MATERIALS AND ENVIRONMENT

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Big Problem Areas

- control of clusters
- process and manufacturing control
- nano-technology
- thin films
- economic control
- supply chain management
- flow control
- geophysics (weather, environment, etc)

Overarching Themes

FOR MATERIALS / PROCESSING
ENVIRONMENT / SOCIAL-ECONOMICS

CONTROL = EVERYTHING

- Modeling
- Computation
- Paradigm shifts
- Experiment/Verification

Modeling

- multi-scale, time and space
- model reduction
- model identification
- heterogeneous model integration
- hierarchical
- uncertainty
- role of data/statistics/noise
- complex systems
- exploiting problem structure

Computation

- algorithmic and software interfacing
- structured algorithms
- distributed computing
- dynamic resource allocation
- algorithmic development
  - » ADIFOR
  - » optimization
  - » sensitivity
- hierarchical/multiscale
- uncertainty/verification

Paradigm Shifts

- data centric
- coordinated control
- complex systems
- spatially distributed (control, sensors…)
- multidisciplinary teaming
- control configured design (and other things, up front)

Experiment/Verification

- physical
- computational
- interface (with modeling, computation)
- new technology (sensor, etc)

Possible Vignettes

- up front design of chemical plants
- process control
- space applications
- sensitivity tools
- combustion modeling
- meteorology

TECH AREAS

- Nano Technology
  - » Nano Electronics
  - » Designer Chemistry
  - » Biological Materials
- Flow Control
  - » Chemically Reacting
  - » Aerodymanic
- Thin Films
  - » RCVD
  - » MBE
  - » IBD

PAYOFFS

- The “Future”
  - » “Smart Dust”
  - » The Next “Transistor”
  - » Embedded Intelligence
  - » Combustion
  - » GMR Devices
  - » Thin Film is $300 Billion Industry

TECH AREAS

- DESIGN OF MEMS
- Process Control
  - » Web
  - » Chemical
  - » Power Generation
  - » Pharmaceutical
  - » Injection Molding
- Supply Chain Management

PAYOFFS

- Enabling New Products
  - » Component Integration
- Economic & Others
  - » $ Billions Per Year
  - » Trees
  - » $ Competitiveness
  - » Health

AREAS	ISSUES
• Nano Technology » Nano Electronics » Designer Chemistry » Biological Materials • Flow Control » Chemically Reacting » Aerodymanic • Thin Films » RCVD » MBE » IBD	• Modeling for **Control** » Quantum,MD, FE? » Reduced Order Models? » Interaction of Devices • Modeling » Computational Methods • Process Sensor Based Control of Product Parameters » Associated Modeling » Model Reduction

AREAS	ISSUES
• DESIGN OF MEMS • Process Control » Web » Chemical » Power Generation » Pharmaceutical » Injection Molding • Supply Chain Management	• Model Reduction & ID » Component Integration • Large Scale Systems » Modeling of Big Systems » Integrated Health Management & Control » Distributed PS • Optimization

EDUCATION

EXPOSURE TO COMPUTING

!!! INTERDISCIPLINARY !!!

MANUFACTURING PROCESS KNOWLEDGE

RESEARCH NEEDS

- **BETTER SOLUTION METHODS FOR MULTIDISCIPLINARY SYSTEMS (FASTER, CHEAPER, MORE ACCURATE)**
  - » **CHEMICALLY REACTING FLOWS**
  - » **AEROELASTIC SYSTEMS**
  - » **COMPUTATIONAL CHEMISTRY**
  - » **TIME DEPENDENT PROBLEMS**
  - » **MOLECULAR DYNAMICS (MD CODES, ETC.)**
- **NUMERICAL METHODS THAT TRAVERSE DISPARATE TIME AND LENGTH SCALES**
  - » **CONTINUUM MODELS (FINITE ELEMENTS, ETC.)**
  - » **MOLECULAR DYNAMICS (MD and QM CODES, ETC.)**
- **LARGE-SCALE COMPUTATIONAL METHODS FOR DESIGNING, CONTROLLING AND OPTIMIZING UNDER UNCERTAINTY**

RESEARCH NEEDS
- SIMULATION FOR DESIGN -

- NEW COMPUTATIONAL METHODS THAT ARE "DESIGN SPECIFIC"
  - » A NUMERICAL METHOD "GOOD FOR SIMULATION" … MAY NOT BE GOOD FOR OPTIMIZATION OR CONTROL
- GEOMETRIC MODELING AND MESH GENERATION TOOLS
- MESH INDEPENDENT COMPUTATIONAL TOOLS FOR
  - » SENSITIVITY ANALYSIS
  - » OPTIMIZATION BASED DESIGN
- INTEGRATED PROBLEM SOLVING ENVIRONMENTS
  - » ARCHITECTURE SPECIFIC ALGORITHMS
  - » HIERARCHICAL ADAPTIVE MODELING FOR DESIGN & CONTROL
  - » VISUALIZATION