



DODGE



Jeep

SRT



Chrysler Brings MultiAir to North America

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Engine Engineering

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Contents

- Overview of future fuel economy regulations
- Chrysler's unique approach
- MultiAir technology, challenges and solutions for the US market

Greenhouse Gas Regulations



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Chrysler powertrain technology primary drivers:

Customer demands and desires

Government regulations

First, a few slides about the evolving regulations for fuel economy and greenhouse gases

2017-25 MY Light-Duty Vehicle Fuel Economy / Greenhouse Gases (GHG)

- Joint government / industry framework released – not a rule yet (November)
- Impacts vehicles under 8,500 lbs GVWR and medium-duty passenger veh's



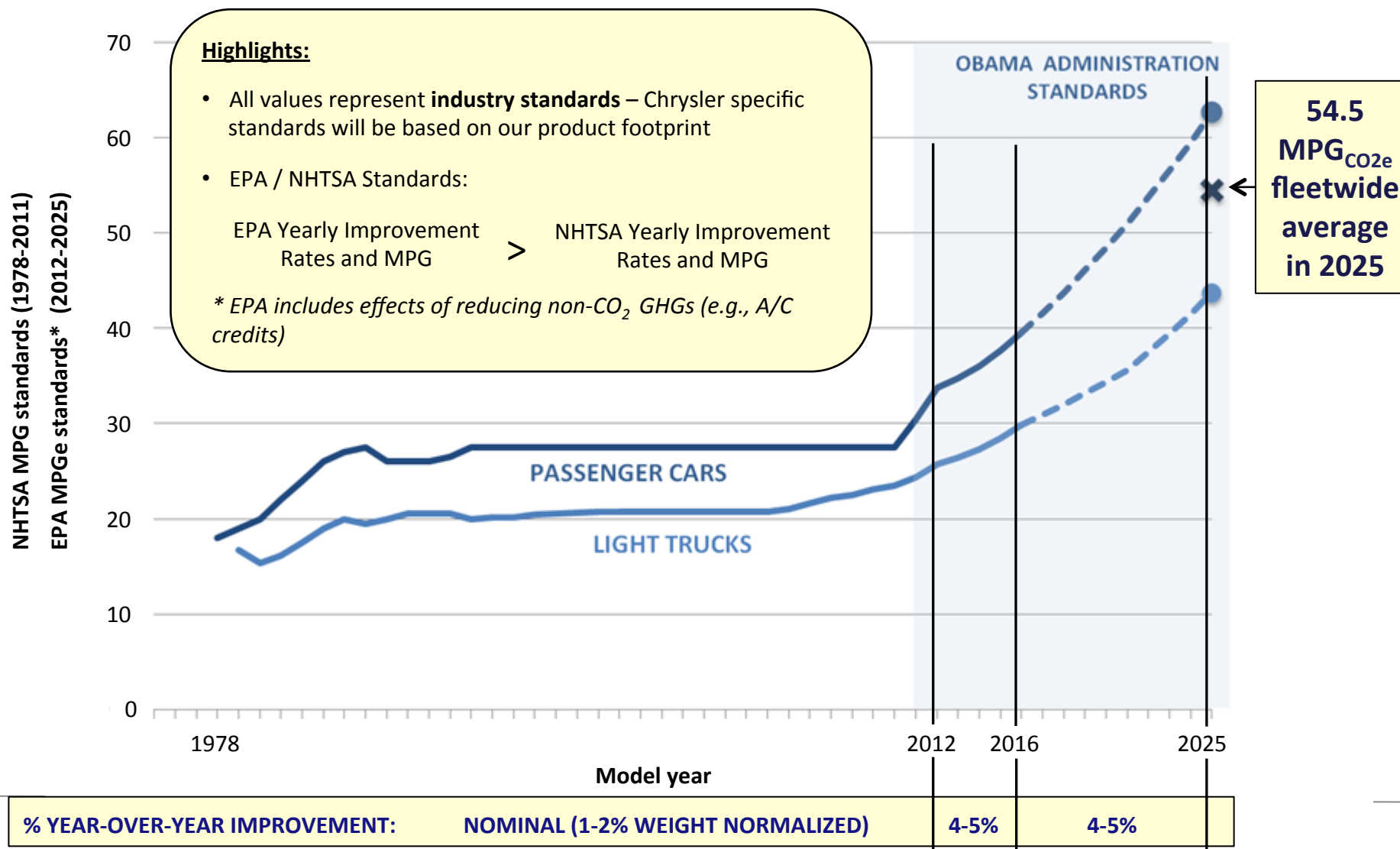
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Fuel Economy Standards – Historical Perspective



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“Chrysler accepts this unprecedented engineering challenge”



Initial Assessments / Next Steps

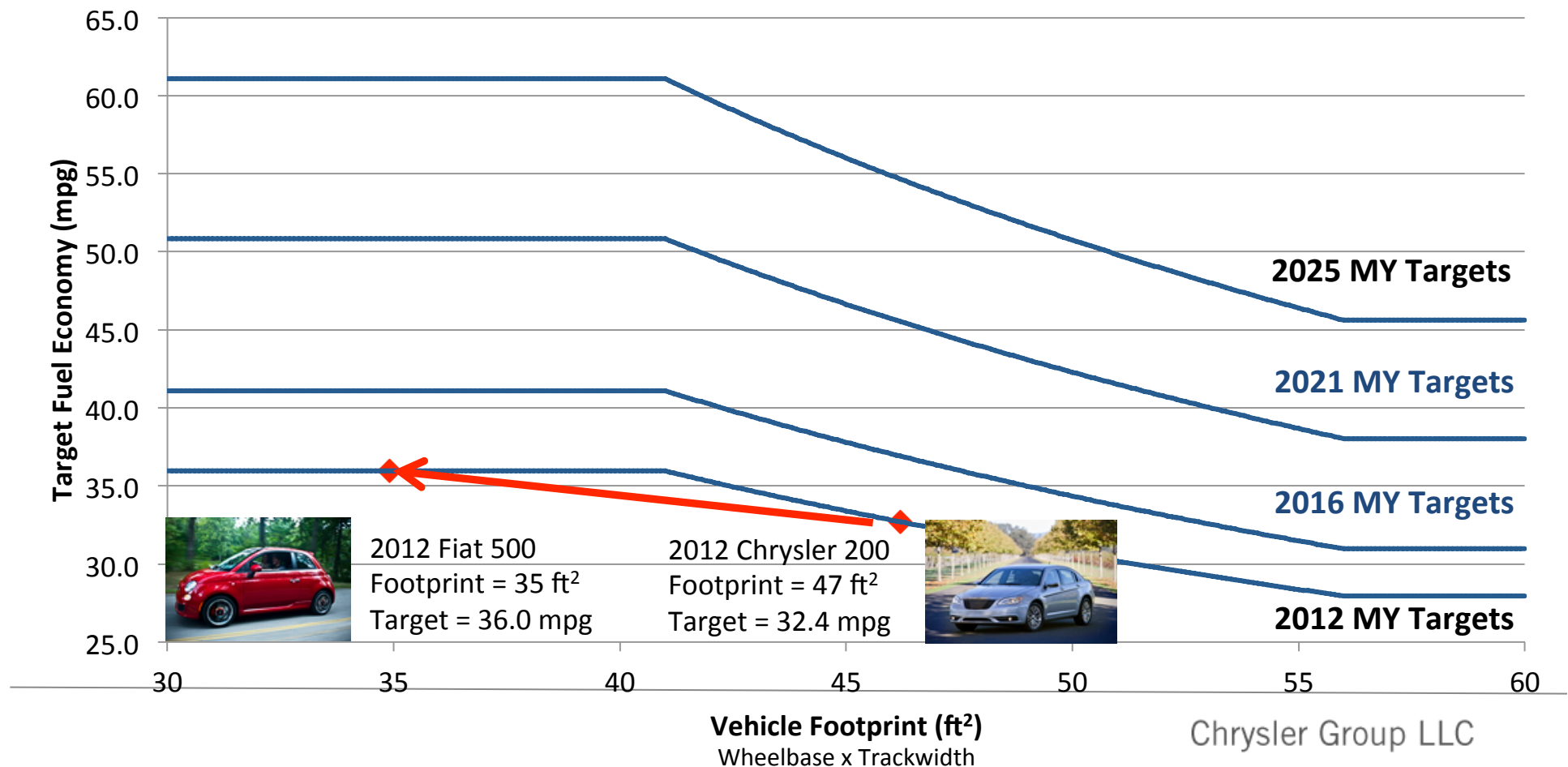


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Vehicle Fleet Downsizing Is Not A Solution

- Fuel economy targets increase as vehicle size decreases.
- Downsizing the fleet actually results in more stringent standards.
- The objective is to have efficient vehicles for their size.

Passenger Car Fuel Economy Target Functions - "Z-Curves"



Summary of 2017-2025 GHG Framework

- 4-5% year-over-year improvements in fuel economy
 - ~ 90% overall for cars
 - ~ 70% overall for light trucks
- Unprecedented levels of advanced technologies anticipated
- Market acceptance will be key to success

- **The formal draft rules (with critical detail) will not be published until November, 2011.**
- **Chrysler will continue to work with the agencies on the final rules.**

How Will We Get There?

When it comes to powertrain innovation and downsizing, Chrysler has a history of daring to be different ... we don't follow the herd.

- In 1978, when US vehicles were large rear-wheel drive, Chrysler launched the first American-made production car with front-wheel drive and transverse engine.

- From 1984-2009 Chrysler made over 1.1 million turbocharged 4-cylinder engines.

**The Original Downsizing!
Even before it had a trendy name**

- Other highlights:

1924 - High speed, high compression 6 cylinder with engine oil filter

1931 - Fully automatic spark control, centrifugal and vacuum

1934 - Automatic overdrive

1941 - Rotor type engine oil pump

1951 - Hemispherical combustion chamber V8

1963 - Limited production gas turbine car

1978 - Hall effect electronic distributor

1984 - FWD minivan introduced

1989 - Fully-adaptive electronically-controlled automatic transaxle

Strategy for Success



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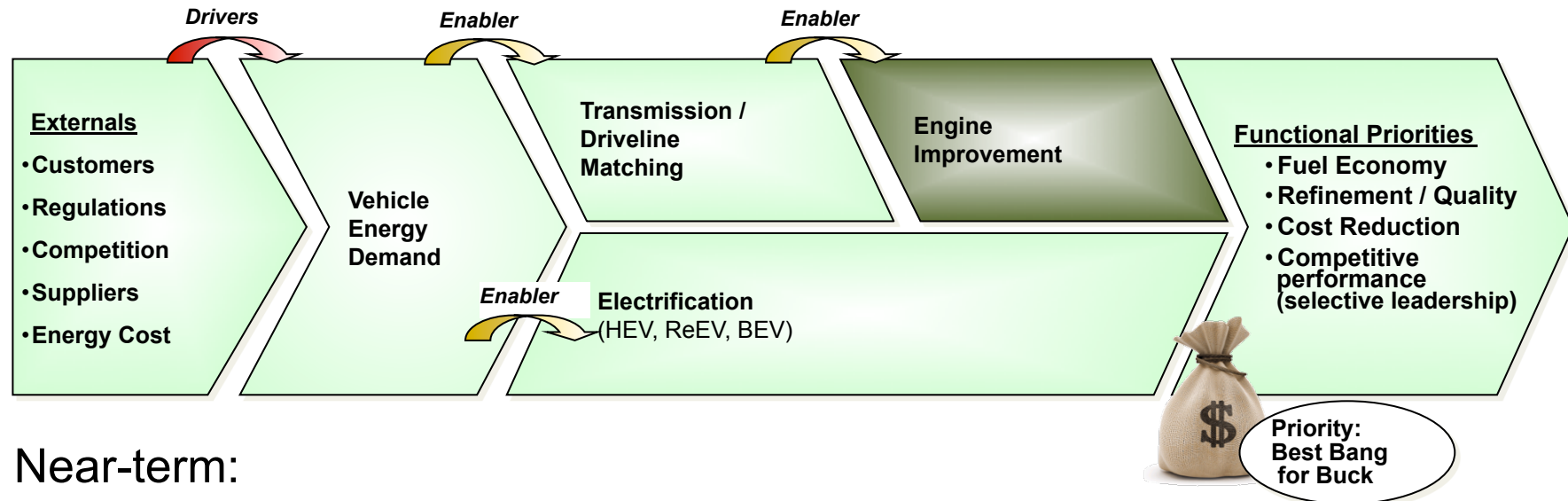
At Chrysler we believe in the objective of reducing GHG and we support the new regulations that guide us toward that objective.

- We're selecting a balanced mix of technologies to meet the requirements with products that customers want to buy
- There are many viable solutions, including combinations of:
 - ▶ Variable valvetrain (e.g. MultiAir)
 - ▶ Turbocharging
 - ▶ Downsizing
 - ▶ Gasoline Direct Injection
 - ▶ Transmissions optimization
 - ▶ Electrification

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Chrysler's Strategic Path

Engine design and manufacture are core activities for the Chrysler-Fiat Alliance



Near-term:

- Improve areas with the greatest inefficiencies first
 - ▶ Axles & transmissions (ratio spread)
- Existing engine technology

Next step:

- Implement appropriate new engine technology
- Cross-family standardization

Chrysler 300
Full-size, RWD sedan with
8-speed transmission ...
Best-in-class fuel efficiency
31 hwy mpg

What's next?

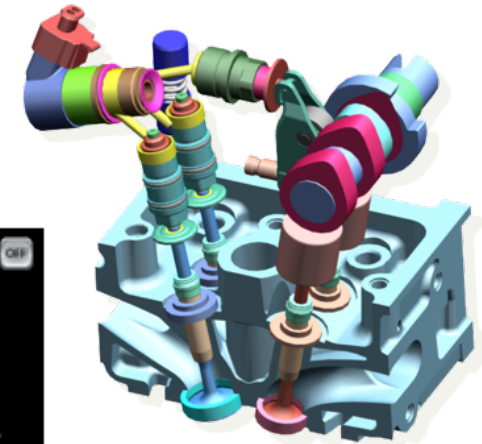
Fiat alliance brings technical innovation from Europe.

- Fiat introduced MultiAir technology in 2009
... voted Best New Engine of 2010 *.
- The potential benefits of MultiAir are so strong that Chrysler was already discussing US applications with Fiat in 2008, a year before the corporate alliance was officially formed.

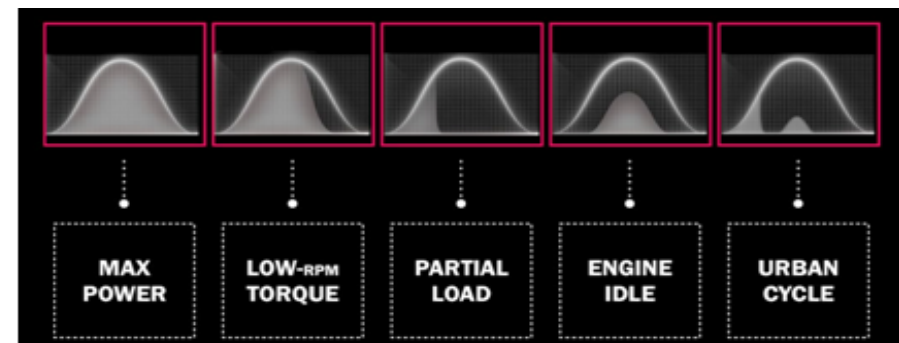
MutiAir Overview

MultiAir integrates electro-hydraulic hardware with dedicated control strategy to achieve the most efficient intake valve operation for each engine running condition.

The system consists of four variable oil chambers (one per cylinder) located between the cam lobe and the intake valve.



By modulating the volume of oil in the chamber during each stroke, the intake valve lift and duration can be customized as desired, within the overall geometric profile of the cam.



Mutiair Overview

The main goal of this technology is to simultaneously:

- enable increased performance (peak power and low-rpm torque)**
- reduce fuel consumption and emissions**
- Power increase up to 10%
- Low-rpm torque increase up to 15%
- Fuel consumption reduction up to 10%
(up to 25% if coupled with downsizing)
- Emission reduction: CO & HC up to 40%; NOx up to 60%

First Application in EU market was the Alfa Romeo Mito (135 HP turbo) in September, 2009

First Application in US market was the Fiat 500 (101 HP naturally aspirated) in January, 2011

MultiAir Evolution

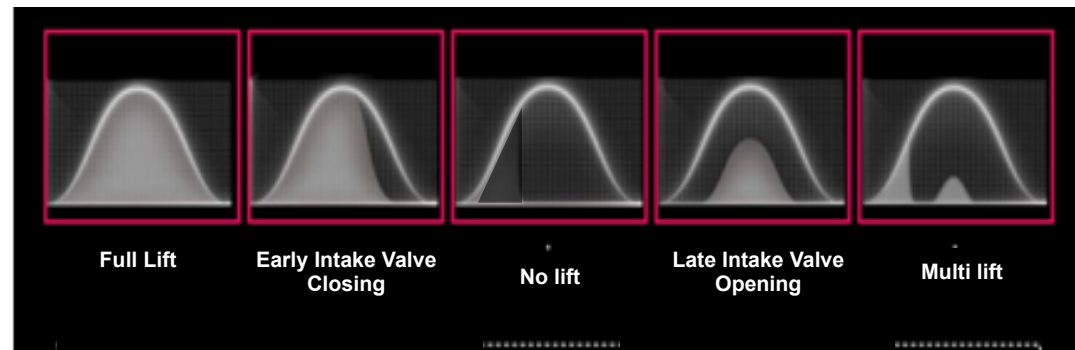
MultiAir 1st Generation Technology

Manages air entering the cylinders via precise control of the intake valve timing, lift and duration, to:

- Improve volumetric efficiency over the entire engine speed range
- Reduce pumping losses
- Improve combustion chamber turbulence

5 different valve actuation modes are available:

- Full Lift
- Early Int. Valve Closing
- No Lift
- Late Int. Valve Opening
- Multi Lift



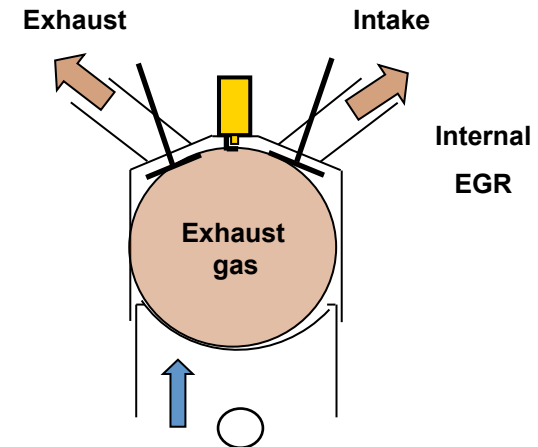
MultiAir Evolution

Further MultiAir technology development activities are underway: MultiAir 2nd Generation Technology

Maximizes the combustion efficiency by simultaneously managing the intake valves and the throttle valve to control both the air quantity and the combustion quality.

An additional “hybrid” valve actuation mode is added to manage valve overlap, making it possible to control the amount of internal EGR and intake manifold pressure to further improve combustion efficiency and reduce pumping losses.

Cylinder deactivation is also possible in this mode.



MultiAir for the US Market

Easy concept ... challenging reality.

- The plan: Build & sell 1.4L MultiAir engine in US (“localize” & “federalize”)
- The challenges:
 - ▶ Timing: 15 months
 - ▶ Localizing:
 - Facilities: Re-tool engine plant (WCM, best Fiat & Chrysler processes)
 - Components: Significant local content
 - ▶ Federalizing (changes & validation):
 - Federal OBD regulations
 - US fuels & oils
 - US climate (temperature, altitude)
 - US customer usage / expectations

... and ethanol-fueled versions for South America.

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US MultiAir Timeline



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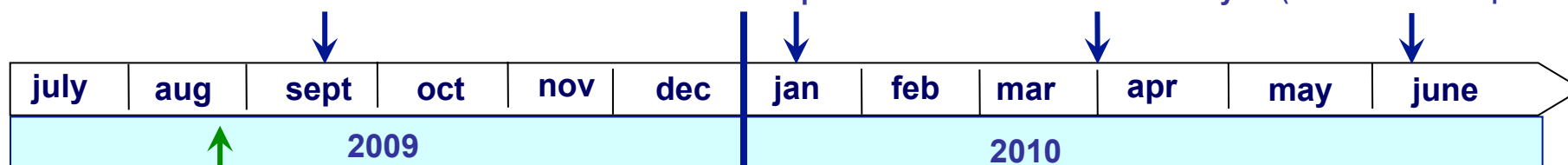
15 months from program approval to engine launch

Beta 1 Engines
Fiat production

Beta 2 Engines
Fiat production w/ proto
NAFTA components

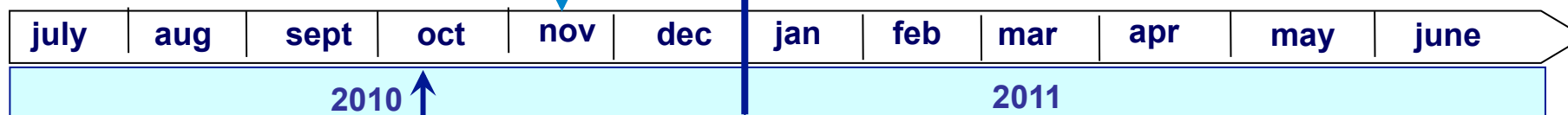
Gamma Engines
GEMA machined
Pilot Line Assembly

VP Engines
GEMA Machined
Pilot Line Assembly
(Prod'n tooled components)



**FIRE 1.4L MultiAir
NAFTA Engine
Program Approval
(Aug 2009)**

**Engine Start
of Production
(Nov 2010)**



PVP Engines
GEMA Machined
Main Line Assembly
(All PPAP components)

**Fiat 500 Launch
(Dec 2010)**

US MultiAir Localization

Same as ... but different.

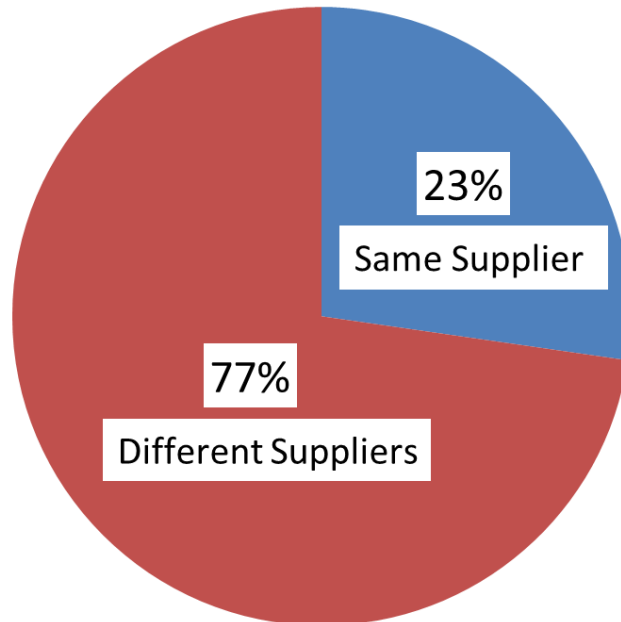
- At first glance, one might assume the 1.4L MultiAir engine is imported from Europe, but
- It's built locally at the GEMA-South Engine Plant in Dundee, MI
 - ▶ The plant was completely re-tooled for this program
 - ▶ Blocks, heads, and cranks are machined on flexible CNC lines
 - ▶ The engine is assembled using World Class Manufacturing methods, combining the best of Fiat & Chrysler processes

US MultiAir Localization

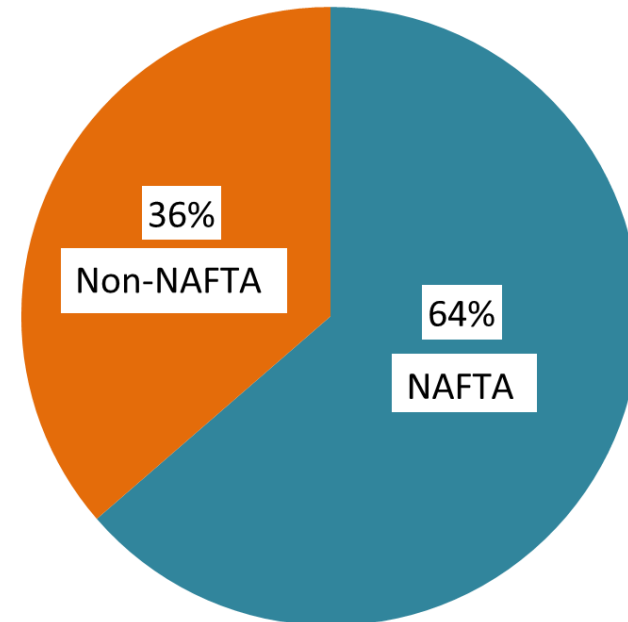
Same as ... but different.

- Although most of the purchased components share core designs with the European version

77% come from
different suppliers



64% come from
NAFTA suppliers



US MultiAir Federalization

An incredible amount of development activity – calibration, software, controls, and validation – was driven by specific US regulatory and market requirements

- Upgraded ECU with faster clock speed
- Chrysler proprietary code meshed with Magneti-Marelli software
- Over 350 software changes incorporated in 27 releases
- Over 85,000 hours of intense calibration activity
- Implemented real-time adaptive controls for the MultiAir solenoid valves
- Optimized diagnostic limits on the solenoid actuation
- Calibrated the oil aeration model for US oil specifications
- Over 23,000 hours of engine testing (> 3.3M customer equivalent miles)

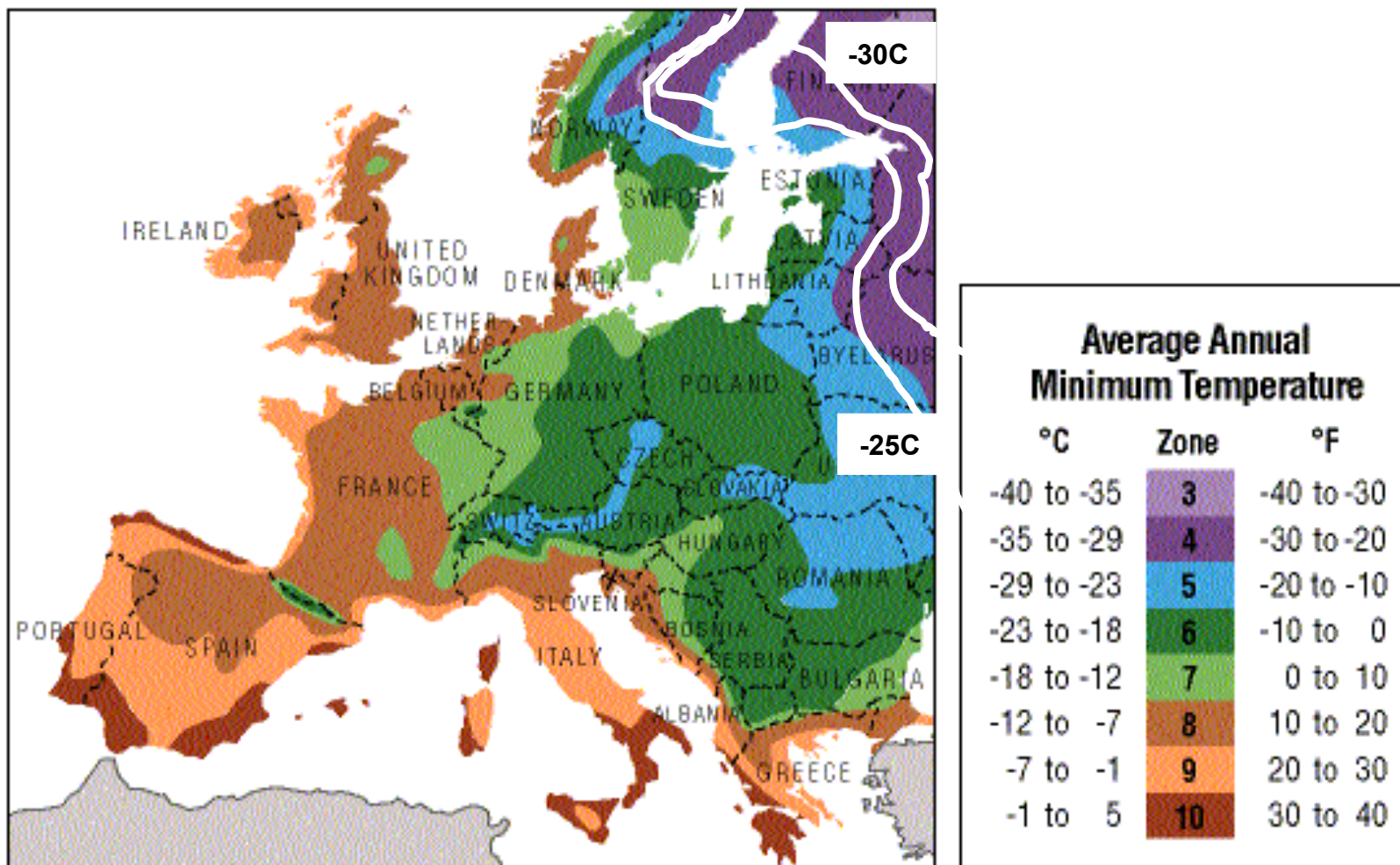
US MultiAir Federalization

Adapting to customer expectations and behaviors.

- US customers expect the engine to start and run perfectly at any temperature and altitude, sometimes regardless of whether the maintenance schedule has been followed (or even whether the correct oil is used)
- The US winter climate can be challenging for sealing and lubrication

European Average Annual Minimum Temperature Range

Most of Europe doesn't get below -25C



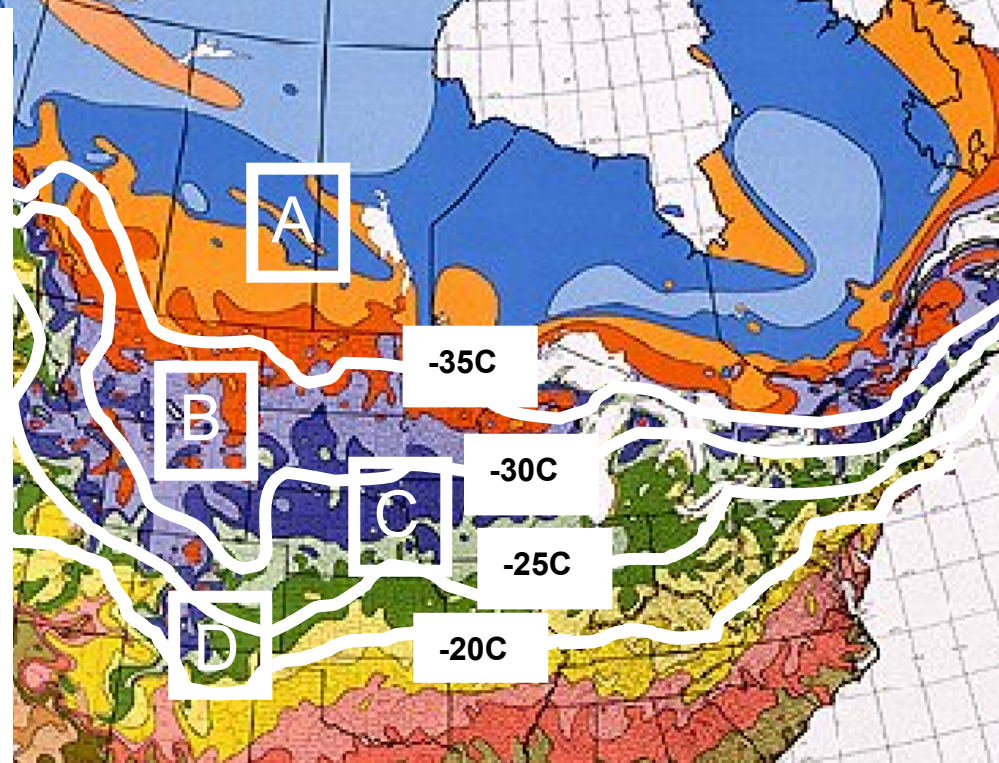
US MultiAir Federalization

NAFTA temperature extremes are more severe than in Europe



USDA Hardiness Zones and Average Annual Minimum Temperature Range

Zone	Fahrenheit	Celsius	Example Cities
1	Below -50 F	Below -45.6 C	Fairbanks, Alaska; Resolute, Northwest Territories (Canada)
2a	-50 to -45 F	-42.8 to -43.5 C	Prudhoe Bay, Alaska; Flin Flon, Manitoba (Canada)
2b	-45 to -40 F	-40.0 to -42.7 C	Unalakleet, Alaska; Pinecreek, Minnesota
3a	-40 to -35 F	-37.3 to -39.9 C	International Falls, Minnesota; St. Michael, Alaska
3b	-35 to -30 F	-34.5 to -37.2 C	Tomahawk, Wisconsin; Sidney, Montana
4a	-30 to -25 F	-31.7 to -34.4 C	Minneapolis/St. Paul, Minnesota; Lewistown, Montana
4b	-25 to -20 F	-28.9 to -31.6 C	Northwood, Iowa; Nebraska
5a	-20 to -15 F	-26.2 to -28.8 C	Des Moines, Iowa; Illinois
5b	-15 to -10 F	-23.4 to -26.1 C	Columbia, Missouri; Mansfield, Pennsylvania
6a	-10 to -5 F	-20.6 to -23.3 C	St. Louis, Missouri; Lebanon, Pennsylvania
6b	-5 to 0 F	-17.8 to -20.5 C	McMinnville, Tennessee; Branson, Missouri
7a	0 to 5 F	-15.0 to -17.7 C	Oklahoma City, Oklahoma; South Boston, Virginia
7b	5 to 10 F	-12.3 to -14.9 C	Little Rock, Arkansas; Griffin, Georgia
8a	10 to 15 F	-9.5 to -12.2 C	Tifton, Georgia; Dallas, Texas
8b	15 to 20 F	-6.7 to -9.4 C	Austin, Texas; Gainesville, Florida
9a	20 to 25 F	-3.9 to -6.6 C	Houston, Texas; St. Augustine, Florida
9b	25 to 30 F	-1.2 to -3.8 C	Brownsville, Texas; Fort Pierce, Florida
10a	30 to 35 F	1.6 to -1.1 C	Naples, Florida; Victorville, California
10b	35 to 40 F	4.4 to 1.7 C	Miami, Florida; Coral Gables, Florida
11	above 40 F	above 4.5 C	Honolulu, Hawaii; Mazatlan, Mexico



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US MultiAir Federalization

Adapting to local fuels and oils

- US fuel considerations
 - ▶ Calibration accommodates wide range of octane* (85 – 93+) found across the US (vs. typical 91 octane in Europe)
- US oil considerations
 - ▶ Because MultiAir operates on hydraulics, it is sensitive to oil type/quality
 - ▶ 5W-30 GF-5 specified (vs. 5W-40 synthetic in Europe)
 - Typical US oils are formulated for low cost and fuel economy
 - Typical European oils are formulated for long-life
 - ▶ Calibration accommodates wide range of viscosity (0W-20 to 15W-40)
 - Sometimes customers use different oil than the OEM specification
 - Sometimes customers don't follow recommended oil change schedules

1.4L Federalization Updates



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MM8GMC ECU

Advanced integrated air and combustion control system with upgraded OBD for US market

MultiAir System

Advanced combustion management
- Upgraded diagnostics for US OBD

PCV & MUA System

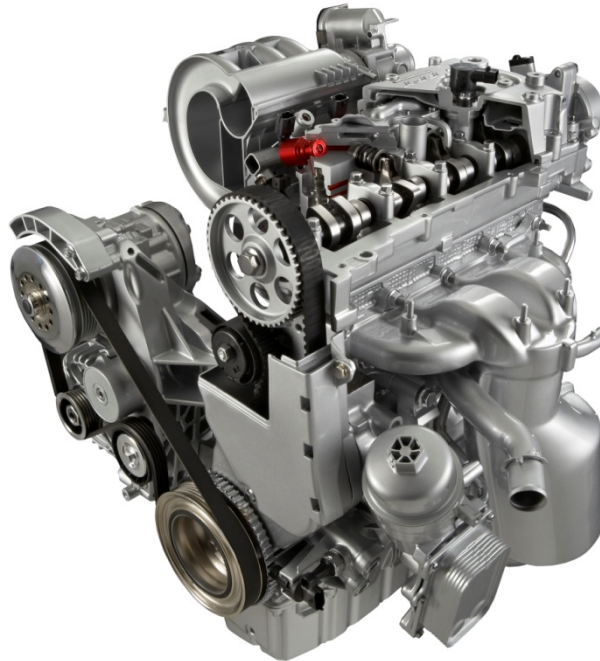
Improved crankcase ventilation for NAFTA market, including cam cover modifications.

Intake Manifold (IAFM)

Plastic intake manifold with fuel rail, injectors, & new higher-flow purge valve.
T/body revised to meet PowerFree req't.

Belt drive & Damper

Cast iron damper and upgraded belt material for 150k mile durability



Upper Cylinder Head

Fasteners with coned washer for improved clamp load retention

Structural Aluminium Oil Pan

Revised drain plug and oil volume

Federalization (impact)

Fuel rail “blocker” + steel rail
Oil pan “blocker”
Oil filter module “guard”

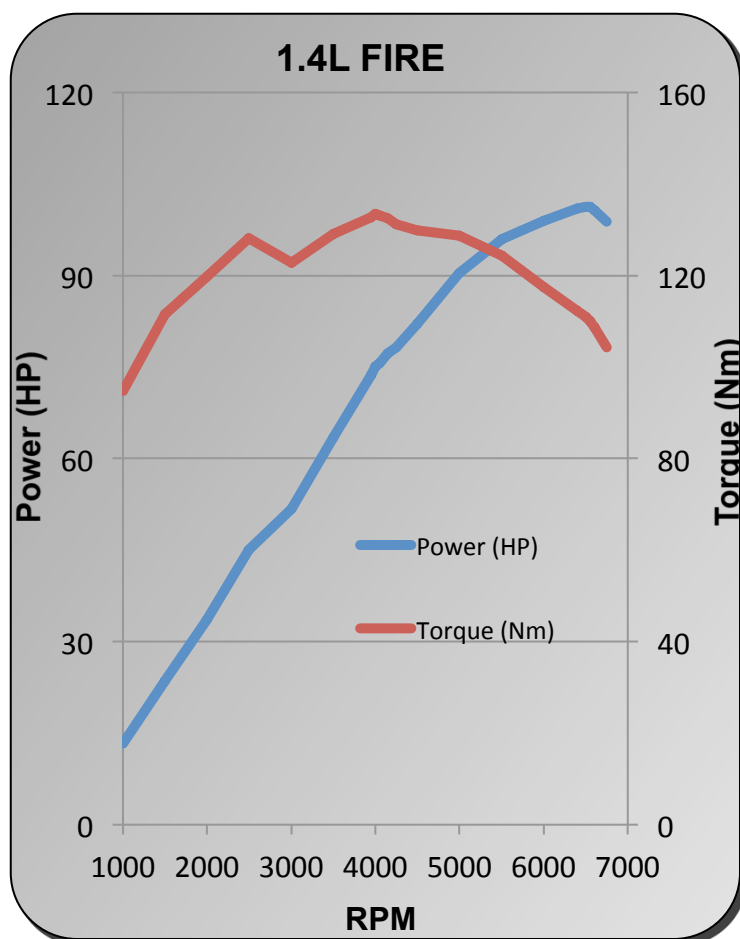
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1.4L FIRE

Project Name: FIRE

Current Applications: A-Segment Car

Plant Location: GEMA, Dundee, MI



Product Features

- Integrated oil module with green filter
- Piston cooling oil jets
- Fixed piston pins
- Front end accessory drive with automatic tensioning single belt drive
- Belt timing drive
- Pencil coil ignition with standard nickel spark plugs
- Structural aluminum oil pan
- Select fit main bearings
- Type I valve train with exhaust side hydraulic tappets
- MultiAir 4V/cylinder advanced combustion management

Specifications

Engine Displacement (cc)	1368
Type	L4 (In-line 4-cylinder)
Fuel System	MPFI
Maximum Power (HP / kW)	101 / 75 @ 6500 rpm
Peak Torque (lb-ft / Nm)	98 / 133 @ 4000 rpm
Compression Ratio	10.8:1
Bore & Stroke (mm)	72 X 84
Bore Spacing (mm)	77
Firing Order	1-3-4-2
Valve Configurations	OHC 4V/cyl w/MultiAir
Valve Dimensions, Int & Exh (mm)	26.9 & 22.4
Oil Specification / Capacity (L)	SAE 5W-30 GF-5 / 3.8
Engine Weight (DIN 70020-7) (Kg)	103 (Manual Trans) / 98 (Auto Trans)
Materials	
Block	Cast Iron
Bedplate / Ladderframe / Main Bearing Caps	Aluminum Bedplate with Integral Cast Iron Main Bearing Caps
Cylinder Head	Aluminum
Intake Manifold	Glass Filled Nylon
Exhaust Manifold	Cast Iron
Crankshaft	Cast Iron
Connecting Rods	Forged Steel

MultiAir for the US Market



Future attractions

- Turbocharged version of the US 1.4L MultiAir engine
 - ▶ All the features and benefits of MultiAir
 - ▶ Plus more performance

Wrap-Up

- New greenhouse gas regulations are driving unprecedented improvements in fuel economy
- Chrysler dares to be different: unique strategy for powertrain efficiency
- New Chrysler-Fiat alliance: global powertrain expertise, with exclusive MultiAir technology
- MultiAir provides outstanding benefits in fuel economy, emissions, and performance
- Federalizing and Localizing MultiAir required great attention to detail and incredibly thorough validation
- MultiAir is a key element in Chrysler's fuel economy strategy, with possible applications across a variety of engines

Thank you.

Any questions?