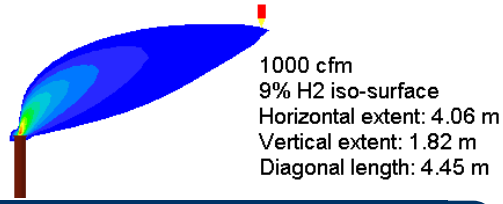
International Energy Agency Hydrogen Implementing Agreement Task 19 Hydrogen Safety

William Hoagland

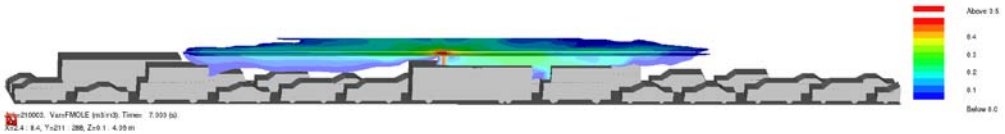
Element One, Inc.

June 9, 2010



Project ID: SCS013

Overview



Timeline

- Project Start: Oct 1, 2007
- Project End: Oct 1, 2010
- % Complete: 80%

Budget

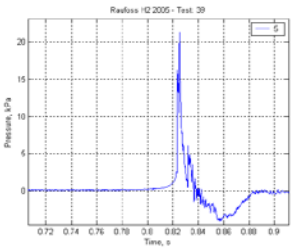
- Total Project Funding
  - DOE: $185K
  - NRCAN: $185K
- Funding FY09: $126 K
- Funding FY10: $ 0 K

Barriers

- Lack of uniform model codes and standards
- Local code officials, policy makers, general public lack of education on safe handling and use

Partners

- **Partners:** Natural Resources Canada
- **Collaborators:** Canada, European Commission, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Switzerland, UK, US
- Project Lead: W. Hoagland



Relevance to DOE Objectives

DOE Program Focus – Safety, Codes and Standards:

- To facilitate the development of hydrogen codes and standards. Support R&D that provides a basis for the requirements cited in codes and standards.

IEA HIA Mission:

- To accelerate hydrogen implementation and widespread utilization.

Task 19 Hydrogen Safety Project Objectives

- To conduct a collaborative program to develop predictive methods, data and other information that will facilitate the accelerated adoption of hydrogen systems.

Relevance - Project Objectives

Goal

To conduct a collaborative program to develop predictive methods, data and other information that will facilitate the accelerated adoption of hydrogen systems.

Specific objectives:

- Characterize and assess risks and hazards and QRA methodologies;
  - Risk informed criteria for permitting approval
  - Simplified methods
- Conduct collaborative testing program to validate the models that have been developed and to further refine those tools for use in real-life scenarios; and
- Document and convey results and data to reduce the barriers that inhibit commercial introduction of hydrogen systems.

Relevance - Impact

The work will provide a technically sound and credible basis for *Risk Informed Codes and Standards* that are

- Not unnecessarily restrictive,
- Allow informed choices of design,
  - Most economic mitigation measures, equipment and safety factors
- Facilitate approvals, permits and insurability.

Overall Technical Approach

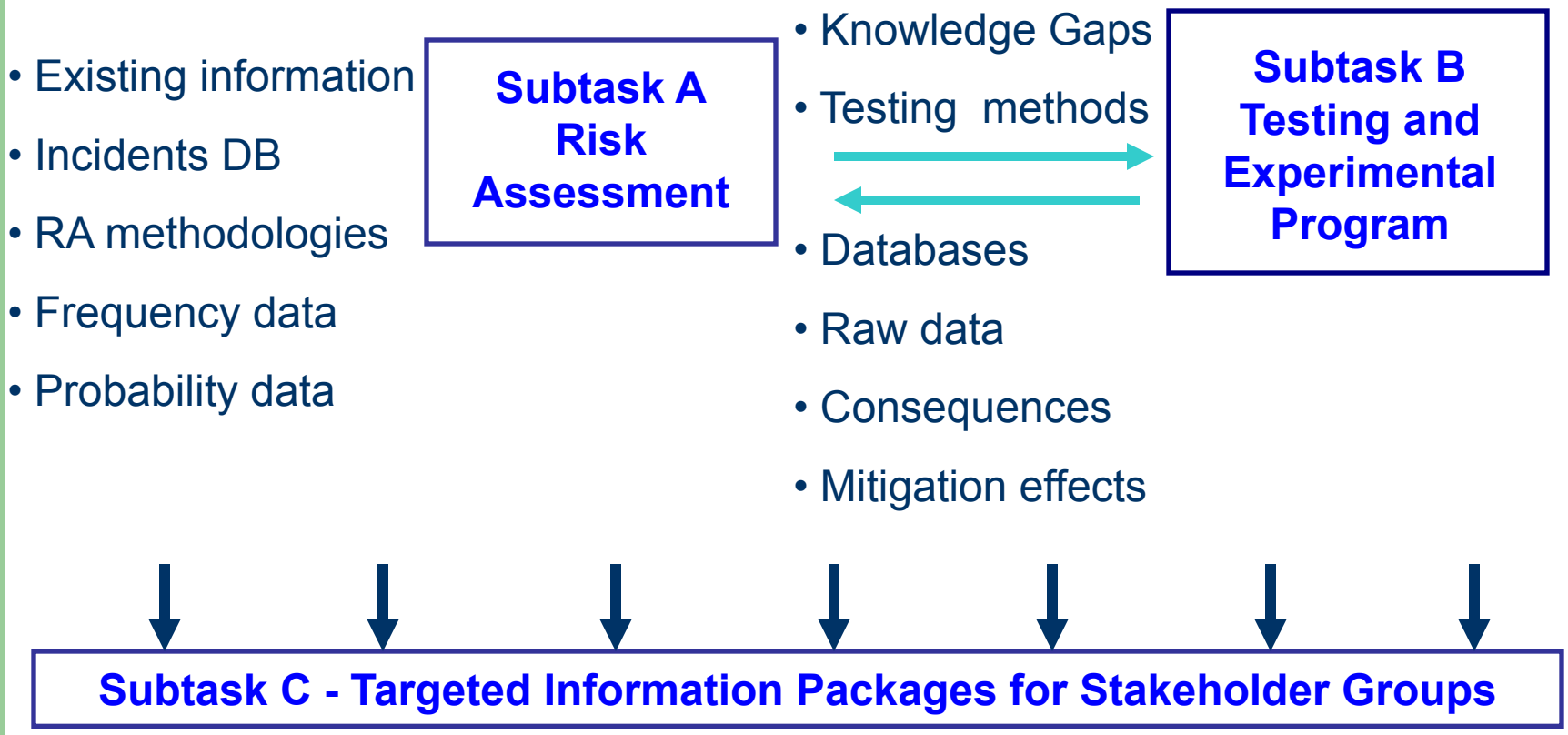
- This collaboration is unique in that its approach brings together the foremost hydrogen safety experts in the world to share:
  - R&D progress and results
  - Different perspectives of each country on hydrogen safety approval criteria and risk management
  - Experimental testing programs
  - Status of Codes and Standards development

Overall Technical Approach

Demonstrate International Leadership by:

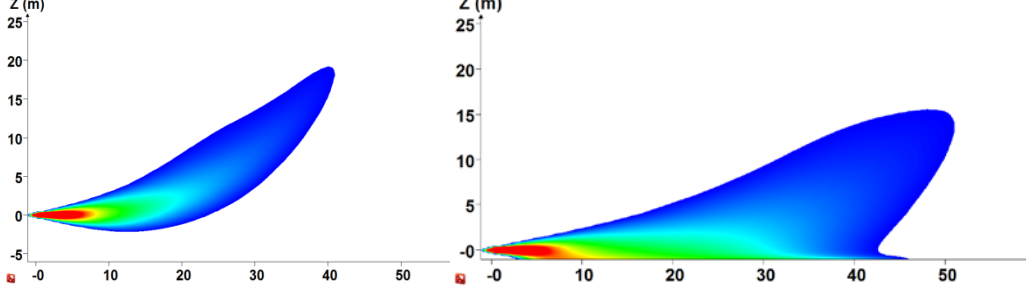
1. Establishing a Task 19 endorsed risk-informed methodology for CDO's to use as a template in evaluating risk prevention and mitigation measures
2. Establish a data base that has been vetted by the technical community (refereed literature)
3. Establish a data base of suggested models that have been validated against the unintended release data base
4. Position Papers – Consensus of experts on major issues
5. White Papers - Authoritative position on technical issues
6. Conference Papers – expanding the base of knowledge
7. End-of-task Forum/Workshop – disseminate results

Task 19 Logical Approach



Subtask Leadership

- Subtask A – Risk Assessment
  - Norway (Angunn Engebø, DNV)
- Subtask B – Testing and Experimental Program
  - U.K. (Deborah Willoughby/Mark Royle, Health and Safety Laboratory)
- Subtask C – Targeted Information Packages for Stakeholder Groups
  - U.S. (Steven Weiner, Pacific Northwest National Laboratory)



Technical Approach

- A1: Develop uniform risk acceptance criteria
  Activity leaders: Jeff LaChance, SNL, USA and Angunn Engebø, DNV, Norway

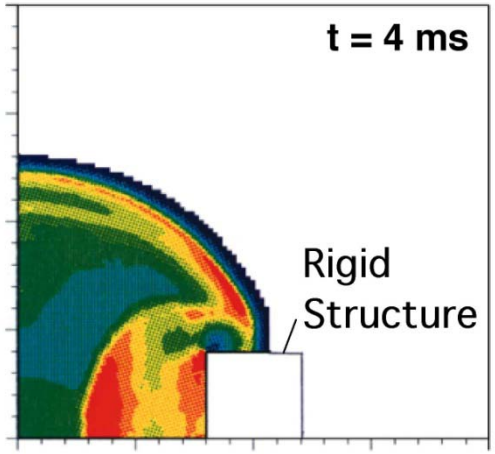
- A2: Develop a list of appropriate engineering models and modeling tools.
  Activity leaders: Pierre Bénard, HRI, Canada and Jay Keller, SNL, USA

- A3: Develop methodology for consistent site risk assessment.
  Activity leaders: Olav Hansen, GexCon, Norway, Koos Ham, TNO, Netherlands and Alessia Marangon, UNIPI, Italy

Work Scope 2007-2010

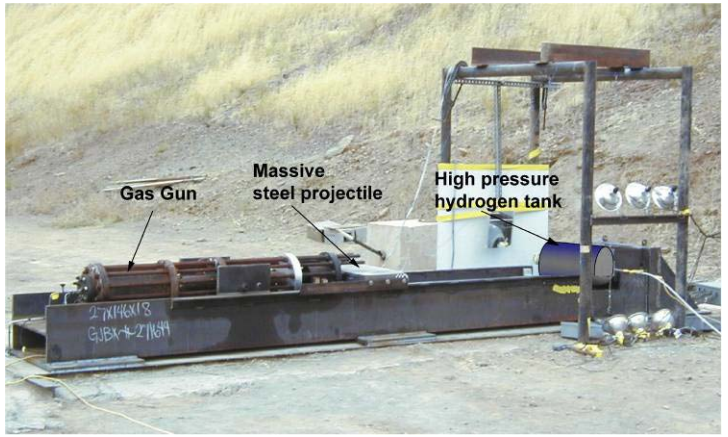
Fundamental Data

Modeling

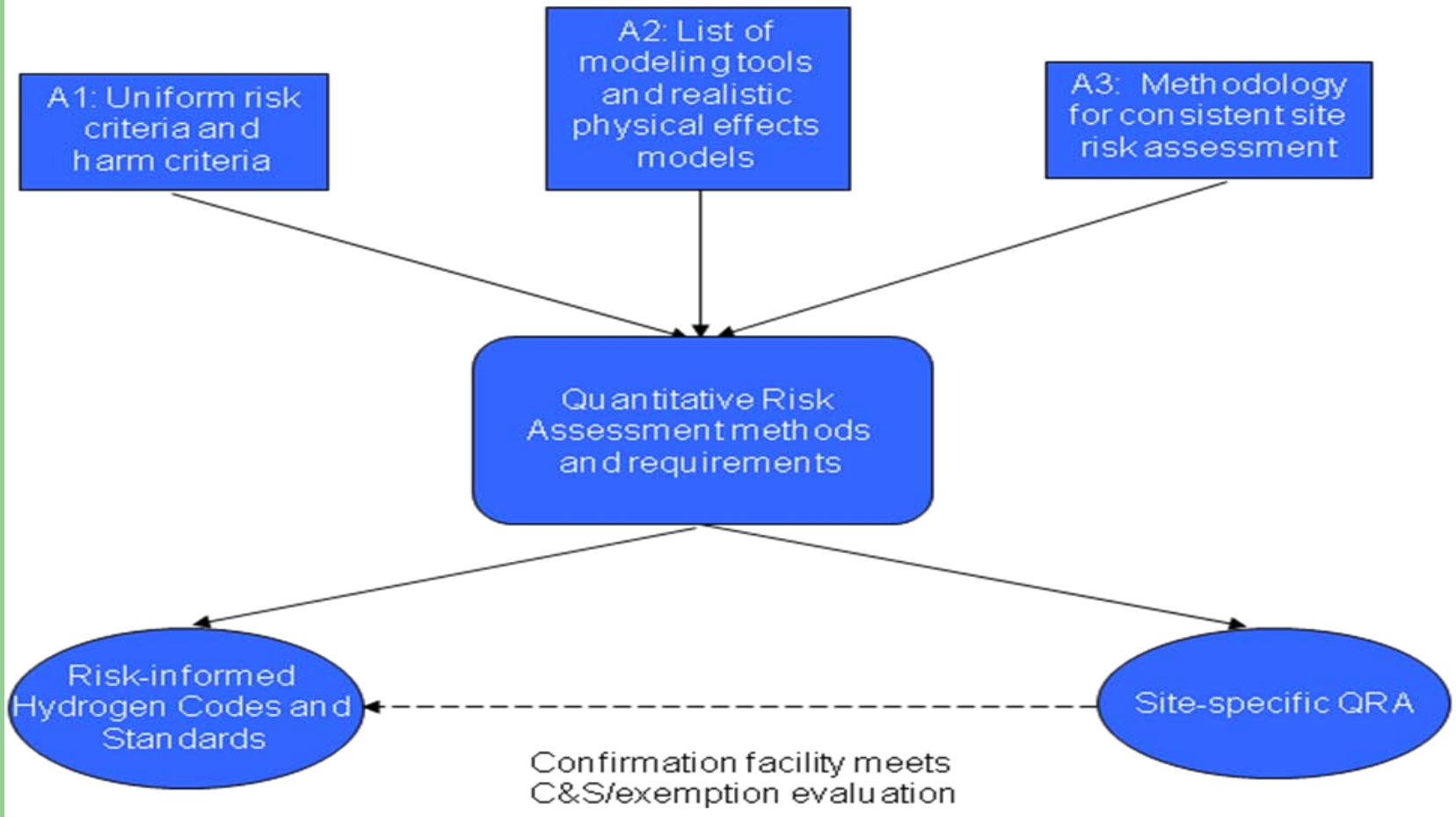


Component Testing

Mitigation



Subtask A – Activity Relationships



Technical Accomplishments and Progress – Risk Management

- ✓ A.1.1 Establish a list of existing engineering models
  - ✓ Categories (March 2008)
  - ✓ Preliminary list (July 2008)
  - ✓ Final list (November 2008)
  - ✓ Comparisons & limitations (November 2009)
- ✓ A.1.2 Further develop dispersion models for H_2 releases
  - ✓ Comparison (April 2008)
  - ✓ Surface and transient effects (November 2009)
- ✓ A.1.3 Develop a more detailed thermal radiation model that would account for crosswinds (November 2009)
- Final Activity Report (June 2010)

Technical Accomplishments and Progress - Experiments and Testing

- Information Exchange
  - Scheduled Experts meetings twice per year to compare experimental data with risk analysis methods
- Hydrogen Technical Experimental Database (HyTEX) launched - November 2009
- HyTEX database populated with data – ongoing as available.

Technical Accomplishments and Progress - Targeted Information Packages

- ✓ Task 19 and other HIA experts contribute to the development of “Hydrogen Safety Best Practices” (http://h2bestpractices.org)
- ✓ Ten Task 19 member countries contribute safety event information and lessons learned to “Hydrogen Incident Reporting and Lessons Learned” (http://www.h2incidents.org)
- ✓ Collaboration enhances other safety knowledge tools, e.g.,
  - Hydrogen Safety Bibliographic Database
  - Hazard and Risk Analysis

(see http://www.hydrogen.energy.gov)

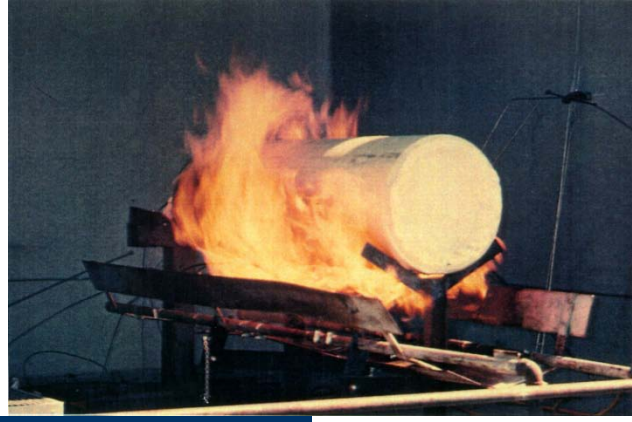
Technical Accomplishments – Other Information and Knowledge Dissemination

- Task participants have presented many papers at technical conferences on the collaborative work.
- The IEA Hydrogen Implementing Agreement co-organized the ***3rd International Conference on Hydrogen Safety*** (September 2009) and Task 19 members presented more than 10 technical papers.
- Multi-author overview paper presented at WHEC 2010 in Essen Germany.
- Task participated in “IEA track” at WHEC 2010 in Essen, Germany.

Collaborations

- The IEA Task 19 is a collaborative task shared effort of more than 25 foremost experts from key organizations in 11 countries:
  - USA
  - Canada
  - France
  - Germany
  - Greece
  - Italy
  - Japan
  - The Netherlands
  - Norway
  - Switzerland
  - United Kingdom

Proposed Future Work

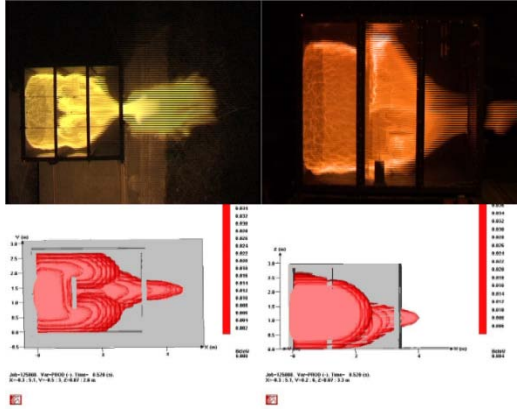


- Continue to refine QRA analysis
  - Robust uncertainty/sensitivity analysis
  - Examine all risk prevention and mitigation measures
    - Separations distances, tiered risk criteria, mean time between failures, walls, maintenance schedules, redesigns …
- Analysis of hydrogen infrastructure
- Barriers/mitigation measures
- Ignition, Flammability
  - Auto-ignition, turbulent flame stability, wall bounded, …
- Unintended leaks in confined areas
  - Garages (domestic and parking), tunnels, …
- Liquid spills and leaks

Proposed Future Work (*continued*)

- Continue to investigate wall jets:
  - Effects of horizontal and vertical surfaces on horizontal and vertical jets flammable extents, thermal flux and pressure effects
- Continue to investigate hydrogen venting:
  - Chamberlain thermal effects model update for hydrogen
  - Vent stacks, flow rates, velocities sized for commercial HRS
- Outflow modeling:
  - Hydrogen dispersion using real gas law (including LES)
  - Hydrogen release from metal hydride storage and comparison with compressed gas storage releases
- Safety knowledge tools: databases and websites

Summary



- All work is according to work plan.
- Unique, cost effective, collaborative, task-shared activity that combines the efforts of the best hydrogen safety experts toward a common work plan to achieve a common objectives.
- International agreement that links into codes and standards activities in many countries to harmonize them and provide a sound, common technical basis.
- Current phase will conclude in October 2010, and a new three-year task is being defined.