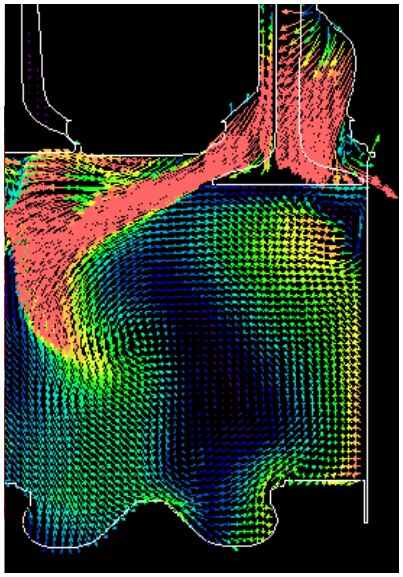
Cummins' Next Generation Tier 2, Bin 2 Light Truck Diesel Engine

Michael Ruth
Principal Investigator
18 October 2012



Advanced
Technology
Light
Automotive
Systems

ATLAS

Changing the Climate on Climate Change

Cummins' Next Generation
Tier 2, Bin 2
Light Truck Diesel Engine

Program

Timeline

Technical approach

Progress

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Changing the Climate on Climate Change

Program Basics

- ½ Ton Pick-up Truck application
- 40% Better miles per gallon
  - Compared to V8 gasoline powered equivalent
- US Tier 2, Bin 2 emissions levels
- Commercially Viable Solutions
  - High quality, Great Performance, Low Total Cost of Ownership

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Program Targets

2010 Nissan Titan

Baseline	Target
5.6L all Al V8 Gasoline	2.8L all Al I-4 Diesel
317 Hp @ 5200 RPM	210 Hp @ 3600 RPM
385 ft-lb @ 3400 RPM	385 ft-lb @ 1800 RPM
5 spd auto trans	**8 spd auto trans (ZF)**
5,078lb Curb	Less than or equal to baseline
Tier 2, Bin 5	Tier 2, Bin 2
18.6 mpg CAFE (476 g/mi CO_2)	**26.1 mpg* CAFE** (390 g/mi CO_2)

***DoE Performance Metric**

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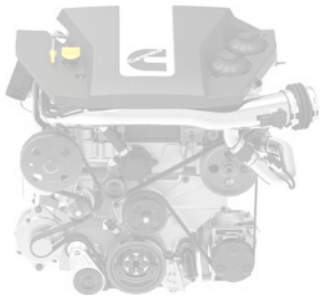
Program Timeline

4 year program
October 2010 Kickoff

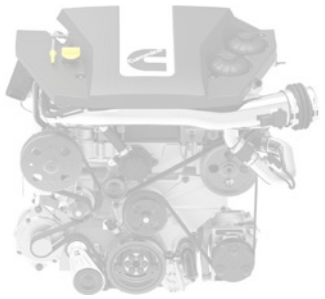
T2B5 Vehicle Demo
December 2013

Engine Out at target
July 2012

T2B2 Vehicle Demo
August 2014



T2B5 Eng Dyno Demo
June 2013



New Engine Available
December 2012

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Technical Approach

- Down sized, high power density, and minimized NVH
- Diesel engine application (charge cooler, catalysts, etc) to be weight neutral to baseline gasoline powertrain application
- Specific design package for a light duty, automotive only application
- Minimize impact on vehicle OEM by close coupling and on-engine hardware packaging
- Analysis Led Design (ALD)

Program

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ATLAS

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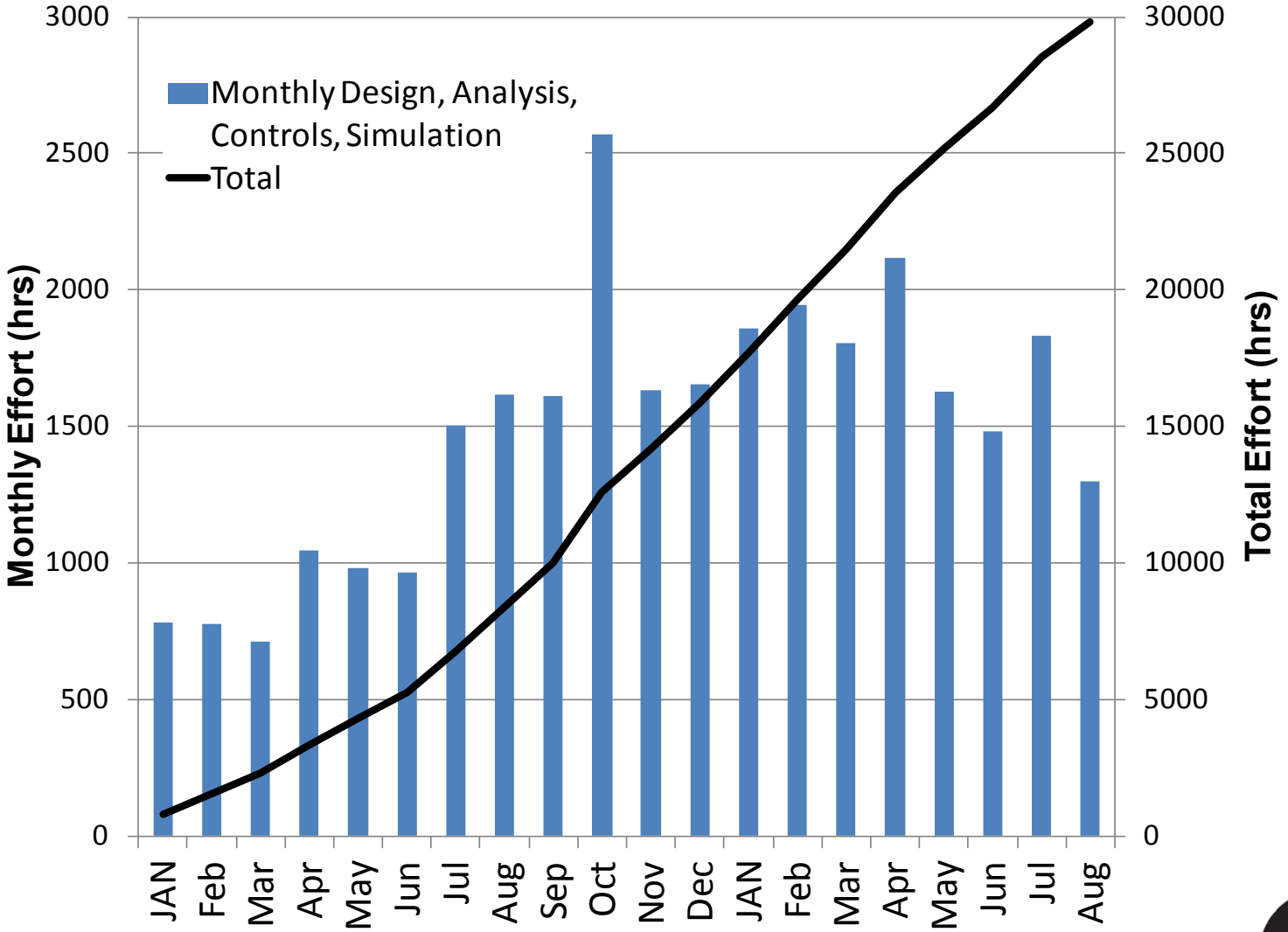
Analysis Led Design



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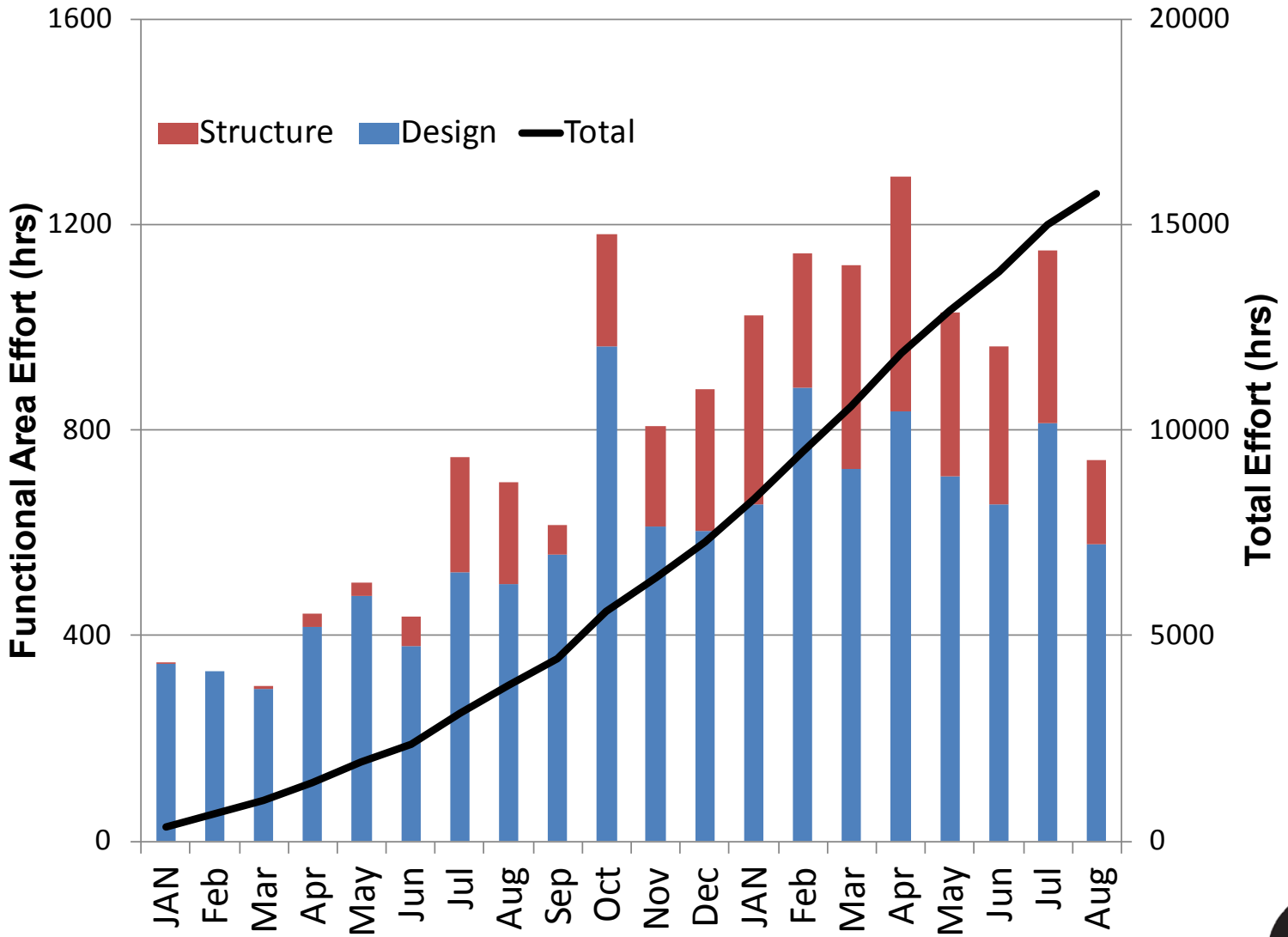
Analysis Led Design



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Weight Comparison

		ATLAS 2.8L	Baseline 2.8L	Gasoline 5.6L
Architecture-Level Subsystems (kg)	Block System	52.7	65.5	-
	Misc. Housings	0	27.1	-
	Head System	23.6	34.4	-
	Rotating/Reciprocating	29.3	31.0	-
	Valve Drive	1.2	5.3	-
	Cam & Drive	7.4	5.9	-
	Balance	6.1	14.6*	-
	Sum	120.4	183.7	-
	Sum / L	43.0	65.6	-
	Rated Power	163 kW	120 kW	235 kW
	Dressed Engine Weight	164 kg**	228 kg	225 kg
	kW / kg	**1.00**	**0.53**	**1.05**

ATLAS architecture is 63.5 kg (140 lbs) lighter than baseline

*Balance shaft not available. 14.6 kg is a displacement-scaled estimate of a bolt-on style balance shaft system Number shown for comparison of architectures.

** T2B5 Configuration

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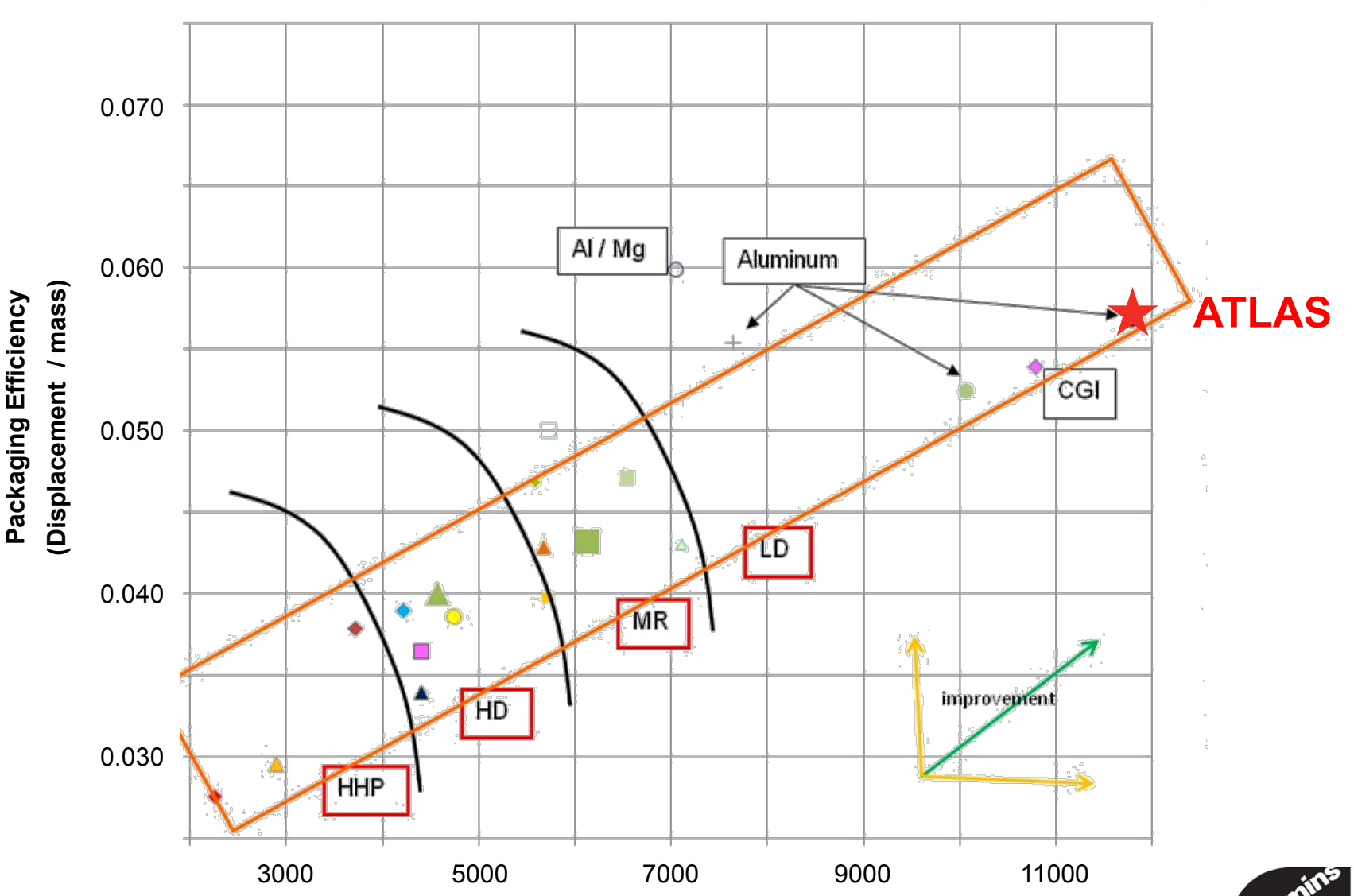
Design Package – Cylinder Block



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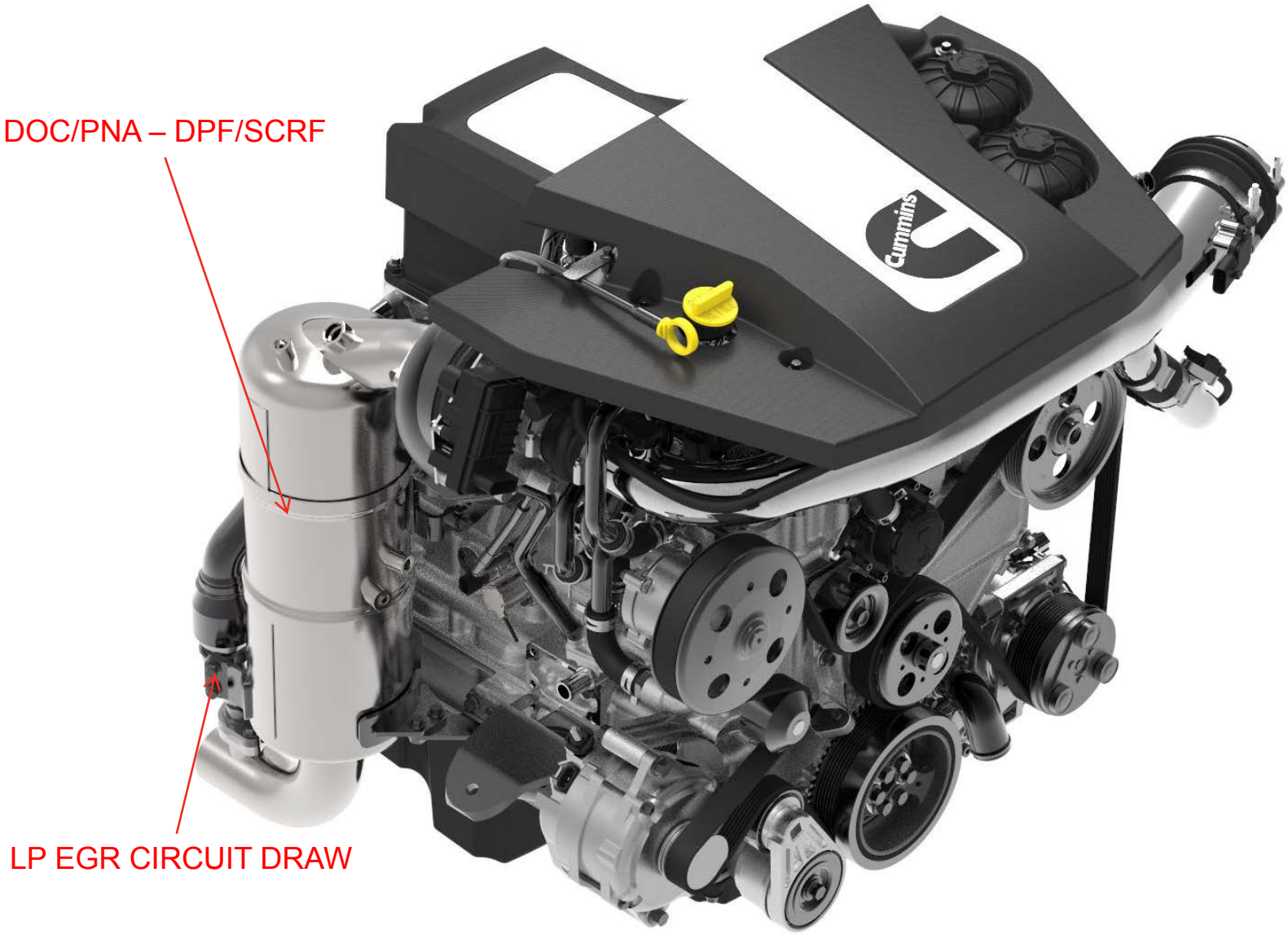
ATLAS Engine Layout



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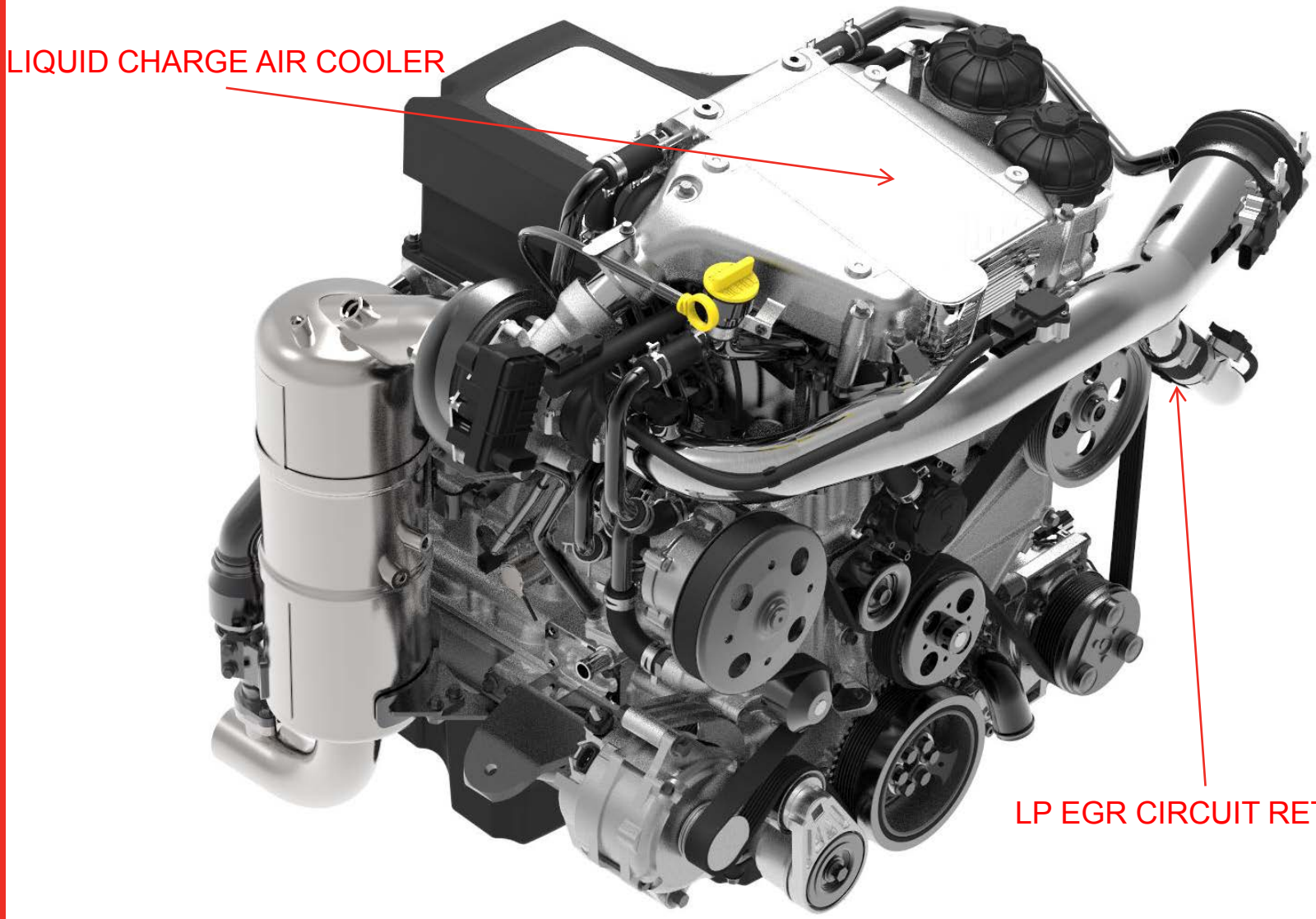
ATLAS Engine Layout



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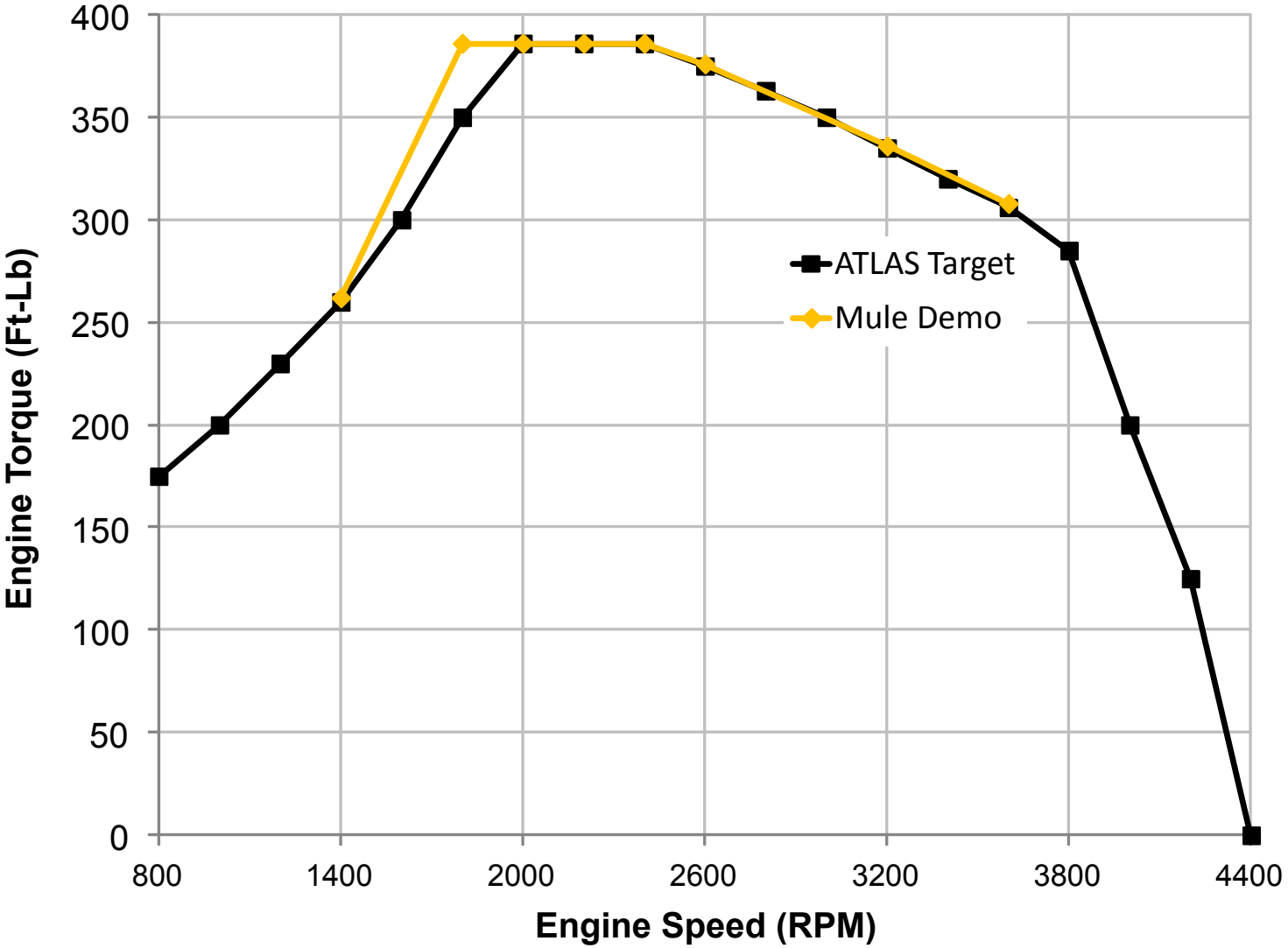
High Power Density



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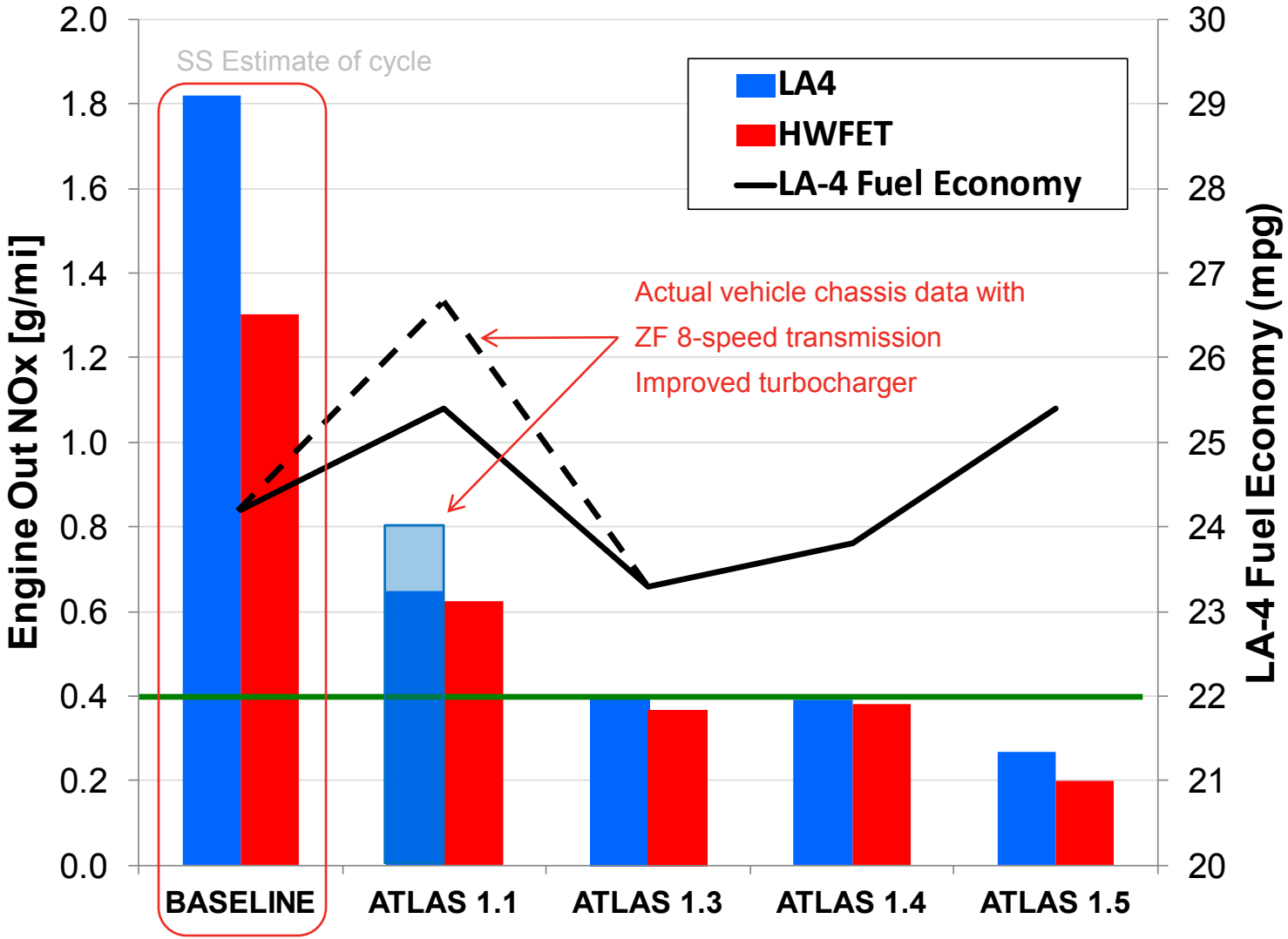
Engine Out Emissions and Fuel Economy



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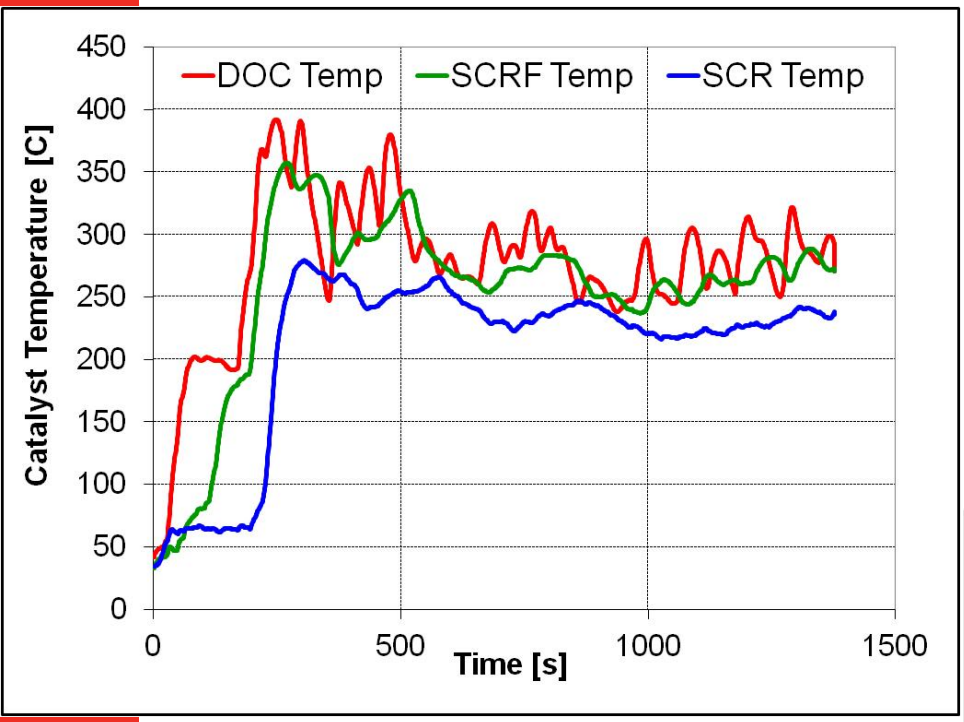
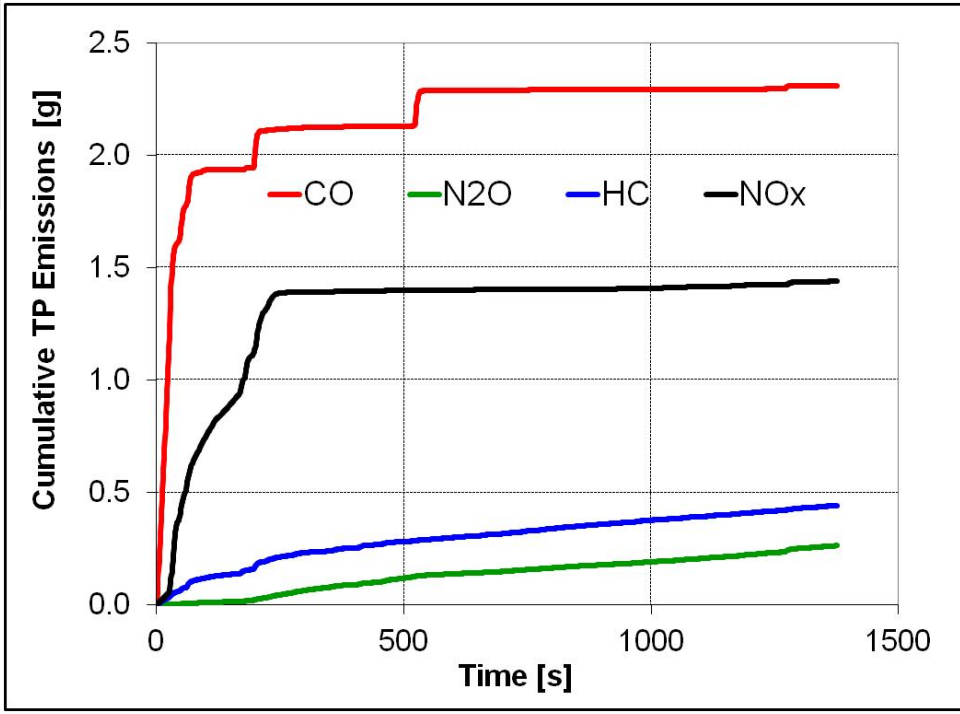
FTP-75 Cold Bag Performance Results



- Results do not include DOC-PNA
- Close coupling of SCRF improves warm-up time
- SCRF and SCR temperatures are above 200°C during entire transient phase



- TP CO ~0.31 g/mi
- TP N_2O ~0.03g/mi
- TP HC ~0.06g/mi
- TP NOx ~0.19 g/mi
- Cold FTP NOx Conversion ~86%

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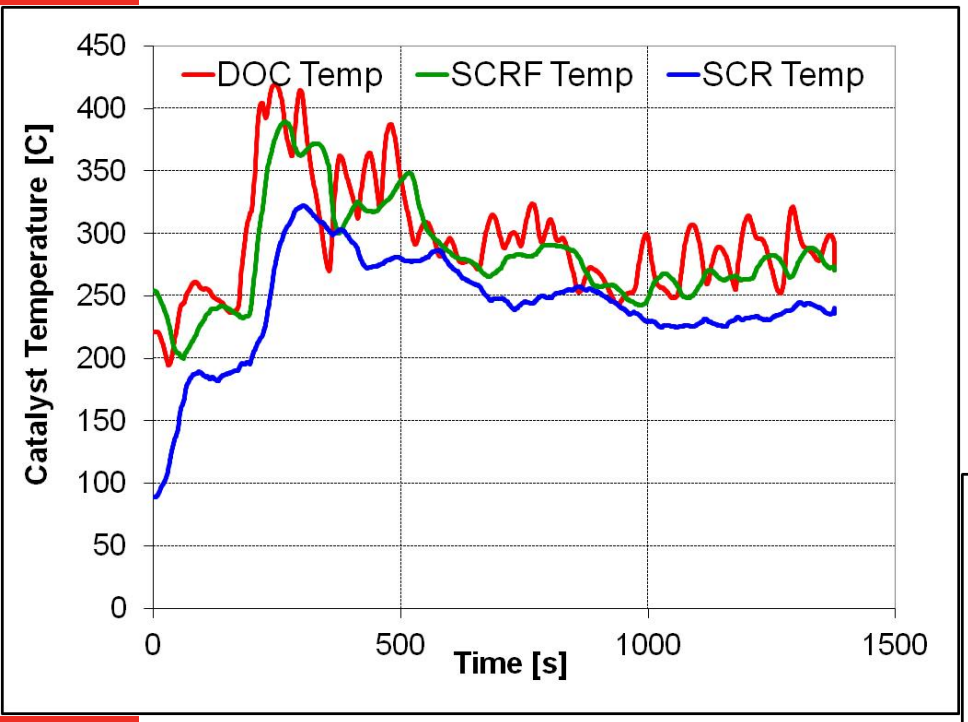
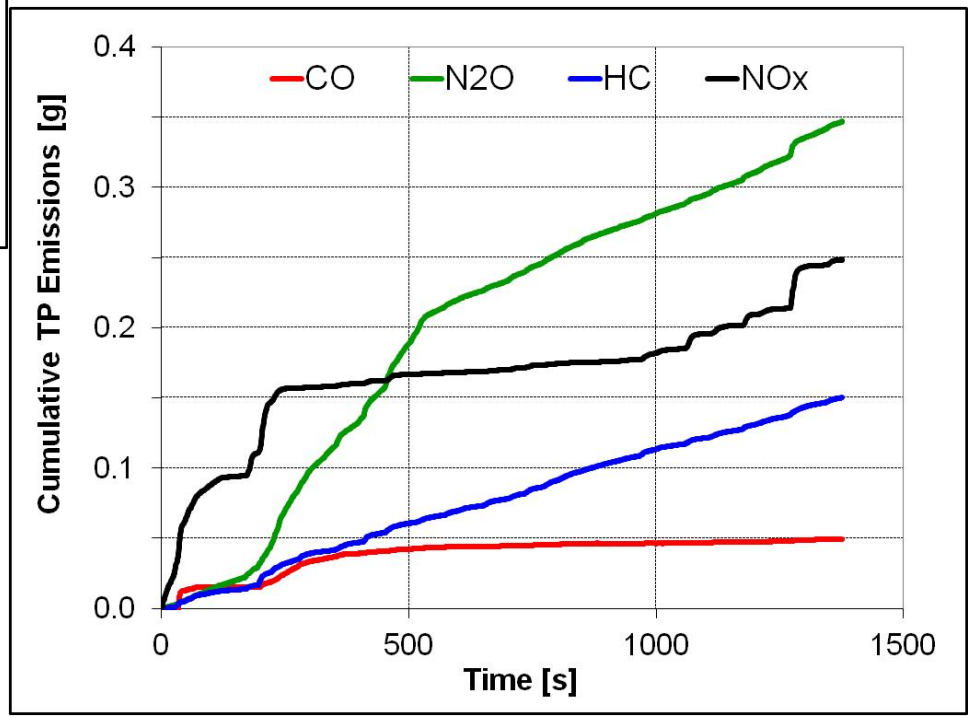
FTP-75 Warm Bag Performance Results



- Close coupling of SCRF reduces thermal losses
- SCRF and SCR temperatures remain above 200°C during entire transient phase



- TP CO ~0.01 g/mi
- TP N_2O ~0.05g/mi
- TP HC ~0.02g/mi
- TP NOx ~0.03 g/mi
- Hot FTP NOx Conversion ~98%

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FTP-75 NOx Emissions DOC-SCRF-SCR

NOx Emissions						
Run	Bag 1 [g]	Bag 2 [g]	Bag 3 [g]	Bag 4 [g]	Total [g/mi]	NOx η [%]
2/25/2012	1.48	0.27	0.24	0.12	0.127	94.0
2/26/2012	1.57	0.20	0.22	0.11	0.126	94.0
2/27/2012	1.30	0.12	0.23	0.10	0.106	95.0
2/29/2012	1.71	0.20	0.28	0.11	0.139	93.4
2/29/2012	1.19	0.07	0.19	0.11	0.094	95.5
3/1/2012	1.40	0.04	0.17	0.08	0.101	95.2

- >80% of NOx released during bag 0
- Expected DeNOx for ATLAS system with 0.4g/mi engine is 97% (0.012g/mi)

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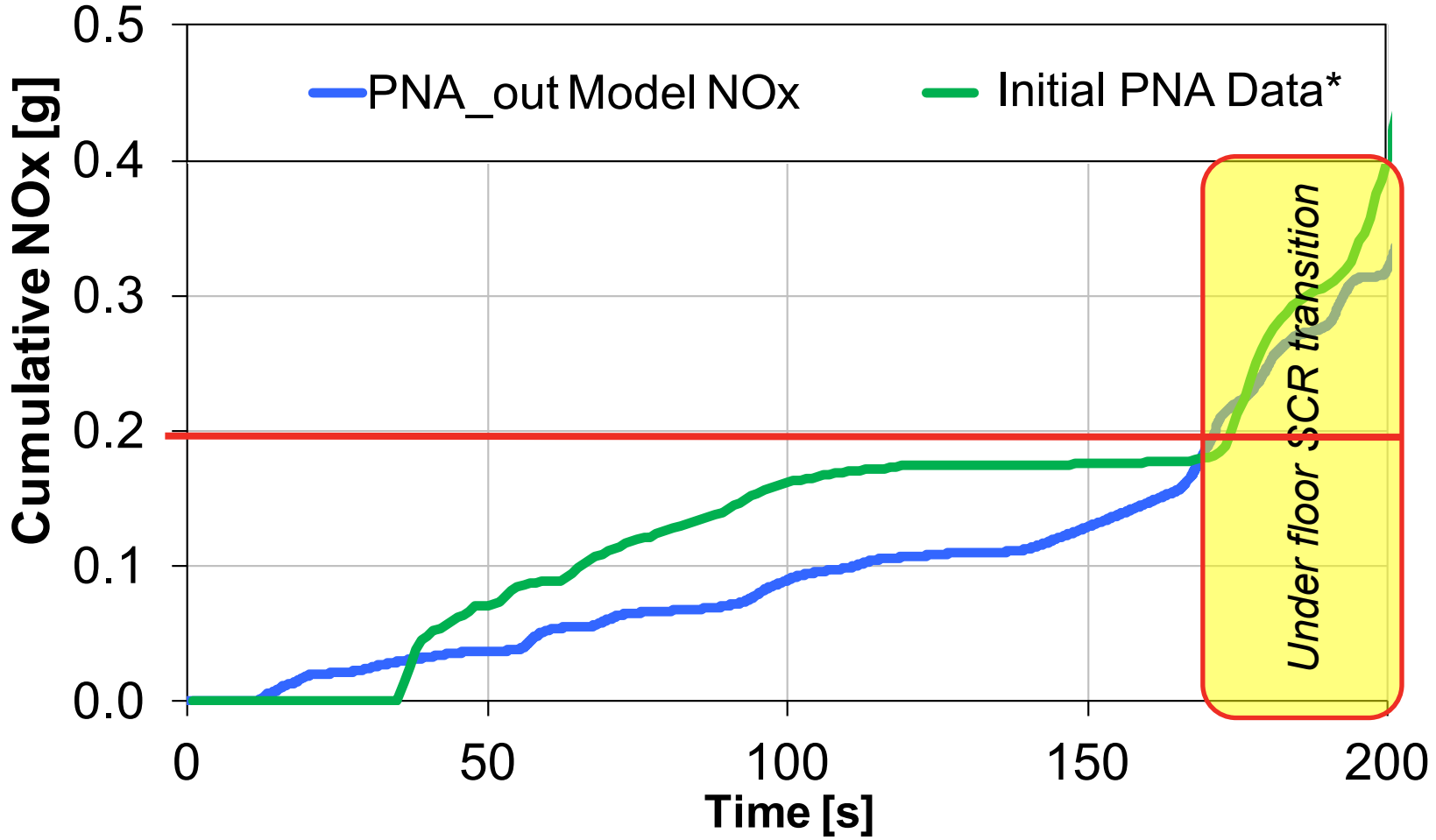
Evaluation of DOC-PNA on Operating Engine



* Data adjusted for DOC-PNA size and NOx flux

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Vehicle Systems Evaluation

- Mule vehicle with baseline engine
- System map for FE accounting
  - Alternator, Vacuum pump, Oil viscosity, etc.

	Base 15W40 Mech Vac	15W40 Elec Vac	5W30 Mech Vac	15W40 Mech Vac No Alt load	
Fuel Economy LA-4	24.2	24.4	25.5	26.9	MPG
Fuel Economy HWFET	33.1	N/A	N/A	N/A	MPG

Acknowledgements

- Partners
  - Johnson-Matthey Inc. Catalyst systems
  - Nissan Motors Light Truck – Vehicle development
- Contributors
  - Rose-Hulman Institute of Technology – Advanced control system analysis
- U.S. Department of Energy
- Cummins management and team members

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