

Jadoo Power Fuel Cell Demonstration

Ken Vaughn
Principal Investigator
Jadoo Power Systems Inc.
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Project ID # H2RA005

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Overview

Timeline

- Start: 1/1/2010
- End: 1/31/2012
- 60% Complete

Budget

- Total: \$4,821,152.00
 - DOE share:
\$2,202,491.00
 - Contractor share:
\$2,618,661.00

Barriers

- Reducing stack and BOS to size allowing portability
- Reliability of SOFC system under rough field conditions
- User factors related to start-up times and refueling
- Effectiveness/complexity of processing propane to remove sulfur
- Potential constraints on type or source of propane

Partners

- Project is led by Jadoo Power
- Development partner is Delphi Inc.
- Field test partners are NASCAR Media Group and the City of Folsom, CA

Objectives

- The development of 2 portable electrical generators in the 1000 watt range utilizing Solid Oxide Fuel Cells as the power element and propane as the fuel.
- The development and demonstration of a proof-of-concept electro-mechanical propane fuel interface that provides a user friendly capability for managing propane fuel in a manner that supports the widespread adoption of fuel cells.
- The deployment and use of the fuel cell portable generators to power media production equipment over the course of several months at multiple NASCAR automobile racing events staged in multiple locations throughout the United States.
- The deployment and use of the fuel cell portable generators at scheduled events by first responders (police, fire) of the City of Folsom California to power equipment in emergency and/or off-grid situations.
- Capturing data with regard to the systems' ability to meet DOE Technical Targets and evaluating the ease of use and potential barriers to further adoption of the systems.

Relevance



- Project is focused on exploring the efficacy of replacing gasoline powered portable generators at large outdoor events and in first responder applications with propane powered fuel cells
- This project will further the development of emerging technologies including SOFC and propane fuel management that could be an alternative to gasoline powered generators
- The combination of a high efficiency fuel cell (SOFC) and a readily available fuel source (LPG) opens up many potential applications
- The ready availability of LPG worldwide for commercial and consumer applications eliminates the requirement for a hydrogen refueling infrastructure
- This project is funding development activities that could lead to near term commercialization of fuel cell technology in multiple applications where internal combustion engine- based generators have significant drawbacks

Approach

- Portable generator to be developed by leveraging parallel work by Delphi related to use of SOFC in trucking APU application
- Delphi SOFC technology to be modified and packaged for portable application with AC power capability
- Delphi modifying reformer from diesel APU to allow the use of LPG
- Delphi developing desulfurizer to allow use of commonly available propane as fuel source
- Jadoo Power developing electromechanical fuel interface by leveraging prior learning from development of a interface between PEM fuel cells and Metal Hydride canisters
- Systems to be developed for 2 key applications that could lead to commercialization
- Systems to be deployed and transported between multiple racing and first responder events to evaluate ruggedness, portability and suitability for real world applications

Key Goals and Targets

- Develop propane desulfurizer with the ability to reduce the level of sulfur in propane to less than 10 ppb for 8 continuous hours
- Develop SOFC portable generator with the ability to produce 1KW using propane for 8 continuous hours by combining an SOFC stack with an AC inverter and relevant balance of plant
- Key targets include operation of generator at minimum 30% efficiency for minimum of 2000 cumulative hours
- Develop a user-friendly electromechanical propane fuel interface that can indicate the amount of propane within $\pm 10\%$ of the actual amount for the entire range from full to empty
- Test 2 SOFC generator units at several NASCAR racing events as replacements for gasoline powered generators
- Test SOFC generators in first responder applications with Folsom Police and Fire Departments
- Analyze technical performance and human factors issues to evaluate readiness of the technology to move into commercialization phase

Tasks and Milestones

Task 1	Requirements Definition
Milestone 1	Complete Applications Specs for portable generator, desulfurizer and propane fuel interface
Task 2	System Design – Generator
Task 3	System Design – Desulfurizer
Milestone 2	Demo ability of desulfurizer to reduce sulfur in propane to <10ppb for 8 continuous hours of operation
Task 4	System Design – Fuel Interface
Task 5	Build and Test Demonstration Generators
Milestone 3	Go/No-Go – Demo ability of portable SOFC to produce 1kW for 8 continuous hours
Task 6	Build and Test the Fuel Interface
Milestone 4	Demo proof-of-concept unit of propane fuel interface that indicates $\pm 10\%$ propane fuel level for entire state of fill range
Task 7	Deployment, Demonstration and Field Test
Task 8	Final Testing
Milestone 5	Delivery of Value Proposition Report of Task 7 to DoE
Task 9	Project Management and Reporting

Accomplishments – General



- Detailed analysis of NASCAR camera equipment power needs completed including baseline load evaluation and logistics evaluation
- Focus group with City of Folsom, City of Sacramento, Office of Emergency Services, CalFire and FEMA has been conducted to identify applications and issues related to potential usage of fuel cell generators by First Responders
- Requirements definition completed
- Desulfurization development and testing completed
- Reformer development and fuel interface development near completion
- Mechanical packaging design and system testing underway
- This project has resulted in job creation/retention in California, New York and Michigan

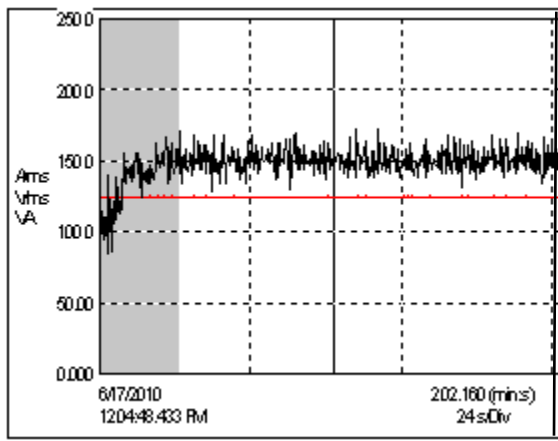
Accomplishments – Requirements

Task 1

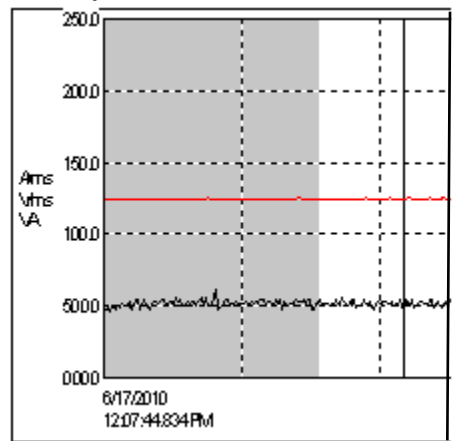
NASCAR Application Characterization



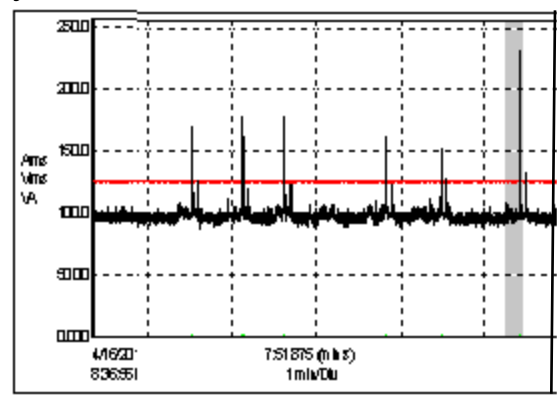
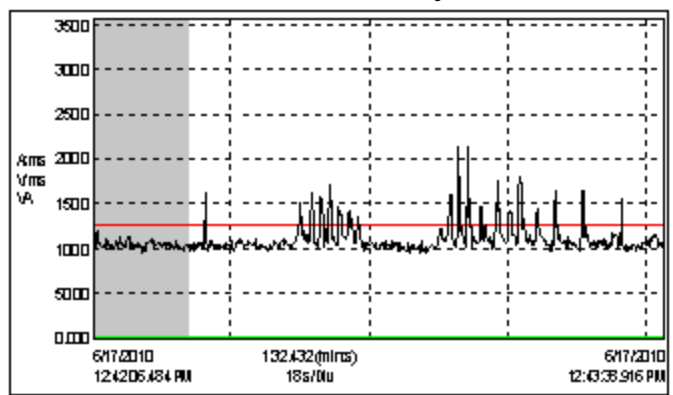
Fixed Camera



Special Effects Module



Robotically Assisted Remotely Controlled Camera

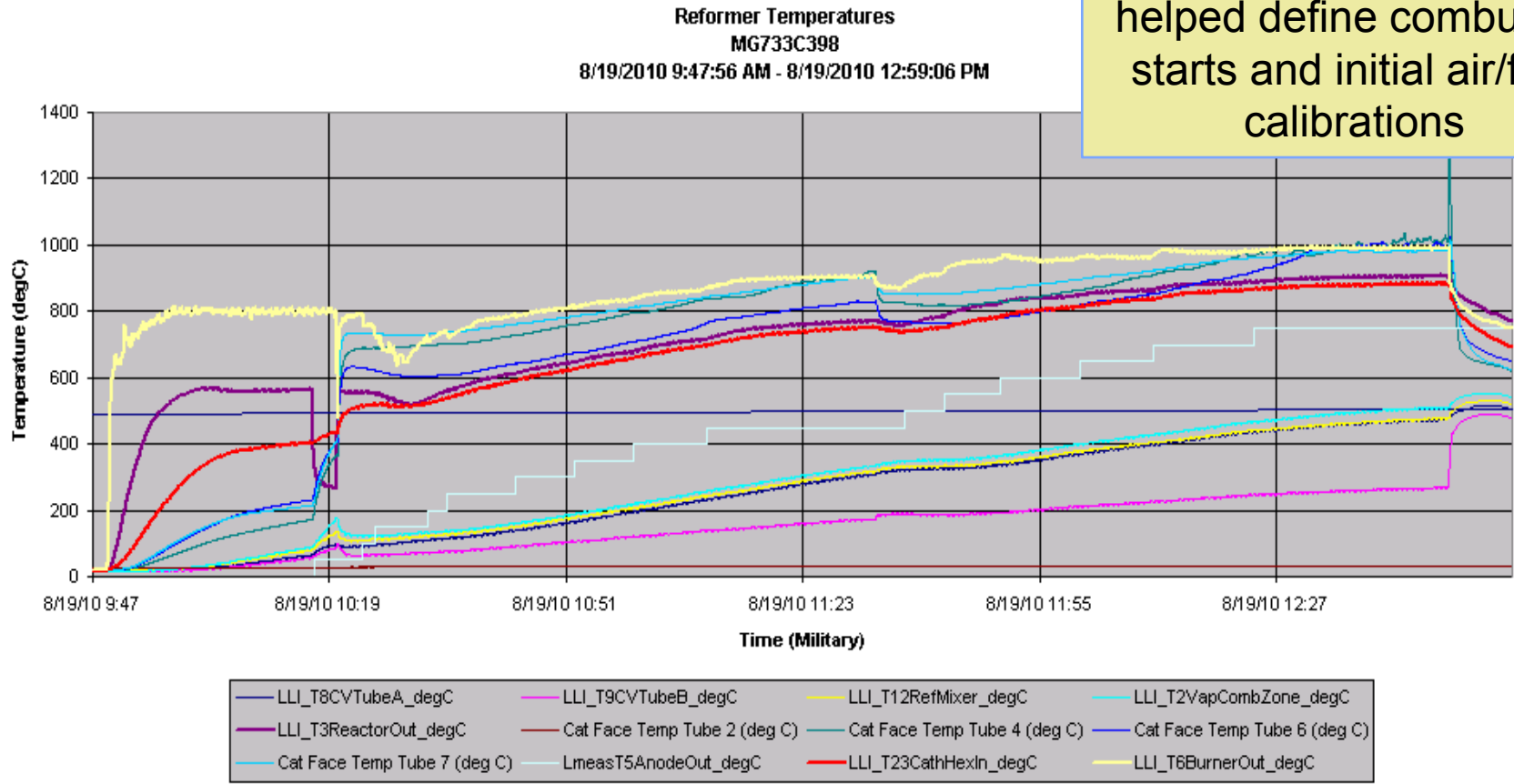


Milestone 1 Completed

Accomplishments - Task 2

Reformer/GPC testing-LPG Starts/operation

Reformer bench testing helped define combustor starts and initial air/fuel calibrations



Accomplishments - LPG Desulfurization Task 3

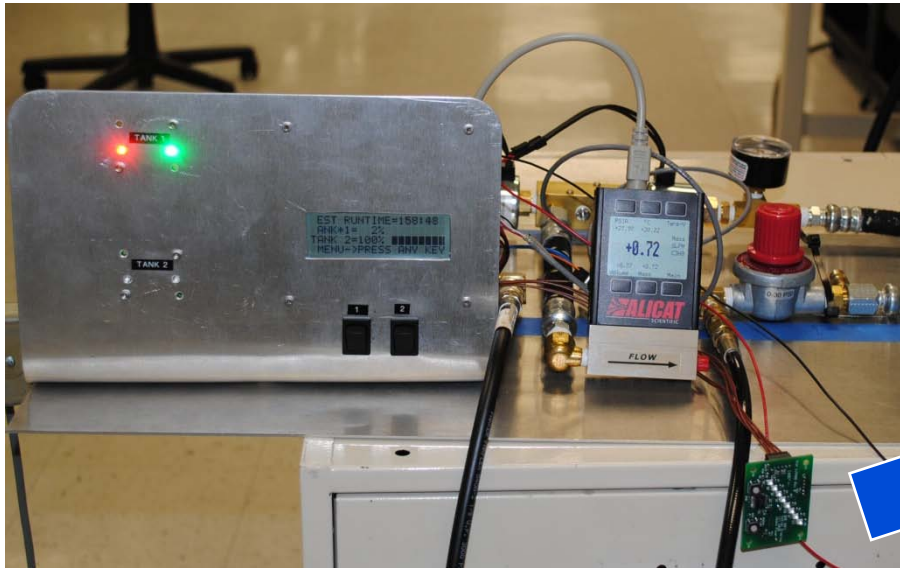


- Source for LPG selected for best known control of LPG composition
 - Blue Rhino
- Initial characterization identified presence and amount of COS (carbonyl sulfide) species to be variable
- First prototype desulfurization beds ordered and received from both Sud Chemie and TDA did not comprehend the presence of COS
- Delphi has since revised the Desulfurizer requirements document
 - Both suppliers (Sud Chemie & TDA) have proposed solutions for dealing with COS by having a bed with either 2 or 3 different sorbent materials (combo sorbent) packed in a single bed

Milestone 2 Completed

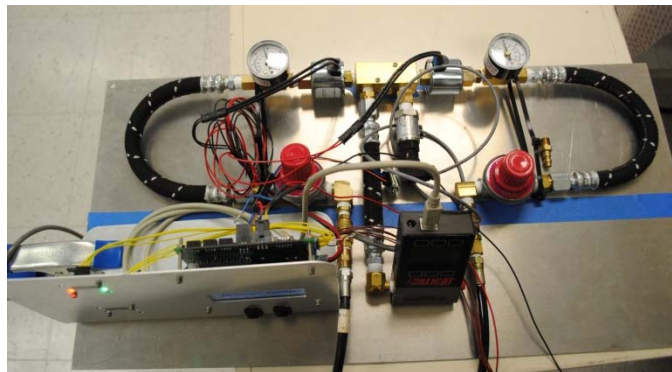
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Accomplishments– LPG Fuel Interface Task 4 and Task 6



**LPG Fuel Interface
Subsystem Testing**

**Fuel Status Display
Attaches to LPG Tank**

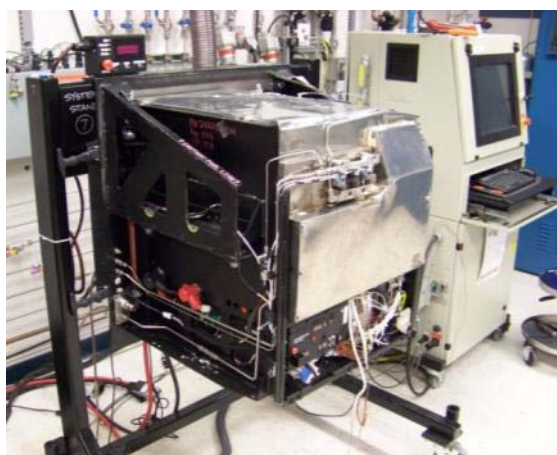
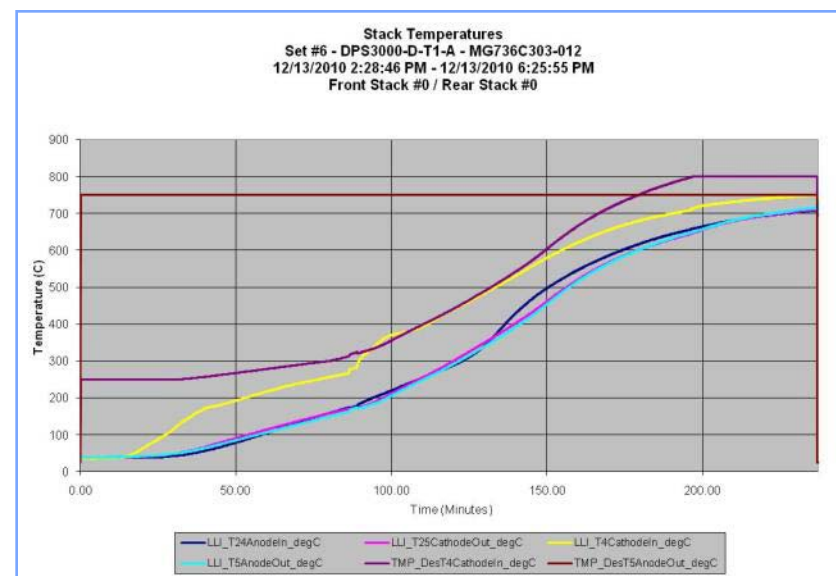
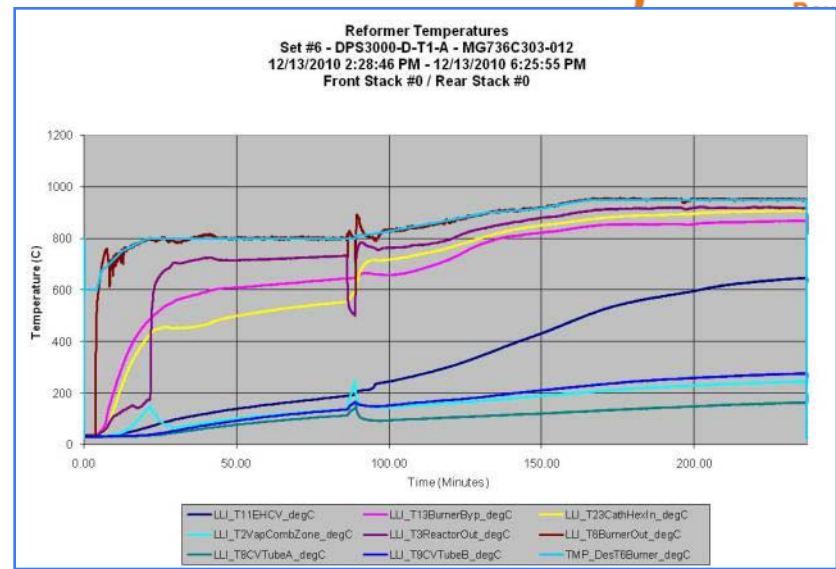


**Hardware designed and fabricated
Firmware designed and under test**

Accomplishments - System Testing

Task 5

- LPG System Set 6
 - 11 System starts completed w/ thermal stacks
 - System calibrations development/optimization in process
 - EC stacks installed 12/16



Set 6 in Lab – Cover removed

LPG - Desulfurizer



Accomplishments – Mechanical Design

Task 5

Original Trailer Concept Design

- (2) 20lb LPG Tanks
- Desulfurizer
- Batteries
- Reducing Gas
- User Interface

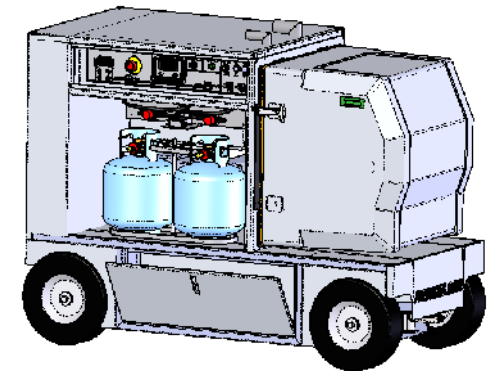


Revised “Pitbox” Design

- Custom built for our system
- Same content and size as trailer
- NASCAR recommendation
- Facilitates transportation

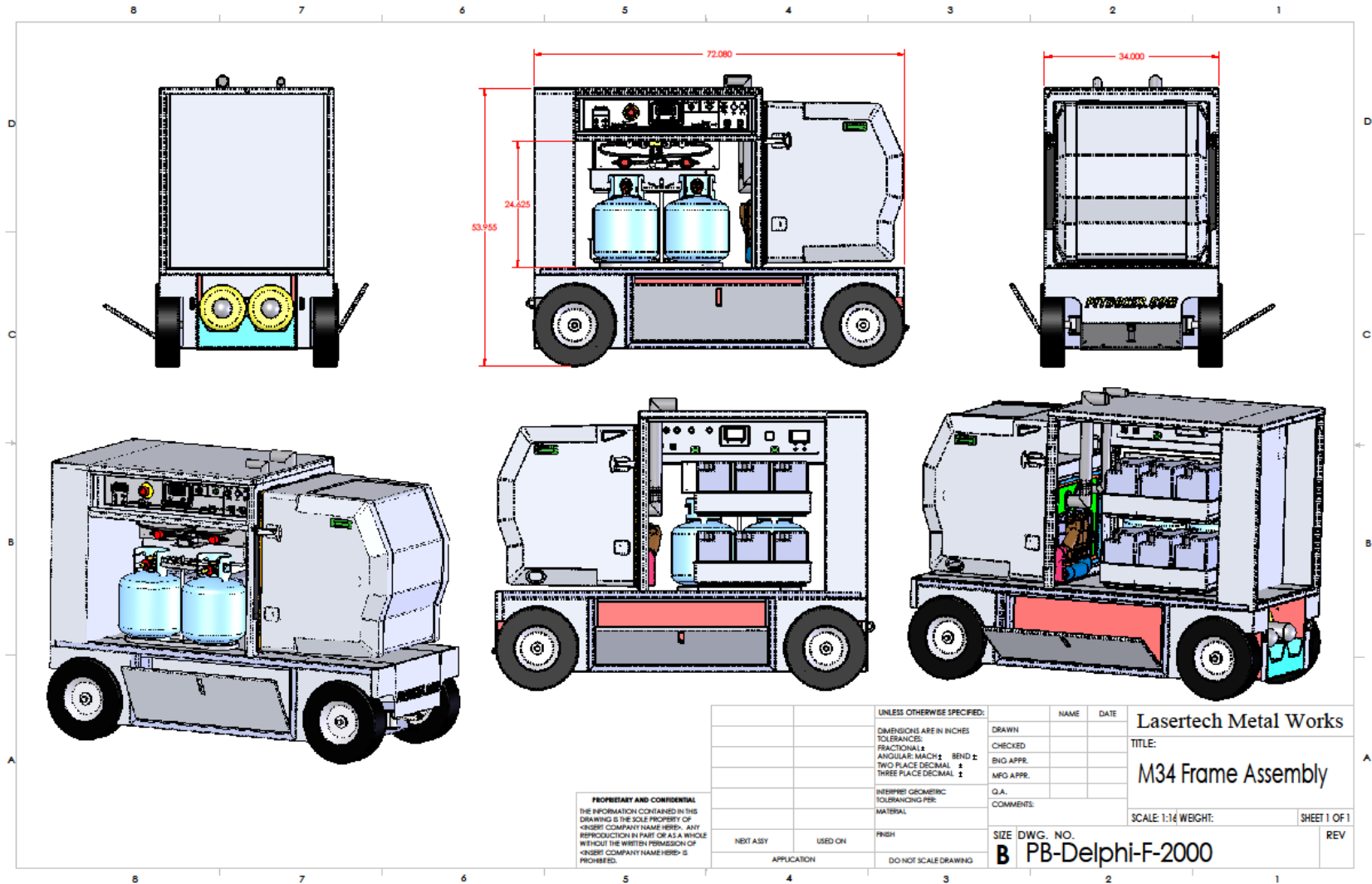


Pitbox



Revised Design

Mechanical Design Overview



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Collaborations



- Jadoo Power System Inc. is the prime contractor
- Jadoo is doing primary development work on the propane fuel interface and will perform final system testing prior to deployment
- Delphi Inc. is a subcontractor with responsibility for the primary development work on the SOFC generator including the desulfurizer, propane reformer, SOFC power plant and the AC inverter
- NASCAR Media Group will provide key operational resources for the deployment, transportation, operation and testing activities as a subcontractor

Future Work

Timing	Activities
<i>New Scheduling Required due to Project Hiatus</i>	<ul style="list-style-type: none">• Complete the development/test remaining subsystems• Finalize mechanical design and build chassis frames• Perform systems integration and final testing to validate performance targets• Make go/no go decision on deployment readiness• Finalize all field test plans, train NASCAR field personnel and arrange logistics for racing season

Summary

- This project has successfully addressed all key technical risk areas in bench and subsystem level testing
- Reduction of the mechanical form factor has been challenging due to the special configuration required for the first articles
- Extensive review of NASCAR operations has identified specific equipment suites that would be suitable in terms of power levels, locations and user needs for the application of the SOFC generators
- Interaction with multiple local, state and federal first responder organizations have indicated some common applications that would be well served by a portable fuel cell generator that does not depend on gasoline as a fuel source