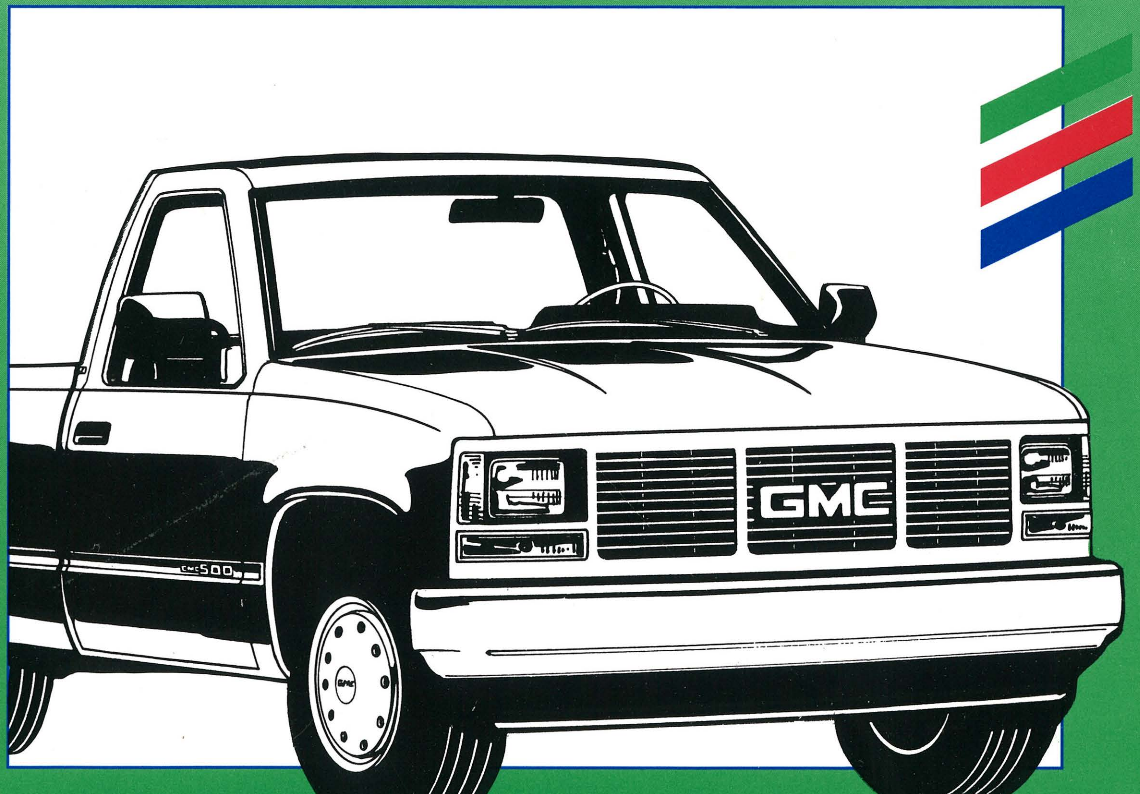
NATURAL GAS VEHICLE CHALLENGE 93

GM

SAE INTERNATIONAL®



Program

Dear Friends:

On behalf of the Texas General Land Office I am pleased to welcome the 1993 Natural Gas Vehicle Challenge to Austin.

It is particularly appropriate that the NGV Challenge is being held in Texas, where we are in the implementation stage of an ambitious clean fuels program. The Texas Plan for Clean Air, enacted in 1989, placed our state on the cutting edge of the alternative fuels revolution. This legislation mandates that certain fleets convert to cleaner burning, domestic alternative fuels such as natural gas.

The NGV Challenge is taking place during Texas' Fourth Annual Alternative Vehicle Fuels Market Fair and Symposium. Our Symposium has become one of the world's largest gatherings of the pioneers in alternative fuels technology. I'm sure NGV Challenge participants will find an audience with real world experience interested in their ideas and willing to offer suggestions and advice.

Sincerely,

Garry Mauro

Garry Mauro
Texas Land Commissioner

GM/SS/gv

Garry Mauro
Commissioner
Texas General Land Office

Stephen F. Austin Building
1700 North Congress Avenue
Austin, Texas 78701-1495
(512) 463-5256

Table of Contents

Sponsors and Administrators

Major Sponsors

- U.S. Department of Energy
- Energy, Mines, Resources - Canada
- Texas General Land Office
- Governor's Energy Office of Texas
- Gas Research Institute
- Austin Area GMC Truck Dealers
- General Motors de Mexico
- Entex
- New York State Electric & Gas
- Southern Union
- Southern California Gas Co.
- Canadian Gas Association

Associate Sponsors

- Minnegasco
- Lone Star Energy
- Brooklyn Union Gas
- MESA Inc.
- Oryx Energy Co.
- Natural Gas Vehicle Coalition
- American Gas Association

Contributing Sponsors

- Impco Technologies, Inc.
- Allied Signal Automotive Catalyst Company
- Liquid Carbonic
- Tren-Fuels
- Sherex Industries, Ltd.
- Texas Department of Commerce
- Colorado Interstate Gas

Administrators

- Argonne National Laboratory
- Society of Automotive Engineers
- Texas General Land Office
- Sports Car Club of America

About the 1993 Natural Gas Vehicle Challenge
June 7-10

Throwing Down the Gauntlet

Twenty-two teams from the United States, Canada, and Mexico have spent over a year converting GMC Sierra pickups from gasoline power to an improved or original natural gas configuration. Seventeen of the teams participated in past NGV Challenges, while the other five are new to the competition. What makes the NGV Challenge stand apart from other student engineering design competitions is that the trucks used for the conversion are the same trucks returning participants used in the 1992 and 1991 NGV Challenges. Now in its third year, the returnees have fine-tuned their vehicles to meet increasingly tough testing standards, and the teams new to the competition are ready to put their truck to the official test. The Natural Gas Vehicle Challenge continues the tradition of rigorously testing competitors' trucks in four areas: *emissions*, *fuel economy*, *performance*, and *design*. In essence, the NGV Challenge throws down the gauntlet with expectations of excellence from these young engineers-in-training, who will most likely make natural gas vehicles a production reality as tomorrow's professional engineers.

Psyched Up to Take Risks

What separates engineering students from seasoned professionals is their gung ho ingenuousness; they are willing to take risks because they haven't learned that some things won't work. To prepare for a competition such as the NGV Challenge, the students know they have to work hard to meet stringent expectations and requirements, but are inspired and inclined to try the untried. Whether it works or not is simply a part of the experiment. For this expanding technology, the students are eager trail blazers who bring a fresh perspective to the field of natural gas technology.

Natural Gas--A Smart Alternative

If natural gas seems like a new technology, that's only because petroleum has been in use for so long. Actually, natural gas was used *before* gasoline was relied upon to power vehicles. In fact, the first automobile engine ran on natural gas. But the economy of the early 1900s drove natural gas out of demand because gasoline was less expensive and seemingly inexhaustible--back in the days when it was unthinkable that a gallon of gas would ever cost more than even a quarter. But today's increasing (and fluctuating) gasoline prices, coupled with environmental damage and the fact that gasoline *isn't* inexhaustible, make natural gas an increasingly attractive alternative to today's consumers. Natural gas is safe and abundant, but most pleasing to today's environmentally-conscious populace is that it is clean-burning. Natural gas, which is mostly methane, releases far less carbon monoxide, nitrogen oxide, and reactive hydrocarbons than other fossil fuels, when used to its best advantage.

Making Natural Gas a Reality

The technology for operating trucks and cars on natural gas is not well-developed, although industry has been researching natural gas for some time. Because NGV technology has ample room for further research, compared with gasoline-power technology, the Natural Gas Vehicle Challenge is the ideal "vehicle" for that further experimentation. The NGV Challenge has annually required the teams to develop or improve upon a natural gas configuration, test it, and then refine it, working out bugs and finding out what went wrong the year before. Their eagerness, enthusiasm, and hard-work ethic can only lead to one thing: making vehicles that operate on clean-burning natural gas a reality for the very near future.

Participants and Vehicle Numbers

#3 -- Colorado State University

#4 -- Concordia University

#5 -- California State University at Northridge

#6 -- Florida Institute of Technology

#7 -- GMI Engineering & Management Institute

#8 -- Illinois Institute of Technology

#9 -- University of Maryland

#10 -- University of Michigan at Dearborn

#11 -- University of Nebraska

#12 -- New York Institute of Technology

#13 -- Northwestern University

#14 -- Ohio State University

#16 -- Old Dominion University

#18 -- University of Tennessee

#19 -- University of Texas at Austin

#20 -- Texas Tech University

#24 -- West Virginia University

#25 -- University of Alberta

#26 -- Instituto Technologico y de Estudios Superiores de Monterrey

#27 -- Texas A&M

#28 -- University of Texas at Arlington

#29 -- University of Texas at El Paso

Event Schedule

DATE	TIME	EVENT	PLACE
6/7/93 *(Monday)*			
	5:00 AM	Cold Driveability	Tech Center
	12:30 PM	Team Registration	Dobie Center
	1:00 PM	Vehicle Display	Austin Convention Center
	5:00 PM	Impound Vehicles	Tech Center
6/8/93 *(Tuesday)*			
	9:00 AM	Opening Ceremony	Austin Convention Center
	9:30 AM	Convoy to Tech Center	Austin Convention Center
	10:00 AM	Range Event Begins	Tech Center
	1:30 PM	Road Rally Begins	EG&G, San Antonio
	5:00 PM	Road Rally Ends	Tech Center
		Impound Vehicles	Tech Center
6/9/93 *(Wednesday)*			
	9:00 AM	Vehicle Display	Thompson Conf. Center Parking Lot
		Design Inspection	Thompson Conf. Center Parking Lot
	9:30 AM	Hot Driveability	Thompson Conf. Center Parking Lot
	10:00 AM	Oral Presentations (2 concurrent sessions)	Thompson Conf. Center
	5:00 PM	Impound Vehicles	Tech Center
	7:00 PM	Oral Presentation Finals	Dobie Center
6/10/93 *(Thursday)*			
	9:00 AM	Acceleration Event	Balcones Research Park
		Sound Check	Balcones Research Park
	10:30 AM	Weight Pull Event	Balcones Research Park
	6:00 PM	Awards Banquet	Scholz' Restaurant
	7:00 PM	Awards Presentation	Scholz' Restaurant

(As of 5/18/93)

About the Events

Cold Start--
The trucks are frozen to sub-zero temperatures and started using a prescribed procedure. The teams will earn bonus points for superior performance.

Cold Driveability--
The teams perform a demanding driving test, which determines their trucks' driveability starting with a cold engine after an overnight park.

Emissions--
The trucks must meet federal tailpipe emission standards for 1992 light trucks or incur penalties. Superior emissions performance earn up to 250 bonus points. Points will be awarded for simultaneous control of several pollutants, per a table prepared by the U.S. Environmental Protection Agency.

Road Rally Fuel Economy--
The teams must drive on public roads, mixing with ordinary traffic while maintaining prescribed average speeds, which must remain below the legal limit at all times. Unknown checkpoints along the route score the teams on their ability to maintain specified speeds. Fuel economy is measured at the event's conclusion (approximately 200 miles). Results indicate fuel economy under everyday driving conditions.

Endurance Fuel Economy--
The teams drive 125 miles at a steady speed of 55 mph. Fuel economy is calculated at the event's end with penalties for refueling and any repairs made along the way. Any team not demonstrating a 250-mile projected range will be penalized.

Design Inspection--
The trucks' designs are judged based upon prescribed criteria by a panel of professionals.

Hot Driveability--
Another driving schedule is performed on each truck after it has completed its acceleration run. This test determines driveability when starting with a hot engine.

Acceleration Event--
One at a time, the teams are timed over a standing start, quarter-mile while carrying a 1000 lb load in the truck bed. Each team has two drivers, and their times are averaged to arrive at the team score.

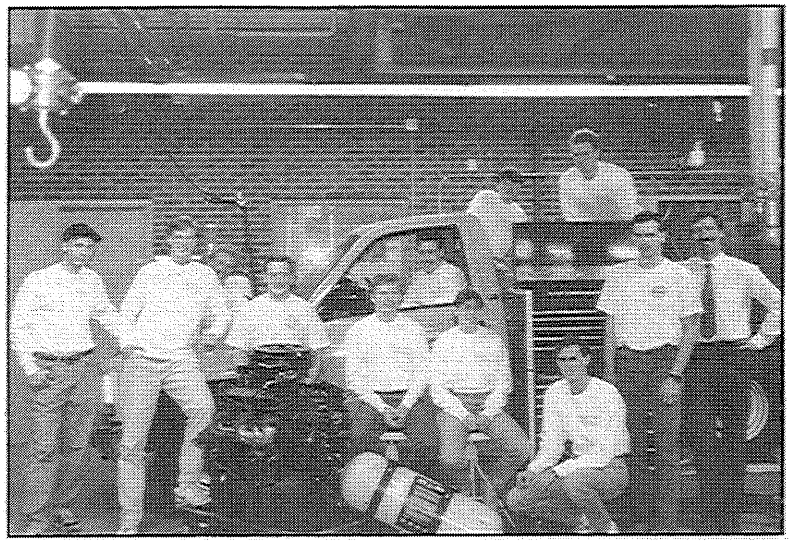
Weight Pull Event--
This event tests each truck's ability to pull a 5-ton dead-weight load against its engine's compression for 100 linear feet. Each team has two drivers, and their times will be averaged to arrive at the team score.

Sound Test--
During the acceleration runs, a modified SAE J986b test procedure is conducted to measure exhaust noise. Teams whose exhaust noise exceeds 80db will be penalized.

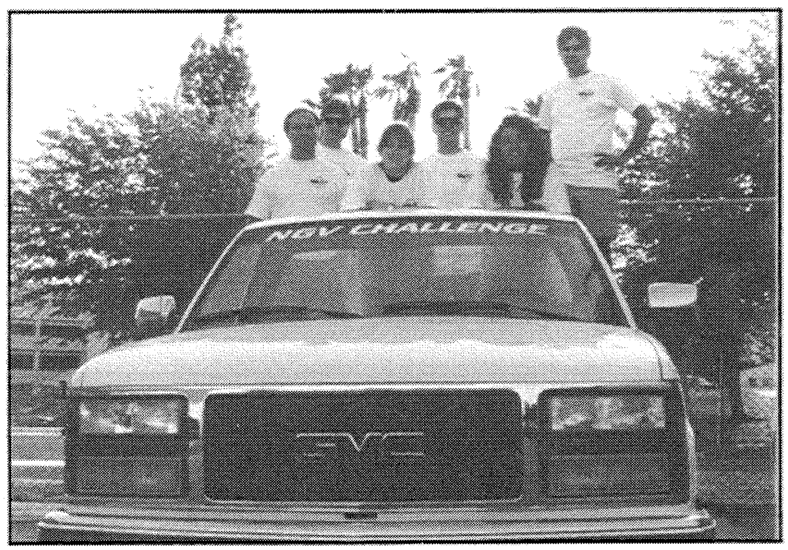
Paper Presentation--
Each team makes a 10-minute presentation of the rationale and approach to their conversion, followed by a 5-minute question-and-answer session. The presentations will be judged on format, content, and delivery by a panel of industry experts.

Event Scoring

Event		Points
Emissions		250
Design		250
Written Design Report	75	
Vehicle Design Inspection	100	
Oral Design Presentation	75	
Fuel Economy		250
Endurance Event	100	
Road Rally	50	
FTP Fuel Economy	100	
Performance		250
-20° Cold Start	50	
Acceleration w/1000 lb load	50	
Weight Pull	50	
Cold Driveability	50	
Hot Driveability	25	
Rally Performance	25	
TOTAL		1000



Warren Salt (Team Leader), Curtis Collie (Drivetrain Leader), Jean Wilson (Chassis Leader), Michael Lindsey (Administration), Harvey Aasman, Bob Armstrong, Remko Brouerius, Bernard Chin, Stuart Corke, Graeme Feltham, Cory Forbes, Tom Gorr, Dennis Hartlieb, Derek Heaven, Steve Larson, Omar Neumann, Snehal Parmar, Todd Rate, Ken Sidhu, Gary Topilko, Dale Ulan, A. Peter Varma, Kevin Visser, Aldous Walters, Trevor Willms, Dr. David Checkel (Faculty Advisor)



Greg Dato, Steve Fierro, Mike Goebel, Kim Urbanesky, Gloria Guerro, Dr. Stewart Prince (Faculty Advisor)

University of Alberta, #25

Engine Size-- 350 in.^{3}

Compression Ratio-- 8.5:1

Induction System-- ANGI LEVS (Automotive Natural Gas, Inc./Low Emission Vehicle System)

Key Technologies--
▪ A bolt-on overdrive unit was added for efficiency and fuel economy.
▪ A feedback-controlled fuel delivery system minimizes emissions.
▪ Headers were used to minimize flow losses and improve the volumetric efficiency of the engine.
▪ A multiple spark ignition system was used to overcome methane ignition difficulty to prevent power and fuel efficiency losses.

California State University at Northridge, #5

Engine Size-- 350 in.^{3}

Compression Ratio-- 9.8:1

Induction System-- supercharged four BKM Servojet injectors controlled by a student-designed electronic control unit

Key Technologies--
▪ A modified gaseous fuel injection system and an electronic control unit to enhance fuel economy were incorporated into the truck; the control unit was built by the team.
▪ Air flow was enhanced through use of the Corvette-tuned intake manifold.
▪ The modified engine is a two bolt main bearing engine block.
▪ An electrically heated pup catalyst was implemented in conjunction with a specially designed under-floor converter.

L to R: Jason Yost, Joe Eves, Jamie Schneider, Brad Boender, Bryan Willson (Faculty Advisor)

Colorado State University, #3

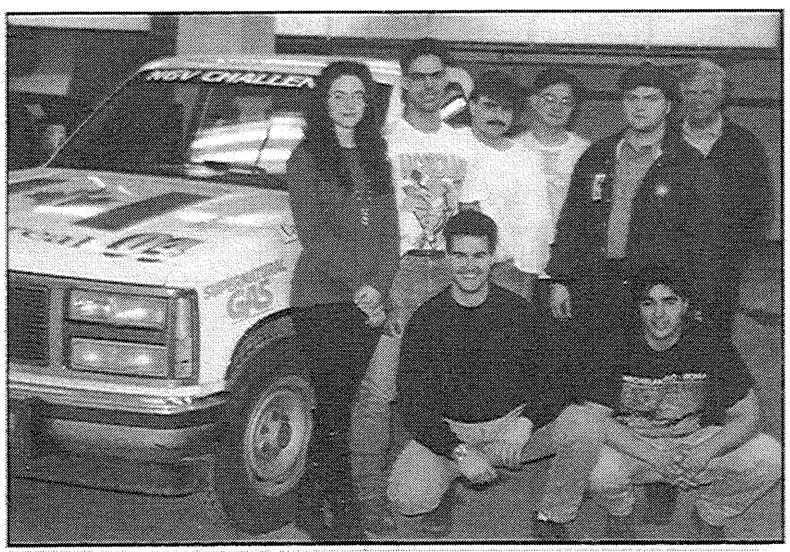
Engine Size-- 355 in.^{3}

Compression Ratio-- 12.0:1

Induction System-- tuned port intake with enlarged runners and ported manifold and plenum

Key Technologies--

- The truck added a micropro- cessor translator to modify ECM throttle body injector signals for fuel temperature and pressure compensation.
- The truck includes on-the-fly adjustable VE tables through laptop PC interface to the translator.
- Wide range oxygen sensor biasing table inside the translator allows ECM feedback fuel control.
- Stewart & Stevenson PING natural gas fuel injectors provide fuel delivery.



L to R: Josie Di Bennedetto, A.J. Whitman, Petrus Frantzeskakis, Byung Son, Larry Marandola, Dr. Tad Krepec (Faculty Advisor)
Kneeling, L to R: Bruno Forcione, Harry Kekedjian

Concordia University, #4

Engine Size-- 350 in.^{3}

Compression Ratio-- 13.0:1

Induction System-- Alternative Fuel Electronics (AFE)

Key Technologies--

- The engine includes milled 1990 aluminum Corvette heads; an Edlebrock high-performance intake manifold is matched to the heads.
- The exhaust system was modified to a single exhaust type.
- The fuel system consists of a high pressure regulator, a low pressure fuel shut-off solenoid and a low pressure regulator.
- A new single exhaust system consisting of a dual bed converter in an in-house-designed casing was installed on the truck to reduce exhaust emissions.

L to R: Bernhard Jokiel, Steve Adams, Chris Baker, Brian Tippett, Erik Gordon
Not pictured: Dr. John J. Thomas (Faculty Advisor)

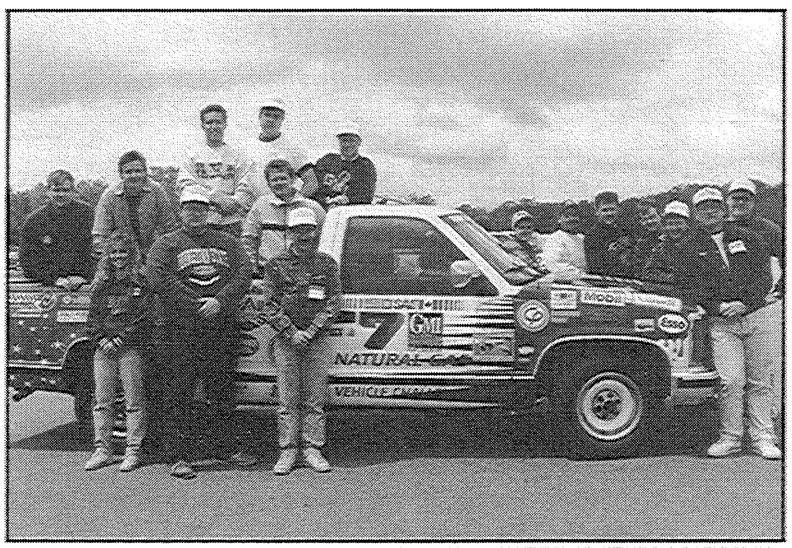
Florida Institute of Technology, #6

Engine Size-- 350 in.^{3}

Compression Ratio-- 11.1:1

Induction System-- ANGI LEVS

Key Technologies--
- The stock camshaft was changed to a 1.080 cm lift intake and 1.115 cm lift exhaust with 114° lobe separation. The camshaft has an 11° overlap to help aid in the low RPM power problems usually associated with CNG conversions.
- Modifications to the engine system include installation of a multiple spark discharge (MSD-6) ignition system, a Super Fix 1 engine signal filter, and the ANGI LEVS induction system.
- Engine performance was monitored using several EGR valves with flow rates both higher and lower than stock flow levels.



David Pray (Team Captain), Mike Schmidt (co-captain), Neil Freiermuth (co-captain), John Roth (co-captain), Mike Mellot, Andy McClure, Jason Caster, Tom Porlick, Eric Balicki, Shawn Dill, Zmauhi Zeng, Mason Weisbrod, Doug Turanchick, George Bowser, Andrew Salas, Dale Williamson, Kurt Tomlinson, Ed DeSmet, Colin Jordan (Faculty Advisor)

GMI Engineering & Management Institute, #7

Engine Size-- 350 in.^{3}

Compression Ratio-- 8.75:1

Induction System-- OHG mixer/GM throttle body

Key Technologies--
- Rivets that held in place the cross member were replaced with Grade 8 bolts and a one-inch-thick steel space block.
- Engine ignition timing and EGR rate were recalibrated for improved performance and emissions.
- Five fuel cells mounted under the bed of the truck between the cab and the rear bumper and between the two frame rails store the fuel.

Photo Unavailable

Team Members: Paul Krupowicz, Mike Corliss, Reggie McKeever, John C. Hiatt, Jr., Todd Hopwood, Bob Drackert, Dr. Francisco Ruiz (Faculty Advisor)

Kevin Murphy (Team Captain), Andrew McNelia, Jon Middleton, Scott Simpson, Marc Butler, James Marsh, James Newton, Delmar Gillus, Lorenzo Taylor, Mike Brennan, Dr. David Holloway (Faculty Advisor)

Illinois Institute of Technology, #8

Engine Size-- 350 in.^{3}

Compression Ratio-- 8.5:1

Induction System-- features natural aspiration, Venturi-type open-loop mixer (ANGI brand), in-line automater

Key Technologies--
- The engine features an alternator and a high-energy ignition system.
- Open-loop pressure control operates in the ultra-lean region.
- The truck's air-fuel ratio is 25 to 30.
- Exhaust headers are ceramic-coated on the inside.
- The intake ozonator operates at over 25,000 volts.

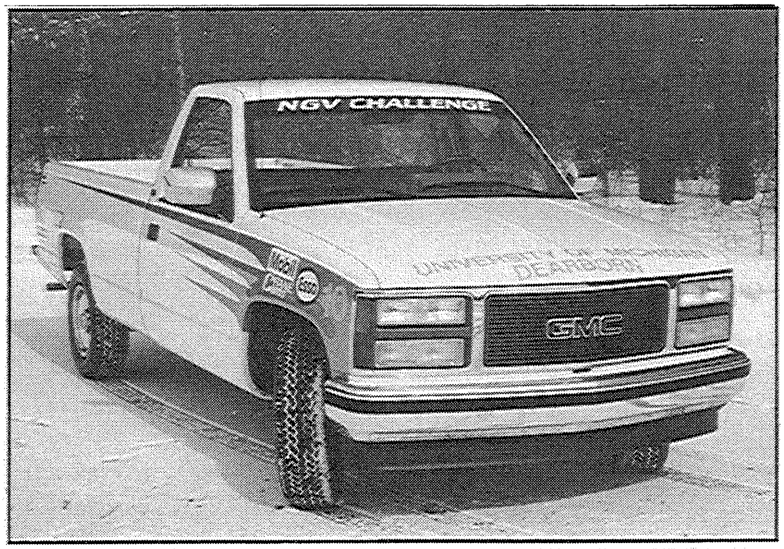
University of Maryland, #9

Engine Size-- 360 in.^{3}

Compression Ratio-- 10.9:1

Induction System-- turbocharged

Key Technologies--
- The truck is the only LNG conversion in the competition, with an estimated range of 450+ miles.
- The truck sports a cryogenic intercooler/vaporizer.
- Four SP021 BKM/Servojet injectors are controlled by the stock GM computer through a Beacon Power Systems translator.
- The truck has dual overdrives.
- Fuel lock is accomplished by an engine compartment isolation solenoid and a fuel rail isolation solenoid.



Steve Ponsock (captain), John Endredy (captain), Matt Stroka, Kirk McGuire, Karen Marx, Mary Jenkins, Jeff Holmes, Brian Stop, Glen McCracken, Valerie Davenport, Dr. Keshav Varde (Faculty Advisor)

University of Michigan at Dearborn, #10

Engine Size-- 355 in.^{3}

Compression Ratio-- 11.5:1

Induction System-- electronic-controlled mixer system

Key Technologies--
- The fuel system features a high pressure shut-off solenoid which operates off the existing fuel pump relay.
- Emissions are controlled by light-off catalytic converters.
- For cold startability, a microprocessor-based system increases the throttle if the ambient temperature is less than 0°C.
- An MSD-6A capacitive, multi-spark discharge ignition was used in the vehicle because of its higher voltage and multiple fires for a more complete combustion.

Robert Braden, Mark Goodwin, Kevin Johnson, Brien Fulton, Joseph Borg (Faculty Advisor), John Rose, Bruce Polnicky, Scott Nelson, Glen Gralheer

University of Nebraska, #11

Engine Size-- 350 in.^{3}

Compression Ratio-- 9.8:1

Induction System-- turbocharged, intercooled

Key Technologies--
- An aluminum-tuned port manifold using dual turbochargers with integral wastegates and water-to-air intercooling replaced the production intake manifold.
- Two composite fiber-reinforced steel cylinders were installed under the cab and box between the frame rails and drive shaft; three cylinders, composed of aluminum liner and composite fiber, were installed behind the rear axle.
- A multi-port fuel injection system replaced the gasoline throttle body.

Photo Unavailable

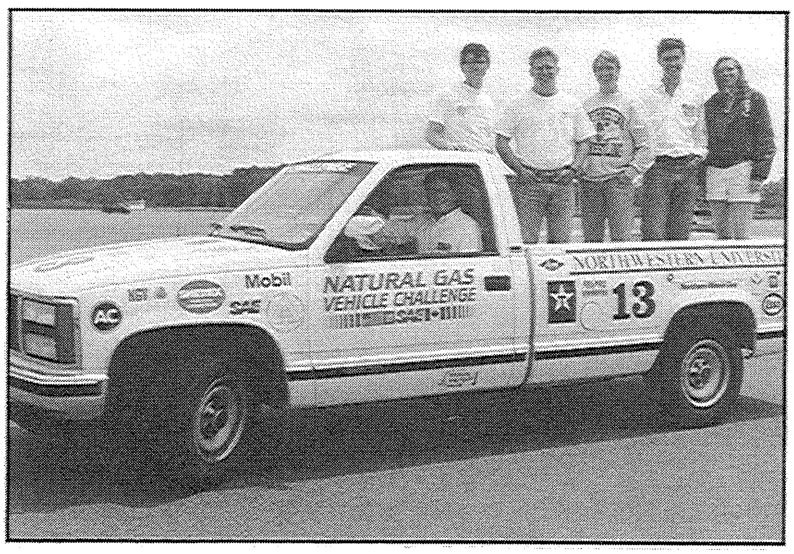
New York Institute of Technology, #12

Engine Size-- 305 $in.^3$

Compression Ratio-- 9:1

Induction System-- single turbo

Key Technologies--



Seated: Scott Phillips (Team Captain)
Standing: Dr. Richard Lueptow (Faculty Advisor), Drew Elste, John Adee, Robert Schoenthaler, Holly Vaughan

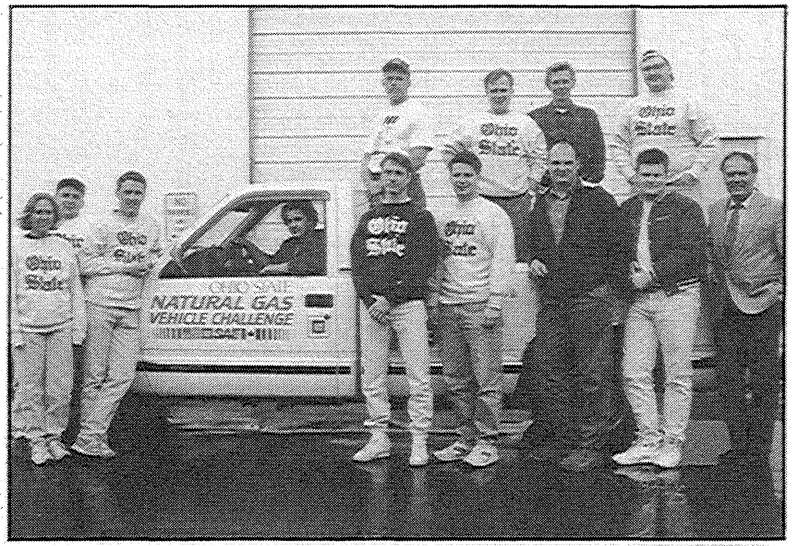
Northwestern University, #13

Engine Size-- 350 $in.^3$

Compression Ratio-- 13:1

Induction System--

Key Technologies--
- The truck uses a stock GM controller to manage sequential port fuel injection for two fuel injectors per cylinder.
- Emissions are minimized through headland piston rings, an EGR system incorporating a water-gas shift catalyst, dual heated oxygen sensors, and dual catalytic converters.
- Two fiberglass-wrapped steel tanks were mounted between the frame rails to contain the compressed gas.
- Intake flow was enhanced by a tuned port intake system and high flow heads.



Mark Bonifas, Sean Doyle, Ken Wilson, Nick Bowers, Yale Jones, Rick Carlisle, Ben Lingel, Jim Cigler, Joe Pallini, Lisa Deringer, Jason Stern, Don Williams (Technical Support), Lawrence E. Kennedy (Faculty Advisor)

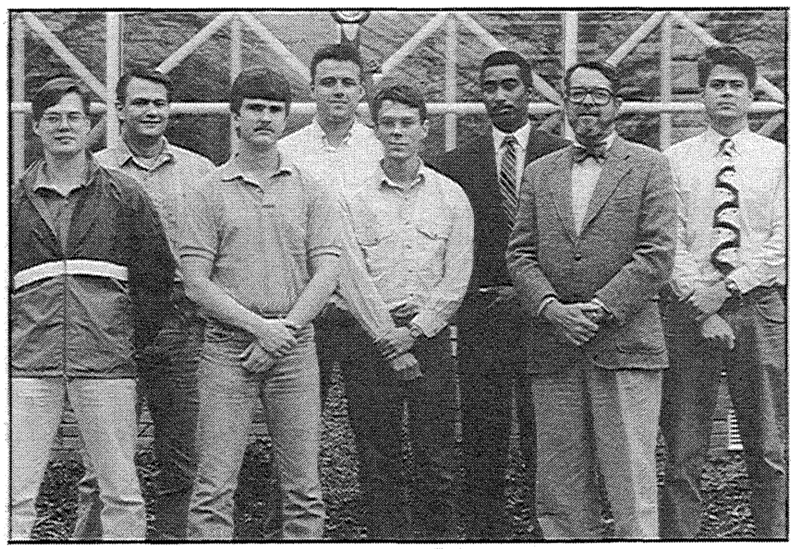
Ohio State University, #14

Engine Size--

Compression Ratio-- 11.0:1

Induction System-- Electronically-controlled fuel flow via a Stewart and Stevenson/GFI fuel system

Key Technologies--
- An intake valve with a multiple angle grind and a tuned intake manifold were used to improve the fuel flow into each cylinder.
- The engine has a special piston-to-chamber relationship to achieve its compression ratio.
- Electrically-heated catalysts improve cold start emissions, and a main catalyst designed for natural gas engine exhaust improves emissions.



L to R: Tim Bradley, Josh Longacher, Dan Kinzie (Co-captain), Ken Radecki, Chris Taylor, Eugene White (Team Captain), Dr. A. Sidney Roberts (Faculty Advisor) Mike Ikenberry (Co-captain)
Not pictured: Pat Arthur, Carlos Bultrago, Chris Coburn, Jimmie "Turbo" Cohen (Technical Advisor), Bethany Ezell, Mark Feldman, Darin Fox, Greg Garrison, Clark Gresham, Hoon Kim, Grif McRee, Lamont Noble, Ben Sablan, Steven Smith, Sam Thompson, Alan Wiggs, Faculty Advisor; Taj O. Mohieldin, Faculty Advisor

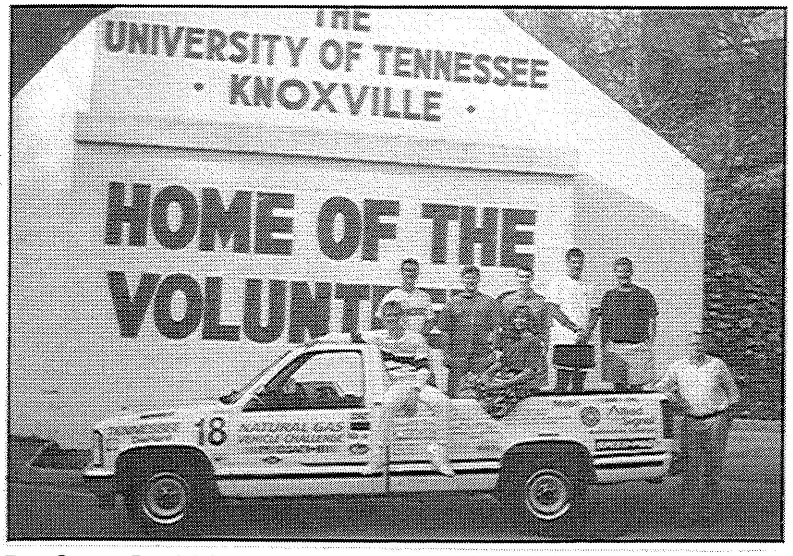
Old Dominion University, #16

Engine Size-- 350 $in.^3$

Compression Ratio-- 10.4:1

Induction System-- 8 Siemens prototype Deka I CNG injectors

Key Technologies--
- The truck maintains full use of its cargo bed and original payload capacity.
- The total conversion weight is within 100 lbs of the truck's original weight before conversion.
- The EGO sensor is heated.
- For safety, the fuel storage system is made up of two composite-reinforced Moly steel tanks mounted inside frame rails forward of rear axle.



Top: George Dominick, John North, Charles Cline, John Douglas, Alan Sherwood
Bottom: Bradley Jared, Lori Snook, Dr. Jeff Hodgson (Faculty Advisor)

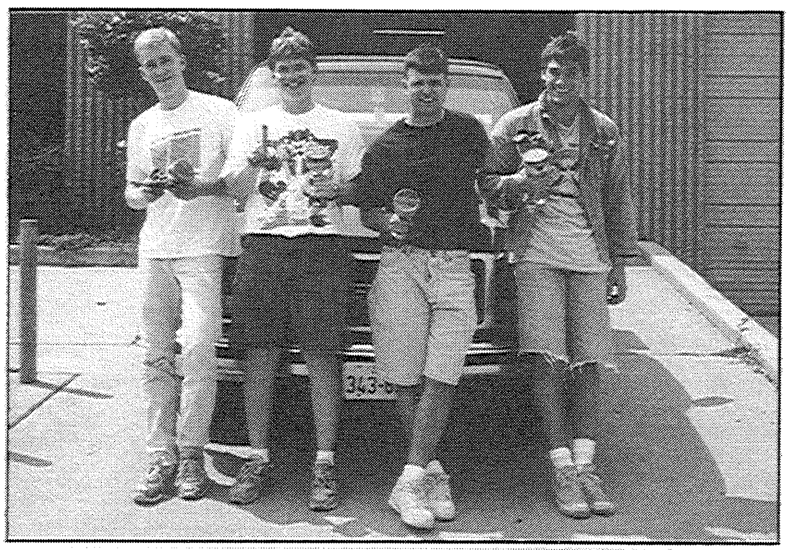
University of Tennessee, #18

Engine Size-- 334 in.^{3}

Compression Ratio-- 9.6:1

Induction System-- turbocharged

Key Technologies--
- The truck was carbureted with supplemental fuel injectors.
- The system functions with a closed-loop control system to maintain a stoichiometric air/fuel ratio for optimum three-way catalyst operation.
- Exhaust gas leaves the turbocharger toward the back of the engine; exhaust exits directly out of the turbine.
- Block learning was incorporated into an Impco 300A mixer, with a modified Impco adaptive digital processor, which uses EGO sensor feedback to control the gas pressure supplied to the gas mixer.



L to R: Brad Haskett, Ben Fisher, Gregg Wilson, Alan Thompson
Not pictured: Yoshiki Mogi, Don Perlick, Greg Grieby, Dr. Tom Lalk (Faculty Advisor)

Texas A&M, #27

Engine Size--

Compression Ratio--

Induction System--

Key Technologies--

L to R, front row: David Eagleston, Charles Speller, Ookyoung Kim, Jeff Scano, Brad Rowe, Bob Bundy, Nick Dringenberg (Team Captain), James Whitt, Gerald Kwan
L to R, back row: Craig Henry, Scott Oller, Shane Scott, Youngbae Kim
Not pictured: Jon Stalk, Dr. Bob Woods (Faculty Advisor), Kliff Black (Assistant Instructor), Stephen T. Kugle (Faculty Advisor)

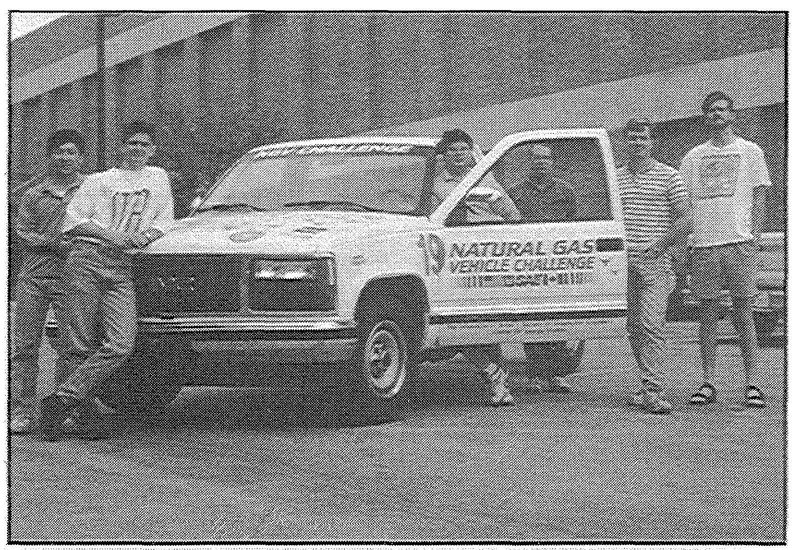
University of Texas at Arlington, #28

Engine Size-- 350 in.^{3}

Compression Ratio-- 11.2:1

Induction System-- multi-port fuel injection system that includes modifications to enhance air mixing

Key Technologies--
▪ The intake air plenum and manifold were constructed around a modified tuned-port injection system; ignition timing and fuel metering (banked-injection) are controlled with after-market electronics.
▪ The truck's engine is naturally aspirated.
▪ Engine operation is stoichiometric, and a three-way catalyst with separate light-off catalyst is installed for exhaust gas treatment; fuel is stored in four 3000 psi fiberglass-wrapped aluminum tanks.



Ben Carroll, Jon Lusky, Jim Harber, Brian Wilson, Jon Nash
Not pictured: Dr. Ron Matthews (Faculty Advisor)

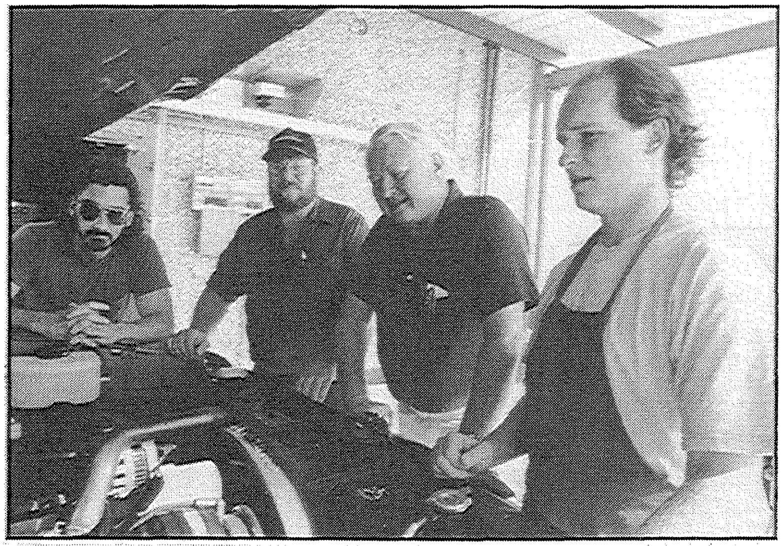
University of Texas at Austin, #19

Engine Size-- 350 in.^{3}

Compression Ratio-- 11.1:1

Induction System-- supercharged, intercooled

Key Technologies--
▪ The engine is composed of a single plane low-rise manifold, an OHG 450 mixer, and a Holley 600 throttle body.
▪ The valve train includes a Crower cam, hydraulic roller lifters, and roller rockers.
▪ The team installed a computer-controlled blower bypass, open under low load and/or low acceleration conditions, closed under high load and/or high acceleration conditions.



L to R: Roberto Dominguez (captain), Jeff Lindblom (captain), Dr. Carroll Johnson (Faculty Advisor), Lew Babenco, Technical Advisor

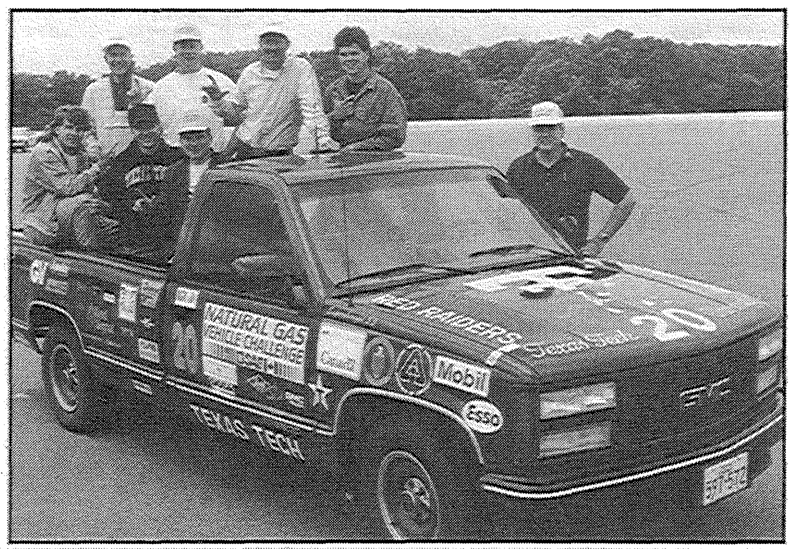
University of Texas at El Paso, #29

Engine Size-- 350 in.^{3}

Compression Ratio-- 13.0:1

Induction System-- Approximately 2220 CFM in four tanks

Key Technologies--
- The truck features modified TRW high compression racing pistons and ceramic-coated rings, pistons, combustion chambers, and valve faces.
- The intake manifolds were modified to accommodate 1992 Corvette aluminum heads.
- EGR system was modified to include an exhaust gas heat exchanger.
- An Autotronics MSD 6A high performance ignition system was modified, as was an Autotronics ignition control system.



Gary Bourn (Team Captain), Kevin Christopher, David Stamm, Bobby Gallaway, Luke Morrow, Darrel Kruse, Ladd Sheets, Kris Stepp, Roland Schaffner, Robert Satsky, Dr. Tim Maxwell (Faculty Advisor), Jesse Jones, Team Advisor

Texas Tech University, #20

Engine Size-- 335 in.^{3}

Compression Ratio-- 10.9:1

Induction System-- supercharged

Key Technologies--
- The exhaust system features catalyzed exhaust gas recirculation (EGR).
- The configuration includes prototype closed-loop fuel injection system with pressure/temperature compensation and learning capability.
- The truck has electronic air injection.
- The engine, which includes boost recirculation, is a 3000 psi custom CNG throttle body injection, controlled both by a GEM controller and the stock ECM controller.

Kneeling, L to R: Ralf Wohl, Robert Tanner, Jim Harris
Standing, L to R: Dr. James E. Smith (Faculty Advisor), Rodney Liston, Matt Duffield, Greg Thompson, Todd Houck
Not pictured: Brian Haught, Chad Reese

West Virginia University, #24

Engine Size-- 350 in.^{3}

Compression Ratio-- 12.0:1

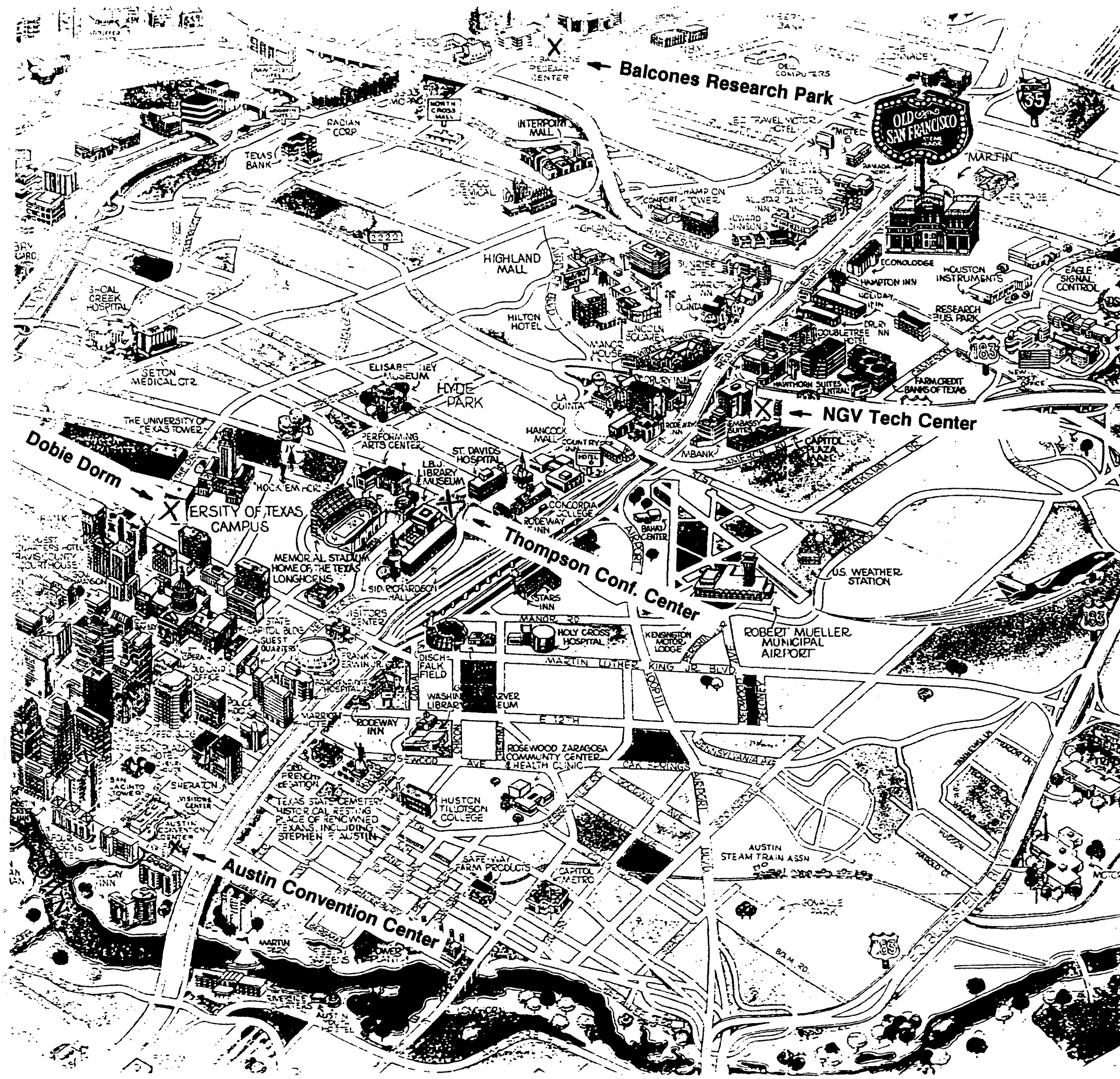
Induction System-- Impco 425 naturally aspirated carburetor and a BMK/servojet gaseous injection valve, Model SP021

Key Technologies--
- The camshaft used has reduced overlap, smaller lift, and longer duration to allow improved performance at a lower engine speed.
- The engine control system is a modified stock ECM.
- Natural gas is supplied to the engine compartment via ¼-inch stainless steel fuel lines routed from the tanks along the driver's side frame rail.
- For closed loop operation, fuel injectors were incorporated to meter and control fuel delivery.

Instituto Technologico y de Estudios Superiores de Monterrey, #26

Photo and Information Unavailable.

Competition Sites



Notes

Program printed courtesy of the Society of Automotive Engineers, Inc.

93-0456/EPF