Mechanical and Aerospace Engineering Research Projects 2007-08

A Novel Approach to the Treatment of Cardiac Arrhythmia: A Robotic Catheter For Epicardial Pacing Lead Placement

Gregory D. Buckner
LIFESCITECH, LLC
$52,337
02/16/09 - 11/15/09

The primary objective of this research is to develop and demonstrate shape memory alloy (SMA) actuated robotic catheters for minimally invasive surgery and catheterization. This technology has the potential to transform such procedures by providing unprecedented maneuverability, visualization and access to open spaces within the body. These computer-controlled catheters have the potential to impact a variety of medical fields including cardiology, cardiac surgery, pediatric surgery and urology. Our specific goals include designing and fabricating a 4 DOF robotic catheter and demonstrating its functionality and advantages by performing epicardial lead placement procedures on pig cadaver models.

Dynamic Tire Modeling for Off-Road Vehicles: Applications to Semi-Active Vehicle Suspensions

Gregory D. Buckner
Lord Corporation
$52,337
01/22/08 - 07/22/09

The design of controllers for active and semi-active vehicle suspensions has been the focus of extensive research in recent years. Low-order, linear time-invariant models are typically used for controller design and simulated performance evaluations. However, the dynamics of tires and suspension components is inherently nonlinear, particularly for off-road vehicles. The objective of this research is to develop and experimentally validate dynamic models of tires and suspension components for off-road vehicles. The focus will be to optimize the accuracy/complexity tradeoff, so that these models may later be used for the synthesis of control algorithms for semi-active suspensions.

Innovative Tools and Techniques for Robotic Heart Surgery

Gregory D. Buckner, Denis R. Cormier, Bryan W. Laffitte
National Institutes of Health
$1,336,792
08/16/04 - 05/15/09

The goal of this multidisciplinary research program is to develop technologies that facilitate and extend the capabilities of Minimally Invasive Robot-Assisted (MIRA) cardiac surgery. Specific objectives include the development of: (1) Devices for rapid and secure fixation of suture materials and prosthetic devices, specifically instruments and cartridges that provide "push-button" fixation for specific procedures (e.g. atrial closure and leaflet repair). (2) Reliable and secure intra-atrial retractors to provide excellent visualization of essential cardiac structures: endoscopically-deployable retractors that utilize the superelastic and shape memory properties of Nitinol to facilitate totally closed surgical procedures.

Reciprocating Micro Saw for Reversible Canal Wall Down Tympanomastoidectomy

Gregory D. Buckner
MicroSyntronics, Inc.
$20,000
01/16/09 - 08/15/09

The project involves the design of a lightweight, reciprocating microsaw for cutting bone in otolaryngology surgeries. The targeted procedure is the reversible canal wall down tympanomastoidectomy for the treatment of aural cholesteatomas. The procedure requires temporary removal of the posterior bony wall canal within a confined region.

Robotic Retraction for Minimally Invasive Pediatric Surgery

Gregory D. Buckner
UNC-CH Department of Surgery, Division of Pediatric Surgery
$20,000
01/16/09 - 08/15/09

The objective of this research is to develop a robotically-actuated thoracic retractor for minimally invasive pediatric surgery. *(Word Count: 17)*

5th Annual NIA/NASA/Space Grant Educator Training Workshop

Fred R. DeJarnette
NCSU NC Space Grant Consortium
$7,500
07/01/07 - 06/30/09

The National Institute of Aerospace (NIA), NASA Langley Research Center, and Space Grant have conducted four two-week summer workshops for middle and high school educators. The first workshop was conducted in 2003 and all educators were from North Carolina. The second and third years included educators from NC and VA, while the fourth year added Georgia and Maryland. The 5th workshop will included 12 middle and high school educators each from NC and VA and four each from GA and MD, making a total of 32. The educators will develop projects that they could use in their classrooms.

Center of Excellence in the Area of Human and Robotic Structures Technologies for Lunar and Planetary Exploration

Fred R. DeJarnette, Robert T. Nagel, Harvey T. Banks, Ashok Gopalarathnam, Vinod K. Saxena, Gregory D. Buckner, Mohammad Noori, Fuh G. Yuan, Jack R. Edwards, Mo-Yuen Chow
National Institute of Aerospace
Unfunded
10/01/02 - 09/25/12

This proposal was for a continuation of a grant from the NIA for research in fluid mechanics, aerodynamics, mathematics, solid mechanics and controls.

National Space Grant College & Fellowship Program

Christopher S. Brown, Fred R. DeJarnette
National Aeronautics & Space Administration (NASA)
$3,639,892
03/15/05 - 03/14/10

NC Space Grant, established in 1991, is an active member of the National Space Grant College and Fellowship Program. NC Space Grant currently has eleven university member institution, 7 industry/government/non-profit partners and has managed and provided more than $14 million in support to North Carolina citizens. NC Space Grant conducts programs in areas of fellowships and scholarships, higher education, research, K-12 professional development and public service to promote, develop and support aeronautics and space-related science, technology and engineering training and programs. This proposal is requesting $785,000 to the existing five-year NASA grant NNG05GG23H. *(Word Count: 93)*

Rapid Method For Computing Heating Rates on Hypersonic Vehicles Using Unstructured Grids

Fred R. DeJarnette, Hubbard Harris Hamilton, Kenneth James Weilmuenster
National Aeronautics & Space Administration (NASA)
$640,666
12/11/07 - 12/10/09

The objective of this topic area is to provide advanced flow-simulation capabilities that include all relevant physical phenomena in the hypersonic flow regime. These capabilities will enable the development of improved predictive and uncertainty qualification techniques that will in turn improve NASA's ability to design, test, operate and maintain future hypersonic vehicles, including HRRLS and HMMES. It is desirable to include most of the physical effects like flows containing multiple bodies, shocks, shear layers, with laminar, transitional and turbulent regions; radiation effects; nonequilibrium gas effects; radiation properties and gas-surface interactions.

Space Grant Programs at N C State University

Fred R. DeJarnette
NCSU NC Space Grant Consortium
$40,000
03/15/06 - 03/14/10

The Consortium Executive Board approved a budget that provides $20,000 to each NC member University for local competition and administration of Space Grant on their campus. The source of the funds is $10,000 from NASA and $10,000 from State Funds. This proposal is for the $10,000 from Phase I NASA Funding. These funds require one-to-one cost sharing. In addition, each member university has the opportunity to receive additional funding in consortium-wide grant competition, which requires one-to-one cost sharing, as well as funds in consortium-wide scholarships and fellowships competition, which do not require cost sharing.

BWXT Automatic Handling Technology

Thomas A. Dow
B&W Y-12, LLC (Babcock & Wilcox Technical Services)
$306,980
01/05/07 - 03/31/09

The goal of this project is to develop a sensor technique to assist in the automatic transfer of a spherical shell with a machined Outside Circumference (OC) on one spindle to a hemispherical pot-chuck on a second collinear spindle. The sensor system should be sensitive enough to detect the relative location of the two spherical surfaces and to sound an alarm if that distance becomes smaller than 10 um.

Improved Cancer Biomarker Detection Using Novel Air Amplifier Designs in ESI-MS

David C. Muddiman, Thomas A. Dow, Jack R. Edwards
National Cancer Institute
$346,802
09/04/08 - 08/31/10

Develop a novel device to sample cancer biomarkers into the orifice of a mass spectrometer for subsequent detection, characterization, and quantification.

LAT - Live Axis Turning

Thomas A. Dow, Jeffrey W. Eischen
National Science Foundation
$436,652
04/01/06 - 09/30/09

The goal of this research project is to improve the shape and surface finish of diamond turned, non-rotationally symmetric optical surfaces. This involves structural design, air-bearing analysis, control system design and implementation and precision diamond machining. The student will assist the faculty and graduate students in both the theoretical and experimental phases of the project.

Machining Miniature Optical Features With the Ultramill, PEC Enhancement Project

Thomas A. Dow
Panasonic Technologies, Inc.
$10,500
04/01/08 - 11/30/08

The objective of this project is to develop 3D fabrication techniques using the elliptical-vibration assisted machining tool, the Ultramill. This tool is installed on a 4-axis diamond turning machine with 3 linear axes (x, y and z) and a rotary axis holding the part. The project will demonstrate the capability of the Ultramill system to machine miniature optical elements within a constrained area. The project will demonstrate the system performance in terms of positioning accuracy in the linear and rotary axes as well as the flexibility of the Ultramill to change the surface features by modifying the tool path.

Material Effects and Tool Wear in Vibration-Assisted Machining

Thomas A. Dow, Ron O. Scattergood
National Science Foundation
$388,378
03/15/08 - 02/28/11

The goal of this research project is to study the wear of diamond tools for traditional and vibration assisted machining operations. This involves machining experiments, analysis of thermal environment, metrology of tools to measure wear due to abrasive and chemical origins, force and thermal modeling and fabrication experiments. The student will assist the faculty and graduate students in both the theoretical and experimental phases of the project.

Optical Probe Integration For Polaris, Enhancement Project in the Precision Engineering Center

Thomas A. Dow, Kenneth P. Garrard, Alexander Sohn
Johnson & Johnson Vision Care, Inc (formerly Vistakon)
$224,823
10/01/07 - 12/31/09

The tasks proposed for this project were: 1. replace the contacting probe on the Polaris 2D at the PEC with an optical Chromatic Aberration (CA) probe 2. extend the capability of that machine to 3D surface measurements (Polaris 3D) 3. demonstrate non-contact 3D measurements of non-rotationally symmetric contact lens molds The goal is to have a 3D measurement system that can measure the figure of an arbitrary surface accurately and in a reasonable amount of time.

PEC (Precision Engineering Center) Membership Pool Agreement

Thomas A. Dow
NCSU Precision Engineering Center
Current members at $30K/year
Lockheed Martin
Vistakon
Lexmark
3M

PEC Enhancement project "Lexmark Scanning Lens Design"

Thomas A. Dow, Kenneth P. Garrard, Alexander Sohn
Lexmark International, Inc.
$210,000
09/01/06 - 12/31/09

The specific goal of this proposal is to develop an integrated pre-scan lens to take the beams generated in the VCSEL and, using a mirror system, to collimate and focus that beam at approximately 100 mm from the laser source.

PEC membership agreement

Thomas A. Dow
Johnson & Johnson Vision Care, Inc (formerly Vistakon)
$180,000
01/01/04 - 12/31/09

Center membership for 3 years - $30,000 per year for a total of $90,000

PEC membership agreement

Thomas A. Dow
Minnesota Mining & Manufacturing Co.
$180,000
01/01/04 - 12/31/09

Renewal of 3-year membership agreement (@ $30,000/yr) between the NCSU Precision Engineering Center and 3M.

PEC membership agreement

Thomas A. Dow
Panasonic Technologies, Inc.
$90,000
04/01/06 - 03/31/09

3 year membership agreement - 30,000 per year for total of 90,000.

PEC Membership Agreement

Thomas A. Dow
Lexmark International, Inc.
$165,000
07/01/06 - 12/31/11

Membership

PEC Membership Agreement

Thomas A. Dow, Kenneth P. Garrard
Lockheed Martin Corp.
$90,000
01/01/08 - 12/31/10

Center membership

An Approach for the Direct Simulation of Subgrid Scale Physics in Fire Simulations

Tarek Echekki
NCSU NC Space Grant Consortium
$25,000
07/01/07 - 06/30/09

The objective of the proposed effort is to implement a novel modeling framework for subgrid scale physics in coarse-grained simulation of fires. Fires represent a critical factor in the planning of space missions and the design of space-crafts. A principal scope in the research effort is to develop a reliable predictive tool for fires based on a coarse-grained simulation approach for fluid dynamics and combustion called large-eddy simulations (LES) combined with a low-dimensional modeling approach called one-dimensional turbulence (ODT).

Computational and Experimental Studies Turbulent Premixed Flame Kernels

Tarek Echekki
National Science Foundation
$29,999
09/01/08 - 08/31/11

The PI's propose collaborative computational-experimental efforts to understand the mechanisms that govern flame dynamics and structure at lean fuel conditions based on a canonical flame-flow configuration: the post-ignition turbulent premixed flame kernel. Operation at fuel-lean mixture conditions may result in flame quenching, which may be followed by reignition. It also contributes to thermo-acoustic instabilities, which plague the operation of practical combustion devices operating at lean conditions, such as gas turbines. The combined computational-experimental efforts will address the mechanisms, which govern flame kernel dynamics (inherent instabilities) and structure (local quenching) under turbulent conditions.

Industrial Assessment Center

Herbert M. Eckerlin, Stephen D Terry, James W. Leach
US Dept. of Energy
$4,380,000
09/01/06 - 08/31/11

Each year, the NCSU Industrial Assessment Center (IAC) must apply for continuing funding from the US Department of Energy to support its operation. Using a team of faculty and graduate students, the IAC conducts energy efficiency analyses of 25 manufacturing plants and prepares detailed technical reports to the plant managers with recommen-

dations on how their energy efficiency can be improved. These experiences provide students with excellent on-the-job training in identifying and implementing energy saving opportunities. The success of the IAC also contributes to reductions in greenhouse gas emissions.

Energy Management Program

Herbert M. Eckerlin, Stephen D. Terry
$453,000
7/1/08 – 6/30/09

Under the Energy Management Program (EMP), faculty, staff and graduate students conduct energy assessments of industrial, commercial and governmental facilities. The objective is to identify energy efficiency opportunities, make appropriate recommendations, and to encourage project implementation. This program has taken on increased importance as the state and nation seek to lessen their dependence on foreign oil.

An Energy Efficiency Program for the NC Community Colleges

Herbert M. Eckerlin
$79,500
5/16/08 – 9/30/08

The Community College Energy Efficiency Program is part of the governor-sponsored Utility Savings Initiative to improve the energy efficiency in state owned and operated buildings. Under this program, MAE faculty and staff conducted energy assessments of 60 buildings at 29 Community Colleges in Eastern North Carolina. Individual reports were developed for each building, outlining where energy waste was occurring and how this waste could be eliminated. The program was very well received by the participating schools and funding is being sought to make the recommended changes.

A Study of Supersonic Compression Corner Interactions Using Hybrid LES/RANS Models

Jack R. Edwards
Army Research Office
$216,604
11/01/08 - 10/31/12

This work will utilize hybrid large-eddy / Reynolds-averaged Navier-Stokes (LES/RANS) models to conduct detailed studies of the structure of supersonic compression-corner interactions. Comparisons with mean-flow and second-moment fluctuation data obtained at Princeton University's Gas Dynamics Lab will be used to assess the performance of the models. Emphasis will also be placed on the mechanisms behind fluctuation amplification, shock system unsteadiness, and mean-flow three-dimensionality for these interactions. The results are expected to provide benchmark quality predictions of these complicated interactions which then may be used to assess simpler closure strategies.

Computational Simulation of the Joint Expeditionary Collective Protection (JECP) System

Jack R. Edwards, Jeffrey W. Eischen, Jung-Il Choi
Naval Surface Warfare Center
$539,497
06/24/08 - 12/31/10

This project will develop a computational fluid dynamics method for simulating ingress / egess into collective protection equipment being developed for the Joint Expeditionary Collective Protection program. The method will incorporate digital animation technology to replicate mission-specific human activity, will link with urban airflow models to provide external environmental conditions, and will utilize fabric-response structural models to simulate the effects of semi-rigid or flexible entryways.

Detailed Modeling of Aerosol Re-Suspension and Deposition

Jack R. Edwards
Environmental Protection Agency (EPA)
$80,000
06/01/06 - 09/29/08

This work will continue the development of the Room Simulator code for simulating particulate transport as induced by human-body motion and other factors. Specific additions are a.) improved models for particle sticking forces b.) improved models for carpet rebound effects c.) thermal boundary layer models d.) overset grid techniques for large-scale simulations

Development of Hybrid Large-Eddy / Reynolds-Averaged Navier-Stokes Methods for High-Speed Internal Flows

Jack R. Edwards
National Aeronautics & Space Administration (NASA)
$487,000
01/04/07 - 01/03/10

This research will develop hybrid large-eddy / Reynolds-averaged Navier-Stokes (LES/RANS) simulation strategies for high-speed flows and will test them for a series of three-dimensional flows characteristic of inlet / isolator / combustor components of advanced engine concepts. LES/RANS techniques exhibit several promising traits, including a direct capturing of the coupled effects of unsteady shock motion along with an ability to simulate the observed rapid recovery of a turbulent boundary layer downstream of a shock-induced separation. The development of this technology will pave the way toward improved simulations of high-speed engine flowfields.

Hybrid LES/RANS Simulation of the Effects of Boundary Layer Control Devices Using Immersed Boundary Methods

Jack R. Edwards
US Air Force-Office of Scientific Research (AFOSR)
$292,204
03/01/07 - 11/30/09

This work will combine hybrid large-eddy / Reynolds-averaged Navier-Stokes models with immersed-boundary procedures to enable efficient analysis of the effects of different control devices on boundary layer transition and shock / boundary layer interaction control.

Numerical Simulation of Multiphase Flows within Scramjet Engine Configurations

Jack R. Edwards
Taitech, Inc
$30,000
04/17/08 - 04/16/09

This work will continue the development of REACTMB-MP for multiphase flow applications.

Experimental and Numerical Investigation of Two-Phase Flow within Pressure Atomizers Used in Trigger Sprayers

Tiegang Fang, Jack R. Edwards
MeadWestvaco Corp.
$295,173
01/01/08 - 12/31/09

Trigger sprayers are often used in our common life. The liquid breakup and atomization behavior dierectly affect the spray quality. The proposed research will conduct experimants on visualization and measurement of droplet size distributions generated by swirl atomizers. At the same time, numerical model will be further developed to predict details of the primary atomization process in spraying nozzles to a degree of fidelity suitable for use as initial conditions for other techniques that model secondary breakup and droplet transport.

Analytical and Computational Investigation of Pitch-Plunge Airfoil Motions at Low Reynolds Numbers

Ashok Gopalarathnam
US Air Force-Office of Scientific Research (AFOSR)
$19,952
03/15/09 - 11/14/09

Analytical and computational investigations will be conducted for airfoils at low Reynolds numbers undergoing high frequency and high amplitude pitch-plunge motions . The results will be compared with experimental investigations being conducted in parallel at the Air Force Research Laboratories. Theory will be used to design pitch-plunge combination motions with desired characteristics such as zero wake strength and zero amplitude in the oscillatory lift. The effectiveness of using theory to superpose the aerodynamics for elementary motions will be explored with the aim of understanding the flows associated with complex motions such as flapping and perching.

Optimization Studies For a Telescoping Wing Concept

Ashok Gopalarathnam
KalScott Engineering, Inc.
$185,118
06/01/06 - 10/01/08

Recent studies have shown the benefits of wing shape adaptation for aircraft performance benefits over a large range of flight conditions. A telescoping wing allows for significant in-flight changes to the wing area and span. The research effort aims to study the aerodynamics of telescoping wings in detail to determine the best ways to adapt the shape of the wing for different flight conditions. Multiple trailing-edge flaps will be used for spanwise load control and the telescoping motion will be used for achieving large aerodynamic changes to the wing.

DESIGN AND DELIVERY OF H-53 PROTOTYPE BATWING SLING

Richard D. Gould, Eric C. Klang
Naval Air Depot, Cherry Point
$15,000
01/07/09 - 04/24/09

The Mechanical and Aerospace Departments MAE 416 senior design section at NC State University will design and build an H-53 Prototype Batwing Sling for NAVAIR.

Development of a Clutch Mechanism for Squirrel Cage Windturbine

Richard D. Gould, Chau Tran
John Ketcham
$6,000
08/09/08 - 11/15/09

The objective of this research is to design and develop one or more clutch mechanisms that are responsive to the rotational speed of squirrel cage windturbine stages. The goal is to demonstrate whether speed sensitive clutches can be used to stage the rotation of stacked squirrel cage impellers in varying wind conditions.

Flash Steam Generator

Richard D. Gould
John Ketcham
$6,000
04/15/08 - 08/15/08

The objective of this research is to create a small boiler, fired by a combustible fuel, which will bring water to steam as quickly as possible. The goal is to achieve 650 psi and a steam temperature of 475 F within 30 seconds. If this is not possible the minimum time to achieve this will be determined.

Investigations of Airworthiness Certification Improvements for U.S. Navy Unmanned Aircraft Systems

Charles E. Hall
Naval Air Systems Command (NAVAIR)
$1,131,976
01/31/08 - 01/30/10

The university will provide focused recommendations for achieving concrete and usable results for improving the standards and procedures for certifying the airworthiness of small Unmanned Aerial Systems (UAS). A System Level Airworthiness Tool will be developed that provides a flexible method for determining inherent airworthiness, compensating airworthiness mitigation techniques, and flight testing techniques. It will be flexible enough to cover the full range of UAS sizes and configurations, while being as transparent and easy to use as possible. The QAS terminology and rating system will be based on the terminology used in MIL-STD 882 for risk assessment. *(Word Count: 128)*

Subscale Flying Wing With Bias Momentum Attitude Stiffening (Task Order No. 6224-NC)

Charles E. Hall, Stearns N. Heinzen
National Institute of Aerospace
$630,432
10/06/08 - 09/25/09

An Unmanned Aerial System will be develop, construct, ground and flight test the use of an angular momentum wheel for attitude stiffening. The UAS will be composed of a straight wing with a fuselage pod. A removable horizontal stabilizer will be added for the initial flight tests for risk reduction. The UAS will be powered by a electric motor in a pusher configuration. Avionics will be installed for data collection and stability augmentation as required. Analysis of the ground and flight test data will document the use of pitch-roll coupling for a flying wing aircraft.

Improved Modeling of the Turbulent Diffusion of Thermal Energy and of Chemical Species in Turbulent, Chemically-Reacting Flow-Field CFD Calculations

Hassan A. Hassan, Xudong Xiao
US Air Force
$1,475,000
08/13/04 - 01/10/09

A detailed proposal for modeling turbulent combustion in ram/scramjets is presented. The proposed model is based on the exact conservation equations and takes into consideration velocity, enthalpy and concentrations fluctuations. As a result of this approach, both the Prandtl and the Schmidt numbers are determined as part of the solution. The development of the model is an extension of the k-turbulence model and, as such, will share with it the following desirable features: no wall or damping functions, coordinate independence for ease of handling complicated geometries, tensorially consistent and, invariant under a Galilean transformation.

Radiative Heating Environment During Planetary Entry

Hassan A. Hassan
National Aeronautics & Space Administration (NASA)
$305,316
02/06/08 - 02/05/10

A number of recent studies have been conducted to evaluate capabilities of existing codes in predicting the aerothermal environment of planetary entry. The focus of these studies was the FIRE II experiment. In general, the various codes gave similar predictions of the convective heating when identical physical models were employed. However, significant differences were noted in predicting the radiative heating especially in the vacuum ultraviolet. The goal of this proposal is to incorporate in the NASA Ames Data-Parallel Line Relaxation (DPLR) a three temperature thermal nonequilibrium model and to update NASA Ames NEQAIR using recent optical data and rates.

Energy Crops for North Carolina, Phase II

Alexander O. Hobbs, Kurt S. Creamer
Golden Leaf Foundation
$1,000,000
02/01/07 - 10/31/08

The purpose of this project is to demonstrate the agronomic and economic viability of carefully selected energy crops and their potential for biofuel production (and secondarily power generation). Growing these crops will provide a new source of revenue for farmers and stimulate biofuel production in North Carolina. This project will also evaluate existing feedstock in North Carolina that could act as a primer for a biofuel industry, thus creating demand for other bioenergy crops.

(a) Title : Two Pilot Projects for Scalability in Engineering Instruction: Free-Body Diagrams and Instructor-led Example Problems

(b) Principal investigator(s): Anna Howard, Afsaneh Rabiei, Melur K. Ramasubramanian, Cheryl Heeter

(c) Granting agency: UNC - General Administration

(d) Funding amount: $41,450

(e) Duration: 05/01/08 - 12/31/08

(f) Brief description of the research project: We propose a pilot project to improve the quality and scalability of our distance and on-campus offerings of MAE 206, Engineering Statics. We will create two resources: 1) an online tool where students can produce and get feedback on their free-body diagrams and 2) a library of worked examples for students. We believe that both of these projects will benefit on-campus and distance students by increasing the student opportunities for feedback and by reinforcing the methods used to solve the problems in MAE 206.

Enhancing Transfer Students Graduation Success in Computer Science, Engineering, Mathematics and Statistics

Tony L. Mitchell, Jeffrey S. Scroggs, Joann D. Cohen, Marcia L. Gumpertz, Christopher G. Healey, Richard F. Keltie
National Science Foundation
$400,000
09/15/04 - 08/31/09

We seek $400,000 over four years to establish the Computer Science, Engineering and Mathematics Scholarships (CSEMS) Program for transfer students at NC State University. Our transfer student population of over 500 annually does not compete successfully for scholarships with other students because of shorter on-campus academic history. We will continue to use student success incentives that have proven to be very successful in administering our current CSEMS project. At project's end, we will have increased the rate at which at least 116 transfer STEM scholars have earned their degree, and built a more diverse, inclusive student population.

Vibration Model of Distributed, Multi-Point Excitations of a Finite Cylinder

Richard F. Keltie
ManTech Systems Engineering Corporation
$91,971
July 1, 2009 – December 31, 2009

This agreement will fund the development of a mathematical model capable of characterizing the key vibration phenomena of a submarine hull form given a known distribution of point-excitation forces as well as analysis of acoustic sound pressure level accuracy of the aforementioned model as implemented in the submarine mine warfare tactical decision aid developed by ManTech.

Computational Studies of JP-8 Fuel Aerosol and Toxic Nanomaterial Transport/Deposition in Models of the Human Respiratory System

Clement Kleinstreuer
US Air Force
$721,418
08/01/07 - 07/31/10

This proposal describes the continuation and extension of our previous AFOSR-contract work (Award No. FA9550-04-1-0422, Dr. Walt Kozumbo, Program manager). The results of the first two years have been documented in 13 journal articles and presented at two conferences and three AFSOR-sponsored workshops. Specifically, employing the validated computer code CFX from Ansys, Inc. (Canonberg, PA) and our proven particle tracking code "F90", the following simulations have been completed: (i) modeling of airflow as well as nano- and micro- particle deposition; (ii)

comparison of micro- and nano-size particle deposition in human upper airways, relying on an actual cast model and the Weibel Type A upper bronchi geometries; (iii) studies of multi-component (JP-8 fuel) and/or impure droplet evaporation (or hydroscopicity) and their effects on lung deposition; and (iv) JP-8 fuel vapor deposition in light of variable wall absorption.

Experimentally Validated Numerical Simulations of Nanomaterial Transport and Uptake in Human Lung Models

Clement Kleinstreuer, Zhe Zhang
National Science Foundation
$430,000
09/01/08 - 08/31/11

Main Grant: Complementary to the AFOSR grant dealing with inhaled jet-fuel vapor and droplets, the NSF-sponsored work focuses on the transport and deposition of nanomaterial in human lung models.

Supplement: An ROA (Research Opportunity Award) supplement has been awarded to NC State University for Prof. C. Kleinstreuer (supported by NSF Grant CBET-0834054, Dr. Marc Ingber Program Director) to employ Assoc. Prof. S. Hyun and his two UG students from Mercer University (Macon, GA) which offers a 4-year UG engineering program as well as a few masters-level courses. Dr. Hyun is an expert in geometry file conversion of patients' medical image files to fluid flow domains for mesh generation and CFD simulations.

Particle-Hemodynamics in the Hepatic Artery system and Targeting of Y90-Microspheres onto Tumors

Clement Kleinstreuer, Andy Kennedy (WROS, WakeMed)
SIRTEX Medical, Ltd.
$65,000
03/01/09 – 02/28/10

The goal is to determine best physical characteristics of Y90-microspheres as well as optimal operational conditions, using a smart micro-catheter, to deliver the radioactive particles to liver tumors in order to destroy cancer cells without harming healthy tissue.

Modeling of Flow Containing Nanoparticles Through Electrostatically Charged Monolith Filters

Warren J. Jasper, Andrey V. Kuznetsov
Defense Threat Reduction Agency
$772,500
01/31/08 - 01/30/11

This proposal aims at determining a correlation between channel diameter, particle size, and the probability of a submicron particle (10-300 nm) entering a channel when Brownian motion and electrostatic charge are taken into account. The proposed approach is unique as it will experimentally map the charge distribution in the monolith using Electrostatic Force Microscopy (EFM). This electrostatic mapping will be a direct input into the CFD and FEA algorithms to be developed so the correlation function will be based on actual experimental data and not on assumptions or ideal charge distributions.

A Cartesian Mesh Method For Turbulent Flow Simulation

Hong Luo
D & P, LLC
$69,422
07/14/08 - 06/30/09

The objective of the proposed Phase I effort is to develop a prototype Cartesian mesh solver for high Reynolds number turbulent flow simulations. This will be achieved by extending an existing inviscid Cartesian mesh solver with gridless boundary conditions to viscous flow simulations. As a feasibility study, the Phase I outcome will ensure the validity of the proposed Cartesian mesh approach for high Reynolds number turbulent flow simulations.

Development of a Regional Structured and Unstructured Grid Simulation Methodology For Propulsion System Analysis

Hong Luo, Jack R. Edwards
National Aeronautics & Space Administration (NASA)
$1,476,200
01/03/08 - 01/02/11

The proposed work develops procedures for incorporating regional unstructured-mesh technology into VULCAN in a manner that preserves all of the original algorithm's components (and efficiency) for structured meshes but greatly increases its flexibility for complex configurations. The significance of this research is that it provides a method for utilizing unstructured and structured mesh technology where each is the most optimal and most efficient. As structured-mesh regions will be solved using the original VULCAN algorithms, memory and CPU overhead associated with a fully unstructured approach will be minimized.

Development of a Simulation Code for Computing Detonation and Shock Waves on Arbitrary Grids

Hong Luo
Engineering and Software System Solutions, Inc.
$49,919
09/24/08 - 08/15/09

There is a growing need to simulate blast and shock waves for complex geometries on a computer platform in a reasonable time and accuracy. Simulation of high explosive detonation, blast propagation, and shock wave diffraction plays an important role in determining and assessing target vulnerability and weapon lethality in our war against terrorists. The objective of the proposed efforts presented in this work is to develop a fast, accurate, and robust method for computing detonation and shock waves past complex geometries by combining the advantage the efficiency of a Cartesian grid method and the flexibility of an unstructured grid method.

Development of an Advanced Coupled Implicit Magnetohydrodynamics and Thermal Conduction Code for Solar Modeling

Hong Luo
National Aeronautics & Space Administration (NASA)
$143,575
03/11/09 - 03/10/12

We propose to develop a new set of advanced and fast explicit and implicit 3D magnetohydrodynamics codes and an implicit thermal conduction code for modeling solar activity

on both local and global scales. These codes will be based on unstructured grid technology and use finite volume, finite element, and discontinuous Galerkin techniques. The integrated code will be designed so that both explicit and implicit MHD can work together as well as work with the thermal conduction code. All codes will be integrated into the Adapt3D framework for the LWS program.

Development of an Instrumented Thermal Manikin Head for Characterizing the Thermal Protective Performance of Military Head Gear in Fire Environments

Roger L. Barker, Kevin M. Lyons
US Army Soldier Systems Center (Natick)
$284,000
07/22/08 - 08/31/09

The large number of burn injuries encountered during in operations in Iraq and Afghanistan has highlighted the need to better characterize the performance of head gear in fire exposures. There is a need, therefore, to develop an enhanced capability to characterize the thermal protective performance of protective gear in these environments. The proposed PyroHead form will be fabricated from flame resistant resin to resist repeated exposures to the extreme fire environment (average flux of 2.0 cal/cm2sec). The head/torso instrumentation will enable enhanced evaluation of potential burns to the head and upper torso region of the body, with or without head gear in place.

Extinction, Entrainment and Stabilization Studies in Spray Flames

Kevin M. Lyons
Army Research Office
$149,994
03/01/05 - 02/28/09

A topic of longtime interest in combustion research has been the stabilization, and blowout, of lifted-jet flames. The problem is still of interest and provides a scientifically interesting situation where application of advanced diagnostics is useful to uncover information about the flame structure and flow dynamics. This phenomenon is witnessed in combustion systems encountered in practical devices where flame stability is of primary importance. Flame stability, and combustion tailoring, is of pressing importance in both gaseous and spray flame environments, and is studied under support from ARO.

Flame Propagation and Blowout in Hydrocarbon Jets: Experiments to Understand the Stability and Structure of Reaction Zones

Kevin M. Lyons
Army Research Office
$512,288
06/01/08 - 11/30/11

Outlined is a proposed research plan for the experimental investigation of flame reaction zone structures. Specifically, the scope of the research will examine fundamental phenomena in a multitude of flame/flow interactions in jets flames: the overall structure of the reaction zone in both laminar and turbulent flames, propagation characteristics, flame hysteretic behavior, blowout/extinction characteristics and effects of air entrainment on reaction zones.

Development of a Space Systems Design Teaching Manual

Andre P Mazzoleni
NCSU NC Space Grant Consortium
$5,388
01/01/09 - 05/15/09

In order to provide students with exposure to topics relative to space, space systems design, and systems engineering, the MAE Department has been developing a Space Systems Design capstone course offered to seniors majoring in Aerospace Engineering. This project involves developing a manual consisting of notes regarding basic class procedures, formal lectures given during the course, exercises developed for use in the course, and other course materials. The intention is for the information gathered through practice over the last 5 years of teaching the course to be passed down to future teaching assistants assisting with the course.

Development of Air Table Facility for Space Systems Senior Design Program

Andre P Mazzoleni
NCSU NC Space Grant Consortium
$10,000
07/01/08 - 12/31/09

Air tables are invaluable tools for conducting table-top experiments involving the design of spacecraft control systems. With an air table, 2-degree-of-freedom satellite motion can be simulated by floating spacecraft mock-ups on a cushion of air, enabling students towo test out differnet mechanisms for controlling spacecraft motion. This proposal requests funds for the 2009-2009 space Senior Design class program to support the design and construction the air table facility described above.

Development of Drop Tower Facility for Space Systems Senior Design Course

Andre P Mazzoleni
NCSU NC Space Grant Consortium
$20,000
07/01/07 - 12/31/09

The Aerospace Engineering program at NC State requires all students to take a two-semester course in aerospace systems design and select either aircraft design or space systems design. The enrollment in the space systems design course has increased from 7 students last year ago to 17 this year, and we anticipate that the numbers for next year will be similar to this year. To ensure that there is a variety of projects for students to select from, this proposal requestes funds to develop a drop tower facility that students can use to test future projects in a reduced gravity environment.

Entry Systems for Human and Robotic Exploration, NIA GRA Student Jamie Wilson

Andre P Mazzoleni
National Institute of Aerospace
$360,316
08/15/06 - 12/31/08

The entry, descent and landing (EDL) of space exploration vehicles in planetary atmospheres provide many important challenges, which must be overcome before a successful mission can be implemented. The flight systems of these vehicles must be well understood and quantified before a successful design can be reliably implemented. Interactions

between the thermal protections system, the guidance and control system, atmospheric uncertainties, interplanetary navigation, etc must be considered to assure entry analysis fidelity. This research will involve the study of general engineering aspects of EDL missions and their impact on the systems level design.

Flight System Identification of Spacecraft (NIA GRA Chris Hartman)

Andre P Mazzoleni
National Institute of Aerospace
$396,680
05/31/06 - 01/31/10

The research area involves analyzing data to developing pilot models for correcting pilot induced oscillations exhibited by pilots interacting with adaptive aircraft controllers. Aircraft-pilot coupling (also called Pilot-Induced Oscillations, PIO) has been exhibited when adaptive controllers have been tested on the NASA Dryden F-15. It is believed that the pilot is adapting to the adaptive control in a manner that leads to the PIO. So, this project proposes to look at data from a tracking task (some data is already in hand) to try to identify a pilot model that can be used in the analysis of adaptive control systems.

Investigation of Intervertebral Stabilizer Selection Criteria For Long Spinal Fusions With Variable Spinal Stiffness

Andre P Mazzoleni
Synthes Spine Company, LP
$55,350
08/16/07 - 08/31/09

About 10 million adult patients suffer from severe back pain that can be reduced or eliminated through spinal surgery (www.brainandspineonline.com). Currently the most widely used techniques use external rods which are aligned parallel to the spinal column and are attached to each vertebra with pedicle screws. Insufficient intervertebral joint stiffness can be corrected by using stabilizing spacers to replace the destabilizing intervertebral discs. This project involves using finite element analysis to develop criteria to aid in the decision of whether or not to incorporate additional stability to the spine by inserting spacers during a spinal fusion procedure.

Mars Rover Technology Development

Andre P Mazzoleni
NCSU NC Space Grant Consortium
$6,000
11/21/07 - 09/30/09

A common challenge in landing a craft during any interplanetary mission involves dealing with the high speed re-entry conditions. The ideas presented will show how a “sand tunnel”, utilizing glass beads flowing past an airfoil model, can be built to model re-entry characteristics, including shock formations, on a variety of airfoil designs. The hardware, in conjunction with analytical software, will be able to display some of the pertinent characteristics involved in entering and descending on a planet with an atmosphere. Overall, the sand tunnel will show how a craft landing on a planet like Mars would interact with hypersonic flow.

Structural Design of Inflatable Atmospheric Entry Systems (NIA GRA For Rafael Lugo)

Andre P Mazzoleni
National Institute of Aerospace
$91,026
08/15/07 - 08/14/09

This project, supported by NASA-Langley, concerns the development of inflatable systems for entry descent and landing flight systems. Specifically this project will involve structural design and non-linear structural analysis of inflatables used in high heating, atmospheric entry systems.

Dynamically Resolved Simulatin of Atmospheric Features and Turbulence Using Advanced Models and Adaptive Algorithms

David S. McRae, Hassan A. Hassan
US Air Force
$510,600
06/17/04 - 09/30/08

This project installed the NCSU adaptive grid algorithm DSAGA and developed and installed an atmospheric version of the NCSU k-ζturbulence model in the numerical weather prediction code MM5. Results compared with observations showed increased accuracy of optical turbulence prediction but indicated that fundamental problems with the basic NWP code algorithms and structure will limit the benefit from increased resolution. A follow on project is addressing these fundamental issues with the NWP code WRF.

High-Resolution Simulation and Modeling of Atmospheric Turbulence

David S. McRae, Hassan A. Hassan
NorthWest Research Associates (NWRA)
$225,000
04/19/07 - 03/19/10

This project will modify the mesoscale atmospheric model WRF-ARW by installing the NCSU adaptive mesh algorithm DSAGA, the NCSU k-zeta turbulence model, and a NWRA developed BHM SGS model for high resolution prediction and simulation of atmospheric turbulence. Other modifications will be installed as determined by analysis of the model and its output. Verification and validation of the high resolution model and integration into a suite of prediction tools will be conducted with NWRA. Code development and maintenance will be conducted jointly with NWRA leading to a single product. NCSU will provide support during delivery and checkout of the code.

CAREER: Meso and Macro Hydroforming of Complex Shapes - Mechanics and Control

Gracious Ngaile
NSF-DMI
$400,000
February 2005-January 2010

The overall objective of this Faculty Early Career Development (CAREER) research is to understand the fundamental mechanics of hydroforming of tubular components at different scale levels (meso and macro) and establish fundamentals to enable manufacturing of complex macro and miniature (meso-scale) tubular components. The characteristics pertaining to fluid-pressure loading and feeding of material are studied through analytical modeling, numerical, and experimentation. As the evolution of tubular surface dur-

ing deformation and material formability are critical to the success of the process, non-conventional loading paths are investigated, i.e., step-wise feeding of material, vibration pressure loading conditions, and dual pressure loading.

Formulation of Environmentally Friendly Lubricant Based on Polymeric Materials for Cold Forging Processes.

Gracious Ngaile
SISU-Chemicals- NSF- STTR Phase II
$ 265,508
June 2006-July 2009

The overall objective is to develop environmentally friendly lubricants for cold forging processes based on polymeric formulation. This lubricant is aimed at replacing zinc phosphate coating. The specific objectives are to: a) formulate polymeric based lubricants for forging processes that will replace the present hazardous zinc phosphate coating lubrication systems, and b) develop a quick and robust online lubrication system for the newly formulated lubricants. The proposed method of producing the synthetic lubricant is by emulsion polymerization. The anticipated water-borne chemistry will incorporate the adhesion and stabilization mechanisms within the matrix of the polymer.

Ultrasonic Assisted Microextrusion and Microtube hydroforming

Gracious Ngaile
NSF
$294,226
06/01/15/09 - 06/30/12

The objective of this study is to study the mechanics of ultrasonic assisted microforming, focusing on micro-extrusions and microtube hydroforming. The influence of ultrasonic vibrations on material formability, and tribological conditions will be studied through analytical modeling, numerical, and experimentation. Models for predicting temperature generation caused by ultrasonic vibrations, coupled with temperature induced due to plastic deformation will be established. The transformation of material characteristics due to temperature rise caused by ultrasonic vibrations at different energy levels will be studied. The effect of ultrasonic energy on the reaction response of lubricant chemicals at the tool-workpiece interface will also be studied.

Collaborative Research: Full-spectral Interrogation of Fiber Bragg Grating Sensors for Damage Identification

Kara Jo Peters, Mohammed A. Zikry
National Science Foundation
$149,000
05/01/09 - 04/30/12

This research project will design, implement and apply a full-spectral interrogator for FBG sensors operating at high data acquisition rates and the associated signal processing algorithms required to interpret the acquired spectral data. The performance of the interrogator and sensor system will be evaluated for two applications: (1) the identification of sub-surface damage states in woven composite specimens subjected to multiple low-velocity impact events and (2) structural health monitoring of bonded composite joints. The research plan is a collaborative effort the Department of Electrical and Computer Engineering at Brigham Young University.

Intelligent Multi-Scale Sensing for Damage Identification and Mitigation in Woven Composites for Aerospace Structural Applications

Kara Jo Peters, Mohammed A. Zikry
US Air Force-Office of Scientific Research (AFOSR)
$264,141
01/15/08 - 11/30/10

This project pursues an integrated analytical, computational and experimental investigation of material damage and failure modes in heterogeneous material systems embedded with combinations of optical sensors. The optimally distributed and embedded fiber optic sensors will provide displacement, displacement gradient fields, and strains at different physical and temporal scales. Concurrently, the sensors will provide functional self-testing to evaluate the validity of each measurement based on their integrity. Relating these local strain measurements to global measurements of material behavior during impact, such as contact forces and dissipated energies, will provide life cycle predictions that will be based on interrelated material mechanisms.

Self-Healing Sandwich Composites

Kara Jo Peters, Mohammed A. Zikry
National Science Foundation
$312,000
08/01/08 - 07/31/11

This research project will create a sensor network and sandwich composite structural system that can self-repair after extreme events. The sensor network will capture the state of the local host structure prior to and post self-healing. Furthermore, a multi-physics predictive computational model of the entire process that would integrate the processes of photopolymerization, lightwave propagation in a heterogeneous structure, opto-mechanical interactions, and thin film polymer damage mechanics will be developed. The success of this research project would provide for reliable structural systems that can be applied at critical structural locations that are susceptible to extensive failure.

SST: Polymer Fiber Waveguide Sensors for Performance-Based Assessment and Health Monitoring of Civil Infrastructure Systems

Tasnim Hassan, Kara Jo Peters, Mervyn J. Kowalsky
National Science Foundation
$457,996
08/15/04 - 07/31/08

The research described in this proposal aims to develop (1) an interferometric polymer optical fiber sensor for the measurement of distributed strains and/or localized strains and (2) a minimally invasive, high sensitivity polymer planar waveguide sensor for embedment into particular structural systems. This research program will focus on the application of the sensors to concrete and steel structures subjected to dynamic load conditions. Sensor development will be evaluated by a combination of lab and field studies in conjunction with non-linear response history analyses.

CAREER- Processing and Development of a New Ultra-Light High-Strength Material

Afsaneh Rabiei
NSF
$430,000
April 2003 - March 2010

In order to address the increasing needs of the aerospace, naval, automotive, medical and other industries for advanced materials to provide the lightweight and high strength components, a new high strength ultra-light material is being developed, processed, and tested. This material is based on improving pore structure of metallic foams and then characterize and model their behavior under various types of loading.

Processing and characterization of functionally graded coatings for biomedical implants

Principal investigator(s): Afsaneh Rabiei
Granting agency: NSF
$220,000
2006-2010

The aim of this study is to develop a functionally graded Hydroxyapatite (FGHA) coating for orthopedic and dental implants with a tailored release rate of an antimicrobial component. As the result, patient receiving an orthopedic or dental implant could return to a normal lifestyle sooner with the reduced antibiotics intake along with less risk of infection and it's subsequent complications.

Design Manufacture And Evaluation Of Advanced Composite Foam Structures For Armors,

Afsaneh Rabiei
Subcontract to KDH for an Air-force funded project
$30,000 is paid as gift and more pending
ongoing

The overall objective of this research is process new light materials with increased energy absorbing capability to improve the performance of body armors and army vehicles. This research includes design and fabrication of the required material and evaluation of the mechanical properties of the new material under high speed impact.

Title: Processing and development of nano-scale thin film Hydroxyappetite coatings for biomedical implants

Afsaneh Rabiei
Oak Ridge National Lab
Free access to ORNL Facilities
March 1, 2009 to February 28, 2010

The overall objective of this research is process new nano-scale thin film coatings for better performance in the body on various orthopedic and dental implants.

IREE: CAREER: Processing and Development of a New Ultra-Light High-Strength Material

Afsaneh Rabiei,
NSF
$22,250
May 2007 to Ma*rch 2010*

The goal of this IREE supplemental was to provide opportunity for an underrepresented undergraduate student to gain international research experience through her involvement in the current project funded by NSF entitled **" CAREER- Processing and Characterization of a New Ultra Light High Strength Material", award # 0238929**. **In this project the student** gains the access to first class facilities at The university of Tokyo to conduct the inverse analysis and acoustic emission/ ultrasound testing to evaluate the failure mechanism of our newly developed composite metal foams.

IREE: Processing and Characterization of Functionally Graded Coatings for Bio-Medical Implants

Afsaneh Rabiei,
NSF
$19,750
May 2007 to March 2010

The goal of this IREE supplemental was to provide opportunity for an PhD student to gain international research experience through his involvement in the current project funded by NSF entitled **" Processing and characterization of functionally graded coatings for biomedical implants**. **In this project the student** gains the access to first class facilities at National Institute of Materials Science (NIMS) in Japan to conduct the cell attachment and evaluation of biological response of Functionally Graded HA coatings doped with antimicrobial components.

REU supplement for CAREER: Processing and Development of a New Ultra-Light High-Strength Material

Afsaneh Rabiei,
NSF
$6000
May 2009 to March 2010

The goal of this REU supplemental is to involve an undergraduate student in research working on processing and characterization of composite metal foams.

A Computational Mechanics Model for the Simulation of Creping Process

Melur K. Ramasubramanian
Procter & Gamble Co.
$412,175
12/01/07 - 11/30/10

The objective of this research is to develop a computational mechanics model for simulating the creping process. The computational model will be developed based on a fundamental understanding of the creping process through analytical and experimental studies. Modeling using a finite element scheme taking into account a customized material model for low density paper materials, and incorporating the delamination-buckling mechanism present in the problem will be developed. Advantages of this approach include rapid simulation of the effects of changing raw material properties, sheet structure, process parameters, and creping conditions, on the resulting creped structure and its performance characteristics. *(Word Count: 98)*

Equipment Grant for GC-FID/TCD to Measure Species Concentrations in High-pressure Flames

William L. Roberts
Army Research Office
$54,098
06/01/08 - 05/31/09

This grant will acquire a gas chromatograph with two detectors to allow the measurement of soot precursor species in high-pressure flames. Measurement of concentrations of hydrocarbon species up to C-14 molecules are of primary importance. The TCD will be used to measure non-hydrocarbon species, primarily CO, CO_2, and H_2O.

Formation of Soot in High-pressure Diffusion Flames

William L. Roberts
Army Research Office
$251,000
03/01/05 - 09/30/08

The fundamental mechanisms of soot formation in high pressure flames are different than those observed in atmospheric flames. The bulk of previous research on soot formation has been conducted at atmospheric or sub-atmospheric pressures, while the majority of practical combustion devices operate at elevated pressures. This project measures species, soot surface temperature, and soot volume fraction in diffusion flames up to 16 atms. Species of particular importance include acetylene and benzene, which are measured via extractive sampling, and hydrogen atom, measured via non-intrusive techniques. Knowing these concentrations and soot surface temperature will allow quantitative assessments of current kinetic models.

High-Value Transportation Biofuels From North Carolina Feedstocks

William L. Roberts, Henry Lamb, Larry F. Stikeleather
Biofuels Center of North Carolina
$200,000
06/30/08 - 07/01/09

Demonstrate a multi-step process for converting triglyceride feedstocks into aviation fuel capable of meeting FAA/DoD specifications. This process includes hydrolysis of the triglyceride feedstock into free fatty acids, the decarboxylation of the free fatty acids into alkanes, and then the hydroreforming of these alkanes into the necessary constituents for an aviation fuel. The biojet fuel's physical and chemical properties will be fully characterized, and tested in an instrumented jet engine to assess fuel performance.

Simulation of Unsteady Reacting Flows in Pulsejets with Ejectors

William L. Roberts, Andrey V. Kuznetsov
Ohio Aerospace Institute
$80,000
06/01/08 - 09/30/09

Augmentors/ejectors are completely passive devices downstream of the propulsion system exhaust and offer the potential to increase the thrust and specific impulse of unsteady propulsive engines by as much as 75%. This is achieved by capturing the starting vortex emitted from the exhaust duct and the resulting entrained fluid. This increases the effective mass flux, at the expense of effective velocity, resulting in higher thrust and better fuel efficiency.

Experimental and Economic Assessment of Plasma Gasification of Solid Fuels

Alexei V. Saveliev
Innovative Energy Solution, Inc.
$25,000
10/01/08 - 03/31/09

The plasma gasification is envisioned as one of the main routes for energy efficient conversion of solid fuels such as coal, biomass, and municipal waste to the gaseous fuels. In the proposed research non thermal plasma of gliding arc is used to process solid fuel streams of various nature and content. The original scope of work was related to processing of coal and biomass in a hybrid plasma/ultra-rich partial oxidation entrained flow gasifier developed by Innovative Energy Solutions. It is proposed to extend the original work scope to gasification of plastic and paper materials.

Optical Diagnostics of Gasifier Flames

Alexei V. Saveliev
Gas Technology Institute
$25,000
11/15/08 - 07/31/09

Rapid development of novel combustion technologies imposes special requirements on diagnostic and control methods used. Industrial combustion and gasificaiton processes will enormously benefit from novel 2-D sensors utilizing imaging techniques to map the flame species and defining the flame zones responsible for pollutant formation and efficiency losses. In this project, the flame diagnostics based on spectrally-resolved optical imaging is proposed for development. Projected characteristics of the method involve collection of real-time data on combustion system performance providing valuable input on optimization and control of coal gasifier flames.

Consulting on Vibration Qualification on CASSIOPE Spacecraft

Terry D Scharton
Canadian Space Agency
$65,510
04/23/07 - 03/31/09

Risk mitigation schemes as related to vibration testing of flight hardware to the CASSIOPE program will be presented. The goal is to (1) define and work out the implementation of the most appropriate vibration qualification program for the spacecraft and pertinent subsystems, (2) build a technical case for the selected qualification approach, and (3) support the dynamic testing of the CASSIOPE spacecraft.

A Smart Inhaler System for Maximum Drug Aerosol Delivery

Stefan Seelecke, Clement Kleinstreuer, William L. Roberts
National Institutes of Health
$290,789
08/01/05 - 07/31/08

The project develops a novel smart inhaler system for targeted drug-aerosol delivery that, for the first time, allows targeting regions at specific generations in either the left or the right lobe of the lung. Together with virtually eliminated parasitic wall deposition in the upper oral airways and on other healthy tissue, this feature is envisioned to enable a new technology for safer and more efficient treatment of lung cancer and other respiratory diseases. The system is validated experimentally using an artificial oral airways model by a laser scattering particle visualization method.

Constitutive Modeling of Shape Memory Alloys (SMA) (Task Order No. 6219-NC)

Stefan Seelecke
National Institute of Aerospace
$288,537
09/08/08 - 07/31/09

The objective of the proposed work is a comparative study of several available shape memory alloy (SMA) models in order to assess their suitability for the simulation of adaptive

structural aerospace components. A number of advanced components are currently being investigated, such as the SMA-actuated chevron system developed by NASA Langley. Standard finite element codes to date do not provide the tools to account for the coupled thermo-mechanical behavior of SMA actuators, and the current project will assess state-of-the-art of constitutive models and analyze their suitability for implementation into the most popular FE codes.

Experimental Characterization of Electro-Active Pumping System

Stefan Seelecke
Parker Hannifin BioCare
$530,866
08/01/08 - 06/30/09

As an extension to Phase 1, NCSU expands the capabilities of the comprehensive high-fidelity real-time DAQ system to characterize the electro-mechanical behavior of electro-active polymer (EAP) cartridge elements. - NCSU will continue to test and benchmark EAP cartridge element samples supplied by Parker BioCare throughout the duration of Phase 2 . In collaboration with and guided by Parker BioCare, NCSU develops an EAP actuator test platform used for developing EAP actuator devices, consisting of one or more EAP cartridge elements, specifically for drive and control of various pump and valve systems for Parker applications in Phase 3.

Autonomous Soaring Algorithm

Lawrence M. Silverberg
US Navy-Office Of Naval Research
$106,721
10/01/07 - 12/31/08

The general goal of the Autonomous Locator OF Thermals (ALOFT) project is to show that capturing atmospheric energy is possible with an Unmanned Aerial System (UAS) and can be used with intelligent path planning to travel a long distance. The specific goal is to break the 1988 140.7 mile cross-country world record for model glider flight. The project addresses issues of remote geo-location of convective air updrafts, efficient flight trajectory utilization of updrafts, path-planning a safe and effective search along the course, real-world application of optimum speed control theory, and system integration.

CPATH CB: Computing Across Curricula

George N. Rouskas, Lisa G. Bullard, Jeffrey A. Joines, Lawrence M. Silverberg, Eric N. Wiebe
National Science Foundation
$517,498
07/01/07 - 06/30/10

With this request, we are seeking REU supplement for two undergraduate students who will be involved in the development of computational tools designed to realize a computational thinking thread in two engineering disciplines. The tools will address general problem solving skills but will initially be developed and assessed/evaluated within the context of a specific discipline; the lessons learned from this effort will guide our future work to extending these tools to other engineering disciplines.

Principles of Autonomous Soaring

Lawrence M. Silverberg
Naval Research Laboratory
$34,149
01/01/09 - 12/31/09

This effort builds on Dan Edwards' pioneering studies into the feasibility of autonomous soaring and other ongoing efforts that he is undertaking to lay a foundation in autonomous soaring. Through this grant, the results will be documented in a seminal paper to appear in the AIAA Journal of Aircraft. The paper will address, among the different topics, the basics of thermal sensing and centering algorithms, speed optimization, system implementation details, and flight testing results.

Real-Time Synthesis of Unsteady Hydrodynamic Loads from Measurements on the Hull Surface

Lawrence M. Silverberg
US Navy-Office Of Naval Research
$95,720
05/01/06 - 12/31/09

The goal of this work is to synthesize, in real-time, unsteady resultant forces/moments (loads) from measurements over the surface of a submarine hull in unsteady flow. The work addresses: (1) Can the loads be obtained from sensors placed on the hull? (2) How does the correlation between loads and stagnation/separation point with 2-dimensional bodies extend to 3-dimesional bodies? (3) Can modal filters be used? (4) Is there a simple relationship between attainable load resolution and sensor number? (5) If so, what is it? (6) Will this method of sensing be useful in non-body of revolution submarine design and control?

State Industrial Assessment Projects

Stephen D Terry, Herbert M. Eckerlin
State Energy Office (NC Department of Administration)
$50,000
07/01/08 - 01/31/10

The State of North Carolina has two main programs that address industrial energy efficiency /conservation, both housed at North Carolina State University (NCSU). The Industrial Assessment Center (IAC) program and the Energy Management Program (EMP), propose to provide industrial assessments and follow-up assistance to manufacturing plants in North Carolina. Both programs are part of the NCSU College of Engineering, which has a long history of working with industry in North Carolina, as part of NCSU?s land grant tradition. Both programs also work closely with the State Energy Office (SEO) to provide assessments and technical assistance to industrial clients.

State Partnerships to Accelerate Industrial Energy Efficiency

Stephen D Terry, Herbert M. Eckerlin
State Energy Office (NC Department of Administration)
$120,000
03/24/08 - 03/31/09

This project provides funding to promote industrial energy efficiency through one-day energy efficiency workshops, in-depth three-day energy savings assessments for selected clients, follow-up work with former IAC/EMP/ESA clients to assist in implementing conservation measures, research into alternative fuels for a NC paper mill, and the establish-

ment of an Energy Information Center at NCSU. All of these efforts promote energy efficiency through education of plant personnel and NCSU students, on-site technical assistance, and research. Primary funding for the project is through the US Department of Energy's Industrial Technologies Program.

CEV Abort Scenario Methods and Tools (GRA Thomas Sebastian)

Robert H. Tolson
National Institute of Aerospace
$168,135
05/31/06 - 08/31/08

NASA is developing a capsule shaped CEV as the human space transportation system. Aerodynamic stability is an issue throughout the aerodynamic range. This research will involve a flight experiment to develop methods to analyze stability during an abort scenario. Trajectory and atmospheric reconstruction will be the primary focus of this research. The student on this project is Thomas Sebastian. The research will be advised by Dr. Robert Tolson of the North Carolina State University and the NASA mentor will be Mark Schoenenberger of the Explorations Systems Engineering Branch. *(Word Count: 88)*

Experimental Data Uncertainty Estimation (NIA GRA Matt Hoover)

Robert H. Tolson
National Institute of Aerospace
$95,775
08/16/08 - 08/15/10

The area of research is supported in the Structural Dynamics Branch and addresses the creation and application of uncertainty estimation for data generated during test programs at NASA. An example might be the development of an uncertainty algorithm that identifies the probability distribution of a set of wind tunnel results taken of an ARES wind tunnel model. Another example just completed by Dr. Horta, the principal investigator in this area, is the creation of an uncertainty model for the results of an airbag support drop test of a simulated crew module

Flight Mechanics Research for Earth and Planetary Missions (NIA GRA for J. Gaebler and J. Fuller)

Robert H. Tolson
National Institute of Aerospace
$354,680
08/15/07 - 08/14/09

The research will cover design, analysis and simulation of CEV entry, manned and unmanned lunar missions, and planetary mission aeroassist studies. The research will include flight mechanics design, evaluating various spacecraft control algorithms, determining the effect of parachute aerodynamics and dynamics, evaluating the effect of environmental variations on atmospheric flight, precision landing capability, and overall vehicle performance. The research will include 3-DOF, 6-DOF and multi-DOF trajectory and Monte Carlo simulations. Aerothermodynamic studies will include aeroassist phases of various missions to develop the flight trajectories, the guidance, navigation and control system, and for use in defining the vehicle thermal protection system. *(Word Count: 100)*

Graduate Student Advisement

Robert H. Tolson
National Institute of Aerospace
$27,612
08/11/08 - 08/15/10

The basic research project supports the Structural Dynamics Branch at NASA in the research area concerning the creation and application of uncertainty estimation of data generated during test programs. An example of potential research would be the development of an uncertainty algorithm that identifies the probability distribution of a set of wind tunnel results taken of an ARES wind tunnel model. Another example is the creation of an uncertainty model for the results of an airbag support drop test of a simulated crew module. As part of this effort Dr. Paul Cooper will advise the research of GRA-Matt Hoover.

Laser-Based Planetary Landing System Analysis (GRA Matthew Aitken)

Robert H. Tolson
National Institute of Aerospace
$200,264
05/19/08 - 05/18/11

This research project involves the development and validation of methods for the application of laser-based systems to enable landing on the Moon and planetary surfaces. The research will address integrated systems that measure altitude, velocity, hazards in the landing area, and provide terrain relative navigation. The research will be conducted at NASA Langley and will utilize data from numerous laboratory and field test of the ALHAT system and components.

Mars Science Laboratory Research (MSL)

Robert H. Tolson
National Institute of Aerospace
$335,197
04/01/05 - 09/25/08

This research will provide atmospheric modeling support to the studies of the flight mechanics of the entry, descent, and landing (EDL) phase of the MSL mission. The studies will contribute directly to the design of the spacecraft entry geometry, parachute sizing and deployment, aeroshell design including the heat shield and the aft cover, guidance laws to assure safe and precise landing, and other aspects of EDL. The mission will require much more precise landing than any prior Mars mission and will include sophisticated hazard avoidance guidance capability. The entry-to-landing phase is probably the most risky part of the mission. *(Word Count: 99)*

Mars Science Laboratory Research (Task Order No. 6233-NC)

Robert H. Tolson
National Institute of Aerospace
$199,542
09/22/08 - 09/30/09

MSL is the first mission where sophisticated Mars mesoscale atmospheric models play a critical role in the entry, descent and landing (EDL) design. Validation of model predicted wave structure is important to reduce mission risk. However, there are limited data sets to perform such validation. The extensive MGS TES data only have a 5 km resolution in the vertical. While MGS radio occultation data set which

provides vertical resolution of a kilometer the data average along the radio path. Nevertheless, these data are the most likely to provide some indication of gravity wave activity for model validation. *(Word Count: 97)*

NIA Foundation Grant Activity 3520-NC

Robert H. Tolson
National Institute of Aerospace
$50,000
10/01/08 - 09/30/09

NIA Foundation Grant Award Number: F320 (for internal purposes only)

Obtaining Winds and High Altitude Density Profiles from MRO Accelerometer Data

Robert H. Tolson
California Institute of Technology - Jet Propulsion Laboratory (NASA)
$179,988
03/06/07 - 06/30/09

The purpose of this study is to produce both new as well as improved mission data products from the Atmospheric Structure Facility (ASF) Investigation that will significantly enhance the scientific value of the ASF investigations to: 1. Characterize the Mars' global atmospheric structure and transport. 2. Characterize the Martian uppper atmosphere in grater detail. 3. Improve atmospheric modeling capabilities for future mission to Mars.

Planetary Flight Systems (NIA-GRA David Busnardo)

Robert H. Tolson
National Institute of Aerospace
$97,461
07/21/08 - 07/20/10

The research performed by this GRA student will be on topics related the LaRC Strategic Goal 3, "Characterization and Traversal of Planetary Atmospheres." He will participate in the research program focused on aero-assisted missions that perform aerobraking, aerocapture, EDL or sustained flight through planetary atmospheres or precision landing technology. The research may be on long-term high payoff technologies like precision landing using large-area hypersonic drag devices (inflatables), mid-term technologies like propulsive hypersonic descent, high L/D hypersonic aeroshells, characterizing planetary atmospheres for aeroassist missions, or precision landing and hazard avoidance. *(Word Count: 89)*

Samuel P. Langley Distinguished Professor Program (LAP)

Robert H. Tolson, Fred R. DeJarnette
National Institute of Aerospace
$9,640,000
01/01/05 - 09/25/12

This activity is in direct support of LaRC Strategic Technical Goal Three: Planetary – Develop a Predictive Capability for Traversing Planetary Atmospheres and use the Atmosphere to Enhance Mission Success. To accomplish the proposed research program, NIA has formed the Center for Planetary Atmospheric Flight Sciences (CPAFS). This Center addresses the need for an end-to-end analysis capability for aeroassist flight systems in Earth and planetary atmospheres. The CPAFS will bring together a multidisciplinary team of university and NASA researchers to improve and leverage the interactions between planetary atmospheric modelers and planetary flight systems engineers.

(Word Count: 93)

Statistical Methods For Intelligent Data Integration (SMIDI)

Robert H. Tolson
National Aeronautics & Space Administration (NASA)
$1,311,909
01/01/08 - 12/31/10

Aerodynamic data for hypersonic vehicles are derived from many sources including wind tunnels, ballistic ranges, full and scale model flight test, CFD, etc. The data are presented in numerous forms, for example, aerodynamic static and dynamic force and moment coefficients, pressure distributions, trajectories, orientation, etc. These data usually cover different ranges of Mach and Reynolds number, vehicle dynamics, orientations and rates and have various level of accuracy. The objective of this research is to develop statistical methods for combining these data into a single data base that characterizes the statistically "best" estimate of the aerodynamics and provide the associated uncertainties. *(Word Count: 100)*

Subsonic Fixed Wing Research

Robert H. Tolson, Paul A Cooper
National Institute of Aerospace
$27,611
08/11/08 - 08/10/10

This research activity will analyze a candidate design of the primary longitudinal splice joint for the ARES V launch vehicle composite interstage structure. The performance of the ARES V composite next generation launch vehicle can be improved through mass-reduction achievable with the use of adhesively bonded joints. This current six month study will use a detailed finite-element 2-dimensional model of a composite splice joint to determine the influence of geometric parameter variations on stiffness and peak strains, the influence of mechanical properties of bonding adhesives and laminate adherends, and the nonlinear inelastic behavior of the joint under high load levels. *(Word Count: 100)*

Subsonic Fixed Wing Research (NIA GRA Seyed-Hossain Mousavi)

Robert H. Tolson
National Institute of Aerospace
$97,461
08/11/08 - 08/10/10

This research, which is part of the subsonic fixed wing project, involves both experimentation and analytical approached to developing and maturing technology aimed at producing lightweight structures for hybrid-wing-body and other aircraft. The project includes the development, application and validation of analytical methods for airplane design. New concepts in structural design such as unconventional cross sections, new manufacturing methods, and adaptive tailored structures are considered. The research will be conducted at NASA Langley.

SGER: Synergistic and Inherently Stable Laser/ Plasma-Jet Welding Processes: Proof of Concept

Juei F. Tu, Pierre A. Gremaud
National Science Foundation
$78,000
09/15/07 - 08/31/09

Laser welding of various materials of limited thickness (under 10 mm) has become a standard production in industry. Applications to heavy industry (shipyards, trucks, heavy machinery, etc) require deep laser welding from 10 mm to 30 mm or beyond. This has proved to be challenging because of the prohibitive cost of very high power laser systems and instability of the deep penetration welding process. This SGER project attempts to understand the source of instability and to improve process efficiency and cost by combining two different energy sources, a laser and a plasma jet.

Developing High Performance, Computationally Efficient Nonlinear Control Techniques For Polynomial Nonlinear Systems

Fen Wu
National Science Foundation (NSF)
$224,997
06/01/08 - 05/31/11

This project is aimed at developing a novel control approach to overcome limitations and computational complexity of existing nonlinear control techniques. The proposed systematic control design approach has the potential to solve challenging nonlinear optimal and robust control problems for polynomial nonlinear systems. This research could also help automate the control design process and verification of high performance nonlinear control laws, thus significantly reducing the cost and design circle of nonlinear control systems. The application of proposed nonlinear control approach to the spacecraft could enhance its robustness property and improve spacecraft operating performance by optimizing its nonlinear control strategy.

Reconfigurable Robust Gain-Scheduled Control for Air-Breathing Hypersonic Vehicles

Fen Wu & Andy Packard (UC Berkeley)
National Aeronautics & Space Administration (NASA)
$463,778
01/01/07 - 12/31/09

Hypersonic air-breathing vehicles offer a very attractive and potentially safer alternative to traditional rockets. In this project, we will develop effective control approaches to address difficult control tasks during hypersonic flight including variable operating conditions, large modeling uncertainties and possible sensor/actuator failures. We will develop reconfigurable control systems for enhanced fault-tolerant capability and design flexibility. Moreover, the study on probabilistic robust control will provide new perspective on robust control techniques. It is expected that the research outcome will play a key role in realizing the potential of hypersonic aircraft as launch vehicle and global transporter.

Acceleration Measurement of Transportation Environment

Fuh G. Yuan
Aerospace Corporation
$4,820
09/23/08 - 12/31/08

The objective of this work is to integrate the chips into a wireless sensor for measuring the acceleration of transportation environment. A number of sensors will be mounted on an object monitoring the motion. The collected data will be stored on the sensor during the entire time of transportatbion and then be downloaded to PC for further use or analysis.

Acoustic Measurements for an Isotropic Plate (Task Order No. 6235-NC)

Fuh G. Yuan
National Institute of Aerospace
$68,194
09/26/08 - 09/25/09

The purpose of this task (and the previous task order NNL07AD23) is to utilize the work done in determining the voltage response to an internal breakage in an isotropic plate to determine the nature and location of the breakage by matching measured and calculated responses. This is the inverse problem to the determination of response from damage. It will enable real-time determination of damage on an aircraft from the monitoring of acoustic emission signals via an array of fuselage or wing mounted sensors and recording devices.

Bio-Inspired Morphing Spacecraft

Fuh G. Yuan
NCSU NC Space Grant Consortium
$2,000
11/01/08 - 09/30/09

The main objective is to utilize the latest materials technology to advance the performance of a small UAV for space exploration using known biologically-inspired methods. The BioFlight Senior Design Team of the NCSU will to pursue this goal. In addition to this, further knowledge of the flight mechanisms used by birds will be sought as well. The ultimate goal of this year?s project will be to produce a workable UAV that will utilize such phenomena as wing morphing to bring its overall performance to a level considerably above that of a conventional aircraft of similar size and configuration.

Initiating Biologically-Inspired Morphing Flight Senior Design Project

Fuh G. Yuan
NCSU NC Space Grant Consortium
$10,000
07/01/08 - 06/30/09

The aim of this proposal is to seek support for setting up the experimental part of a senior design class, Biologically Inspired Morphing Flight. The ultimate goal will be to build an autonomous small morphing aircraft. The course demands creative integration of traditionally disparate disciplines such as aerodynamics; controls; structural topology and design approaches; smart materials and structures; signal processing; circuit design and control electronics; wireless sensors and communications; systems integration. An important component of the project is the wing sensing and actuation.

Integrated Diagnostic and Prognostic Airframe Structural Health Management

Fuh G. Yuan
National Aeronautics & Space Administration (NASA)
$90,000
08/01/08 - 07/31/09

Integrated vehicular health management (IVHM) refers to a developing technology that continuously monitors the structural integrity of an airframe and provides information about the length of useful life remaining for the airframe components. The diagnostic capabilities have been developed by to the point of being capable of producing relatively high resolution virtual images of any damage to structural components. The next steps in the development of the technology are the addition of Bayesian updating to dramatically improve the probability of detection and decrease the uncertainty associated with the life predictions.

Integrated Probabilistic Diagnosis and Prognosis for Airframe Structural Health Management

Fuh G. Yuan
University of Florida
$544,000
01/01/08 - 12/31/10

Continual on-line structural health monitoring/management (SHM) which is vital to IVHM is based on dynamic processes through early damage detection, determination of damage location and size (diagnosis) and then prognosis of damage propagation and remaining life. The results of the proposed research will pave the road towards improving safety of future air transportation systems, reducing component failures, replace preventive maintenance by predictive (on-demand) maintenance, and revolutionize vehicle maintenance and design.

Intelligent Health Monitoring of Aerospace Structures Using Wireless Sensor Networks

Fuh G. Yuan
National Science Foundation
$1,105,944
08/15/03 - 10/31/09

The research under IREE will consist of two primary self-contained tasks: One of the key objectives of task I is to define the requisite properties of the wireless sensing system (e.g., sensor type, number, location, sensitivity, bandwidth) before the system is deployed on a structure. The task II aims at determining the POD for the strain gage sensor in determining the confidence limit of the damage location. Inattention to these issues is one of the prime reasons SHM technology has not made the transition from a research topic to actual structures for in-situ structures.

Nature and Location of Damage from Acoustic Emission Measurements for an Isotropic Plate

Fuh G. Yuan
National Institute of Aerospace
$47,715
06/26/07 - 03/25/09

The purpose of this task is to utilize the work done in determining the strain and displacement response to an internal breakage in an isotropic plate to determine the nature and location of the breakage by matching measured and calculated responses. This is the inverse problem to the determination of response from damage. It will enable real-time determination of damage on an aircraft from the monitoring of acoustic emission signals via an array of fuselage or wing mounted sensors and recording devices.

Probability Based Integration of Structural Health Monitoring into the Aging Aircraft Sustainment Program

Fuh G. Yuan
University of Florida
$685,665
12/01/06 - 11/30/09

Structural health monitoring/management is based on two complementary processes of damage diagnosis and prognosis of remaining life, each entailing much uncertainty in the limited, uncertain nature of the sensor data, modeling and material and geometric properties. Based on the need and potential for a probabilistic framework, this proposal has two broad objectives. The first is to develop a framework and demonstrate by simulations the benefits the framework will impart to an SHM. The second objective is to demonstrate the application of the framework to a specific SHM system, focusing on the use of Bayesian updating.

Self-Contained Wireless Sensor Networks for Aerospace Structures Monitoring

Fuh G. Yuan
National Science Foundation
$239,998
05/15/07 - 04/30/10

The research plan will focus on three major tasks. Namely: Develop, and build an MsM energy harvesting device; Develop self-diagnosis and self-calibration capabilities in WIS; Prototype and test the WIS in both laboratory and field environments. This study will identify and address basic scientific and engineering challenges toward establishing SHMS in aerospace structures. Due to basic design constraints of miniature smart sensors, results from this research will advance such SHM systems by addressing fundamental limits along with conflicting constraints imposed by hardware/system software, power sources, collaborative processing, and wireless tradeoffs..

US-China Workshop on Smart Systems: Bio-inspired Materials, Mechanics, Control, and Sensor Innovation

Fuh G. Yuan
National Science Foundation
$38,665
09/01/08 - 08/31/09

It is proposed to conduct a joint U.S.-China workshop on the topic of Smart Systems: Bio-inspired Materials, Mechanics, Control, and Sensor Innovation at the Dalian University of Technology, Liaoning Province, China. The objectives of the workshop are: (a) to evaluate the current status of research and education in the topic areas in the United States and China; (b) to identify critical and strategic research and educational issues of mutual interest; (c) to identify possible joint projects and potential research teams for collaborative research activities; and (d) to identify existing research data, experimental test beds, and other resources that can be shared by those engaging in joint research projects.

Heat Transfer from Nanoparticles to Liquids

Taofang Zeng
National Science Foundation
$334,198
09/01/05 - 08/31/08

The PI proposes a comprehensive research plan to develop fundamental understanding of nanoscale thermal transport from single nanoparticles to surrounding liquid medium. The plan includes development of techniques to precisely measure the temperature distribution of the nanoparticle and the surrounding medium, and characterization using advanced photon sources. The PI will also develop molecular dynamic simulations to predict the atomistic and molecular structures and heat transfer from single nanoparticle to liquids at nanoscale.

Mechanical and Piezoelectric Characterization of ZnO Nanowires for Energy Harvesting Applications

Yong Zhu, Paul I. Ro
National Science Foundation
$100,000
01/01/09 - 06/30/10

Piezoelectric nanowires have been recently demonstrated for converting mechanical energy into electricity. However, the fundamentals involved in the energy harvesting process are not yet clearly understood due to the lack of well-characterized electromechanical properties of these nanowires. The objective of this research is to investigate the coupling between mechanical and electrical properties of ZnO nanowires. A microelectromechanical platform will be developed to test the mechanical and piezoelectric properties of ZnO nanowires at both quasi-static and dynamic conditions. Fundamental issues of piezoelectric nanowires, such as size effects and strain-gradient effects (uniaxial loading versus bending) on electromechanical coupling, will be addressed.

Probing the Electromechanical Properties of Functional Nanowires Using a Microfabricated Device

Yong Zhu
NCSU Faculty Research & Professional Development Fund
$6,000
07/01/08 - 06/30/09

One-dimensional (1D) nanostructures including nanotubes, nanowires and nanobelts have been demonstrated in a large number of applications in nanoelectronics and nanophotonics with excellent performance. However, the applications in nanoelectromechanical systems (NEMS) are relatively behind. This is likely due to the fact that electrical and optical properties of 1D nanostructures have been better understood than mechanical properties. It is in fact a grand challenge to characterize the mechanical properties of individual 1D nanostructures. In this proposed research, electromechanical properties, such as piezoelectricity of ZnO nanowires and piezoresistivity of Si nanowires will be investigated.

Microstructural Modeling and Representation of Simultaneous Failure Modes in Crystalline Aggregates Subjected to Dynamic Loading Conditions

Mohammed A. Zikry
Army Research office
$300,000
9/1/07-8/31/10

Material failure in f.c.c. and b.c.c. systems can initiate and evolve simultaneously over different spatial and temporal scales. The reliability and life-service of systems subjected to extreme loading conditions have been severely hampered by the lack of understanding and validated predictive capabilities of how multiple failure modes, such as stress induced void initiation and coalescence, and intergranular and transgranular cracks can simultaneously initiate, interact, and evolve.

Microstructurally Engineered Armor System for Enhanced Survivability Through Optimum Energy and Momentum Dissipation

Mohammed A. Zikry, Donald W. Brenner
Army Research Office/JIEDDO
$1.98 M
10/01/06-9/3010

As an alternative to the traditional trial-and-error approach to armor materials design, we propose here the integration of combinations of tailored brittle and ductile materials that would effectively optimize the fracture toughness of high strength materials that have been damaged due to blast and impact, in-situ over time scales commensurate with propagating wave and blast phenomena.

MURI: Multi-functional Extreme Environment Surfaces: Nanotribology for Air and Space

Jacqueline Krim, Donald W. Brenner, Angus I. Kingon, Mohammed A. Zikry
AFOSR (450K MAZ share)
$5.1M
05/15/04 - 12/14/09

New computational tools are being developed to model and characterize NEMS and MEMS devices at different scales.

NIRT: Reduced Degree of Freedom Predictive Methods for Control and Design of Interfaces in Nanofeatured Systems

Donald W. Brenner, Marco B. Nardelli, Ron O. Scattergood, Mohammed A. Zikry, Gerald Iafrate ($425K share for M.A. Zikry)
National Science Foundation
$2M (($425K share for M.A. Zikry)
07/01/03 - 06/30/08

The objectives are to study the nanocomponent-environment interaction, and to provide adequate modeling capability for elucidating the robustness of the nanocomponent quantum characteristics due to the interaction with the environment.

Predictive Microstructural Modeling of Failure Modes in High Strength Steels

Mohammed A. Zikry
US Navy-Office Of Naval Research
$330,00
06/01/08 - 05/31/11

A three dimensional thermo-mechanistic physically-based predictive framework is needed to understand interrelated effects such as grain orientation, rotation and morphology, interfacial thermal, stress and strain gradients, and GB distribution and orientation. The dominant failure mechanisms, which are pertinent to life-cycle operation that may occur on different length scales have to be identified and characterized.

Intelligent Multi-Scale Sensing for Damage Identification and Mitigation in Woven Composites for Aerospace Structural Applications,

K. Peters, M.A. Zikry
$275,000 (MAZ share: $138K)
1/08-12/11

The development of new sensors for damage detection in aerospace composite structures

Sensing for Fracture Identification for Civilian Structural Applications

K. Peters, M.A. Zikry
National Science Foundation
$300,000 (MAZ share: $150K)
6/08-5/11

Failure modes in large scale structures

Self Healing Sandwich Composites,

K. Peters, M.A. Zikry
National Science Foundation
$300,000 (MAZ share: $150K)
11/08-10/11

Sandwich composites failure modes and control

Visual+Tactile Instrumentation for High Throughput Virtual Design of Insensitive Munitions and Blast Mitigating Armor

Donald W. Brenner, Mohammed A. Zikry, Douglas Lee Irving
Army Research Office
$81,000
05/01/09 - 04/30/10

Instrumentation will be assembled that will enable high throughput virtual design of new materials through the integration of a semi-immersive visual display, a three-dimensional haptic for image manipulation and analysis, and a dedicated mini-computing cluster. This unique instrumentation will allow multi-scale materials simulations to be simultaneously run, manipulated and analyzed in a real-time, as opposed to traditional remote queuing and post-run analysis, hence providing a powerful tool for high throughput virtual design of materials with tailored properties.

CONTACT INFORMATION

For more information about Mechanical and Aerospace Engineering at NC State University, visit

www.mae.ncsu.ed