, spray, foam) and implement them in their computational suite HyCodes.
- DTU in collaboration with UU will develop coupled CFD/FEM simulation capability for concurrent action of fire and explosion.

Beyond the state-of-the-art (2/2)

- IFA will develop new and enhance existing procedures to cope with hydrogen incidents in tunnels and introduce it to its internationally acclaimed training programme.
- KIT will develop a model for attenuation of blast wave and hydrogen combustion by water mist/spray.
- UU, HSE, CEA will estimate the fraction of energy released after tank rupture in a fire on deformation of car body.
- UU, HSE, CEA will scrutinise the breakthrough safety technology of TPRD-less tank that excludes tank rupture in a fire and its catastrophic results. The technology provides:
    - No blast wave
    - No fireball
    - No projectiles
    - No long flames
    - No pressure peaking phenomenon

HyTunnel-CS expected impacts (1/3)

- The outcomes of HyTunnel-CS will contribute to the development of RCS for safer use of hydrogen in underground traffic systems and similar confined spaces.
- HyTunnel-CS will underpin the commercialisation, safer deployment, and public acceptance of FCH technologies.
- HyTunnel-CS contributes to each of 8 expected impacts in the FCH2 JU work plan as follows:
  1. "*Unique experimental data concerning the interaction of hydrogen with tunnel safety equipment and … confined infrastructures*" by performing series of experiments in the best European facilities including real tunnels.
  2. "*Deeper knowledge of the relevant physics will provide better hydrogen safety engineering to underpin the development of innovative prevention and mitigation strategies*" will be through performing integrated theoretical, numerical and experimental studies to close knowledge gaps and develop and validated contemporary CFD/FEM models and novel engineering correlations.

HyTunnel-CS expected impacts (2/3)

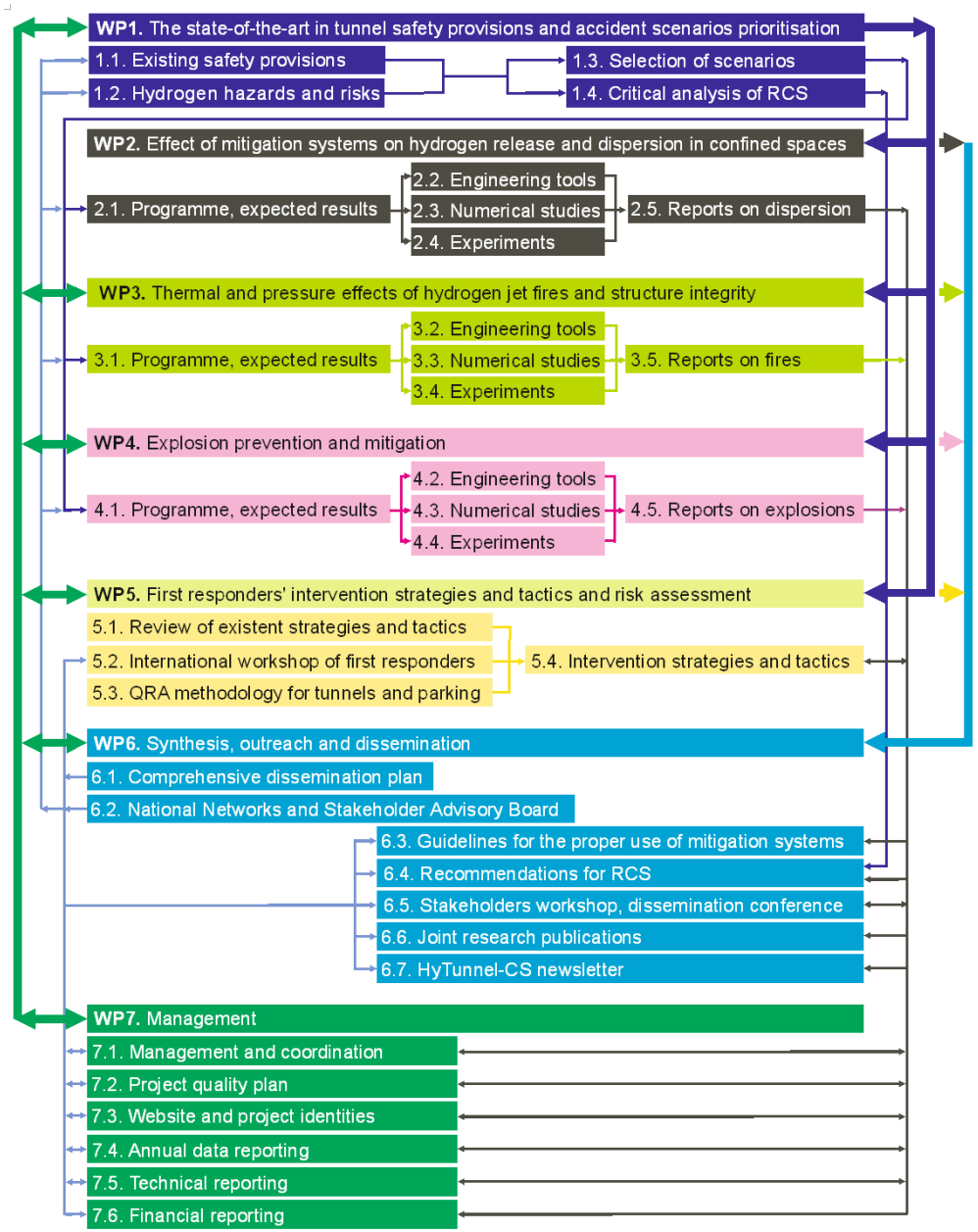
3. "*Experimental data to support further development and validation of relevant physics models, simulation and risk assessment tools*" will be achieved through the use of experiments to validate models (WP2-4) to be used in the quantitative risk assessment (WP5).
4. "*Recommendations for prevention and mitigation concepts for inherently safer use of hydrogen vehicles and safer transport of hydrogen in tunnels, and other confined infrastructures, such as underground parking*" are the key outputs of the project (D6.9).
5. "*Analysis of effectiveness of conventional safety measures in tunnels and other confined infrastructures like underground garages, etc*." will be performed at the start of the project (D1.1) and as a result of studies on the interaction of conventional safety measures (ventilation, water sprays, mist, foam, bulkheads, etc.) with hydrogen in WP2-4 (including D2.3, D3.3, D4.3).
6. "*Potential reduction of over-conservatism and increased efficiency of installed safety equipment will save costs*" will be done through the "system level" approach, in which a vehicle and an underground traffic facility are considered together as one "system" over which hazards, and associated risks are assessed.

HyTunnel-CS expected impacts (3/3)

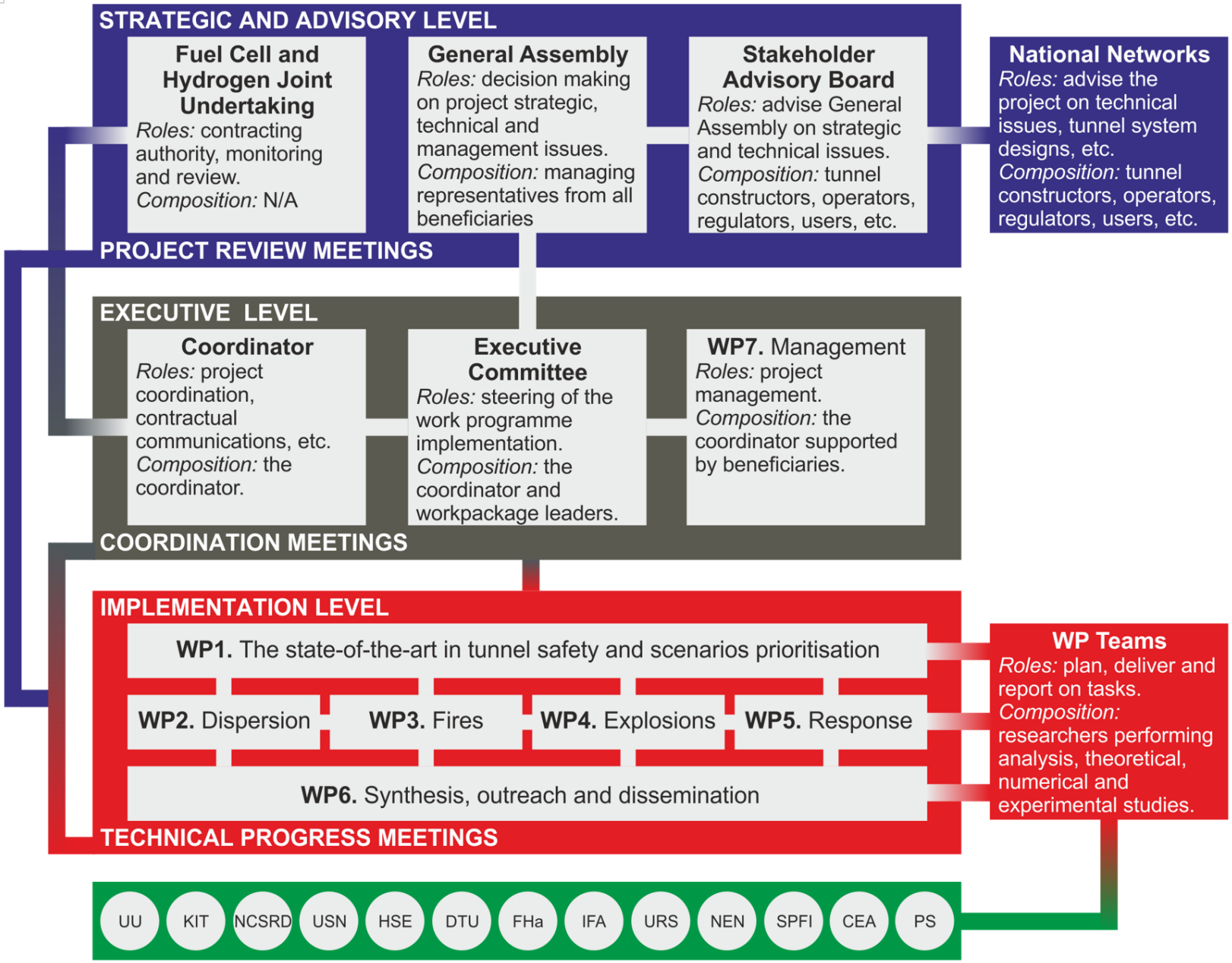
7. One of the most important impacts is "*More appropriate intervention strategies and tactics for first responders to tackle potential accidents with hydrogen powered vehicles in tunnels and underground parking etc. will protect life of first responders, people and property*". Leading experts in hydrogen safety will transfer knowledge to emergency services. This will be done through internal seminars, external workshops, communications with members of SAB and National Networks. The outcome is D5.4 "Harmonised recommendations on response to hydrogen accidents". Collaboration with HyResponder.
8. Contribution to impact "*Commonly agreed, scientifically based recommendations for the update of relevant RCS will lead to a more harmonised normative landscape and level up the safety culture in general*" will be throughout the project, including active participation of HyTunnel-CS partners in activities of SDO and regulatory groups. It will be finalised as "Recommendations for RCS" (D6.10).

The outcomes of HyTunnel-CS will be applicable beyond the Transport to Energy Systems, e.g. validated engineering tools on dispersion, fires and explosions will also be relevant for power and heat generation plants, large-scale storage and more. They are planned to be included into online free access **e-Laboratory of Hydrogen Safety (NET-Tools output)**.

HyTunnel-CS components interaction



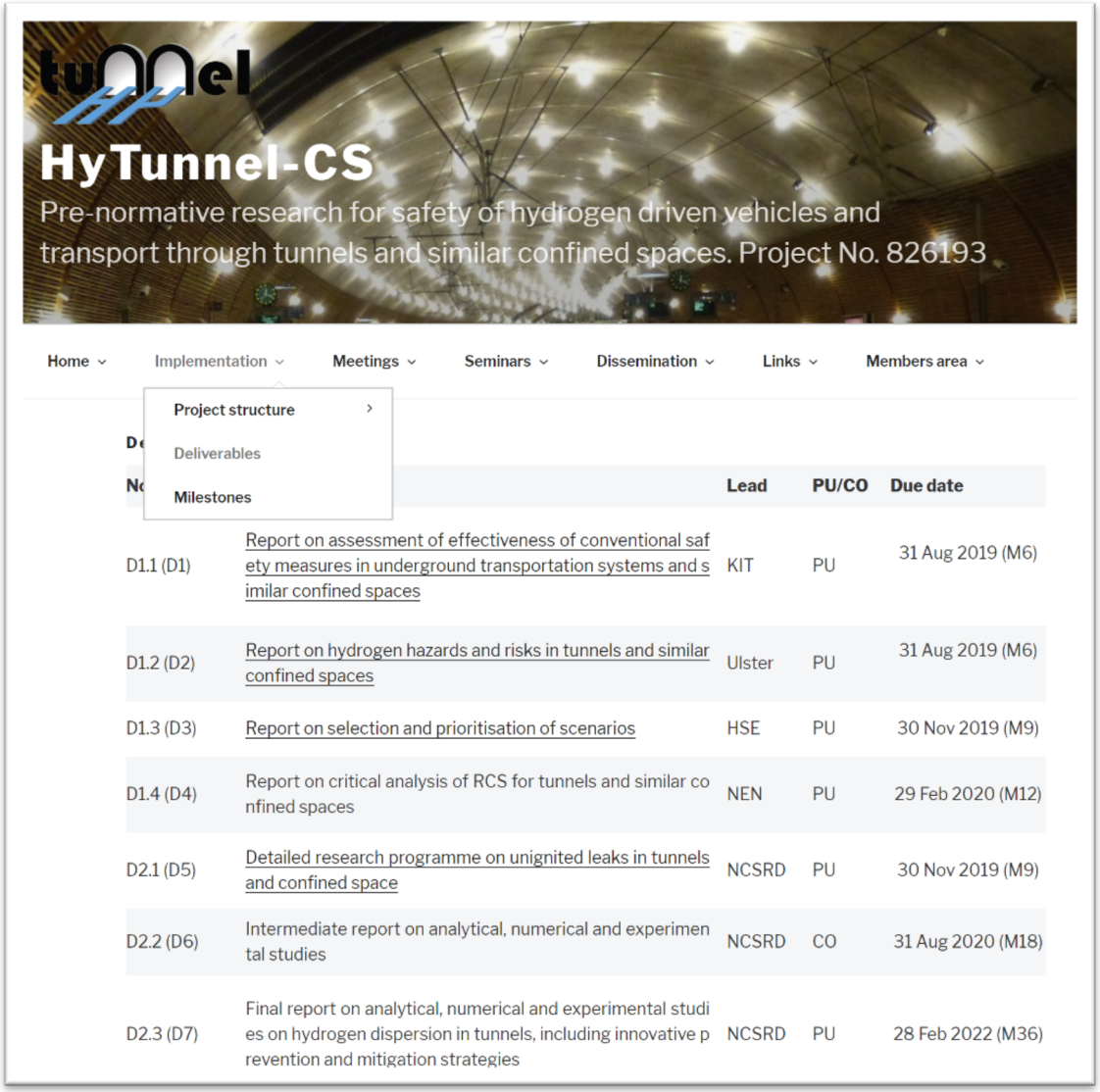
HyTunnel-CS organisational structure



HyTunnel-CS website

www.hytunnel.net

- Contact channel
- Access to all project outcomes (26 after the project completion)
- Schedule of meetings and events
- Newsletters
- Journal and conference publications



		Lead	PU/CO	Due date
D1.1 (D1)	Report on assessment of effectiveness of conventional safety measures in underground transportation systems and similar confined spaces	KIT	PU	31 Aug 2019 (M6)
D1.2 (D2)	Report on hydrogen hazards and risks in tunnels and similar confined spaces	Ulster	PU	31 Aug 2019 (M6)
D1.3 (D3)	Report on selection and prioritisation of scenarios	HSE	PU	30 Nov 2019 (M9)
D1.4 (D4)	Report on critical analysis of RCS for tunnels and similar confined spaces	NEN	PU	29 Feb 2020 (M12)
D2.1 (D5)	Detailed research programme on unignited leaks in tunnels and confined space	NCSRD	PU	30 Nov 2019 (M9)
D2.2 (D6)	Intermediate report on analytical, numerical and experimental studies	NCSRD	CO	31 Aug 2020 (M18)
D2.3 (D7)	Final report on analytical, numerical and experimental studies on hydrogen dispersion in tunnels, including innovative prevention and mitigation strategies	NCSRD	PU	28 Feb 2022 (M36)

Acknowledgements

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