A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

2007 DOE Hydrogen Program Annual Merit Review

Hydrogen Fuel Quality

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This presentation does not contain any proprietary or confidential information

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Overview

Timeline

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

Budget

- Total project funding
  - DOE share: $1190K
  - Contractor share: $0K
- Funding received in FY06: $200K
- Funding for FY07: $890K

Barriers

- Codes and Standards Barriers addressed
  - Consensus national agenda on codes and standards (J,A,B,D,L)
  - Limited DOE role in development of ISO standards and inadequate representation by government and industry at international forums (F,G,H,I,K)

Partners

- FreedomCAR-Fuel Partnership C&S Technical Team
- North American H2 Fuel Quality Team
- ISO TC197 WG12, SAE J2719 WG, USFCC HQ TF, ASTM D03
- DOE Fuel Quality Working Group

Acknowledgement: North American Team for ISO TC197 WG12

- Shabbir Ahmed, Romesh Kumar, Rajesh Ahluwalia, ANL (DOE FQWG)
- Bhaskar Balasubramanian, John Lemen, Chevron (C&STT, HPTT)
- Robert Benesch, Air Liquide
- Brian Bonner, Air Products
- Bob Boyd, Linde Group (ASTM, SAE)
- Pamela Chu, NIST
- Bill Collins, UTC Fuel Cells (ISO/TC197 WG12, USFCC, SAE)
- Raul Dominguez, SCAQMD (ASTM D03)
- Tony Estrada, PG&E (ASTM D03, SAE, ISO/TC197 WG12)
- James Goodwin, Clemson University (DOE Solicitation)
- Karen Hall, NHA (ISO TC197 and WG12)
- J.P. Hsu, Smart Chemistry (ASTM D03)
- Hector Colon-Mercado, William Rhodes, SRNL (DOE Solicitation)
- Trent Molter, University of Connecticutt (DOE Solicitation)
- Jim Ohi, NREL (DOE HFCIT, C&STT)
- Rick Rocheleau, Guido Bender, University of Hawaii (ISO/TC197 WG12, DOD)
- Nikunj Gupta, Shell Hydrogen (HPTT, SAE, ASTM D03)
- Jesse Schneider, George Mitchell, Daimler-Chrysler (C&STT, SAE, ISO/TC197 WG12)
- Joe Schwartz, Praxair
- Jim Simnick, BP (ASTM, HDTT)
- Mike Steele, Fred Wagner, GM (C&STT, FCTT, SAE)
- Tommy Rockward, Ken Stroh, Francisco Uribe, LANL (FCTT, USFCC/SCTRR, DOE Solicitation)
- John Van Zee, University of South Carolina (ISO/TC197 WG12)
- Gerald Voecks, consultant to NREL (ISO/TC197 WG12)
- Silvia Wessel, Ballard Power Systems (ISO/TC197 WG12, CaFCP, USFCC)
- Doug Wheeler, consultant to University of Hawaii (ISO/TC197 WG12)
- Robert Wichert, USFCC (ISO and TC197 WG12, IEC)

Background: ISO TC197 WG12 Recent History

- 7th Meeting, Paris, June 9, 2006 (1st meeting, Tokyo, June 2004)
  - completed final editing of international guidelines for hydrogen fuel quality (ISO DTS14687-2)
    - intent and limitations of DTS carefully specified
  - discussion of R&D/testing approaches by Japan, EC, North America
    - JARI/Japan Gas Association and US/Canada harmonized
    - role of Korea identified
    - formal participation by EC through FCTESTQA and JRC/EC
    - agreement to develop collaborative R&D/testing program
- 8th meeting, November 9-10, 2006, HNEI, Honolulu, in conjunction with FC Seminar
  - presentations of detailed R&D/testing plans by Japan, North America
  - initiate consensus plan with priorities, timetables, possible task "assignments"
- 9th meeting, June 5-6 2007, Seoul, Korea
  - launch consensus R&D/testing plans

Approach: R&D/Testing Structure

Collect, evaluate, and report assemblage of data and information
Recommend H_2 fuel quality specifications

Fuel cell vehicle performance characteristics as a function of H_2 fuel contaminants

Fuel cell performance characteristics as a function of H_2 fuel contaminants

- Single contaminant/level
- Contaminant/level combinations
- Test conditions
  - operational
  - physical
- Long duration tests
- Transient tests
- Alternate catalysts and materials

H_2 fuel quality dependence on suppliers' processing technology

- Source of H_2 fuel production
- Method of cleanup
- Alternative processes, methods for cleanup
- Technical, economic fuel quality drivers

H_2 storage media characteristics as a function of H_2 fuel contaminants

- Single contaminant/level
- Contaminant/level combinations
- Choices of materials
- Long duration tests
- Cyclic and transient tests
- Operating conditions

Analytical instrumentation to monitor H_2 fuel quality

- Determine analytical parameters and constraints for key contaminants
- Identify/analyze alternative methods
- Conduct field tests

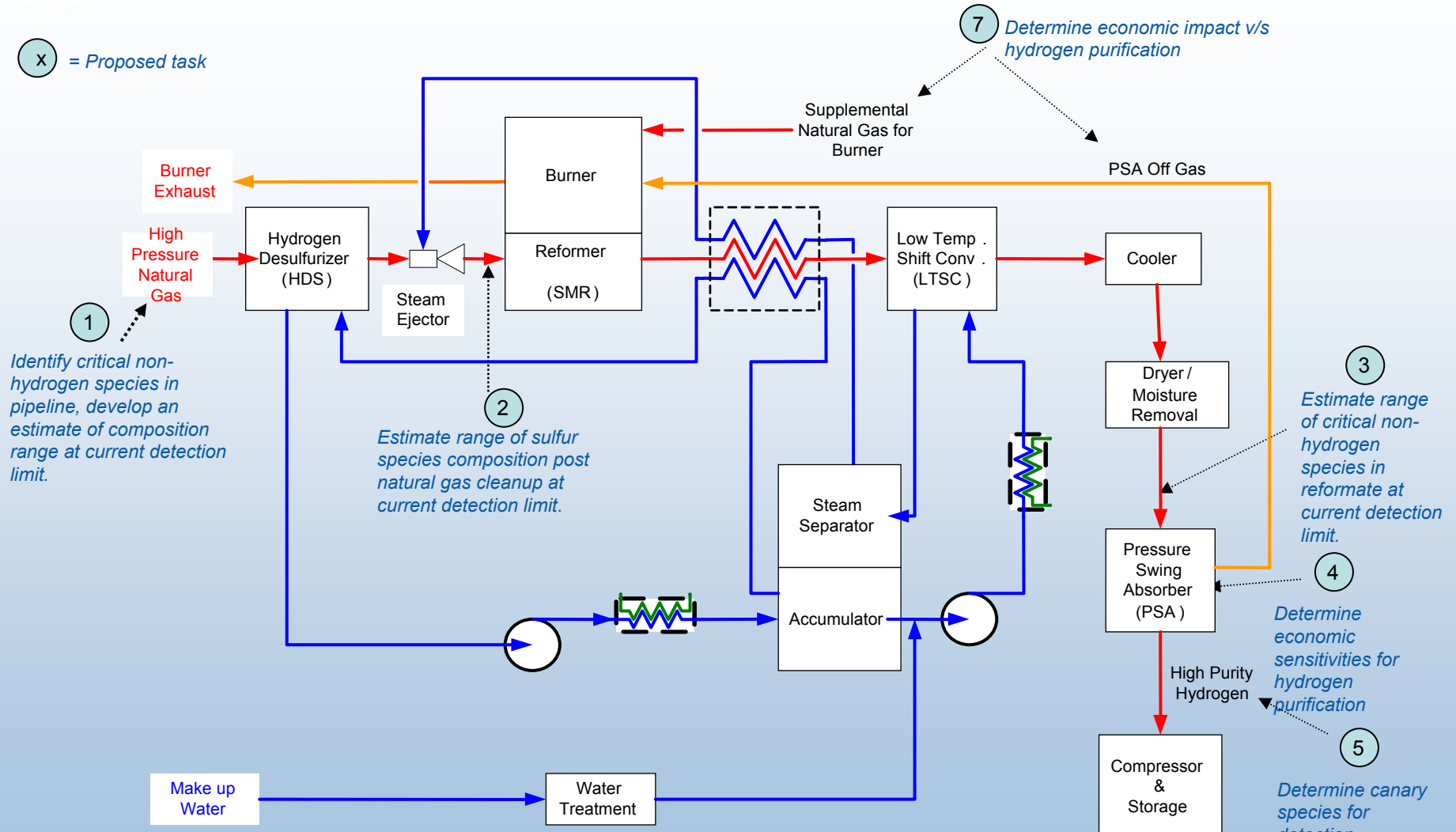
- Assessment of H_2 fuel quality
- BOP issues
- Correlation of model with vehicle
- Vehicle fuel cell pre and post test

Modeling to support understanding of failure mechanisms, production/supply, material development, vehicle systems

Approach: R&D/Testing

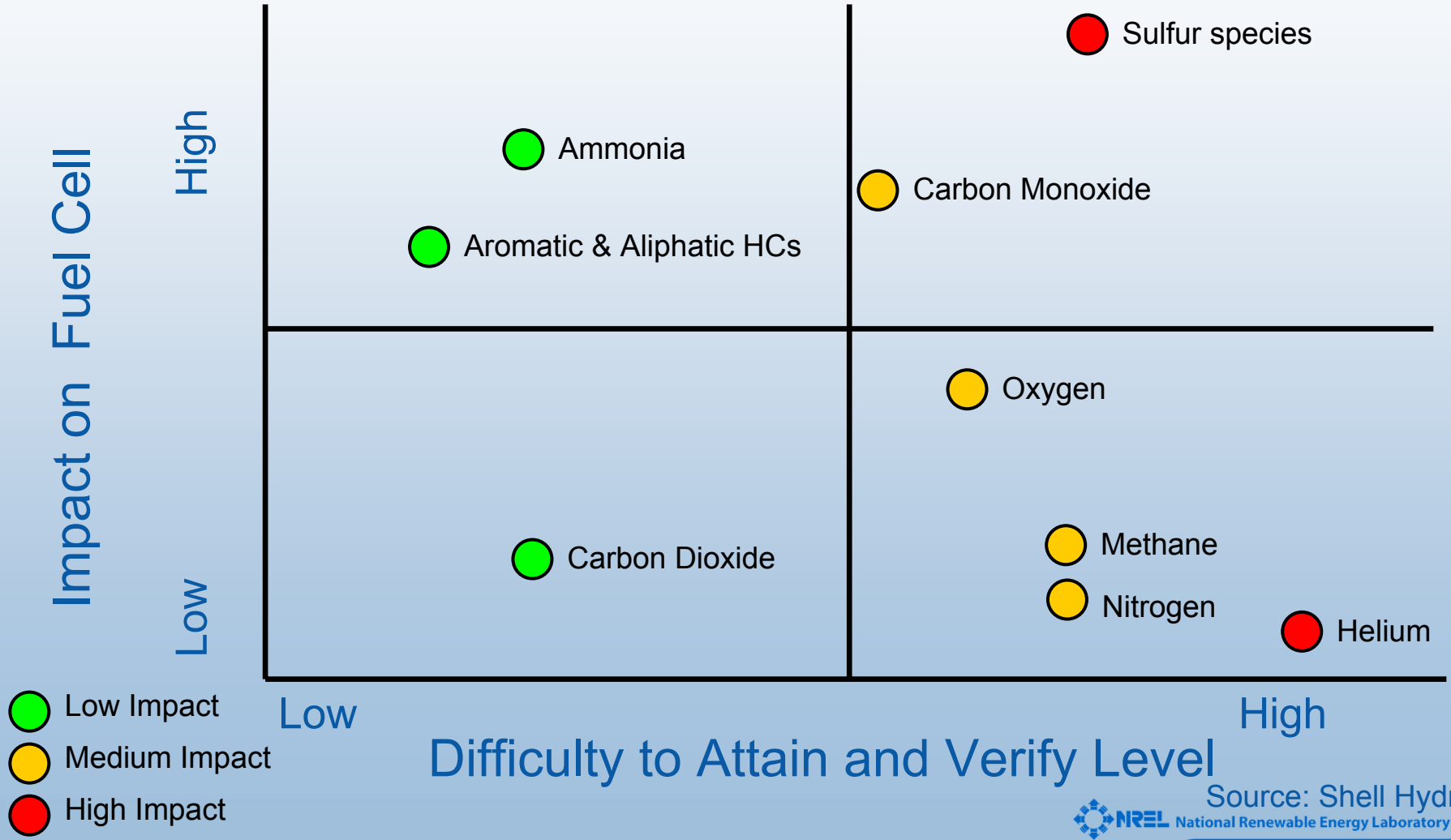
- Conduct R&D and testing in parallel with preparation of national and international standards
  - establish collaborative program among Asia, EC, North America
  - integrate on-going and planned work (DOE solicitation winners)
  - focus on critical constituents (cost/technology drivers) for fuel cell performance and fuel cost
- Develop consensus on critical analytical methods and procedures needed to verify recommended maximum levels of contaminants (e.g., calibration gases)
  - work with ASTM D03, NIST, KIER, JIS, FCTESQA (EC), HyQ
  - establish collaborative analytic sampling and measurements effort
- Form two subteams to focus separately but iteratively on single-cell testing (performance-durability) and fuel cell system and fuel infrastructure engineering requirements and costs
  - combine data and analysis to establish consensus requirements based on trade-offs between fuel quality and fuel cost
- Form modeling subteam to develop and apply empirical model
  - focus testing and enable projection of test results, enhance understanding of mechanisms

Technical Progress: Baseline Production and Purification System Defined



Source: Preliminary Information Compiled by Chevron for WG12

Technical Accomplishments: Fuel Quality-Relative Tradeoff Drivers Identified



Source: Shell Hydrogen

Technical Accomplishment: Potential Canary Constituent Identified

- Carbon Monoxide (CO) may be possible “canary” constituent for detection at many fueling stations and production facilities using hydrocarbon feedstocks
- Subteam 2 will attempt to estimate relationship between CO concentration and other critical constituents (inerts, CH_4, S species, etc.) with respect to PSA breakthrough properties
  - Quantifiable data may be difficult to obtain from PSA adsorbent suppliers due to proprietary nature of the technology (use H_2 recovery rates as surrogate)
  - Estimate rough Order of Magnitude information for breakthrough of other critical constituents in relation to respective composition limits and to CO composition measurement
  - Address simple, cost effective analytical methodologies – when, where, and what techniques to employ?

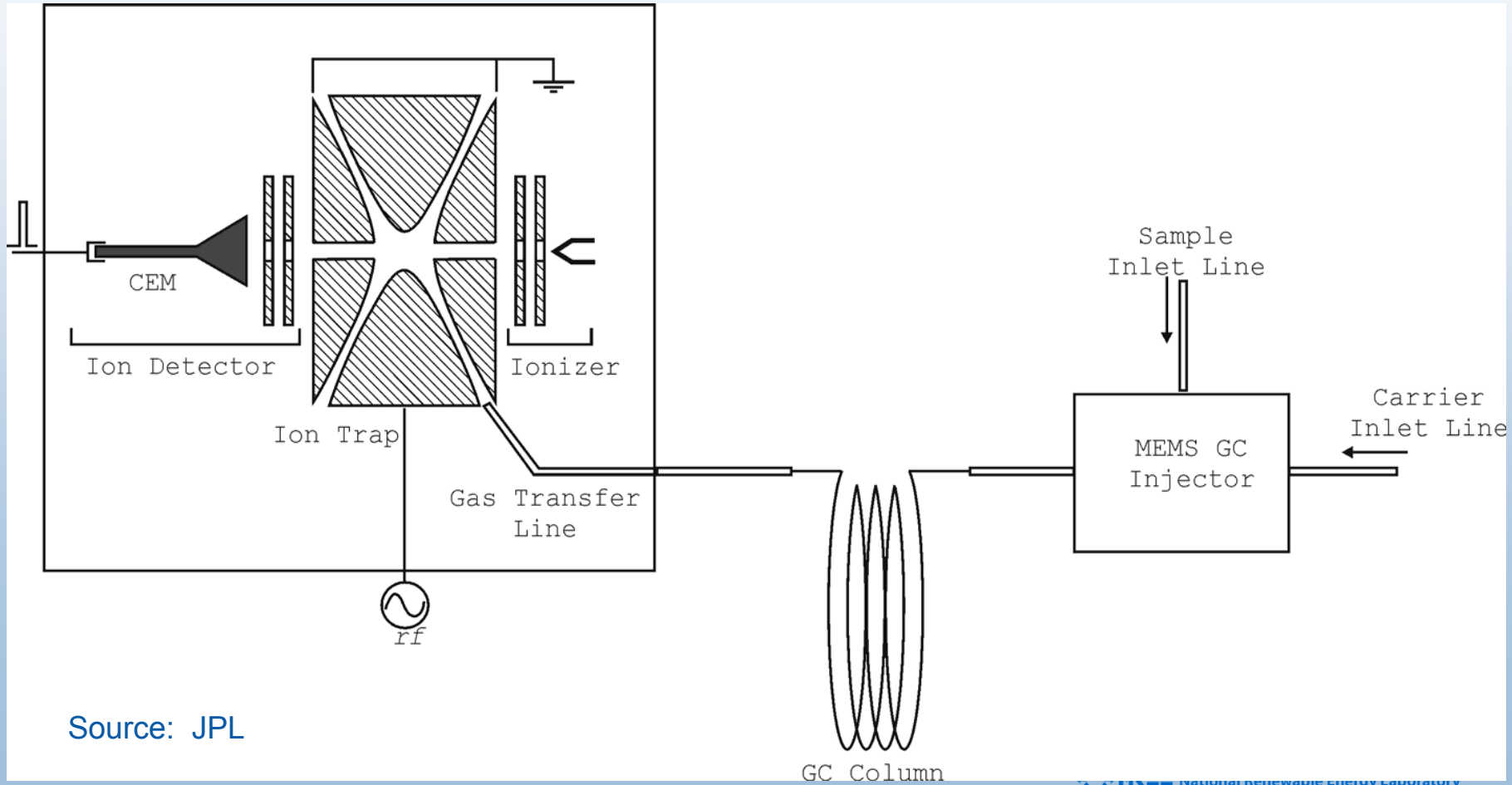
Technical Progress: ASTM Priorities for H_2 Quality Test Methods Defined and Underway

- Design, fabricate, validate 700 bar hydrogen quality sampling apparatus; prepare procedures for safe operation and measure samples
  - schematic and parts assembly under review
- Task ordering agreement under negotiation
  - sampling storage container stability study
  - beta testing of new test method using GC and multiple detectors (WK 4548) with several laboratories
  - inter-laboratory round robin testing of new ASTM analytical test methods

Source: ASTM

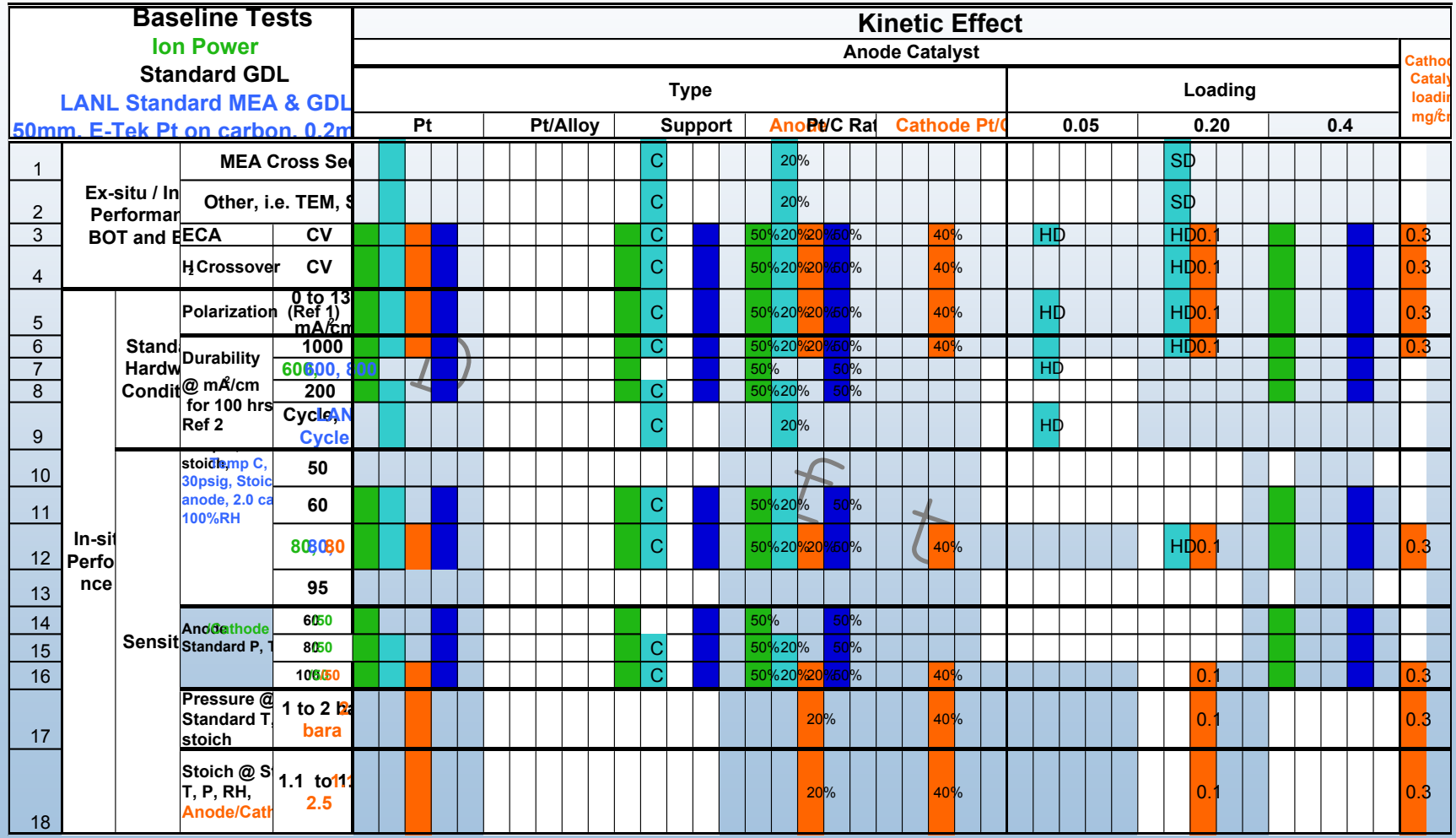
Technical Progress: Miniature GCMS Adapted for H2

Schematic of miniature-GCMS developed at NASA-JPL



Source: JPL

Technical Accomplishment: Composite Test Matrix



Future Work: Develop ISO Standard

- ISO DTS 14687-2 approved unanimously by TC197 “P” members
  - comments submitted by P members must be addressed by WG12
  - publication by mid-2007
- Committee Draft (CD)
  - due one year after approval of TS 14687-2: December 2007
  - revision of recommended allowable limits of non-hydrogen constituents
    - focus on “critical contaminants”
    - initial incorporation of test data, analysis, modeling
- Draft International Standard (DIS)
  - due one year after CD (December 2008)
- Final Draft International Standard (FDIS)
  - due one-year after DIS (December 2009)
- International Standard (IS)
  - due six months after FDIS (June 2010)

note: timetable subject to approval by TC197 Secretariat

Summary

- Consensus national and international fuel quality guidelines available
  - ISO Technical Specification (TS 14687-2) approved and in press
  - ISO TS and SAE J2719 are nearly identical
- Significant progress on R&D/testing to obtain data needed to convert guidelines into standards
  - Test protocol, test matrix, data reporting format adopted
  - Testing underway at LANL, HNEI
  - FQ solicitation winners integrated into overall effort
  - International collaboration underway
  - Modeling subgroup formed
- International and national standards under preparation
  - Committee draft for ISO standard
  - Updating of SAE J2719