



Multi-Materials Vehicle R&D Initiative Lightweight 7+ Passenger Vehicle

Project ID #LM029
MMV 903

***2011 DOE Merit Review Presentation
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Overview

Timeline

- Start: October, 2009
- End: Sept. 30, 2010

Budget

- Total project funding
 - DOE share: \$184 K
 - USAMP share: \$135 K
- Funding received in FY10 : \$184 K
- Funding plan for FY11: \$ 0K
(project concluded in FY10)

Barriers/Targets

- Cost-competitiveness of lightweighting solutions for high volume manufacturing
- Need improved strategies for full vehicle weight reduction to meet vehicle performance
- Insufficient materials, process, performance and business case information in OEM database

Partner s

- OEMs: Chrysler, Ford, GM
- FEV, Inc.

Relevance

- Overall MMV Objective
 - Developing lightweight materials technologies and full vehicle weight strategies for cost-effective, large-scale implementation in vehicles that meet consumers' needs while providing increased fuel efficiency.
- 2010 Objective for MMV903
 - Complete "L7" Lightweight 7+ Passenger Vehicle R&D Project powertrain benchmarking, vehicle performance and weight simulation.
 - Determine weight reduction required, using vehicle performance / fuel economy simulation analysis, to enable a current production vehicles to achieve fuel economy improvements when retrofitted with a smaller current production gasoline engine and a state of the art transmission, while maintaining the performance metrics of the current production vehicles, i.e., 0-60 mph time, towing on grade, etc.
 - 7-passenger minivan to achieve 40-45% fuel economy improvement, 24.3 mpg → to new rating of 34-35 mpg.
 - 8-passenger Crossover Utility Vehicle (CUV) to achieve 20-25% fuel economy improvement, 24.7 mpg → to new rating of 30-31 mpg.

FY2010 Milestones

- Analyzed the weight reduction required, based on analyses of vehicle performance and fuel economy analyses, to achieve the targeted 40-45% and 20-25% desired fuel economy improvements (for a 7-passenger minivan and 8-passenger CUV respectively) while maintaining performance comparable to the current production vehicles.
- For the two vehicles evaluated in this project, a seven passenger minivan and an eight passenger Crossover Utility Vehicle (CUV) weight reductions between 11% and 50% are required, depending on aero improvements and engine technology, to meet the targeted 40-45% and 20-25% fuel economy improvements while maintaining performance in six customer driven metrics.
- Reached consensus with USAMP Steering Committee to end MMV activities after final report for L7+ Phase 1 is completed, at the end of FY 2010.

Note: All of these have been completed and the project concluded in Sept. 2010

APPROACH

Simulations of vehicle performance and fuel economy determined the appropriate weight reductions to achieve the targeted fuel economy improvements.

- Two engine selections were made for each vehicle, each with different peak power ratings.
- Using the vehicle simulation software **GT-Drive** by Gamma Technologies, the simulation models were first correlated to the two reference vehicles, with their standard production powertrains, for both fuel economy and performance.
- Each vehicle was simulated at three distinct starting (prior to weight reductions) weight classes. The EPA equivalent test weight (ETW) is the vehicle base curb weight plus an additional 300 pounds rounded to the nearest EPA weight class. The gross vehicle weight rating (GVWR) is the vehicle curb weight plus additional passengers and luggage. The gross combined weight rating (GCWR) is the GVWR weight plus additional weight to account for trailer towing.
- The six performance criteria required of the newly configured vehicles were four acceleration tests (five-second distance, 0-30 mph, 0-60 mph, and 0-100 mph times), hill climb ability at 55 mph (including trailer tow), and top speed. The newly configured vehicles had to meet or exceed the current production vehicle's performance in these six customer relevant performance metrics.

FY2010 Accomplishments: Engine and Transmission Choices

Minivan

- **Production: 3.8L-V6** Naturally Aspirated, Port Fuel Injection, Overhead Valve (197 hp), with Chrysler 62TE (auto-6)
- **Max Fuel Eff: 2.4L-I4** Naturally Aspirated, Port Fuel Injection, Single Overhead Camshaft (152 hp), with dry clutch 6-sp DCT
- **Max Power: 1.6L-I4** Turbocharged, Direct Injection Dual Overhead Camshaft (177 hp), with wet clutch 6-sp DCT



CUV

- **Production: 3.6L-V6** Naturally Aspirated, Direct Injection, Dual Overhead Camshaft (281 hp), with GM 6T75 (auto-6)
- **Max Fuel Eff: 2.0L-I4** Turbocharged, Direct Injection Dual Overhead Camshaft (198 hp), with wet clutch 6-sp DCT
- **Max Power: 3.2L-V6** Naturally Aspirated, Direct Injection, Dual Overhead Camshaft (251 hp), with wet clutch 6-sp DCT

FY2010 Accomplishments:

Summary for Minivan base: 24.3 mpg → target: 34.5 mpg

- The 1.6L engine was fuel efficient and more powerful than the 2.4L
- For the vehicle with the 1.6L DI engine in the vehicle with reduced aerodynamics, 10.5 ft² vs. 8.5 ft² Cd*A (aggressive aero actions!), the weight reduction needed is 500 lbs.

Baseline Minivan Curb weight = 4507 lbs. 3.8L V6 NA PFI OHV	2.4L I4 PFI SOHC		1.6L I4 TC DI DOHC	
	Original Aero	Improved Aero (19%)	Original Aero	Improved Aero (19%)
Required Curb Weight (lbs)	2257	2757	3507	4007
Required weight reduction (lbs.)	2250	1750	1000	500
Required weight reduction (%)	50%	39%	22%	11%



Vehicle Performance	EPA test wt.	GVWR	GCWR
5 second distance (ft.)	156	138	124
0-30 mph (sec)	3.5	4.1	4.7
0-60 mph (sec)	10.4	12.4	14.5
0-100 mph (sec)	30.6	41.5	57
Max grade at 55 mph (%)	11.2	8.8	7.3
Top speed (mph)	126		

FY2010 Accomplishments:

Summary for CUV base: 24.7 mpg → target: 30.5 mpg

- The 2.0L I4 engine meets the fuel economy target with ~500 lbs. weight reduction but needs 2000 lbs. removed to achieve the performance targets
- The 3.2L V6 engine meets the performance targets with ~1000 lbs. weight reduction but needs 2000 lbs. removed to achieve FE target

Uplevel CUV Curb weight = 4720 lbs. 3.6L V6 NA DI DOHC	2.0L I4 TC DI DOHC		3.2L V6 NA DI DOHC	
	Original Aero	Improved Aero (6%)	Original Aero	Improved Aero (6%)
Required Curb Weight (lbs)	2720	2720	2720	2720
Required weight reduction (lbs.)	2000	2000	2000	2000
Required weight reduction (%)	42%	42%	42%	42%



Vehicle Performance	EPA test wt.	GVWR	GCWR
5 second distance (ft.)	166	142	105
0-30 mph (sec)	3.3	4	5.7
0-60 mph (sec)	7.9	9.7	14.7
0-100 mph (sec)	20.9	26.7	43.6
Max grade at 55 mph (%)	12.8	9.6	5.6
Top speed (mph)	136		

FY2010 Accomplishments: Minivan and CUV Summary

Without aero ($C_d \cdot A$) improvements...

- Minivan must reduce 22% to 50% weight to gain over 40% fuel economy improvement while meeting carry over performance.
Base Minivan 4507 lb $\rightarrow$ 2257 lb w/2.4L I4 (ref: PT Cruiser 3222 lb)*
or $\rightarrow$ 3507 lb w/1.6L I4 (ref: Sebring 3310 lb)*
- CUV must reduce 42% weight to gain over 25% fuel economy improvements while meeting carry over performance.
Base CUV 4720 lb $\rightarrow$ 2520 lb w/ either engine (ref: Aveo 2568 lb)**

Notes: * from Chrysler web site and howstuffworks.com

** from GM web site and howstuffworks.com

Summary

- MMV 903 completed all project deliverables.
- The minivan must reduce between 500 lb (11%) if aggressive aerodynamic actions can be implemented and 2250 lb (50%) to move from 24.3 mpg to 34.5 mpg with a current production gasoline engine.
- The uplevel CUV must reduce 2000 lb (42%) to move from 24.7 mpg to 30.5 mpg with a current production gasoline engine.
- These weight reductions are based on simulations to meet fuel economy plus vehicle acceleration, top speed and trailer tow requirements but, **DO NOT** consider meeting safety, durability, noise, vibration and harshness, vehicle dynamics, or other requirements.
- There are no plans to continue with the project. The final report on Lightweight 7+ Passenger Vehicle R&D Project has been delivered.

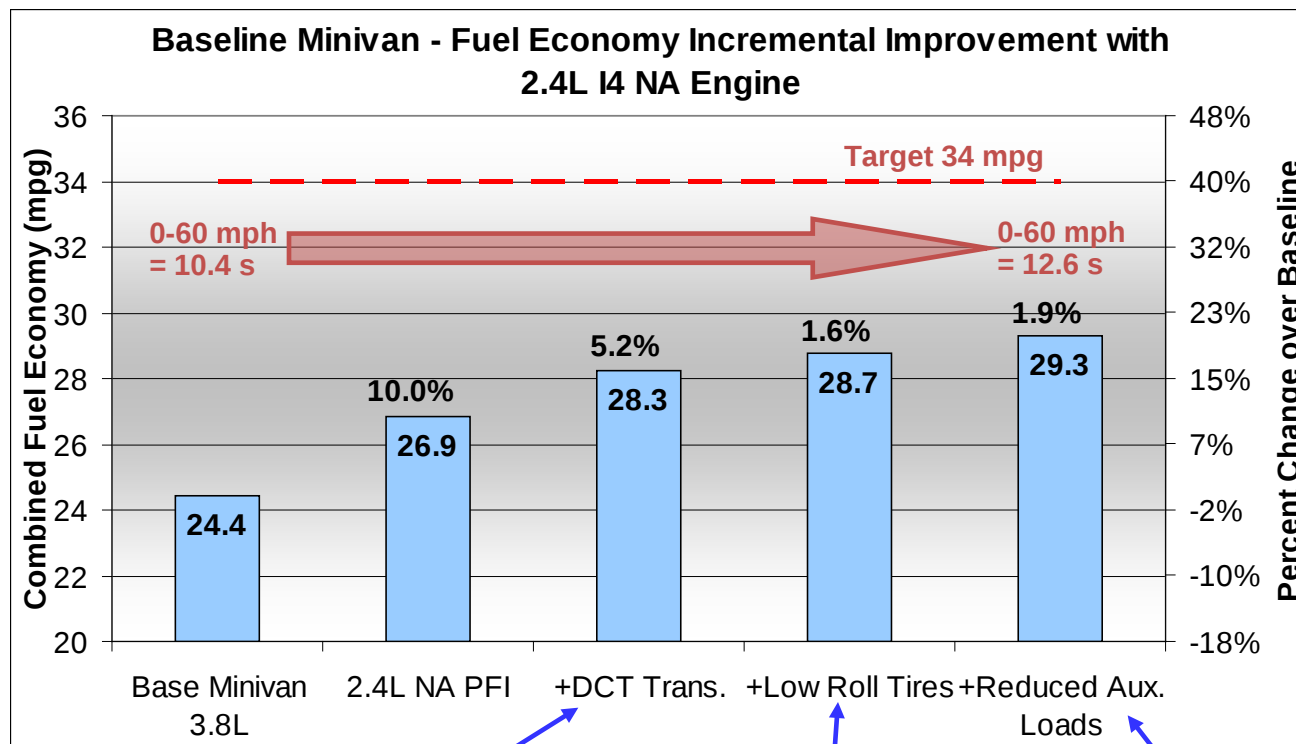


Technical Back-Up Slides

Minivan Incremental FE Improvement (Max FE Engine)

Baseline Minivan at original ETW 4750 lbs.

Max Fuel Efficiency Engine 2.4L I4 NA PFI SOHC – 152 hp

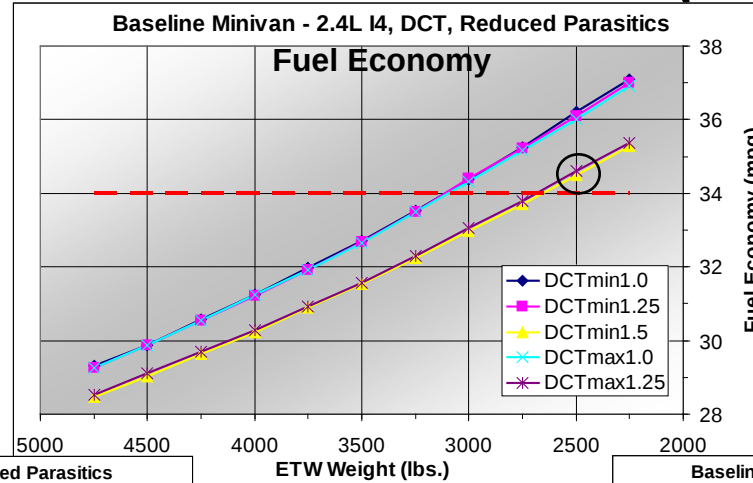


DCT Min 1.0 transmission (shown here) is most fuel efficient of the 5 variants

The speed dependant C_{rr} is reduced 7.5%

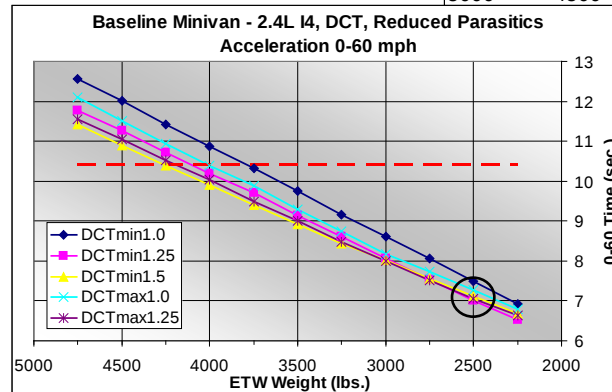
Electric power steering and high efficiency alternator

Minivan Weight Reduction for FE and Perf. (Max FE engine)

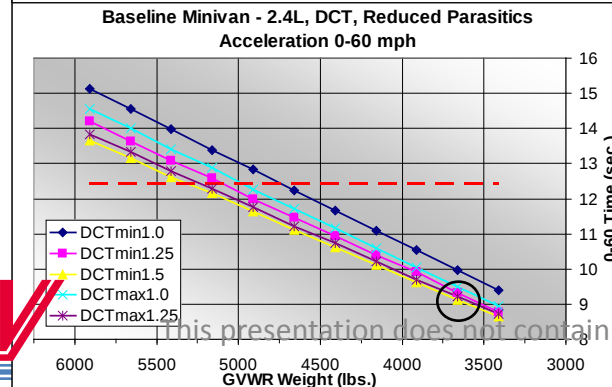
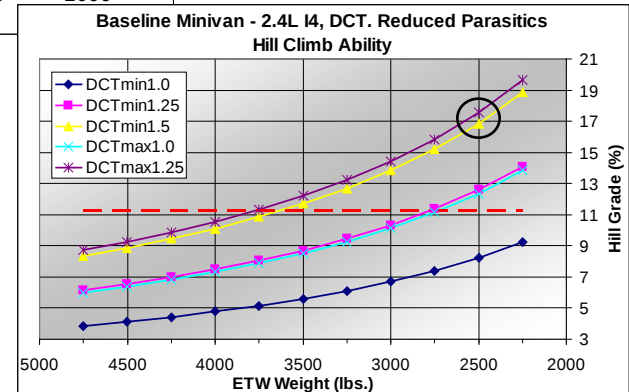


2250 lbs. weight reduction needed

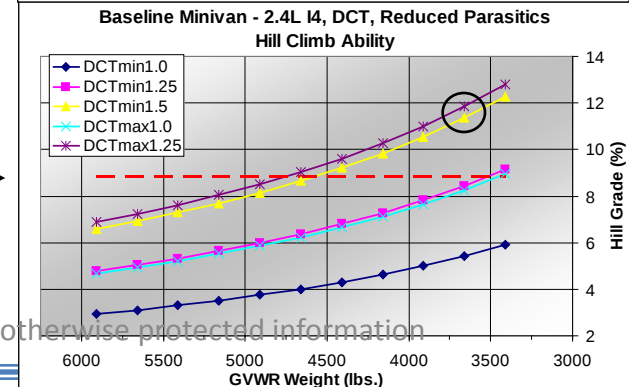
0-60 mph



ETW



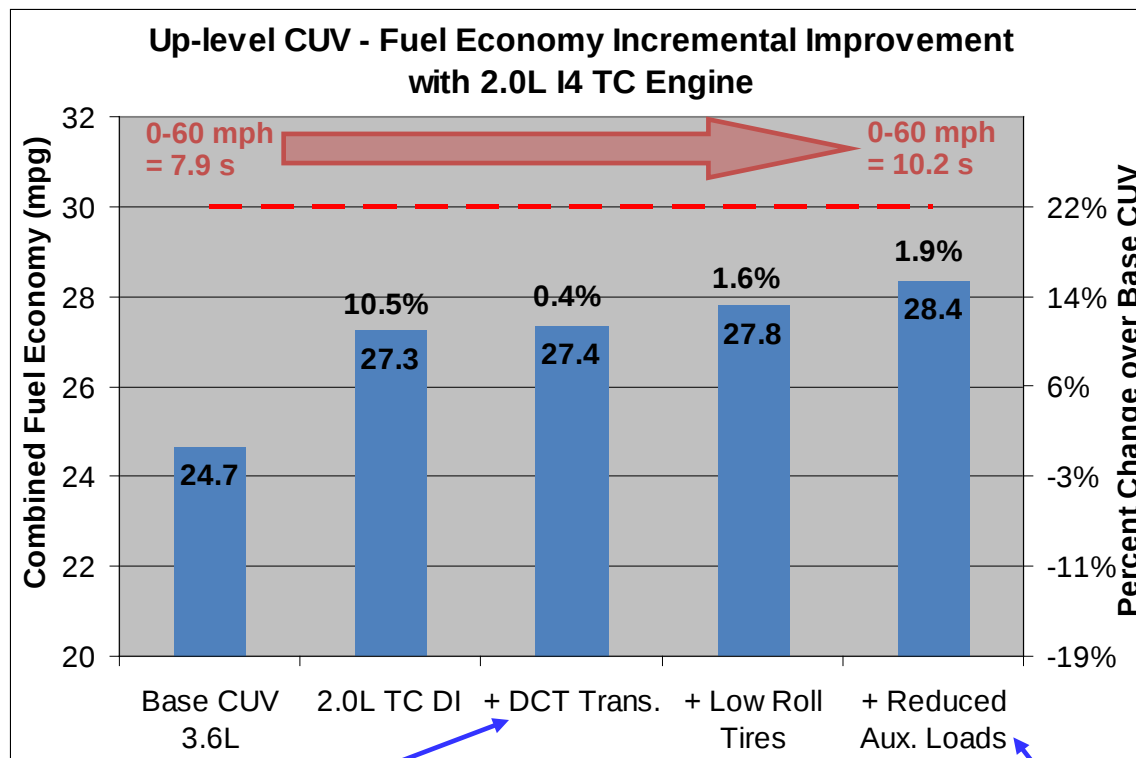
GVWR



CUV Incremental FE Improvement (Max FE engine)

Uplevel CUV at original ETW 5000 lbs.

Max Fuel Efficiency Engine 2.0L I4 TC DI DOHC – 198 hp



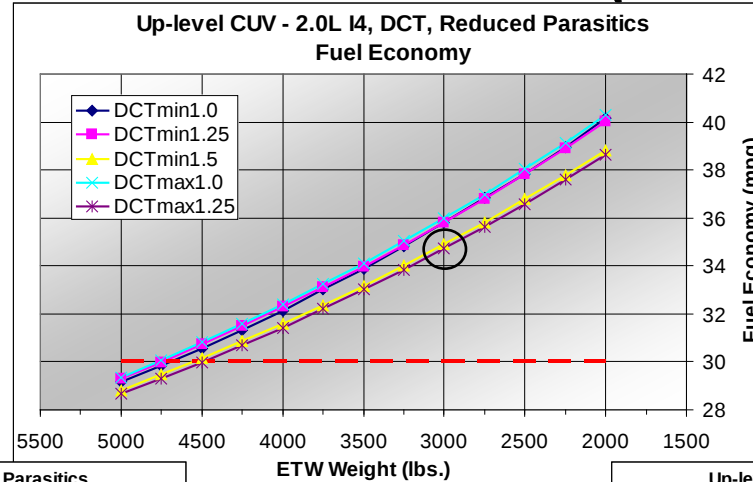
- DCT Min 1.0 transmission
- FE gains appear negligible but the 1500 rpm minimum shift speed “washes out” any gains from improved transmission mech. efficiency (i.e. 6T75 is programmed with lower shift points than this)

The speed dependant C_{rr} is reduced 7.5%

Electric power steering and high efficiency alternator

CUV Weight Reduction for FE and Perf. (Max FE engine)

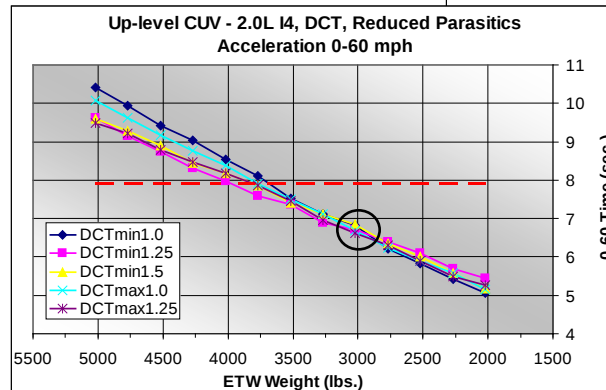
2000 lbs. weight reduction needed



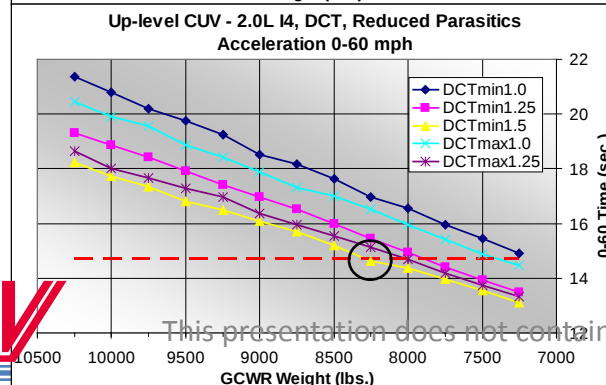
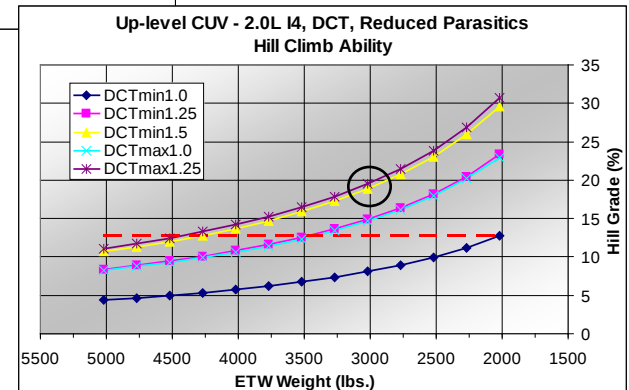
Fuel Economy

0-60 mph

Hill Grade



ETW



GCWR

