Missouri S&T Hydrogen Transportation Test Bed

List of Specific Scholarly Deliverables

Investments through the National University Transportation Center at Missouri University of Science and Technology have really scored on the Center's mission areas and particularly ***Transition-state fuel vehicle infrastructure leading to a hydrogen economy***. Already this investment has produced three programs, Hydrogen Fueling Station, the EcoCAR Garage, and the Renewable Energy Transit Depot, that have lead to a new 2008 Missouri S&T major strategic theme. Chancellor Carney calls it "E^3=C" challenge, i.e., Energy, Environment, and Education equals Civilization. With the strong start empowered by NUTC funds, a new transportation test bed at Missouri S&T, coined "E^3 Commons", is being constructed to develop, demonstrate, and deploy hydrogen vehicles and supporting infrastructure including hydrogen production from renewable energy sources. Another round of investment is needed to keep this momentum going and capitalize where success has grown much more than anticipated. Table 1 provides an overview of the hydrogen transportation test bed timeline.

Table I. Hydrogen Transportation Test Bed Timeline.

	2006-08	**2008-11**	**2011-16**
	Phase I: Development	**Phase II: Technology Demonstration**	**Phase III: Commercial Deployment**
Infrastructure	Analyze hydrogen generation options	Evaluate hydrogen generation from multiple feedstock	Demonstrate viability of hydrogen infrastructure
Vehicles	Evaluate emerging pathways to hydrogen vehicles	Evaluate hydrogen powered vehicles under real-world conditions	Demonstrate commercial viability of hydrogen fuel cell vehicles
Research	Address safety issues, codes and standards, and performance and cost barriers.		

<u>Phase I</u>: (2006-2008)

The "ShowMe the Road to Hydrogen" initiative which was funded initially by the NUTC seed funds resulted in the Defense Logistics Agency sponsored "Hydrogen Infrastructure Technology" via an Air Force Research Laboratory contract for $1.94M.

The list of deliverables for Phase I is noted below:

- Commuter Bus Service (non H2) for FLW Established (May 07)
- Temporary H2 Air Products Refueler Utilized Prior to Installation of Fixed H2 Fueling Station (May 07)

- Ford H2 Internal Combustion Engine (ICE) Buses Utilized on Missouri S&T Campus for Evaluation Purposes (Jun 07)
- Air Products Mobile H2 Refueler Operational at Missouri S&T (Jun 07)
- First Responder Training Completed (July 07)
- Ford H2 ICE Bus Service at Missouri S&T Operational (Jul 07)
- Missouri S&T - Air Products Contract Negotiations for Fixed H2 Fueling Station Unsuccessful (Oct 07)
- Missouri S&T Signed Contract with Gas Technology Institute (GTI) for Fixed H2 Fueling Station-Steam Methane Reforming (Dec 07)
- Open GTI H2 Fueling Station and Host 2008 Hydrogen Road Tour (Aug 08)
- Begin FLW H2 Bus Commuter Service (Rolla-FLW) (Aug 08)
- Negotiated for Continued Operation Through 2009
- Install GTI SMR at H2 Fueling Station (May 09)
- Resume FLW H2 Bus Commuter Service (Rolla-FLW) (May 09)
- Continued Operation Through 2009
- Negotiating with Ford for Operation Through 2010

Phase II: (2008-2011)

As one of the next alternative fuel initiatives at Missouri S&T in Phase II, the Federal Transit Administration funded the Alternative Energy Research Project 00021459 to expand the Hydrogen-Powered Rural Transit Test Bed by installing on-site hydrogen production via electrolysis powered by two renewable energy sources, i.e. solar photovoltaic panels and wind turbines mounted on the renewable energy transit depot. The U.S. Department of Energy (DOE) and General Motors (GM), as well as by Natural Resources Canada and other industry leaders, established a new collegiate advanced vehicle technology competition (AVTC), the “EcoCAR: The NeXt Challenge.” EcoCAR challenges engineering students from universities across North America to re-engineer a light-duty vehicle, minimizing energy consumption, emissions, and greenhouse gases while maintaining the vehicle’s utility, safety, and performance. Missouri S&T was selected in May 2008 as one of the 17 universities in North America (14 USA and three Canada) selected to join the three-year EcoCAR Challenge (2008-2011). In February 2009 Missouri S&T was selected by GM & DOE as the only team in U.S.A. to receive hydrogen fuel cells, the cutting-edge powertrain technology, for the EcoCAR Challenge. The latest infrastructure investment is funded by funds from the Missouri S&T NUTC and this latest investment totals $605,000.

The list of deliverables for Phase II is noted below:

- Re-commissioning of the 15 kg/day on-site mobile hydrogen unit via steam methane reformation at the E-cubed Commons (May 27, 2009)
- Re-establishment of the hydrogen shuttle bus service between Rolla and Ft Leonard Wood in Missouri (May 27, 2009)
- Design/build a green building fabricated from four recycled shipping containers (2009)
- Design/build/install an electrolyzer integrated into the GTI designed hydrogen fueling station (2009)
- Design/build/install the renewable energy components: solar photovoltaic panels and architectural wind turbines on the renewable energy transport depot. (2009)
- Commission the fully integrated, four-pathway, hydrogen fueling station (2010)

The general goals of the EcoCAR Challenge competition can be summarized as follows:

i. Educate participants in methods and processes involved in automotive vehicle development through a coordinated and structured research, development, and validation program.
ii. Provide a high-quality engineering educational experience for all participants.
iii. Build popular awareness of and support for improving the energy efficiency and reducing the environmental impact of automotive transportation.
iv. Ensure that vehicle conversions are performed and competition operations are conducted safely.
v. Project a positive image of the participants, organizers, and sponsors and their respective institutions.
vi. Build a foundation of understanding concerning energy security for the nation.

The general missions of the EcoCAR Challenge competition can be summarized as follows:

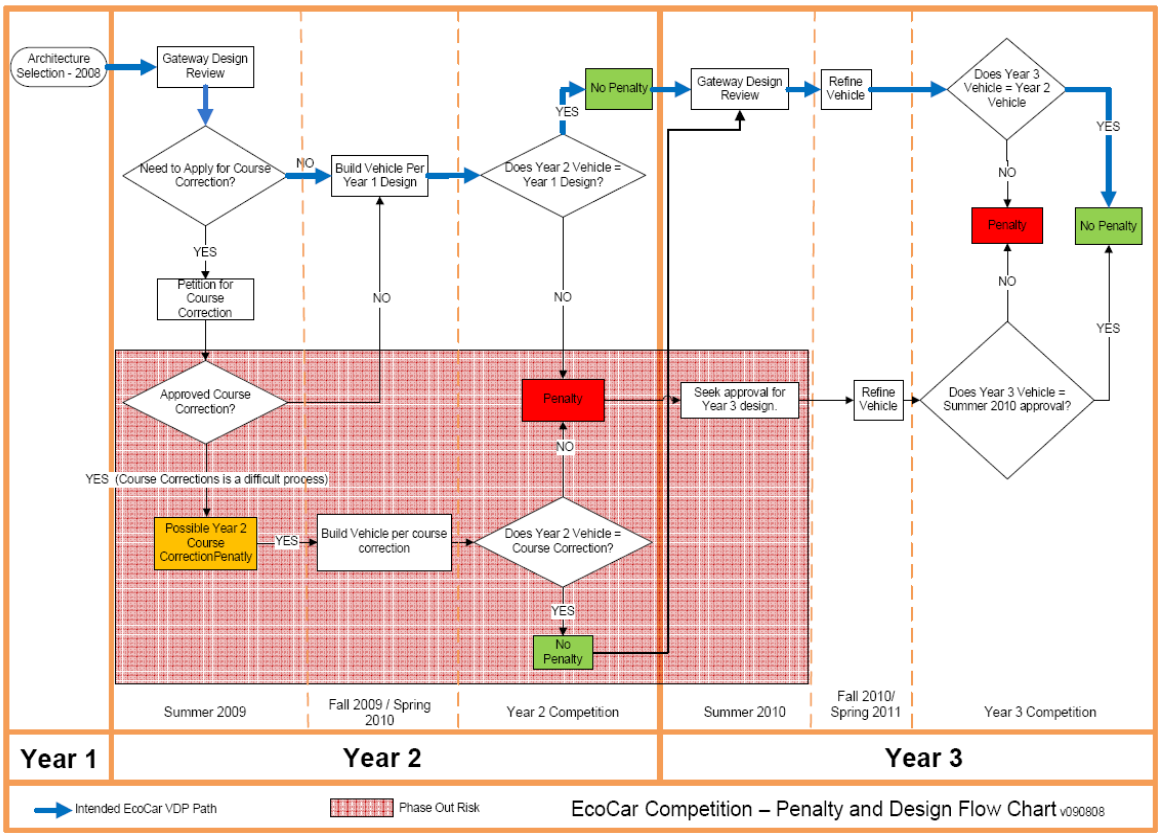
i. Develop the potential of sustainable mobility technologies and move forward technical progress toward reducing the energy consumption and environmental impact of vehicles.
ii. Provide a hands-on, real-world engineering experience that incorporates the use of math-based tools to improve engineering education, reduce development time, foster practical learning, and better prepare students to work in the domestic automotive and electronics industries.
iii. Develop highly skilled students with a strong understanding of advanced vehicle and simulation technologies that will prepare them to lead the automotive industry into the 21st century and ensure that North America remains competitive in the global marketplace.
iv. Incorporate the EcoCAR Vehicle Development Process (EcoCAR VDP), which mimics GM's Global Vehicle Development Process (GVDP), into the dedicated educational curriculum for EcoCAR at the participating universities/colleges.

v. Meet demanding schedules for such deliverables as working vehicles, reports, simulation results, and student-collected test data, which will be coordinated with milestone timing of the EcoCAR VDP.

vi. Achieve a demonstrated understanding of competition team structure and completed program deliverables that will be due throughout each competition year.

vii. Foster networking between teams to build relationships that will follow participants through their careers.

The following table provides a snap-shot of the three-year project flow chart with various gateways.



The specific deliverables for the EcoCAR Challenge include several reports in each of the three years, similar to the 1st Year's Schedule:

- Report #1 – Production Vehicle Modeling
- Report #2A – Vehicle Architecture Proposal
- Report #2B – Revised Architecture Proposal
- Report #3 – Subsystem Design
- Report #4 – System Development and Integration
- Report #5 – Final Design Report
- Technical Success Stories Report
- Final Business Report
- Award Presentations & Appointment

Other specific deliverables include the following:

- Submit three technical abstracts to the HYSYDAYS 2009 - 3rd World Congress of Young Scientists on Hydrogen Energy Systems in Torino, Italy (June 2009)
- Submit full-length manuscripts for each of the technical abstracts accepted to HYSYDAYS 2009 (Oct 2009).
- Submit for publication of the accepted research papers for HYSYDAYS 2009 as papers for a special edition of the International Journal of Hydrogen Energy. (2010)
- Procure and install the Killark electrical fittings, fixtures and devices in the EcoCAR garage as specified in the Killark sponsored senior design projects from Spring 2009 semester. (2009)
- Specify, select and procure the hydrogen leak system of catalytic beads for the EcoCAR garage. (2009)
- Design/built office/lab space for design, modeling & simulation activities of the EcoCAR team. (2009)
- Propose the establishment of an “Energy, Environment and Innovative Transportation” research group at Missouri S&T to focus at demonstration and applied research projects. (2010)
- Secure the continued funding from FTA for transportation electrification demonstration of BEVs as the first step towards the establishment of hydrogen fuel cell plug-in hybrid electric vehicles. (2009)
- Secure new funding from DOD’s US Army Tank, Automotive, Research, Development and Engineering Center for an additional transportation electrification demonstration project with Smith Electric Vehicle’s BEVs. (2010)
- Secure continued funding from DLA for hydrogen shuttle bus infrastructure project (2010)