EFRI Planned Topic Areas for FY 2008

Two new topic areas were announced for the FY 2008 EFRI activity on April 19, 2007, at the Engineering Directorate Advisory Committee's Spring meeting. The tentative titles for and preliminary information about these topics are as given below. The EFRI Office intends to develop a solicitation around these topical areas for release in Summer 2007. These are planned to be for multidisciplinary teams of three or more investigators. You may find more information and updates on the EFRI Office by referring to ENG Advisory Committee website: http://nsf.gov/eng/advisory.jsp .

1. Cognitive Optimization and Prediction through Reverse Engineering.

Key idea: Understanding subsymbolic intelligence can lead to the development of new designs and algorithms for optimal decision making and prediction in engineered systems.

This topic area intends to provide partnership opportunities for engineers, physical scientists and neuroscientists to address two goals. The first goal is to understand how massively parallel circuits in brains address complex tasks in adaptive optimal decision-making and prediction, and to understand the system identification circuits in the brain which help make it possible. The second goal is to use this understanding to develop new general-purpose designs and/or algorithms for optimal decision making over time, or prediction, or both, powerful enough to work on existing benchmark challenges in simulation or in physical testbeds taken from engineering. This topic area does not include all aspects of cognitive science or cognitive engineering. The focus is on subsymbolic intelligence, because it is a difficult and important prerequisite to a deeper understanding of human intelligence. Engineers have unique qualifications to address optimal decision-making and prediction over time under uncertainty. A grand challenge is to develop new concepts of anticipatory optimization that can cope with spatial complexity in time and nonconvexity as required to improve probability of survival in nonlinear, stochastic environments. Transformative benefits expected are: (1) to put science firmly on the path to a truly 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; (2) new designs for optimal decision making which can handle complexity beyond the capacity of today's methods, as required for truly optimal rational management of complex engineered systems; (3) improved performance in specified simulation testbeds; and (4) development of new and more general ways to harness the potential power of massively parallel "supercomputers on chips."

2. Resilient and Sustainable Infrastructures.

Key idea: Design, renew, expand, monitor, and control critical interdependent infrastructures to be both resilient and sustainable.

Infrastructures, such as water and wastewater; energy generation, transmission, and distribution; communications; transportation; agriculture and food; and public health networks, are critical to our nation's welfare, security, and ability to compete in a global economy. Over the past century, these critical "backbone" infrastructures have evolved into a highly coupled, or interdependent, web of networked systems - through complex physical, natural resource, cyber, information, geographic, human, social, and logical connections. Design, construction, and operation of these interdependent infrastructures in the 21st century are major national challenges. These infrastructures face degradation and are legacy systems coping with integrating new technologies. Recent catastrophic events have highlighted the vulnerability of interdependent infrastructures to natural and technological disasters: they must be re-

engineered to become more resilient. These systems consume a significant portion of the nation's nonrenewable energy and materials and natural resources, and, hence, are not sustainable over the long term. Therefore, the research frontier for this topic area is complex and multidisciplinary. Research is needed to expand the theoretical frameworks for understanding, modeling, and simulating interdependent infrastructure systems at multiple time scales, i.e., under short-term disturbances and over the longer term. Research is also needed to advance the fundamental engineering science that will enable interdependent infrastructures to be both resilient and sustainable. Researchers should take an integrative approach to address interdependent infrastructure modeling and engineering science for resiliency and sustainability in the context of specific critical infrastructures. The overall goal of this topic area is to advance the nation's capacity to build, renew, expand, monitor, and control these interdependent infrastructures to be both resilient and sustainable.