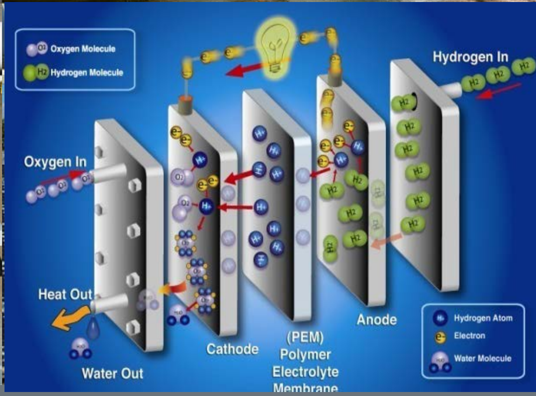
Hydrogen Fueling Infrastructure Research and Station Technology

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

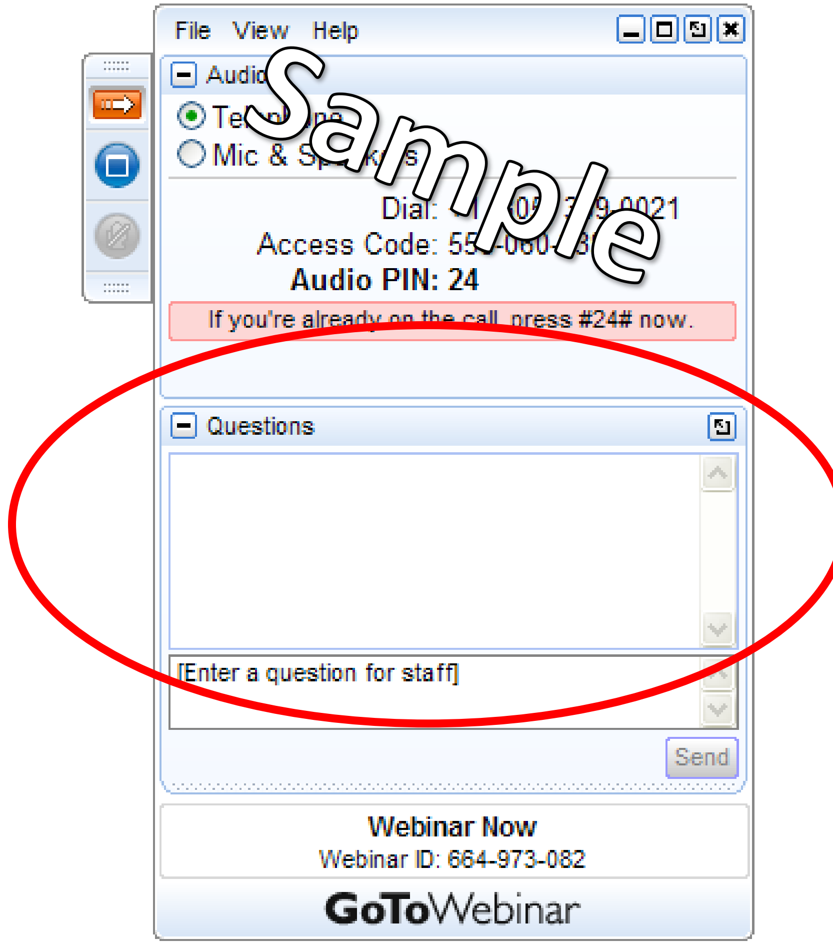


Erika Sutherland

U.S. Department of Energy
Fuel Cell Technologies Office

Question and Answer

- Please type your question into the question box



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H2FIRST

Hydrogen Fueling Infrastructure Research and Station Technology

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Brian Somerday, Danny Terlip, Terry Johnson

November 18, 2014

The Hydrogen Fueling Infrastructure Research and Station Technology Project

H2FIRST

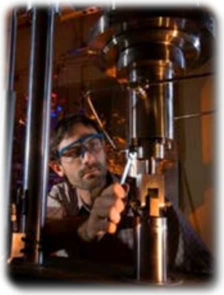
Objective: Ensure that FCEV customers have a positive fueling experience relative to conventional gasoline/diesel stations as vehicles are introduced (2015-2017), and transition to advanced refueling technology beyond 2017.

Distributed Energy Resources Test Facility

NREL

- ***Co-led by NREL and SNL***
- ***Leverages lab core capabilities***
- ***Supports goals and objectives of H2USA***

Sandia National Laboratories



Existing Project Tasks:

Hydrogen Station Equipment Performance (HyStEP) Device

- Goal: Develop hydrogen station test device to validate dispenser fueling protocol
- *September 2014 – August 2015*

Hydrogen Contaminant Detector

- Goal: Develop requirements for inline fuel quality system for installation at stations
- *Timeframe under development*

Reference Station Design

- Goal: Develop station designs based on state-of-the-art components and characterize cost, throughput, reliability, and footprint using DOE models
- *June 2013 - December 2014*

H_2USA
Mission Statement

The mission of H_2 USA is to promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private collaboration to overcome the hurdle of establishing hydrogen infrastructure.

Goals

- Establishing necessary hydrogen infrastructure and leveraging multiple energy sources, including natural gas and renewables
- Deploying FCEVs across America
- Improving America's energy and economic security
- Significantly reducing greenhouse gas emissions
- Developing domestic sources of clean energy and creating jobs in the United States
- Validating new technologies and creating a strong domestic supply base in the clean energy sector

H2USA

Signatories on the Letter of Understanding

U.S. Department of Energy

State of California

Northeast States for Coordinated Air Use Management

Air Liquide

American Gas Association

American Honda Motor Company

ARC: Hydrogen

Argonne National Laboratory

Association of Global Automakers

California Fuel Cell Partnership

Chrysler Group LLC

Electric Drive Transportation Association

Fuel Cell & Hydrogen Energy Association

General Motors Holding LLC

Hawaii Natural Energy Institute

Hydrogenics

Hyundai Motor America

Intelligent Energy Ltd.

ITM Power

Kobelco Compressors America, Inc.

Linde North America

Massachusetts Hydrogen Coalition

Mercedes-Benz USA, LLC

National Association of Convenience Stores

National Renewable Energy Laboratory

Nissan North America R&D

Nuvera

PDC Machines

Plug Power Inc.

Pacific Northwest National Laboratory

Volkswagen Group of America

Proton Onsite

Sandia National Laboratories

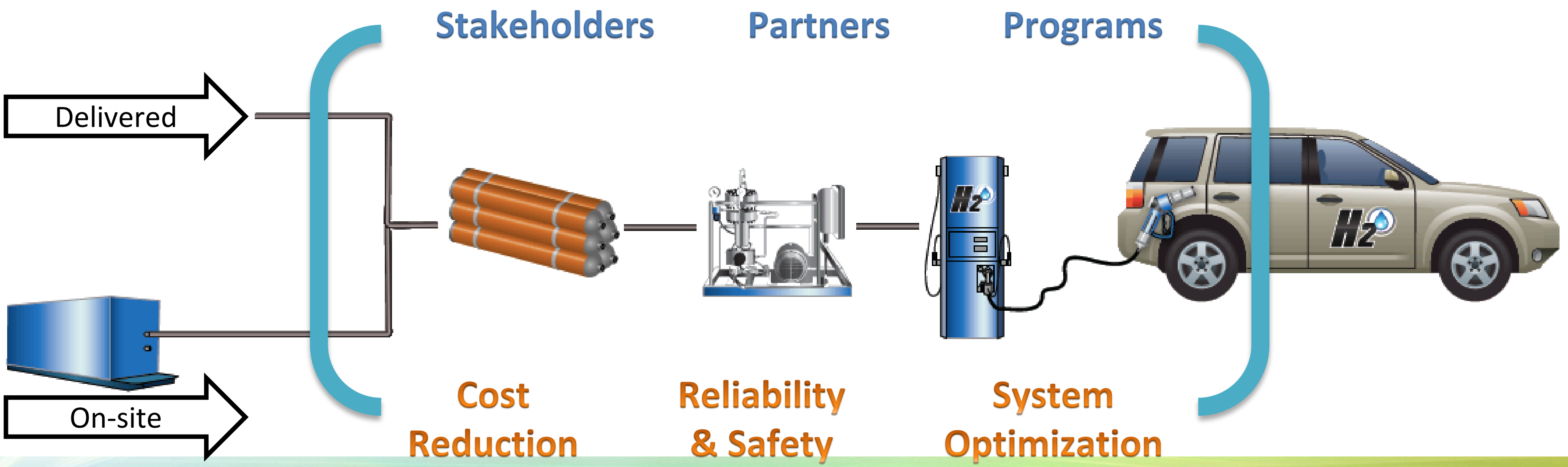
Savannah River National Laboratory

SCRA

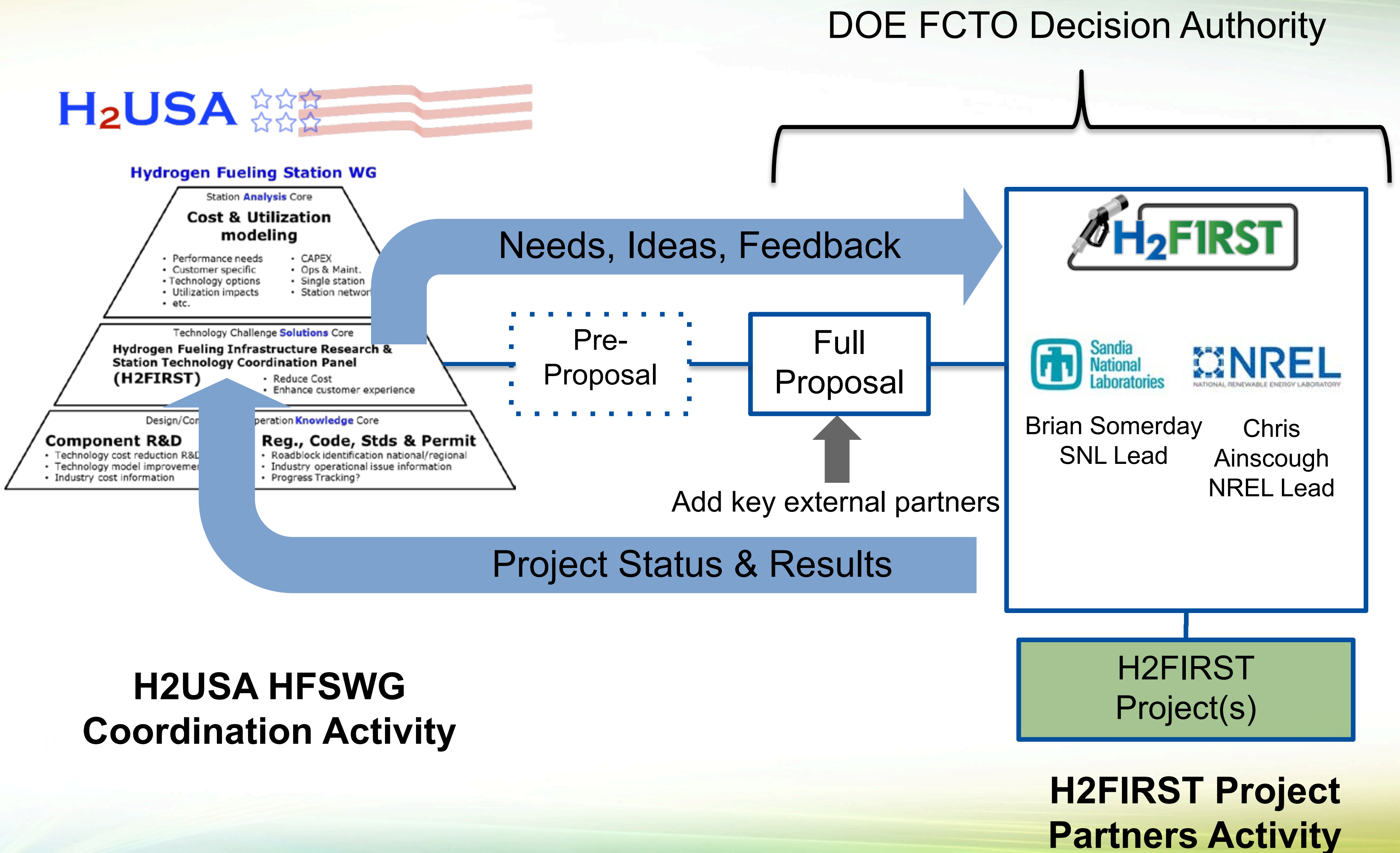
Toyota Motor North America

H2FIRST Long-term Objectives

- Reduce the installation cost of a hydrogen fueling station to be competitive with conventional liquid fuel stations.
- Improve the availability, reliability, and cost while ensuring the safety of high-pressure components.
- Focus a flexible and responsive set of technical experts and facilities to help solve today's urgent challenges and the future unpredicted needs.
- Enable distributed generation of renewable hydrogen in a broader energy ecosystem.



H2FIRST Project Coordination



Task Overview

HyStEP **Hy**drogen **St**ation **E**quipment **P**erformance Device

HyStEP Task Overview

Objective – *Accelerate commercial hydrogen station acceptance by developing and validating a prototype performance test device.*

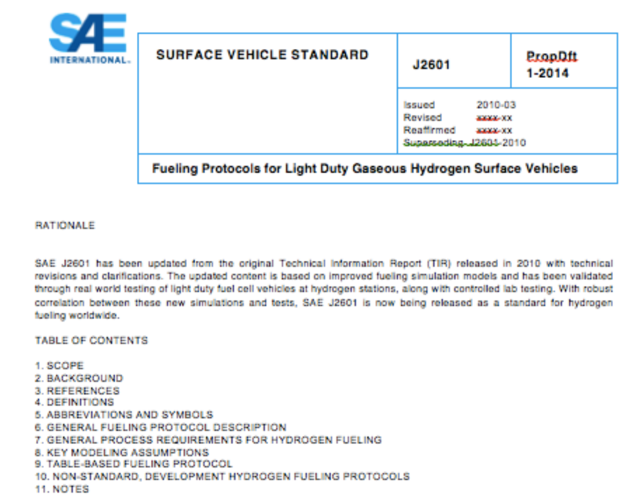
- Team consists of vehicle OEMs, station providers, state and government agencies and lab teams (SNL and NREL)
- Highest priority: Device to test fueling protocol (SAE J2601/CSA HGV 4.3)

CSA Group

CSA HGV 4.3-12

HGV 4.3 – Test methods for hydrogen fueling parameter evaluation

CSA America Participant Copy Only. Distribution Prohibited



SAE INTERNATIONAL

SURFACE VEHICLE STANDARD	J2601	PropDft 1-2014
	Issued 2010-03 Revised xxxx-xx Reaffirmed xxxx-xx ~~Superseding J2601-2010~~	
Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles		

RATIONALE

SAE J2601 has been updated from the original Technical Information Report (TIR) released in 2010 with technical revisions and clarifications. The updated content is based on improved fueling simulation models and has been validated through real world testing of light duty fuel cell vehicles at hydrogen stations, along with controlled lab testing. With robust correlation between these new simulations and tests, SAE J2601 is now being released as a standard for hydrogen fueling worldwide.

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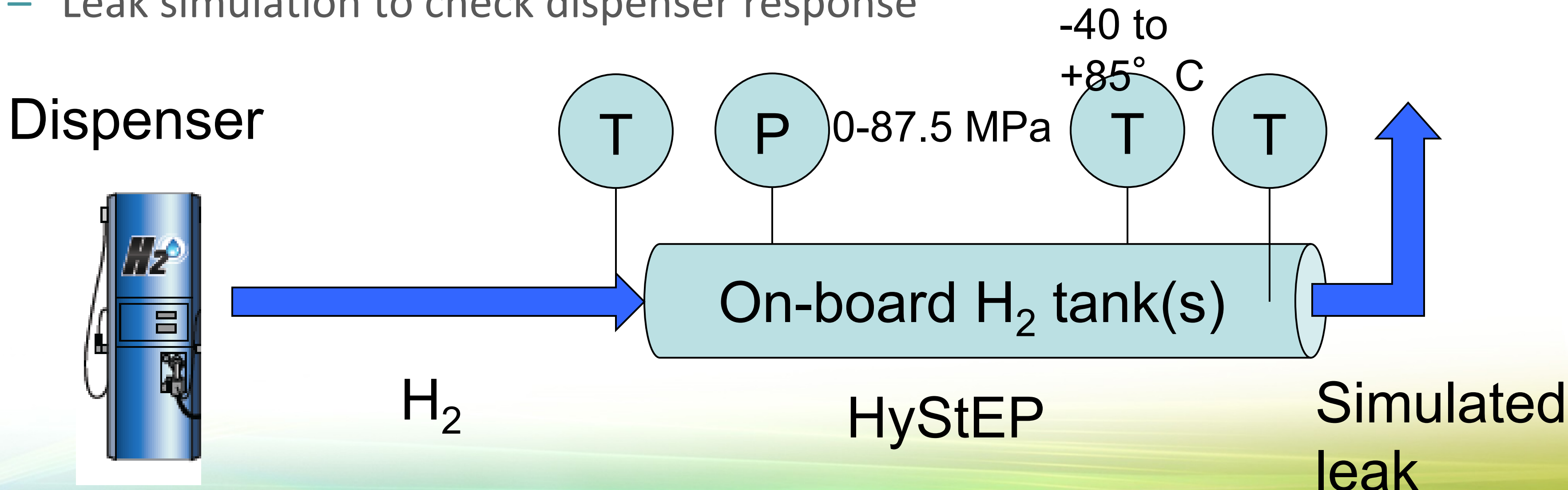
HySTEP Task Overview

H2FIRST

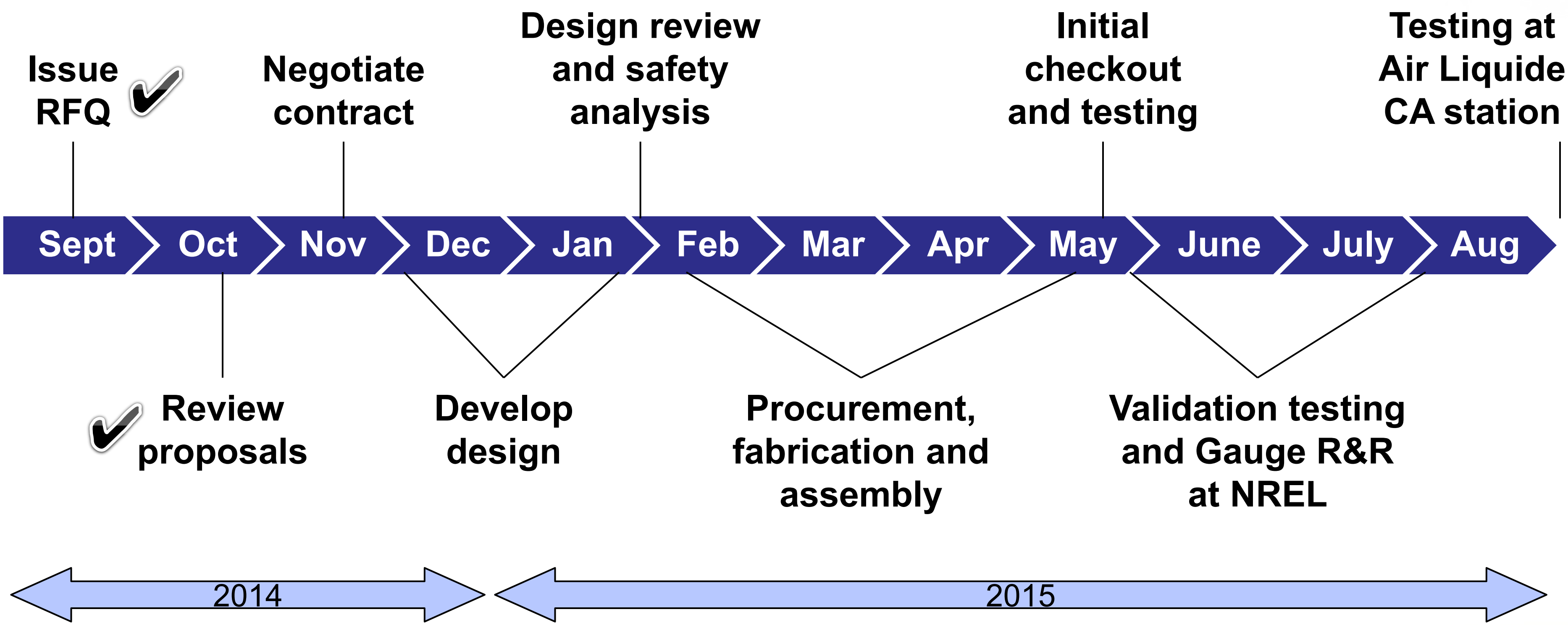
- Why we need HyStEP:
  - As hydrogen is compressed into a vehicle tank, it heats up.
  - Hydrogen is pre-cooled as low as -40°C, and the fill rate is controlled.
  - Carbon fiber vehicle tanks have thermal limits that must not be exceeded.
  - The fueling protocol standards SAE J2601 and CSA HGV 4.3 specify how to fill hydrogen vehicles safely.
  - Vehicle manufacturers, consumers, station operators, and state stakeholders all want to know that stations are filling safely.

HyStEP Task Overview

- Specifications for HyStEP
  - Device is mobile: Mounted in truck bed or trailer
  - Type IV 70 MPa tank(s) with 4-7 kg capacity
  - Designed to perform subset of CSA HGV 4.3 tests, may add others in the future (e.g. MC fill)
  - SAE J2799 IrDA for communication tests and fills
  - Tank and receptacle instrumented with multiple P, T sensors to monitor pressure ramp rate, ambient, tank, and gas conditions.
  - Leak simulation to check dispenser response



HySEP Device scheduled for completion September 2015



Task Overview

Hydrogen Contaminant Detector

Hydrogen Contaminant Detector (HCD) Task Overview

Objective – *Develop requirements for inline fuel quality system for installation at stations.*

Current Activity

Market Survey	Requirements Document
Perform a market survey of current detection technology characteristics including detector availability, capabilities, cost and maintenance	Incorporate input from industry and government experts with research from the market survey to develop a set of engineering requirements for a detector

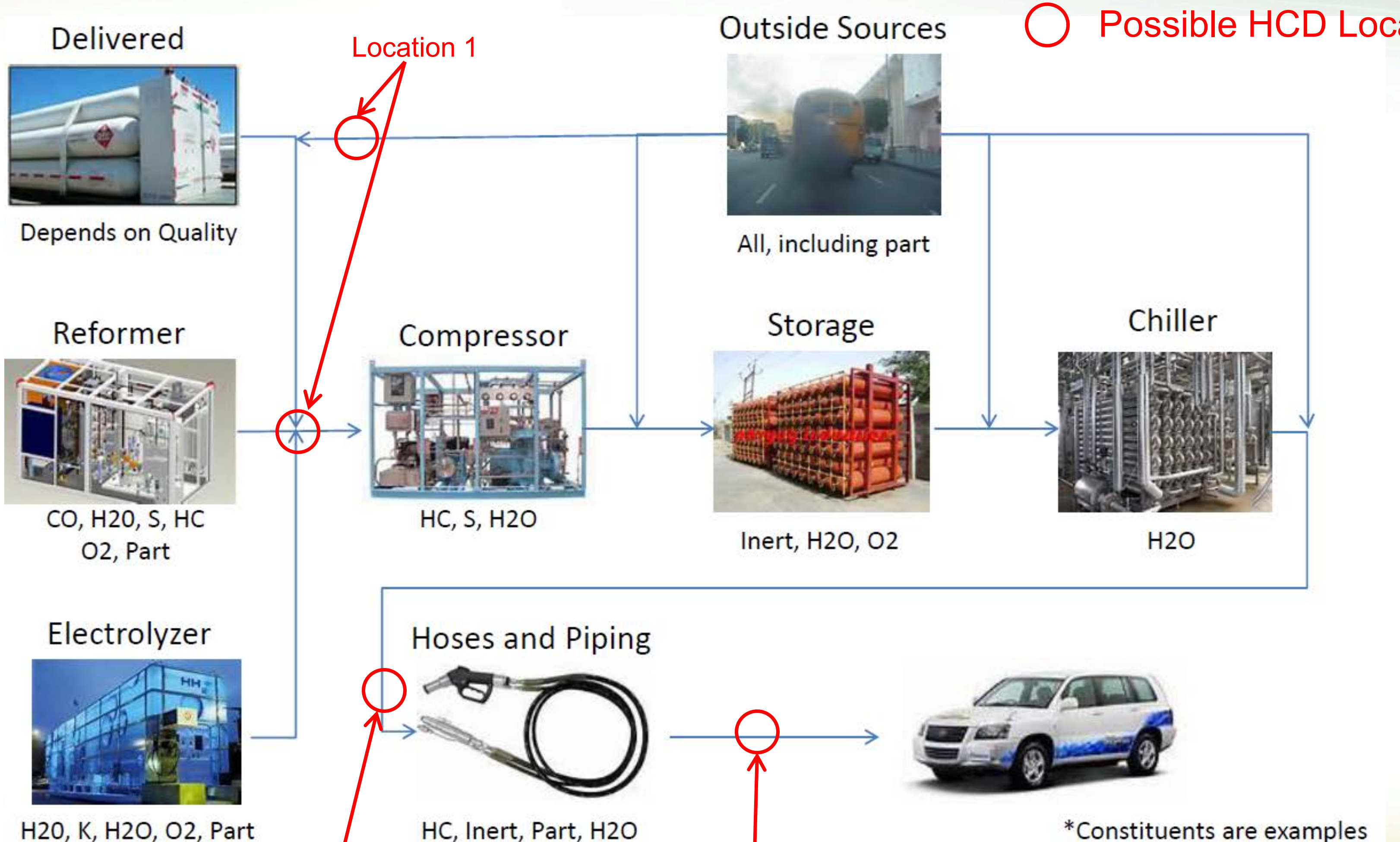
Hydrogen Contaminant Detector Challenges

Desired Characteristics	Challenges
Ease of station integration	• Multiple station configurations • Extreme gas pressure and temperature

Near term solutions will likely be tailored to individual station technologies based on probable contaminants.

Hydrogen Station Integration

Risk Based Approach

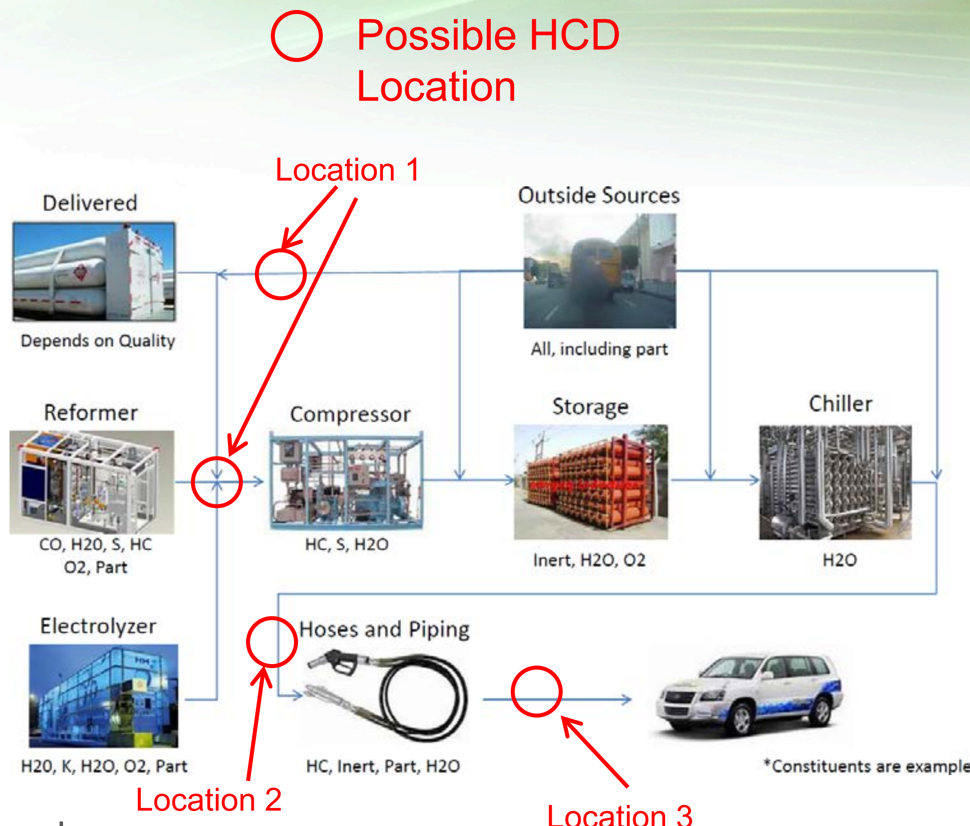


Credit: Spencer Quong

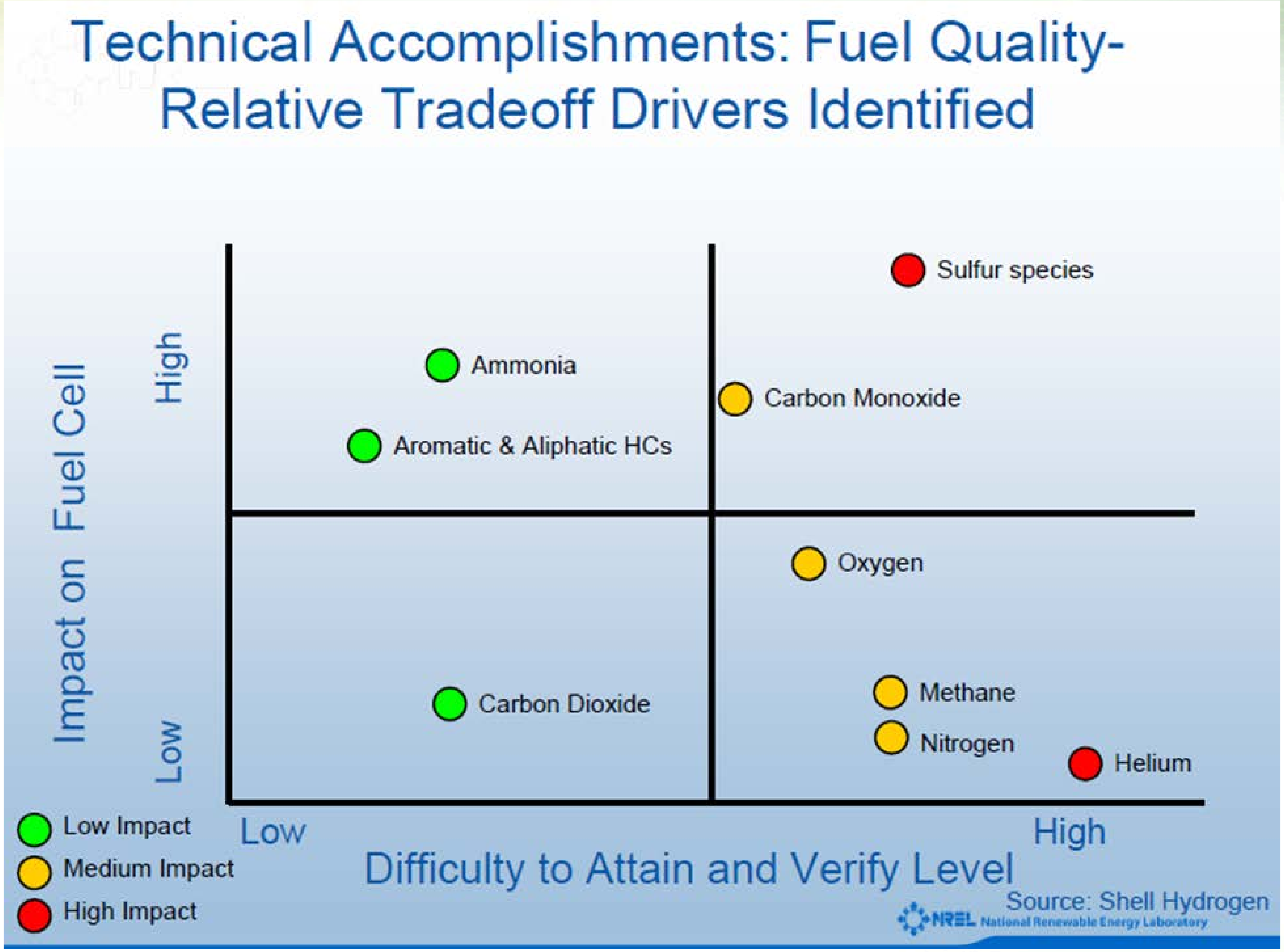
Hydrogen Station Integration

Risk Based Approach

- Delivered Hydrogen (SMR Production)
  - Gaseous
  - Liquid
- On-site Hydrogen Production
  - Water Electrolysis
  - Steam Methane Reformation
- Pros
  - L1: low pressure requirements
  - L2: captures most contaminant sources
  - L3: captures all contaminant sources
- Cons
  - L1: misses potential contaminants from downstream sources
  - L2: must be integrated with <87.5 MPa and > -40° C gas
  - L3: burden on vehicle OEM; many more cars than stations



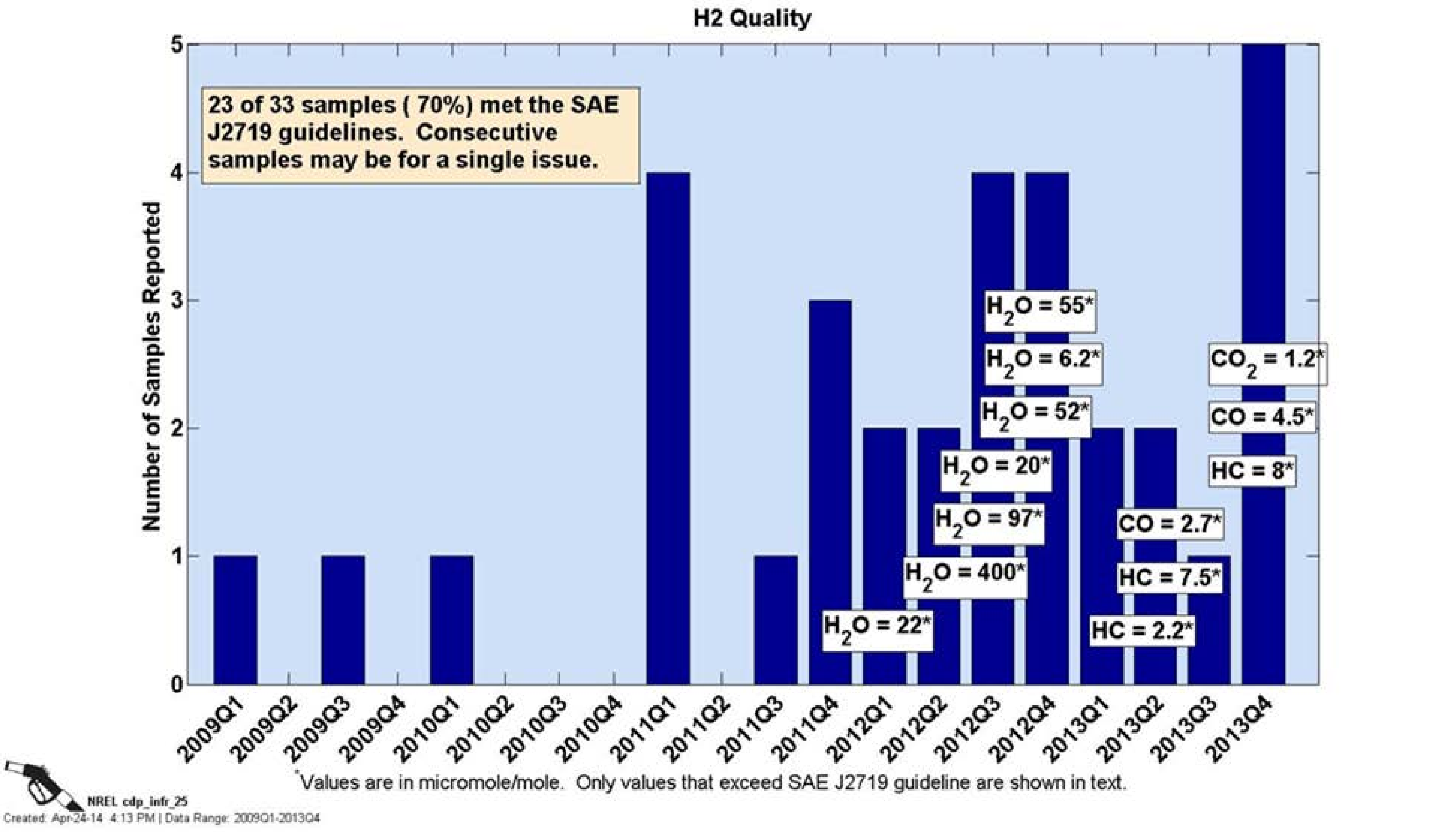
Critical Contaminants



CO is the most critical constituent in the specification

Contaminants Detected and Levels

Current station data: Field observations



Market Survey

- Study of available hydrogen contaminant detectors. Task elements include:
  - Gather data on relevant technologies
  - Prioritize detectors for most impactful contaminants
  - Prioritize commercial technologies for station deployment
  - Define engineering requirements for a deployable HCD
  - Identify gaps
- NREL and SRNL developing work plan, timeline and milestones
- Output: market survey and engineering requirements

Market Survey
Technologies Investigated

Gas Chromatograph Technologies	Mass Spectrometry
• GC/PDID – Pulsed Discharge Ionization Detector • GC/DID – Discharge Ionization Detector • GC/ECD – Electron Capture Detector • GC/PFPD – Pulsed Flame Photometric Detector	• APIMS – Atmospheric Pressure Ion Mobility Spectrometry
Piezoelectric	**Optical**
• QCM – Quartz Crystal Microbalance	• TDL – Tunable Diode Laser • ICOS – Internal Combustion Optical Sensor • FTIR-Gas Cell – Fourier Transform Infrared spectroscopy • CRDS – Cavity Ring Down Spectroscopy

Task Overview

Reference Station Design

Reference Station Design Task Overview

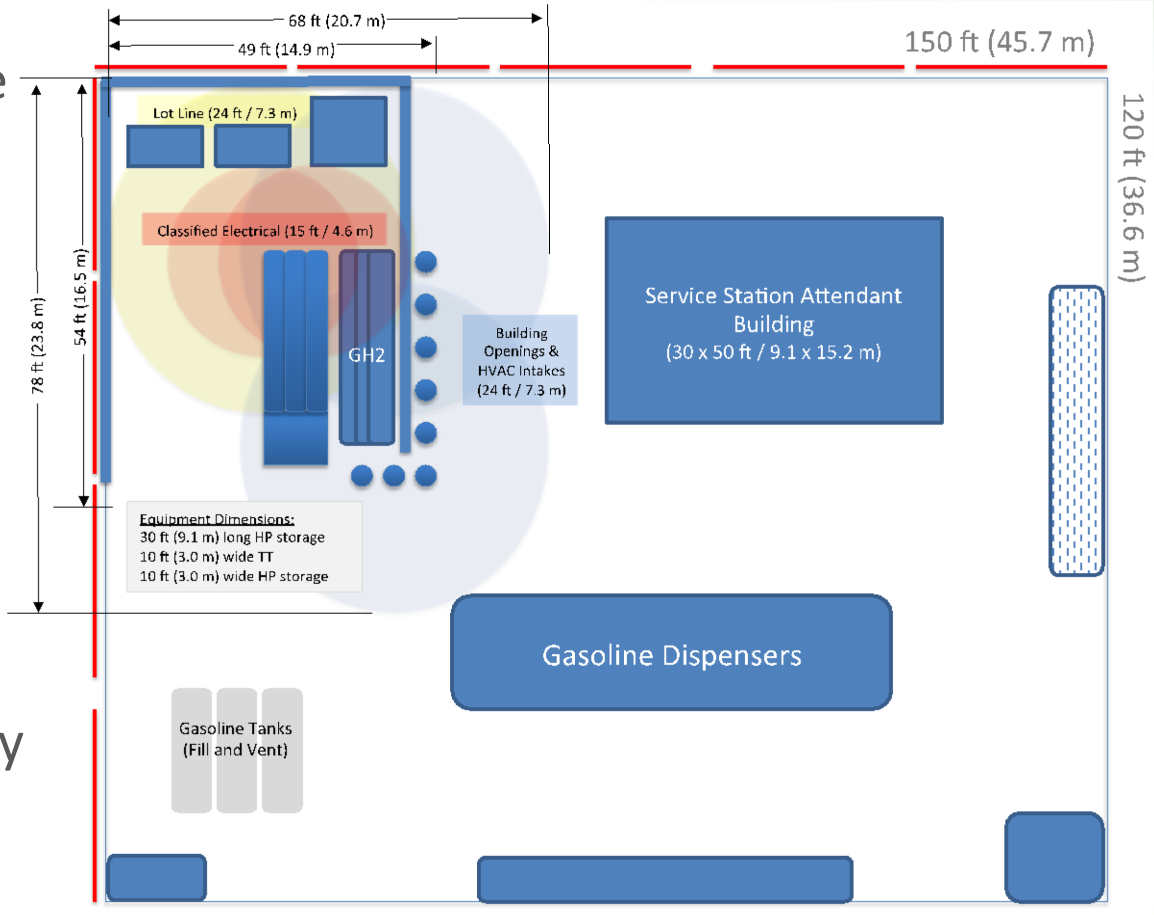
Objective – *Develop station designs based on state-of-the-art components and characterize cost, throughput, reliability, and footprint using DOE models.*

Approach

- Develop a station design matrix.
- Identify priority options of 10-15 stations.
- Complete an external review with stakeholders.
- Develop three to five high-impact station designs.
- Report on gaps, recommendations for testing, and R&D.
- Hold a stakeholder information webinar

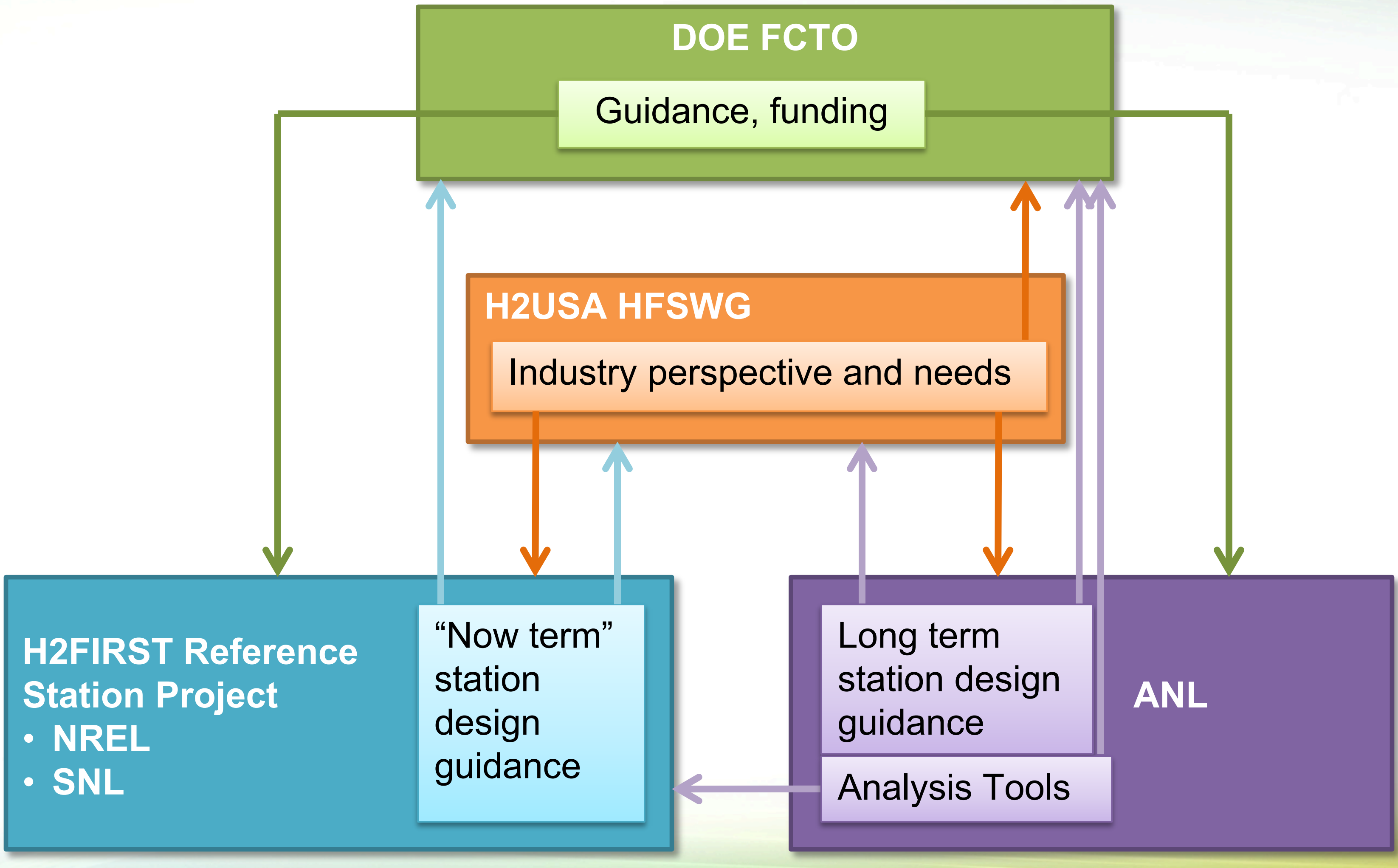
Station Characteristics

- Hydrogen delivery type
- Daily capacity
- Land area requirement
- Fuel cost
- Capital investment
- Compressor configuration
- Storage size
- Consecutive fill capacity
- Number of hoses



Source: Safety, Codes and Standards for Hydrogen Installations: Hydrogen Fueling System Footprint Metric Development, SAND2014-3416 Sandia National Laboratories, 2014.

This is a highly-collaborative project between H2FIRST, H2USA, ANL, and DOE



Reference Station Design Task Process

Utilization, capacity, size, dispenser…

1. Define parameters and ranges

Compressor, land, O&M, 875 bar storage, …

2. Specify cost data and metrics. Review.

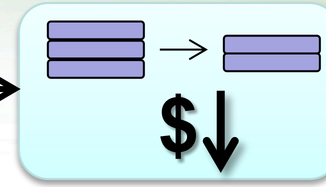
HRSAM Model Development

Station	Utilization	Capacity	Dispensers
1	20%	50	1
2	Ramp	100	1
3	Ramp	200	2
	...	...	...
N	...	...	...

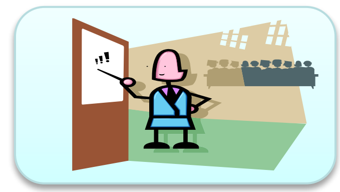
3. Specify and simulate station concepts.

Station	Cost per kg	Capital Cost	ROI Period
1	$	$	Y
2	$	$$	Y
3	$$	$	YY
4	$$	$$	YYY
5	$$$$$	$$$	YYYYY

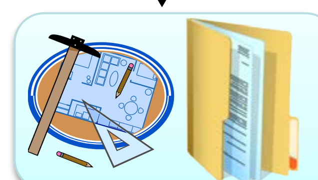
4. Station selection based on comparative economics and technical feasibility. Review.



5. Optimization of selected stations



6. Review of final stations



7. Station designs

Status: Step 4. Down-select ongoing.

How to get involved in H2USA

- To join H2USA, email info@h2usa.org, or visit http://h2usa.org

How to get involved in H2FIRST

Contact

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Questions

- Please type questions into the chat box in the webinar software.
- For more information, please visit.

http://energy.gov/eere/fuelcells/h2first

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BACKUP

Supporting Capabilities – CIRI Materials Science & Engineering Science Focus

CIRI Capabilities

- Materials and Components
  - Materials testing in high-pressure H_2 at variable temperature
  - Customized testing on metals and non-metals
  - Weld research and development
  - Full-scale component testing in H_2
- Systems Engineering
  - Full-scale H_2 station breadboard for system optimization
  - Real world equipment evaluation and innovation platform

Status

- Assessing HyReF (full-scale component testing and H_2 station breadboard) planned for 2015

Supporting Capabilities – ESIF & DERTF Testing & Analysis Focus

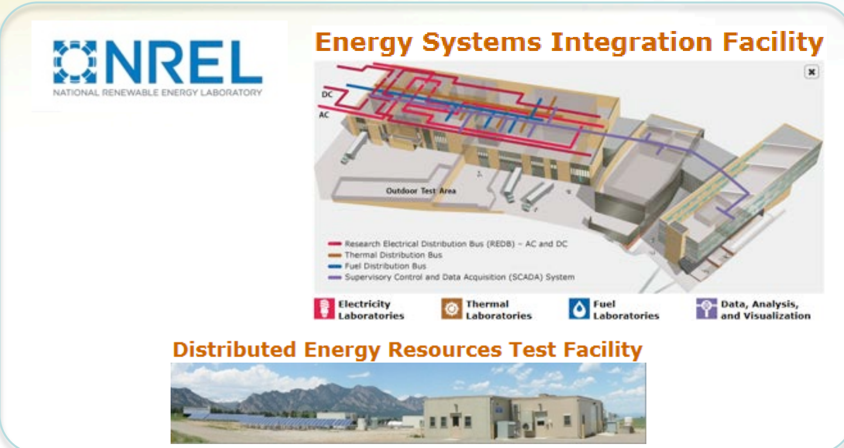

Photo credit: NREL (April 2014)

Capabilities

- On-site hydrogen generation (electrolyzers)
- High pressure component testing
- Flexible, renewable-ready hydrogen energy storage platform
- Advanced hydrogen sensor testing
- 700-bar and 350-bar (nom) dispensing
- Research Electrical Distribution Bus (REDB) capability for grid integration
- Physical and photo-electrochemical material characterization
- Systems integration & device under test platforms

Research Station Status

- 700-bar research station construction for basic system architecture started and expected completion in December 2014