Design and Manufacturing Innovation Programs

Warren R. DeVries, Division Director
Design and Manufacturing Innovation Directorate for Engineering

ASEE Engineering Research Council
February 28, 2005
DMI’s Mission

Enabling the Nation’s future through discovery, learning, and innovation by identifying and supporting:

Fundamental research that defines the frontiers of design, manufacture, and service, and interfaces with other disciplines, to create the enterprises of tomorrow and assure the future competitiveness and productivity enterprises today.

Integration of education and research that develops the diverse, adaptable and knowledge-enabled engineering workforce vital in assuring global competitiveness.
### Balanced by Our Responsibilities as Part of ENG and NSF (FY 05)

<table>
<thead>
<tr>
<th>Priority Areas</th>
<th>NSF</th>
<th>ENG</th>
<th>DMII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocomplexity in the Environment</td>
<td>$296.6M</td>
<td>$127.8M</td>
<td>$17.0M</td>
</tr>
<tr>
<td>Nanoscale Science and Engineering</td>
<td>$89.1M</td>
<td>$2.9M</td>
<td>$0.5M</td>
</tr>
<tr>
<td>Mathematical Sciences</td>
<td>$38.3M</td>
<td>$2.0M</td>
<td>$1.0M</td>
</tr>
<tr>
<td>Human and Social Dynamics</td>
<td>$17.0M</td>
<td>$127.8M</td>
<td>$2.0M</td>
</tr>
<tr>
<td>Sensors &amp; Sensor Networks</td>
<td>$1.2M</td>
<td>$6.0M</td>
<td>$99.2M</td>
</tr>
<tr>
<td>CLEANER</td>
<td>$0.2M</td>
<td>$1.0M</td>
<td>$0.2M</td>
</tr>
<tr>
<td><strong>Total Priority Area Planned Investments</strong></td>
<td><strong>$523.2M</strong></td>
<td><strong>$159.7M</strong></td>
<td><strong>$23.9M</strong></td>
</tr>
</tbody>
</table>
DMI Budget Resources

Fiscal Year

2002 2003 2004 2005 2006

Request

DMI Priorities/Programs  NSF/ENG Priorities
About DMI

The disciplines we benefit directly:
- Primarily industrial engineering/operations research and part of mechanical engineering, with
- some materials and chemical engineering, and business.

In FY 04 DMI:
- received 1077 proposals and made 210 awards,
- convened 53 panels with more than 420 panelists.
- for competitive research proposals DMI’s success rate was 16%, with a
- mean annual award amount of $111.5k and mean duration of 2.8 yrs
Bridging Programs Across NSF
Grant Opportunities for Academic Liaison with Industry
Innovation and Organizational Change

DMI’s Academic Programs

Engineering Decision Systems Cluster
Operations Research & Service Enterprise Engineering
Manufacturing Enterprise Systems Engineering Design

Manufacturing Processes & Equipment Systems Cluster
Manufacturing Machines and Equipment
Materials Processing & Manufacture NanoManufacturing
Current funding in the Engineering Design Program
- Fundamentals of the Product Realization System
- Life Cycle
- Design for “X”
- Design theory
- Visualization

New focus on the convergence of design research into a fundamental framework for:

- Environmentally Benign Design and Manufacture
  EBDM requires a comprehensive systems approach to engineering design and manufacturing with specific consideration of total life cycle management - needed are tools to assess materials use, to design for performance, and design for recycle or remanufacture.
Manufacturing Enterprise Systems

Current program emphasis areas:
- Modeling and analysis tools
- Real-time coordination of complex systems
- Enterprise design
- Planning and control of manufacturing operations

Future emphasis areas:
- Sensor integrated operations management
- Nano, bio, info convergent supply chains
- Multi-scale modeling approaches
- Statistical methods for diagnostics and control
- Systems for reverse logistics and product take-back
Operations Research

- **Stochastic networks & queues**
  - Great progress with “fluid approximations” which approx stochastic networks as continuous flows

- **Optimization methods**
  - Advances rapidly extending the range of solvable models – especially in stochastic programming (optimization under uncertainty)

- **Simulation & Monte Carlo analysis**
  - Central to stochastic programming & financial engineering as well as system simulation

Service Enterprise Engineering

- **Vision is**
  - Foster research on modeling and analysis issues unique to service operations
  - Build collaborations within NSF and in other agencies for behavioral and domain knowledge
  - Lead engineering academia to focus on unfamiliar sectors like health care, financial, hospitality & entertainment.

- **Focus areas:**
  - generic issues inherent in inventoryless service operations
  - domain-specific operations
Advancement of the fundamental knowledge base that is needed for the realization of desired product attributes (i.e., form and function) through:

- The systematic study of processing - material-performance relationships
- Integration of analytical and experimental research
- Connectivity of this materials processing knowledge to sensing systems for process characterization and control

Future Emphasis Areas

- Integration of dissimilar materials and structures at nano/micro/meso/macro scales.
- Novel netshape processing to reduce material and energy waste
- Fabrication of bio-compatible materials and complex structures (implants, restoration)
- Multi-scale and multi-physics modeling of processes to predict performance and producibility related to material microstructure and processing conditions
Manufacturing Machines & Equipment Systems

Program Goal
- The MME program supports research on fundamental issues that relate to the advancement of manufacturing machines and equipment and their use.
- A key goal is to accelerate the transition of the manufacture of discrete parts and products from a skill-based activity to a knowledge-based activity.

Program Emphasis areas
- Material removal
- Sensing and control
- Planning and optimization
- Metrology
- Machine design

Program Vision is
Manufacturing processes will continue to become:
- More knowledge-based
- More automated
- More nearly optimal
- More capable of dealing with uncertainty
- More efficient/more economical
- More environmentally friendly

New and Additional Emphasis
- Material addition
- Fundamentals of both additive and subtractive processes

George Hazelrigg
Nano Manufacturing

Scale-up for: producibility, predictability, productivity

3-D systems across dimensional scales: nano-structures → functional devices → system architectures → products & services

Multi-functionality across energetic domains: mechanical, electromagnetic, biological etc.

Intelligence/information value added at nanoscale: materials, processes, equipment

Theory, modeling, simulation and controls

Physical and human infrastructure, impact on education, society, economy and environment

Future Directions in Nanomanufacturing

- Learning from Nature
  - Biomimetic systems design
  - Bioinspired manufacturing processes

- Working with Nature
  - Biotechnology-based processing
  - Hybrid bio/technical structures

- Assisting Nature
  - Recycle/Reuse/Remediation processes
  - Environmentally benign manufacturing

- Improving Human Life
  - Technologies for information, cognition, transportation

Kevin Lyons
Grant Opportunities for Academic Liaison with Industry & Innovation and Organizational Change

GOALI - Collaborative Research Projects:
- Industry co-PI; must present a real industry commitment
- Detailed plan for industry-university collaboration, w/division of research tasks
- Industry cost-sharing and technological relevance are essential evaluation criteria
- Proprietary issues - agreement on intellectual property is required

IOC - Foster Innovation and Manage Change:
- Integration of new technologies
- New products and services
- Organizational learning
- Process improvement
- Apply industrial engineering outside of manufacturing and R&D: healthcare, education, government
What’s New Operationally?

The Division’s name reflects the fact that the SBIR/STTR portion of the Division is a separate Office of Industrial Innovation.

The DMI Grantees’ Conference
- annual event for 30 years, is going to an 18 month cycle
- next one scheduled for July 2006 in St. Louis hosted by University of Missouri-Rolla

Innovation and Organizational Change program
- FY 05 support from DMI at 50% of our FY 04 level,
- In FY 06 DMI will discontinue supporting IOC
- The Directorate for Social, Economic & Behavioral Sciences, ENG’s partner for the past decade, will make the decision on IOC’s future.
DMI’s Frontiers and How We Explore Them? And Fund Them?

Study on Systems Engineering for Healthcare Delivery
- NAE/IOM conducted, NSF(DMI & BES)/IOM/RWJ funded.
- Report and public forum expected in April 4, 2005.

Two WTEC benchmarking studies:
- Micro-manufacturing - Nano/Micro/Meso Machines
  - NSF(DMI, CMS, CTS, BES, EEC)/ONR/DOE/NIST/ATP funded.
  - Final workshop, April 22, 2005 at Hilton Arlington & Towers
- Additive/Subtractive Manufacturing Research and Development in Europe

Workshops engaging the community
- Cyber Infrastructure
  - CyberInfrastructure-Operations Research Workshop
    - August 31-September 1, 2004
  - Exchanging CyberInfrastructure Themes in Engineering Design
    - Workshop Leaders: Tim Simpson, Kemper Lewis, and Wei Chen
    - February 28, March 1, 2005
- ED2030: Strategic Plan for Engineering Design
  - March 26-29, 2004
DMI Always Needs Reviewers and Program Directors

**Benefits for the Individual:**
- See a range of proposals and assess how yours stacks up.
- Learn that clarity and conciseness are key.
- A free trip to NSF to meet program officers face-to-face.
- Develops breadth, leadership skills and provides visibility.

**Benefits to University & Department:**
- Understanding of and alignment with NSF goals
- A connection to keep up-to-date on NSF.

**Benefits to NSF:**
- New reviewers are usually very conscientious.
- Broader and more diverse reviewer base.
- New ideas & NSF understands the issues in academe.

**Volunteer to be:**
- A Reviewer by sending a short email to us or a Program Director with a one page resume attached.
- A Program Director by watching NSF/ENG/DMI’s website or responding to our emails requesting nominations or applications.
National Science and Technology Council
Interagency Working Group on Manufacturing R&D

Chartered Functions:
- Propose policy recommendations for manufacturing R&D.
- Facilitate interagency program planning and budgeting, collaboration, coordination, and leverage.
- Review agency priorities and technical issues for Federally-funded manufacturing R&D.
- Promote communications among the government, private sector, and academia on R&D requirements and programs.
- Report to Committee on Technology and OSTP summarizing IWG activities and recommendations.

Goals:
- High Level: to lead development and promote implementation of advanced manufacturing technologies for the benefit of U.S. economy and U.S. manufacturing sector in particular.
- Secondary: to improve planning, coordination, and collaboration among federal agencies in these key technology areas to increase effectiveness of the overall federal manufacturing effort.
NSTC IWG on Manufacturing R&D Technical Priorities

White papers drafted by IWG on 3 technical topics form basis for a coordinated, multi-agency focus on:

- Intelligent and Integrated Manufacturing Systems
- Manufacturing for the Hydrogen Economy
- Nanomanufacturing

Public Forum by the IWG on Manufacturing R&D
- Department of Commerce on March 3
- See http://www.ostp.gov/mfgiwg/ for the agenda and to register.
What Questions Do You Have?

dmii@nsf.gov
Or
http://www.eng.nsf.gov/dmii/
Or
703-292-8330