Office of Emerging Frontiers in Research and Innovation
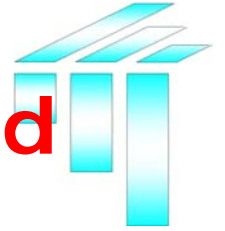
Sohi Rastegar

Director

19 April 2007

Emerging Frontiers in Research and Innovation

FY 2007

Office Director
Sohi Rastegar

FY 07:
Auto-Reconfigurable
Engineered Systems
(ARES)

ENG Programs and Divisions Define Topics & Teams

FY 07:
Cellular and Biomolecular
Engineering
(CBE)

COORDINATORS:
Abhi Deshmukh, CMMI
Scott Midkiff, ECCS

TEAM MEMBERS:
Mario Rotea, CMMI
Maria Burka, CBET
Bruce Hamilton, CBET
Stephen Nash, CMMI
Kishan Baheti, ECCS
Glenn Larsen, IIP

COORDINATORS:
Jimmy Hsia, CMMI
Fred Heineken, CBET

TEAM MEMBERS:
Lenore Clesceri, CBET
Lynn Preston, EEC
Robert Wellek, CBET
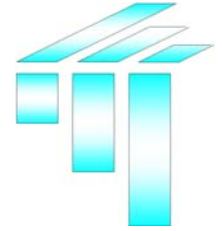
EFRI OFFICE PROJECTION

Steady State: 8-10 Active Topics

~50 Active Awards

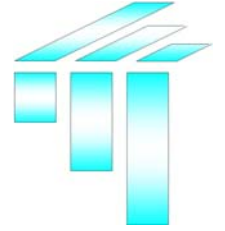| FY 07:
Auto-Reconfigurable
Engineered Systems
(ARES) | FY 07:
Cellular and Biomolecular
Engineering
(CBE) | FY 08:
Cognitive Optimization
& Prediction (planned) | FY 08:
Resilient and Sustainable
Infrastructures (planned) |
| FY 09: | FY 09: | FY 10: | FY 10: |
| | FY 11: | FY 11: | |
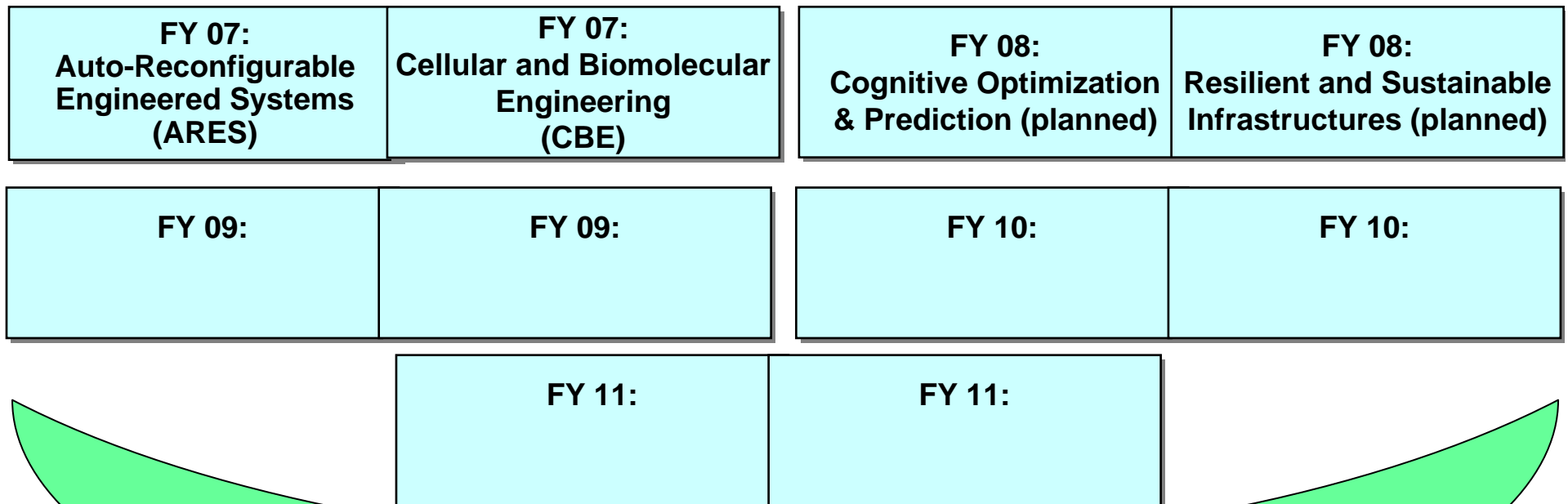
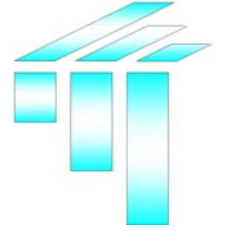**ENG Programs & Divisions Define Topics &Teams**

Motivation: ENG VISION

NSF/ENG will be the global leader in advancing the frontiers of fundamental engineering research, stimulating innovation, and substantially strengthening engineering education.

Purpose/Mandate of EFRI

EFRI will serve a critical role in helping the Directorate for Engineering focus on important emerging areas in a timely manner. EFRI will recommend annually a prioritization, fund, and monitor initiatives at the emerging frontier areas of engineering research and education.
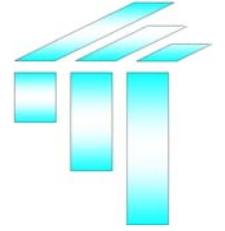
Office of Emerging Frontiers in Research and Innovation
## ~*Working Vision Statement*~

All NSF ENG Programs support research at the frontiers of research and innovation.

EFRI Office provides opportunities in interdisciplinary areas at the *emerging* frontiers of research and innovation that (a) are transformative, (b) address national needs/grand challenges, and (c) will make ENG unrivaled in its global leadership.
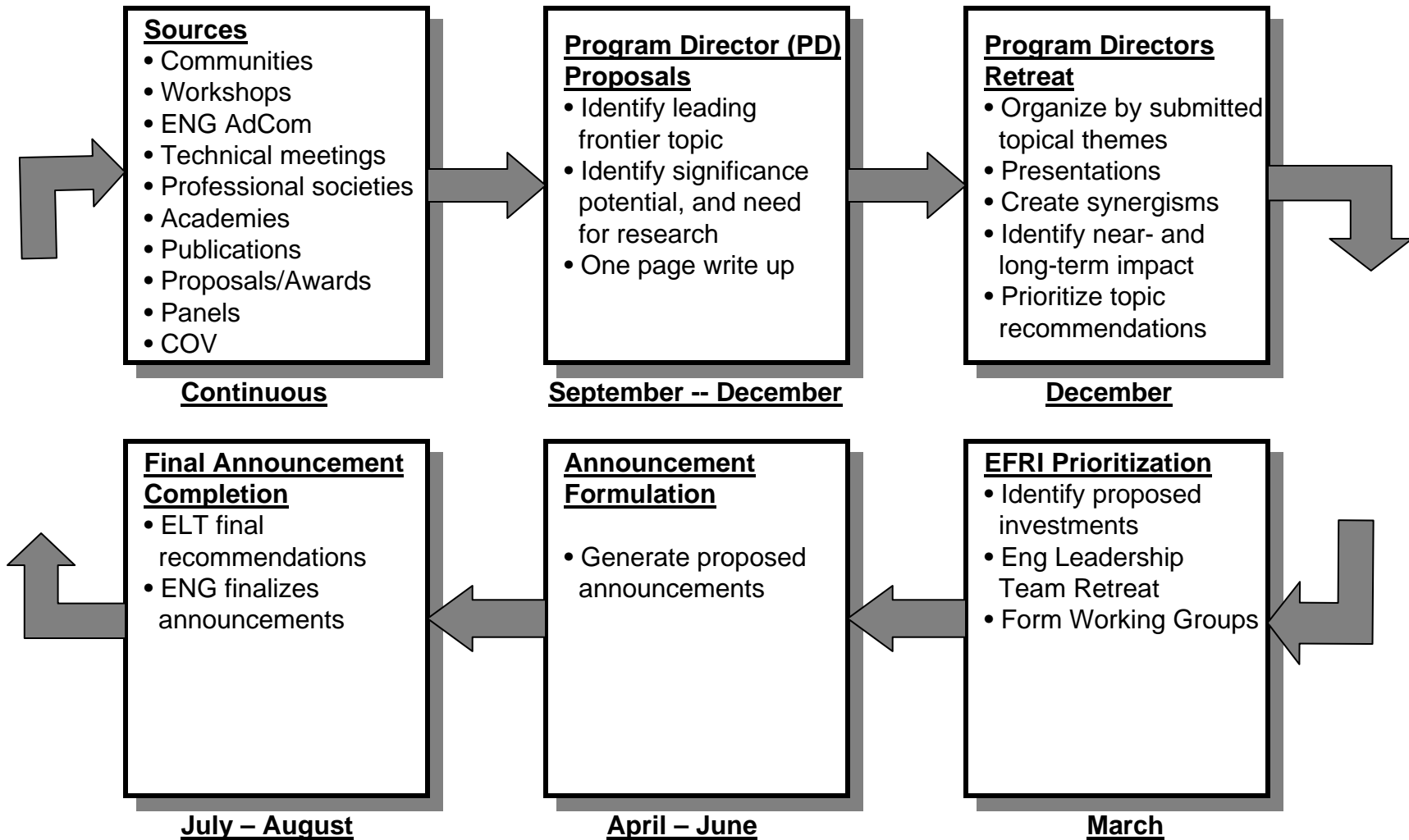
EFRI- "One Slide Description"

- Established on October 1, 2006, EFRI supports higher risk, higher payoff opportunities leading to:
  - new research areas for NSF, ENG, and other agencies
  - new industries/capabilities resulting in a leadership position
  - significant progress on advancing a "grand challenge"
- Successful topics would likely require:
  - small- to medium-sized interdisciplinary teams
  - the necessary time to demonstrate substantial progress and evidence for follow-on funding through other established mechanisms
- The current investment for EFRI totals $25 million for 4-year awards at $500k per year.
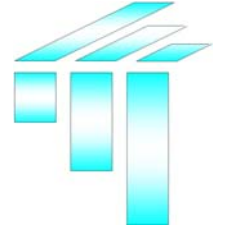
EFRI Criteria

- **TRANSFORMATIVE**- Does the proposed topic represent an opportunity for a significant leap or paradigm shift in a research area, or have the potential to create a new research area?

- **NATIONAL NEED/GRAND CHALLENGE**- Is there potential for making significant progress on a current national need or grand challenge?

- **BEYOND ONE DIVISION**- Is the financial and research scope beyond the capabilities of one division?

- **COMMUNITY RESPONSE**- Is the community able to organize and effectively respond?

- **ENG LEADERSHIP**- Are partnerships proposed, and if so, does NSF/ENG have a lead role?
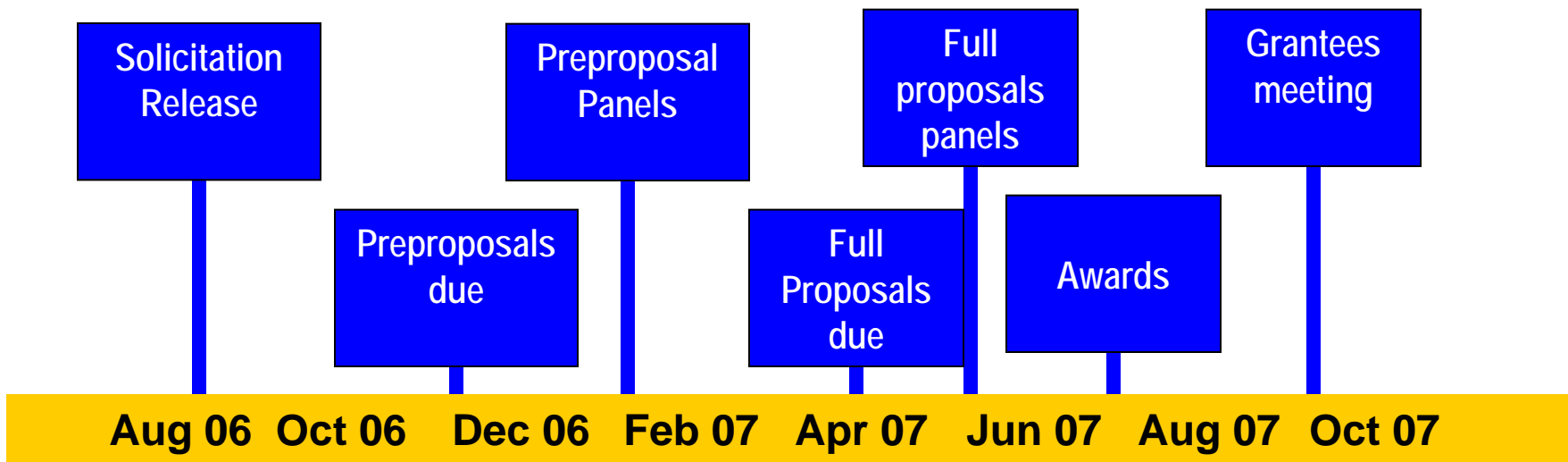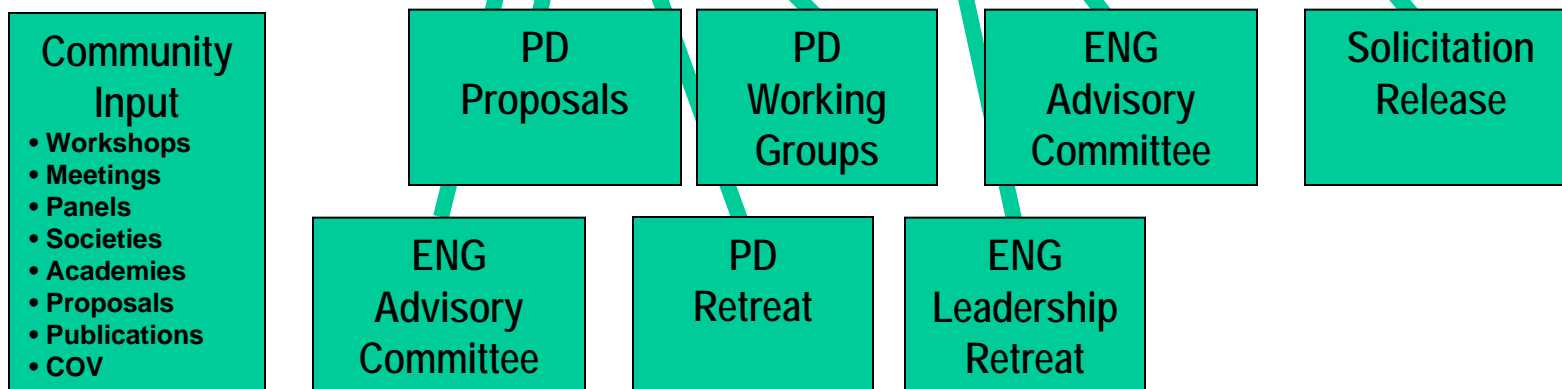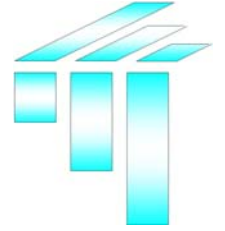
EFRI Annual Process

Sources
- Communities
- Workshops
- ENG AdCom
- Technical meetings
- Professional societies
- Academies
- Publications
- Proposals/Awards
- Panels
- COV

Continuous

Program Director (PD) Proposals
- Identify leading frontier topic
- Identify significance potential, and need for research
- One page write up

September -- December

Program Directors Retreat
- Organize by submitted topical themes
- Presentations
- Create synergisms
- Identify near- and long-term impact
- Prioritize topic recommendations

December

Final Announcement Completion
- ELT final recommendations
- ENG finalizes announcements

July – August

Announcement Formulation

- Generate proposed announcements

April – June

EFRI Prioritization
- Identify proposed investments
- Eng Leadership Team Retreat
- Form Working Groups

March

EFRI Timeline

FY 2007 Cycle

Solicitation Release	Preproposal Panels	Full proposals panels		Grantees meeting
	Preproposals due	Full Proposals due	Awards	

Aug 06   Oct 06   Dec 06   Feb 07   Apr 07   Jun 07   Aug 07   Oct 07

FY 2008 Cycle

Community Input
- Workshops
- Meetings
- Panels
- Societies
- Academies
- Proposals
- Publications
- COV

PD Proposals	PD Working Groups	ENG Advisory Committee	Solicitation Release
ENG Advisory Committee	PD Retreat	ENG Leadership Retreat	

Post-EFRI Support
Possible Routes

- Possible routes
  - Centers Programs (ERC, STC)
  - New Program in a Division
  - Change/Restructure an existing Program
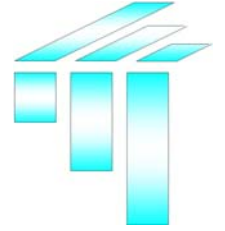 - New Program at interface of Divisions

ENG Programs Snapshot

- 5 Divisions + EFRI Office

- > 80 Program Leaders (PDs, Senior Advisors, SES, and Experts)

- 62 Programs (16 Program Clusters)

✓ *Program Leaders are key connections to ENG community*

✓ *EFRI Challenge: Think Beyond Programs and Divisions*

PD Activities for EFRI

- Frontier Idea Proposals
- Brown Bag Presentations
- PD Retreat
- Candidate EFRI Topics
- Preliminary Working Groups
- Proposals for and Presentation at ELT Retreat
- Solicitation Working Groups
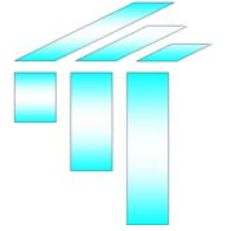- Information Webcast
- Manage Competition
- Manage Awards
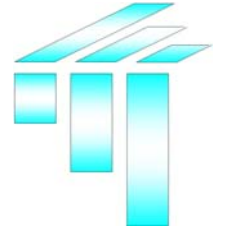
PD Retreat
Goals

1. Review, Critique and prioritize, candidate topics for Solicitation

2. Review/Discuss ENG Themes

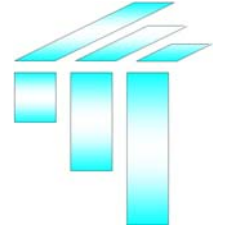**T H I N K   E N G I N E E R I N G**

"my program shoes off

"DD hats off"

# Proposals Presented at
ENG Leadership Retreat for FY07

1. RECONFIGURABLE ENGINEERED SYSTEMS ENABLED BY CYBERINFRASTRUCTURE

2. CELLULAR AND BIOMOLECULAR ENGINEERING: CONTROLLING MOLECULAR, CELLULAR, AND INTERCELLULAR/INTERFACIAL BEHAVIOR

3. SIMULATION-BASED ENGINEERING SCIENCE (SBES) OF MULTI-PHENOMENON AND MULTI-SCALE SYSTEMS IN MANUFACTURING OPTIMIZATION

4. THE ENERGY INTERGRID

# Two Topic Areas Selected for FY 07
Program Solicitation NSF 06-596

- **AUTONOMOUSLY RECONFIGURABLE ENGINEERED SYSTEMS ENABLED BY CYBERINFRASTRUCTURE (ARES-CI)**

  – **_Key idea:_** _Autonomously reconfigurable engineered systems robust to unexpected/unplanned events_

- **CELLULAR AND BIOMOLECULAR ENGINEERING (CBE):**

  – **_Key idea:_** _Comprehensive modeling, measurement, and control of coupled biological, chemical, electrical, mechanical, and thermal processes at the cellular and biomolecular level under multiple stimuli._
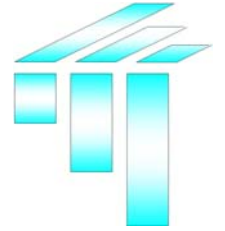
OVERVIEW OF EFRI
ARES-CI TOPIC AREA

- ARES-CI will support research projects that integrate frontier research across the computational, algorithmic, and engineered system domains into a single theoretical framework for the analysis and synthesis of systems that are adaptive, evolving and reconfigurable. <u>Each proposal is expected to address the following three areas</u>:

  1) Theoretical and Algorithmic Foundations,

  2) Methods for Analysis and Synthesis, <u>and</u>

  3) Reconfigurable System Test Beds.
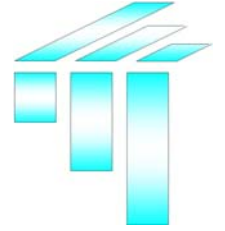
OVERVIEW OF EFRI
CBE TOPIC AREA

- CBE will support interdisciplinary teams to pursue innovative research that includes modeling, simulation, and experimentation to produce transformative knowledge and technology by working at the frontiers of disciplines. Teams of investigators may submit proposals that address one of the following two themes:
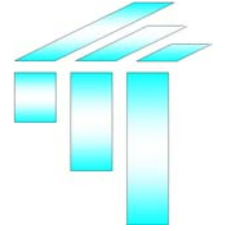
1) **Knowledge of the Cell and Interfacial Responses OR**

2) **Knowledge of the Interaction of Biomolecules with Cells and the Environment**

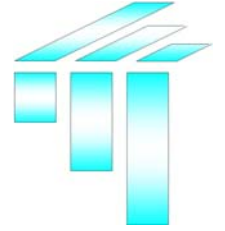# Award Size and Information
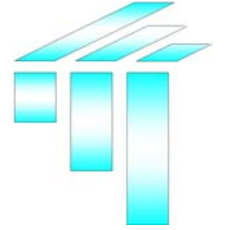
- Team Proposals Only:
  - 3 or more PIs
  - 3 or more disciplines

- Award size will depend on the type of research program proposed

- Up to 4 years in duration

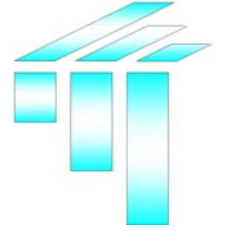- Up to $500K/year (direct plus indirect cost)

REVIEW CRITERIA

- NSB-approved Merit Review Criteria
  - Intellectual Merit

  - Broader Impacts

- NSF Staff will give careful consideration to the following:
  - Integration of Research and Education

  - Integrating Diversity into NSF Programs, Projects and Activities
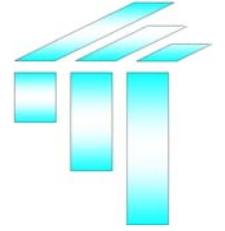
REVIEW CRITERIA (Cont'd)

- Additional EFRI Criteria

  - **MULTI- and/or INTER-DISCIPLINARY- Multiple Disciplines (3 or more disciplines)**

  - **TRANSFORMATIVE- Significant shift in fundamental engineering knowledge**

  - **NATIONAL NEEDS/GRAND CHALLENGE- Strong potential for long term impact on national needs or a grand challenge**

Status of FY 07 Cycle

- Aug 15, 2006   First Solicitation released
- Sep 19, 2006   Information Webcast Workshop
- Nov 17, 2006   252 Pre-proposals Received

  (96 ARES, 156 CBE)

- Jan 30, 2007   40 Full Proposals Invited
- Apr 30, 2007   Full Proposal Deadline
- June, 2007   Full Proposal Panels
- July, 2007   11 Awards Expected
- Fall, 2007   Grantee Meeting

Proposals Presented at
ENG Leadership Retreat
March 2007

- Resilient and Sustainable Infrastructures

- Hydrogen-based Energy Systems

- Healthcare Systems Engineering

- Cognitive Optimization and Prediction Through Reverse Engineering
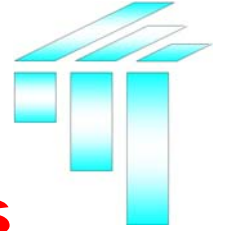
- **Resilient and Sustainable Infrastructures**
  - **<u>Key idea:</u>** Design, renew, expand, monitor, and control critical interdependent infrastructures to be <u>both</u> resilient and sustainable.

- **Hydrogen-based Energy Systems**
  - **Key idea:** Frontier science and engineering research to find new processes, materials, distribution methods, and manufacturing techniques for a sustainable hydrogen-based energy economy.
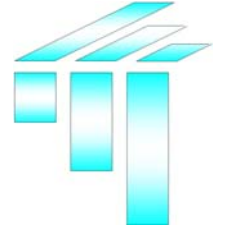
- **Healthcare Systems Engineering**
  - **Key idea**: engineering led research in ideas, tools and techniques to integrate advances in bioinformatics, health care information systems, distributed decision-making, point-of-care technology, diagnostic and treatment procedures into cost effective, high quality healthcare systems.

- **Cognitive Optimization and Prediction through Reverse Engineering**
  - **Key idea**: Understanding subsymbolic intelligence can lead to development of new designs and algorithms for optimal decision making and prediction in engineered systems.

Topics Selected for EFRI for FY 2008 Cycle

1. COGNITIVE OPTIMIZATION AND PREDICTION THROUGH REVERSE ENGINEERING

2. RESILIENT AND SUSTAINABLE INFRASTRUCTURES

Cognitive Optimization and Prediction through Reverse Engineering
(Preliminary Ideas)
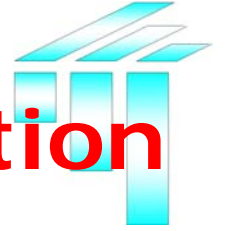
- to understand how massively parallel circuits in brains and the associated system identification circuits address complex tasks in adaptive optimal decision-making and prediction.

- to develop cognitive engineered designs or algorithms for optimal dynamic decision-making and/or prediction.

Cognitive Optimization and Prediction through Reverse Engineering
(Expected Transformative Benefits)

- to put science and engineering firmly on the path to a *functional*, unified mathematical and systems understanding of intelligence in the brain – a transformation as important in its way as the Newtonian revolution was to physics;

- new designs for optimal decision making which can handle complexity beyond the capacity of current methods;

- development of new and more general ways to harness the potential power of massively parallel "supercomputers on chips."

Resilient and Sustainable Infrastructures
(Preliminary Ideas)

Research to design, renew, expand, monitor, and control critical interdependent infrastructures to be both resilient and sustainable.

- **Infrastructures**: energy, water, wastewater, communications, transportation, agriculture and food, public health networks, etc.

- **Interdependencies**: through physical, natural resource, cyber, information, geographic, human, and social connections.

- **Resiliency**: ability to recover from shorter term events.

- **Sustainability**: long-term reliability through renewable energy and materials and reduced impact on natural systems.

Resilient and Sustainable Infrastructures
(Expected Transformative Benefits)

**Fundamental engineering principles for**
- Multi-infrastructure

- Multi-physics, multi-scale

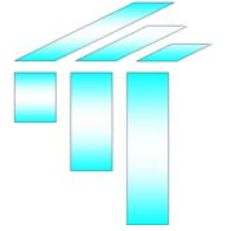- Performance metrics for interdependencies & vulnerabilities

Models for interdependent infrastructures
- To predict and control demand across multiple infrastructures over multiple time scales

- To assess risk for comparing resiliency and sustainability of infrastructure alternatives

New technologies
- Renewable for integration into legacy systems

- Design for reconfigurability: disassembly/reuse
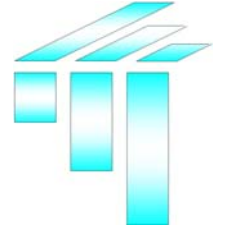
- Cyber-enabled to monitor and control performance
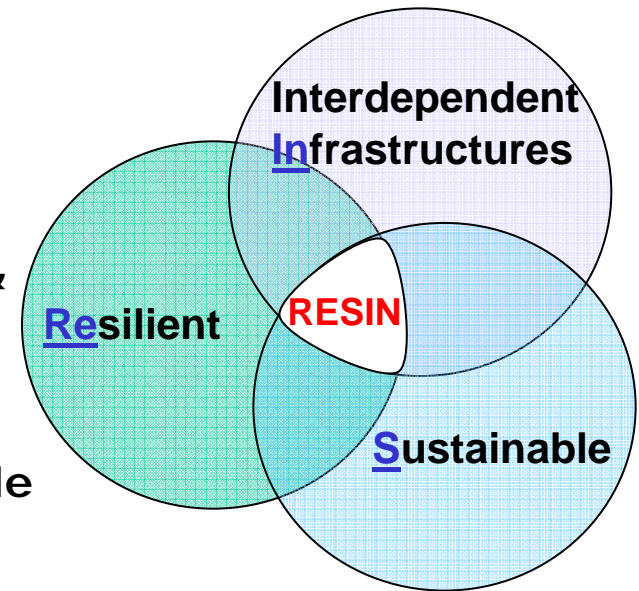
Status of FY 08 Cycle

- Dec 2006   Program Director Retreat
  Preliminary Working Groups
- March 2007   Eng Leadership Retreat
  Solicitation Working Groups
- Apr 19-20, 2007   ENG Ad Com

- Apr-Jun, 2007   Formulate Solicitation

- July/Aug 2007   Release Solicitation (planned)

Key website Address

- **EFRI Website for up-to-date information on EFRI**

www.nsf.gov/eng/efri