Development of the Hydrogen Station Equipment Performance (HyStEP) Device

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Project ID # TV026

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Task Start Date: 08/22/2014
- Task End Date: 10/31/2015
- Percent Complete: 50%

Budget

- Total Task Budget: $880.5K
  - DOE Share: $828.5K
  - Cost Share: $ 52K
    - Air Liquide ($11.3K)
    - Toyota ($11.3K)
    - CARB ($21.5K)
    - Boyd Hydrogen ($7.5K)
- DOE Funds Received To-date: $828.5K

Barriers – Technology Validation

D. Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

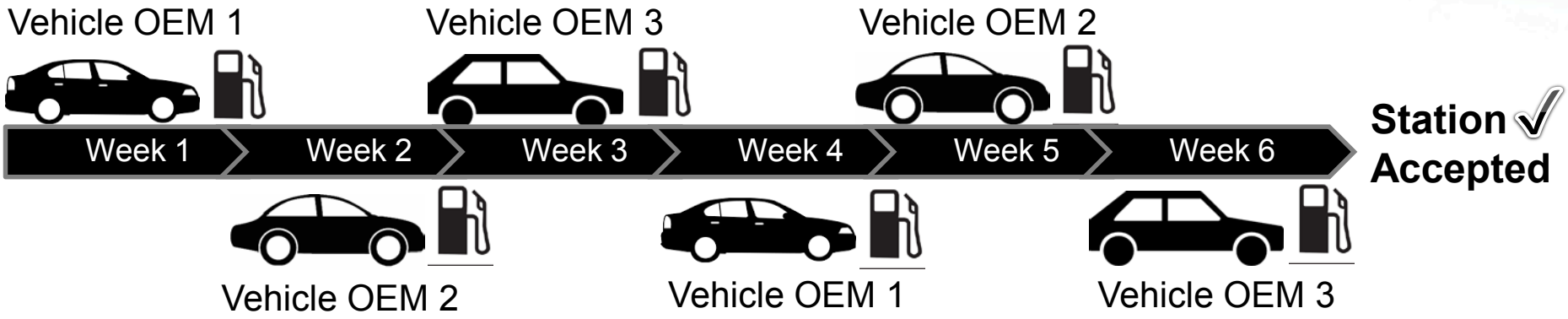
E. Codes and Standards

Partners

- Lead: Sandia National Laboratories
- National Renewable Energy Laboratory
- Air Liquide
- Boyd Hydrogen
- CA Air Resources Board
- Toyota

Relevance: HyStEP Device will shorten lengthy station acceptance process

Today's Problem: Each OEM performs vehicle test fills to validate the station



Tomorrow's Solution: HyStEP Device is surrogate for vehicles, operated by testing agency

Relevance: Objectives

Main Objective – *Accelerate commercial hydrogen station acceptance by developing and validating a prototype device to measure hydrogen dispenser performance.*

- **Fill safely:** Common goal of vehicle manufacturers, consumers, station operators, and state stakeholders
- **Follow standards:**
  - SAE J2601-2014 (fueling protocol), specifies how to fill hydrogen vehicles safely.
  - CSA HGV 4.3 (test method), defines how to test dispensers for compliance with SAE J2601.
- **Test stations:** HyStEP Device will be capable of testing to the CSA HGV 4.3 test methods.
  - Task Output: Government-owned device that has been validated to measure station performance relative to standards.
  - Once pre-deployment testing is complete, the unit will be loaned to a designated CA agency.
  - The resulting HyStEP Device design will be published and available at no cost.

Approach: Mobile device co-designed by Project Team and fabricated by industry stakeholder

Specifications for HySTEP

- Device is mobile: Mounted in a trailer
- Type IV 70 MPa tank(s) with at least a 4-7 kg capacity
- Designed to be able 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

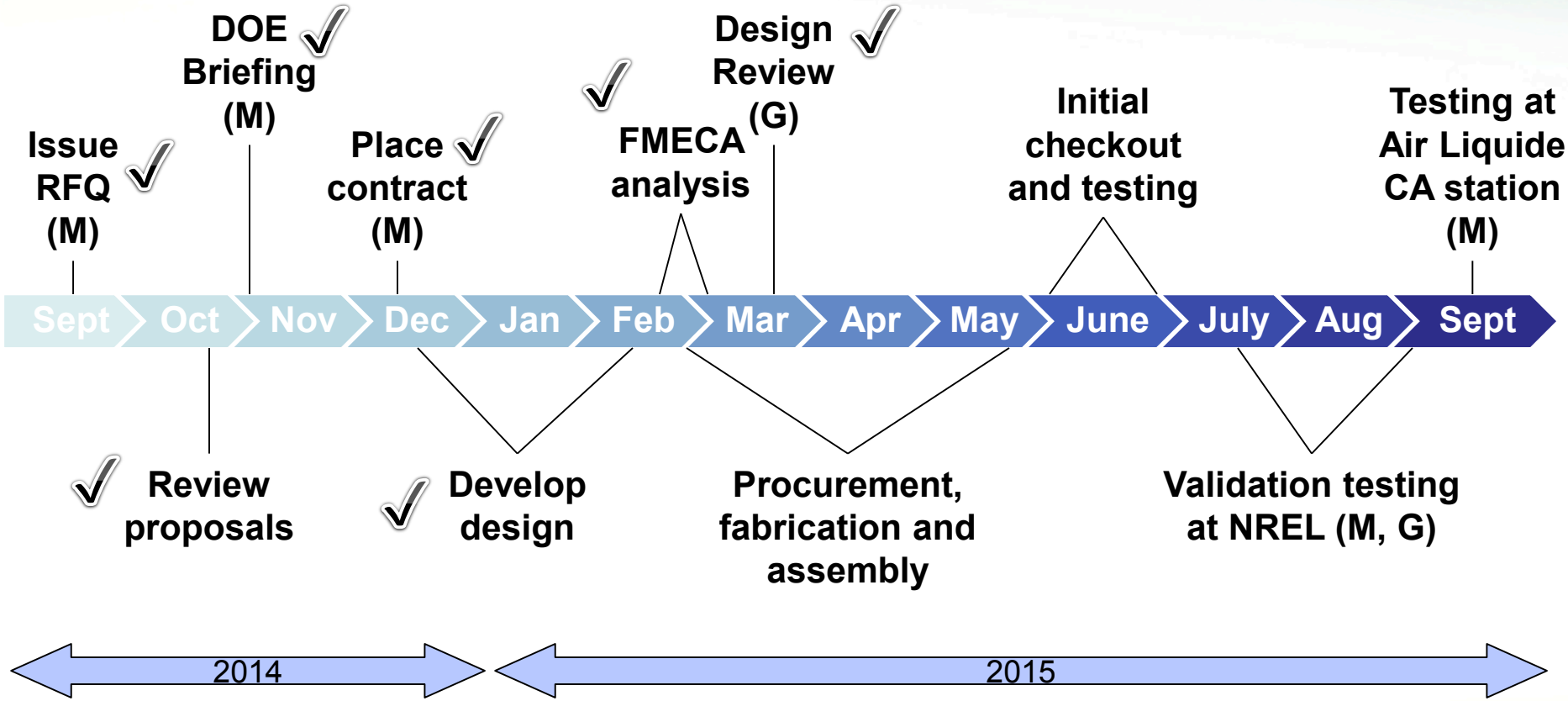
Example of mobile H2 system from Powertech

HyStEP Device will be fabricated by Powertech Labs

- Co-designed by H2FIRST HyStEP Project Team
- Powertech fabricates 70 MPa H2 refueling stations and has H70-T40 testing capability
- SAE J2601-2014 validation testing was performed at Powertech
- Experience with mobile, high pressure H_2 systems
- Designed and built hydrogen station test devices for commissioning fueling stations

Shell Newport Beach station built by Powertech

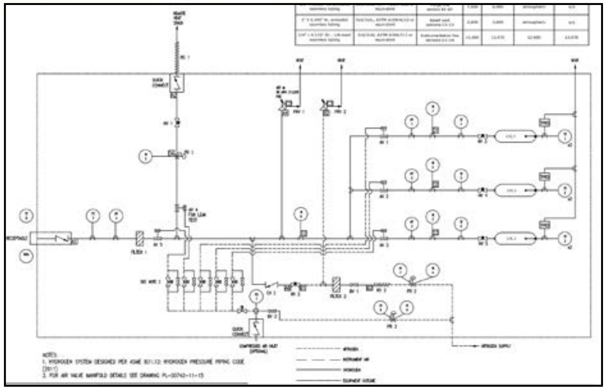
Approach: Project milestones on track



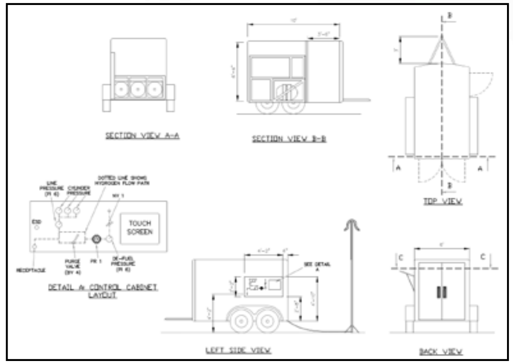
M = Milestone; G = Go/No-Go Decision

Accomplishments: HyStEP Device design completed

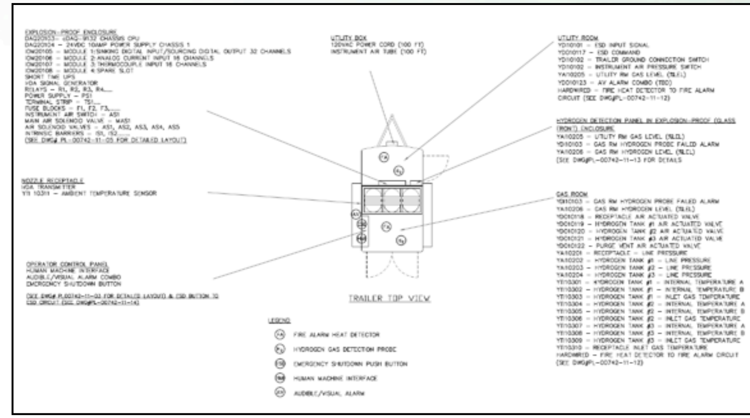
Piping and Instrumentation Diagram (P&ID)



Trailer Layout



Electrical Equipment Layout



Mechanical Component List

Device Tag #	ID	System	Component Name	Specification	Manufacturer	Pressure Rating	Part/Model #
AV 1,2,3,4,5	2	H2	Valve	Air actuated on/off needle valve, Autoclave, 3/8" MPI Ends 316SS, angled, Cv 1.12, rated to -100F (cryo-trim)	Parker Autoclave	15,000 psig	6MP7-MANAB-T-SS-01S-B
PT 1,2,3,4	3	H2	Pressure Transducer	15,000psig, 4-20 mAmp, rated for HAZ, 9/16-18 UNF connections	Stellar Technology	15,000 psig	GT2250-15000G-215 *update for
TT 4,5,6,7	4	H2	Temperature Transducer	Thermocouple T type, Grounded 1/8" OD 316 sheth, 120" cable teflon/SS	Sandelius Instruments	15,000 psig	2T-125T316G-312-T1-120
PR1	5	H2	Regulator	1/4" FNPT, max inlet pressure 15,000psi, Outlet Pressure 5-500 psig	Tescom	15,000 psig	26-2097D24S271
PR2	6	N2	Regulator	1/4" FNPT, Max inlet pressure 6,000 psig, Outlet Pressure 0-1,500 psig, Spring activated, no vent port but 2 gauge ports	Tescom	6,000 psig	44-166124
NV1, NV2, NV3, NV4, NV5	7	H2	Valve	Needle Valve, 3/8" MPI ends, SS, regulating tip	Parker	15,000 psi	6MP7-MANLR-T-SS-HYD
CV 1, CV 2	8	H2	Valve	Check Valve, 3/8" MPI ends, SS body, 5psi spring, ball check	Parker	15,000 psi	6MP7-MPCBL-5-SS
Filter 1	9	H2	Filter	Filter, 1/4" FNPT x 1/4" FNPT, Drain size 1/4" FNPT	Headline Filters	15,000 psig	661-122HHP
Filter 1	9a	H2	Filter Element	Stainless Steel Particulate Filter Element 3um	Headline Filters	15,000 psig	4-6 X4"HBMP7-SS
Filter 2	10	N2	Filter	Filter 5um	Swagelok	TBD	TBD
PRV1	11	H2	Relief Valve	Relief Valve set at 96 MPa(13,920psig), Inlet 1/2"	FM Valve	Set Pressure Range of	151101-2150S16
PRV2	12	H2	Relief Valve	TBD	TBD	TBD	TBD
PI 1, PI 2, PI 3, PI 6	13	H2	Pressure Gauge	2 1/2" dia. Pressure gauge, 0 - 100 Mpa (1-15,000 PSI), center back mount, 1/4" MNPT, Silicone Filled (-40-140F), with Panel Mount Clamp	Swagelock	15,000 psig	PGI-63CMG100-C-A0-3-F
	14	H2	Fitting	Adapter, 1/8" thermocouple, 1/4" MNPT connection	HIP	15,000 psig	15-21AF2NMB-T
Receptacle	15	H2	Receptacle	TN1 P70 Receptacle with UNF 7/16-20 Female connections, 20um filter and no IR device	WEH	70 MPA NWP, 87.5 MPA MAWP	C1-87745
	17	H2	Fitting	Tee, 3/8" MPI union	Parker	15,000 psig	6-6-6 JBMP7-SS
	18	H2	Fitting	Tee, 3/8" MPI run x 1/4" FNPT branch	Parker	15,000 psig	6-6-4 OBMP7-SS
TT 1,2,3	19	H2	Temperature Transducer	Thermocouple T type, 1/8" OD, Copper Conductor, 316SS Sheath, Grounded Junction Dual Element, 22" long with readings at tip and 6" back from tip, 120" cable teflon/SS overbraid	Sandelius Instruments	15,000 psig	MPV0331U
	20	H2	Fitting	Quick Disconnect Female Coupler with Check Valve x 1/2" NPT Male	Spir-Star	15,000 psig	SPC600-0-NMB
HS 1	22	H2	Hose	Hose 6/2W c/w Type M SS ele. Pin prick and loctite for hydrogen service	Spir-Star	18560	H62W-025F-TMS-SS
PI 4	23	H2	Pressure Gauge	2 1/2" dia. Pressure gauge, Pressure range TBD, PSI primary and bar secondary	Swagelok	TBD	TBD
PI 5	24	H2	Pressure Gauge	2 1/2" dia. Pressure gauge, Pressure range 0-4MPa, Center back mount, 1-4" male adapter, Silicone Filled (-40-140F), with Panel Mount Clamp	Swagelok	4MPa	PGI-63C-MG4-C-A0-3-F
Cyl 1, Cyl 2, Cyl 3	25	H2	Cylinder	70 Mpa, Type 4 tank for hydrogen service, 76L	Quantum	70 MPA NWP, 87.5 MPA MAWP	110636
TPRD 1, TPRD 2, TPRD 3	26	H2	TPRD	Thermal Pressure Relief Valve	Luxfer	70 MPA NWP, 87.5 MPA MAWP	PRD-700-020
	27	H2	Fitting	Adapter, 1/4" High Pressure fitting to 3/8" MPI Tube Stub, 9/16"-18 thread	Parker	15,000 psig	4-6 X41HT7-SS
	28	H2	Fitting	Adapter, 3/8" MPI X 1/4" MNPT	Parker	15,000 psig	6-4 FBMP7-SS
	29	H2	Fitting	Adapter, 1/4" MPI x 1/4-18 FNPT	Parker	15,000 psig	4-4 GBMP7
	30	H2	Fitting	Tee, 3/8" MPI, 1/4" MPI Branch	Parker	15,000 psig	6-6-4 JMP7
	31	H2	Fitting	Adapter, 9/16" MP (13/16-16 thread) x 3/8" tube stub	Parker	15,000 psig	0-6 X42HT7
	32	H2	Fitting	Adapter, 3/8" MPI male thread x 1/4" Female NPT thread	Parker	15,000 psig	6-4 GM7
	33	H2	Fitting	Adapter 3/8" tube stub x ¾" SAE Male	Parker	15,000 psig	6-4 T7HOA-SS
	34	H2	Fitting	Adapter 1/4" MPI x 1/4 NPT	Parker	15,000 psig	4-4 FBMP7
	35	H2	Fitting	Plug, 1/4" MNPT	HIP	15,000 psig	15-7NMB
	36	H2	Fitting	Adapter 3/8" MPI x 1/2" MPT	Parker	15,000 psig	6-8 FBMP7-SS
	37	H2	Fitting	Plug, 1/4" MNPT	Swagelok	8,000 psig	SS-4-P
	38	H2	Fitting	Adapter, 1" Tube X 1" tube, bulkhead union	Swagelok	7,500 psig	SS-1610-61
HS2	39	N2	Hose	Nitrogen Hose, 6,000 psi rated	TBD	TBD	TBD
	40	N2	Fitting	Quick Connect to Flexible Nitrogen Hose	TBD	TBD	TBD
	41	H2	Fitting	Tee, 3/8" tube union	Swagelok	7,500 psig	SS-600-3

Electrical Component List

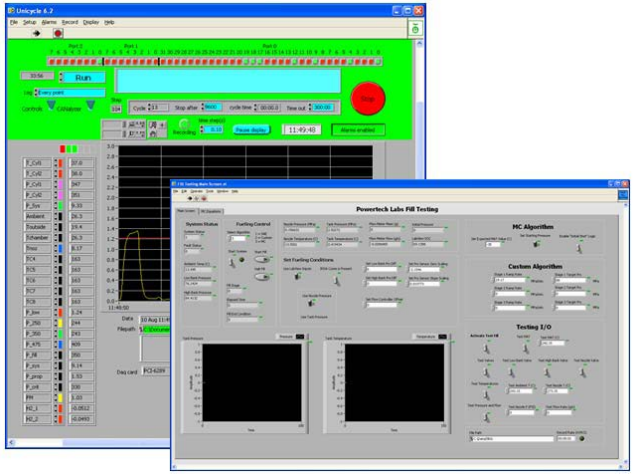
Location	Device ID	Description	Manufacturer	Part Number	Details	Certification
Gas Room	JB 10101	I.S. JB 1 Junction Box	Hoffman	A14128PHC	Type 4, 4x, 12, 13	cULus
Gas Room	TS 10102	Terminal Blocks	Weidmuller	WDU 2.5 WPE 2.5	Non-Incendive Device installed in IS Junction Box	UL
Gas Room	LT 10103	Area Lighting	Appleton	FDN 2C2408SBU	Class I, Division 2, Group A,B,C,D T5	UL
Gas Room	HGD 10104	Hydrogen Gas Detector	RKI Instruments INC	65-2451RK	4-wire to 4-20mA transmitter 2-wire to controller. Class I, Division 2, Group A,B,C,D	UL
Gas Room	HD 10105	Heat Detector	Kidde-Fenwal	12-E27121-000-02	Class I, Division 2, Group A,B,C,D T5	UL
Gas Room	PT 10106	Pressure Transducer	Stellar Technologies	GT2250-15000G-215	24VDC, 4-20mA, protected by Intrinsically Safe Circuit	UL
Gas Room	TT 10107	Thermocouple - Single Element	TBD	TBD	Type T, protected by Intrinsically Safe Circuit	UL
Gas Room	TD 10108	Thermocouple - Dual Element	TBD	TBD	Type T, protected by Intrinsically Safe Circuit	UL
X-Proof Enc (Utility Rm)	ENC 20101	Explosion-Proof Enclosure (7X7)	Akron Electric	TBD	TBD	TBD
X-Proof Enc (Utility Rm)	ENC 20102	Explosion-Proof Enclosure (GLASS WINDOW)	Akron Electric	TBD	TBD	TBD
X-Proof Enc (Utility Rm)	DAQ 20103	DAQ CPU	National Instrument	NI 9132	General Purpose	cULus
X-Proof Enc (Utility Rm)	DAQ 20104	DAQ Chassis - Power Supply - 120VAC-24VDC, 5A	National Instrument	NI PS-15	General Purpose	cULus
X-Proof Enc (Utility Rm)	IOM 20105	DAQ Module 1 - 32 channel 24 VDC Sinking/Sourcing Input Module	National Instrument	NI 9375	Class I, Division 2, Group A,B,C,D T4	cULus
X-Proof Enc (Utility Rm)	IOM 20106	DAQ Module 2 - 16 Channel Analog Current Input Module	National Instrument	NI 9208	Class I, Division 2, Group A,B,C,D T4	cULus
X-Proof Enc (Utility Rm)	IOM 20107	DAQ Module 3 - 16 Channel Thermocouple/Mv Input Module	National Instrument	NI 9213	Class I, Division 2, Group A,B,C,D T4	cULus
X-Proof Enc (Utility Rm)	IOM 20108	DAQ Module 4 - MODBUS INTERFACE	National Instrument	NI 9871	General Purpose	cULus
X-Proof Enc (Utility Rm)	ISB 20109	I.S. Barrier x 11	Pepperl + Fuchs	7960	Class I, Division 2, Group A,B,C,D	cULus
X-Proof Enc (Utility Rm)	ISB 20110	I.S. Barrier X 4	Pepperl + Fuchs	Z787.F	Class I, Division 2, Group A,B,C,D	cULus
X-Proof Enc (Utility Rm)	PSU 20111	Power Supply	ABB	CP-E 24/10	115-230 VAC to 24VDC, 10A	UL
X-Proof Enc (Utility Rm)	FH 20112	Fuse Holders (24VDC)	Weidmuller	WSI-6	General Purpose	UL
X-Proof Enc (Utility Rm)	FH 20113	Fuse Holders (24VDC)	Weidmuller	WSI-6/2	General Purpose F9-F13	UL
X-Proof Enc (Utility Rm)	FH 20114	Fuse Holders (120VDC)	Weidmuller	WSI-6/2	General Purpose F3-F8	UL
X-Proof Enc (Utility Rm)	FUS 20115	Fuses	BUSS	AGC-3, AGC-5	General Purpose (250V-3A/5A, Fast Acting)	UL, CSA
X-Proof Enc (Utility Rm)	R 20116	Relay	Omron	LY2N / LY4N	24VDC	UL
X-Proof Enc (Utility Rm)	APS 20117	Independent Air Pressure Switch	SMC	IS3000-N02L5	DC24V4A, 0.1-0.7 MPa	n/a
X-Proof Enc (Utility Rm)	MSV 20118	Main Air Solenoid Valve	SMC	NVS 3115-0209D	110V	n/a
X-Proof Enc (Utility Rm)	SV 20119	Solenoid Valve	SMC	VQZ312-5M1-02T	24V	n/a
X-Proof Enc (Utility Rm)	TS 20120	Terminal Blocks	Weidmuller	Weidmuller	General Purpose for 120VAC/24VDC	UL
X-Proof Enc (Utility Rm)	TS 20121	Terminal Blocks	Weidmuller	WDU 35	General Purpose for 480V	UL
X-Proof Enc (Utility Rm)	TS 20122	Terminal Blocks	Weidmuller	DK4Q	General Purpose for Thermocouples	CSA
X-Proof Enc (Utility Rm)	R 20123	Relay	Omron	LY4N	24VDC	CSA,CE
X-Proof Enc (Utility Rm)	IR 20124	IrDA Signal Generator	IRDI	TBD	TBD	TBD
X-Proof Enc (Utility Rm)	IR 20125	Short Time UPS	TBD	TBD	TBD	TBD
Utility Room	GAS 30101	Gas Detection System Controller	RKI Instrument	Beacon 410 Gas Monitor	4-Channel Continous Monitoring, 115V/1Amp	cCSAus
Utility Room	LT 30102	Area Lighting	Appleton	FDN 2C2408SBU	Class I, Division 2, Group A,B,C,D T5	UL
Utility Room	HD 30103	Heat Detector	Kidde-Fenwal	12-E27121-000-02	Class I, Division 2, Group A,B,C,D T5	UL
Utility Room	HGD 30103	Hydrogen Gas Detector	RKI Instruments INC	65-2451RK	4-wire to 4-20mA transmitter 2-wire to controller. Class I, Division 2, Group A,B,C,D	UL
Utility Room	AC 30104	Air Compressor (to be operated/powered remotely)	Makita	MAC700	120VAC, 2HP, 2.6 Gallon, 3.3 SCFM@90PSI	CSA, UL
Operator Control Panel	ENC 40101	Audible/Visual Alarm	TBD	TBD	Strobe light and siren rated for Class 1 Div 2, 24VDC.	TBD
Operator Control Panel	HMI 40102	15" HMI	TBD	TBD	15", Outdoor Daylight Readable, Capacitive Touch, Class 1 Div 2, 24VDC	TBD
Operator Control Panel	ESD 40103	ESD Station	Appleton	EFDCB175UM1	Heavy Duty, Class I, Group BCD 600VAC	cULus
X-Proof Enc (Utility Rm)	IR 40104	IrDA Signall Transmitter	IRDI	TBD	TBD	TBD

Accomplishments: Design will include multiple tanks to accommodate all J2601 size classes

- Three 77L Type IV tanks from Quantum Technologies
  - 3.1 kg H_2 capacity at 70 MPa and 15 ˚C
  - 500 mm diameter by 720 mm length
- Allows for testing all SAE J2601 tank sizes
- Five tanks were produced in Dec. The two extra tanks will be tested at Powertech
- Tank design has been qualified to EC 79 (European standard for vehicle tanks)
  - To meet ANSI/CSA NGV2 for H2 vehicles, a full Extreme Temperature cycle test will be completed at Powertech
  - Additionally, Powertech will perform a bonfire test with the TPRD planned for this device.
  - All testing data will be furnished to the Project Team for review

Accomplishments: Robust and flexible data acquisition and control system

- National Instruments LabVIEW software will monitor and control the device
  - Operator interface via touchscreen panel.
  - CSA HGV 4.3 test options listed for selection.
  - Real-time display of test progress and measured and calculated parameters.
  - Parameters flagged that are outside of specifications.
  - Control algorithms and screen layouts designed with flexibility for ease of modification



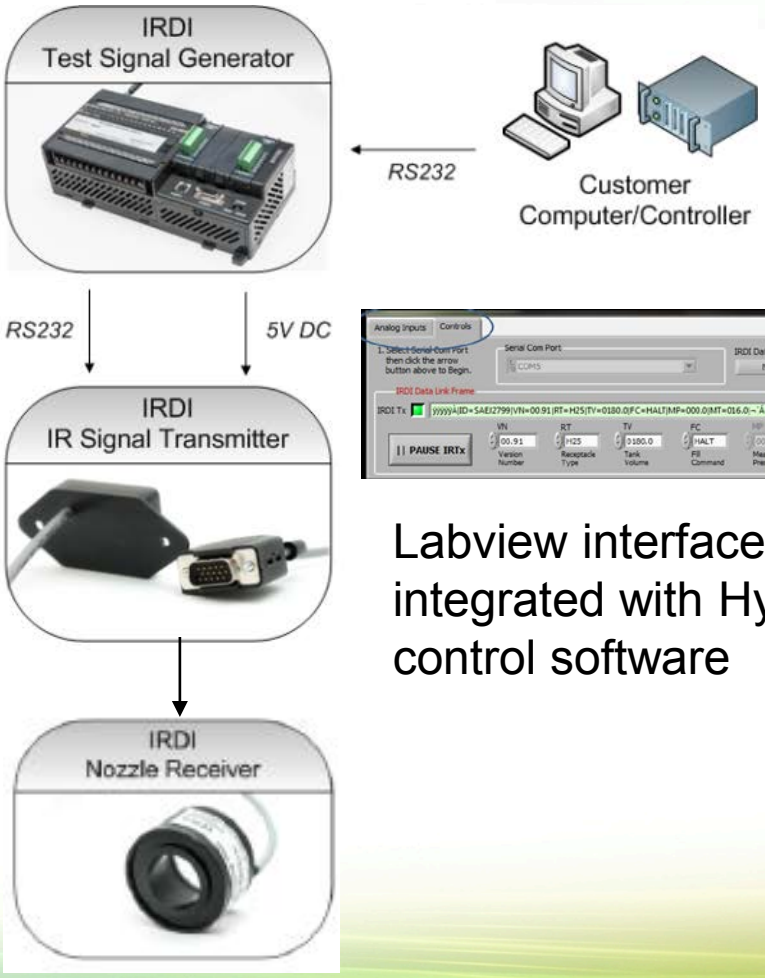
- Chassis based DAQ system designed for robustness
  - Handle up to 50g shocks and 5g operational vibration testing.
  - Data stored on DAQ computer hard drive will be easily searchable and transferable

Accomplishments: Communication tests and fills enabled with IR system per SAE J2799

Communications Tests

- Abort
- Halt
- Data Loss then Abort
- Data Loss and resume
- ID Protocol
- Version #
- CHSS Volume
- Receptacle Type
- Fueling Command
- Measured Pressure
- Measured Temperature

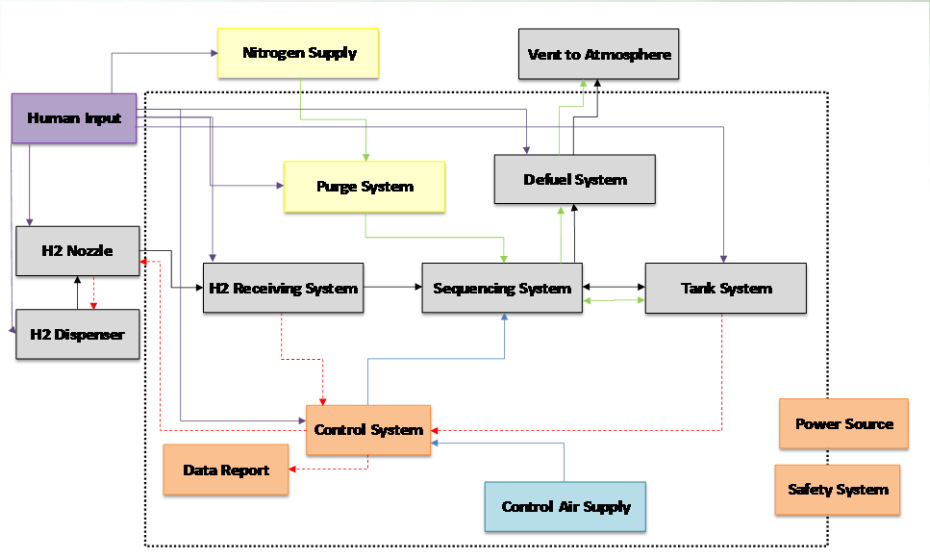
Vehicle side communications will be provided by IRDI System, Inc.



Labview interface will be integrated with HySTEP control software

Accomplishments: FMECA identified safety hazards and risks which will be mitigated

- Intertek Consulting facilitated the FMECA carried out by Powertech and the Project Team
- 7 functional blocks were analyzed
- 44 functions were defined
- 202 failure modes and effects were identified
- Each effect was assigned severity, occurrence, and detection/prevention ratings
- 47 failure mode effects had severity of 9 or 10 indicating a safety hazard
- 20 failure mode effects had RPN* > 100 and all have recommendations to lower the risk



FMEA Worksheet

Intertek Consulting

Component/ System/ Process/ Operations/ Index	Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) / Mechanism(s) of Failure	Occurrence	Current Design/ Process Control PREVENTION	Current Design/ Process Control DETECTION	Detection	RPN
H2 Receiving System	Connection to H2 dispenser nozzle	No connection	No fueling	8	Damage/defector obstruction to nozzle/receptacle	1	SAE J2600 H50, protected during transport, plastic cap	Operator inspection	1	8
				8	Operator Error	3	Operator training	Operator inspection	1	24
		Loose Connection	Hydrogen Leakage	9	Damage/defector obstruction to nozzle/receptacle	2	SAE J2600 H50, protected during transport, plastic cap	Operator detects audible leak or dispenser leak detection	3	54
			Nozzle pop-off	9	Damage/defector obstruction to nozzle/receptacle	2	Dispenser Leak Check	Operator inspection	1	18
				9	Operator Error	3	Operator training	Operator inspection	1	27
		Stuck Connection (mechanical)	Cannot remove nozzle	7	Nozzle pressure not vented	1	SAE J2600 H50, protected during transport, plastic cap	Operator inspection	1	7
				7	Damage/defector obstruction to nozzle/receptacle	1	SAE J2600 H50, protected during transport, plastic cap	Operator inspection	1	7
		Stuck Connection (frozen)	Cannot remove nozzle	7	High ambient moisture, back to back fills	4	SAE J2600 H50, protected during transport, plastic cap	Operator inspection	1	28

*Risk priority number (RPN) = Severity x Occurrence x Detection
Max RPN possible = 10 x 9 x 9 = 810

Accomplishments: Go/No-Go criteria met for device fabrication

Name	Description	Criteria	Date
HyStEP Device Design Review	HyStEP Device is ready for Fabrication. (Task 2.10, Go/No-Go 10.1)	HyStEP device design reviewed by the Project Team, DOE HQ, and the Hydrogen Safety Panel and found acceptable.	3/31/2015

Review and Acceptance by Project Team

Status: Project Team has had extensive reviews and has approved the design ("Go")

Review and Acceptance by Hydrogen Safety Panel

Status: Project Team has determined that the current design addresses all HSP comments and recommendations ("Go"). Response submitted to HSP for confirmation of acceptance.

Review and Acceptance by DOE HQ

Status: Based on the above reviews and a briefing on March 26, 2015 the DOE Managers have determined that the HyStEP device design is acceptable and ready for fabrication.

Accomplishments: Responses to Previous Year Reviewer's Comments

- This project task was not specifically reviewed last year.

Collaborations: HyStEP Project Team consists of key stakeholders

Partner	Project Roles
Sandia National Laboratories	Project lead, management and coordination; device design; safety analysis
National Renewable Energy Laboratory	Device design; safety analysis; device validation testing
Air Liquide	Device design; safety analysis; facilitate pre-deployment testing
Boyd Hydrogen	Device design and safety analysis
CA Air Resources Board	Device design; safety analysis; facilitate pre-deployment testing
Toyota	Device design; safety analysis; vehicle participation/comparison for pre-deployment testing
PNNL H_2 Safety Panel	HyStEP design and safety review by HSP

Remaining Challenges and Barriers

Control software

Challenge 1: Simple operation with user-friendly interface. Information easy to understand and interpret resulting in clear decision making. No manual data processing required by operator.

Challenge 2: Achieving functionality when CSA HGV 4.3 is in draft form and achieving flexibility such that changes to 4.3 can be easily incorporated.

- SAE J2601-2014 includes a number of changes: five tank size classes, three pre-cooling temperatures, new protocols, new definitions, large number of tables (30 standard tables; 24 optional).
- Current CSA HGV 4.3 draft: Protocol Tests (com/non-com, H35/H70, T40/30/20, size class, top-off, cold dispenser), Communication and Fault Detection Tests (expanded from HGV 4.3-2012)

Schedule

Challenge: Timeline to pre-deployment testing is aggressive. Delays in component delivery, fabrication, integration or validation testing will result in schedule slips.

Proposed Future Work

- **Procurement/fabrication – Powertech - April**
- **Mechanical assembly and integration – Powertech - May**
- **Control and DAQ integration – Powertech – May**
  - **Challenge: CSA HGV 4.3 is currently being re-written**
- **Initial checkout and testing – Powertech - June**
  - **Subtask 14.1: On-site visit prior to shipment – Project Team**
  - **M14.1 – July 16:** HyStEP device recieved by NREL for testing.
- **Final checkout and verification – NREL/ Powertech /SNL – July/August**
  - **Go/No-Go 15.1:** Results of the NREL testing will be reviewed by the project team, DOE HQ, and communicated to H2USA members and additional DOE-approved stakeholders
- **Publication of Documentation – Powertech/SNL - July**
- **Pre-deployment test #1 – SNL/Project Team - September**
  - **Milestone 17.1:** Testing has been completed at the first CA station
- **Pre-deployment test #2 – SNL/Project Team - October**
- **Performance analysis and report – NREL – October**
- **Initiate loan to State of CA agency (CARB/DMS) – SNL - November**

Proposed Future Work/Tech Transfer: CA Implementation Plan

- CA HyStEP Task Force is working to develop an implementation plan
- Task Force is led by Mike Kashuba from CARB and includes representatives from CaFCP, CDFA, CEC, SCAQMD, vehicle OEMs, station providers, NREL and Sandia
- Task Force provides input or develop solutions for the following:
  - Real-time data display and report template
  - Data reporting/sharing (what and with whom)
  - Legal consequences of test results and enforcement agency
  - Operators: Identified a two-person team – Measurement Standards Specialist from CDFA/DMS and Air Resources Engineer from CARB
  - Funding: Proposing a $625K budget co-funded by CARB, CaFCP, CEC and SCAQMD
  - Implementation/testing schedule: Proposed a 2-year loan starting Q4 2015 for operating HyStEP in CA

Technology Transfer Activities: HySTEP Device design package will be published

1. Device specification
2. User manual including operating instructions and a troubleshooting guide
3. Maintenance schedule and instructions
4. A final piping and instrumentation diagram (P&ID)
5. Dimensioned drawings of the overall system
6. Electrical wiring diagram
7. Control software code, description, and instructions for modification
8. Report summarizing the HA/FMEA
9. List of components (Bill of Materials) and the manufacturer's documentation (if applicable)
10. Component certifications
11. Documented leak and pressure tests
12. Device Validation Test Report

Summary – Progress and Accomplishments

- HyStEP Device will enable more rapid hydrogen station commissioning
- A diverse team of experts are collaborating to design the device
- Powertech is an extremely well qualified supplier
- Device design completed and “Go” decision made for device fabrication as of March 26, 2015
- The project is on schedule to test the first CA H2 station in September, 2015

Technical Back-Up Slides

Approach: Milestones and Go/No-Go Decisions

Milestone Name/Description	End Date	Status
Post the RFQ for the HyStEP Device (Task 1)	9/30/2014	Complete
A detailed specification for the HyStEP device including main components, instrumentation, test requirements, and data collection and reporting will be completed by the project team and provided to DOE HQ for review and acceptance prior to including in the RFQ. (D1, Task 1)	9/30/2014	Complete
Brief DOE HQ on the review processes and justification for the choice of HyStEP device supplier. (SNL/NREL Task 2)	10/31/2014	Complete
Contract for the HyStEP device placed for the fabrication of the station test device (SNL Task 4)	11/30/2014	Complete
HyStEP device received by NREL for validation testing. (M14.1, Task 14)	7/16/2015	Not started
Complete at least 3 rounds of CSA HGV 4.3 tests 2.2.1 - 2.2.5, 2.3.1 - 2.3.3, and 2.4.1 - 2.4.2 at a station. Successful operation includes that the HyStEP device temperature and pressure measurements for each round of testing are within a target value of 10% depending on the station variation and the results of the NREL validation tests. The data output of the device will also be compared with the station temperature and pressure measurements. (M17.1, Task 17)	9/30/2015	Not started
Publish the HyStEP design documentation per Task 19 (SNL D2-D12, Task 19)	9/30/2015	Not started
Final performance report of HyStEP from operation at three different stations. (Task 20)	10/31/2015	Not started

Go/No-Go Name/Description	Criteria	Date	Status
HyStEP Device is ready for Fabrication. (Go/No-Go 10.1)	HyStEP device design reviewed by the Project Team, DOE HQ, and the Hydrogen Safety Panel and found acceptable.	3/31/2015	Met
HyStEP device performance is acceptable (Go/No-Go 15.1)	Results of the HyStEP validation testing show that the device accuracy and precision are acceptable. The results are to be reviewed by the project team and DOE HQ as well as communicated to H2USA members and additional stakeholders identified by DOE via webinar.	8/31/2015	Not started

Approach: Safety and Performance Validation

Safety

- Safety features by design:
  - Emergency Shutdown System activated by hardware, software or the operator
  - PRVs and TPRDs
  - H_2 detection
  - Class 1 Zone 2 electrical
  - Grounding connection
- Facilitated HA/FMEA will be carried out by Powertech and Project Team
- Final design review by Project Team
- H2 Safety Panel review
- Onsite visit to Powertech for initial acceptance testing
- Testing at NREL's ESIF facility
  - Training and technical support from Powertech

Performance

- At Powertech:
  - Control and DAQ communications
  - IrDA operation
  - Leak checks and proof test of the pressure components
  - Automated procedures
- NREL-ESIF: Device validation testing
  - H70-T40 research dispenser
  - All required tests will be carried out and verified per CSA HGV 4.3.
  - Measured and calculated parameters checked for completeness and accuracy.
- Pre-deployment station testing in CA
  - Air Liquide Anaheim station
  - 2nd station TBD

Accomplishments: Trailer-based system chosen based on Powertech's experience

- Powertech experience:
  - Mobile fueler for HCEV road rally
  - 45 MPa Hydrogen Transport Trailers
  - Standard dual axle spring suspension cargo trailer used for field testing

- Trailer pros:
  - Protection from the environment/weather
  - Easy to hand off to various end-users
  - Allows for isolation of hazardous location
  - Easy access to controls/user interface
  - Doesn't require a dedicated vehicle
  - Better access to system for maintenance

- Trailer options investigated by Powertech:
  - Similar design to mobile refueler, but smaller: 6-7' wide and 10-12' long.
  - Partitioned with front room for electrical/DAQ and rear for H2 system.
  - Tandem axle design with torsion axles to provide a smooth ride and mitigate road vibrations.

Accomplishments: HyStEP Device design completed

FM Valve 1511 Series PRV

Tescom Regulator: 0-15,000 psi inlet, 0-500 psi outlet

Parker-Autoclave MAN Series Normally Closed, Air to open 15,000 psi rated

Stellar GT2250 Series high accuracy model (0.10% FSO)

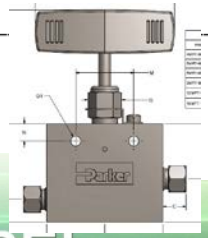
1/8" TC Probe with HiP Adaptor (15,000 psi rating)

WEH 70 MPa SAE J2600 Receptacle

Parker MPI Series: 3/8" tubing; 15,000 psi rated

Headline 3 µm particulate filter

Quantum 77L Type IV Tanks



Parker-Autoclave Needle Valve

Accomplishments: Instrumentation will include multiple pressure and temperature sensors

Sensor	Measurement Range	Accuracy
Receptacle Pressure	0 to 100 MPa	0.1% of full scale
Receptacle Temperature	-45 to 100 °C	± 1 °C
Tank Gas Pressure	0 to 100 MPa	0.1% of full scale
Tank Gas Temperature*	-45 to 100 °C	± 1 °C
Ambient Temperature	-45 to 55 °C	± 1 °C
Tank Inlet Temperature	-45 to 55 °C	± 1 °C