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DEPARTMENT OF ENERGY
Grant/Cooperative Agreement DE-FC36-94GO10016
Quarterly Report
April 1 - June 30, 1997

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CALSTART Program Management:

A program review was conducted at AlliedSignal with James Merrit, Beth Peterman and Jim Spaeth attending from the Department of Energy. Selections from the review presentations are attached. The review was held at AlliedSignal on June 24, 1997. On June 19, 1997, Beth Peterman sent CALSTART a counter-offer facsimile in response to CALSTART's January 13, 1997 offer.

AlliedSignal has not yet signed the Cooperative Agreement with CALSTART. Now that AlliedSignal and Northrop-Grumman are ready to begin their technical work, it's imperative that this agreement be signed. CALSTART will do its best to insure that an agreement is completed during the next quarter. No technical reports have been submitted to CALSTART yet from either AlliedSignal or Northrop-Grumman.

Meanwhile, CALSTART continued with a wide array of activities in support of the Turbogenerator program as summarized below.

Significant effort during this quarter went into finishing the design, receiving approval from AlliedSignal and then posting – in May – its new, customized turbogenerator information “site within a site” page to the CALSTART Advanced Transportation Web site.

The printed version of the material, down-loaded from the Web, is attached to this report. The Web address is www.calstart.com/alliedsignal/home.html, which gives a far better demonstration of its look and capability.

What this custom site does is give AlliedSignal something it does not have now: a specific place to market its turbogenerator to a world audience. AlliedSignal does not currently support turbogenerator information on its own company web site because its not yet a big enough product. CALSTART was able therefore to greatly extend the reach and value of the investment in this program with this information.

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The AlliedSignal turbogenerator site provides clear, visually appealing and concise information on the importance of the technology for transportation, the unique quality of the AlliedSignal approach, its efficiency and emissions benefits, and key contact information. The page also provides value to AlliedSignal overall by providing a direct link to the company's main home page for users wanting more information on the company. This connection actually can send additional traffic to the AlliedSignal company pages.

This new custom site serves two purposes: as a stand-alone information offering for the now more than 250,000 (and climbing each month) monthly requests for information on the CALSTART industry site, and as an extension of AlliedSignal's existing web presence. CALSTART worked to match the AlliedSignal graphic style both to reduce duplication of effort and save resources, but also so that the look would blend with the AlliedSignal home page and be accessible as an extension of it. This is important. On the web, location of a page is meaningless: everything is just a mouse click away. Therefore, this new site can be blended in to AlliedSignal's existing efforts with just the programming of a "hotlink".

To ensure visitations off the CALSTART main pages, a "banner" ad featuring AlliedSignal's turbogenerator has been placed on the highest traffic locations of the site, including the Home page and Yellow Pages. In advertising parlance, these are the highest value banner locations on the site. They guarantee visitors to the site receive an "impression" of the turbogenerator and what it can do simply by virtue of having the name so centrally positioned. Through a simple click on the banner, visitors are then transported to the AlliedSignal turbogenerator custom site directly. There is no way of more highly featuring and promoting a technology. Currently the site receives visitation that is 80% domestic, 20% international (from over 70 countries), with the highest percentage of users being automotive OEMs, technology developers/researchers, governmental policy makers, and fleet and consumers.

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During this quarter, CALSTART also maintained its support of the turbogenerator at key conferences and in high-profile industry briefings. CALSTART positioned Charles Weinstein and AlliedSignal as the featured speaker for a panel of larger companies providing new directions at the Advanced Transportation Industry Conference held at the CALSTART facility, April 17. The conference was attended by nearly 200 high level participants of the advanced transportation industry and provided excellent networking opportunities, particularly with electric utility, technology developer and vehicle manufacturer representatives. The conference also featured the technology exhibit as part of its venue, with the turbogenerator receiving the highest profile and central location. Breakout meetings were actually held in this area.

Additional conferences attended where the turbogenerator received high positioning and description were the UCLA ECO (Environment, Commerce, Opportunity) Conference held in Los Angeles April 11, featuring UCLA Anderson Business School MBA students and local clean technology businesses, and a major international conference on Sustainable Energy and Transport, held in Amsterdam May 27. The audience of this later conference were European policy makers, investors and technology/auto OEMs, and the session here the AlliedSignal turbogenerator was featured in a briefing dealt with new investment opportunities in advanced transportation. The presentation placed the turbogenerator and other technologies in the context of the global need and push for cleaner, more efficient transportation.

During this quarterly period several other groups were directly exposed to the turbogenerator, including a member of parliament and advisor to the environment minister in the Netherlands, April 3; a transportation trade delegation from Cost Rica, April 7; and the Deputy Mayor of Paris, April 14. The turbogenerator is receiving particularly high interest from French transportation companies.

AlliedSignal continues to receive sponsorship positioning, visibility and benefits from the e-mail NewsNotes weekly publications.

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During this period, CALSTART's Executive Vice President, John Boesel, became the CALSTART person responsible for the over-all management of this program. Linda Wasley remains as the Contract Administrator and the primary point of contact. Laura Nelson was hired as the organization's first Chief Financial Officer. Both Glenn Perry and Josephina Panganiban, CALSTART personnel formerly involved with this project, have left the organization to pursue other career opportunities.

Overall objectives remain: *1) efficiently and responsibly manage the program and; 2) assist in the commercialization of the technology by doing the following: identifying potential strategic partners; explaining need and value of turbogenerator; reach important audiences for AlliedSignal; showcase technology at key conferences/briefings; raise technology profile via custom Web information; and extend AlliedSignal turbogenerator outreach efforts.*

Main Accomplishments

- Designed and delivered new industry exhibit featuring turbogenerator in prime location
- Designed phase 1 of interactive program to explain/educate about turbogenerator
- Took exhibit to several key conferences/trade shows, briefed on turbogenerator at dozens of others, created AlliedSignal briefing opportunities
- Designed custom Web site for turbogenerator, link from high traffic page

Increased Profile via World Wide Web

- CALSTART's Web site receives 250,000 hits per month
- AlliedSignal's turbogenerator receives prime positioning on home page, with direct link...

Increased Profile via World Wide Web

AlliedSignal

- ...to a distinctive and unique "home" page just for AlliedSignal's turbogenerator
- This greatly extends the reach of AlliedSignal's efforts

Your Best Information Source for Advanced Transportation Technologies

- News Center
- Clean Car Catalogs
- Industry Yellow Pages
- Fleet Resource Center
- Open Forum
- Recharge / Refuel Site Directory
- CALSTART Services
- Other Resources
- Classifieds
- Participants Only

We have a NEW look! Click scissors for details.

Our Mission:
Create an advanced transportation technologies industry and markets.

Our Technology Focus:
Electric vehicle, hybrid-electric vehicle, natural gas vehicle technologies and intelligent transportation systems.

Click Here!

Turbogenerator Power Systems for Tomorrow's Transportation Needs

What's Hot Today!	FAQs	Join CALSTART	Daily News Notes
Send Us Your Feedback!	Web Site Map	Advertising Opportunities	Electric Vehicles: An Industry Prospectus

SEARCH CALSTART SITE

- **Clean Car Catalog** - Get the specs on the latest clean vehicles available now or coming soon!
- **Industry Yellow Pages** - The business directory on the Net for advanced transportation companies/organizations.
- **Fleet Resource Center**- Our full-service web site for fleet managers interested in using clean vehicles in their fleets.
- **Open Forum**- Share your ideas publicly with other industry enthusiasts.
- **Recharge/Refuel Site Directory** - Locate the nearest EV charge or NGV refuel location nearest you.
- **CALSTART Services**- Find out how CALSTART's services can help your company or organization.
- **News Center** - The news resources you need to track this industry. Check Daily!
- **Other Resources** - Glossary, Technical papers, Legislation, related web sites and more!
- **Classifieds** - Find and list the hottest industry opportunities here. [NEW!](#)
- **Participants Only** - The latest FYIs, Insider Reports and open forum for CALSTART participants.

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The AlliedSignal TurboGenerator™ Power System

Dubbed "pint-size power plants" in a 1996 issue of Fortune Magazine, turbogeneration systems offer clean, quiet, cost-effective and portable energy generating capability. Their creation was inspired by the meshing of the best in U.S. aerospace technology with the nation's high-volume manufacturing capability.

Long a producer of turbine-powered electric generators for aircraft, AlliedSignal began studying ways to adapt turbo technology for other uses in the late 1980s, when we developed an electric power and water-heating cogeneration system for the U.S. Gas Research Institute.

The technology next found its way into an under-armor APU installed in U.S. Army tanks. From there, we began applying turbogeneration technology to **hybrid electric vehicles**. Our customers include the joint alliances of the U.S. Department of Energy and Ford as well as French automakers Renault and Peugeot. Their requirements? Low-cost, high-volume, energy-efficient units that are lightweight to boot.

Now, as we move into full-fledged production of the world's most promising small-scale power source, turbogeneration's greatest potential lies in the industrial arena. It is there that turbogeneration's economic and technological advantages can be put to best use today.

The **Allied Signal** turbogenerator is unique when compared to other power sources. The turbine, compressor, and permanent-magnet (PM) generator are all mounted on a single high-speed shaft that is supported on air bearings. Since air is used as the bearing lubricant, oil and the associated lubrication subsystems are not required. Additionally, since the generator is built into the shaft (and rotates at the same speed) no gearbox is required. This eliminates a considerable number of moving parts when compared to a conventional gas turbine or spark ignition engine. This significantly increases reliability and reduces cost. The only moving part is the shaft, shown on the front of this sheet.

The AlliedSignal turbogenerator approach has numerous advantages for automotive applications. Hybrid electric vehicles will require a source of auxiliary power that is low in cost, produces little if any exhaust emissions, consumes little fuel, exhibits high reliability, is small and compact, and operates quietly. The simplicity and design features of the AlliedSignal turbogenerator results in meeting these requirements.

A gas turbine using air bearings and a permanent magnet generator was first demonstrated by

AlliedSignal on the successful APU developed under the U.S.Army contract for the armored systems modernization program (ASM). AlliedSignal started this program in 1991, and the APU's developed have accrued over 600 operating hours in AlliedSignal laboratories and army vehicle tests. It was subjected to various tests, including: endurance, multifuel, sand and dust ingestion, shock and vibration, acoustic, and performance tests.

The turbogenerator is a recuperated gas turbine cycle that will achieve 30 to 35 percent cycle efficiency in the production configuration, depending on the recuperator size.

BEARINGS -The prototype turbogenerator has one moving part, the high-speed rotating shaft. The shaft is supported on a thin film of air generated by the compliant foil air bearings. These are hydrodynamic and do not require a source of pressurized air. They consist of two journal bearings to support radial loads, and two thrust bearings to support axial loads.

AlliedSignal has been developing compliant foil air bearings since 1957 and has incorporated this technology on over 45 types of aircraft and groundbased applications. AlliedSignal has produced over 14,000 foil air bearing turbomachines that have accumulated over 300,000,000 operating hours.

GENERATOR - The generator rotor, located in the middle of the shaft is a two-pole permanent magnet. The APU developed for the U.S.Army produces 20 kw at 66,200 rpm, and the production unit will produce over 50 kw at 80,000 rpm.

CATALYTIC COMBUSTOR - The catalytic combustor burns very lean fuel/air mixtures resulting in an adiabatic flame temperature below NO_x forming temperatures, while still attaining high combustion efficiency (>99.5%) in a small combustor. It is suitable for operation on unleaded gasoline, diesel fuel, alcohol fuels, and natural gas. The estimated emission levels are shown below.

	Nox gm/mi	CO gm/mi	HO gm/mi
1993 Standard	0.4	3.4	0.2S
ULEV	0.2	1.7	0.04
Turbogenerator*	0.016	0.11	0.004
EZEV Requirement*	.02	0.17	0.004

* Based on 0.35 kw-hr/mile, steady state conditions

CONTACT US!

For additional Information on AlliedSignal's turbo generator program, contact:

- AlliedSignal Power Systems Inc.
2525 West 190th St.
Torrance, CA 90503
Phone: (310) 512-4127
Fax: (310) 512-1561

www.AlliedSignal.com/aerospace

Conferences Highlighting Turbogenerator

CONFERENCE	DATE	AUDIENCE
• EVS-13	10/12-16/96	Auto/tech
• NAEVI	11/12-15/96	Auto/tech
• World Car Conf.	1/19/97	Policy/auto
• JETRO ★	1/27/97	Auto/tech
• So. Cal. Econ. Partnership	3/11/97	Industry
• Alt. Fuels Conf.	3/20/97	Fleet/policy
• UCLA ECO Conf.	4/11/97	Policy
• Adv. Trans. Industry Conf ★	4/17/97	Industry
• Sustainable Trans. Conf.	5/27/97	Financial

★- Featured Speaker

CALSTART Visitors

Exposed to Turbogenerator

AlliedSignal

Partial Listing

- Norwegian AFV group 11/5
- British Broadcasting Corp. 12/2
- Fox news Network 12/4
- Chinese trade delegation 12/6
- Swedish consulting group 1/7
- Chinese/Sichuon group 1/21
- Soc. of Environ. Engineers 1/24
- West Atlantic trade org. 2/27
- French transportation reporters 3/27
- MP, Netherlands briefing 4/3
- Costa Rican trade group 4/7
- Deputy mayor, paris 4/14

APPENDIX

CALSTART CONFERENCE MATERIALS

CALSTART Advanced Transportation Industry Conference
The Expanding Industry: New Players & Products
Burbank, California
Thursday, April 17, 1997
Agenda

- 8:00 a.m. **Registration/Continental Breakfast**
- 9:00 a.m. **Opening Remarks**
Michael Gage, CALSTART President and CEO
- 9:15 a.m. **CALSTART Briefings:**
Developing Market Segments, *Bill Van Amburg, Vice President, Communications*
Fleet Application Opportunities, *Susan Romeo, Marketing Director*
EV and NGV Buyer Cooperatives, *Alf Brandt, General Counsel*
CALSTART Program Updates, *John Boesel, Executive Vice President*
New CALSTART Programs, *John Boesel, Executive Vice President*
- 10:00 a.m. **Existing Players/New Market Strategies**
Claude Picard, Director of Marketing and Sales, Bombardier
B. Samra, Vice President, International Marketing, Taylor-Dunn
Kevin Barnes, Manager Product Sales, Unique Mobility
- 11:00 a.m. **Break/Networking**
- 11:20 a.m. **Changing Role of Traditional Automotive Suppliers**
Charlie Weinstein, Director Business Development and Operations, Allied Signal
- 12:00 p.m. **Lunch/Networking**
- 1:00 p.m. **Michael Shnayerson, Author of The Car That Could**
- 1:30 p.m. **Existing Players/New Market Strategies continued**
Antonio Prietto, Business Development Mgr., Mesa Pacific LNG
Carl Perry, Vice President, U.S. Electricar
- 2:30 p.m. **Break/Networking**

Tracking a New Industry™

CALSTART Advanced Transportation Industry Conference
The Expanding Industry: New Players & Products
Burbank, California
Thursday, April 17, 1997

Agenda

2:45 p.m. **Opportunities for Industry Training**
Gerald Geismar, Executive Director, Employment Training Panel

3:00 p.m. **Technology & Discussion Tracks (concurrent sessions):**

Heating, Ventilation, and Air Conditioning Systems

Facilitator: Bill Van Amburg, Vice President, Communications, CALSTART

Kevin Alston, President, Glacier Bay

Kaveh Khalili, Senior Engineer, Rocky Research

Greg Peterson, Vice President, Energy Management Systems Smart Power Systems

NGV Technologies

Facilitator: John Boesel, Executive Vice President, CALSTART

Paul Clifford, Director of Research and Development, Mosaic Industries

Sam Madonian, Vice President, Whittaker Controls

Paul Goodson, President, Engine Corporation of America

John Case, President, NGV USA

HEV Directions

Facilitator: Alf Brandt, General Counsel, CALSTART

Howard Longee, Project Manager, Vehicular Applications, Capstone Turbine Corporation

George Schuh, Manager, Production and Procurement, ISE Research

Ren Tubergen, Engine Program Manager, Moller International

Funding for Company Training: Securing Public Funds for a Training Program that Meets Your Needs

Steve Duscha, Partner, Steve Duscha Advisories

4:00 p.m. **Refreshments/Networking/Adjournment**

Tracking a New Industry™

CALSTART Advanced Transportation Industry Conference
The Expanding Industry: New Players & Products
April 17th, 1997
Speaker Biographies

Claude Picard Bombardier, Inc.

Claude Picard is the Marketing Director and Project Coordinator for Bombardier's Motorized Consumer Products Group in Sherbrooke, Quebec. His energies are focused toward identifying emerging markets for innovative products, such as the Neighborhood Electric Vehicle. Most recently, his priority has been planning the NEV's product launch, including establishing a network of dealers and service centers and developing strategies for advertising and public relations campaign.

Claude is a member of the Institut d'Ingenierie Simultanee, the Quebec Order of Professional Engineers, and the American Marketing Association. He also serves as President and Chairman of Liaison Design, a Montreal-based non-profit organization dedicated to the promotion of design professionals. Claude Picard holds a bachelor's degree of applied sciences in mechanical engineering and a master's degree in business administration, both from Sherbrooke University in Sherbrooke, Quebec.

Balwinder Samra Taylor-Dunn Manufacturing Company

Balwinder Samra is the Corporate Vice President of Marketing and Sales at Taylor-Dunn Manufacturing Company. His responsibilities include developing new markets for on and off-road utility vehicles. In 1990, he joined Taylor-Dunn as Vice President of Operations, responsible for the development of new products that address off-road utility vehicle markets. During the development process, he identified a market niche for on-road vehicles for distribution applications in developing countries. In 1993, he had a major breakthrough in addressing this niche in Mexico, which resulted in fleet sales of 400 vehicles in Mexico City.

Kevin Barnes Unique Mobility, Inc.

Kevin A. Barnes is the Manager of Product Sales at Unique Mobility, Inc. He is responsible for worldwide product sales and much of the marketing and contract services programs for the company. After joining the company in October of 1988, Mr. Barnes pioneered the company's entrance into the electric traction drive market through the sale of brushless permanent magnet motors and controllers for the solar racing market and later, through the sale of products for electric and hybrid/electric vehicle traction drives and systems. He received his B.S. in Power, Instrumentation and Control and his minor in Alternative Energy from the Colorado School of Mines.

Charles Donnelly 3M Company

Charles Donnelly is the Program Manager of the lithium polymer battery contract at the 3M Company. This contract was awarded to 3M/HydroQuebec/Argonne National Laboratory in December of 1993. The purpose of this initiative was to develop advanced batteries for electric vehicles. Prior to this assignment, Mr. Donnelly managed programs in the Magnetic Media and Data Storage divisions of 3M.

Charles H. Weinstein AlliedSignal, Inc.

Mr. Weinstein is the Director of Business Development and Operations for AlliedSignal TurboGenerator Systems. His responsibilities include the business development and marketing of the turbogenerator for industrial power generation and hybrid electric vehicles.

Prior to coming to AlliedSignal, Mr. Weinstein worked at Rocketdyne and Marquardt. Mr. Weinstein holds a B.S. and M.S. in Mechanical Engineering from Cooper Union and the University of Southern California, respectively.

Michael Shnayerson Author: The Car That Could

Michael Shnayerson is the author of the book, The Car That Could. He has been a long time contributing editor to both Vanity Fair and Conde Nast Magazines. In 1991, Michael was considering a unique approach to a cross-county trip he was planning. While doing research for his journey, he became aware of the General Motors Impact program. Sensing a unique moment in automotive history, Mr. Shnayerson approached GM in 1992, with the idea of following the progress of their efforts to produce an electric car. In a highly unusual decision, General Motors agreed to his proposal. For the next three years, Michael was allowed to observe the internal functions of the EV1 program and record his observations in The Car That Could. Michael received his bachelor's degree from Dartmouth. He is the author of a biography of the writer Irwin Shaw. He lives in Sag Harbor, New York.

Antonio J. Prietto Mesa Pacific LNG

Antonio J. Prietto is the Business Development Manager responsible for new LNG business activities for both vehicle and stationary applications. Mr. Prietto has over 12 years experience in the natural gas industry focusing on various end uses, with the last 3 years dedicated to vehicle and LNG applications. Mr. Prietto received his B.A. from Gonzaga University and his B.S. in Engineering from California State University at Los Angeles.

Carl Dean Perry U.S. Electricar

Carl Dean Perry is the Executive Vice President and a member of the Board of Directors of U.S. Electricar. Previously, Mr. Perry served as Executive Vice President of Canadair Ltd., Canada's largest aerospace corporation. Mr. Perry served as Executive Vice President of the Howard Hughes Helicopter Company, now known as McDonnell Douglas Helicopters. In these positions, he was responsible for general management, worldwide business development, international operations, and joint ventures.

Gerald G. Geismar California Employment Training Panel

Mr. Geismar is Executive Director of the California Employment Training Panel. He is responsible for the administration and operation of one of the state's major workforce training programs. Prior to being appointed to his present position by Governor Wilson in 1992, Mr. Geismar spent 40 years in the aerospace industry, most of them with TRW.

Currently, Mr. Geismar is a board member of the California Manufacturing Technology Center, the Corporation for Manufacturing Excellence, the Industry Education Council of California, CalSkills-Alliance for Transportation Technology Training, CalEd, and is a member of the Project California Select Panel, and the California Defense Conversion Council. Mr. Geismar received a B.S. in Electrical Engineering from Union College in Schenectady, New York, and an M.B.A. from Columbia University.

Kevin Alston Glacier Bay, Inc.

Kevin Alston is the President and founder of Glacier Bay, Inc., a leading manufacturer of high efficiency and battery-powered mobile cooling products. The company was formed in 1990 as a manufacturing entity for TACK Corporation and has since become the preeminent international supplier of DC-powered thermal storage refrigeration systems to the marine market.

Glacier Bay is currently working under a DARPA contract to apply its high efficiency cooling technologies to mobile air conditioning for EV's. Mr. Alston's previous business credits include the founding of CLP, a \$20M construction employment company. He was previously employed by Kawasaki in speed development work on two and four stroke internal combustion engines.

Kaveh Khalili Rocky Research

Kaveh Khalili joined Rocky Research as a Senior Engineer in August of 1991. He has managed several solid-vapor projects especially the Air Force, NASA, and DOE residential heat pump development. Prior to coming to Rocky Research, Mr. Khalili worked at Stirling Thermal Motors in Ann Arbor, Michigan. He has strong background and extensive experience in thermodynamics and development of thermal devices.

While at Stirling Thermal Motors, Mr. Khalili was deeply involved in design, fabrication, and testing of heat pipes/Stirling cycle heat pumps and engines. He has earned Masters of Science in Mechanical Engineering from the University of Michigan in Ann Arbor 1986 and his B.S.M.E from the University of Michigan in 1984.

Gregory Peterson Smart Power Systems

Gregory Peterson is the Vice President of Energy Management Systems at Smart Power Systems. His responsibilities are developing a new low pressure, two stage centrifugal modular electric a/c system for mobile and non-mobile applications and developing a new pressure-regulated, flow sensing, variable orifice valve for vapor-compression a/c systems.

Prior to joining Smart Power Systems, Mr. Peterson has had over twenty years of experience in thermal and air management systems. He was also the Manager of HVAC, engine cooling, and aerodynamics for General Motors and the Program Manager at GE Plastics. He received his B.S. in Mechanical Engineering from General Motors Institute and conducted his graduate studies in Management Science.

Paul Clifford Mosaic Industries, Inc.

Paul Clifford is the Director of Research and Development at Mosaic Industries, Inc. Since co-founding Mosaic Industries in 1985, Dr. Clifford has directed research aimed at the development of true artificial olfaction: the rapid and low-cost electronic identification and measurement of aromas and odors. This has required improving the characteristics of chemical sensors by computationally enhancing their performance.

He has designed instruments that extract steady state and spectral information from arrays of chemical sensors and applied novel nonlinear analysis, neural network, and chemometric techniques that process these responses to achieve reliable and selective gas detection. Mosaic Industries markets several compact real-time instruments for selective gas analysis. He received a B.S. in Physics and Electrical Engineering in 1976, an M.S. in Measurement and Control in 1977, and a Ph.D. in Electrical Engineering in 1981 from Carnegie-Mellon University.

Vahe S. Madonian Whittaker Controls

Vahe S. Madonian is the Vice President of Engineering at Whittaker Controls and has more than 33 years experience with cryogenic control components, and fuel and hydraulic systems and components on military and commercial aircraft. He is responsible for all fuel, hydraulic, quick-disconnect and ground refueling products programs. He has extensive experience in managing as well as designing and developing fuel and hydraulic valves products.

Prior to joining Whittaker Controls, Mr. Madonian spent 13 years with ITT General Controls, Aerospace Products Division, where he was Section Manager of the Design Engineering Department. Before that, he was Chief Project Engineer for Vacco Industries, Space Division. His training and education are from the University of Southern California and the Northrop Institute of Technology

John Case NGV/USA

John H. Case is the President and one of the original founders of NGV/USA, Inc. Formed in 1993, NGV/USA, Inc. develops innovative natural gas vehicle designs and fuel storage systems. The company recently completed the world's first long-range natural gas vehicle by redesigning the chassis of a Chrysler Dodge Ram van to accommodate additional fuel storage.

John Case also brought the country's first bicycle commuter facility to the City of Long Beach as part of an intermodal Metropolitan Transportation Authority project. Mr. Case received a bachelor of arts degree from the University of Denver and attended the MBA program at Pepperdine University in Los Angeles.

Howard Longee Capstone Turbine Corporation

Howard Longee is the Project Manager of Vehicular Applications at Capstone Turbine Corporation. His responsibilities included developing a 45kW turbogenerator and developing vehicular applications. Prior to joining Capstone Turbine, Mr. Longee worked for the Allied Signal Corporation as the Business Manager/Program Manager to develop new products and coordinate with major customers.

He has also worked as an Associate Director, Operating Contractors Project Office for the Department of Energy where he was responsible for system engineering and the Recycle and Assembly Facility for the Gas Centrifuge Uranium Enrichment Program. Mr. Longee received his B.S. in Electrical Engineering, with high honors, at Southern Methodist University in Dallas, TX.

George Schuh ISE Research

George Schuh is the Production and Procurement Manager for electric and hybrid vehicles at ISE Research. His primary responsibility at ISE Research is to oversee the management of production and the purchase, acquisition, and management of installation of all components in the company's hybrid and electric vehicle prototypes and production vehicles.

Before joining ISE, Mr. Schuh worked at Sandia National Laboratories as an electro-optical engineer specializing in optical computing/vision recognition and processing for autonomous decision making in robotics system applications. He has also worked for companies such as AT&T Bell Labs and AlliedSignal Corp., and has worked as an engineering assistant/prototype assembly worker for an all-terrain vehicle designed for the rigorous climate of the Alaskan slope.

Renard Tubergen Moller International

Renard Tubergen is the Engine Program Manager at Moller International, a research and development organization with over 30 years of history. Moller's R&D efforts have included: SuperTrapp exhaust systems, continuously variable transmissions, electronic control and stability systems for fly-by-wire aircraft, and two current areas of interest: VTOL vehicles and rotary engines.

Dr. Tubergen was previously the Director of Engineering Services at Engineering Methods located in Indiana where he provided software support and training for the ANSYS finite element program. Dr. Tubergen has a MSE and Ph.D. from Purdue University.

Steve Duscha Steve Duscha Advisories

Steve Duscha is a Partner at Steve Duscha Advisories. His responsibilities include consulting in workplace training and government relations. Clientele consists of businesses, business associations, community colleges, and training vendors. In addition, Mr. Duscha is the publisher of *Steve Duscha Advisories*, a monthly guide to the California Employment Training Panel. The guide contains reports on policy, trends in contracting, contract effectiveness, a database of employers, types of training, costs, and training vendors.

Prior experience includes the Employment Training Panel, The California Worksite Education and Training program, and the Governor's Office in Sacramento. Mr. Duscha is a co-author of a study of national training programs conducted for the U.S. Congress, Office of Technology Assessment, and has also authored its annual updates. Mr. Duscha's background also includes being the lead manager for a government study of Hong Kong's retraining program.

**CHANGING ROLE OF TRADITIONAL
AUTOMOTIVE SUPPLIERS**

**CHARLES H. WEINSTEIN
ALLIED SIGNAL TURBOGENERATOR SYSTEMS
PRESENTED AT CALSTART**

APRIL 17, 1997

\$14.0 Billion

1996 Sales

**AlliedSignal
Inc.**

76,600

Employees Worldwide

AlliedSignal Aerospace

**AiResearch • Bendix •
Bendix/King • Garrett**

Tradenames

- Aerospace Equipment Systems
- Commercial Avionics Systems
- Government Electronic Systems
- Engines
- Marketing, Sales & Service

\$5.7 Billion

AlliedSignal Automotive

**Bendix • Garrett •
Autolite • Fram**

Tradenames

- Brake Systems
- Safety Restraint Systems
- Turbochargers
- Friction Materials
- Filters & Spark Plugs

\$4.2 Billion

*AlliedSignal
Engineered Materials*

**Aquatech • Metglas •
Norplex Oak • AC**

Tradenames

- Fibers
- Chemicals
- Plastics
- Advanced Materials

\$4.0 Billion

SUBJECTS

- CERAMICS

- CATALYSTS

- FUEL CELLS

- TURBOGENERATORS

SUBJECTS

- CERAMICS

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Engine Programs Provide Experience to Apply Ceramic Technology to Production

85 Ceramic Nozzle Program Demonstrates Long-Term Durability

Turbine Nozzle Segment

Completed

- 21,000+ hours and 10,000 starts
- Nine 85-98DHF APUs fielded on MD-80
- Four military ground carts fielded
- >7,500 hours on high-time set
- Received over 1000 nozzles

Planned

- 65,000 hours of commercial field testing with 15 units

331-200[CT] Ceramic Turbine Program Demonstrates Axial Nozzle and Blade

Turbine Blade

Turbine Nozzle Segment

Completed

- 900 hours and 2,500 starts nozzle engine testing
- Blades completed three successful starts

Planned

- 7000 hours of endurance testing
- 40,000 hours of commercial field testing with 10 units

G250 Program Demonstrates High Temperature Nozzle Performance

First Engine Test Successfully Completed

Advanced Ceramics Offer Cost, Reliability, and Weight Advantages

Initiatives

- Replace metallic wheel with silicon nitride wheel
- Reduce weight of radial containment
- Rotor brake utilizing friction materials replaces axial cutter assembly
- Hybrid bearings

Technology Issues

Reduce manufacturing cost

- Near net shape forming of silicon nitride
 - Gel casting
 - Aqueous injection molding
- Low cost ceramic machining
- Low cost ceramic/metal attachments

Containment design not optimized for ceramic wheels

Benefits

- Silicon nitride wheel demonstrated 50% reduction in containment weight
- Hybrid bearings are exhibiting high reliability under low lube conditions

Starter 2000

Industrial Turbine Ceramic Blades

- Initial Blades Bisque Machined
- Formed in Hours

- Aqueous Injection Molded
- Formed in Minutes

**Ceramics Key to Additional Industrial
Power Efficiencies in the Future**

Commercialization Complex Shaped Components

**Gelcasting Manufacturing
Large
Thick Crossection**

**Aqueous Injection Moulding
Thin Crossection**

Products Incorporating Ceramic Components

Within AlliedSignal					Year
Brake System	731 Lube Oil Modules	APU	Starter 2000		
Other Seal Runners					
Outside AlliedSignal					Year
		Missile	Helicopter	Turbogenerator	2000
	GE F110		Industrial Turbine		1999
					1998
					1997
					2001

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AlliedSignal Activity in Automotive Exhaust Purification and Gas Turbine Catalytic Combustion

- **Active in Development of Catalysts for Purification of Automotive Exhaust since 1958.**
- **AlliedSignal Environmental Catalysts (ASEC) is Second Largest Supplier Worldwide of Automotive Exhaust Purification Catalysts from Plants in Tulsa, France and Mexico City.**
- **AlliedSignal Environmental Catalysts and General Motors formed a Joint Venture.**

- **AlliedSignal R&T is Currently Developing Combustor Catalysts for Use in Automotive Gas Turbine Engines.**
- **AlliedSignal R&T is participating with Garret S.A. and ASAC S.A (ASEC) in the French/Swedish AGATA Program.**
- **AlliedSignal R&T is participating with Aerospace and Automotive in the AGATA, French VERT and FORD/DOE Programs.**

Catalytic Combustor

VEHICLE EMISSION STANDARDS

	NOx gm/mi	CO gm/mi	HC gm/mi
1993 STANDARD	0.4	3.4	0.25
ULEV	0.2	1.7	0.04
TURBOGENERATOR*	0.014	0.067	0.004
EZEV	0.020	0.17	0.004

* Based upon 0.240 kw-Hr/Mile

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PRODUCTS IN

**UNDER ARMOR APU
DEVELOPMENT FUNDED
UNDER THE US ARMY CCATD
PROGRAM**

**DEVELOPMENT TESTING IS
CONTINUING WITH ARMY FUNDING**

**APU WILL BE DEMONSTRATED IN THE
M1 TANK**

DUAL USE PRODUCT WILL RESULT

TRANSITION

**CCATD DEVELOPMENT DESIGN PLANNED
FOR INITIAL AUTOMOTIVE PROTOTYPE
DEMONSTRATIONS**

**PRODUCT DEVELOPMENT THROUGH
DEFENSE CONVERSION FUNDING
DOE AND ARPA**

AlliedSignal Turbogenerator Program

Aerospace Systems & Equipment

Evolution of Automotive Turbogenerator

Aerospace Technologies

- Air bearings
- Permanent Magnet Generators
- Recuperators
- Combustors

Military APU

Hybrid Electric Vehicle Power Unit

Automotive Experience

- Turbocharger Manufacturing (Garrett)
- Filter Manufacturing (FRAM)
- Catalyst Production
- Charge Air Coolers (Garrett)

Turbogenerators Benefit from AlliedSignal Technologies

TECHNOLOGY

- AIR BEARINGS
- PERMANENT MAGNET MOTORS AND GENERATORS
- RECUPERATORS
- CATALYTIC COMBUSTORS
- CERAMICS

BENEFIT

NO OIL SYSTEM, HIGH RELIABILITY

ELIMINATES GEAR BOX AND SEPARATE STARTER, HIGH EFFICIENCY

LOW FUEL CONSUMPTION

ULTRA LOW EMISSIONS

HIGH PERFORMANCE, LOW WEIGHT

Prototype Turbogenerator Plate Fin Recuperator

M-03757A.PPT

Turbogenerator Manufacturing Plan

AlliedSignal Will be the Market Leader in Commercial Turbogenerators

Strengths are Numerous

- Product Depth
- Automotive Volume Capability
- All Key Technologies are In-House
 - Air Bearings
 - Catalytic Combustor
 - High-Speed Generator
 - Ceramic Components

**ALLIEDSIGNAL IS UNIQUE IN HAVING BOTH THE TECHNOLOGY AND
THE POTENTIAL FOR LOW COST, HIGH VOLUME PRODUCTION**