Name and brief description of program:
Department of Veterans Affairs Rehabilitation Research and Development Service Center of Excellence for Limb Loss Prevention and Prosthetic Engineering

Brief description of goals of initiative:
The Seattle-based center conducts basic and clinical research to improve the quality of life and functional status of veteran amputees and veterans at-risk-for amputation. One goal of the research program is to explore the relationship between the structure and function of the foot at-risk-for amputation. The human foot is well-suited for computational modeling as it is a mechanical, multifunctional system that serves as the primary physical interaction between the body and the environment during gait. To explore normal and pathologic foot behavior and improve our knowledge of the transition from healthy to diseased feet, our researchers have developed a first generation finite element model of the foot and ankle consisting of 28 bones, 75 ligaments, cartilage and the soft tissue beneath the foot. In collaboration with Radiologists at the University of Washington, center staff are currently acquiring new geometric data of the various foot structures using both computer tomography (CT) and magnetic resonance imaging (MRI) for the second generation model. In addition to the improved geometry, muscles will be added to the model and parametric analyses will be conducted to determine the role and/or sensitivity of each parameter. The long-term goal is to develop patient-specific models that proceed rapidly from computer scan to functional model. This will provide timely feedback to the clinician on the role of foot deformities that lead to ulceration, the role of prophylactic correction of deformity, and the role of protective footwear.

Director: Bruce Sangeorzan MD, Seattle VA Medical Center, University of Washington
Associate Director: Joseph M Czerniecki MD, Seattle VA Medical Center, University of Washington
Program contact information: Wesley Edmundson 206-764-2991; wesley.edmundson@med.va.gov

Website address of initiative: http://www.seattlerehabresearch.org

Department of Veterans Affairs Rehabilitation Research and Development Service Center of Excellence in Task Oriented Exercise and Robotics in Neurological Disease

Brief description of goals of initiative:
The Baltimore-based center is dedicated to the development of novel models of task-oriented exercise integrated with motor learning based module robotics to improve mobility function, cardiovascular health, and quality of life for veterans with walking impairments due to stroke and other neurological conditions. The research mission leverages mechanistic studies of neuroplasticity across exercise and robotic interventions to better understand the biological underpinnings of plasticity in order

to advance future rehabilitation interventions. Through an international consortium of collaborating institutes including University of Maryland, Johns Hopkins University, Massachusetts Institute of Technology Robotics Engineering, and the Hertie Brain Research Institute in Tubingen, Germany, biomedical computing networks are being developed to support and standardize neuroplasticity and neuroimaging research studies including fMRI, volume metrics, and diffusion tensor imaging. Real time internet-based coding and confidential data processing abilities are under development to enhance the quality of data management, treatment fidelity, and the study of relationships between quantitative motor performance gains produced by novel exercise and robotics interventions on measures of brain plasticity. Descriptors of ongoing research studies for professionals and lay persons are under construction. Please watch the website below.

Principal investigator: Richard Macko, MD, Baltimore VA Medical Center, University of Maryland
Program contact information: Shereece Singleton 410-605-7000 ext. 5413; Shereece.singleton@va.gov

Website address of initiative: http://medschool.umaryland.edu/robotics.asp

Department of Veterans Affairs Rehabilitation Research and Development Service Center of Excellence in Advanced Platform Technology (APT)

Brief description of goals of initiative:
The Cleveland-based APT Center focuses on capturing new developments in polymer science, nano- and micro-scale fabrication and micro-electro-mechanical systems (MEMS) and applies them to the clinical needs of disabled Americans. The APT Center utilizes state of the art computational methods to design, fabricate and test biologically inspired dynamic polymer materials, novel application-specific circuitry and implantable sensors utilizing wireless communication systems. The center has made a significant investment in the area of neural interfaces and the development of innovative methods to exchange information with the nervous system. Under the direction of Drs. Dustin Tyler and Ronald Triolo, center staff have constructed realistic computer models of the physiological behavior of peripheral nerves. After acquiring cross-sections of targeted nerves and identifying their fascicular structure via digital image processing techniques, three dimensional computer representations of neuroanatomy are being constructed to optimize the design of new stimulating and recording electrodes through a series of FEA computer simulations prior to intra-operative and clinical testing. The cycle of capturing anatomical data, generating computer models, performing realistic and meaningful simulations and intra-operative testing is being repeated for numerous neural targets. This approach allows one to customize the configuration of the electrode to maximize its the ability to selectively record from or activate individual fascicles within the compound nerve trunk, thus increasing the surgical efficiency in deploying implanted neuroprosthetic systems and enhancing their performance. Center staff have also been collaborating with Drs. Steven Garverick, Pedram Mosheni, Darrin Young and Christian Zorman at

Case Western Reserve University to design, prototype and test new systems to monitor internal cavity pressures with wireless implantable sensors for diagnosis, monitoring and treatment. Applications include total joint replacements with wireless data acquisition and transmission; implanted myoelectric signal telemeters to control powered limb prostheses; and fabrication methods for micro-scale structures for neural interfaces. All of these activities utilize computer-aided-design (CAD) techniques and state-of-the-art software tools for schematic capture and circuit simulation. The APT Center also utilizes advanced computer-based rapid prototyping facilities to construct prototypes as an alternative to conventional machining and assembly. Designs of intricate and miniature mechanical components are specified in three dimensional CAD software such as Solid Works, and their kinematic and kinetic performance simulated with other design and analysis tools (Cosmos 3D) before prototype construction. Parts are essentially "printed" in three dimensions directly from their description in the computer software by rapid prototyping equipment that cross link molecules of a polymer resin with a laser, facilitating the construction of intricate and complex structures. Drs. Jeffrey Capadona, Dustin Tyler, Christof Weder and Stuart Rowan are using computer aided synthesis and analysis techniques to design and test new dynamic polymers that can change properties to meet environmental demands. That is, upon the proper chemical, electrical, or physical trigger, the stiffness of the material can be modulated. Applications of this unique material range from "mechanically invisible" implants for neural interfaces that match the compliance of neural tissue to dynamic splinting and casting methods or new prosthetic sockets adjusted to fit the changing shape of the residual limb during the course of the day.

Director: Ronald J Triolo, PhD, Cleveland VA Medical Center, Case Western Reserve University
Associate Director Clinical Needs Assessment Division/Medical Director: Graham Creasey, MD, Cleveland VA Medical Center, Case Western Reserve University
Associate Director for Concepts/Innovation Division: Kevin Kilgore, PhD, Cleveland VA Medical Center, Case Western Reserve University

Associate Director for Design/Prototyping Division: Dustin Tyler, PhD, Cleveland VA Medical Center, Case Western Reserve University

Associate Director of Operations & Program contact information: Suzana C. Iveljic, MBA, 216-791-3800 ext 6001; siveljic@fes.case.edu

Website address of initiative: http://www.aptcenter.org

Department of Veterans Affairs Rehabilitation Research and Development Service Center of Excellence in Functional Electrical Stimulation (FES)

Brief description of goals of initiative:

The Cleveland-based FES Center has a substantial research component focused on the simulation of human movement, especially on the effects of potential interventions on functional performance that has been very active for more than 10 years. This work has the goal of mathematically describing the mechanics of movement and the effects of muscle action (via both natural activation and functional electrical stimulation) on such movement with sufficient accuracy to allow the rapid development of effective rehabilitation interventions that improve functional performance. The primary investigators in this effort are Drs. Robert Kirsch, Ronald Triolo, Musa Audu, and Edward Chadwick, with contributions from a number of post-doctoral fellows and graduate students over the years. Much of the modeling effort has used several standard software packages, including SIMM (for defining musculoskeletal model parameters), SD/Fast (for developing mechanical equations of motion), Matlab/Simulink (for running model simulations and embedding these simulations in control systems), and various optimization procedures (for running inverse dynamic simulations that assess feasibility of an intervention). This effort has resulted in several sophisticated and innovative models of the human shoulder and arm, of both lower extremities and the pelvis, and of the torso. Exploratory simulations performed with these models are now routinely used to guide the selection of muscles to stimulate in neuroprostheses that restore movements lost to paralysis and for the development of command and control interfaces for neuroprosthesis users. This work has been supported by the VA RR&D Merit Review program and by various NIH mechanisms.

Dr. Robert Kirsch from the Cleveland FES Center is member of the advisory board of one of the NIH National Centers for Biomedical Computing, “Simbios” (Physics-Based Simulation of Biological Structures Center, U54 GM072970, http://simbios.stanford.edu/), led by Russ Altman, M.D., Ph.D., and Scott Delp, Ph.D., of Stanford University in California. Dr. Kirsch attended the first meeting of this board June 1-2, 2006 and participated in a very active discussion of the objectives of this center with regards to musculoskeletal modeling. Simbios is developing new open-source simulation software (called SimTK for “simulation toolkit”) that will eventually supersede the software suite currently used by the FES Center and by many other groups. The open-source nature of SimTK will greatly facilitate the sharing of information across different research groups, especially as it becomes the standard approach to musculoskeletal modeling. The Simbios developers solicited and received extensive feedback from the 10-member advisory board regarding the specifications of this software and features that would make it attractive to the community. Dr. Kirsch emphasized features that would make this effort an effective tool for developing future rehabilitation interventions. It is expected that the key components of this software will be available within the next 12 months, with continued development and specialization continuing into the future.

Executive Director: Hunter Peckham, PhD, Cleveland VA Medical Center, Case Western Reserve University
Medical Director: Robert Ruff, MD, PhD, Cleveland VA Medical Center, Case Western Reserve University

Associate Director, Clinical Affairs: John Chae, MD, Cleveland VA Medical Center, Case Western Reserve University
Associate Director, Education: Janis Daly, PhD, Cleveland VA Medical Center, Case Western Reserve University
Associate Director: Kevin Kilgore, PhD, Cleveland VA Medical Center, Case Western Reserve University
Associate Director, Research: Robert Kirsch, PhD, Cleveland VA Medical Center, Case Western Reserve University

Website address of initiative: http://fescenter.case.edu

Department of Veterans Affairs Rehabilitation Research and Development Service Center of Excellence for Innovative Visual Rehabilitation

Brief description of goals of initiative:
The Boston-based center is dedicated to the creation of a retinal prosthesis to restore vision to blind veterans. Having made a first prototype of their device, the researchers must now learn how to utilize the device to create visual images. The task is very challenging because the retina is a part of the brain, and its circuitry is quite complex. The Boston researchers are following a plan to learn more about the "neural code of vision"; basically to understand how the retina normally communicates visual information to the brain. The researchers have team up with Professor John Wyatt of MIT to initiative a new computational neurobiology program to analyze experimental data that is obtained from the retina and visual cortex by other researchers on the team who perform the biological experiments. The computational team will analyze the responses of up to hundreds of nerve cells simultaneously, and they will study how those responses change as the visual stimuli to the eye are varied.

Director: Joseph F Rizzo, MD, Boston VA Medical Center, Massachusetts Eye and Ear Institute, Harvard University
Associate Director: Ralph Jensen, PhD, Boston VA Medical Center
Program contact information: Mary Ramos 857-364-6548; civr@med.va.gov

Website address of initiative: http://www.bostonretinalimplant.org