Advanced Petroleum-Based Fuels - Diesel Emissions Control (APBF-DEC) Project

Project Summary

Japan Clean Air Program (JCAP)
Conference 2002 - Tokyo, Japan

February 2002

DEC Mission

- Identify optimal combinations of fuels, lubricants, diesel engines, and emission control systems to:
  - Meet projected emission standards during the period 2000 to 2010 while maintaining continuous improvement in engine efficiency and durability
  - Maintain customer satisfaction with vehicle performance
  - Provide the basis for economical transport of people and goods
  - Meet additional potential constraints (e.g., emissions of unregulated substances, including ultra-fine particulate matter and greenhouse gases)
- Explore the potential to achieve even lower emissions of criteria and unregulated pollutants beyond 2010

APBF-DEC Products

- Light and heavy-duty platforms for measurement of effects of fuel and lubricant composition on emissions under transient operation
- Comprehensive data on status of fuel-engine-emission control technologies for reducing criteria emissions for U.S. EPA's biennial technology assessments
- Comprehensive data on effects of fuel & lubricant properties on emissions of unregulated substances

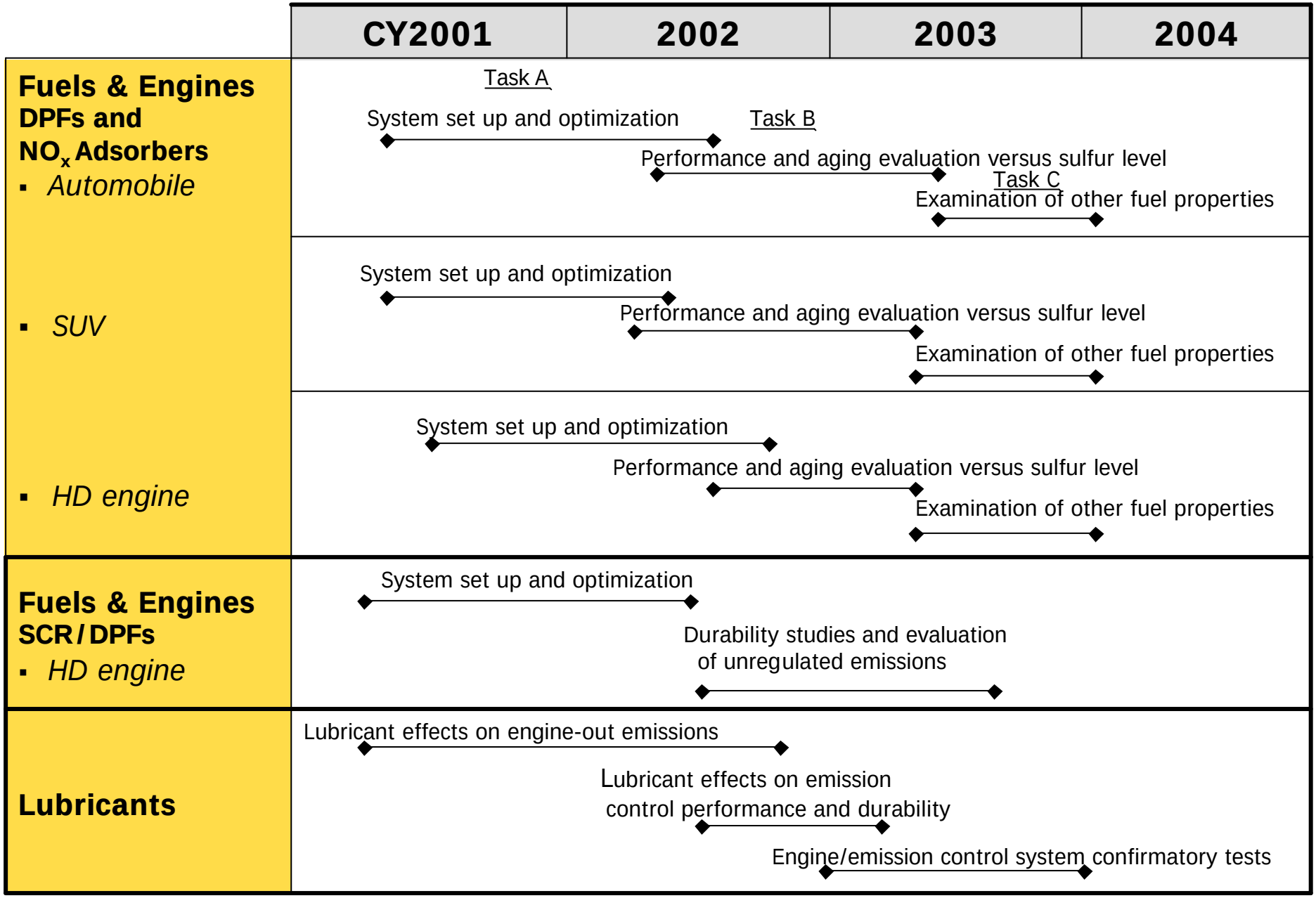
DEC Summary

- Includes vehicles from automobiles to heavy-duty trucks
- Systems approach investigating fuels, lubricants, engines, emission control systems
- Initial timeframe 2000 to 2003 to provide information to industry and government within regulatory environment
- Resource needs of $33 million, including $19.3 million in cash and $14 million in in-kind contributions
- Government planning for $14 million of the $19.3 million cash contribution
- Government/industry Steering Committee and Work Groups guiding the DEC Project

APBF-DEC Project Schedule

	CY2001	2002	2003	2004	2005	2006	2007
Fuels, Engines, DPFs, SCR, and NO_x Adsorbers	***Phase I*** →			***Phase II*** →			
	Develop test platforms →			Post 2010 fuels and emissions →			
		Fuel sulfur and criteria pollutants →					
			Fuels and unregulated emissions →				
Lubricants	Lubricant effects on engine-out emissions →						
		Lubricant effects on emission control performance and durability →					
			Engine/emission control system confirmatory tests →				
Regulatory Environment	EPA technology reviews of NO_x adsorbers:		*2002 EPA status report* ◆		*2004 EPA status report* ◆		*2006 EPA status report* ◆
							Diesel sulfur fuel (15 ppm S cap) →
							Heavy-duty emission standards (phased in MY07-10) →
							Tier 2 emission standards (phased in MY04-09) →

APBF-DEC Phase I Project Schedule



Studies of Fuel Composition Effects

	Phase I 2001-2003	Phase II (Tentative) 2004-2007
Fuel Effect Studied	Sulfur	Sulfur, other substances & properties (e.g., aromatics, oxygen, cetane)
Test Fuels	**DECSE** • 3 ppm sulfur (set-up) • 8 & 15 ppm sulfur • 30 ppm sulfur Refinery process fuel A	Refinery Process Fuels • Fuel B • Fuel C • Fuel D Fischer-Tropsch Fuels • Fuel E • Fuel F
Emission Measurements	NO_x Particulate matter • Soluble organic fraction • Sulfate Hydrocarbons (HC) Carbon monoxide (CO) Unregulated substances (limited measurements)	NO_x, HC, CO, N_2O Particulate matter • Soluble organic fraction • Sulfate • PAH , Nitro-PAH Speciated non-methane organic gases Formaldehyde Other unregulated substances

DEC Participants

- U.S. DOE
- U.S. Environmental Protection Agency
- American Petroleum Institute
- National Petrochemical and Refiners Association
- Engine Manufacturers Association
- Manufacturers of Emission Controls Association
- American Chemistry Council
- California Air Resources Board/South Coast Air Quality Management District

Participating Companies/Organizations

Automobile:

Ford
GM
DaimlerChrysler
Toyota

Engines:

EMA
Caterpillar
Detroit Diesel
Cummins
John Deere
Mack Trucks
International Truck & Engine

Government:

DOE
NREL
ORNL
EPA
CARB / SCAQMD

Technology:

Battelle

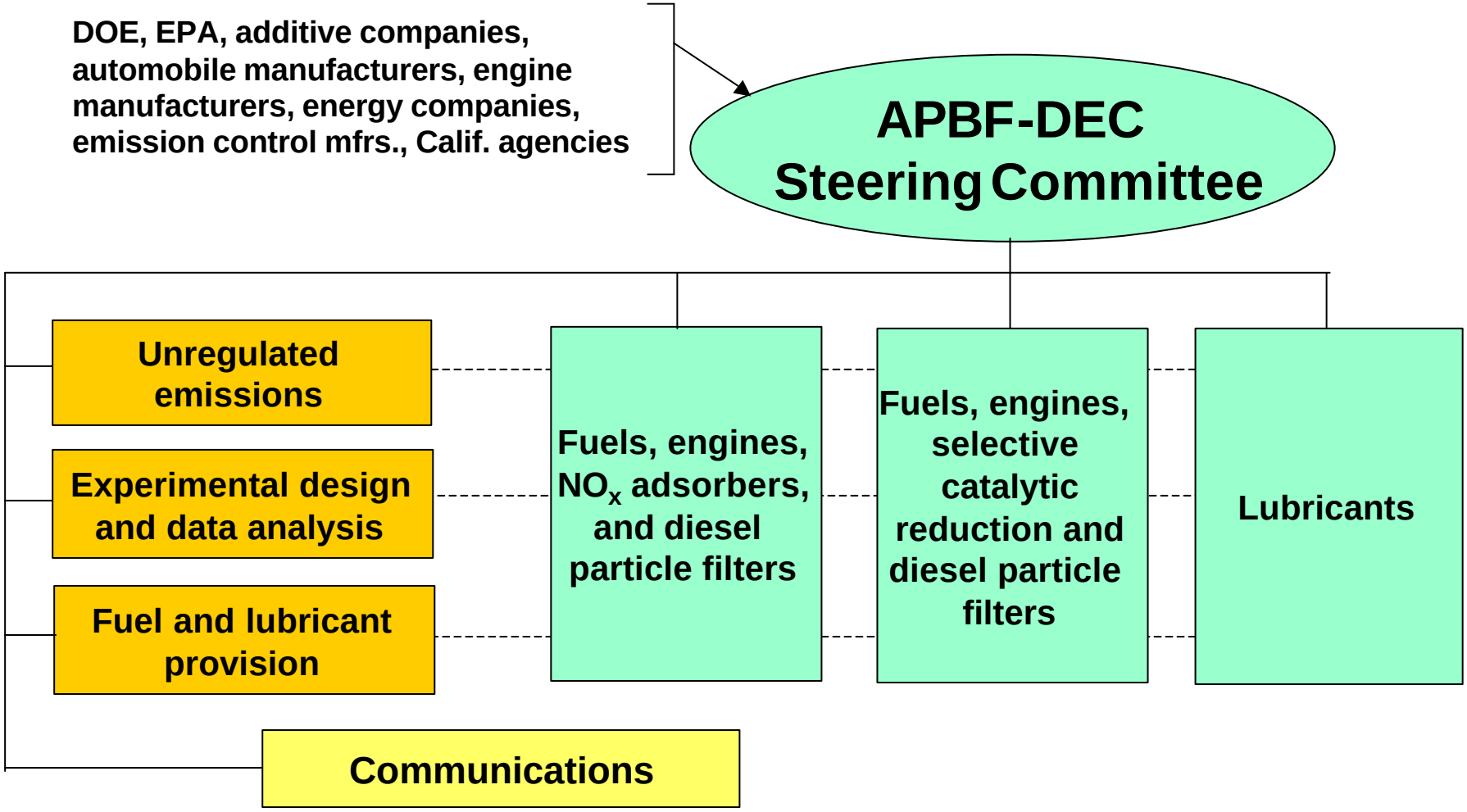
Emission Control:

MECA
Johnson Matthey
Delphi
3M
Engelhard
Siemens
Benteler
Arvin Meritor
Clean Diesel Tech.
Corning
Donaldson Co.
OMG
NGK
Rhodia
Tenneco Automotive

Energy / Additives:

API
American Chemistry Council
NPRA
BP
Ethyl
ExxonMobil
Marathon Ashland
Pennzoil-Quaker State
Lubrizol
Equilon
ChevronTexaco
Chevron Oronite
Ciba
Ergon
Valvoline
Motiva
Infineum

Integrated Systems Approach

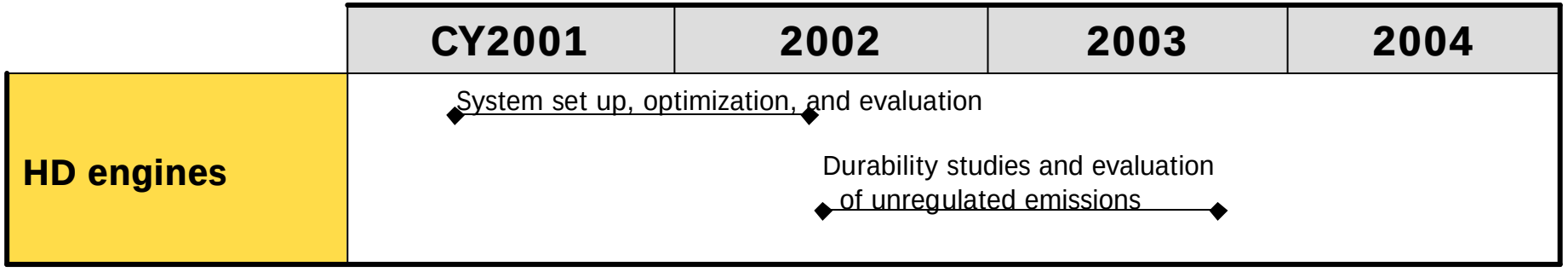


Fuels, Engines, SCR/DPF Technologies

- ***Goal*** - Demonstrate low emissions performance attainable with SCR and diesel particle filter technologies (SCR/DPF). Evaluate sensitivities to fuel variables.
- ***Deliverables:***
  - Optimized SCR/DPF systems for testing heavy-duty engines
  - SCR/DPF emissions performance
  - Effects of fuel variables including sulfur and aromatics
  - Durability data, emissions performance with aging
  - Assessment of urea infrastructure barriers
- ***Contractors:***
  - Southwest Research Institute - testing
  - A.D. Little - urea infrastructure assessment

Fuels, Engines, SCR/DPF Technologies

- ***Scope:***
  - Two heavy-duty engines (Caterpillar C12, 12-liter, ~MY2000)
  - SCR catalysts (two of the following: vanadium, zeolite, base metal) with DPFs
  - Fuels matrix - DECSE fuels (3, 8, 15, 30 ppm sulfur), Fischer-Tropsch, variable aromatics
  - Durability data out to 6,000 hours
  - Emissions - regulated, PM fractions (soluble organic fraction, sulfate), N_2O, NH_3, C_6H_6, HCHO, CH_3CHO, 1,3-butadiene
- ***Schedule:*** April 2001 - September 2003



SCR Test Cell at SwRI

Fuels, Engines, NO_x Adsorber, DPF Technologies

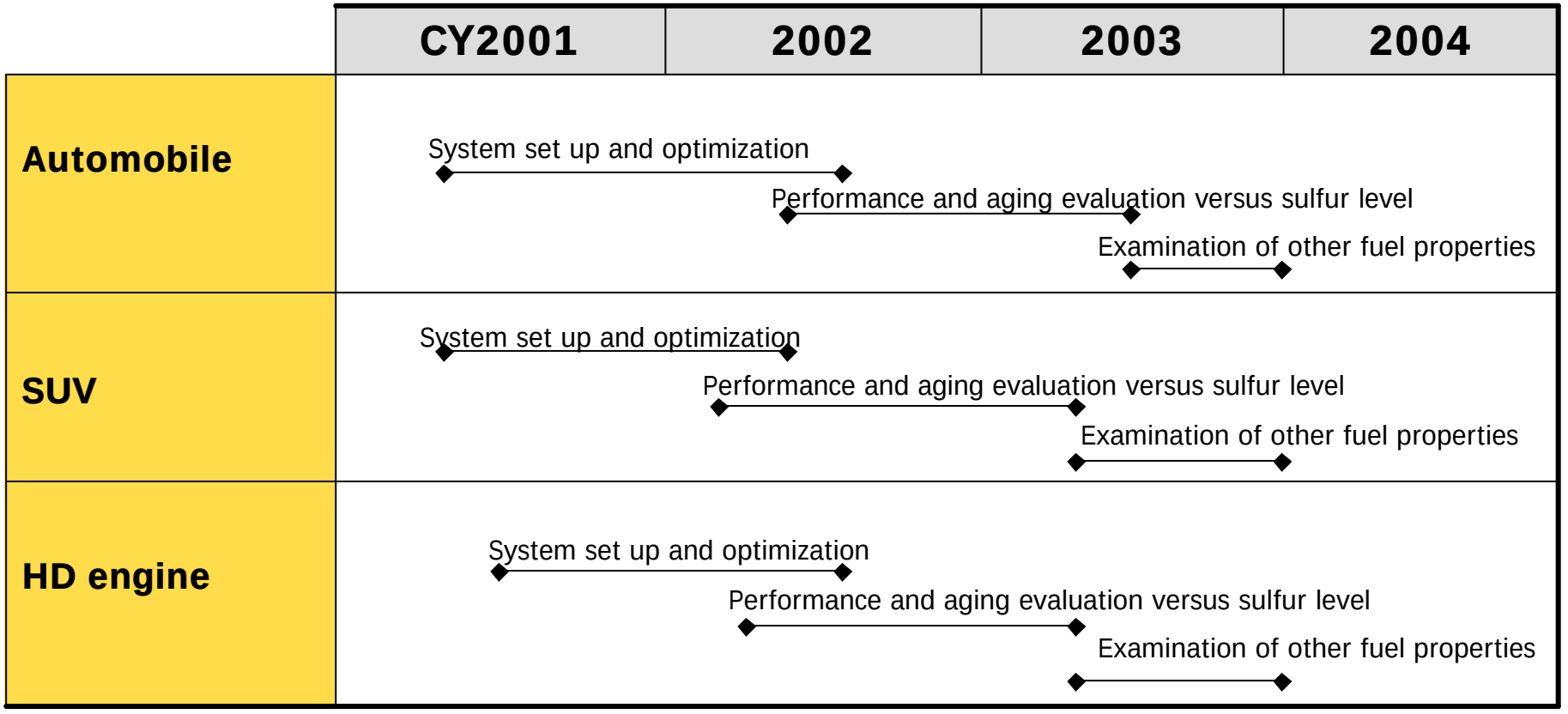
- ***Goal*** - Demonstrate low diesel emissions performance with system of engine, controls, fuel, NO_x adsorber, diesel particle filter, thermal management technologies
- ***Deliverables:***
  - Optimized NO_x adsorber/DPF systems for testing heavy- and light-duty engines utilizing late-cycle injection
  - NO_x adsorber/DPF emissions performance
  - System durability
- ***Contractors:***
  - FEV Engine Technology - passenger car
  - Southwest Research Institute – pick-up truck/SUV
  - Ricardo - heavy-duty engine

Fuels, Engines, NO_x Adsorber, DPF Technologies

- ***Scope:***
  - One heavy-duty engine (15-liter Cummins ISX) and one light-duty engine (1.9-liter TDI in Audi A4 passenger car) and one medium-duty engine (6.6-liter GM Duramax in a pickup)
  - Two emission control systems in each project, including NO_x adsorbers and DPFs, and thermal management technologies
  - Initial demonstration on DECSE fuel - other fuel properties examined after demonstrating ultra-low emissions

Fuels, Engines, NO_x Adsorber, DPF Technologies

- ***Schedule*** - May 2001 - October 2003

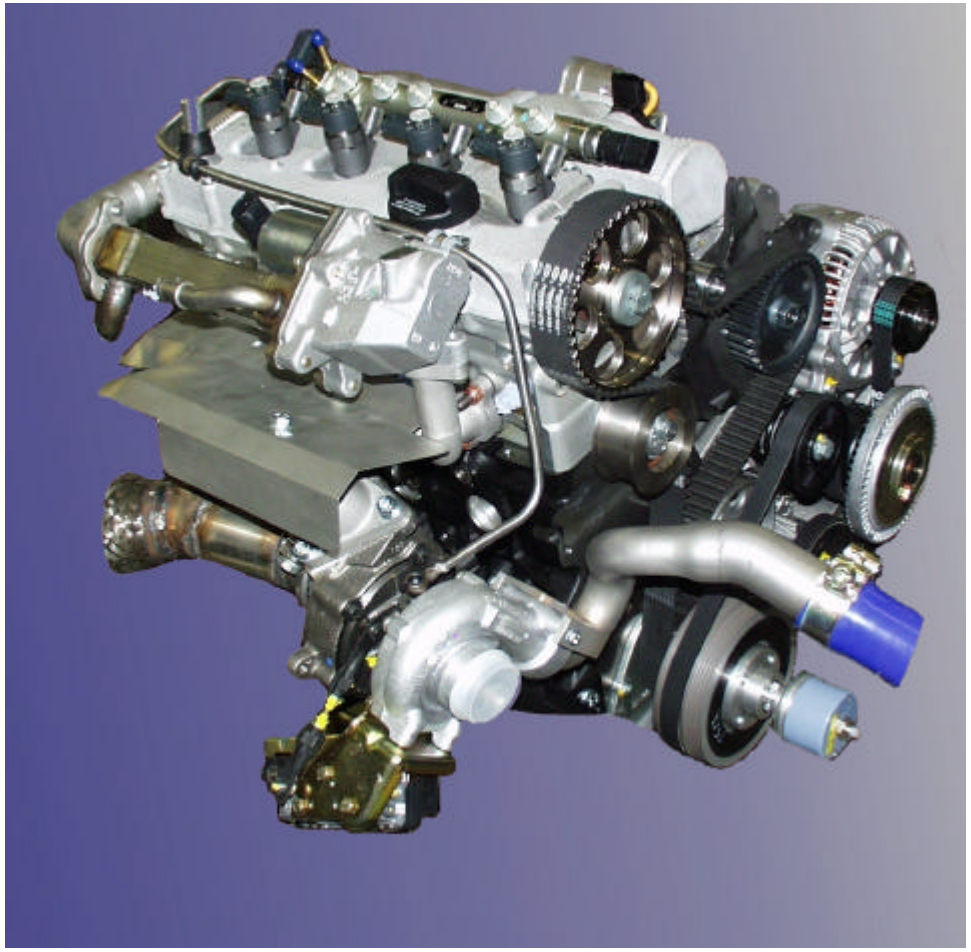


FEV Light-Duty Passenger Car Project

Vehicle: Audi A4 Avant 1.9 L TDI

FEV Light-Duty Passenger Car Project
1.9 L Diesel Future II HSDI Common Rail Engine

APBF-DEC



SwRI SUV/Pick-Up Project

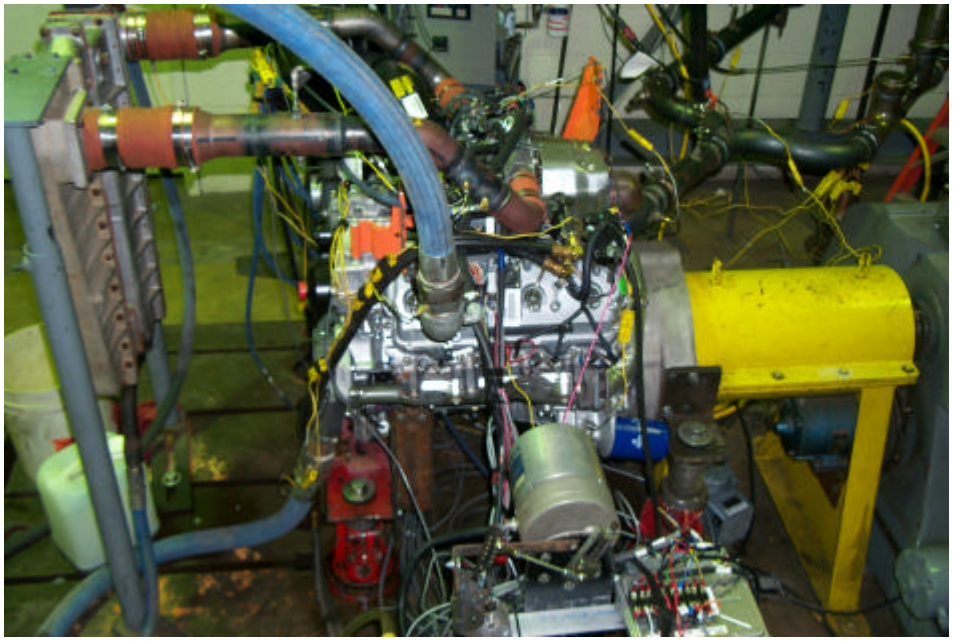
Vehicle: 2002 Chevrolet Silverado, 2500 Series

SwRI SUV/Pick-Up Project

6600 V8 Duramax/ ZF 6-speed Manual

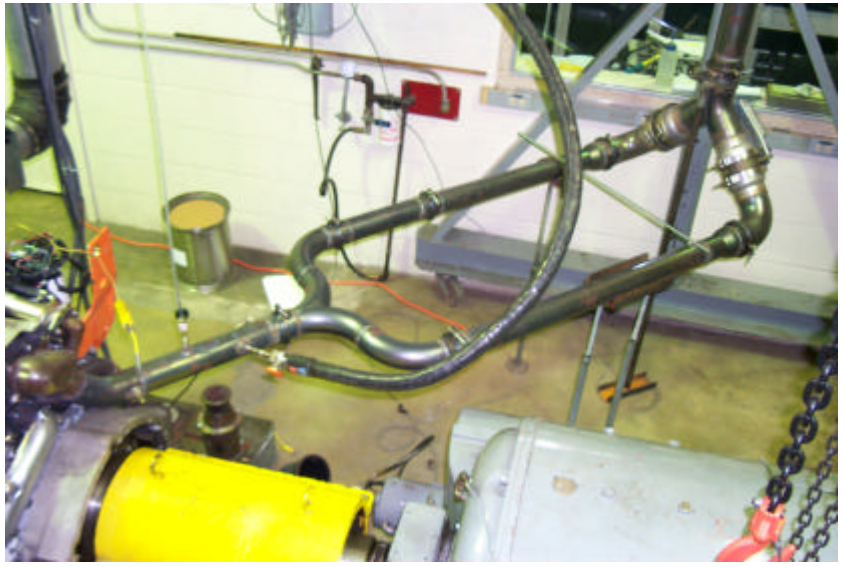
- Center-mounted turbocharger
- Charge Air Cooled
- Bosch Common rail fuel injection
- Noise optimized FI rate
- OH 4-V
- 2002 CA calibration with EGR
- Weight: 835 lbs.

SwRI SUV/Pick-Up Project
Test Cell Set up



6.6L Duramax CIDI Engine

Dual Leg Exhaust



HD NOx Adsorber/DPF
Ricardo

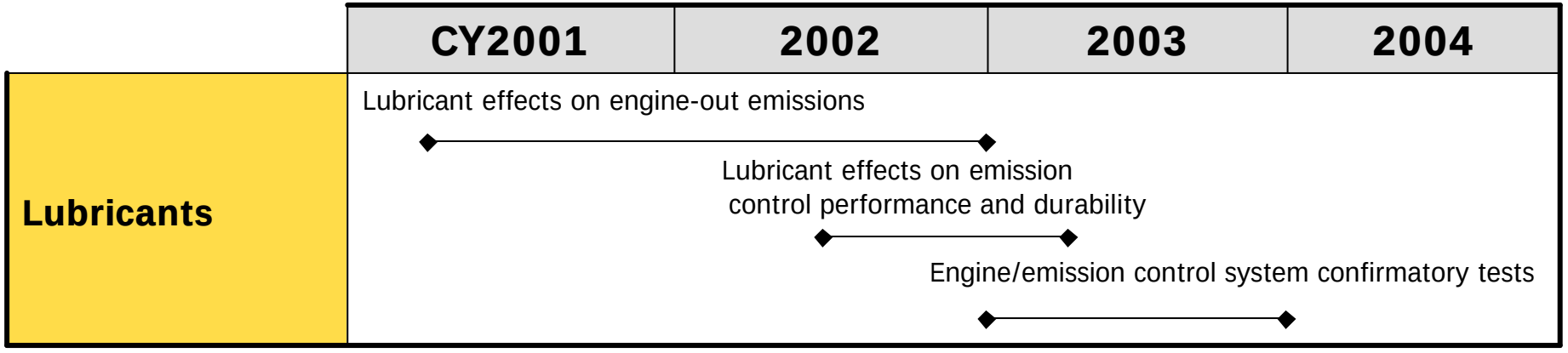
- Cummins ISX engine
  - 15L, DOHC
  - Integrated EGR w/ VGT
  - Secondary fuel injection system for NOx adsorber regeneration (to be developed by Ricardo)
- ECS architecture
  - Single leg (system ‘A’)
  - Twin-bed (system ‘B’)

Lubricants

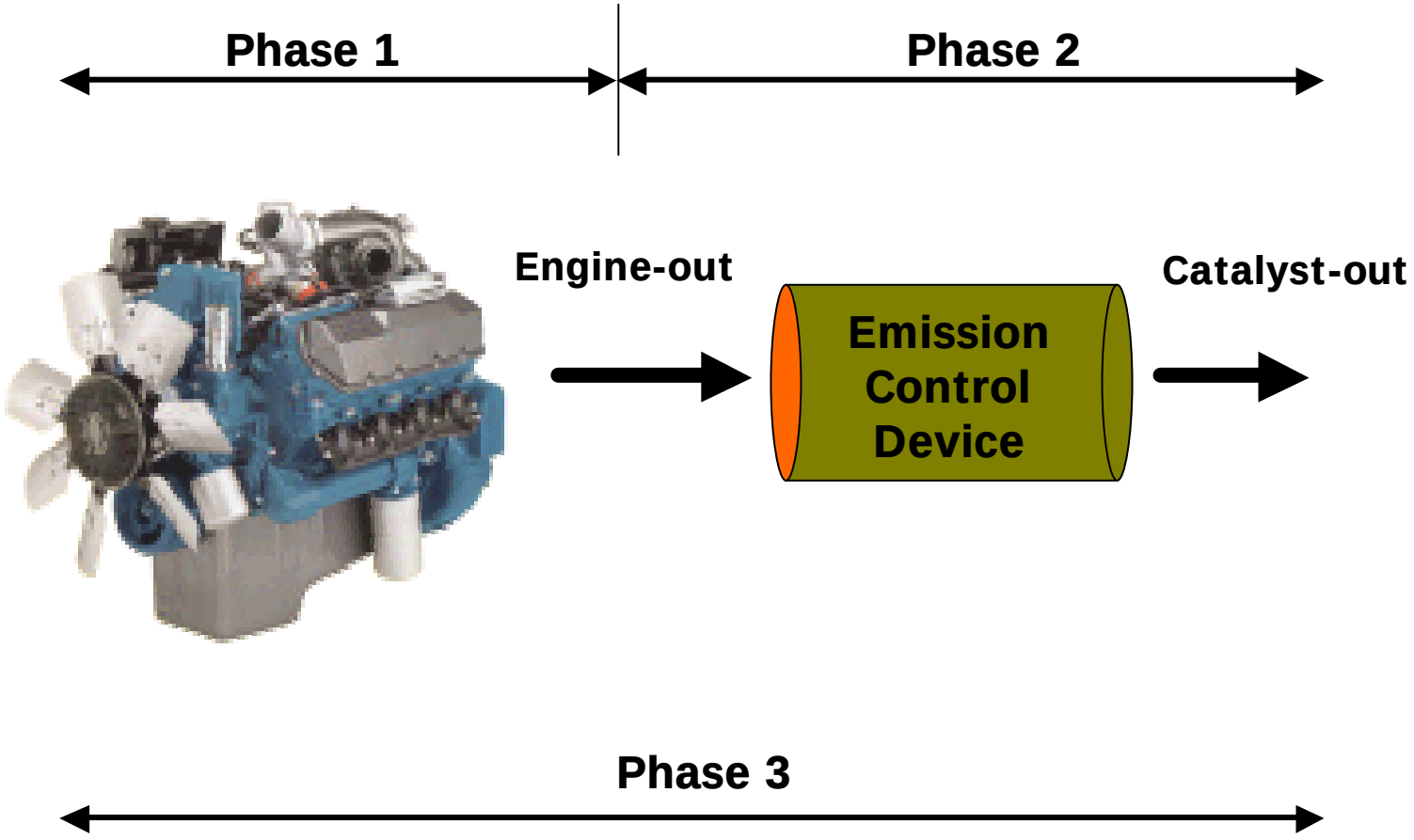
- ***Goal*** - To determine which (if any) lube-derived emission components are detrimental to performance/durability of emission control systems
- ***Deliverables:***
  - Documentation of effects of lubricant composition on emissions and performance of advanced emission control technologies
  - Guidelines for formulation of lubricants
    - Basestock selection
    - Additive development
- ***Contractor –*** Automotive Testing Laboratories

Lubricants

- ***Scope:***
  - Engine and accelerated aging tests will determine the impact of lubricant formulation on the performance and durability of diesel emission control devices.
  - International T444E (7.3-liter, V8) engine equipped with CCV and cooled exhaust gas recirculation
- ***Schedule*** **-** April 2001 - December 2003



Planned Phased Approach



APBF-DEC Project Funding