

# 2005 DOE Hydrogen Program Review Hydrogen Codes and Standards

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Project ID# SA2

This presentation does not contain any proprietary or confidential information

# Overview

## Timeline

- Project start date: 10-1-04
- Project end date: 9-30-05
- Percent complete: 50

## Budget

- Total project funding
  - DOE share: \$1.6M
  - Contractor share: \$10K
- Funding received in FY04: \$2.0M
- Funding for FY05: \$1.6M

## Barriers

- Codes and Standards Barriers addressed
  - Consensus national agenda on codes and standards (J,A,B,D,L)
  - Limited DOE role in the development of ISO standards and inadequate representation by government and industry at international forums (F,G,H,I,K)
  - Current large footprint requirement for hydrogen fueling stations (P,N,M)

## Partners

- National Hydrogen and Fuel Cells Codes and Standards Coordinating Committee
- FreedomCAR-President's H<sub>2</sub> Fuel Initiative C&S Tech Team
- North American Hydrogen Fuel Quality Team

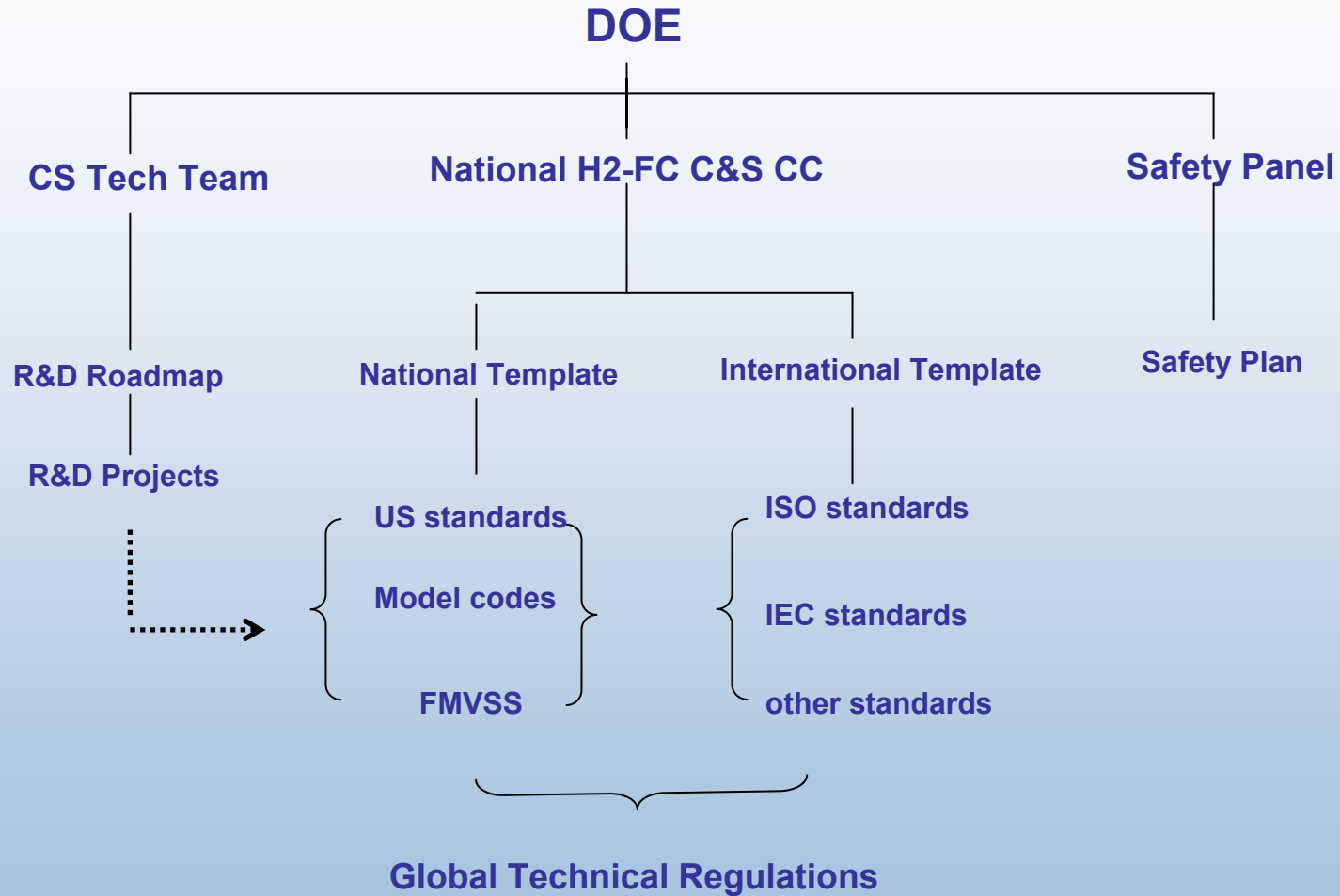
# Objectives

- Develop and implement consensus national agenda on domestic and international codes and standards for hydrogen systems in commercial, residential, and transportation applications
- Enhance DOE's role in development of ISO and other international standards and strengthen representation by government and industry at international forums
- Facilitate harmonization of requirements for hydrogen applications based on consensus R&D
- Integrate codes and standards activities from R&D to pre-commercialization

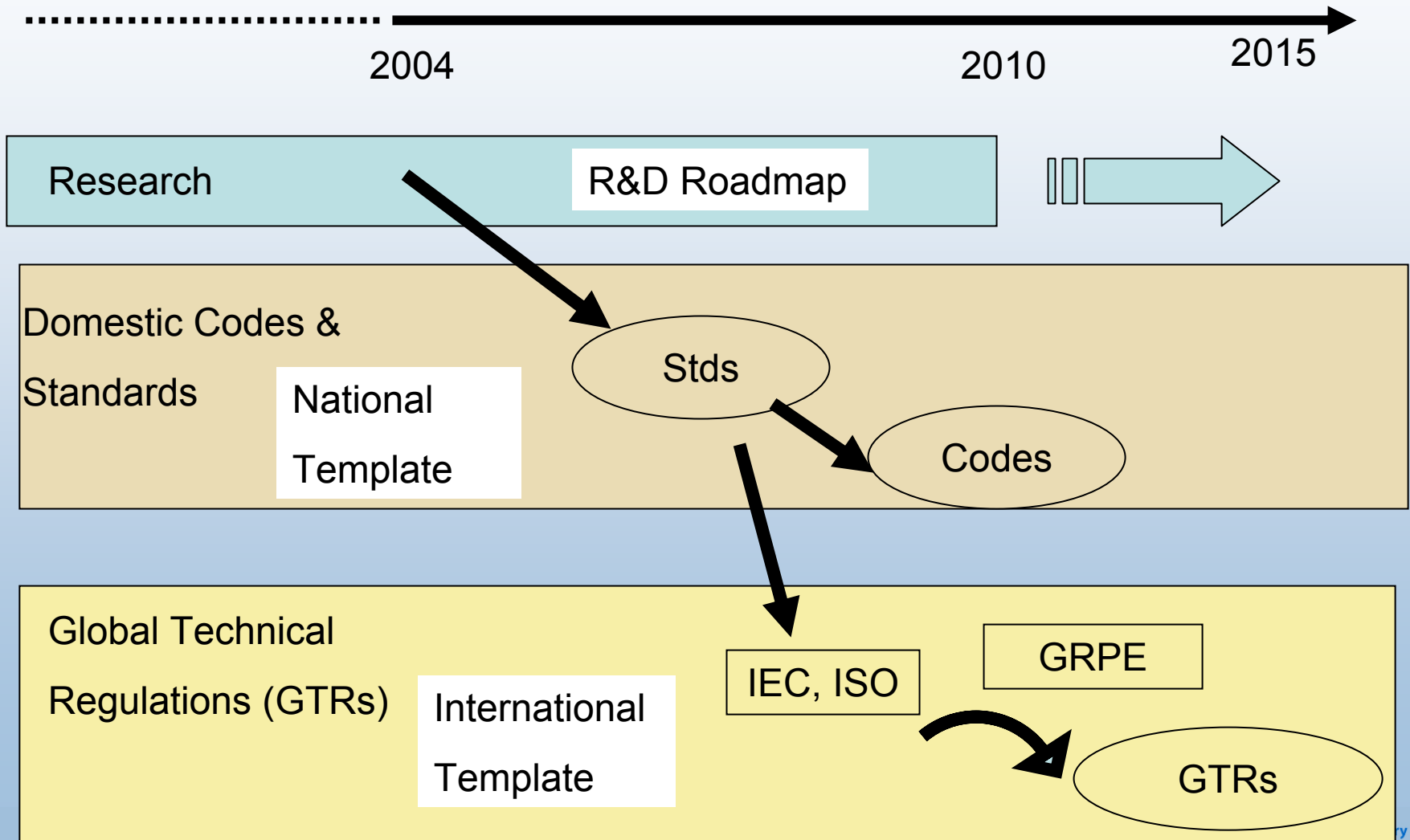
# Approach

- Develop unified national agenda for codes and standards
  - National templates adopted by consensus of SDO/MCDs
    - accelerate development of priority standards
    - designate and support lead SDO/MCDs
    - facilitate access to standards/model codes through ANSI website
  - Coordinate national/international codes and standards activities
    - National H<sub>2</sub>/Fuel Cells Codes and Standards Coordinating Committee
- Coordinate R&D through Codes and Standards Tech Team R&D Roadmap
  - Hydrogen Behavior
  - Vehicles
  - Fuel Infrastructure
  - **Fuel-Vehicle Interface**
    - fuel quality specifications
    - integrated safety engineering
- Harmonize technical standards and global technical regulations
  - International template

# Approach: Overall Structure



# Approach: from R&D to GTRs



# Approach: Overall Timetable

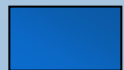
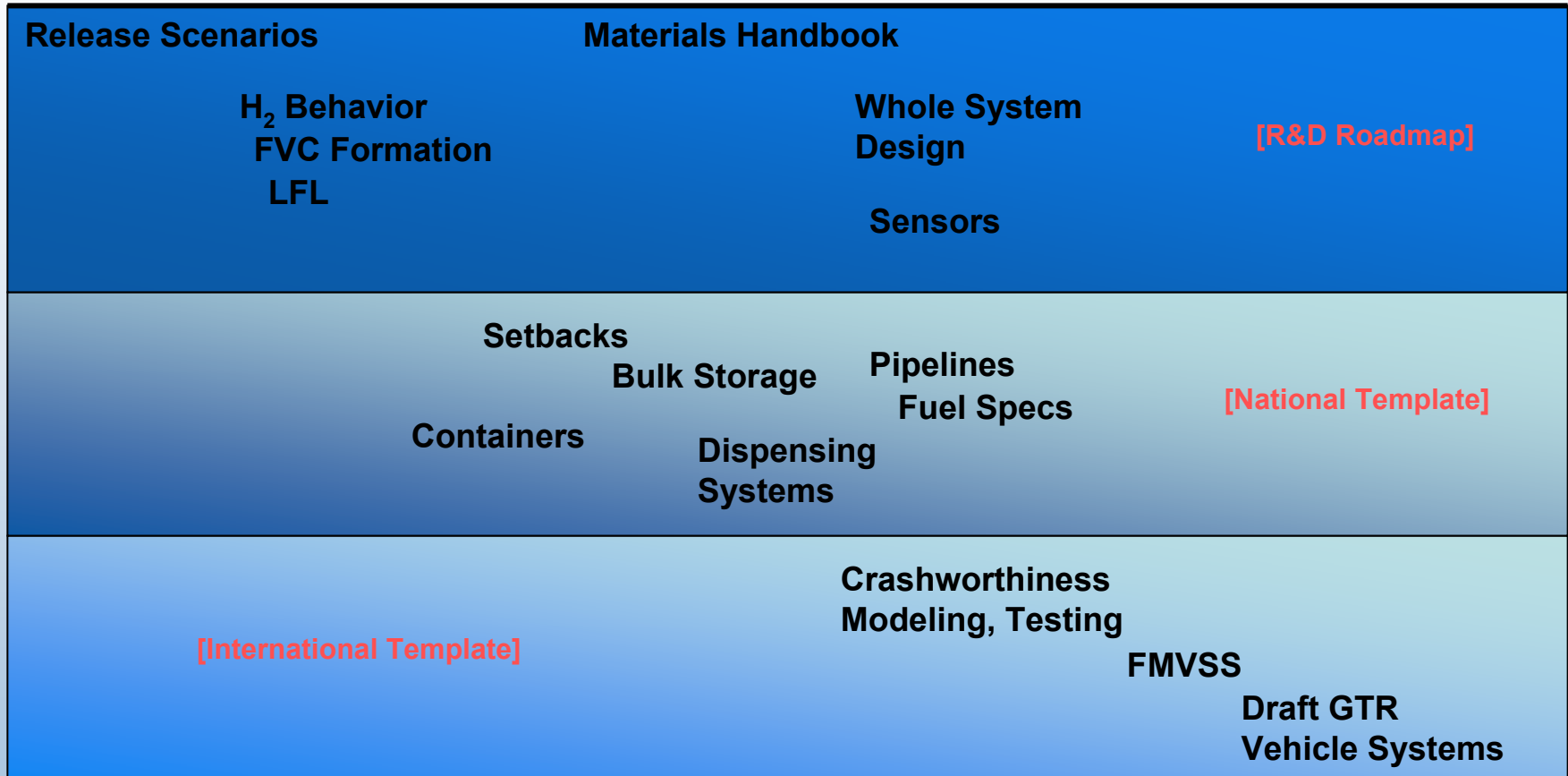
2004

2006

2008

2010

2015



R&D



Codes and Standards



Regulations

Commercialization Decision

# Technical Accomplishments/Progress

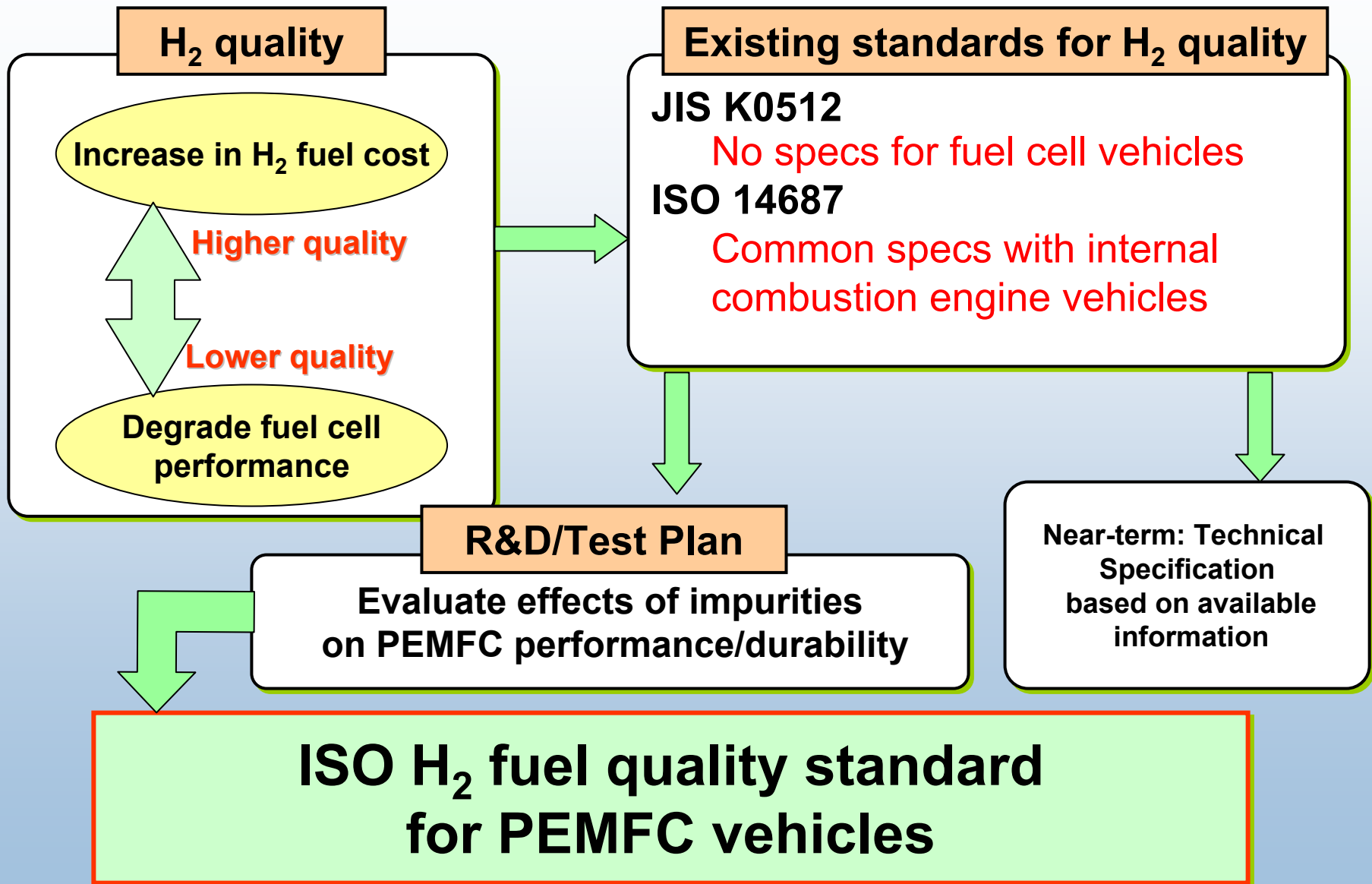
- Unified national agenda for codes and standards
  - consolidated national coordination groups and activities
    - DOE, USFCC, NHA created National H<sub>2</sub>-FC C&S Coordinating Committee
    - establish national focal point and consensus on key C&S issues, needs
  - ANSI hydrogen portal ([www.hcsp.ansi.org](http://www.hcsp.ansi.org))
    - incorporated C&S matrix and website ([www.fuelcellstandards.org](http://www.fuelcellstandards.org))
    - agreement with key SDO to post and browse H<sub>2</sub>/FC standards and model codes
  - work with all key SDO/MCO to develop essential standards and model codes
- Coordinate R&D to develop defensible standards for hydrogen systems
  - Codes and Standards Tech Team and R&D Roadmap implementation
  - initiate whole-system engineering research approach for hydrogen safety
  - coordinate long-term R&D/test plan for hydrogen fuel quality
- Harmonize technical standards and global technical regulations
  - member US Technical Advisory Group, ISO/TC197, Hydrogen Technologies
  - member of ISO/TC197 WG 12 to prepare hydrogen fuel quality specification
  - work with CGA and CSA to coordinate ISO/TC197 and IEC/TC105



# Technical Accomplishments/Progress

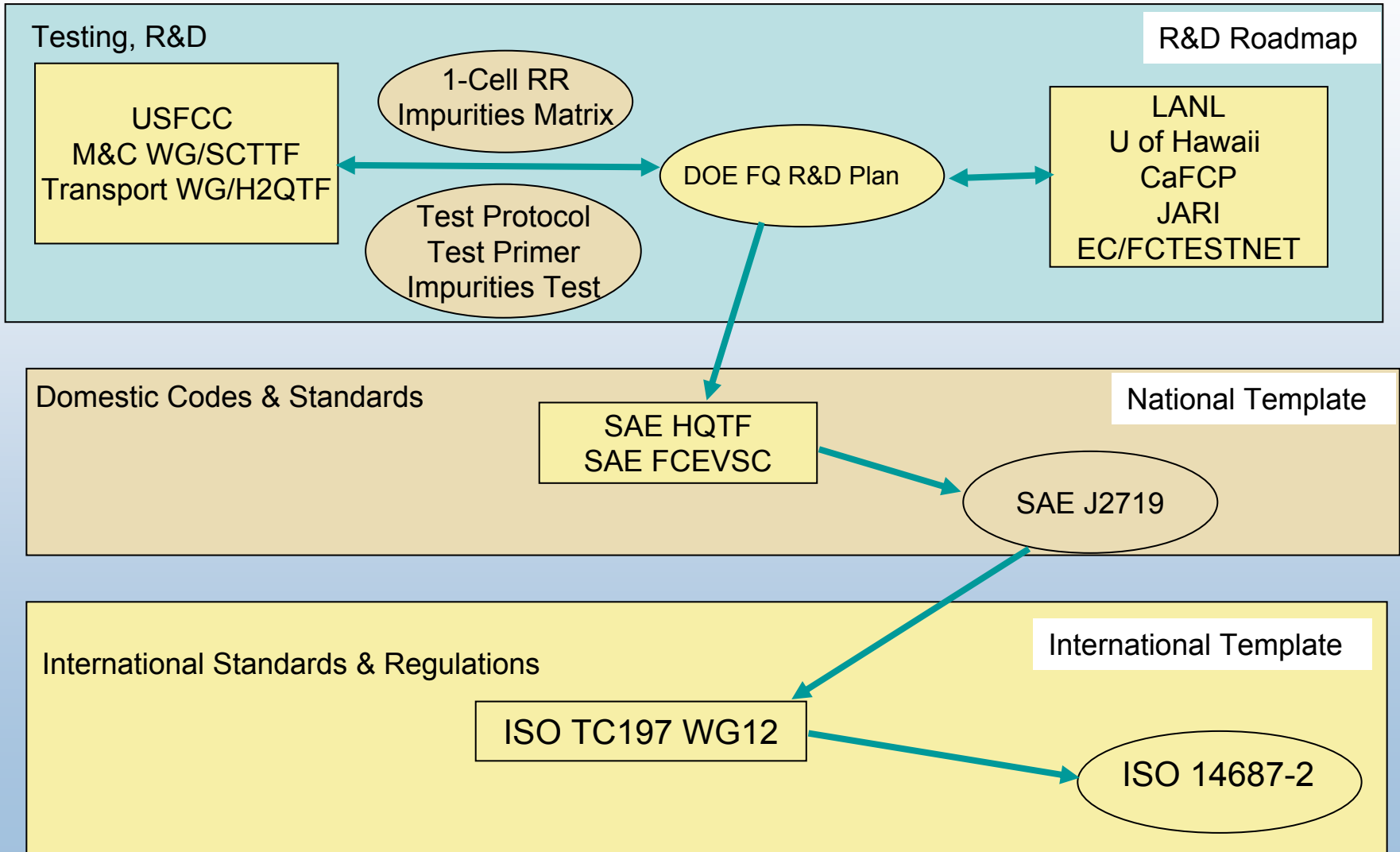
- Support and facilitate development of standards and model codes
  - Draft standards for fueling systems, containers (on-board), sensors, fuel cells for hand-held devices and telecommunications under review
  - Draft standards for piping, bulk storage, composite containers, transportable containers under way
  - Fuel cell electric vehicle standards published, under review, or being developed
  - Draft ISO Technical Specification for hydrogen fuel quality under review
  - Model codes will provide for additional hydrogen applications
    - 2006 ed., International Code Council model codes
    - NFPA 52 and 55 under revision

# Technical Accomplishments: Fuel Quality



Source: adapted from JARI

# Technical Accomplishments: Development of International H<sub>2</sub> Fuel Quality Standard (PEMFC Road Vehicles-Anode)



# Technical Accomplishments: International Template for Hydrogen Standards and Regulations

## Standards/Codes

### Key International Organizations:

IEC, ISO

### Key Domestic Organizations:

ANSI, ASME, CGA, CSA, SAE, UL  
ICC, NFPA

DOE, DOT, EPA, NASA, NIST

NHA, USFCC, CaFCP

### Key Foreign Organizations

Japan: METI, NEDO, JARI

EU: FCHP

## Coordination/Harmonization

DOE

DOC, DOT, EPA, NASA

API, ANSI, NHA, USFCC

US TAG chairs IEC, ISO

Workshop

Strategic Plan

Annual Plan and Review

## Regulations

### Key International Organizations:

UN/ECE WP29/GRPE, NAFTA

### Key Domestic Organizations:

NHTSA (Crashworthiness)

RSPA (Transport, Pipelines)

EPA (Emissions)

### Key Foreign Organizations

Japan: Transport Ministry

EU: ECE, TUV

## Research, Testing,

## Validation

### Key International Organizations

IPHE

### Key Domestic Organizations:

ASTM, CaFCP, DOE, NHA, NASA, NIST  
USFCC, national labs, universities

### Key Foreign Organizations

Japan: Millennium Project, FCCJ, JARI

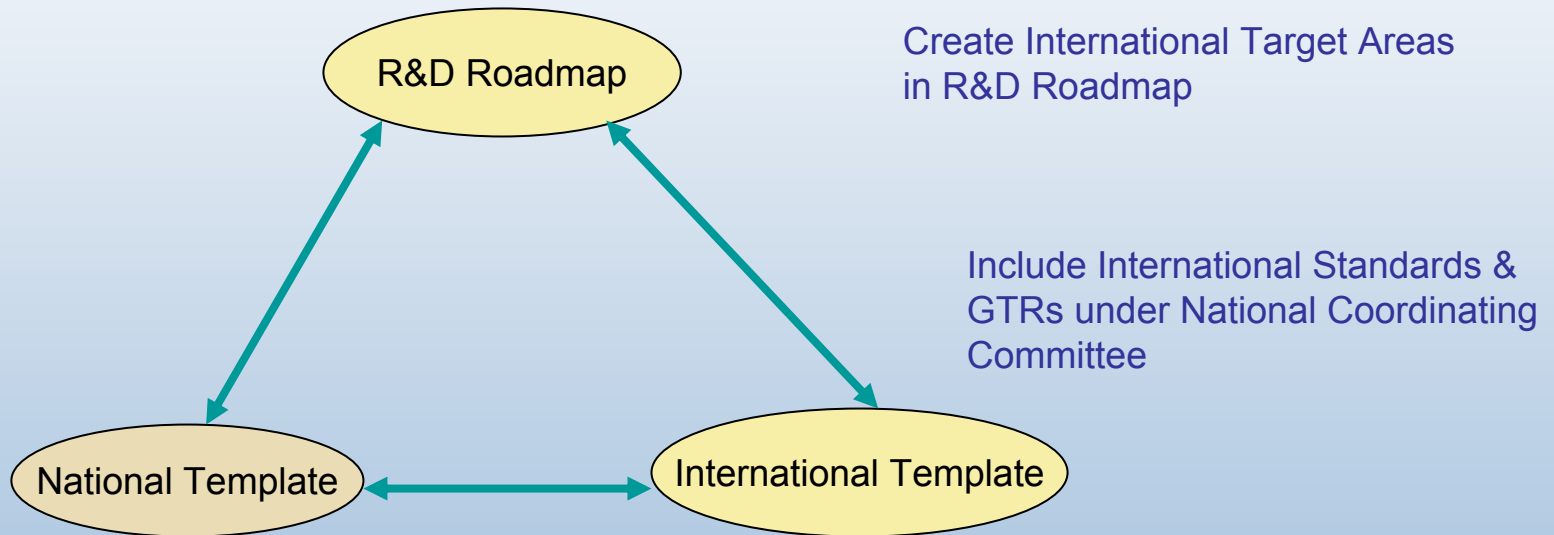
EU: FCTESTNET, FCTESTQA, HySafe

Canada: CFCTA

# Technical Accomplishments: Harmonization of International Standards and Regulations

Japan: Millenium Project  
EC: HFCEP, HySafe, FCTESTNET  
Canada: CFCTA

## C&S Tech Team



## National H2-FC C&S CC

US TAGs ISO TC197, TC22/SC21  
IEC TC105  
WP29/GRPE--EPA/NHTSA

# Responses to Previous Year Reviewers' Comments

- Clear definition between portions of budget directed toward code setting bodies, . . . , etc., and that part . . . used specifically for R&D
  - R&D part (fuel quality, testing/validation, integrated engineering) are separate subtasks in FY05
  - National/international templates, subcontracts to SDOs are separate subtasks in FY05
- Gather international input if available
  - developing international template for standards and regulations
  - developing international collaboration on R&D for hydrogen safety, codes and standards
  - member of US delegation to ISO TC197 plenary
  - member of US TAG to ISO TC197
  - working with JARI, FCTESTNET, HySafe, HyApproval, etc.

# Future Work: Codes and Standards Development

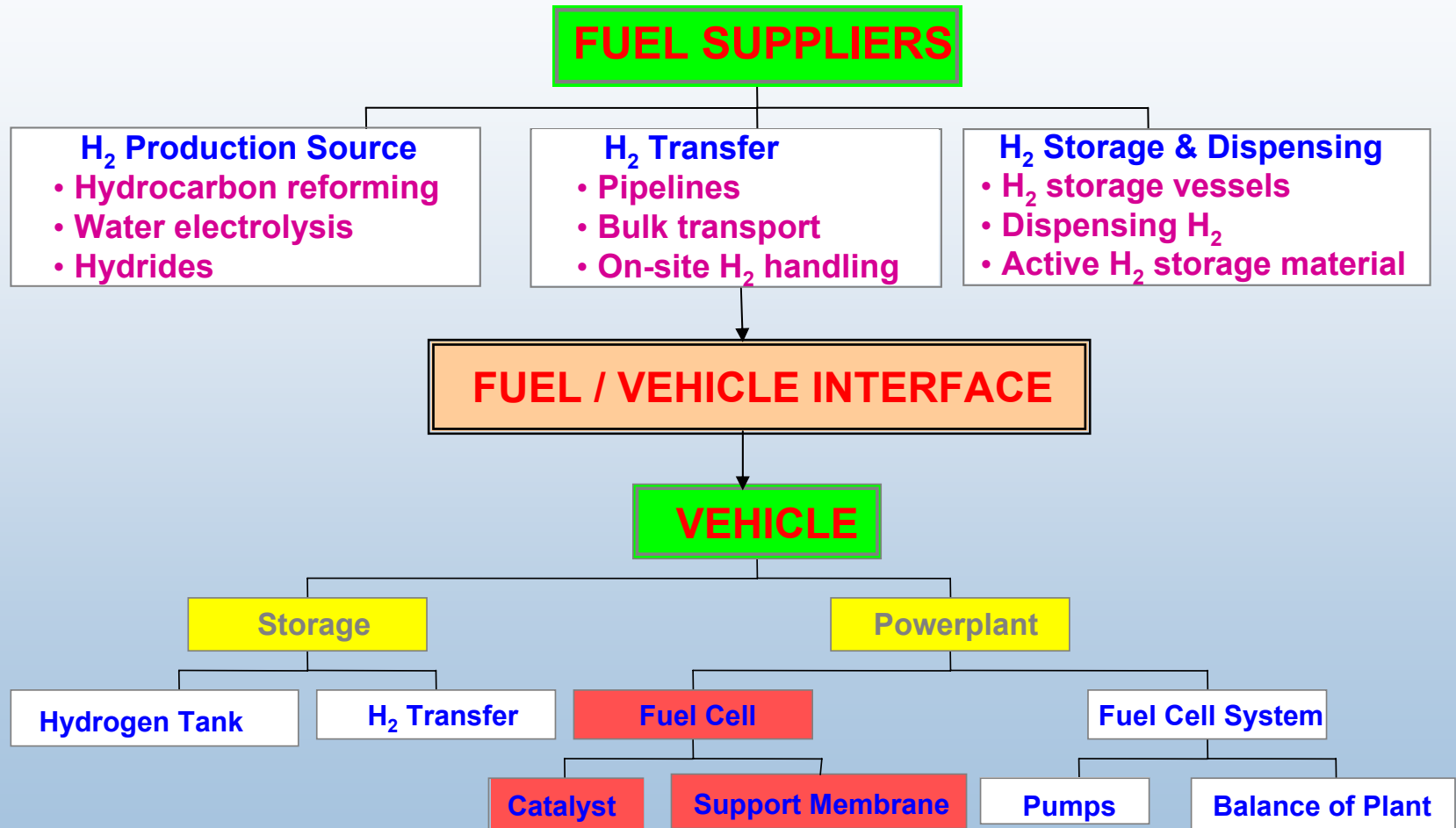
- Expand coordination role for national template
  - re-evaluate C&S development, synchronize with R&D
  - transition to performance-based standards
- Develop and implement international template for hydrogen-fueled vehicles based on GTR process
  - on-board storage components and subsystems
  - whole-vehicle safety
  - energy, environmental considerations
- Develop sustained industry participation in ISO, IEC, and GTR process to implement international template
  - bring international standards and regulations coordination under purview of National H2-FC C&S Coordinating Committee
    - coordinate linkages to EC and Japan

# Future Work: R&D for Safety, Codes & Standards

- Conduct scenario analysis/risk assessment for C&S process
- Coordinate R&D for Vehicle-Fuel Interface Focus Area
  - integrated engineering and design
    - whole-system safety requirements and evaluation
      - link R&D in all four focus areas
    - system design approaches to meet technical requirements
      - innovative approaches to inherently safe, energy efficient design
    - case studies
      - link to DOE fleet vehicle validation sub-program, other demo-validation projects
  - fuel quality
    - develop and coordinate comprehensive testing project
  - refueling station
    - coordinate feedback strategies, dispenser testing
    - develop, test siting template in key states, e.g., CA Hydrogen Highway
- Conduct and coordinate R&D for Detection and Mitigation
  - comprehensive testing and verification project
  - detection technology development, testing, and verification

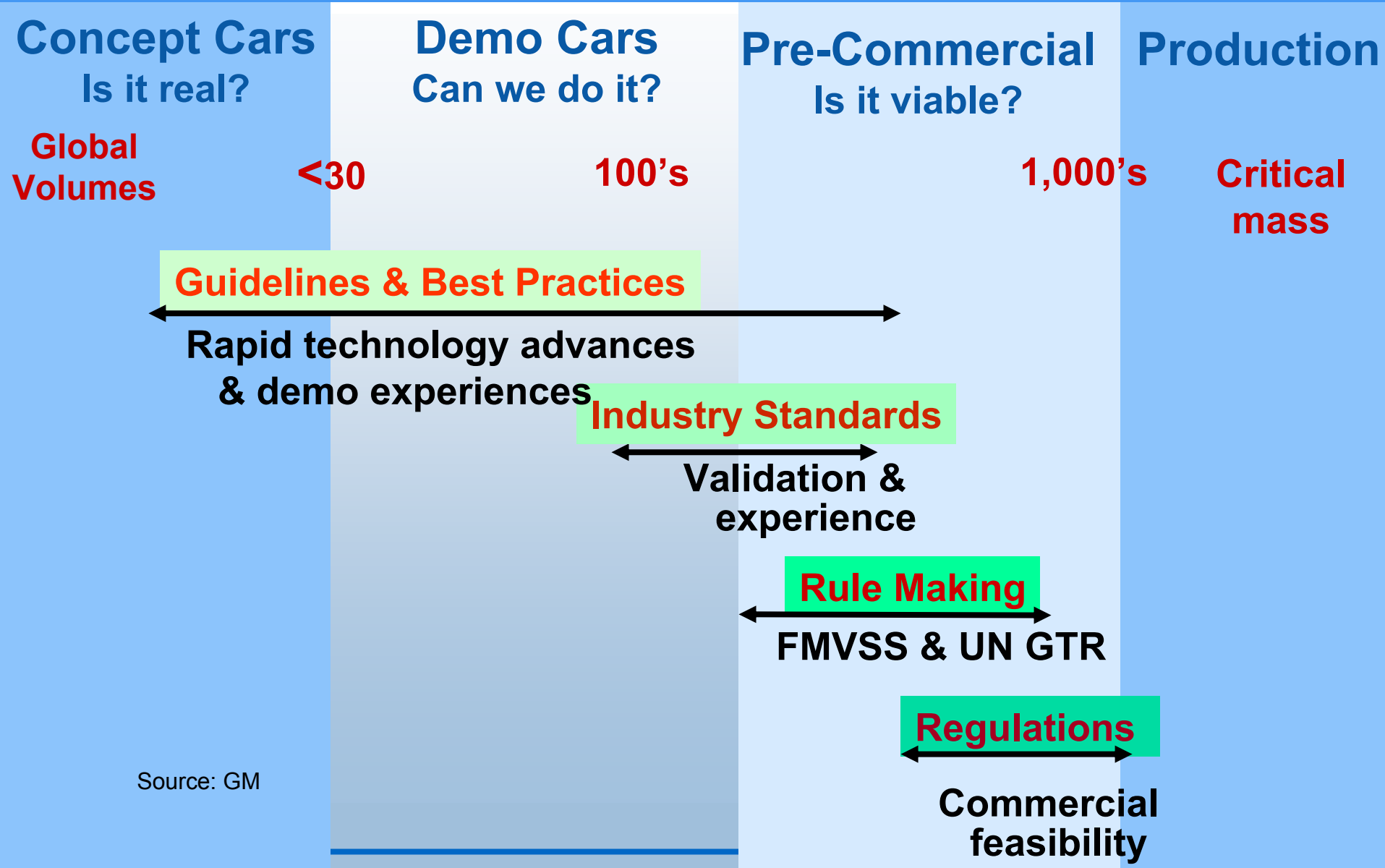


# Future Work: Address Hydrogen Fuel Specifications for Total Energy Cycle



Source: [SAE International](https://www.sae.org/)

# Future Work: Time Phasing of Standards and Rulemaking with Technology Development



Source: GM

# Future Work: Timetable for Fuel Quality Standard

**2004**

**2007**

**2010**

*FCVs introduction stages*

Initial introduction (Fleet, Demo)

Mass production

*Corresponding fuel requirements*

End of 2005

ISO14687

Cor

Exclude "PEMFC" from "ISO14687-1"

TS14687-2

Rev. 2008

Exp. 12/2011

Technical Spec for demo/pre-commercial phase

Long term: ISO 14687-2

(includes global R&D/testing)

Standard for mass production

Source: adapted from JARI

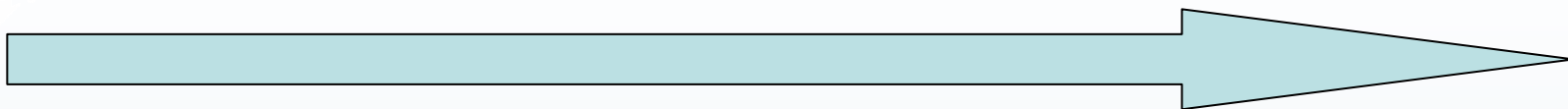
# Future Work: Fuel Quality

- Prepare Technical Corrigendum for ISO 14687
  - Remove references to fuel cells
- Prepare Technical Specification for hydrogen fuel quality for PEM fuel cells for road vehicles
  - Prepare consensus data table at next meeting, January 2005
- Refine single-cell baseline testing at University of Hawaii
  - Ballard, GM, UTC donating test hardware, expertise
- Develop joint R&D Plan for fuel quality
  - Part of overall Japan-US-EU collaboration on RD&D for hydrogen safety, codes and standards
    - METI/NEDO-DOE workshop to initiate joint RD&D Plan
      - invite EU participation to draft RD&D Plan
    - annual meeting on R&D(Japan, US, EU)
      - exchange information and data
      - coordinate strategy for international standards, GTRs

# Future Work: Fuel Quality R&D

- Develop R&D plan and testing program as foundation for international hydrogen fuel quality specifications
  - Delineate key tasks, timetables, budgets
  - Build on JARI, ASTM, USFCC, SAE, CAFCP, U of Hawaii, FCTESTNET work
  - Incorporate into C&STT R&D Roadmap
- Develop collaborative international R&D Plan
  - Create and link expert teams in NA, Asia, EU
- Initiate R&D and Testing
  - Correlate activities to eliminate duplication of effort
  - Provide strong NA technical support in meeting objectives
- Review Technical Specification
- Develop new ISO standard based on R&D and test data
  - Joint NA-Asia-EU effort

# Future Work: Overall FQ R&D Plan Approach



**Single-Cell Test Protocol**  
**Steady-state Testing**  
**Single-constituent Testing**  
**Short-term Testing**

Multi-cell Testing  
 Dynamic Testing  
 Dual-constituent Testing  
 Long-term testing

Short-stack Testing  
 Duty cycle Testing  
 Multi-constituent Testing  
 Accelerated Life Testing

Advanced Analytic Techniques  
 New Material & Compositions  
 Life Cycle Testing  
 Fuel Cell Modeling

Failure Mechanisms  
 Regeneration Conditions  
 Accelerated Test Protocol  
 Material/Fuel Cell Modeling

Basic Degradation Paths  
 Contamination Resistance  
 Accelerated Test Correlation  
 Total System Modeling

Vehicle Demonstration  
 Information  
 Vehicle Systems Modeling  
 Analyses of H<sub>2</sub> Fuel at Site

Advanced Hydrogen Storage  
 Material  
 Production/Delivery Paths  
 Systems/Cost/Data Analysis

Updated H<sub>2</sub> Fuel Quality  
 H<sub>2</sub> Delivery/Vehicle Demos  
 Demo Operation/Cost  
 Analysis Correlation

# Future Work: Coordinated Approach for GTRs

- Develop and implement international template for US
  - achieve NA consensus on GTR(s) for hydrogen fuel cell vehicle systems
  - harmonize development of domestic standards and GTRs
    - overall strategy, objectives, priorities, timing
    - develop and support expert roster and assignment system
    - support and coordinate key ISO/IEC TAGs and WG/SC
- Manage international template through National H2FC C&S CC
  - annual objectives, review strategy and priorities
  - facilitate coordination through ISO TC197 US TAG website
  - coordinate with C&S Tech Team
- Facilitate collaborative R&D effort with Japan and EU
  - consensus testing/data to establish foundation for technical requirements
    - start with hydrogen behavior, fuel quality specifications
    - harmonized test and validation protocols

# Partners for Hydrogen Fuel Quality

- DOE Hydrogen, Fuel Cells and Infrastructure Technologies
  - Pat Davis, Antonio Ruiz
- SAE International Hydrogen Quality Task Force
- USFCC Joint Hydrogen Quality Task Force
- ISO TC197 Working Group 12
  - Professor Yasuo Takagi, Musashi Institute of Technology, Convener
  - Dr. Hidenori Tomioka, JARI, Secretary
- ISO TC197 US TAG and WG12
- “North American H<sub>2</sub> FQ Team”
  - Bill Collins, UTC Fuel Cells (USFCC, SAE)
  - Tony Estrada, PG&E (ASTM)
  - Karen Hall, NHA (ISO TC197)
  - Rick Rocheleau, University of Hawaii
  - Jesse Schneider, Daimler-Chrysler (CaFCP)
  - Ron Sims, consultant to NREL (SAE)
  - Mike Steele, Stella Papasavva, GM (SAE)
  - Andrei Tchouvelev, Tchouvelev and Associates (CTFCA)
  - Gerald Voecks, consultant to NREL
  - Silvia Wessel, Ballard Power Systems
  - Doug Wheeler, consultant to NREL
  - Robert Wichert, USFCC



# Supplemental Slides

The following six slides are for the purposes of the reviewers only.

# Publications and Presentations

Patents: Two under preparation for hydrogen safety sensor

Papers:

- Hydrogen Codes and Standards: An Overview of U.S. DOE Efforts (with DOE), WHEC 15, Yokohama, Japan

Presentations:

- *ANSI Hydrogen Codes and Standards Portal*, New York State Building Officials Conference, Albany, NY
- FCTESTNET conference and international workshop on codes and standards, Ulm, Germany
- NHA Annual Conference, Los Angeles, CA
- NHA workshops, Fuel Cell Seminar, San Antonio and SCAQMD, Diamond Bar, CA
- World Hydrogen Energy Conference 15, Yokohama, Japan
- ISO TC 197 Working Group 12, Newcastle, UK
- DOE Hydrogen Safety Panel, Washington, DC

# Hydrogen Safety

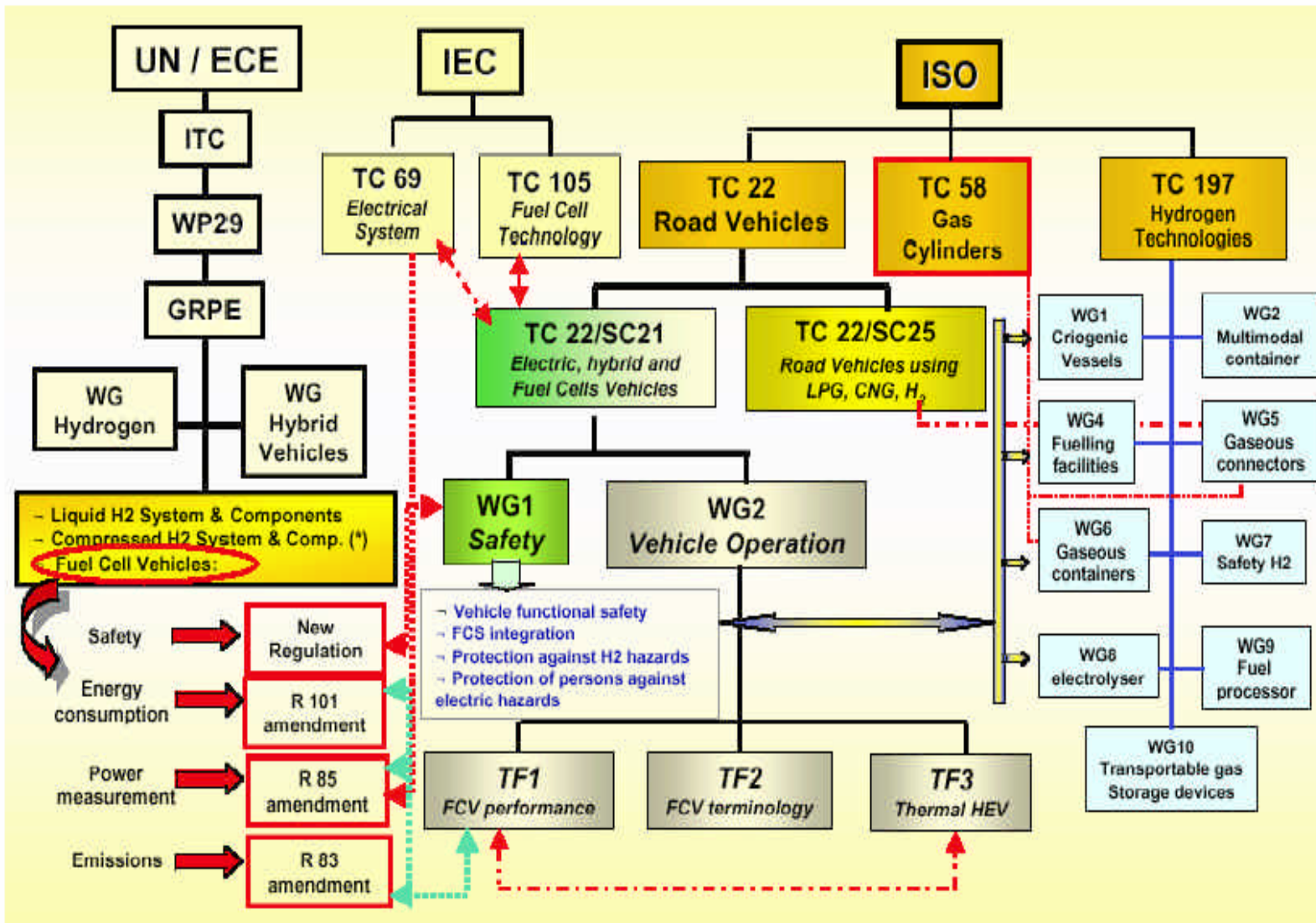
To date, no hydrogen hazards have been associated with this project as no laboratory or field work has been conducted. Fuel quality testing initiated at the University of Hawaii is funded under a different program.

# Hydrogen Safety

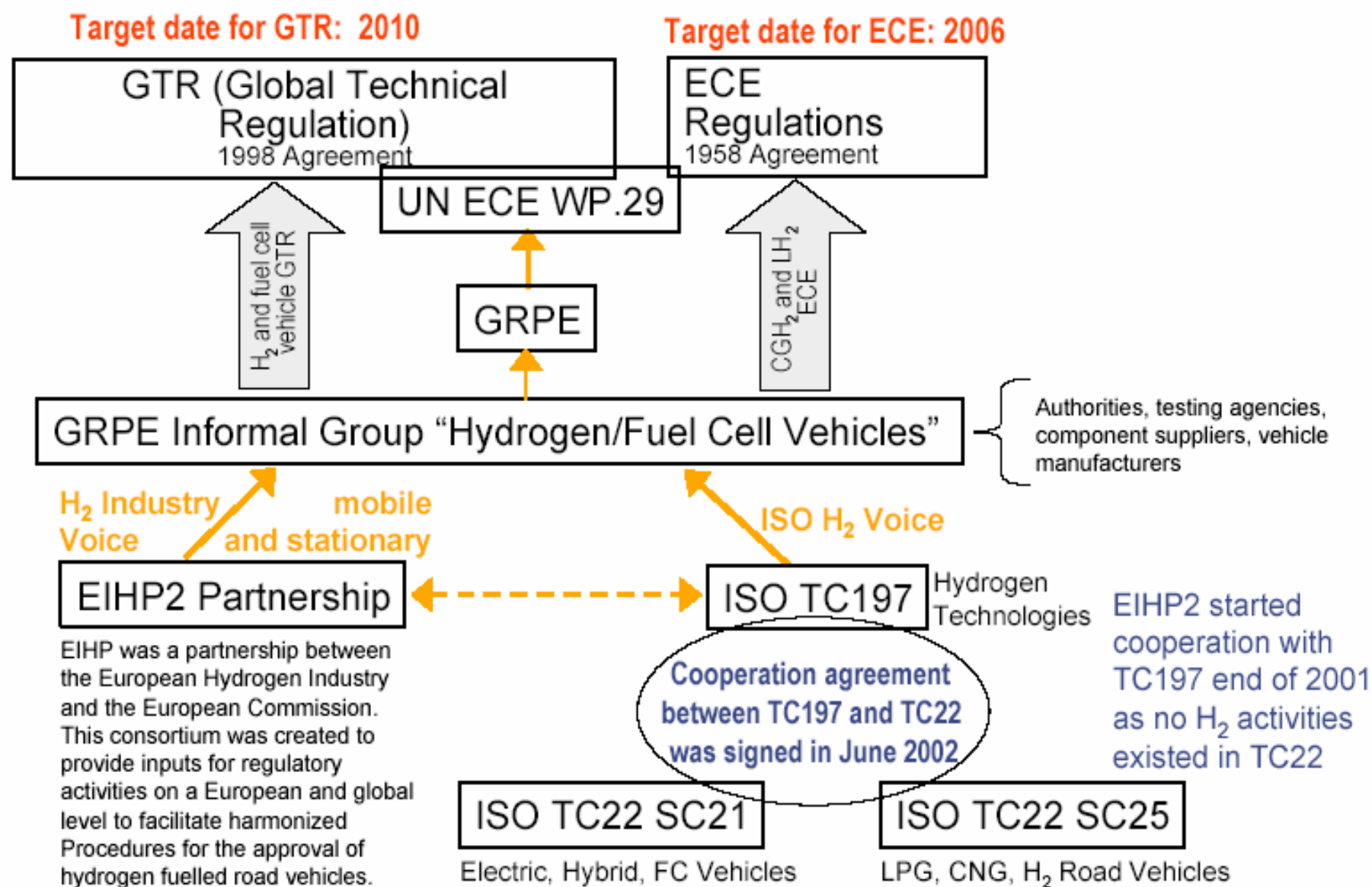
When fuel quality or other testing is initiated under this project, our approach to deal with hazards is to:

- follow all provisions of the Guidance for Safety Aspects of Proposed Hydrogen Projects issued by the DOE Hydrogen Safety Panel
- follow all relevant provisions contained in test protocols
- follow all standard operating procedures established by the institution conducting the tests

# International Landscape of Vehicle Legal Requirements and Standards



# Globally Harmonized Vehicle Approval – Possible Path



# Future Work: Test Plan-Part 1

Specifically address vehicular PEM fuel cell performance issues affected by H<sub>2</sub> fuel contaminants

- Identify relationships between contaminant type/level and fuel cell material properties, considering:
  - anode catalyst
  - membrane material
  - MEA assembly
  - contaminant species
  - fuel cell operating conditions
- Provide basis from which to better define H<sub>2</sub> fuel quality
  - use in conjunction with vehicle system requirements (storage, BOP, etc.)
  - serve as guide for H<sub>2</sub> fuel providers/suppliers
- Generate database from which alternative resolutions may result
  - alternate materials (MEA) that are contaminant 'immune'
  - regenerative procedures (operational functions) for performance recovery
- Provide basis for international collaboration
  - address issues common to all PEM fuel cell vehicles
  - data to help guide DOE-funded activities