HySafe Research Priorities Workshop Findings

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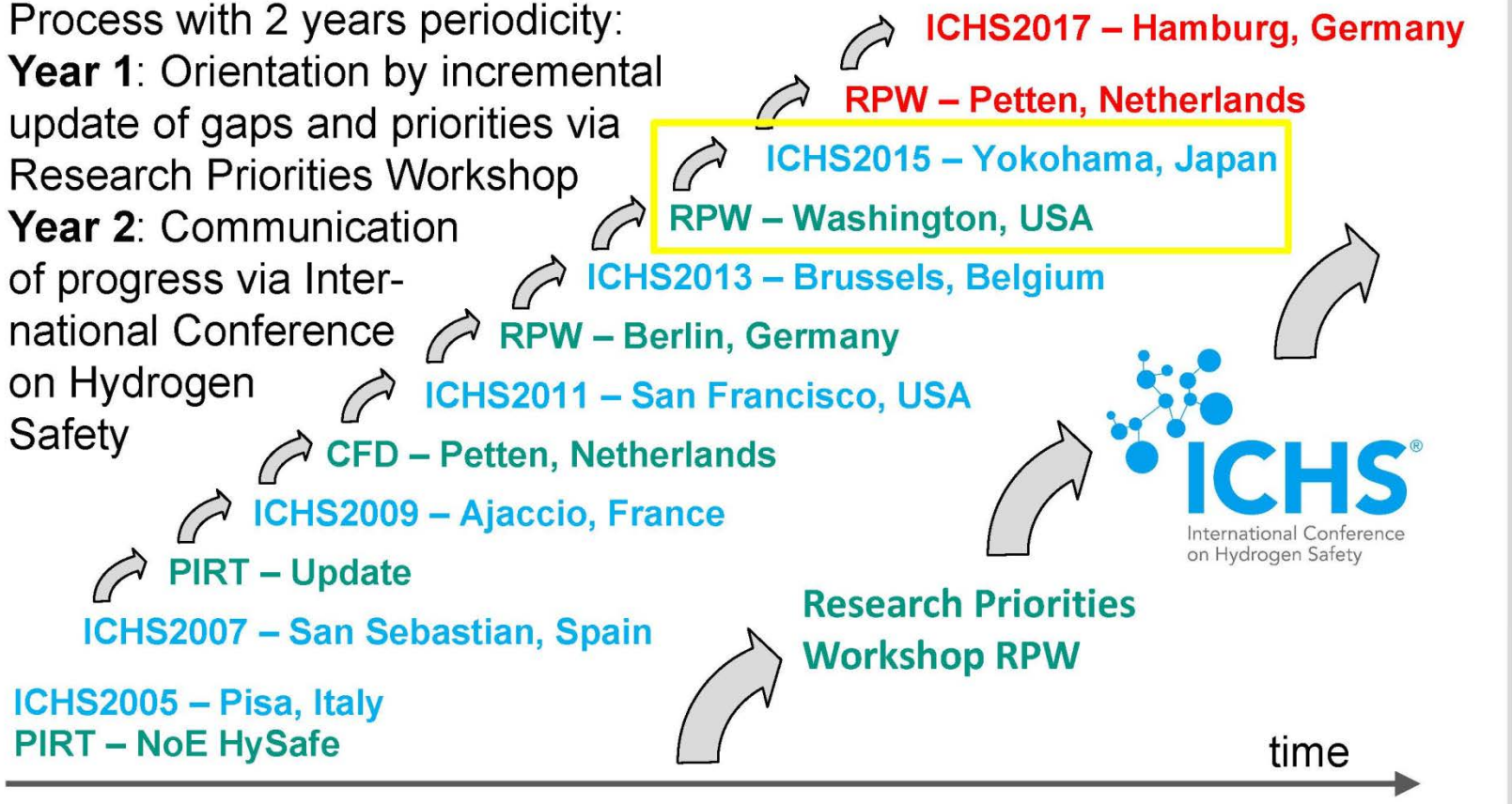
Purpose of Prioritization Effort

- Identify those research activities deemed most critical by workshop attendees
  - Ensure that research priorities are aligned with the needs of the hydrogen industry
- HySafe Research Priorities Workshop held September 26-27, 2016, in Petten, The Netherlands.
  - Attendees included international members of the academic community, national laboratories, funding agencies and industry.
  - Workshop to address the state of the art in hydrogen behavior understanding with a focus on safety
  - Following the workshop, participants and other IA-HySafe members were asked to prioritize and provide feedback on topics within each research category
    - we did not prioritize the research categories as we had done for 2014 PRW

Purpose of Prioritization Effort

Continuous Development of the State-of-the-Art

Process with 2 years periodicity:
Year 1: Orientation by incremental update of gaps and priorities via Research Priorities Workshop
Year 2: Communication of progress via International Conference on Hydrogen Safety



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Research Category Prioritization – RPW 2014

Normalized results of research category prioritization from RPW 2014:

- QRA Tools ..... (23%)
- Reduced Model Tools ..... (15%)
- Indoor ..... (13%)
- Unintended Release-Liquid ..... (11%)
- Unintended Release-Gas ..... (8%)
- Storage ..... (8%)
- Integration Platforms ..... (7%)
- Hydrogen Safety Training ..... (7%)
- Materials Compatibility/Sensors ..... (7%)
- Applications ..... (2%)

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Research Category Prioritization – RPW 2016

Starting from the priorities list RPW 2014 and adding new topics in need of attention we developed the following topics for RPW 2016:

- Industrial programs
- Integrated computational tools
- Accident Physics
  - Gas phase
  - Liquid phase
- Hydrogen Storage
- Materials
- General Aspects of Safety

We present here the highlights of this workshop.

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Industrial Programs

Presentations from

- HySut (Japan)
  - The new HySut roadmap targets (40,000 FCEV by 2020, 800,000 by 2030 and 160 HFS by 2020 plus an additional 100 small scale HFS by 2020
- H2FIRST (U.S.A)
  - Focus is on cost for HFS at the component level
  - California funding programs to deploy the first 100 stations (currently there are 31 open retail stations, 37 by the end of the year.) Funding is in place @ 20 million USD per year to fund up to 100 HFS.
  - North-East is different – financial contribution from industry is playing a key role – governmental funding at the state level is still needed.

Industrial Programs

Presentations from

- FCH2-JU
  - An overview of FCH2-JU projects focused on safety was presented

- GTR n°13
  - Working Group consists of governmental participants from China, European Union, Korea, Canada, United States and India. Industrial participants from standards developing organizations, OEM, and component manufacturers.
  - Three main FCEV components considered
    - The **high** pressure fuel container system
    - Fuel system at the vehicle level
    - Electrical integrity of high voltage system

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Accident Physics

Gas phase

- Premixed combustion is given the **highest priority**
  - Modeling of flame acceleration and DDT associated pressure effects for large scale application with obstacles needs further work
  - Venting, water sprays needs further work.

- Non-Premixed combustion was deemed to be of a **much lower priority.**
  - Reduced order models have been developed for these non-premixed jet flames and have been incorporated in QRA tools such as HyRAM.
  - Validation data for radiation properties of large scale fire balls and jet flames are needed.

Accident Physics

Liquid phase

- Validated models are lacking for all accident phenomena
  - Multiphase releases
  - Accumulations in congested areas – indoors and outdoors have the **highest priority**
- Pool spreading and fires as well as BLEVE's and fire resistance of cryo-containers are a **secondary priority**

Materials

Data base

- Fatigue data for the most relevant pressure vessel materials received the **highest priority**.
- Better understanding of pressure, purity and temperature on the data is needed
- Need to agree on suitable qualification metrics and test strategies.
- Polymers
  - Appropriate models for life time prediction under realistic conditions
  - Standard test protocols and selection criteria are prioritized at a similar high level

Integrated tools - QRA

HyRam

- Prioritized highest in the RPW 2014
  - Several supporting activities have been initiated globally as a result
  - Of integrated tools HyRam has the highest level of maturity
- Frequency data – **highest priority**
- Models to account for mitigation measures are lacking – **highest priority**
- Validation concepts for these tools need to be developed
  - Possibly results from FCH-JU project SUSANA could be used.

Applications

Public Infrastructure - HFS

- Scale up of HFS will require LH2
  - Safe transfer, general fire, pressure vessel ruptures and rapid combustion of premixed systems leading to large overpressures – all need to be investigated
- **First priority** is to account for cascading effects, pressure or accident initiation with conventional fuels.
- Models for mitigation concepts need to eliminate over-conservatisms and avoid raising unjustified safety concerns.
- Low cost material compatibility and assembly technologies like welding need further attention.

Applications

FCEV

- Accidental scenarios in confined or partially confined spaces
  - Tunnels, garages, repair shops … **Highest priority**
- Safe strategies for first and second responders

Storage Systems

- Mitigating catastrophic pressure vessel ruptures
  - Up grade the GTR to address realistic car fires (heat flux to the tank measurements and testing) is required to standardize the testing
  - Improved protection against fire or thermal excursions has the **highest priority**
  - Structural health monitoring has the **2nd highest priority** in this storage topic
  - Modeling of aging and thermal degradation with a special focus on the liner stability and permeability has the **3rd highest priority**

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Applications

Power to Hydrogen (PtH)

- This has matured considerably
- Most issues are material related
- Safety related parameters for hydrogen / natural gas blends have been evaluated and just about to be published.
- International harmonization and standardization is needed.
- Collection of field data is considered to be the most **important priority**
- High temperature high pressure electrolysis will create new safety issues.

Applications

Hydrogen aerospace and aviation

- LH2 used primarily for gravitational benefits
  - For these systems the gaps and basic understanding for LH2 systems noted earlier apply.

Applications

Sensors

- Successfully being deployed to assure safety.
  - Gaps exist with respect to sensor technology (H2Sense project)
  - **Most urgent** is guidance on selection and placement in different applications

Concluding Remarks

As in previous RPWs we are preparing a report that is currently in draft form and is in review. It will be published as a JRC report. Please refer to that document for further discussion on these findings.

The priorities obtained from these workshops find there way into research and funding priorities. They also are used to feed the ICHS series of meetings.

Thank You!

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