

# Aus der Forschung lernen: Vorstellung des Netzwerkes “HySafe”

1. Sicherheit von Wasserstoff
2. Integration / Koordination internationaler  
Sicherheitsforschung mit „HySafe“
3. Ausbildungsangebote

Dr.-Ing. Thomas JORDAN  
Institut für Kern- und Energietechnik  
Forschungszentrum Karlsruhe GmbH  
im Karlsruhe Institut für Technologie KIT

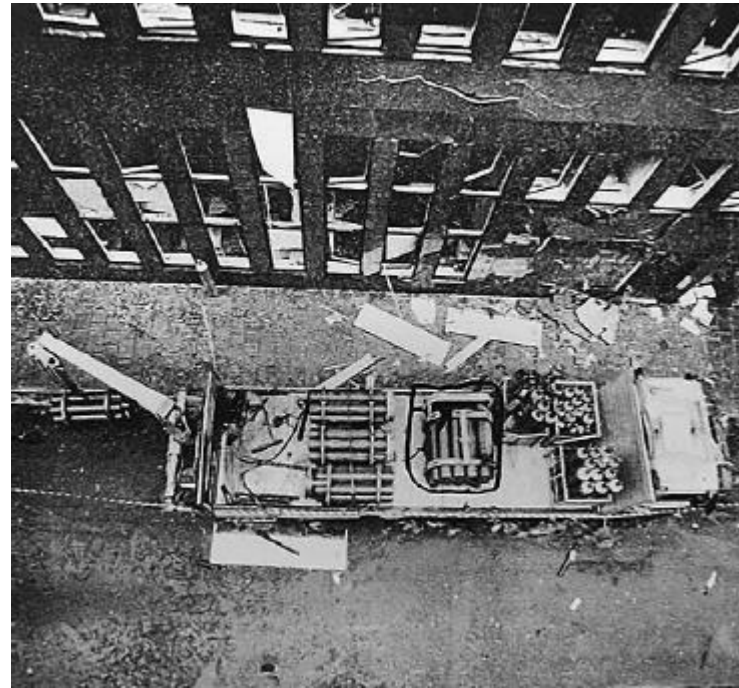
# UNFÄLLE MIT WASSERSTOFF

Norwegen 1984



Detonation von ~5 kg,  
2 Tote, Zerstörung  
des gesamten  
Industriegebäudes

Stockholm 1984



H<sub>2</sub>-Quelle 180 Nm<sup>3</sup>  
16 Verletzte, beschädigte  
Fahrzeuge u. Gebäude  
im Umkreis von 90 m

Köln 2005

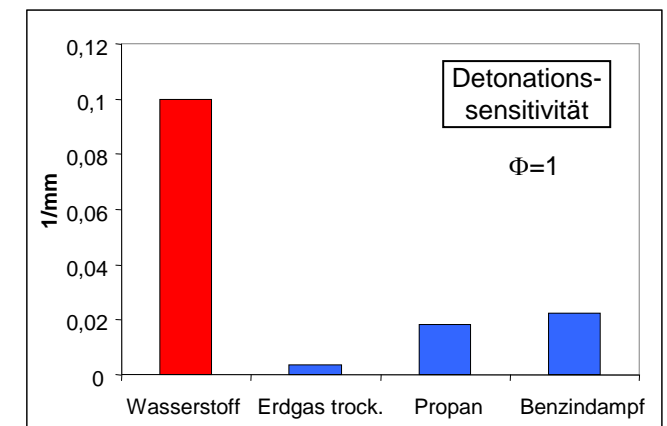
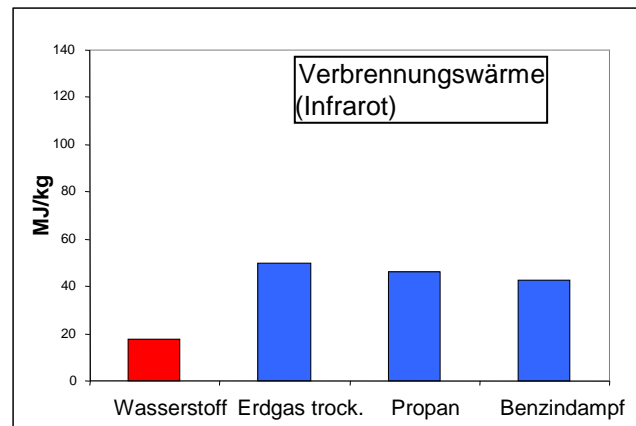
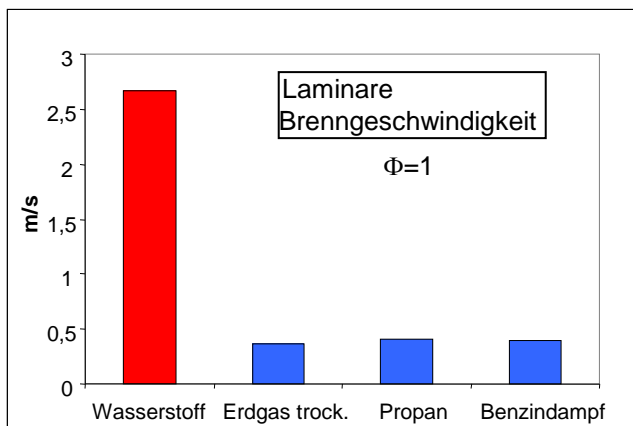
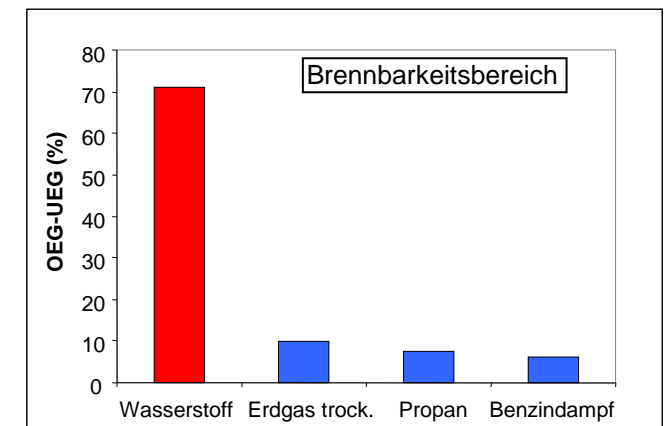
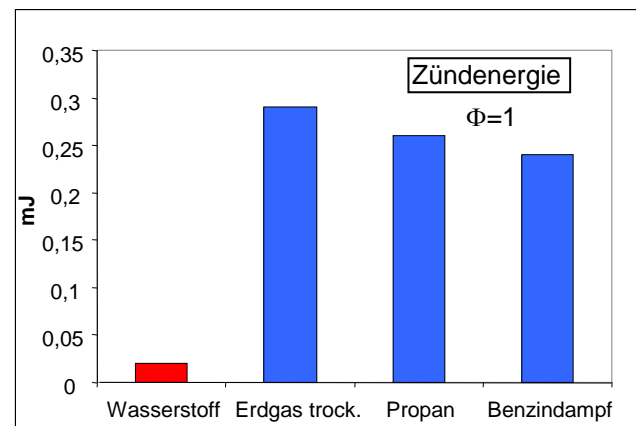
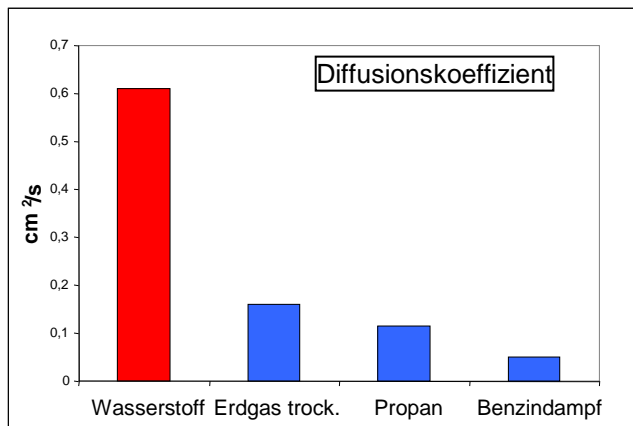
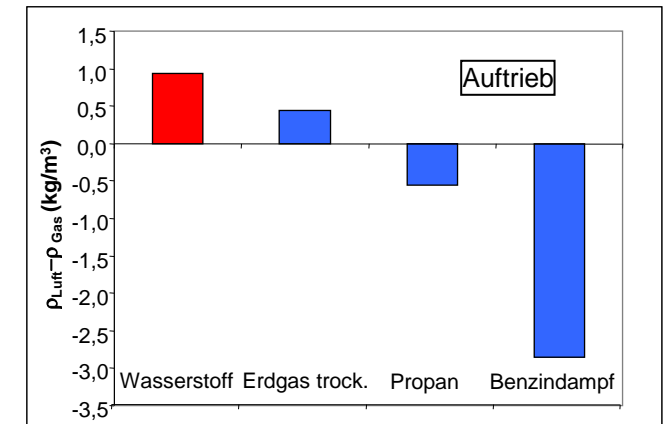
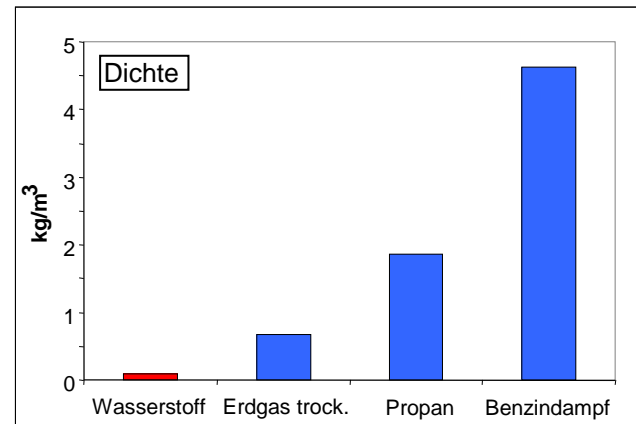


Was wäre wenn...?

# SICHERHEITSRELEVANTE EIGENSCHAFTEN $\text{GH}_2$

Sicherheitsrelevante Eigenschaften von

- Wasserstoff
- Erdgas trocken
- Propan
- Benzindampf



# SPEZIFISCHE GEFAHREN MIT LH<sub>2</sub>



- 253°C → Kaltverbrennungen, Erfrierungen,  
Materialdegeneration (Tiefkaltversprödung NDTT)
- 780 x Volumenzunahme beim Verdampfen → Erstickung
- Pool kann durch Kryopumpeneffekt O<sub>2</sub> einlagern →  
Spontanzündungen möglich

# Grösste Unfalldatenbank HySafe/HIAD

ie

Hydrogen Incidents & Accidents Database (HIAD)



> 250 H2 spezifische Fälle

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Main menu

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H.I.A.D.  
events

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## HySafe - Hydrogen Incident and Accident Database (HIAD)

Welcome to the H.I.A.D. BETA version!!!!



Courtesy of Holmefjord:  
Livorno Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:  
Beijing Hydrogen Refuelling Station



Courtesy of Gerd Petra Haugom:  
Beijing Hydrogen Refuelling Station

Over the last few months JRC and DNV have been working on HIAD application. As you know, the previous-version of the Data Entry Module (DEM) - on Graphical User Interface (GUI) - was available for comments the last few months. The developed carried out has mainly been related to integrating a new

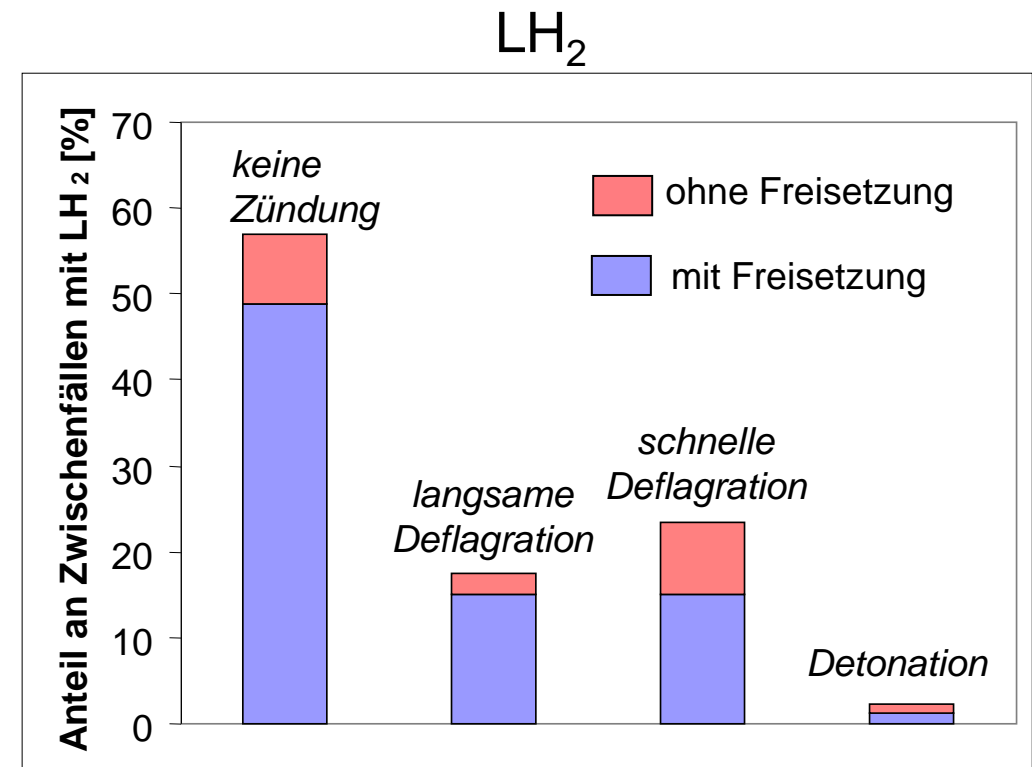
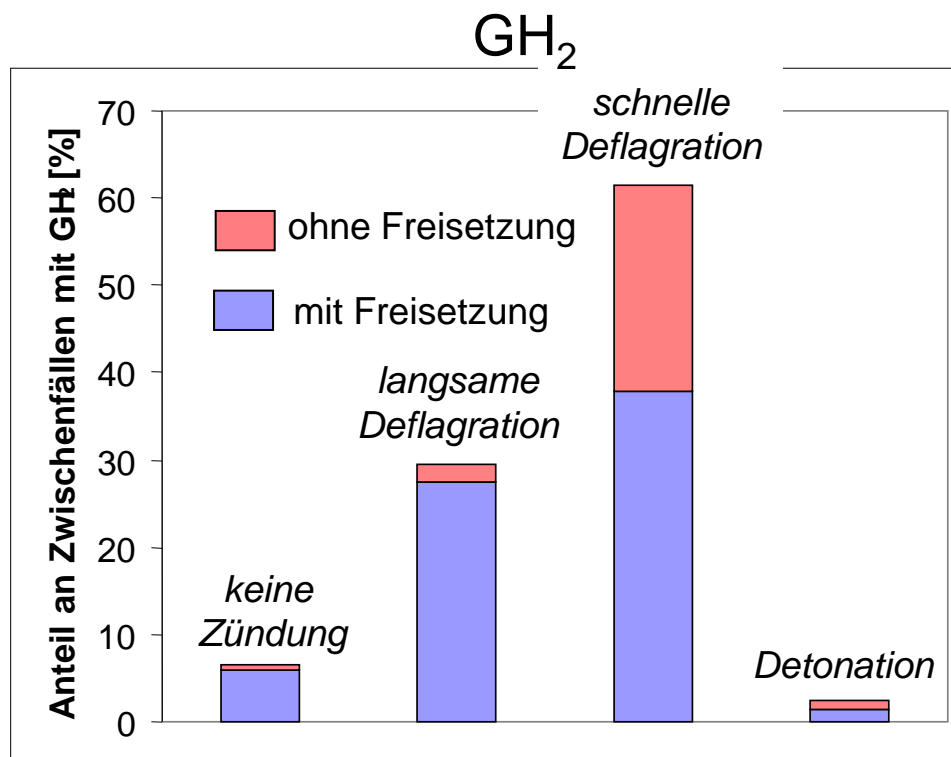
Done

Internet

# ZWISCHENFÄLLE MIT WASSERSTOFF: FOLGEN

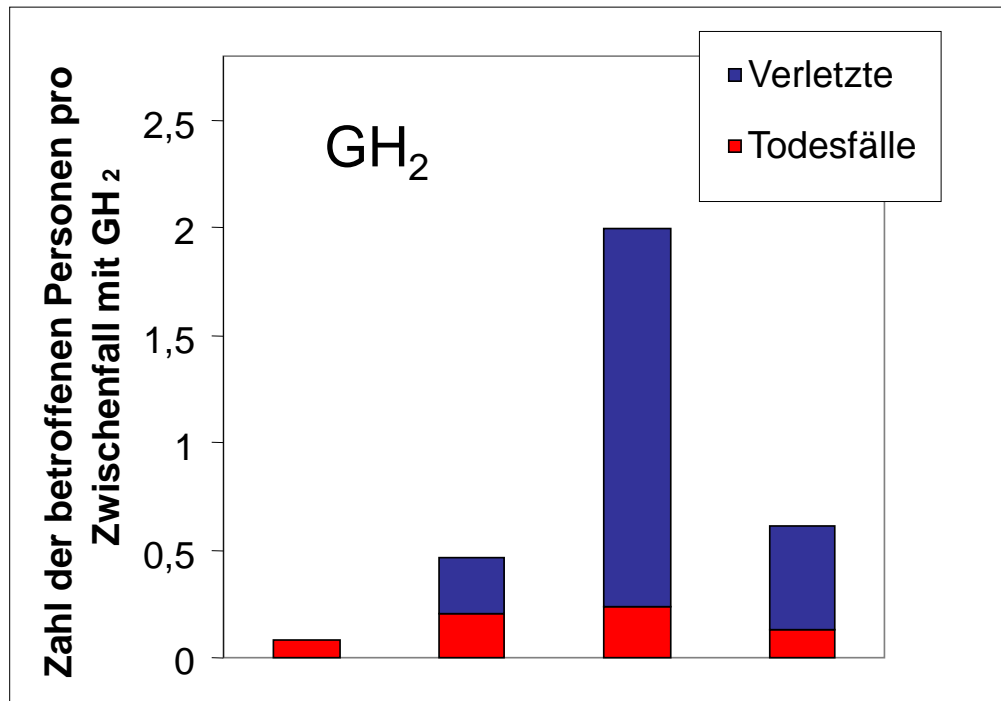
Störfällen werden unterschieden in:

- ohne Freisetzung (Wasserstoff verbleibt in Speicherbehälter oder Prozessanlage)
- mit Freisetzung, (Wasserstoff wird in Umgebung freigesetzt, oder in für Menschen zugängliche Räume)

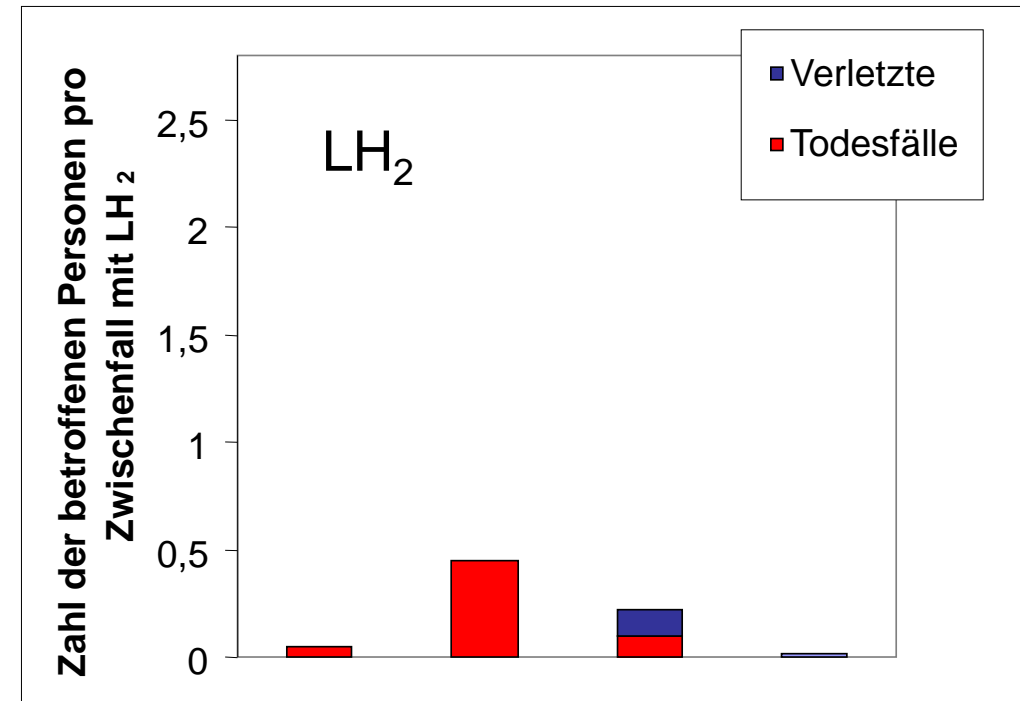


- Zwischenfälle mit GH<sub>2</sub> führen überwiegend zur Zündung und schnellen Deflagrationen
- Zwischenfälle mit LH<sub>2</sub> zünden wesentlich seltener als solche mit GH<sub>2</sub> (Gemischbildung)

# ZWISCHENFÄLLE MIT WASSERSTOFF: PERSONENSCHÄDEN



Freisetzung ohne Zündung    Freisetzung und Feuer    Freisetzung und Explosion    Keine Freisetzung



Freisetzung ohne Zündung    Freisetzung und Feuer    Freisetzung und Explosion    Keine Freisetzung

- Wesentlich weniger Verletzte mit LH<sub>2</sub> als mit GH<sub>2</sub>, aber vergleichbare Anzahl an Todesopfern
- Fazit: Es treten alle Verbrennungsregimes auf, Konsequenzen hängen von vielen verschiedenen Einflussparametern ab, systematische Analyse notwendig



## Konsortium

- 24 Partner aus 12 europäischen Ländern  
+ Kurchatov Institute, Russland + University of Calgary, Kanada
- 13 Forschungsinstitute, 7 Industriepartner,  
5 Universitäten
- ~150 Wissenschaftler aktiv beteiligt

## Budget

Gesamt > 13 M€ [EC Beitrag 7 M€]

## Zeitraum

NoE Start: 03/2004

Dauer: 5 years

→ 02/2009 Übergang zur International Association HySafe  
(eigen finanzierte AISBL nach belgischem Recht)



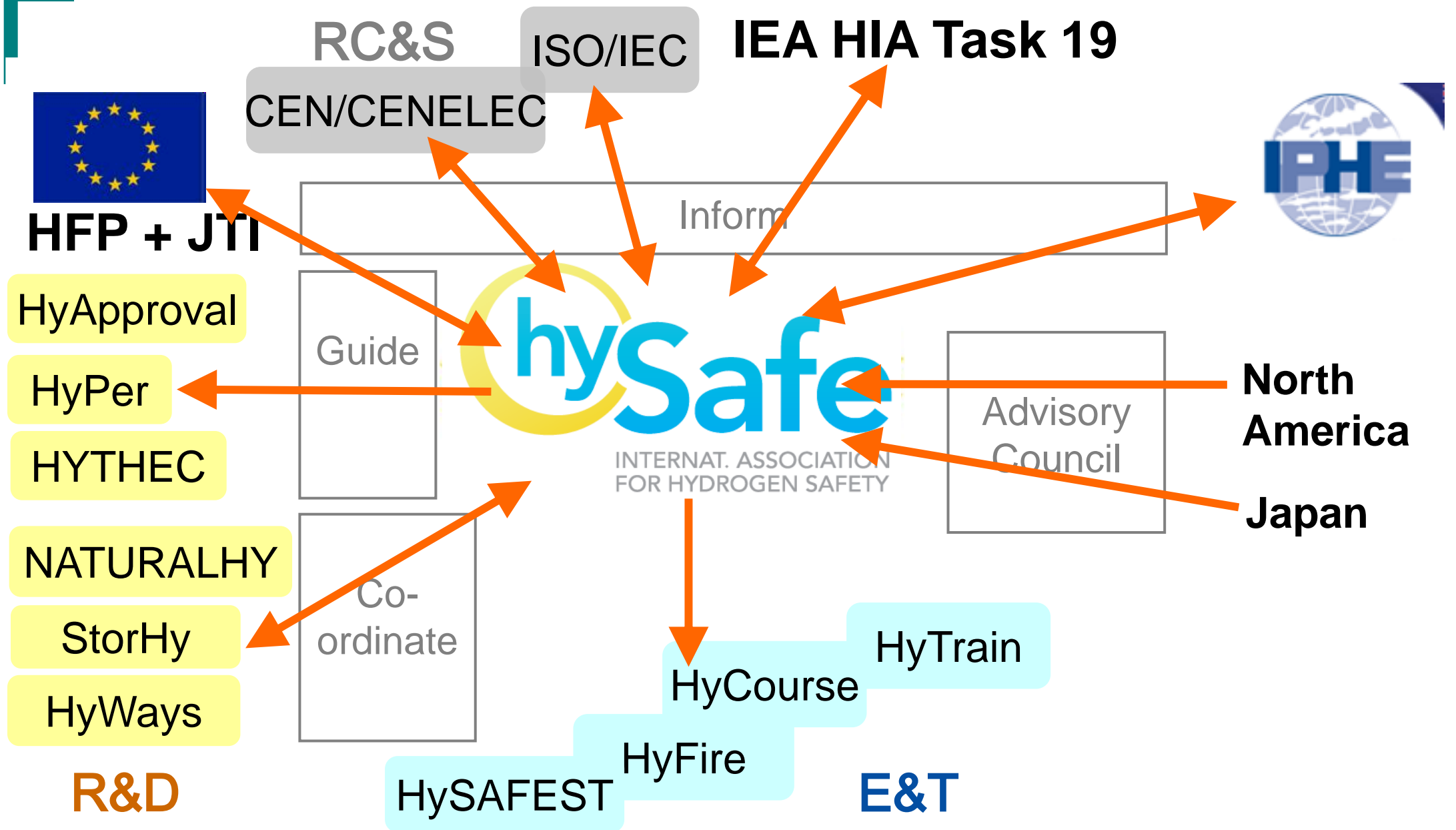
# HySafe Consortium



0 500 Km

Forschungszentrum Karlsruhe GmbH	DE
L'Air Liquide	FR
Federal Inst for Materials Research and Testing	DE
BMW Forschung und Technik GmbH	DE
Building Research Establishment Ltd	UK
Commissariat à l'Energie Atomique	FR
Det Norske Veritas AS	NO
Fraunhofer-Gesellschaft ICT	DE
Forschungszentrum Jülich GmbH	DE
GexCon AS	NO
The UKs Health and Safety Laboratory	UK
Foundation INASMET	ES
Inst Nat de l'Environm industriel et des RISques	FR
European Commission - JRC - Inst 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
Russian Research Centre Kurchatov Institute	RUS

# Internationale Einbettung von HySafe



- Freisetzungen in (teilweise) geschlossenen Räumen
- Sensorik und Unfallfolgenbeherrschung

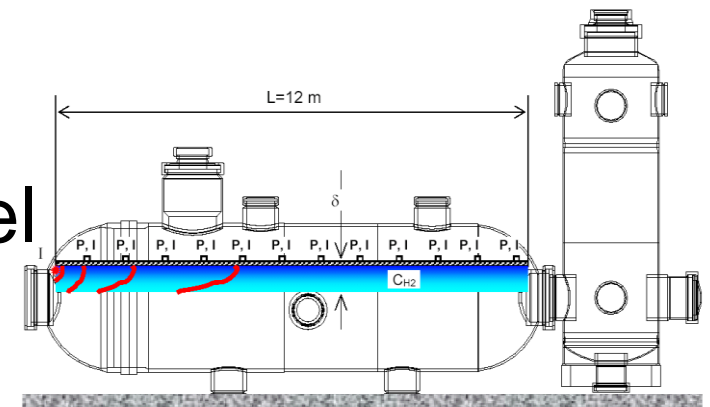
Festgelegt durch eine

- PIRT Studie
- Expertenbefragung
- State-of-the-art Studie

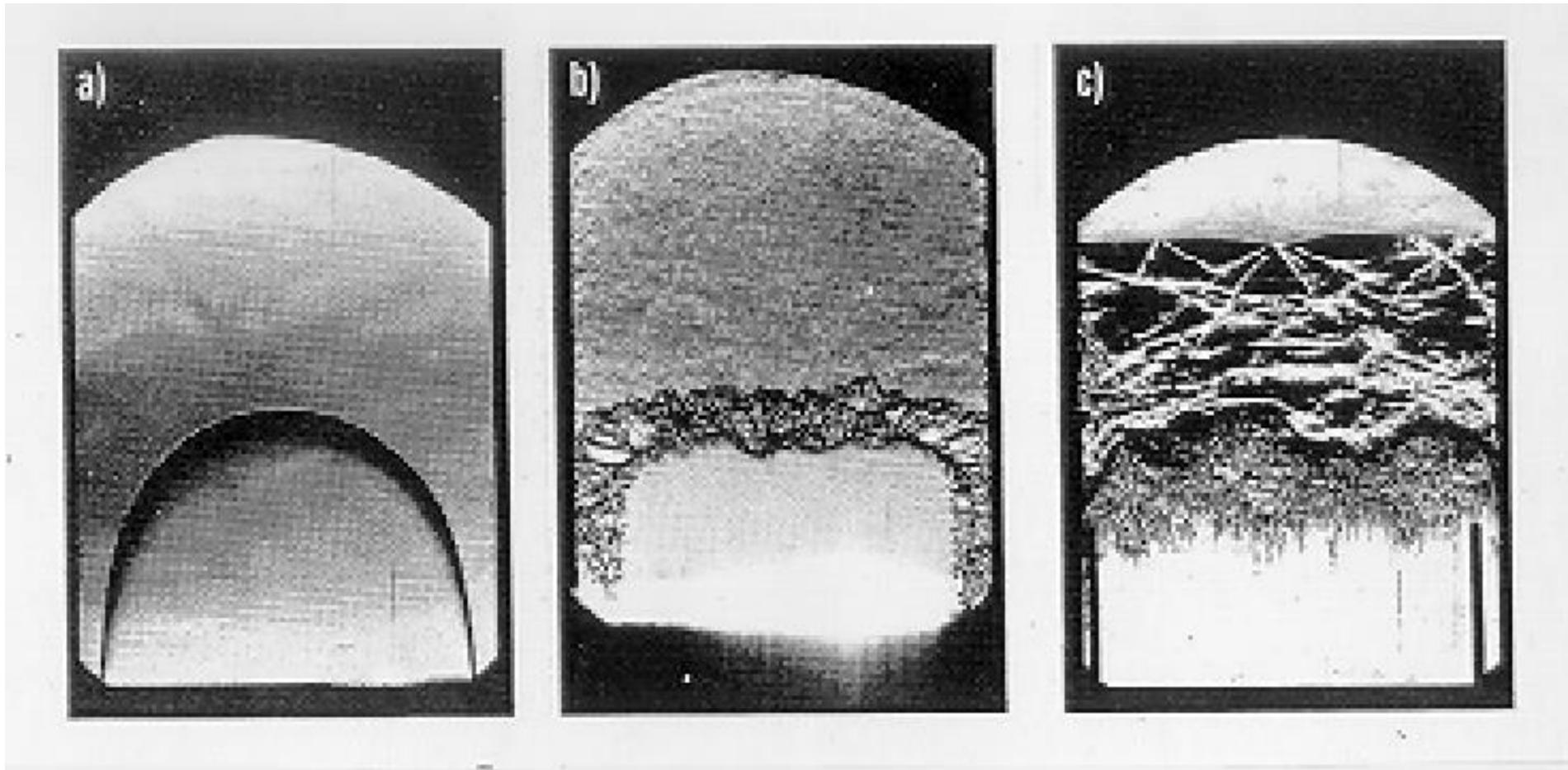


zur

**Priorisierung** von Arbeiten →  
interne Projekte InsHyde und HyTunnel  
**Kommunikation** der ggw. Ausrichtung



# VERBRENNUNGSREGIMES VON H<sub>2</sub>-LUFT

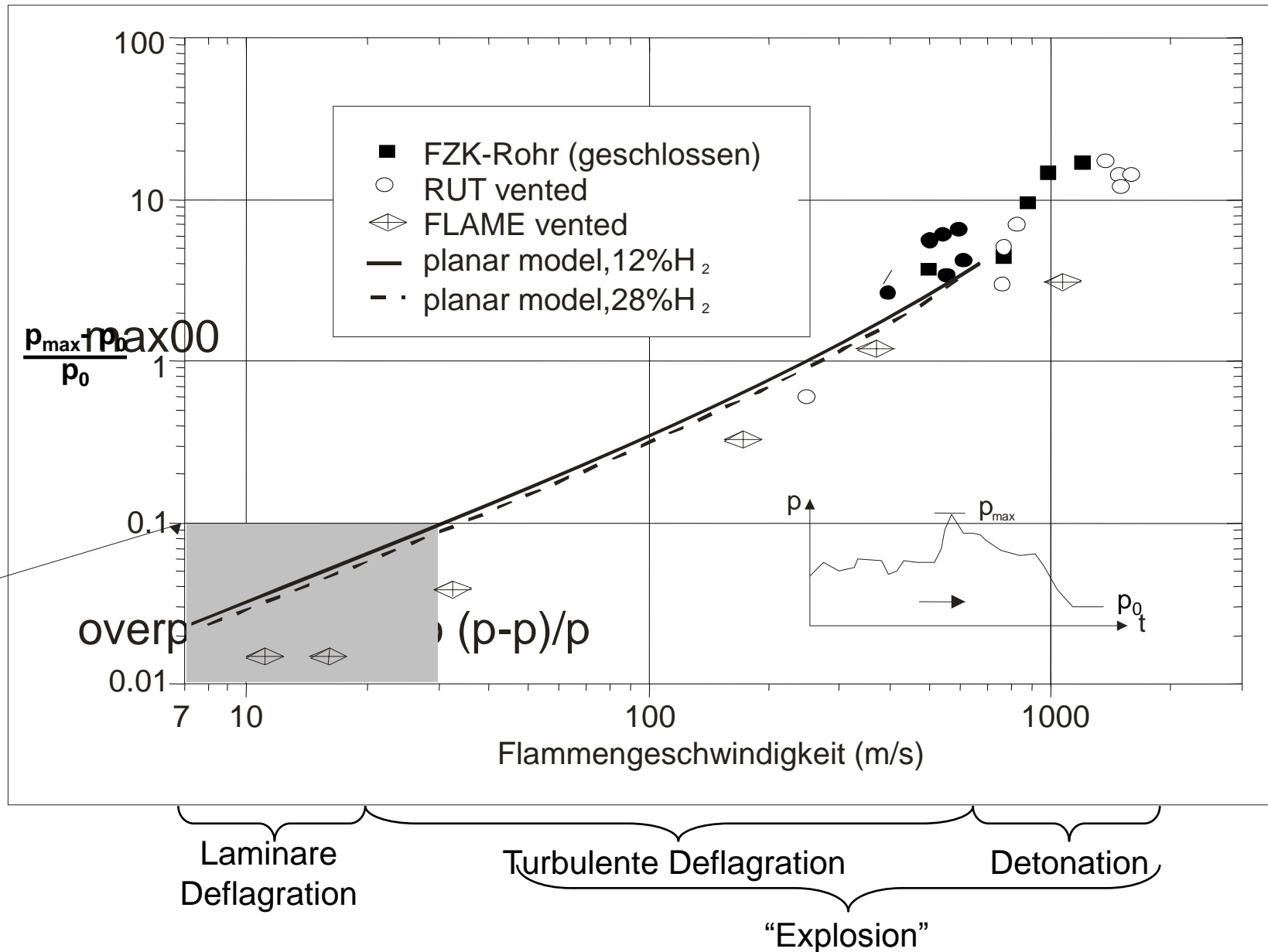


Laminare Flamme  
 $v \approx 1 \text{ m/s}$ ,  $Ma \ll 1$

Turbulente Flamme  
 $v \approx 300 \text{ m/s}$ ,  $Ma \approx 1$

(Quasi-) Detonation  
 $v > 1000 \text{ m/s}$ ,  $Ma > 1$

# ÜBERDRÜCKE VON H<sub>2</sub>-LUFT - FLAMMEN

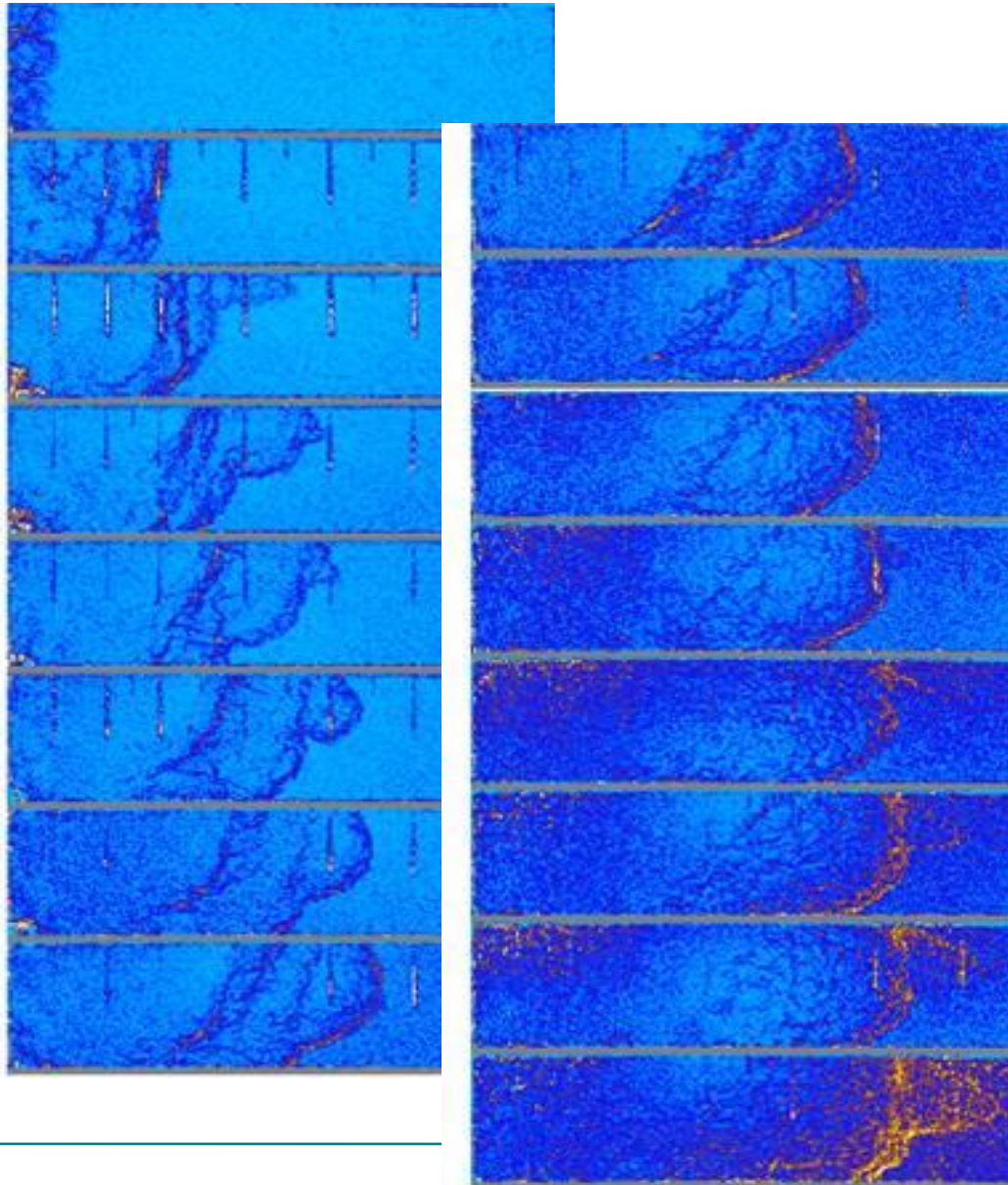


Maximale akzeptable statische Last für typische Wandstrukturen

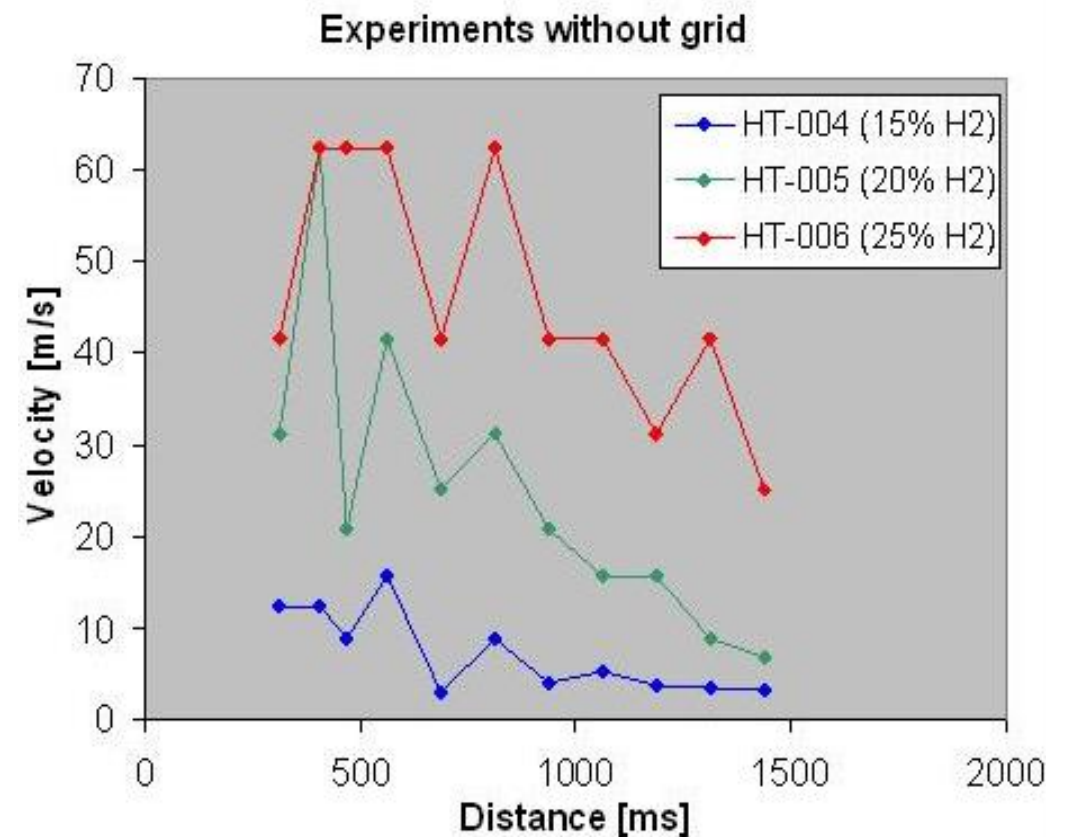
overp  $(p-p)/p$

# “HyTunnel” – Pretests Results

BOS 15 % H<sub>2</sub>/air w/o obstacles



## Flame velocity vs. distance



# HyTunnel – Experimente

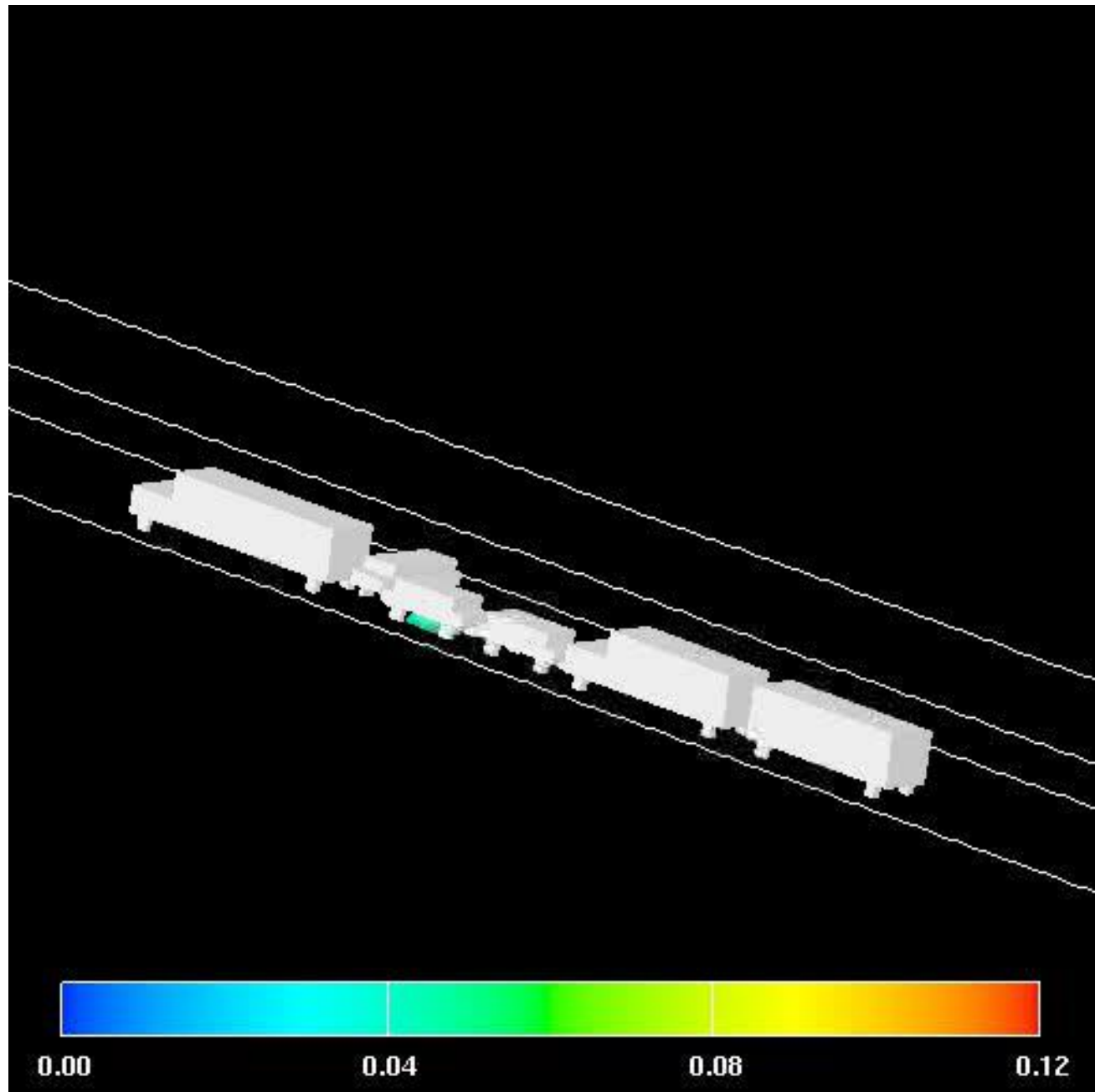
Große Versuchsanlage (5.7 x 1.6 x 0.6 m)

- Belüftungsverhältnis  $\alpha = 0.46$  (Schichtdicke  $\delta = 0.15$  m)



Folien-Öffnung

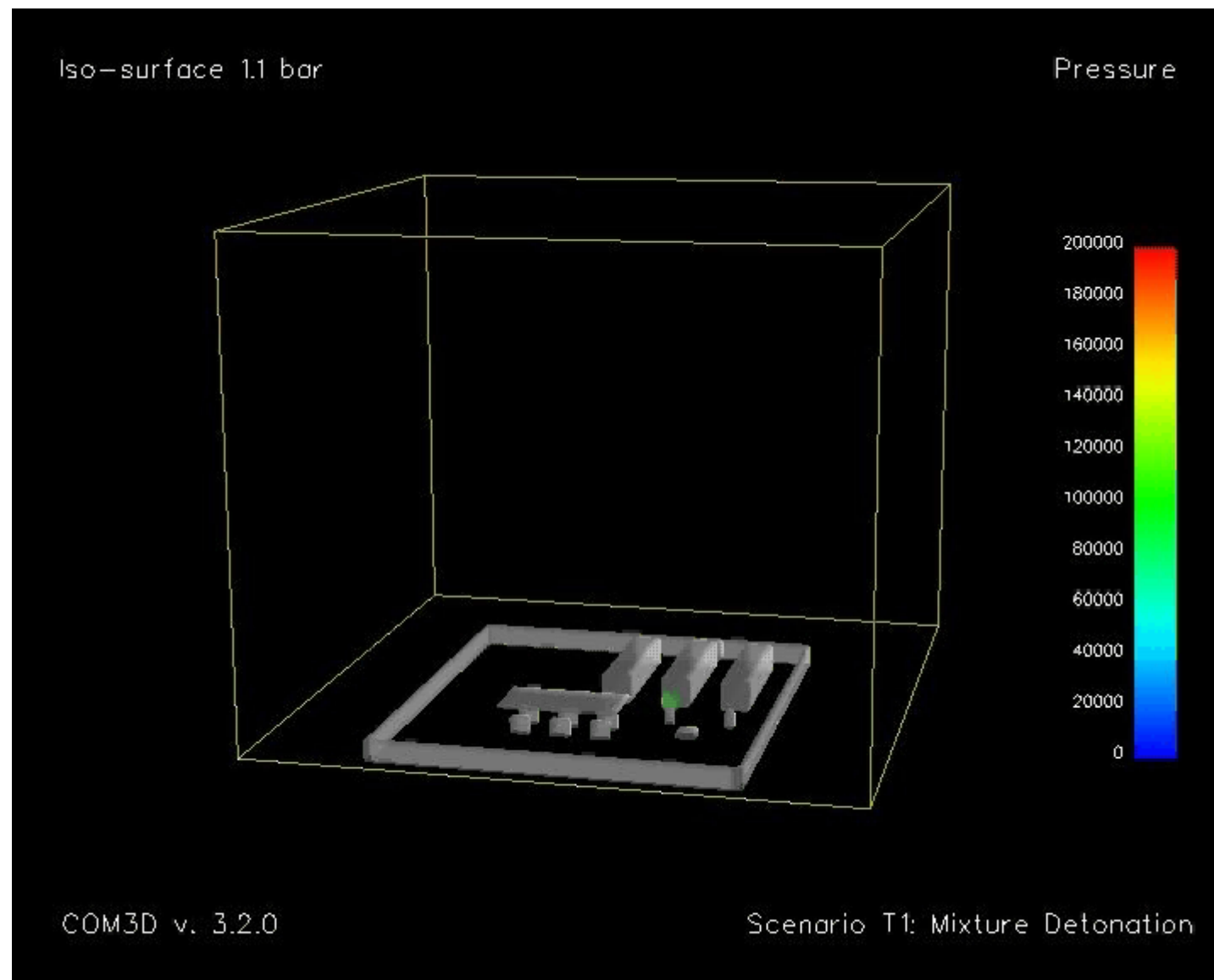
# HyTunnel-Simulation



Zündfähige  
Wolke bei  
Freisetzung  
von 5 kg LH2



# Wasserstoff-Tankstellen



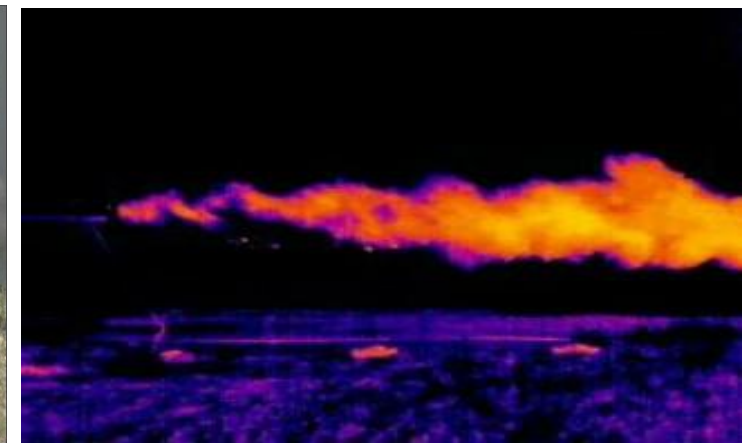
Ein Beitrag zum EC Projekt HyApproval „Handbook for the safe installation/operation of a HRS“ (weitere Infos auf <http://www.hyapproval.org>)

# Andere “unglaubliche” Szenarien?



Prinzipielles Verständnis für die Sicherheitseigenschaften nano-skaliger Festkörperspeicher-Materialien und – Systeme

- (i) Entwicklung neuer Testmethoden für das Material und die Systeme
- (ii) Beschreibung der Reaktionsmechanismen
- (iii) Entwicklung von Methoden zur Reduktion der involvierten Risiken



Nano-strukturiertes, vorzykliertes, H<sub>2</sub> beladenes Alanat; Systemdruck 10 bar T=120 °C (Zeitgleicher Ausschnitt aus Hochgeschwindigkeitsvideo (links) Infrarot-Video (rechts))

# SCHULUNGSMATERIAL

## Introduction to Hydrogen Safety for First Responders



COURSE MATERIALS LIBRARY EXIT ►

Hydrogen Basics Transport & Storage Hydrogen Vehicles Hydrogen Dispensing Stationary Facilities Codes & Standards Emergency Response Summary

INCREASE YOUR

# H<sub>2</sub>IQ

www.hydrogen.energy.gov

### Hydrogen Storage for Transport




Photo: Praxair, Inc.

**Tube Trailers**

Hydrogen

Tube trailers transport hydrogen gas, liquid hydrogen, and compressed gas. Markings are required to help first responders identify the material and respond to an emergency.



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## PGCert Hydrogen Safety Engineering

### Introduction

The Postgraduate Certificate programme in Hydrogen Safety Engineering offered at the University of Ulster is the only such programme in the UK and worldwide, giving graduates the opportunity to specialise in a new field. The programme comprises of two 30 CATS point modules, namely, one on "Principles of Hydrogen Safety" and one on "Applied Hydrogen Safety".

The topical content of the modules complies with the International Curriculum on Hydrogen Safety <http://www.hysafe.org/index.php?ID=68> There is a growing need for specialists in hydrogen safety engineering. Graduates with a PGCert in Hydrogen Safety Engineering will be suitably qualified for employment opportunities at various industrial corporations, governmental bodies, research organisations, and educational institutions.

**Quick Facts**

**Course Name**  
PGCert Hydrogen Safety Engineering

**Faculty**  
Engineering

**Course Code(s)**  
PGCert: C514PJ

**Duration**  
PGCert: One year (two semesters)



## Progress in Hydrogen Safety

*International short course series*

# Hydrogen and fuel cell technologies: Safety issues

29 September - 3 October 2008, Belfast, UK



Early booking recommended for all courses!

**Further courses in 2008/2009 series**

**Hydrogen regulation, codes and standards**  
January 2009

**Safety of hydrogen fuelled vehicles**  
April 2009

**The hydrogen and fuel cell infrastructure**  
June 2009

*Supported by*







Organised by



Hydrogen Safety Engineering and Research, University of Ulster

Forschungszentrum Karlsruhe  
in der Helmholtz-Gemeinschaft

MSc-HSE@ulster.ac.uk

for details see [www.hysafe.net/PGC](http://www.hysafe.net/PGC)  
 or [www.hysafe.net/eAcademy](http://www.hysafe.net/eAcademy)  
 or [www.ehammertraining.us/energy/hydrogen/controller.cfm](http://www.ehammertraining.us/energy/hydrogen/controller.cfm)

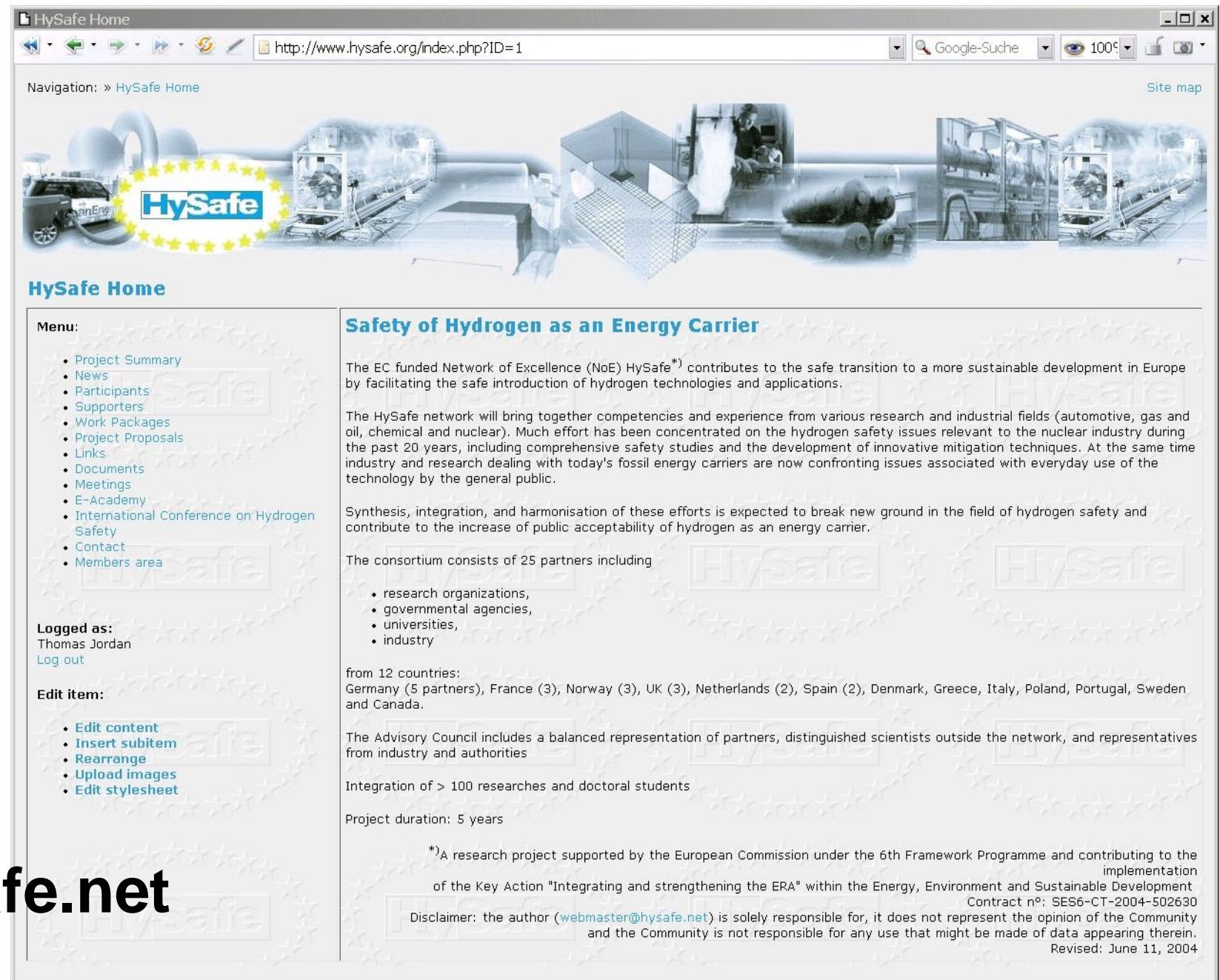
# Einladung zur 3. Int. Conference on Hydrogen Safety September 16-18th, 2009 Ajaccio, Korsika, Frankreich



Contact: [ICHS@hysafe.org](mailto:ICHS@hysafe.org)

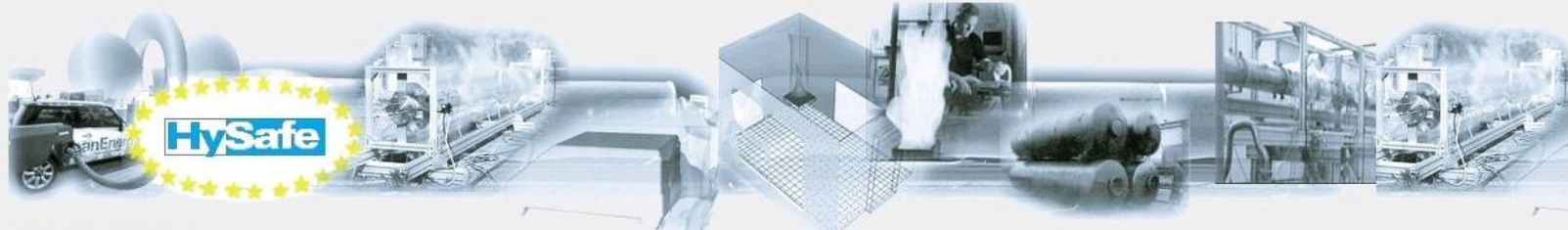
INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY

# WEITERE INFORMATIONEN → ...



The screenshot shows the HySafe website homepage in a browser window. The browser address bar displays <http://www.hysafe.org/index.php?ID=1>. The page features a navigation menu on the left, a main content area with a large image of hydrogen-related technology, and a sidebar with a menu and a section titled "Safety of Hydrogen as an Energy Carrier".

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](#)

**Logged as:**  
Thomas Jordan  
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**Edit item:**

- [Edit content](#)
- [Insert subitem](#)
- [Rearrange](#)
- [Upload images](#)
- [Edit stylesheet](#)

### 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

→ [www.hysafe.net](http://www.hysafe.net)

## **Danke an die EC**

NoE HySafe is co-funded by the European Commission within the 6th Framework Programme (2002-2006);  
Contract n°: SES6-CT-2004-502630.

## **Danke an alle HySafe Kollegen...**

**... und an Sie, für Ihr Durchhaltevermögen!**