

European Network of Excellence HySafe

## **“Safety of Hydrogen as an Energy Carrier”**

(Contract No. SES6-CT-2004-502630, 01.03.04-28.02.09, €13M/€7M)

Presented by Vladimir Molkov, University of Ulster, on behalf of HySafe partners  
H2NET Seminar (in association with UKHA) – 17 October 2006

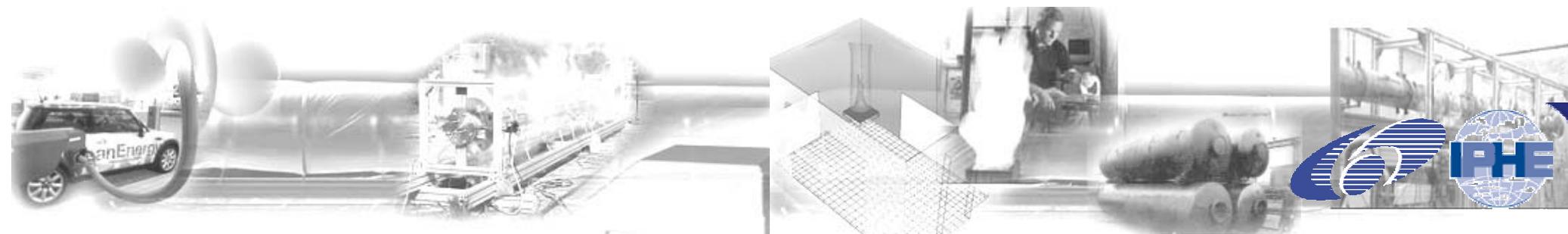
[www.hysafe.org](http://www.hysafe.org)





**Think SAFETY first!**

**Fire and explosions on refuelling station**





## ***General Goal of NoE HySafe***

Contributing to a **safe transition** to a **sustainable development** in Europe by facilitating the **safe introduction of hydrogen technologies/applications**

## ***Objectives***

- Strengthen and focus, **integrate fragmented research** on hydrogen safety → **(establish European Institute for Hydrogen Safety)**
- Promoting **public awareness and trust** in hydrogen technologies
- Development of an excellent **safety culture**



# Consortium

## 25 partners from:

- 12 research organizations and governmental agencies,
- 6 universities,
- 7 industrial partners

## From 13 countries:

- Germany (5 partners)
- France (3)
- Norway (3)
- UK (3)
- Netherlands (2)
- Spain (2)
- Denmark (1)
- Greece (1)
- Italy (1)
- Poland (1)
- Portugal (1)
- Sweden (1)
- Canada (1)

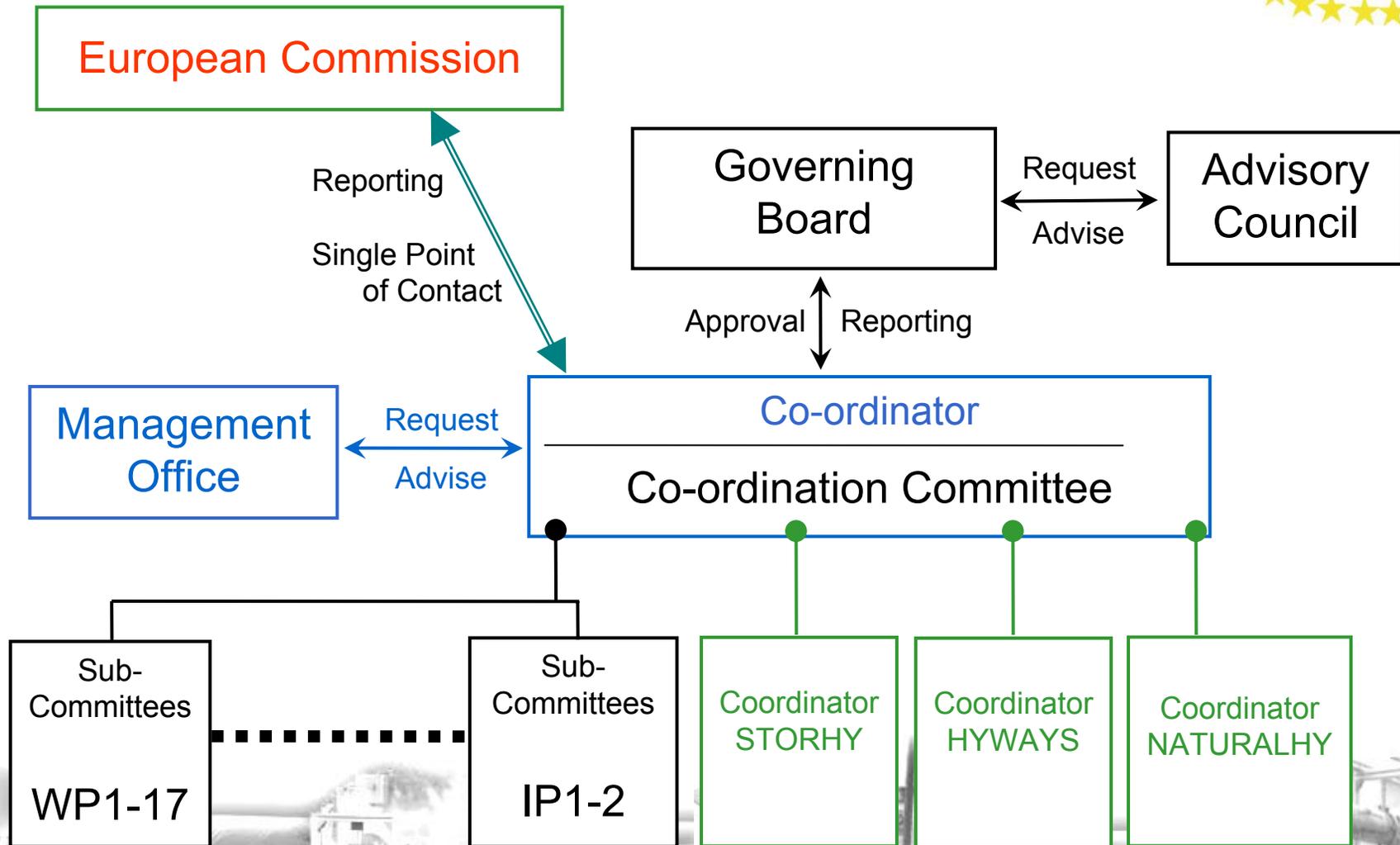
**New partner – KI (Russia), 2006**

**About 150 researchers**

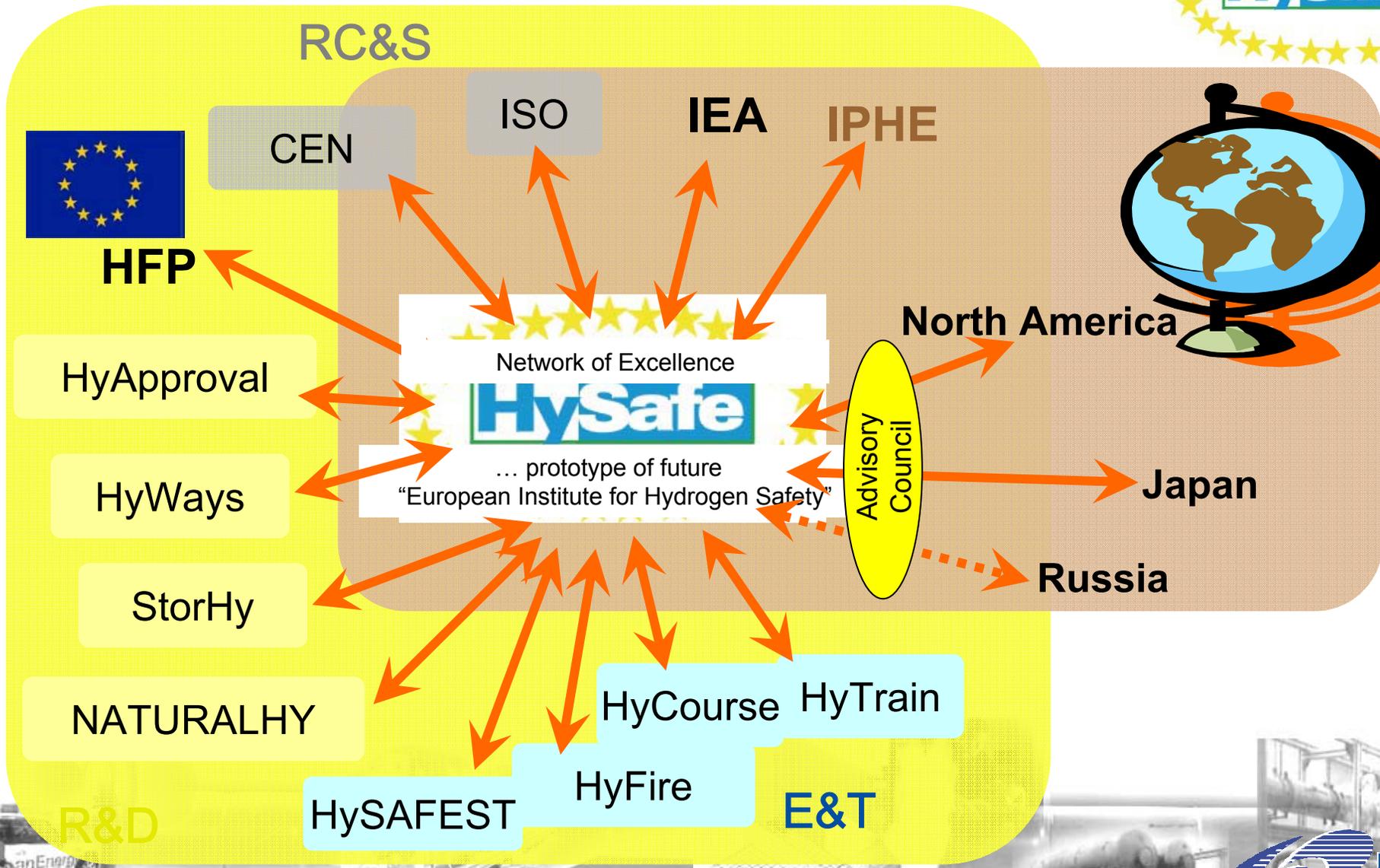


Forschungszentrum Karlsruhe GmbH, coordinator	DE
L'Air Liquide	FR
Federal Institute for Materials Research and Testing	DE
BMW Forschung und Technik GmbH	DE
Building Research Establishment Ltd	UK
Commissariat à l'Énergie Atomique	FR
Det Norske Veritas AS	NO
Fraunhofer-Gesellschaft ICT	DE
Forschungszentrum Jülich GmbH	DE
GexCon AS	NO
The United Kingdom's Health and Safety Laboratory	UK
Foundation INASMET	ES
Inst. Nat. de l'Environnement industriel et des RISques	FR
Instituto Superior Technico	PT
European Commission - JRC - Institute for Energy	NL
National Center for Scientific Research Demokritos	EL
Norsk Hydro ASA	NO
Risø National Laboratory	DK
TNO	NL
University of Calgary	CA
University of Pisa	IT
Universidad Politécnica de Madrid	ES
University of Ulster	UK
VOLVO Technology Corporation	SE
Warsaw University of Technology	PL

# Organisational structure



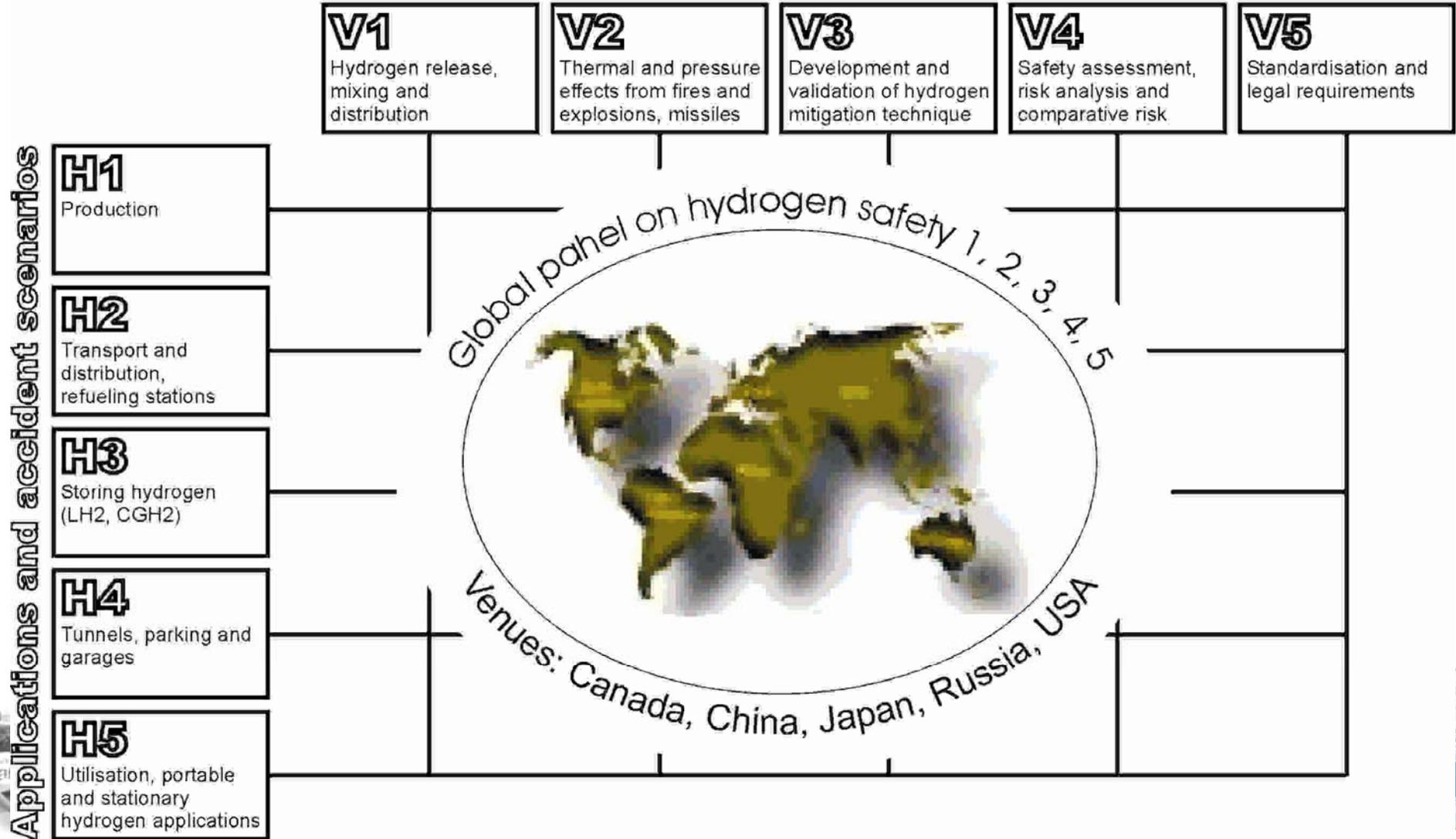
# Enhancing external collaboration



# The HySafe activity matrix



## Phenomena, hazards and risks



# 4 Clusters, 15 Workpackages, 2 Internal Projects

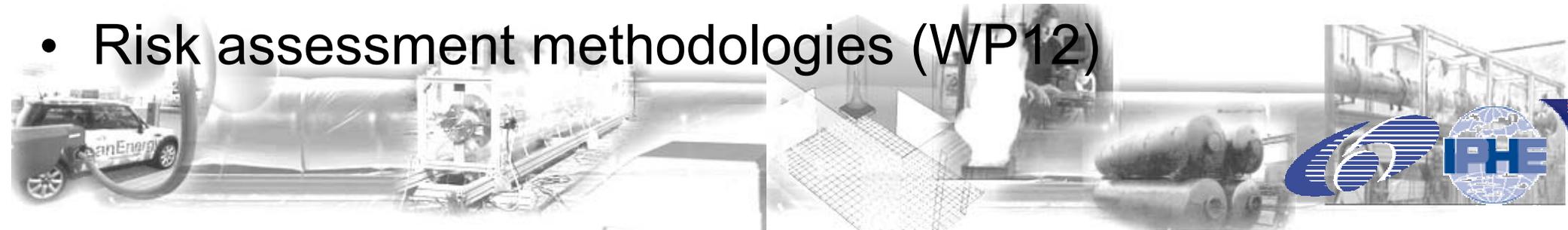


## Cluster “Phenomena”

- Hydrogen release, mixing and distribution (WP8)
- Hydrogen ignition and jet fires (WP9)
- Hydrogen Explosions (WP10)
- Mitigation (WP11)
- Material Compatibility and Structural Integrity (WP18)

## Cluster “Tools”

- Integration of Experimental Facilities (WP2)
- Numerical Tools (WP6)
- Risk assessment methodologies (WP12)



# 4 Clusters, 15 Workpackages, 2 Internal Projects



## Cluster “Dissemination”

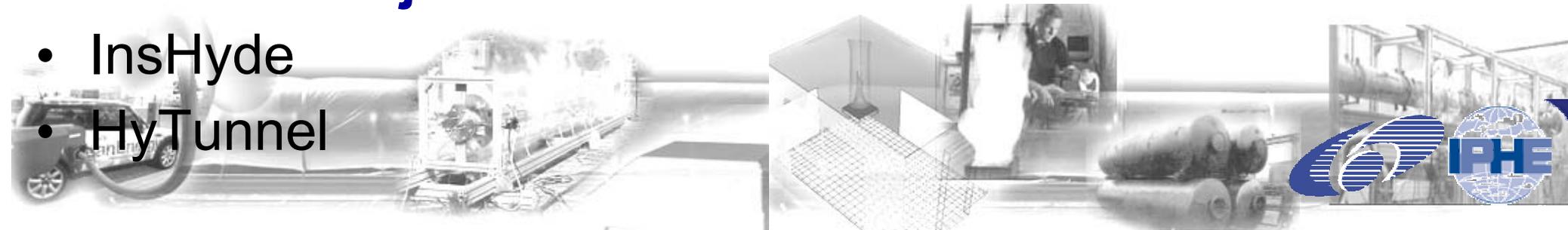
- Biennial Report on Hydrogen Safety (WP1)
- Hydrogen Incident and Accident Database (WP5)
- International Conference on Hydrogen Safety (WP14)
- e-Academy of Hydrogen Safety (WP15)
- Contribution to Standards and Legal Requirements (WP16)

## Cluster “Management”

- Strategies (WP7)
- Management (WP17)

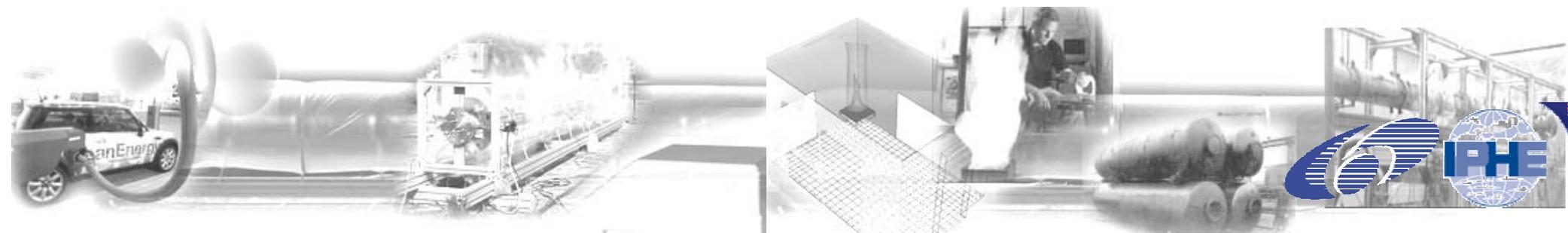
## Internal Projects

- InsHyde
- HyTunnel





Some examples of  
**SUCCESSFUL INTEGRATION**



# Integration success

# The most informative Website



www.hysafe.org

HySafe Home

Navigation: > HySafe Home

Site map

## HySafe Home

**Menu:**

- Project Summary
- News
- Participants
- Supporters
- Work Packages
- Project Proposals
- Links
- Documents
- Meetings
- E-Academy
- International Conference on Hydrogen Safety
- Contact
- Members area

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Thomas Jordan  
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**Edit item:**

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### Safety of Hydrogen as an Energy Carrier

The EC funded Network of Excellence (NoE) HySafe<sup>\*)</sup> contributes to the safe transition to a more sustainable development in Europe by facilitating the safe introduction of hydrogen technologies and applications.

The HySafe network will bring together competencies and experience from various research and industrial fields (automotive, gas and oil, chemical and nuclear). Much effort has been concentrated on the hydrogen safety issues relevant to the nuclear industry during the past 20 years, including comprehensive safety studies and the development of innovative mitigation techniques. At the same time industry and research dealing with today's fossil energy carriers are now confronting issues associated with everyday use of the technology by the general public.

Synthesis, integration, and harmonisation of these efforts is expected to break new ground in the field of hydrogen safety and contribute to the increase of public acceptability of hydrogen as an energy carrier.

The consortium consists of 25 partners including

- research organizations,
- governmental agencies,
- universities,
- industry

from 12 countries:  
Germany (5 partners), France (3), Norway (3), UK (3), Netherlands (2), Spain (2), Denmark, Greece, Italy, Poland, Portugal, Sweden and Canada.

The Advisory Council includes a balanced representation of partners, distinguished scientists outside the network, and representatives from industry and authorities

Integration of > 100 researches and doctoral students

Project duration: 5 years

<sup>\*)</sup>A research project supported by the European Commission under the 6th Framework Programme and contributing to the implementation of the Key Action "Integrating and strengthening the ERA" within the Energy, Environment and Sustainable Development  
Contract n°: SES6-CT-2004-502630

Disclaimer: the author ([webmaster@hysafe.net](mailto:webmaster@hysafe.net)) is solely responsible for, it does not represent the opinion of the Community and the Community is not responsible for any use that might be made of data appearing therein.  
Revised: June 11, 2004



# Integration success

# Experimental Facilities (6 of 80)



## MISTRA

*cylindrical steel vessel*

*originally designed as 1/10<sup>th</sup> in linear scale of Pressurized Water Reactor containment*

*studies of H<sub>2</sub> (simulated by He) release and distribution in a confined geometry*



**366m gallery/tunnel**

*Concrete test enclosure/tunnel*

*Full/large scale*

*Combustion and ventilation controlled overpressures  
Fragmentation.*

V1, V2 and H4, H5

## REKO-2



## GexCon 168 m<sup>3</sup> open geometry with internal obstructions

*explosion vessel*

*large scale (168 m<sup>3</sup>)*

*studies on explosions in open, congested geometries*



## Flame Acceleration Pad (FAP)



## A1 Vessel

*cylindrical vessel*

*full or large scale*

*studies on turbulent combustion and detonations, vented explosions, hydrogen distribution, integrity of mechanical structures under high pressure load*

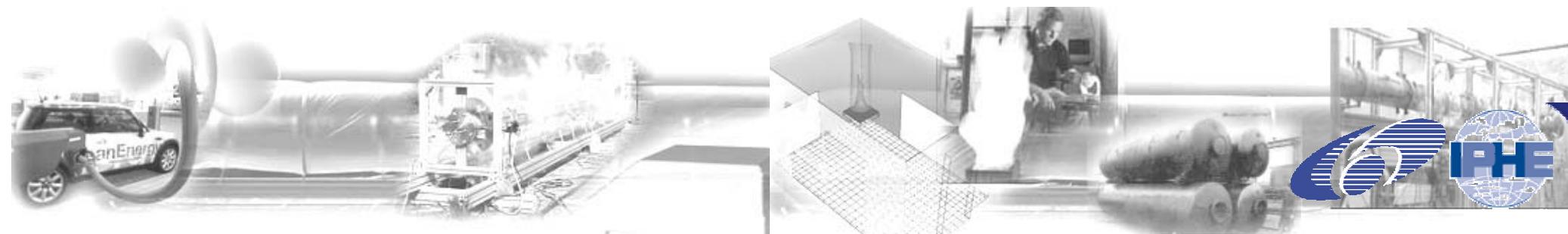


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# CFD benchmark exercises



- GH2 release and distribution in enclosures
- LH2 release in open atmosphere
- Stoichiometric H<sub>2</sub>-air deflagration in atmosphere
- High pressure free hydrogen jets
- Deflagration-to-detonation transition
- ...

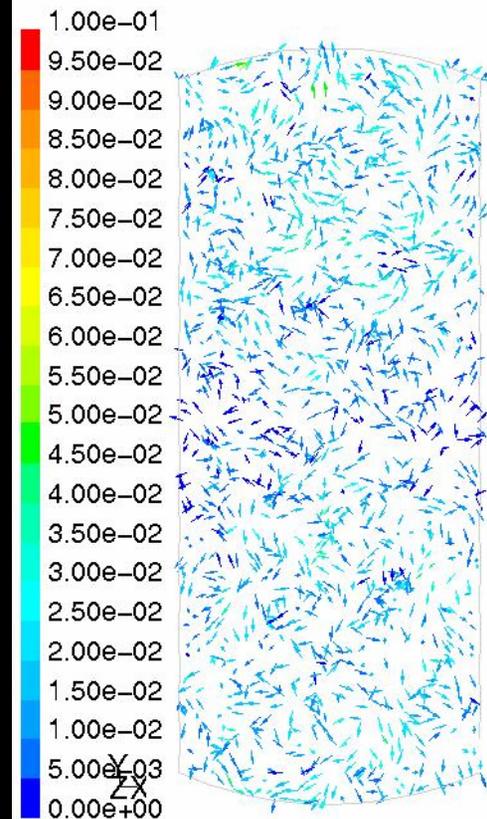


# SBEP: subsonic release

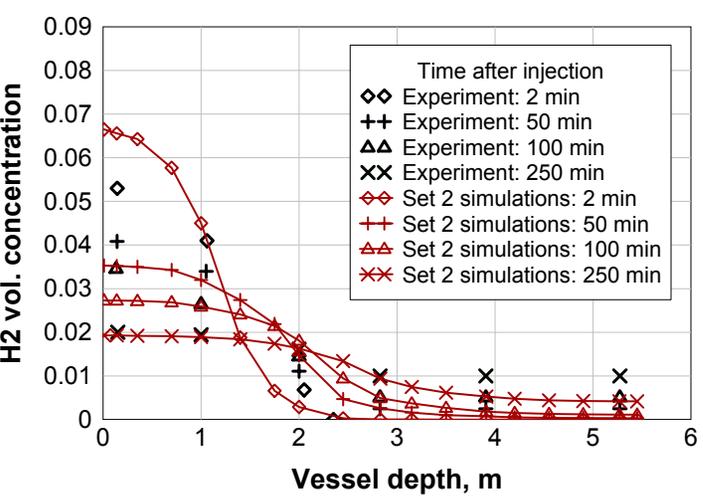
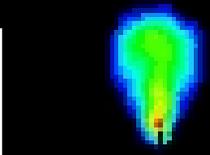
Vessel: 20m<sup>3</sup> (Russian test 2)  
Injection: 10mm, 60s, 57m/s



**Residual velocity:  
 250min V=5 cm/s**



0.80  
 0.54  
 0.49  
 0.43  
 0.38  
 0.32  
 0.26  
 0.21  
 0.15  
 0.10  
 0.04



# **SBEP: Largest LH2 spill (NASA)**

361.8 kg of LH2 in 38 s



## **NASA Test 6 (movie)**

**NASA Test 6 simulation (movie)**



# SBEP: Largest deflagration in atmosphere

Volume 2094 m<sup>3</sup>; D=20 m (Fraunhofer ICT, Germany)



10  
m

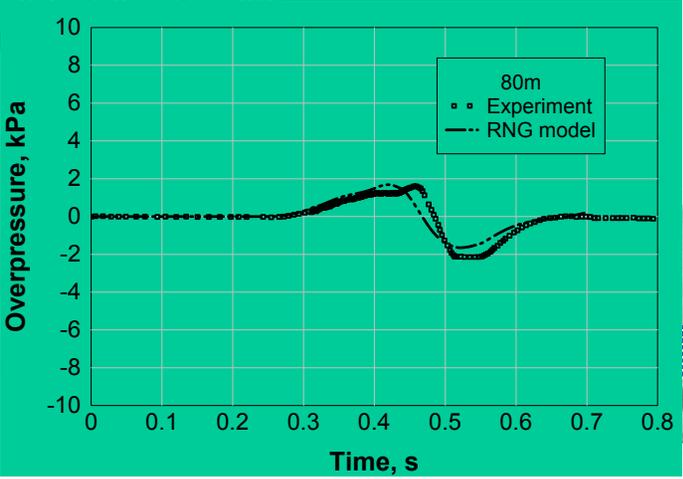
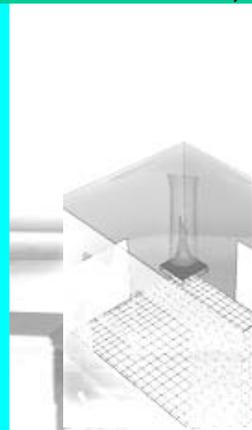
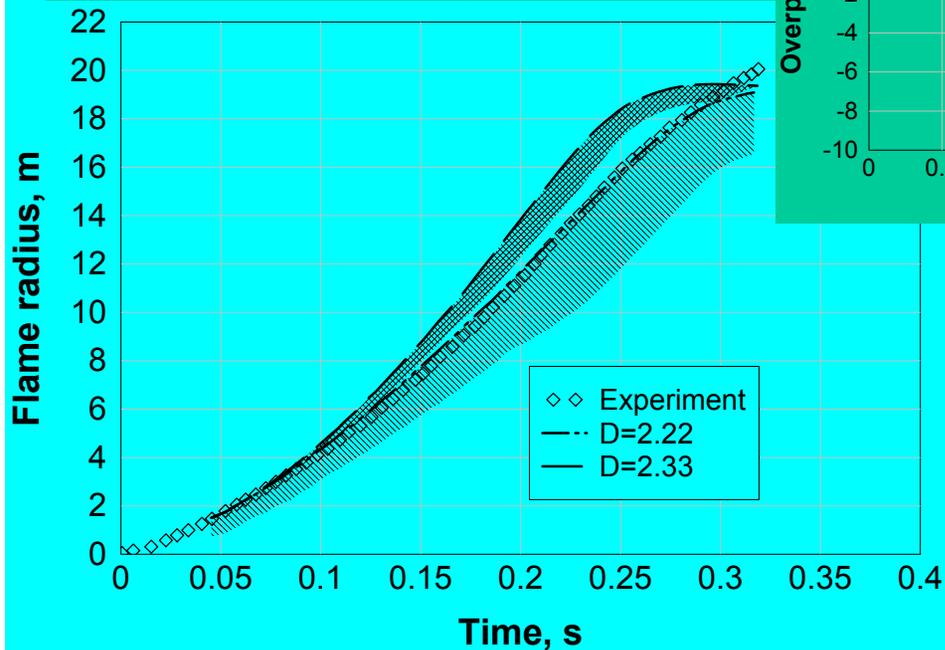
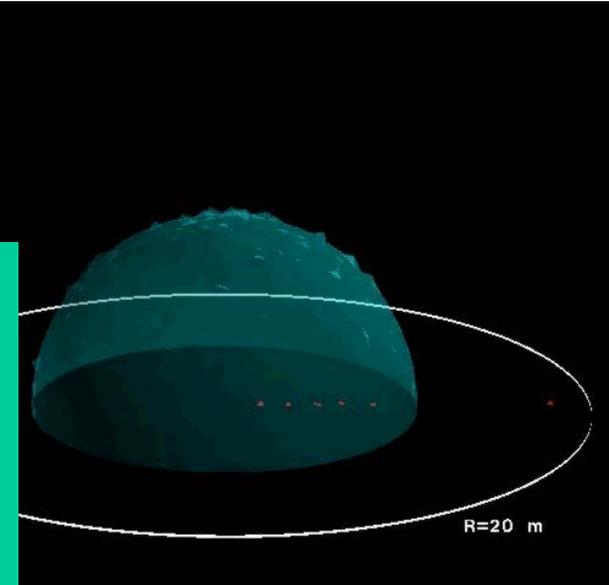
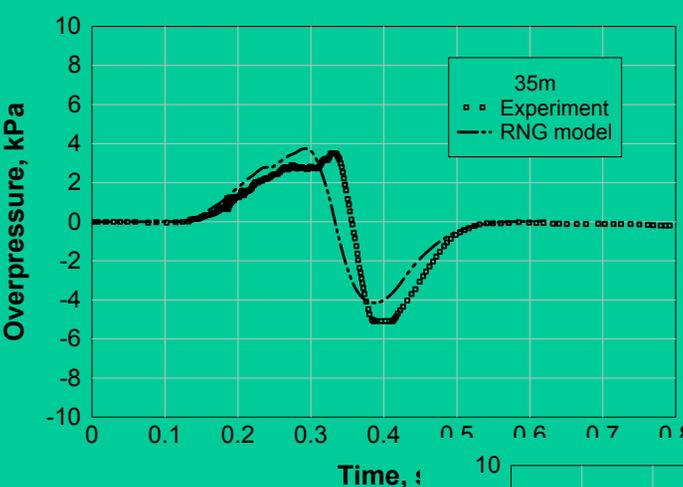
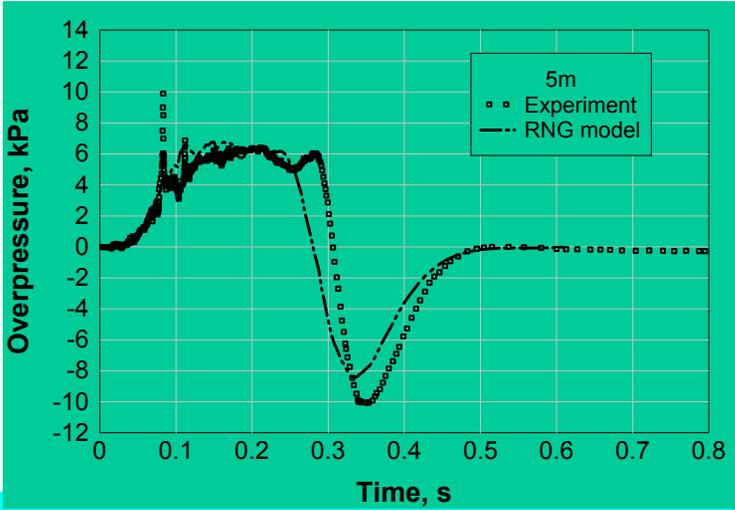


20 m



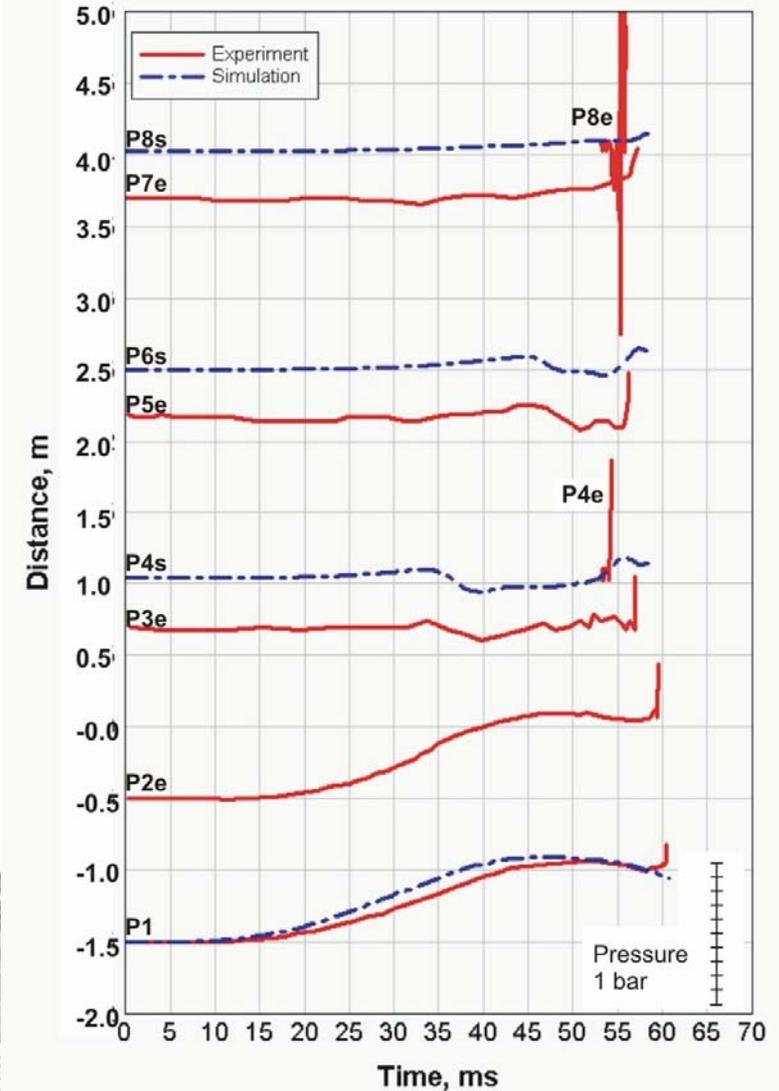
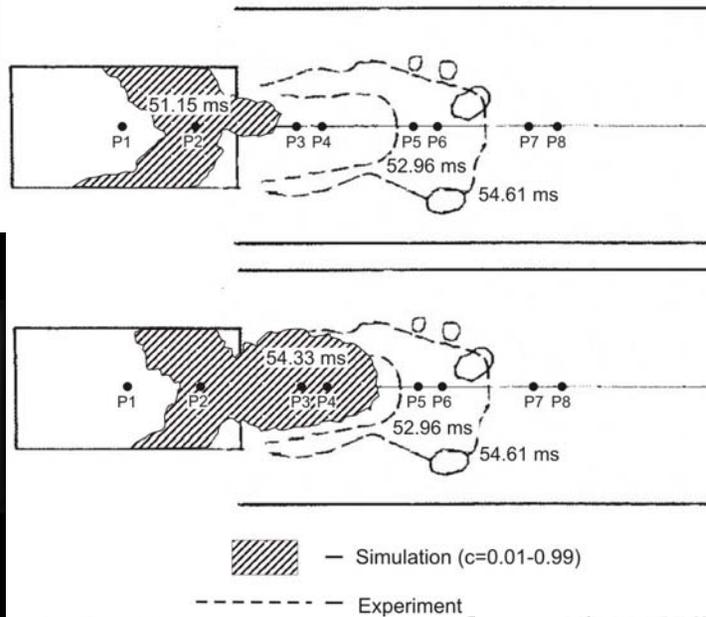
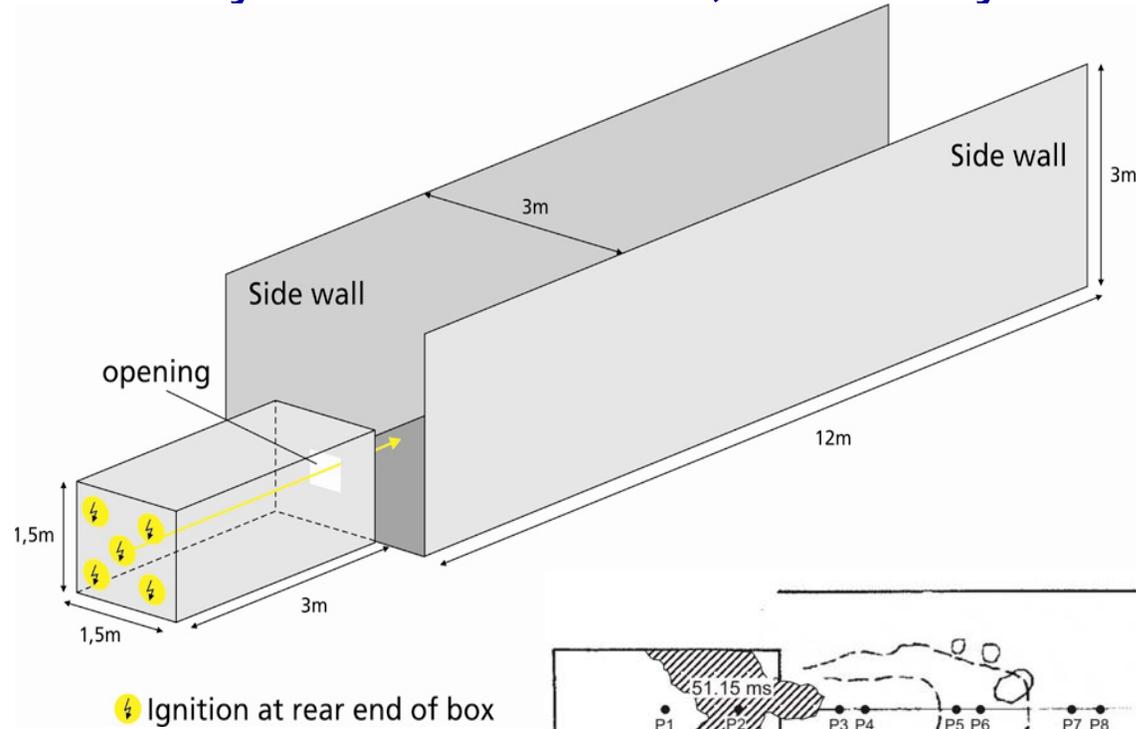
# SBEP: Largest deflagration in atmosphere

Volume 2094 m<sup>3</sup>; D=20 m (Fraunhofer ICT, Germany)



# SBEP: Deflagration-to-detonation transition

Test by Fraunhofer ICT, Germany



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# International Conference on H2 Safety

Microsoft Internet Explorer  
Address: <http://conference.ing.unipi.it/ichs2005/index.html>

September 8-10, 2005  
Congress Palace  
Pisa - Italy

ARDENTHY  
Development of Safe Utilization and Infrastructure of Hydrogen, NEDO Project, JAPAN

CUTE EU Project

NATURALHY EU Project

STORHY EU Project

IPE  
International Partnership for the Hydrogen Economy

ITALIAN NATIONAL FIRECORPS

INTERNATIONAL ASSOCIATION FOR HYDROGEN ENERGY

Hydrogen Safety

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY

September 8-10, 2005  
Congress Palace  
Pisa, Italy

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Anno A. Evers FAIR-PR  
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Hydrogen + Fuel Cells  
HANNOVER FAIR 2006  
April 24 - 28  
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Download paper of the 1<sup>st</sup> ICHS at:

<http://conference.ing.unipi.it/ichs2005/ICHS-Papers/index.htm>

Microsoft Internet Explorer  
Address: <http://conference.ing.unipi.it/ichs/>

In association with:

Auto21  
Safety and Infrastructure Study of Hydrogen Fuelled Vehicles

Canadian Hydrogen Safety Program

Hydrogen Safety, Codes and Standard Program

HyFLEET CUTE  
HyFLEET: CUTE

International Partnership for the Hydrogen Economy

IEA Task 19 "Hydrogen Safety"

ISO/TG 197 "Hydrogen Technologies"

The Research on Safety of Hydrogen Facilities and Fuel cell power system

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY

September 11-13, 2007  
S. Sebastian  
SPAIN

Hydrogen Safety

INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY

September 11-13, 2007  
S. Sebastian  
SPAIN



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# e-Academy of Hydrogen Safety



- International Curriculum on Hydrogen Safety Engineering:  
<http://www.hysafe.org/index.php?ID=68>
- European Summer School on Hydrogen Safety (HyCourse): <http://www.engj.ulst.ac.uk/esshs/hycourse/>
- EST in Fundamentals of Hydrogen Safety (EC funded project HySAFEST – new European cadre in H2 safety)
- First higher education programme in the world (Jan 2007): Postgraduate Certificate in Hydrogen Safety Engineering:  
<http://www.engj.ulst.ac.uk/esshs/1stesshs/pgchse.php>



*European Summer School on*  
**HYDROGEN SAFETY**

August 2006-2009



Marie Curie Conferences and Training Courses The Commission of the European Communities

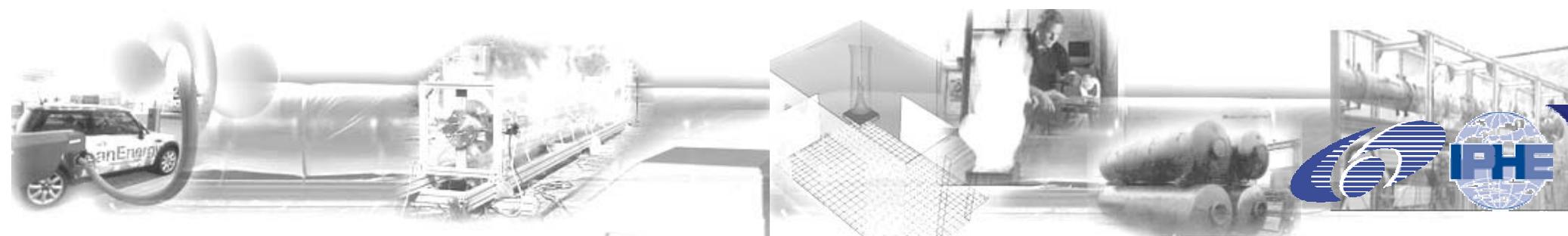


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# Coming soon



- On-line access to Biennial Report on Hydrogen Safety (H2 Safety Handbook) will be available through [www.hysafe.org](http://www.hysafe.org) in the beginning of 2007
- Hydrogen Incident and Accident Database will be inaugurated soon (on-line access HIAD [odin.jrc.nl](http://odin.jrc.nl))
- RCS issues (ISO, CEN, national activities, etc) on HySafe website.
- ...



# International Association for Hydrogen Safety (IAHS)



**“HyGlobe” Global Panel on Hydrogen Safety (SSA proposed to the EC ENERGY-4 call by a HySafe sub-consortium):**

- The International Association for Hydrogen Safety, established as a result of this project, will work in close collaboration with the European Institute for Hydrogen Safety (EI HySafe) and will be focused on gathering and dissemination of available knowledge on hydrogen safety rather than research and services to industry itself.

