Education for the Manufacturing Industries of the Future

presented to the

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Gerry Graves, Ph.D.
Sr. Vice Pres.
Advanced Technology Institute
Charleston, SC
http://www.aticorp.org

Outline

- Background – need for manufacturing R&D initiatives
- The international Intelligent Manufacturing Systems (IMS) Program
- The national Next Generation Manufacturing Technology Initiative (NGMTI)
- Conclusion

Core Message

Assumptions

1. ***New manufacturing technologies are essential to the long-term viability of the U.S. industrial base.***
2. ***The continued adoption, growth and use of these technologies depends on an educated and motivated workforce.***

New Technology Transition Models are needed for today's globally competitive environment.

Manufacturing is the engine that drives American prosperity. It is central to our economic security and national security.

- **Economic Growth. Every $1.00 in manufactured goods generates an additional $1.43 worth of additional economic activity - more than any other economic sector.**
- **Invents for the future. Manufacturers are responsible for almost two-thirds of all private sector R&D, which ultimately benefits other manufacturing and non-manufacturing activities.**
- **Internationally competitive. The United States is the world's largest exporter; 62 percent of all U.S. exports are manufactured goods, double the level of 10 years ago.**
- **Productivity increases. Over the past two decades manufacturing productivity gains have been double that of other economic sectors. These gains enable Americans to do more with less, increase our ability to compete and facilitate higher wages for all employees.**
- **Rewarding employment. Manufacturing compensation averages more than $63,000, the highest in the private sector, and manufacturers are leaders in employee training.**
- **Pays taxes. Manufacturing has been an important contributor to economic growth and tax receipts at all levels of government, contributing one-third of all corporate taxes collected by state and local governments.**

The Need for Advanced Manufacturing Initiatives in the U.S.

- Manufacturing in the USA is being challenged:
  - Sharpened competition from low cost imports
  - Impacted 2.3 million jobs over the last 3 years
- Investment in both basic and applied manufacturing science and technology is decreasing
- Uncertainties in the global supply chain introduce risks
- Manufacturing companies are primarily focused on the short term, bottom line
- Our trade imbalance is increasing as more manufacturing is being “off-shored”

Offshoring innovation is the real threat.

What is the Intelligent Manufacturing Systems (IMS) Program?

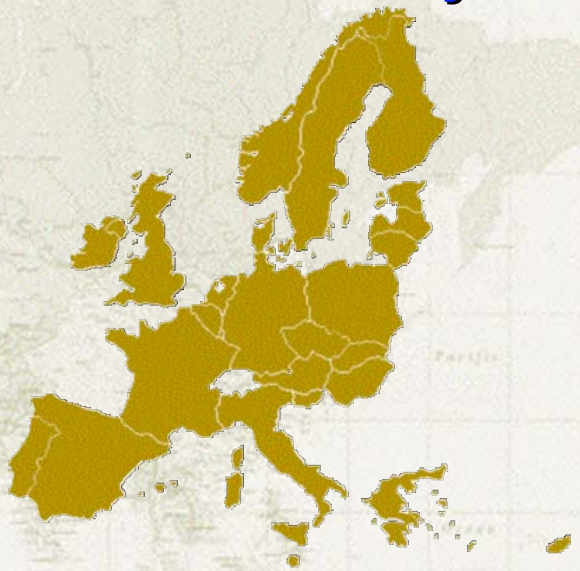
- An industry-led, global, collaborative manufacturing R&D program involving…
  - Large & small companies
  - Users & suppliers
  - Universities & research organizations
  - Governments
- Conceived in 1989
- Phase 1: 1995 – 2005
- Seven member regions
- Phase 2: 2005-2015

Member Countries

Japan

Canada

European Union
And Norway



Korea

United States
of America

Australia

Switzerland

The IMS Vision

- Enable greater sophistication in manufacturing operations
- Improve the utilization efficiency of resources (renewable & non-renewable)
- Enlarge & open world-wide markets
- Disseminate results of IMS projects and transfer knowledge
- Significantly enhance the quality of life in the world community through new product creation
- Advance manufacturing professionalism
- Improve the quality of the manufacturing environment & the global environment

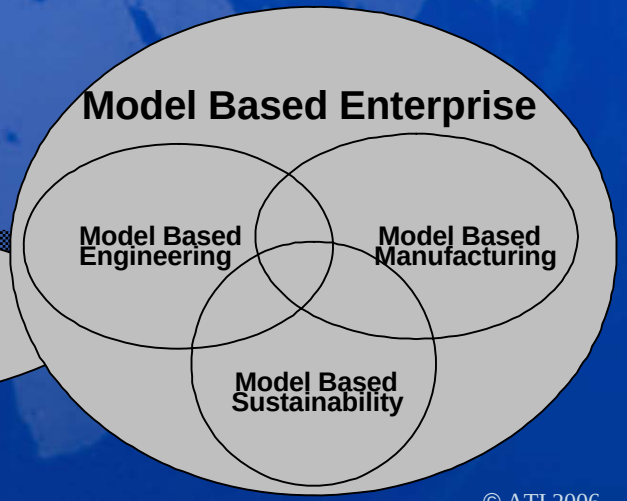
Proposed U.S. IMS Projects Phase 2

- Model Based Enterprise (MBE) for the Electro-Mechanical (EM) Industry
- Sustainable Product Initiative (SPI)
- Radio Frequency Identification (RFID)
- Manufacturing business process Pattern Ontologies for the *extended* Service-oriented Enterprise (MPOSE)

Model Based Enterprise for the Electro-Mechanical (MBE – EM) Industry

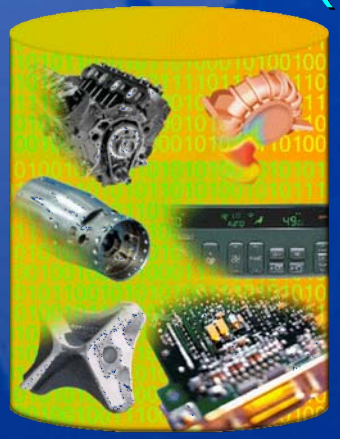
- Total life cycle costs are driven by decisions made during the development phase
- Need to focus on the tools, and their interoperability, and methods to optimize design, effective manufacturing, and supportability
- MBE is defined as the linkage in model based engineering, manufacturing, and sustainability
- Rockwell, Boeing, Raytheon, and other U.S. companies have already begun work on the project

In the future, designers & customers interact in an immersive environment to explore and evaluate options based on modeling, simulation, optimization, and visualization techniques.



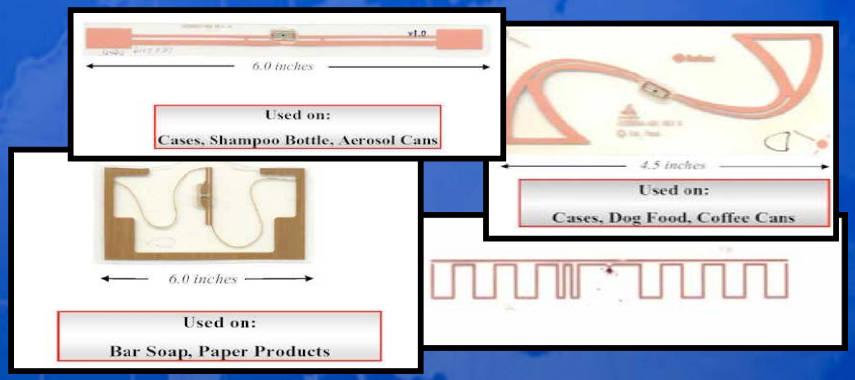
Sustainable Product Initiative (SPI)

- The environmental impact of the ***products*** of some industries is greater than the impact of the ***processes*** used to manufacture them.
- The SPI is looking for market-based incentives to mitigate the impacts of products.
- Work is now under way in several sectors, including automotive, aerospace, furniture, building and construction materials, batteries, coatings, and others.
- Biggest project is material substitution data base (to locate more sustainable materials)



Radio Frequency Identification (RFID)

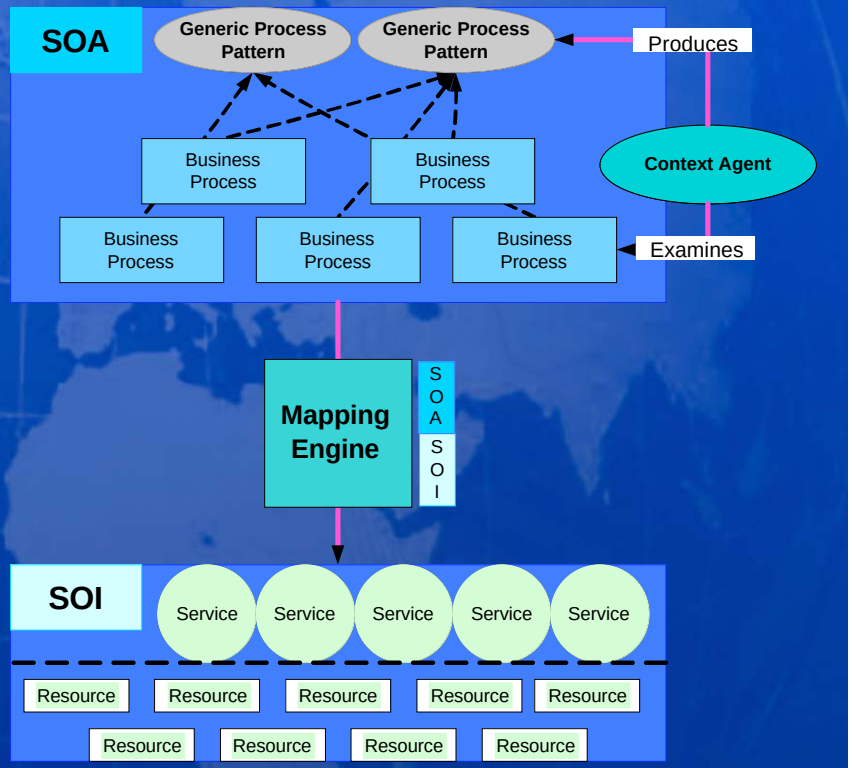
- RFID technology (hardware, software, & services) will reach $6.1B by 2010
- RFID encompasses 4 types of standards:
  - Technology Standards
  - Data Standards
  - Conformance Standards
  - Application Standards
- Project will focus on:
  - Global compatibility
  - Global research agenda
  - Logic & data collection development
- Potential Partners (U.S. Region):
  - Interactive Mobile Systems, Inc
  - Symbol Technologies
  - IDENT-Net
  - I-Mobile Systems
  - Code Plus
  - Acsis Inc.
  - LXE Inc.



Manufacturing business process Pattern Ontologies for the *extended* Service-oriented Enterprise (MPOSE)

A robust set of formally defined business process templates to vastly improve the integration speed, reliability and maintenance of manufacturing and supply chain IT systems.

- U.S. project team defining technical task details
- Team members include:
  - Intel
  - Arizona State University
  - TopQuadrant, Inc.
  - Visual Knowledge, Inc.
  - NIST
- Participants from other regions are being solicited
- Web-based collaborative work environment (CWE) is being established to enhance distributed collaboration



Ontology: A computer-readable set of definitions of terms, relationships, and the logic rules that describe behavior

Global Education in Manufacturing (GEM) Deployment in the U.S.

- Identified U.S. educational point of contact – Professor Tom Kurfess of Clemson University
- Attended Education Working Group Meeting in Leuven, Belgium, in Nov 05
- Curricula content currently being reviewed by several other U.S. universities – Massachusetts Institute of Technology, Purdue University, etc.
- Planning a national summit to review and discuss GEM deployment opportunities throughout the U.S.

U.S. On-going Plans include …

- Conducting workshops and forums to allow businesses to learn how to position themselves in a global economy
- Continuing to support the creation of “what’s next” and technical infrastructure projects that lead to timely decision making
- Focusing on the global needs of the community and the workforce
- Influencing government understanding of the global dynamics of competition, collaboration, and trade

NEXT GENERATION MANUFACTURING TECHNOLOGY INITIATIVE℠

A U.S. Initiative

Next Generation Manufacturing Technology Initiative will…

- Energize a consensus for a U.S. manufacturing technology investment strategy
- Initiate the transformation of the U.S. industrial base by investing in high-leverage, high-impact manufacturing technologies
- Facilitate increased innovation, productivity and competitiveness enabling rapid delivery of advanced systems
- Support a reduction in the trade deficit

NEXT GENERATION MANUFACTURING TECHNOLOGY INITIATIVE℠

Technology and Technical Approach

Thrust Areas

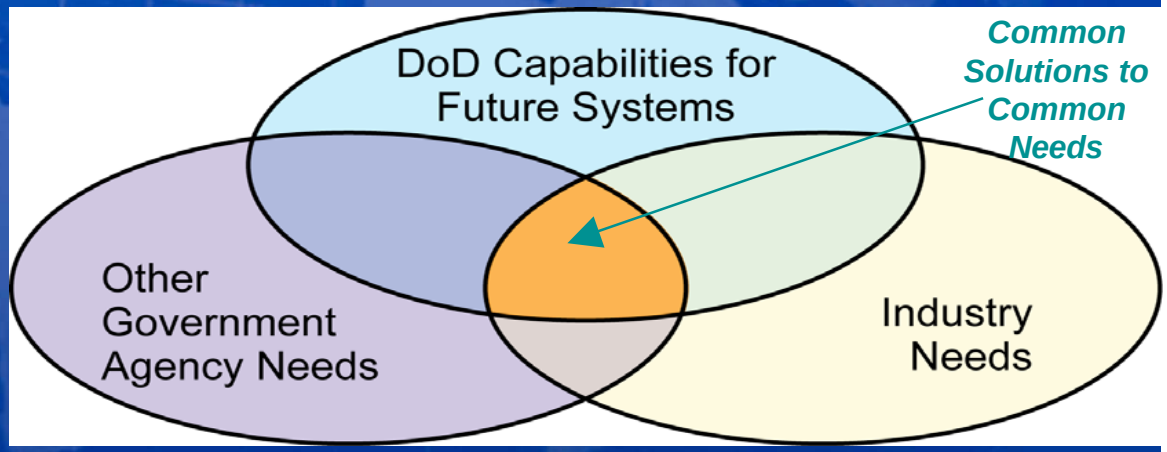
- Emerging Process Technologies
- Model-Based Enterprise
- Intelligent Systems
- Enterprise Integration
- Knowledge Applications
- Safe/Secure/Reliable Manufacturing Operations

Technical Approach

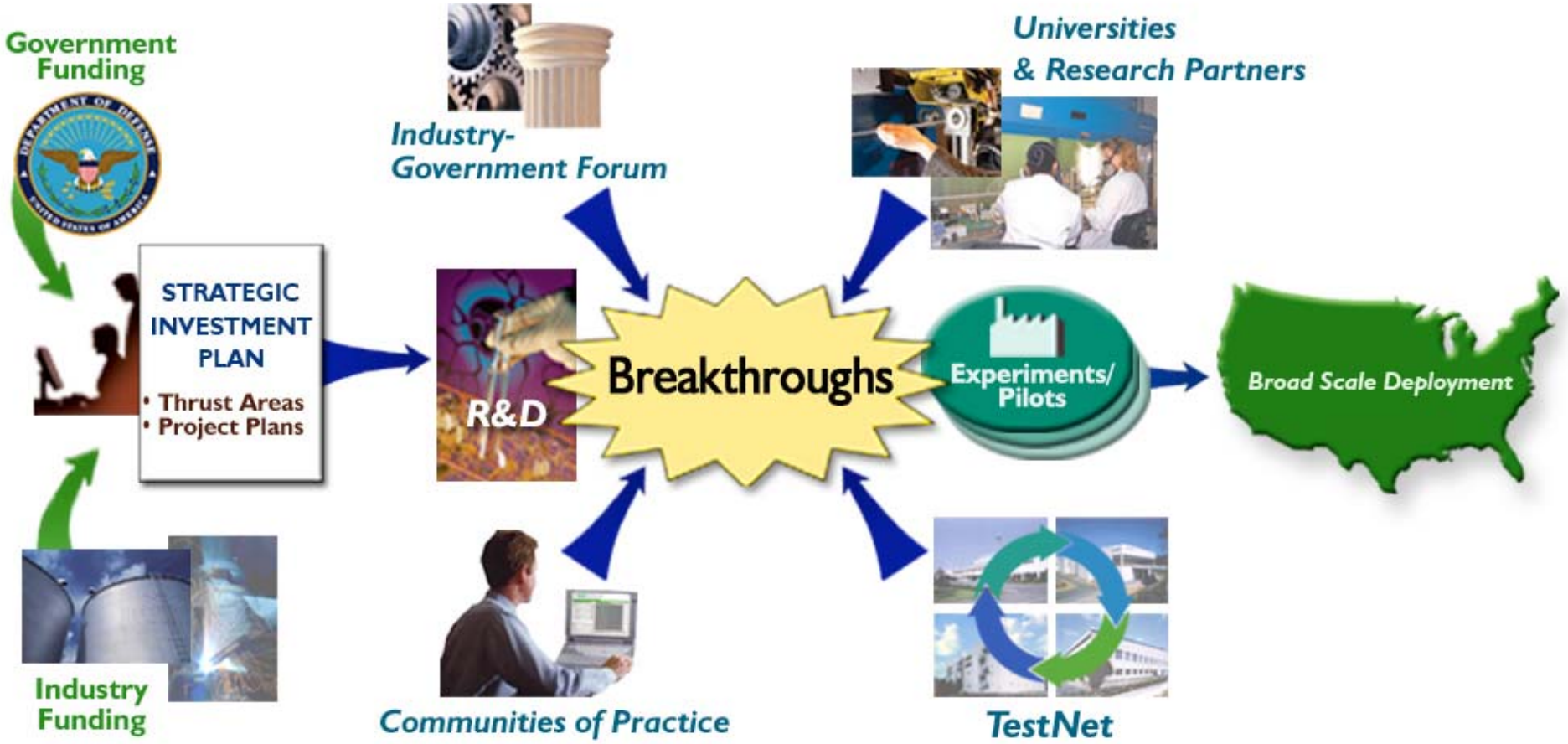
- Develop Technology Roadmaps
- Create Strategic Investment Plans
- Value-Based Prioritization of Key Goals
- Develop Focused White Papers
- Form Teams and Launch Projects

Results/Relevance

- Breakthrough, transformational technologies that radically improve design and manufacturing
- Improve affordability and sustainability, reduce cycle time
- Create innovative opportunities for fast-response manufacturing of new products



NEXT GENERATION MANUFACTURING TECHNOLOGY INITIATIVE℠



Evolving List of "Significant" Emerging Technologies

- Product-Embedded sensors
- Electro-optic sensing
- Wide-band electronics
- Affordable fuel cell component manufacturing methods
- Low-cost titanium and processing methods
- Friction-stir welding of Al, Fe, Ti
- Digital-Direct manufacturing (advanced freeform)
- Microdrilling of shaped precision holes
- Manufacturing methods for long-length superconducting wire
- Defect-free thin wall investment casting technology
- Small-infrastructure, low-energy primary metal manufacture
- Integrated unit manufacturing & materials process models and simulation tools
- Computational materials development
- Automated manufacturing process planning
- Nanometer additives to polymers
- Nanoscale manufacturing methods
- Nanoscale multifunctional coatings
- Microfabrication of electro-mechanical devices (MEMS)
- Plastic composite material systems
- Affordable, lightweight structural composites manufacturing
- Microreactors for chemical processing
- Net shape, flashless forming of plastics and metals
- Multi-functional film coating systems to replace traditional painting
- Environmentally benign paint and coating stripping methods
- In-mold coating methods for net-finished product
- Joining and adhesive technology for rapid assembly
- 95% recyclability and biodegradability
- Modular machine tools and tooling for low-lot manufacturing
- Intelligent machine tools
- Sensor technologies as a broad topic (microscale, affordable, reliable)

NGMTI projects

- Friction Stir Joining Technology
- Digital Direct Manufacturing
- Low-Cost Titanium Production
- Affordable, Lightweight Large Structural Composites Manufacturing
- Improvements for Investment Castings
- Advanced Casting Processes
- System-of-Systems Modeling
- Shared Model Libraries
- Model-Based, Real-Time Factory Operations
- Product-Driven Product & Process Design
- Multi-Enterprise Collaboration
- Model-Based Distribution
- Configuration Management for the Model-Based Enterprise
- Hybrid Bearing Manufacture
- High-Frequency Laser Machining
- Thin-Film Coating for Paint Elimination
- Manufacturing Applications for Carbon Nanotubes
- Improved Thin-Film Processes for Semiconductor Fabrication
- Precision Optical Finishing
- Nanomaterials for Glass Coatings
- Model-Based Resource Management
- Model-Based Product Life-Cycle management
- Intelligent Models
- Flexible Representation of Complex Models
- Enterprise-Wide Cost Modeling
- EM -- MBE

What's wrong with this picture?

An Innovative and Comprehensive Approach:

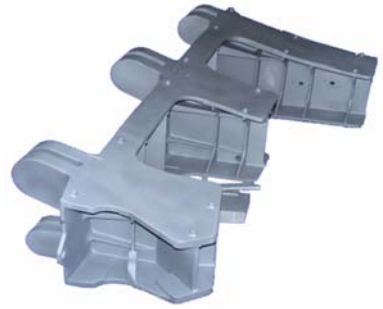
- **Building on national educational programs**
- **Linking Technology Programs to Innovation Labs and education programs in Universities**

An educated and motivated workforce

Conclusion

- **While U.S. manufacturing is diminishing …**
  - **More aggressive participation in IMS will improve our position in the global marketplace**
  - **Programs like NGMTI will help re-energize our competitiveness**
  - **Establishing strong, effective relationships with the education and university research community will help to solidify our future position as a nation**

Innovation in products, manufacturing technologies and processes, and business models is the path to remaining globally competitive



PROJECT OBJECTIVE

Fighter engine costs need to be reduced. Castings comprise ~1/3 of the engine component costs. In producing castings, the inspection, rework and scrap is ~35% of the casting cost.

This project is to upgrade the inspection systems to digital radiography and incorporate the standard e-process with all jet engine and casting suppliers. By qualifying and implementing digital radiography, we can reduce inspection expenses and cycle times. Quality issues can be handled instantly across the country. In addition, environmental concerns and increasing cost of silver from x-ray films is reduced.

Advanced Aerospace Castings – Digital Radiography

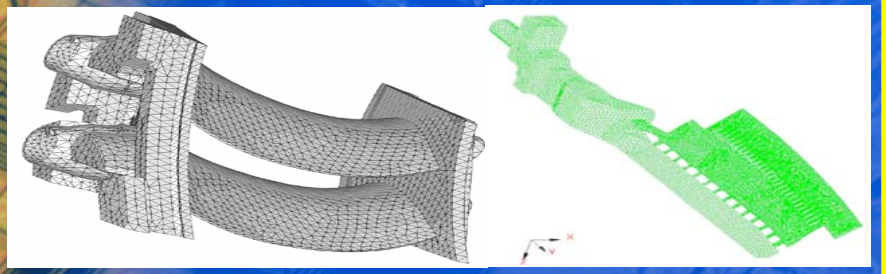
PROJECT TEAM

AFRL	RALDEN
Belcan	Rolls-Royce
GE	Pratt & Whitney
USAF	Belcan
Boeing	Howmet
PCC	Army/ARL

ROI > %

Turbine Blade

Digital Image of Internal Walls



PROJECT OBJECTIVE

New 3D designs and the introduction of non-metallic components require gentler, higher speed dimensional data systems. Current systems of CMM require a compromise of data points with cycle time. The new light and laser gages offer more data collection at faster rates without touching the parts or needing expensive fixturing.

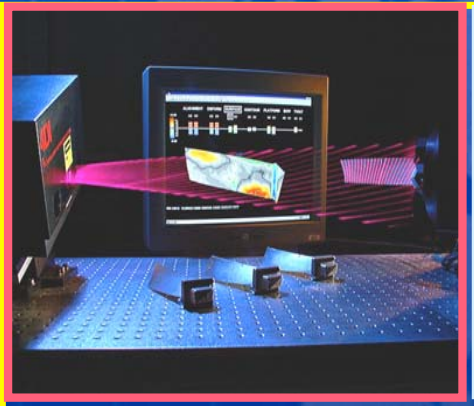
The goal of this project will be the establishment of industry standards and methodologies for non-contact 3D inspection techniques. Data format, transfer/exchange and engine supplier acceptance criteria will be addressed.

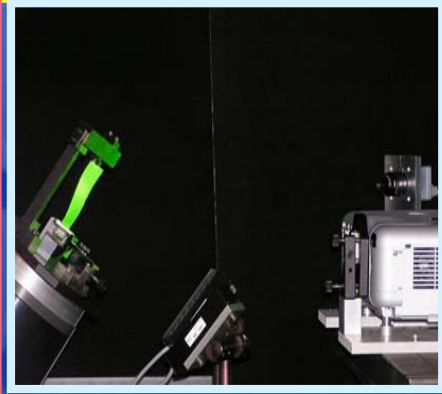
Advanced Aerospace Inspections

PROJECT TEAM

AFRL	RALDEN
Belcan	Rolls-Royce
GE	Pratt & Whitney
USAF	Belcan
Boeing	Howmet
PCC	Army/ARL

ROI > %





Light and Laser gaging systems

PROJECT OBJECTIVE

Provide the critical technologies for the development, specification, demonstration and deployment of manufacturing capabilities which result in affordable fuel cells.

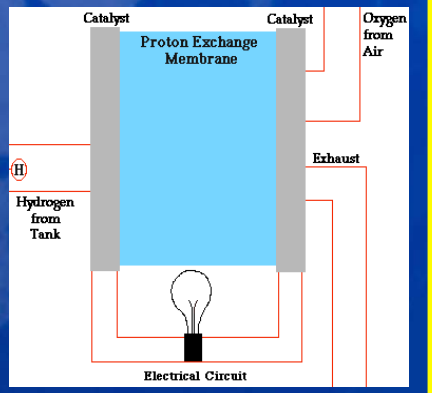
Alternatives energy source for both hybrid and battery replacement for power generation. Alternatives energy source to motor driven applications where higher power requirements exist.

Defense Fuel Cell Manufacturing

PROJECT TEAM

Belcan	Mississippi State University
Boeing	NASA
CAPITOL CONNECTIONS LLC	NCMS
Caterpillar	Palmetto Fuel Cell Technologies, LLC
Clemson University	Pantex
Delphi	Parker Hannifin Corporation
DuPont	Praxair
Festo	Purdue University
Fuel Cell South	Raytheon
General Electric	Rockwell Automation
General Motors	Rolls Royce
Honeywell	Tetramer Technologies
IdaTech LLC	University of Missouri-Rolla
John Deere	University of South Carolina
LANL	US Navy
Lockheed Martin	

ROI > %



PROJECT OBJECTIVE

This phased project will utilize a spiral development approach to develop a robust, scalable manufacturing method that may integrate layered manufacturing, real time inspection, and in-situ machining technologies for direct manufacturing of high tolerance parts.

Initially this project will extend current DDM technologies to titanium material systems and implement it on selected high value DoD components.

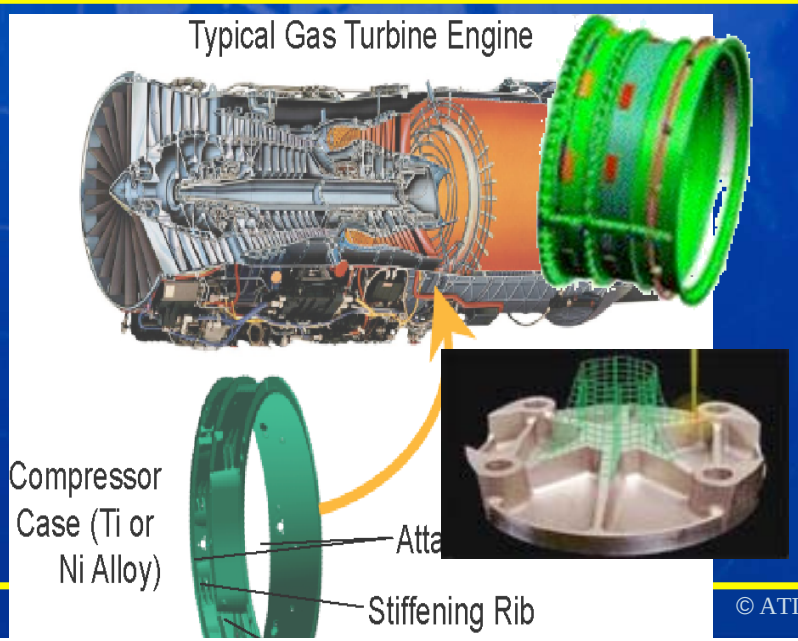
Building on the success of the initial phase the team will transition DDM technologies to other materials.

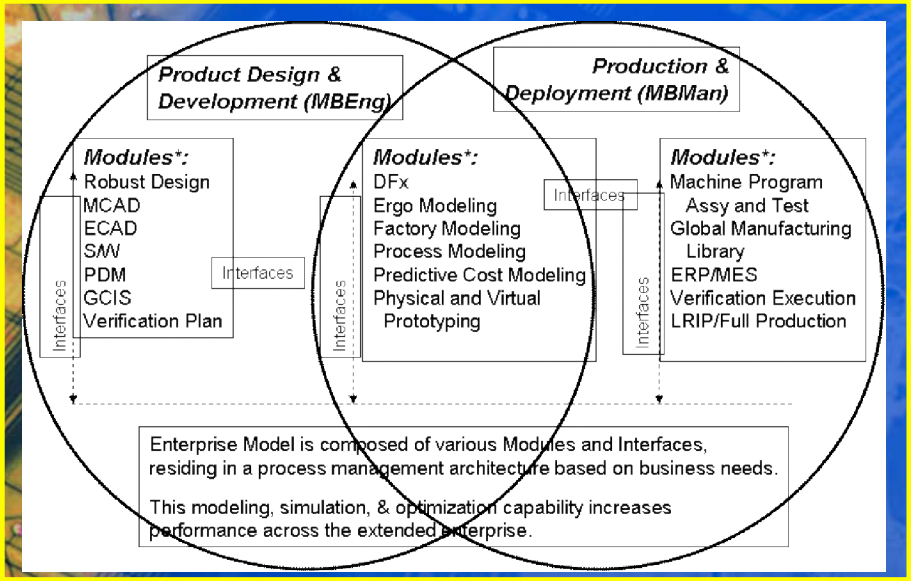
Digital Direct Manufacturing

PROJECT TEAM

Aeromet	LANL
ATI	Lockheed Martin
BAE Systems	Mississippi State University
Belcan	Motorola
Boeing	NASA
Caterpillar	NCMS
Delphi	Pantex
Dow	Raytheon
Doyle Center	Rockwell Automation
DuPont	Rolls Royce
EWI	Solidica
Festo	Southern Methodist University
General Electric	Tiburon
General Motors	University of Kentucky
Honeywell	University of Louisville
John Deere	University of Missouri-Rolla
Keystone	Welding Accessories Technology

ROI > %





PROJECT OBJECTIVE

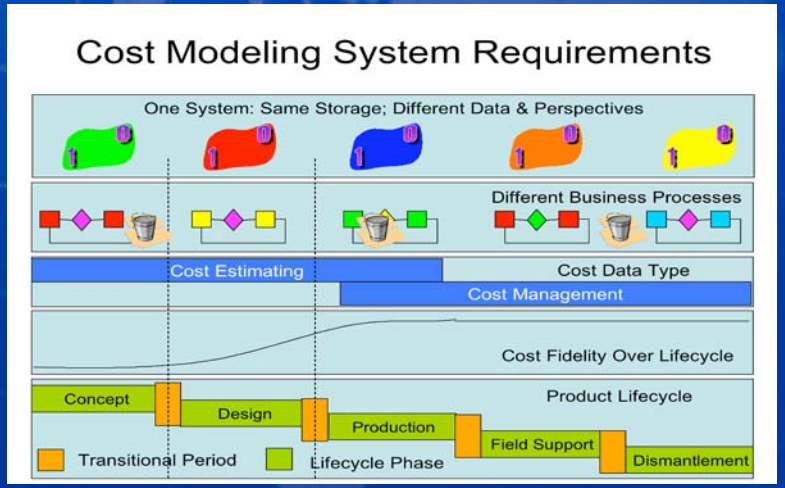
Identify and implement tools/processes to support design decisions which optimize life cycle cost. The tools will support the tracking against targeted cost goals and provide the ability to deliver design trade-off strategies. The project will extend over a three period, with yearly deliverables defined. This project when complete can be commercially adaptable and used for all platform developments.

Electro-Mechanical Industry

PROJECT TEAM

BAE Systems
Boeing
DOE
Honeywell
InterCax
LMCO
NASA
P&G
Raytheon
Rockwell Collins
Sandia

ROI > %



PROJECT OBJECTIVE

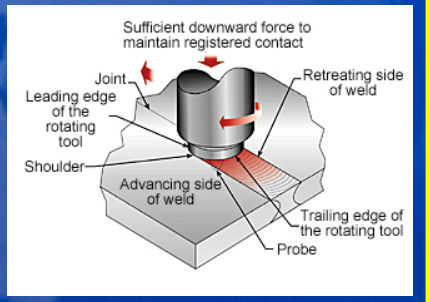
The key is to advance FSJ and mature the process for use in both military and commercial applications. This includes developing process and machine technology for welding high performance alloys and complex configurations, while lowering the barriers to wide process implementation by establishing process standardization, specification and inspection requirements, plus characterizing and disseminating weld joint static, fatigue, corrosion, and other material property data for designers and developers.

Friction Stir Joining (FSJ)

PROJECT TEAM

AFRL	Ford R&D Dearborn	ORNL
Alcoa	Friction Stir Link	Rockwell Scientific
American Welding Soc.	General Electric Aircraft Engines	Rolls - Royce
Army -AMCOM-G4	GM R&D Center	Sikorsky
Army Picatinny Arsenal	Kirtland AFB	South Dakota State - MT
Brigham Young University.	LANL	The Boeing Company
Daimler Chrysler	Lockheed Martin MFC	University Missouri Rolla
DARPA	Mississippi State University	University of Kentucky
Eclipse Aviation	NASA/MSFC	University of South Carolina
Edison Welding Institute	Navair	University of Wisconsin
ESAB	Northrop Grumman NN	Wichita State University
	ONR	

ROI > %



PROJECT OBJECTIVE

The objective of this project is to establish a high-throughput domestic production source for large diameter bearings employing ceramic rolling elements and corrosion-resistant races. Widespread use of hybrid bearings would allow higher rotational speeds for gas turbine engines, reduce system weight, extend service life, reduce maintenance, and improve “oil out” operating capability. These bearings are of particular interest in applications such as the lift fan system in the short takeoff and vertical landing (STOVL) variant of the F-35 Joint Strike Fighter (JSF), where their use is anticipated to provide a 100+ pound weight savings compared to conventional bearings.

Hybrid Bearing Manufacture

PROJECT TEAM

American Welding Soc.	LANL
BAE Systems	Lockheed Martin
Belcan	Motorola
Boeing	NASA
Caterpillar	NCMS
Delphi	Pantex
DuPont	Parker
Festo	Praxair
General Electric Aircraft Engines	Proctor & Gamble
General Motors	Raytheon
Honeywell	Rockwell Collins
John Deere	Rolls Royce

ROI > %

PROJECT OBJECTIVE

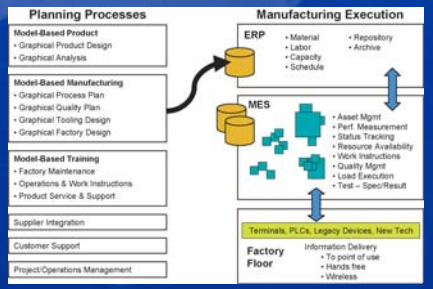
The objective of this project is to develop and demonstrate model-based technologies that deliver information to end users at the point of use, wherever that user might be. The information will be delivered through flexible, affordable systems that provide for heads-up, hands-free operation. Concentrating on graphical views of information provided by model-based systems, this project will demonstrate the sharing of information created in the enterprise's planning processes (e.g., product design, manufacturing planning) to the four primary "execution systems" of the enterprise: manufacturing execution, product service/support, factory maintenance, and training. It will go far beyond the passing of visual files and text, providing users with interactive access to physical and logical models useful in guiding operations, with appropriate levels of detail and security.

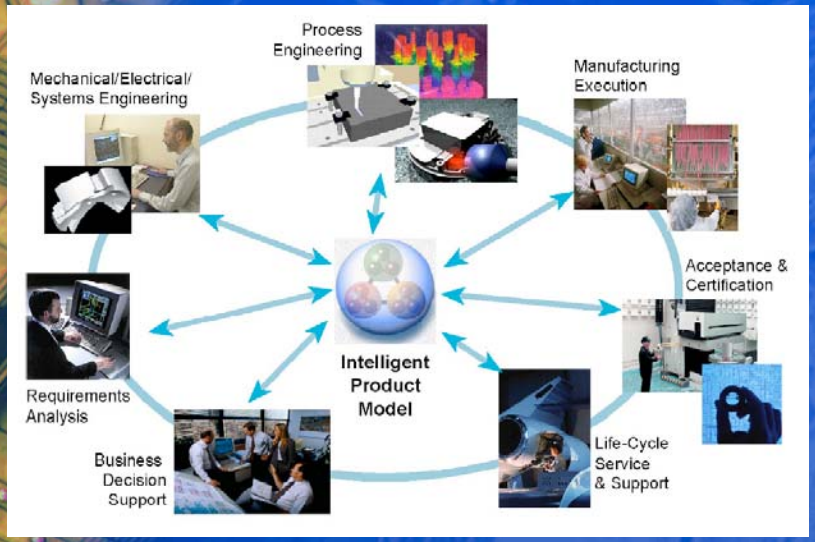
Information Delivery to Point of Use

PROJECT TEAM

American Welding Soc.	Lockheed Martin
BAE Systems	Motorola
Belcan	NASA
Boeing	Pantex
Caterpillar	Parker
Delphi	Praxair
DuPont	Proctor & Gamble
Festo	Raytheon
General Electric Aircraft Engines	Rockwell Collins
Honeywell	Rolls Royce
John Deere	Tiburon Associates
LANL	

ROI > %





PROJECT OBJECTIVE

The objective of this project is to develop enabling technologies and demonstrate the use of intelligent models that understand, seek out, acquire, and act on the information they need to execute their functions.

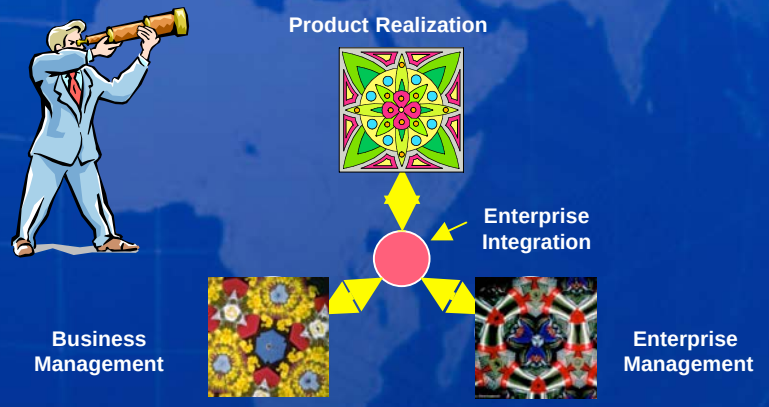
The project will establish linkages between the physical modeling realm and the logical models that provide intelligence to product, process, and enterprise models. The addition of intelligence in the modeling environment will radically improve the ability of manufacturers to design products and processes, configure and operate production facilities, and manage their business processes.

Intelligent Models for Manufacturing

PROJECT TEAM

Aegis Technologies	National Institute of Standards and Technology (NIST)
AIM	Oracle
ARES Corporation	Procter & Gamble Company (P&G)
Boeing Company	Purdue University
Delphi	Rockwell Automation
Doyle Center for Manufacturing Technology	Sandia National Laboratories
General Motors Corporation (GM) (GMC)	Techsolve, Inc.
Georgia Institute of Technology (Georgia Tech)	Tennessee Technological University
Honeywell Federal Manufacturing & Technologies	University of Kentucky
Lockheed Martin Corporation (LMCO)	US Air Force - Air Force Materiel Command (AFMC)
Mississippi State University	

ROI > %



PROJECT OBJECTIVE

Convert Titanium Industry and applications from use of Kroll Process and Ingot Metallurgy to Direct Alloy Reduction and Solid-State Consolidation.

Expand use of titanium alloys for aerospace applications to the full range of DoD systems, enabling reduction in weight and improvements in durability and corrosion resistance.

Advance state of art of US titanium industry to maintain strategically important dominant competitive and capability position worldwide.

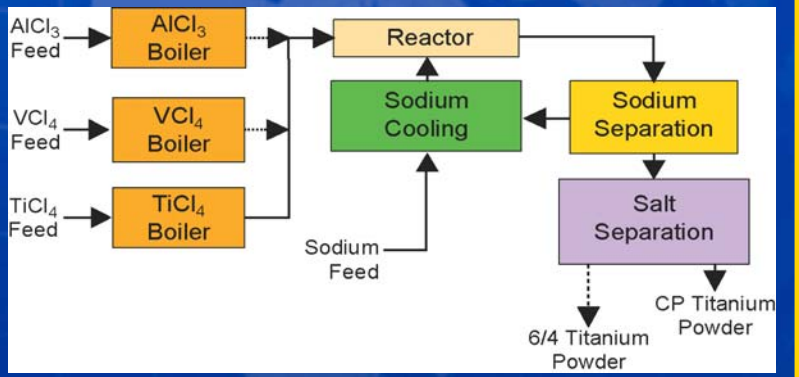
Advance use of titanium in US produced components and systems to maximize efficiency, life-cycle costs, and reliability.

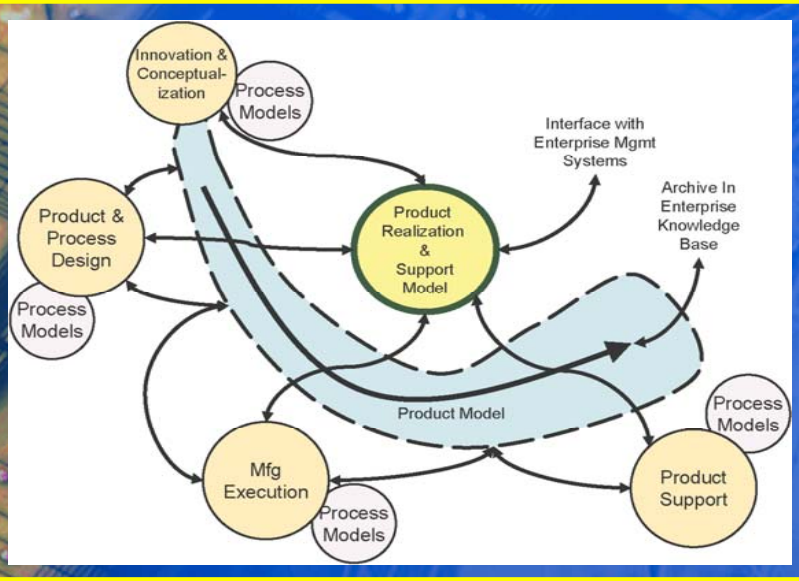
Low Cost Titanium Production

PROJECT TEAM

Army research Laboratory	John Deere
BAE Systems	Keystone
Belcan	LANL
Boeing	Lockheed Martin
Caterpillar	NASA
Delphi	NSWC
DoE Albany	Pantex
DuPont	Parker Hannifin
Electric Boat	Praxair
Festo	Rockwell Automation
General Electric	Rolls Royce
General Motors	TIMET
Gneral Electric	US Army
Honeywell	Welding Accessories Technology
ITP	

ROI > %





PROJECT OBJECTIVE

The objective of this project is to develop and pilot modeling and simulation capabilities that enable a product model to automatically drive downstream applications. While "product design" creates a model that describes *what* is to be made, "process design" provides a model of *how* the product will be produced. These are usually two very different kinds of models requiring highly skilled (and usually manual)
translation of information from one domain to another. This project will demonstrate collaborative interaction between product and process models in an enterprise's product realization environment, to evaluate the current state of capability and provide business-case data regarding the impacts of decisions made at each step of product design and manufacturing.

Product-Driven Product and Process Design

PROJECT TEAM

Air Force	**John Deere**
BAE Systems	**Lanl**
Boeing	**Lockheed Martin**
Caterpillar	**Motorola**
Delmia	**NCMS**
Delphi	**NIST**
Doyle Center	**Praxair**
Dupont	**Proctor & Gamble**
ESAB	**Raytheon**
General Electric	**Rockwell Automation**
General Motors	**Rolls Royce**
Honeywell	**Sandia**
HR Technology	**Tennessee Tech University**

ROI > %

PROJECT OBJECTIVE

The advancements of new hybridized thermoplastic based composite armor solutions have shown to provide additional ballistic protection as well as increased protection from blunt force trauma when compared to traditional “soft armor” solutions. The benefits of this new technology have been demonstrated. However, the lack of a low cost, effective means of rapidly fabricating these materials was also revealed. The utilization of these new materials for the development of personnel protection has presented issues from a manufacturing aspect as well as the ability to “scale up” to meet high volume production needs of our armed services.

Advanced Leg Armor

PROJECT TEAM

ARL

Clemson University

TPI Composites Inc.

MPT

ARDI

Simula

Mentis Science, Inc.

Diaphorm Technologies

ROI > %

PROJECT OBJECTIVE

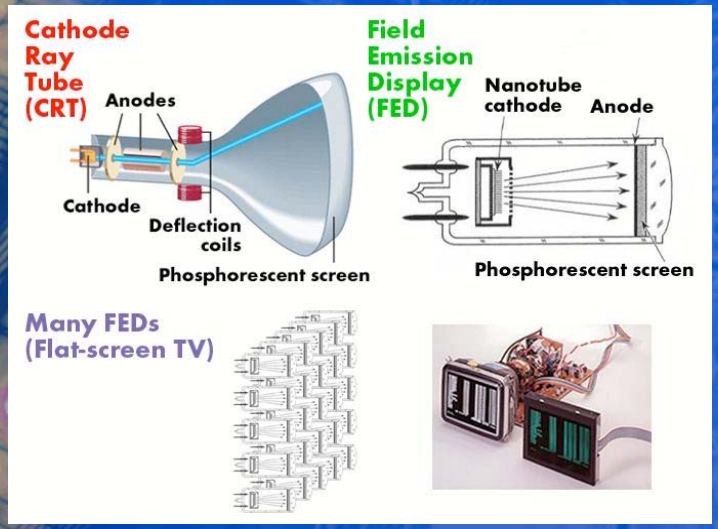
The military has a need to make its tactical vehicles faster, more mobile, easier to maintain and less detectable with lower life cycle cost. At the same time, the Army and other Services remain committed to improving payload requirements by making its vehicles lighter and stronger allowing them to become quicker and more fuel efficient. The use of lighter weight materials in vehicle structures provides the opportunity to enhance crew protection schemes while increasing vehicle performance during combat and peace time applications.

Next Generation Lightweight Survivable Composites for Tactical Military Vehicles

PROJECT TEAM

TPI Composites Inc.
MPT
ARDI
Army Research Laboratory
Simula
Boeing
Diaphorm Technologies

ROI > %



PROJECT OBJECTIVE

The primary activity of this project will be to develop an integrated metallic Single Wall Carbon Nanotubes (SWNT) manufacturing capability, combining two manufacturing technologies ("forest grown" SWNT synthesis and "chiral separation") that have been demonstrated at laboratory / pilot scale, and transitioning to commercial production scale.

Nano Manufacturing

PROJECT TEAM

Applied Research and Development Institute	Lockheed Martin
BAE Systems	Motorola
Belcan	NASA
Boeing	NCMS
Caterpillar	Pantex
Clemson University	Parker
Delphi	Praxair
Dupont	Raytheon
Festo	Rockwell Collins
Fuel Cell South	Rolls Royce
General Electric	SCRA
General Motors	SouthWest NanoTechnologies, Inc.
Honeywell Specialty Materials	University of Oklahoma
LANL	US Navy

ROI > %