COVER PAGE FOR TRADITIONAL AND UNDERGRADUATE ENHANCEMENT PROPOSALS
BOARD OF REGENTS SUPPORT FUND, FY 2007-08

014MUL

1. This Proposal Involves: __X__One Institution ____More Than One Institution	2. Enhancement Subprogram: (check one) __X__ **TRADITIONAL** ENH Program (Includes all multidisciplinary proposals) ____ **UNDERGRADUATE** ENH Program

3. This Proposal Is: (check one) _X_ Primarily an Equipment Request ___ Not Primarily an Equipment Request

4. Name(s) of Submitting Institution(s) of Higher Education: (Include Branch/Campus/Other Components) Louisiana Tech University

5. Address of Institution of Higher Education (Include Dept/Unit, Street Address/P.O. Box Number, City, State, Zip Code) Department of Biomedical Engineering, 818 Nelson Avenue, Ruston, LA 71272

6. Title of Proposed Project H-DIML: High-speed Digital Imaging and Modeling Laboratory

7. First-Year Support Fund Money Requested $64,656	8. Second-Year Support Fund Money Requested (if applicable) $N/A	9. Proposed Duration (Circle # of Yrs.) (1) 2

10. Category In Which Proposal Is Being Submitted (check one only) __ **BUSINESS** _x_ **MATHEMATICS** __ **CHEMISTRY** __ **PHYSICS/ASTRONOMY** __ **EDUCATION** _x_ **Special Multidisciplinary** (See Section III.B.2.c of the RFP.) **NOTE: If you check this category, you must also check at least one other eligible discipline.)**	11. Using the Taxonomy in Appendix A of the RFP, Identify All Specific Subcategories of the General Category That Apply to This Proposal and Provide Taxonomy Numbers: Subcategory(ies): Taxonomy Number(s): Applied Mathematics 0702

12. This Proposal Is a: __x__ New Request ____ Request for Continuation of a Previously-Funded Support Fund Project (check one) Provide previous contract number:

By signing and submitting this proposal, the signators are certifying that: (1) the proposed project has not already been funded/is not currently being funded/has not been promised funding; (2) this proposal has been reviewed and approved by an Institutional Screening Committee; and (3) the institution and the proposed project are in compliance with all applicable Federal and State laws and regulations, including, but not limited to, the required certifications set forth in: (a) Grants for Research and Education in Science and Engineering, NSF Grant Proposals Guide (GPG), NSF 03-2, effective 10/1/02, and (b) 45CFR 620, Subpart F (Requirements for a Drug-Free Workplace).

Name/Title/email (type or print) Institution (if different from Item #5 above)	Dept./Telephone No.	Degree/Year	Signature
PI/PD Mark A. DeCoster, Associate Professor decoster@latech.edu	318-257-5118	Ph.D. 1989	[signature]
Co-PI/PD Katie Evans, Assistant Professor kevans@latech.edu	318-257-3011	Ph.D. 2003	[signature]
Co-PI/PD Alan Chiu, Assistant Professor alanchiu@latech.edu	318-257-5231	Ph.D. 2006	[signature]
Co-PI/PD			
Co-PI/PD			

Campus Head or Authorized Institutional Representative		**Dean**		**Authorized Fiscal Agent**	
Name/Title/email: (type or print) Daniel D. Reneau President		Name/Title/email: (type or print) Stanley A. Napper College of Engineering and Science		Name/Title/email: (type or print) Joseph R. Thomas, Jr. Vice President for Financial Services	
Signature: [signature]		Signature: [signature]		Signature: [signature]	
Date: 10/23/07	Telephone Number: 318-257-3785	Date: 10-22-07	Telephone Number: 318-257-4805	Date: 10/23/07	Telephone Number: 318-257-4325

(Form 1-ENH, Rev. 2007)

PROJECT SUMMARY

Name of Institution (Include Branch/Campus and School or Division)
Louisiana Tech University

Address (Include Department)
Department of Biomedical Engineering, 818 Nelson Avenue, Ruston, LA 71272

Principal Investigator(s) Mark A. DeCoster, Ph.D.

Title of Project H-DIML: High-speed Digital Imaging and Modeling Laboratory

Abstract (DO NOT EXCEED 250 WORDS)*

This project aims to enhance Graduate and advanced Undergraduate student research and classroom experiences in the College of Engineering and Science at Louisiana Tech University by establishing a high-speed digital imaging and modeling laboratory (H-DIML). The goal is to target multidisciplinary education and research, by providing the first of its kind high speed imaging technology to biological disciplines (Biomedical Engineering), with integrated hardware and software tools for Mathematics applications. This will impact the independent Ph.D. programs in Biomedical Engineering (BME) and in Computational Analysis and Modeling (CAM), both well established at Louisiana Tech, by now joining these disciplines into the common goal of understanding fast-dynamical systems. We propose that H-DIML will provide acquisition of new, dynamic data sets from cellular activity such as neuronal networks (BME), and will provide new, enhanced applications for mathematical analysis and modeling (CAM). We propose to incorporate these new research tools on campus into BME and mathematics graduate and upper-level undergraduate courses, and H-DIML will certainly expose local science and math teachers and summer fellowship students to examples of interdisciplinary science through currently funded educational grants. Development of H-DIML at Louisiana Tech will aid in recruiting and retaining top-notch faculty at the University, both in BME and Mathematics. Novel high-tech laboratories such as H-DIML will also be a key in retaining and attracting the best students to our state and our region, fostering continued growth in Louisiana's economy and building on current growth momentum occurring on the Louisiana Tech campus.

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4. NARRATIVE AND BIBLIOGRAPHY

a. THE CURRENT SITUATION

a.1 Institutional Description

The University: Louisiana Tech University, founded in 1894, is located in North Central Louisiana. The University is classified by the Southern Regional Education Board as a Four-Year (III) University and a Doctoral II University using the Carnegie Classification. Sixty-eight percent of the students are North Louisiana residents; however, students from a wide range of geographic locations choose to attend the University. There are students from every parish in Louisiana, every state in the US, and 70 countries.

The University seeks to provide excellent educational opportunities for these students and is committed to providing strong baccalaureate programs in a broad range of studies in the liberal and fine arts, pure and applied sciences, agriculture, professional aviation, and teacher preparation. The University's expanding commitment to research and graduate-level education is reflected in masters degrees offered in the arts and sciences, business, engineering, and human ecology, in master's and specialist's programs in teacher and school service personnel preparation, and in doctoral programs in selected areas. Enrollment in Fall 2006 is 11,611. Undergraduate students account for 84% of enrollment. Of the current student body, approximately 48% are male and 52% are female. Approximately 22% of the total students are minorities, with 15 per cent of the total enrollment being African-American. The University employed approximately 385 full-time faculty members in Fall 2006. Sixty-five per cent have earned doctoral degrees. The number of part-time faculty varies from term to term; however, full-time faculty teach the majority of the courses. The student/faculty ratio is 23:1.

The College: The College of Engineering and Science (COES) at Tech is characterized by strong cross-disciplinary traditions in both research and education. The College's non-traditional administrative structure promotes administrative efficiency and an interdisciplinary team-based approach to all aspects of College functions. The vision of COES is to "be the best college in the world at integrating engineering and science in education and research" [1]. COES has over 112 faculty members in various specializations, and for 2007, 341 graduate students, including 117 doctoral students, and 1,579 undergraduate students. The College offers 11 B.S. degrees, 8 M.S. degrees, and 3 Ph.D. degrees. There are three doctoral programs within COES: (a) Biomedical Engineering (BME), (b) Computational Analysis and Modeling, (CAM) (interdisciplinary) and (c) Engineering (interdisciplinary) that attract students from a broad range of backgrounds. The numbers above from 2007 are especially encouraging given the drop in student enrollment in other colleges at Louisiana Tech University and the wide-spread reports of drops in enrollments at other Louisiana universities. In this regard COES at Tech did remarkably well. Compared to 2006, our total enrollment on the Main Campus in COES was exactly the same, 1,920 students for both years. Average freshman ACT was up from 24.4 in 2006 to an average of 25.34 for 2007. Thus we are bringing in potentially better students, and indeed, COES retention rate for first-time freshman also increased from 78.4% (2006) to 78.9% currently.

The programs: **Biomedical Engineering (BIEN).** Established in 1972, the Biomedical Engineering program at Louisiana Tech University is one of only thirty-six in the U.S. accredited by the Accreditation Board of Engineering and Technology (ABET) and was the seventh program to achieve this goal. The program was one of the first in the country to award a Ph.D. in Biomedical Engineering. The program, which emphasizes a balance between theory and practical application, has played a continuous leadership role in defining the nascent field of biomedical engineering. It offers degrees through B.S., M.S., Ph.D., and a joint M.D./Ph.D. program with Louisiana State University Health Science Center in Shreveport. The Biomedical Engineering Program remains as one of the oldest, largest, and strongest such programs in the U.S. It is the only such program at a public university in the State of Louisiana and the only one in the surrounding region, including Northeast Texas, Arkansas, and Mississippi.

Computational Analysis and Modeling (CAM) is an interdisciplinary doctoral degree program intended to produce professionals, who have a firm grasp of the fundamentals of mathematical modeling, and have the expertise to implement, analyze and evaluate such models using state of the art computing environments and advanced visual data analysis techniques. As one of only twenty U.S. universities in 2003 offering a degree in Computational Sciences [6], Louisiana Tech University in a relatively unique position to participate in the education of students interested in computational science and engineering, "a rapidly growing multidisciplinary area with connections to the sciences, engineering, mathematics, and computer science" [8]. The University is in the process of expanding and revising the curriculum of the CAM Ph.D. program to make the program of study more flexible and more appealing to a wider spectrum of students, including those with research interests in the areas of computational finance, bioinformatics, and computational biology.

a.2 Rationale for Project

In a recent steering committee report underwritten by the National Science Foundation, the panel acknowledges the "fundamental role of mathematics" in multidisciplinary opportunities for future research related to brain science [2]. More specifically, the committee remarks

> *Although the intrinsic complexity of the problems addressed in the biological and social sciences have caused them to lag the physical sciences in this march toward mathematical understanding, the last few decades have seen major steps toward precisely formulated mathematical theories for particular aspects of brain function. Advancing from these first steps to something that could be legitimately called a theory of the brain constitutes a great challenge to all of the mathematically oriented disciplines, including the physical sciences, computer science, engineering, and mathematics itself.*

With the integration of the disciplines in this proposal, our goal is to provide applications for the mathematics classroom at Tech, feedback to the neuroscientist for better modeling and understanding of fast cellular dynamics, and a more technologically advanced infrastructure for our team to tackle the kinds of research questions that will likely require a multidisciplinary team to answer (see letter of Support from Program Chair in Mathematics at Louisiana Tech, Appendix).

This proposal was developed with the growing recognition that the field of optical imaging is progressing rapidly and has the potential to have a significant and lasting impact across a wide range of disciplines: bioscience, biomedical engineering, chemistry, health and medical sciences, life science, and nanotechnology. Enhancing student understanding and training in the use of new and emerging bioimaging techniques will only be possible if 'state-of-the-art' technology is available for their use. This proposal requests funding to create a new equipment-rich, core instrument facility on the Louisiana Tech campus that includes mathematical modeling modules for classroom instruction and for research purposes.

The High-speed Digital Imaging and Modeling Laboratory (H-DIML) proposed here will allow students to learn and master microscopy, bioimaging, and image analysis techniques that will be crucial for their future careers. The H-DIML will be part of a dedicated digital imaging system (microscope, digital microscopy camera, and multi-media computer) equipped with a number of advanced software programs for image acquisition and analysis. The lab will be linked to 12 student image acquisition and analysis workstations that have recently been purchased separately as part of the educational infrastructure housed within the new Biomedical Engineering Center (BEC), which just opened its doors in May 2007. A major goal of this proposal is to further promote team-taught instruction that crosses traditional disciplinary boundaries, to increase student involvement in these fields, and to encourage multidisciplinary research that emphasizes active student participation. H-DIML will help promote this goal by impacting Mathematics and BME courses taught and directed by the PI and Co-PIs of this proposal.

The proposed H-DIML will be housed in an instrument suite in the BEC consisting of 1) an inverted microscope equipped with Fluorescence, Phase, and Brightfield capabilities, 2) high-speed digital camera and photometry outputs and fast shutter monochromator input for acquisition of quantitative cellular dynamics data, 3) a computer workstation with software for fast data buffering and storage, and instrumentation control, and 4) three computer workstations for cellular data analysis, and for mathematical analysis and modeling. We propose to have combined workstations that host both cellular analysis and mathematical analysis software, thus encouraging the student or faculty to "learn the second language" of cell science or mathematical applications, as the case may be. Three major software packages will be hosted on each workstation: 1) Intracellular Imaging data acquisition software, 2) Image Pro Plus image analysis software, and 3) MATLAB software. H-DIML will be housed in the BEC. The BEC has over 50,000 sq. feet of lab, classroom, and office space, and currently houses 10 faculty. Two more faculty will be joining BME in January 2008 and will also be located at the BEC. Drs. DeCoster and Chiu have lab and office space at the BEC. Dr. Evans is located in Madison Hall, but she and her students will have free access to H-DIML, and with the aid of the server in the BEC as well as high-speed internet connections and wireless internet across campus at Louisiana Tech, data archiving and storage can be easily ported to individual student or faculty machines, thus promoting the collaborative efforts. Furthermore, for two of the software packages that will be heavily used in this project, (Image Pro Plus and MATLAB), additional access can be gained from multiple machine locations. In the case of Image Pro Plus, with other funding, Dr. DeCoster, with the support of BME, acquired 15 network licenses which will allow controlled access to this analysis software via a server located in the BEC.

For MATLAB, Louisiana Tech has a classroom (instructional) campus site license which we can utilize for instructional purposes on appropriate machines. As part of this proposal, we will add instruction and research mathematics and visualization tools (see quote). H-DIML, physically to be located in one building (BEC), can be accessed and utilized across campus (or beyond), to retrieve already stored data, to analyze data using software tools, or for classroom instructional purposes using smart classrooms that hook computers to digital projectors, thus bringing some of the laboratory into the classroom.

a.3 Impact on existing resources

H-DIML will complement existing resources by enhancing the present infrastructure of basic computer workstations and inverted and upright microscopes connected by internet connections. The lab will be linked to twelve student image acquisition and analysis workstations already housed in the BEC. Making use of Louisiana Tech's high speed internet access, faculty and students will be able to easily store and transport data from one campus location to another, including offices, laboratories, and even classrooms. This project will utilize and enhance the Image Pro Plus and MATLAB software licenses already available on campus for instructional purposes.

The PIs and associated faculty will use the equipment proposed in this project to enhance student training and research activities. Students will be able to use high-speed digital imaging to image specimens, obtain data and perform analyses on cells, proteins, and nanophase specimens, which cannot be obtained from other commonly available laboratory microscopes. These microscopes can be used qualitatively and quantitatively and are outstanding tools for educating students in micro-analytical principles, techniques and applications, and image analysis. The obtained images and cellular data will be used for mathematical analysis and modeling, thus offering students the opportunity to participate in meaningful interdisciplinary research that develops critical thinking and problem-solving skills in a collaborative environment.

b. THE ENHANCEMENT PLAN

b.1 Project Goals and Objectives

This BORSF project proposes to:

Provide a unique, one-of-a-kind campus ability to record, visualize, and analyze high-speed biological and other fluorescence-based dynamical events, which will be integrated with mathematics and analysis tools for enhancing the research and classroom experiences of students and the scientists who teach them. We propose that this enhancement will come to fruition with BORSF approval of H-DIML: High-speed Digital Imaging and Modeling Laboratory.

More specifically, the main goals are to:

- Enhance the depth of research and teaching resources available to the student and the scientists who teach them by providing one-of-a-kind technology and modeling tools for assessing high-speed dynamical events.
- Improve and integrate the exposure levels for students in both the Biomedical Engineering and Mathematics disciplines, increasing their ability to visualize, analyze, and understand dynamical fluorescence-based processes, such as cellular events. H-DIML will be a hands-on tool for student researchers and for the professors who teach them.
- Modify and bridge the limited resources currently available to Louisiana Tech, by outsourcing H-DIML virtually: 4 iMAC workstations currently located in the BEC, where H-DIML will be located, will be used with their webcams to port live images of experiments being conducted in H-DIML to other appropriate classrooms on the Louisiana Tech University campus (such as Mathematics). Thus students in modeling- and applications-based courses can see how data are collected, presenting a better idea of the data set and potentially providing feedback to the researchers conducting the experiments.

b.2 Work Plan of Proposed Project

The overall work plan will be implemented as follows:

1. **Acquire equipment** – select, purchase, and acquire the hardware and software for H-DIML.

The list of hardware and software to be acquired is discussed in detail in Section c.1 Equipment Request and in the Budget Narrative. The necessary equipment will be acquired by September 2008.

2. **Install and test equipment** – install and test the acquired hardware and software with the existing equipment.

The necessary hardware and software will be installed and tested within 90 days of acquisition.

3. **Provide training support** – provide necessary training in H-DIML to core group of faculty and student users. The PI and Co-PIs will provide training (see below).

A digital how-to-guide will be hosted by Drs. DeCoster, Chiu, or Evans, using the 4 iMAC workstations already in place with included webcams and in combination with campus internet and web resources. Live examples of data acquisition, data storage, data retrieval and analysis, mathematics tools and modeling will be shown. Immediately after installation and testing, the PI and Co-PIs will conduct hands-on training for each other and a small group of faculty and students in H-DIML so that the available resources are clearly indicated to the core group of users.

4. **Develop experiments and projects** – develop new laboratory experiments and projects based on these experiments and modify present experiments that utilize

the upgraded equipment. New data sets developed in this manner will then be integrated into coursework.

The PI will coordinate with Co-PIs and other faculty members to ensure that the H-DIML becomes an integral part of course offerings in BME and in Mathematics. It is anticipated that other departments at Louisiana Tech interested in utilizing the unique assets of H-DIML may also include its use in instructional material. Beyond the need for hands-on use of the instrumentation and workstations, "data-sets" from high-speed dynamical experiments will be made available for real-world applications examples in existing courses (see below). It is also anticipated that funding of H-DIML will provide a logical foundation for the growth of future courses at Louisiana Tech such as in computer science and bioinformatics.

Instructional Goals: Drs. Evans and Chiu will design computational projects based upon the data collected using H-DIML for undergraduate and graduate courses. Descriptions of projects to be developed in support of these courses include the following.

MATH308, "Introduction to Linear Algebra" (Evans, taught every year in Winter term). This course is required of all math majors, and many engineering students take this course to satisfy a technical elective requirement. The course primarily focuses on matrix operations and methods of solution of linear systems. Students will be given a linear system of the form $Ax=b$, where A will be an $n \times n$ matrix of data representing calcium concentrations of n cells, all from the same substrate, measured at n time values, and b represents the cumulative level of calcium we would like to achieve over the whole substrate at a given time. Students will explore using both direct and indirect (iterative) techniques for solving this linear system for x, the amount of calcium that would have to artificially be applied to the substrate to achieve the desired level. Students will also make comparisons about the computational expense required for the different methods.

MATH405, "Linear Algebra" (Evans, taught every Spring term). Students often struggle with this proof-based course due to the challenging theoretical concepts of orthogonality, matrix decomposition, vector spaces, linear independence, basis, and linear transformations. Since this course may be taken for graduate credit, its typical audience is diverse, including math undergraduates, and CAM graduate students. Students will be provided with vectors of time series data, each representing the calcium concentration of one neuron, along with visual representations of the data made available through florescence microscopy. These vectors of data and visual images portraying the data can be used as a common theme of the course to help students visualize some of the more difficult mathematical concepts of the course.

MATH414 and MATH415, "Numerical Analysis" (Evans, sequence taught every Fall and Winter terms). This sequence emphasizes a wide range of numerical techniques, including the study of relevant error estimates, for developing approximating solutions to problems where the analytical solution may be known or is too computationally expensive to calculate due to the dimension of the problem. The Numerical Analysis courses may also be taken for graduate credit, and these courses are part of the core curriculum for the CAM Ph.D. program. Interpolation methods make up a large unit of material in MATH414. Students will be provided with a time series data set of calcium concentration of one neuron and be asked to find an interpolating function that satisfies some specified error tolerance. A similar project will follow in MATH415, where students will be asked to do a curve fit of a given data set. Solutions to each problem will require students to blend both computational and mathematical skills.

BIEN557, "Special Topics – Quantitative Neuronal Networks" (Chiu, taught Winter 2007 and to be offered every other year). This course emphasizes techniques used in modeling single neuron and neuronal network dynamics using differential equations. The proposed H-DIML will provide students with the tools to correlate the intracellular calcium concentration with the transmembrane potential in a cellular network. Students will be using these data to estimate the ionic conductance parameters of the Hodgkin-Huxley-based model and apply statistical tools to compare the simulated data with the recorded biological signals.

BIEN557, "Special Topics - Advanced Biomedical Signal Processing" (Chiu, course in development and to be taught in the Winter of 2008). This course will emphasize the advanced topics such as time-frequency analysis, spatial coherence and biomedical image processing. The funding support of the proposed H-DIML will provide high quality images of cellular network activity which will enable our students to analyze real-time biomedical signals in a spatial-temporal domain. Specific projects that will be developed through the acquisition of the H-DIML will include: 1) Implementation of edge-detection algorithm for cell-counting which will have other potential application such as brain-computer interface for eye-tracking device. 2) Implementation of spatial coherence algorithm for the computation of synchronization in cellular network under different electrical and chemical stimuli.

BIEN225 "Biomedical Systems" and BIEN425 "Advanced Biomedical Instrumentation Systems" (Chiu, taught every year in the Fall and Spring terms.) Like most undergraduate biomedical system courses, these courses focus on the analysis of biomedical signals in time and frequency domain. With the funding support of the H-DIML, our students will have a competitive advantage in that they will also be exposed to analysis of biomedical signals in spatial distributed environment. The proposal will strengthen the students' conceptual understanding of the impulse response by considering the neuronal network as a linear system. Students will perform linearization of biological network response. As a capstone project, students will design computer signal processing tool based on the data obtained by the H-DIML using LabView instrumentation software.

Dr. DeCoster will integrate H-DIML data and experiments into two graduate-level biomedical engineering courses emphasizing neuroscience:

BIEN 557, "Neural Cell Measurement Methods" (DeCoster, taught Spring 2007 and to be offered Spring 2008). This course emphasizes cell measurement applications and techniques for neuroscience cell biology. Examples of experiments from H-DIML that will enhance course material include techniques for high speed imaging, choice of fluorescent probes, and digital image analysis.

BIEN 557, "Integrative Cellular Neuroscience" (DeCoster, taught Fall 2006 and currently, Fall 2007). This course emphasizes the integration and communication of multiple cell types of the brain with each other (neurons, astrocytes, microglia) as well as the integration of brain cells with nanotechnology. Examples of how technology from

H-DIML will be used in the class include conceptual and theoretical assessment of calcium dynamics in cells using fluorescence microscopy, imaging of nanotechnology based probes and sensors.

5. **Disseminate results** – dissemination of the results of this project will include to others in the educational community and area industry, in addition to web page content on individual and departmental website as well as "webinars" utilizing our 4 iMac workstations for viewing live experiments from H-DIML to classrooms on the Louisiana Tech Campus or beyond. Outreach to visiting area high school teachers and to the graduate student fellows funded through an NSF GK-12 grant (2007-2009), will also expand the impact of the H-DIML. According to Dr. David Mills, Director of these outreach programs at Louisiana Tech: *"H-DIML is exciting and very timely. It addresses the need to educate and communicate with undergraduate and graduate students regarding advanced scientific research as well as providing opportunities to involve K-12 teachers and their students in our summer research programs."* (see letter of support from Dr. D. Mills, Appendix).

Project Schedule

The PI and Co-PIs will be jointly responsible for achieving the objectives listed in Section b.1. The schedule of activities is given in Table 1.

Table 1. Project timeline

	Term			
Task	**Sum**	**Fall**	**Win**	**Spr**
Acquire equipment [1]				
Install and test equipment [2]				
Provide training support [2]				
Develop experiments and projects [3]				
Disseminate results [4]				

(1) Hardware will be acquired by DeCoster and Chiu. Software will be acquired by Evans.
(2) Drs. DeCoster, Evans, and Chiu will each contribute to testing and provide training based on his/her expertise.
(3) Each PI will develop experiments/projects, and selected coursework appropriate to his/her area of expertise as described earlier in Section b.2.
(4) Web/internet content and iMac web cam "webinars"

b.3 Evidence of Potential to Achieve Recognized Eminence at the Regional, National, or International Level Commensurate with Degree Offerings and/or Functions

Louisiana Tech is the largest state supported University in north Louisiana. The University has developed a master plan: “Good to Great”, part of which is to expand academic and research opportunities in the bioscience, biomedical engineering and engineering programs. Mathematics stands central as a discipline needed for integrating the Engineering and Science disciplines contained within the College of Engineering and Science (COES) at Louisiana Tech University. In this regard the PI and Co-PIs on this proposal, all within COES, are well-positioned for this integrative approach.

The attached CVs of the PI and the Co-PIs show evidence of their involvement in graduate and undergraduate training, dissemination of their research, and success in receiving external funding for their outreach and research efforts. The principal investigators on the current proposal are also demonstrating the ability to work effectively together. While all are new faculty to Louisiana Tech University, they have been motivated to begin already to collaborate, as reflected by joint meeting presentations and multiple grant proposals already submitted or to be submitted. We anticipate that funding of H-DIML at Louisiana Tech University will continue the momentum of this collaborative research group in Mathematics and Biomedical Engineering, leading to greater local, national, and international prominence for the research areas and for the University, benefiting student experiences in multiple disciplines.

It is our belief that the goals of the proposed project, along with our team's integrative research approach, are well-aligned with observations forcasting future research priorities and opportunities at the national level [2]. The National Science Foundation steering committee noted that:

> *The shift in measurement scale from one of a few nerve cells to the study of networks and large populations requires new capabilities in instrumentation and measurement... Increases in the scope of experimental measurements necessitate vastly greater capacities for data acquisition and analysis, and in scope and complexity of the mathematical and computational models employed.*

The committee identified four broad areas of opportunity for the physical and mathematical sciences, computer science, and engineering to engage collaboratively in brain science research. The areas include 1) Instrumentation and Measurement; 2) Data Analysis, Statistical Modeling, and Informatics; 3) Conceptual and Theoretical Approaches; and 4) Building in Brain-like Devices and Systems. The funding of H-DIML will immediately position Louisiana Tech to take advantage of research opportunities in the first three of these areas. Depending on future governmental and/or private funding initiatives, the 4th area of opportunity to build brain-like devices and systems could also be in our future.

b.4 Impact on Curriculum and Instruction

The enhanced curricula, laboratory, and research opportunities funded by this grant would provide students with current, hands-on experience in problem-solving and critical thinking in an emerging technology across disciplines. Biomedical engineering courses that will be directly impacted by the proposed project are: Neural Cell Measurement Methods, Integrative Cellular Neuroscience, Quantitative Neuronal Networks, Advanced Biomedical Signal Processing, Biomedical Systems, and Advanced Biomedical Instrumentation Systems. Since H-DIML will be "virtually" accessible through the internet, students will be able to study web-based remote data acquisition and control of experiments, which will become more common in industry in the future.

As the individual or co-course coordinator for the aforementioned Linear Algebra and Numerical Analysis courses, Dr. Evans is in a position to design projects and make recommendations about how to utilize collected data to demonstrate particular mathematical concepts for instructional purposes. Due to the structure of the freshman and sophomore Integrated Engineering and Science Curricula [3-5,7] at Louisiana Tech, undergraduate students who would take the identified mathematics courses are already accustomed to coursework where content across disciplines is directly linked. The projects developed for the Numerical Analysis sequence could also be used in ENGR 592 (Engineering Computational Methods), which is cross-listed with PHYS 540 (Computational Methods in Physics Modeling and Simulation); Dr. Evans will be teaching ENGR 592/PHYS 540 in the Winter 2007-08 term. Visual representations and digitized data obtained through H-DIML also have the potential to impact the research and instruction by Louisiana Tech mathematics faculty studying graph theory and matroid theory, like Drs. Jinko Kanno and Galen Turner.

b.5 Impact on Quality of Students

Implementation of H-DIML on the Louisiana Tech campus will promote student research by providing hands-on as well as virtual opportunities to learn about how fast dynamic data sets (especially those linked to cellular events) are acquired, analyzed, and modeled. This is essential towards bridging the gap between the modelers and the experimentalists. As we are training students to become future scientists, an appreciation of both aspects of fast dynamic events – the experimental tools and instrumentation as well as the modeling and mathematics – will be key. At both the undergraduate and graduate levels, H-DIML will enable participating COES faculty to more broadly expose their students to multidisciplinary concepts and research, which will result in more diverse graduates who will be more sought after in the job market upon degree completion.

b.6 Impact on Faculty Development

H-DIML on the Louisiana Tech campus is designed to enhance graduate and undergraduate student education in the multidisciplinary area of mathematical modeling and applications derived from fast dynamical biological systems (neuronal networks) by providing unique instrumentation and integrated analysis workstations not currently available. The development of H-DIML will enable the principal investigators in the departments of Biomedical Engineering and of Mathematics to become more productive in carrying out fast dynamic experiments and modeling and analysis, leading to more productive publishing and training research students in cutting edge imaging technology and its associated analysis tools. This should result in major improvements in the quality of student research, enhanced faculty productivity, increased competitiveness in attracting external research funding, and in garnering national and international recognition. It is expected that the improved, novel technology demonstrated by H-DIML will also assist in the recruitment and retention of top-notch faculty to the academic programs at Louisiana Tech University. In fact, a recent faculty hire to the department of Biomedical Engineering, Dr. Mark Cheng (joining us in Jan. 2008), has expressed a keen interest in H-DIML, and anticipates that this technology will very favorably impact his research and his ability for enhanced student learning (see attached letter of support, Appendix).

b.7 Performance Measures

- The assessment by the instructors of the affected courses.
- Exit interviews of the students graduating from the BME and Mathematics programs.
- Interviews of the students by the BME Advisory Board.
- Survey of users, especially students, of future improvements in the lab.

c. EQUIPMENT

c.1 Equipment Request

The equipment requested and corresponding price information are given in Table 2.

Table 2. Equipment requested

Equipment	Manufacturer	Unit Price	Quantity	Total
Fluorescence Imaging System	Intracellular Imaging, Inc	$64,240	1	$64,240
Imaging Workstations	Dell	$3,099	3	$9,297
MATLAB software	MathWorks			$7,284
Total Equipment				$80,821
Requested from the Board of Regents (80%)				**$64,656**
Matched in cash by Louisiana Tech University (20%)				**$16,165**

Equipment specifications are as follows:

<u>InCyt High Speed I/P Fluorescence Imaging System</u>, Intracellular Imaging, Inc.

Component summary: 1. High speed microscopy (Olympus, with Low-Light CCD Camera); 2. Fast microphotometry system, including photomultiplier tube housing, Hamamatsu fast photon counter, viewing ocular and computer-controlled shutter. 3. Excitation illumination source/wavelength changer: polychrome till IV monochromater with motorized entrance and exit slits for intensity and bandwith control. 4. Includes one computer workstation.

Off-line Imaging Workstations (3), Dell Computers.

Component summary: Dell 490 workstations (32 bit), Quad Core, 2 GHz, 256 MB video with dual 19" flat screen monitors, and fast Ethernet card, 2 GB ram, 160 Gb hard drive. CD/DVD read/write drives; 3 year limited warranty plus 3 year NBD On-site service.

MATLAB software (simulation, analysis and modeling upgrade from classroom, or instructional, to research-level license), MathWorks.

Upgraded components will include: Control System Toolbox, Distributed Computing Engine, Distributed Computing Toolbox, Neural Network Toolbox, Optimization Toolbox, Signal Processing Toolbox, Symbolic Math Toolbox, Statistics Toolbox, Wavelet Toolbox, and will include first year MathWorks software maintenance service.

c.2 Equipment on Hand for the Project

The new BEC building on the Louisiana Tech University campus has a growing infrastructure of basic computer workstations and inverted and upright microscopes (including from Olympus), connected by fast internet. The Biomedical Engineering Program has invested in multiple copies (15) of image analysis software: Image Pro Plus. This software will be the foundation for H-DIML, bridging the acquisition and analysis of dynamic cellular events with mathematical data analysis and modeling, which will be carried out in such programs as Excel and MATLAB. For the case of MATLAB, Louisiana Tech has a university classroom (instructional) site license which we will utilize for the instructional aspect of this project.

c.3 Equipment Housing and Maintenance

The equipment proposed to compose the H-DIML suite will be housed in the new BEC building. H-DIML will have adequate space to accommodate up to 8 students at a time. The equipment will be connected to a set of servers in BEC: the servers have been delivered including rack-mount system and storage as of 10/20/07. These servers will allow the virtual expansion of H-DIML off-site, for example to the Department of Mathematics (located in another building at Louisiana Tech), and/or to up to 12 additional workstations already located in BEC. These workstations will make use of the 15 network copies of Image Pro Plus already acquired by BME. Four of these 12 workstations are iMacs with webcams, allowing us to put one of these in the H-DIML suite to show real-time "experiments-in-action" for enhanced campus classroom learning experiences and/or remote visualization of these experiments ported to other buildings on campus. Dr. Evans and her students associated with H-DIML will have full access to the laboratory suite.

d. FACULTY AND STAFF EXPERTISE

Dr. DeCoster joined the BME program as an Associate Professor in September of 2006. Prior to this, he was a faculty member at the LSUHSC in New Orleans. He and Dr. Chiu are developing a research collaboration focused on the effect of stochastic resonance on cellular networks and computer models of neurons as illustrated by their recent NSF grant proposal entitled "Resonance in small neuronal assembly and coupled oscillator model" submitted in August 2007 (Chiu, PI, DeCoster, Co-PI). Drs. DeCoster and Evans have begun collaborating on modeling calcium dynamics in neuronal systems as reflected by a meeting presentation given by Dr. Evans at the Atlantic Coast Conference on Mathematics in the Life and Biological Sciences in May 2007 entitled "Modeling Depolarization-induced Calcium Dynamics".

Dr. Evans joined the faculty at Louisiana Tech University in the Program of Mathematics and Statistics in September 2005 as an Assistant Professor. Her expertise is in the control of systems governed by partial differential equations, numerical analysis, and mathematical modeling. Prior to arriving at Louisiana Tech, Dr. Evans worked as a Research Associate on the dynamic modeling and control of unmanned aerial vehicles in the Department of Mechanical Engineering at Oregon State University.

Dr. Chiu joined the BME program in September of 2006 after completing a Ph.D. in the Electrical Engineering and Biomedical Engineering Program at the University of Toronto. His main research is focused in the areas of neural signal processing, artificial neural networks and neuronal modeling.

e. ECONOMIC AND/OR CULTURAL DEVELOPMENT AND IMPACT

e.1 Relationships with Industrial/Institutional Sponsors

An advisory board consisting of scientists and engineers from industry and academia serves the COES at Louisiana Tech. An advisory council (with state and national industry representatives) for academic programs in the College meets biannually to review curriculum and planning issues for the academic units. For example, for Biomedical Engineering, the 12-member advisory council includes individuals from industry and academia. Recently, Louisiana Tech Faculty and alumni from Ph.D. programs at Tech were involved in two start-up companies: Aura Nanotechnology and Better Paper Technologies. These start-ups are currently tenants at the Enterprise Center located on campus (http://enterprise.latech.edu/current_tenants.php?u=2). Louisiana Tech University strongly encourages and supports interdisciplinary educational and research activities, including industrial ties, which have recently been expanded into a second enterprise center located on the first floor of the BEC, and the recent approval of full funding from the State (September 2007) for a $25 million research technology park to be located adjacent to the Louisiana Tech University campus.

e.2 Promotion of Economic Development and/or Cultural Resources

The main objective of this project it to enhance the student research and classroom experiences in cellular dynamics experimentation, imaging and analysis, and modeling. This effort will encourage the integration of mathematical and biomedical applications, by bringing students and their teachers together in the laboratory and in the classroom. In a sense, this is a cultural change at the University, but can also impact and promote economic development for the following reasons:

1) Digital imaging and image analysis of the biological and the biomedical, is a technological growth area. For example, as stated in a recent job ad on the Media Cybernetics website: Job Title: Application Support Specialist: Job Description: "*The ideal candidate will have a strong background in Life Sciences imaging and microscopy applications. Extensive knowledge of image acquisition, processing and visualization software is a must. Knowledge: Extensive background in Life Sciences imaging applications; thorough understanding of imaging software; practical knowledge of imaging optics, ancillary hardware and cameras.*"

Students will be using software (already in place) from Media Cybernetics for image analysis as part of this project, if funded.

2) Mathematics, especially applied mathematics and modeling are a logical integration bridge to the biosciences, as indicated by a recent steering committee report underwritten by the National Science Foundation [2]. The committee comments, "Comprehensive measurements of the brain in space and time, combined with new approaches to the analysis and modeling of comprehensive multi-scale data, will enable the exploration of much richer conceptual and theoretical approaches to understanding the brain at all levels."

As Louisiana (as well as other states) moves away from the vagaries of oil and natural gas revenues, new high tech jobs are a promising future home for our graduated students. For us to attract and retain the best students, to provide a local workforce ready to be hired for high tech jobs, and to thus drive this new economic engine forward, we must be providing applied mathematics, imaging, and image analysis tools to our students in the classroom and in the lab. This is a goal of the proposed project, and is anticipated to help our students find jobs both in academia as well as in industry.

f. ADDITIONAL FUNDING SOURCES

The College of Engineering and Science is committed to providing $16,165 in cash match towards the purchase of the hardware detailed in Section c.1, representing 20% of the total budget. The College will also provide 1 month of academic release for the PI, Dr. DeCoster, representing an in-kind contribution of $7,777 (+ fringe=$10,382 total). The University will also provide an in-kind match by waiving all indirect costs of the project, which is an in-kind contribution of $20,064 (22%). Thus, the total University commitment to the project is $46,611.

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5. PREVIOUS BoR SUPPORT FUND AWARDS

DeCoster: Dr. DeCoster was Co-PI last year on a BORSF grant entitled: "Bioimaging and Digital Microscopy Training Laboratory". This grant was funded at $74,455 ($50,000 from BOR and $24,455 from Louisiana Tech University). Dr. Mills in the School of Biological Sciences at Louisiana Tech was the PI of this funded grant. This grant funded acquisition of 3 optical microscopes with digital cameras to be used biological and materials examination. Currently (20 October 2007), two of these microscopes have been ordered and the third is out on bid. Since one of the microscopes on order is to be provided by Olympus, this will be a good platform to complement H-DIML. Research and training as part of this funded grant complement the research and education efforts of BME and the Biological Sciences. There are no high-speed cameras as part of these systems and no integrated-mathematics-cellular dynamics workstations. Thus, there is no overlap with H-DIML; however, it is anticipated that if funded, H-DIML and the funded Bioimaging and Digital Microscopy Training Laboratory would complement and enhance each other in a synergistic (more than additive) manner.

Evans: Dr. Evans was the sole PI last year on a BORSF grant, through the Research Competitiveness Subprogram, entitled "Sensitivity Analysis for the Design of MinMax Controllers." The total award amount is $73,413. The project began June 1, 2007, and is scheduled to conclude June 30, 2010. To date, Dr. Evans has derived the sensitivity equation for a nonlinear cable-mass system that was to be studied during the first year of the project and the corresponding sensitivity equation for the algebraic Riccati equations appropriate for the MinMax controller. During the last month, Dr. Evans has recruited a CAM Ph.D. student to work on the project. He is currently learning fundamental concepts of linear control design of partial differential equations and will soon begin the computer coding required to solve the sensitivity equations numerically. The current proposal is not related the previous award.

Chiu: Dr. Chiu was the sole PI on a Louisiana Board of Regents RCS grant last year for a project entitled "Application of hippocampal neuron dynamics in artificial neural networks for the development of brain function restoration strategy" (LEQSF(2007-10)-RD-A-20). The total award amount is $115,712. Dr. Chiu has recruited a PhD candidate, Fernando Puno, with undergraduate background in Electrical and Computer Engineering on the development of neural network learning rules. An undergraduate student, Drew Thomas (B.S. candidate in Biomedical Engineering, pre-med track) has been hired to assist us in setting up the electrophysiological equipments. During the summer of 2007, the Biomedical Engineering Program supported our lab with the purchase of a new multichannel microelectrode array system ($37,000). The current proposal is not related to the previous awards.

BOARD OF REGENTS SUPPORT FUND
TRADITIONAL AND UNDERGRADUATE ENHANCEMENT, FY ___2007-2008________

Budget and Budget Justification Pages

Directions: Each line item under the columns "Support Fund Money Requested," "Institutional Match," and "Private Sector/Other Match" must be itemized, fully explained, and justified **on a separate budget justification page(s).** Attach additional justification pages as needed.

Title of Proposal: _H-DIML: High-speed Digital Imaging and Modeling Laboratory__________________________
Project Director(s): ___Mark A. DeCoster ____

Institution(s) of Higher Education: Louisiana Tech University______________________________

PROPOSED BUDGET:

	Support Fund Money Requested	Institutional Match[1]	Private/Other Match[2]
A. Equipment[3]	64,656	8,881	
B. Software		7,284	
C. Supplies			
D. Shipping/handling			
E. Installation			
F. Personnel training			
G. Other			
1. Fac. Release		10,382	
2.			
3.			
4.			
5. (etc.)			
H. Indirect costs	Not allowed	20,064	
I. Maintenance	Strongly discouraged		
J. Total costs (A-I)	64,656	46,611	

1 Stipulate whether in-cash or in-kind. The Board strongly encourages the sharing of costs for proposed projects. Applicants and institutional officials should note, however, that the employing institution will be required to honor the commitments made in the original proposal before any awards are made. Discounts for equipment purchases are not allowable as institutional match.

2 The budget page(s) must reflect and the budget justification pages must explain any external funds that are claimed in the proposal. External funds and their expenditure must be accounted for in the same manner as Support Fund money and institutional match.

3 Equipment. If applicable, itemize and describe briefly the proposed equipment and its intended use in the project. Include the name, model number, and manufacturer(s).

6. BUDGET JUSTIFICATION

A. Equipment ($64,656 requested from the Board of Regents; $16,165 matching funds in-cash from the Louisiana Tech University College of Engineering and Science.)

The hardware to be purchased is outlined in the table below.

Hardware	Manufacturer	Unit Price	Quantity	Total
Fluorescence Imaging System	Intracellular Imaging, Inc	$64,240	1	$64,240
Imaging Workstations	Dell	$3,099	3	$9,297
Total Hardware				$73,537

Table 3. Hardware requested

Equipment specifications are as follows:

InCyt High Speed I/P Fluorescence Imaging System, Intracellular Imaging, Inc.

Component summary: 1. High speed microscopy (Olympus, with Low-Light CCD Camera); 2. Fast microphotometry system, including photomultiplier tube housing, Hamamatsu fast photon counter, viewing ocular and computer-controlled shutter. 3. Excitation illumination source/wavelength changer: polychrome till IV monochromater with motorized entrance and exit slits for intensity and bandwith control. 4. Includes one computer workstation.

Off-line Imaging Workstations (3), Dell Computers.

Component summary: Dell 490 workstations (32 bit), Quad Core, 2 GHz, 256 MB video with dual 19" flat screen monitors, and fast Ethernet card, 2 GB ram, 160 Gb hard drive. CD/DVD read/write drives; 3 year limited warranty plus 3 year NBD On-site service.

B. Software ($7,284)

MATLAB by MathWorks will be purchased for simulation, analysis, and modeling of data derived from fast dynamical biological systems. This software purchase constitutes an upgrade from a classroom, or instructional, to research-level license. Upgraded components will include: Control System Toolbox, Distributed Computing Engine, Distributed Computing Toolbox, Neural Network Toolbox, Optimization Toolbox, Signal Processing Toolbox, Symbolic Math Toolbox, Statistics Toolbox, Wavelet Toolbox, and will include first year MathWorks software maintenance service.

C. Supplies

Required supplies will be included as part of the manufacturer's purchase price.

D. Shipping/Handling
Shipping and handling charges will be included as part of the manufacturer's purchase price. No funds are requested in this category.

E. Installation

The installation of the InCyt Fluorescence Imaging System is included as part of the manufacturer's purchase price. No funds are requested in this category.

F. Personnel Training

Training of faculty and graduate students will be conducted by the principal investigators. No funds are requested in this category.

G. Other (\$10,382 in-kind and \$16,165 in-cash from COES)

Faculty Release- The College of Engineering and Science will provide one month of academic release time (\$7,777) for Dr. DeCoster. This release time is needed for purchasing, installing, and testing of equipment and software. The University fringe benefit rate is 33.5% and is included as a part of the match (\$2,605). Thus, the match is a total value of \$10,382.

H. Indirect Costs (\$20,064 in-kind match from COES)

The University normally charges indirect cost based on 22% of total direct costs for a project of this type. The indirect cost provided by the University, a value of \$20,064) will be considered as part of the University's contribution to the project.

I. Maintenance

No funds are requested in this category.