

2012 DOE VEHICLE TECHNOLOGIES PROGRAM REVIEW PRESENTATION

Smith Electric Vehicles:
Advanced Vehicle Electrification + Transportation Sector
Electrification

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Smith Electric Vehicles- US Corp

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ARRAVT072



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OVERVIEW

Timeline

- Start: Apr 2010
- Completion: Nov 2014
- Completion so far: 53%

Budget

- Total Project Funding:
- DOE \$32M
- SMITH US \$37.5M
- DOE funding received \$17.1M

Barriers & Risks

- Supply chain maturity and transition
- Component Supply and Cost
- Data Transfer Efficiency

Partner & Collaborators

- SMITH Europe
- Launch Customers
- Technical Partners & Bridge Suppliers
- Institutions
- Other DOE Funded Projects



OBJECTIVES/RELEVANCE

Relevance to American Recovery and Reinvestment Act-

- Accelerate the development, production and acceptance of AEV's in the US commercial market to substantially reduce petroleum consumption, reduce vehicular emissions of greenhouse gases, increase energy security, and create US jobs.

Project Objectives-

- Manufacture and sell to customers 510 medium duty commercial All Electric Vehicles (AEVs) operating different duties in several geographical regions of the USA.
- Collect and submit to the National Renewable Energy Laboratory (NREL) 2 to 3 years of performance data utilizing Smith Link telemetry.
- Develop Second Generation Smith Power, Smith Drive and Smith Link charging to enhance performance and reduce costs.
- Create 225 new jobs at Smith USA.



PROJECT MILESTONES

Milestone Title	Milestone Description	Planned Start Date	Planned End Date
Initial Customer Program Vehicle Build Complete for Project	Initial vehicle deliveries as part of the project	4/1/2010	4/30/2010
Installation of telemetry system on initial customer program vehicle	Vehicle data received on Smith Servers	9/1/2010	10/31/2012
Initial customer vehicle initial data capture and reporting to DOE	Send complete data set to DOE for initial vehicles	11/1/2010	10/31/2014
Customer vehicle final data capture and reporting to DOE	Final data receipt from vehicles and final report submission to the DOE	10/31/2010	10/31/2014
255 Vehicles Deployed under program	Halfway point of vehicle deployment	4/1/2010	1/31/2012
Vehicle Deployment Complete	Final Vehicle deployed under program	4/1/2010	10/31/2012



PROJECT APPROACH

- Maintain fund raising activity to support corporate goals
- Complete knowledge transfer from Smith UK to Smith USA.
- Secure US purchase commitments and participation agreements to support the demonstration project.
 - 92% of the \$32M DOE/ARRA Grant will be paid to AEV buyers participating in the DOE Electric Fleet Data Collection Program.
 - On order placement and completion of the participation agreement at the time the customer agrees to either a two or three year data collection program.
 - The amount paid to each participating company is based upon the duration of participation and the value of the base vehicle.
 - The encrypted performance data is collected via Smith Link, held and processed on secure servers for transmission to NREL monthly.
 - The remaining 8% of the Grant is a 24% reimbursement of Project Development costs.
- Establish technical teams to
 - Deliver US Homologation and European type approvals
 - US Platform Introduction.
 - Develop Second Generation Smith Power ,Smith Drive and Smith Link systems.
 - Deliver Corporate cost down targets in line with project objectives



PROJECT APPROACH

- Establish US facility achieving ISO quality accreditation.
- Establish post deployment Service and Training resource to support customer adoption.
- Environmental (NEPA status) and Safety to meet -
 - California Air Resources Board Zero Emissions Standards
 - NHTSA safety requirements.
 - NEPA approval was obtained February 2010 (Categorical Exclusion CX-B).



2011/12

TECHNICAL ACCOMPLISHMENTS

Technical Accomplishments

QTR 1-4, 2011 Development, Integration and validation of-

- Smith Drive-150kw permanent magnet motor, controller and gearbox.
- Smith Power- Modular battery with supporting BMS and charger.
 - GEN 1.5 utilizing 5kWh modules and the Smith BMS
 - GEN 2 still in development with capability to utilize alternate cell chemistry and Smith BMS
 - Continued development of the Smith Charging system, to include vehicle to grid capabilities (V2G)
- Smith Link- Integration with Smith Power and Smith Drive

QTR 3 2011

- Updated facilities and operating procedures to start of production for Gen2 vehicles during QTR 4.



2011/12

TECHNICAL ACCOMPLISHMENTS

QTR 4 2011

- Start of Production for Gen2 vehicles using GEN 1.5 Smith Power and Gen 2 Smith Drive.

QTR1 2012

- Extended the Newton Platform by introducing an AEV stripped chassis for the production of Step-Thru vans.
- Pilot of the Smith-Link customer portal

QTR2 2012-

- Planned introduction of the Newton AEV Shuttle bus.
- First customer deliveries of the Newton Step Thru Van

QTR3/4 2012-

- Planned introduction of the Newton Based AEV School Bus

QTR4 2012-

- Planned introduction of Smiths cell agnostic modular battery system



2011/12 Progress

Project Progress at 30th April 2012

- 281 vehicles delivered.
- Order commitments for 238 additional vehicles against a revised target of 537 eligible vehicles under the program.
 - 100 Newton GEN2 Step-thru Vans
 - 18 vehicles still to be placed.
- Total Smith U.S. employees 130
- Gen2 Smith Drive and Smith Power supply chain established.
- Cost out activity in progress .



2011/12 PROGRESS

Fleet statistics

• Total miles driven (Nov 2010) ¹	1,795,000 miles
• Fleet mileage per week ²	33,158 miles
• Fleet energy consumed per week ²	42,897 kWh
• Fleet energy regenerated per week ²	5,329 kWh
• Weekly efficiency ²	1.2937 kWh/mile
• Average distance traveled per day ³	31.2 miles
• Average Number of stops per day / per mile ³	70.1 / 2.7
• Average Brake (Regen) Events ³	12.5 per mile
• Average Maximum Acceleration ³	0.4 g's
• Average Daily Maximum Driving Speed ³	47.5 mph
• Average Daily Driving Speed ³	20.2 mph

1 Month in which Smith Link started recording data

2 At 30th April 2012

3 Sample of 100 vehicles - 10/1/2012 to 12/31/2011

- Vehicle days driven 3610

- Number of operating



SMITH LINK

Developed specifically for the DOE project to collect real time performance data from customer vehicles participating in the project.

- Now utilized across all Smith Vehicles (USA and ROW)
- System metrics
 - Approx 2500 data points collected per second per vehicle.
 - Approx 1.8 billion data points per day.
 - All data is encrypted
 - All data consolidation and processing is carried out on secure Smith servers
 - 22 Gb of data transmitted to NREL each month.
- Data utilized by the following
 - Smith Service- support customer calls
 - Smith Engineering- continuous improvement
 - Smith Business Development- pre sales duty cycle analysis
 - DOE- research and justification support
 - Customers- Fleet performance



SMITH LINK- SERVICE PORTAL

SMITH LINK

DASHBOARD

PERFORMANCE

CARBON

SETTINGS



LIVE



ROUTE



HISTORY



USAGE



SETTINGS



ANALYSIS



FAULTS



SERVICE



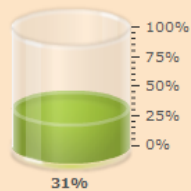
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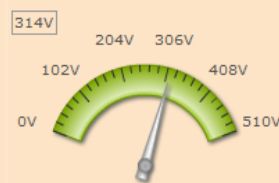
DEVICE ISSUE



DASHBOARD



State of Charge



Voltage



Current



Speed

FAULT

BATT WARN

DT OVERTEMP

REGEN ENABLED

ABS ACTIVE

VS STATE

MS STATUS

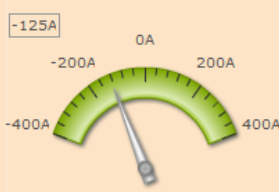
MS STATE



DRIVETRAIN



RPM (x1000)



Torque Command

Accelerator pedal

25%

Brake pedal

0%

Availability

100%

24V Battery

24V

MSVDCL

123

MSVDCB

132

Fan

Pump

REVERSING

Motor



TEMPERATURES

Battery 1°C

Drivetrain 1°C

Cab 1°C

Inverter T1 1°C

Inverter T2 1°C

Inverter T3 1°C

Inverter T4 1°C

Motor T1 1°C

Motor T2 1°C

Smith Link → Customer area → Performance report

PERFORMANCE REPORT

Performance Summary: 1st Apr 2012 - 1st May 2012	
Statistics	
Distance	104558 miles
% over 40mph	50%
Cumulative Energy Draw	152131kWh
Total Regenerative Braking Energy	12503kWh
Regenerative Energy Per Mile	0.12kWh/mile
Regenerative Energy Ratio	8%
Efficiency	0.7488 miles/kWh 1.3354 kWh/mile
Vehicle key-on time	5057:43:34
Vehicle drive time	3474:04:49
A/C Usage (hours)	612:48:09
Heater Usage (hours)	426:29:37
Carbon offset details (Estimated)	
Carbon cost for journey	9415.4700000001Kg
Typical cost for journey using diesel truck	21969.26Kg
Carbon saving	12553.79Kg

Details
1st Apr 2012
2nd Apr 2012
3rd Apr 2012
4th Apr 2012
5th Apr 2012
6th Apr 2012
7th Apr 2012
8th Apr 2012
9th Apr 2012
10th Apr 2012
11th Apr 2012
12th Apr 2012
13th Apr 2012
14th Apr 2012
15th Apr 2012
16th Apr 2012
17th Apr 2012

Project Delivered QTR4 2011

Objectives of Project

Continuous Improvement Initiative

- Technological: Keep pace with drivetrain developments.
- Commercial: Support value management.
- Quality: Influence specification, design, validation, manufacture.

Project Features and Benefits

- Technological:
 - PM Machine Support Energy Efficiency, Weight out
 - Greater Power Improved acceleration
 - Greater Torque Improved launch feel
 - Greater Max RPM Support future proofing, Vmax
 - Modular Motor/Gearbox Support future proofing, Vmax, Gradeability
 - Operational Environment -20 Deg to +50 Deg C
- Commercial:
 - Cost down opportunity

SMITH DRIVE



Motor: Manage HV electrical energy and produce useful work at the wheels

Type: Permanent Magnet

Cooling: Water/Glycol jacket cooled

Weight: 97Kg

Torque: PEAK 600 Nm, CONT 400 Nm

Power: PEAK 150 kW, CONT 80 kW

Efficiency: 93%

Gearbox: Torque multiplication, prop speed reduction

Type: Single ratio (3.4:1) , parallel shaft, helical cut

Lubrication: Oil, Splash lubricated

Mating Flange: Supports Stock Avia

Tachograph Supported: Yes

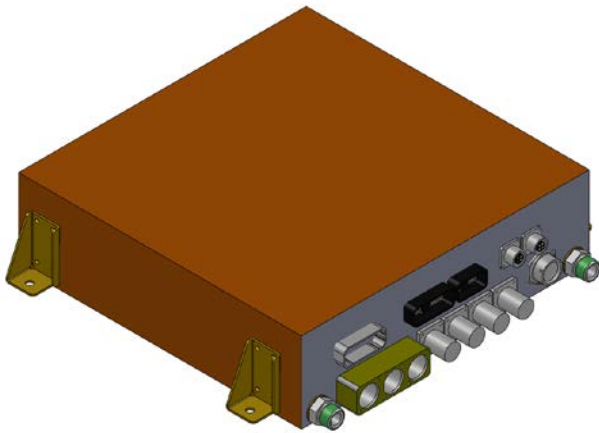
SMITH DRIVE

Drive Controller:

- Function is to manage the energy and power flows to the driveline, domestic and aux systems
- Process all I/O's from the driver
- Process all communication between the other vehicle systems like the battery, and driver display

Cooling: Water/Glycol cold plate

Fully integrated with Smith Link and Smith Power





SMITH POWER

Project delivered QTR4 2011

Objectives of Project

Continuous Improvement Initiative

- Technological: Keep pace with cell and integration developments.
- Commercial: Support value management.
- Quality: Influence specification, design, validation, manufacture.

Project Features and Benefits

- Transitioned from Cylindrical cells to pouches.
- Use of Battery Module and component technology which is developed, tested and validated to latest automotive standards and installation best practices.
- Investment into Smith dedicated installation componentry and connectivity systems.
- Development of Smith dedicated Battery Management and Control system and components.
- Modular to battery pack sizing to meet customer requirements



SMITH CORPORATE LESSONS LEARNED

Customer Expectation

- Managing customer expectation – a plan for success
 - Duty Cycle Analysis
 - Performance
 - Training
 - Handover
 - Expectation Reinforcement and After-Sales
- VOC
 - Placing customer requirements at the center of the systems engineering process.
- Customer Relationships
 - Must be proactive
 - Advocacy “the bottom up approach”



COLLABORATIONS/PARTNERSHIPS

Collaborations:

- TARDEC V2G Performance Analysis - Missouri University of Science & Technology,
- Duty Cycle Forecast Model- Kansas University Center for Research.
- GEN 3 Smith Charger - Manchester University (UK).
- E-Van- Ultra Efficient System development UK DFT TSB funded program
 - High Efficiency Drive Train- Bristol University (UK).
 - TTE 32 Leicester University
- QM Power on a ARPA-E project to develop electric motors using non-rare earth magnets.

Under Consideration:

Jointly responding with a partner to a DOE RFI to integrate a fuel cell range extender into an electric vehicle. It is Smith's intention to do so.



FUTURE WORK

- Meet the revised 537 vehicle deployment milestone of October 31, 2012

Smith Link

- System data efficiency improvements.
- Bi -Directional data transfer.
- Load sensing.
- Prognostics.

Smith Drive

- ROW launch and EWVTA.
- Light and Medium duty multispeed transmission.

Smith Power

- Development of cell agnostic Smith Module
- Development of active thermal management
- Continued development and optimization of the Smith BMS



SUMMARY

•**Objectives/Relevance-** Manufacture and sell 537 commercial all electric vehicles, and deliver to the NREL 2 to 3 years of operating data in order to accelerate the development and production of electric drive vehicle systems in the US to reduce petroleum consumption, reduce vehicular emissions of greenhouse gases, promote US energy security, and create 225 new US jobs.

•**Approach-** Utilize existing Smith UK technology and systems to develop a Smith US DOT-compliant all electric commercial vehicle for various industries in several geographical regions of the United States. Smith UK acquired by Smith USA to provide access to the core technology and create global access to the commercial EV market. Now leveraging Brand, Technology and customer relationships into emerging markets which will provide business scale.

•**Technical Accomplishments-** Developed and improved GPS-based operational monitoring system; Gen 2 AEV drive and battery systems now being delivered to customers; Gen 2 charging system is well into development; created 130 new US jobs; ongoing cost down strategy in place.

•**Collaborations/Partnerships-** Originally licensed with Smith UK for technology transfer and engineering/manufacturing training and assistance; worked with government and educational institutions on technology, education and training; made agreements with commercial industry leading companies to purchase Gen 2 vehicles; worked with vendors to improve supply chain, reduce cost and improve quality; collaborated with customers to define the requirements for next generation commercial EV's.

•**Future Work-** Continuous improvements to existing manufacturing processes; hire and train 95 new US workers; meet order/delivery milestones for the 537 vehicle demonstration; further improve the Gen 2 products and secure intellectual property; drive down purchase and manufacturing costs of primary and secondary components; continuously strive to improve quality..



TECHNICAL BACKUP SLIDES



NEW PRODUCTS



Smith US Step-thru Van.



Smith Cold Plate.

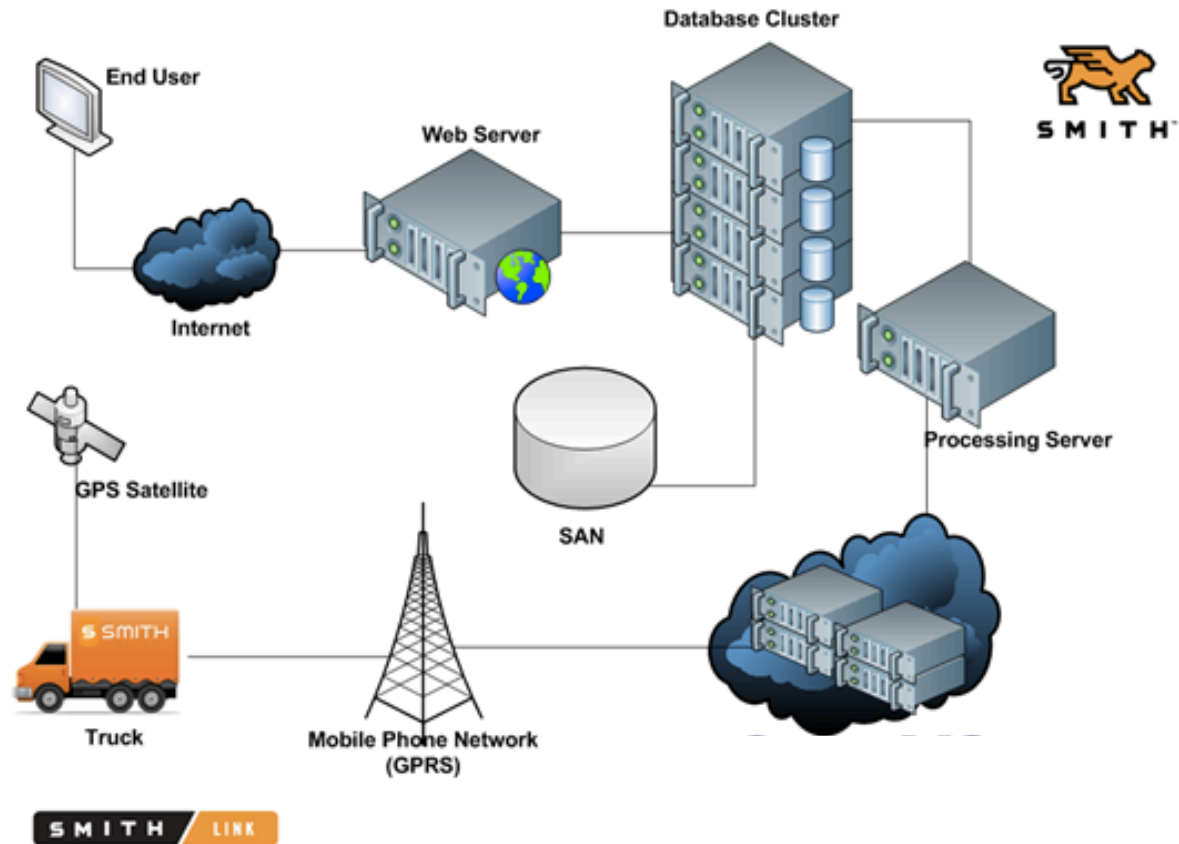


Smith US Shuttle Bus.



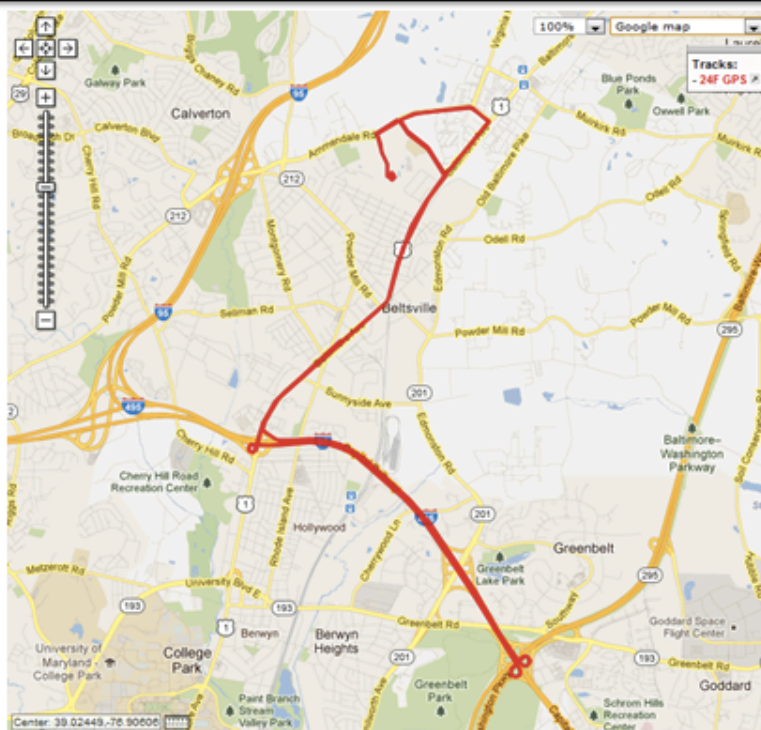
Smith US School Bus.

SMITH LINK



ROUTE ANALYSIS – ROUTE MAP AND DETAILS

BELTSVILLE, MARYLAND -- 7170



Route Conditions	Actual Route	Summer Prediction	Harsh Winter Prediction
Base Weight [kg]	7700 (17,000 lbs)		
Payload Profile	Linear Decrease 1000kg – 0kg (2200 lbs – 0 lbs)		
Battery Temp [C](F)	10 (50)	23 (73)	-5 (23)
Aux. Draw [kW]	4.4	2.3	6.5
Key on Time	1.5 hours		
Total Route Time	8 hours		
Distance Traveled [miles]	38.5	38.5	38.2
Ending State of Charge	17	32	<10
Route Recommendation	Marginal	Yes	Very Marginal



SMITH POWER

Gen I,

- 40 KWh String
- 40 80 120 Configurations.
- 24 Mod / String
- 320 VDC Nominal
- 1 string per charger
- Fuse/controls in Battery Pod
- Master/Slave Battery Pod
- Manually intensive sealed box
- No Interlock Pins for HVDC
- Common power cables
- Pre-charge circuit in Batt Pod
- Battery Supplier BMS

Gen II,

- 20 KWh String
- 40 60 80 100 120 KWh Conf
- 4 Mod / String
- 346 VDC Nominal
- 2 strings per charger unit
- JB- Accessible fusing/controls
- Master Distribution Box
- Full gasket sealed ox
- Interlock-Pins for HVDC
- Power Shielded cables/ferrites
- Pre-charge circuit in CEU
- Smith BMS



SMITH POWER



SMITH POWER/DRIVE INSTALLATION

