INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPRISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Mohammed Y Hussaini

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other ____________
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

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PI/PD Name: Geoffrey C Fox

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☒ White

Disability Status:
(Select one or more)

☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other ____________
☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 00-2

NSF-005 01/25/00

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NSF PROPOSAL NUMBER

0080220

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

DIRECT FOR COMPUTER & INFO SCIE & ENGINR

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☐ A RENEWAL
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IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYMS(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Florida State University

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Florida State University
Tallahassee, FL. 32306

AWARDEE ORGANIZATION CODE (IF KNOWN)

0014894000

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

PERFORMING ORGANIZATION CODE (IF KNOWN)

IS AWARDEE ORGANIZATION (Check All That Apply)
(See GPG II.D.1 For Definitions) ☐ FOR-PROFIT ORGANIZATION ☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS

TITLE OF PROPOSED PROJECT **Research and Education Infrastructure Proposal**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
$ 1,950,000	60 months	07/31/00	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG 1.A.3)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)
☐ NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)
☐ HISTORIC PLACES (GPG II.D.10)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)
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PI/PD DEPARTMENT

PI/PD POSTAL ADDRESS
School of CSIT
150 Dirac Science Center Library
Tallahassee, FL 323064120
United States

PI/PD FAX NUMBER
850-645-0300

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Mohammed Y Hussaini	Ph.D.	1970	850-645-0305	myh@cse.fsu.edu
CO-PI/PD Geoffrey C Fox	Ph.D.	1967	315-443-2163	gcf@cs.fsu.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators:

I certify to the best of my knowledge that:

(1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and
(2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of this application.

I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001).

Name (Typed)	Signature	Social Security No.*	Date
PI/PD **Mohammed Y Hussaini**		**SSNs are confidential and are not displayed** *ON FASTLANE SUBMISSIONS*	
Co-PI/PD **Geoffrey C Fox**			
Co-PI/PD			
Co-PI/PD			
Co-PI/PD			

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 00-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuring award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflict which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Debt and Debarment Certifications

(If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt?	Yes ☐	No ☒
Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency?	Yes ☐	No ☒

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure Form to Report Lobbying,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME/TITLE (TYPED) **Raymond E. Bye, Jr.,Interim VP Rsrc**		**01/27/00**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
850-644-5260	**nsfaward@res.fsu.edu**	**850-644-1464**

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Executive Summary

The Florida State University has a tradition of excellence in advanced scientific computing and applied sciences, with particular strengths in applied numerical mathematics, physics, meteorology, oceanography. In order to meet the challenges of the twenty-first century, FSU has established an interdisciplinary School of Computational Science and Information Technology (CSIT) to support both graduate and undergraduate concentrations, provide a leading-edge high-performance computational facility, and contribute to a high level of computational culture beneficial to the State of Florida and to the nation. The School's content embraces all of the possible inferences drawn from its name: its scope will include the science and technology of performing, analyzing, visualizing, communicating and archiving large-scale computations over wide-area networks, and its goal will be to employ large-scale computer and network resources in pursuit of scientific and technological research goals. The initial thrusts of the School are in the broad areas of **computing sciences**, computational biology, computational climate dynamics, computational materials science and computational hydrology. The computing sciences program goals, in addition to research in computer and information science per se, are i) to develop and implement efficient algorithms (of common interests across disciplines) on the state-of-the-art architectures, ii) to develop integrated software environment that simplifies the computational effort of application researchers in doing high-performance computing, and iii) to carry out research in cross-cutting themes in close collaboration with discipline experts, and coordinate its research across diverse disciplines. As such, the computing sciences program critically supports the applications research and in turn is driven by it.

A few of the core topics in the computing sciences program (whose importance is almost universal in application areas, whether these application areas are in physics, biology, meteorology, engineering or in the social sciences) addressed in the current infrastructure research proposal include high-performance numerical algorithms for the solution of partial differential equations, visualization, data management, and programming and problem-solving environments. These topic areas overlap with the core CISE-research at the National Science Foundation. This choice of the core technologies is dictated in a truly interdisciplinary fashion by the particular needs of the application areas where FSU has well-recognized strengths.

The area of advanced numerical algorithms addresses the high-order and high-performance issues for the discretization of partial-differential operators, such as compact finite-difference methods or discontinuous spectral methods. It also addresses iteration acceleration strategies (inherently amenable to parallelization) in an adaptive mesh refinement context for speeding up the time-stepping procedure of a numerical method. The wide variety of physical processes in various disciplines, which are governed by partial differential equations ensures the importance and rather universal application of this work.

The second core technology area of scientific visualization is an integral part of high-performance computing research. The proposed research effort addresses concurrent interactive visualization of scalar and vector fields, especially relevant to climate dynamics and liquid composite molding process. Surrogate models of the main algorithms and parallelism are exploited to boost interactive visualization.

The third core technology is the area of problem solving environments – application-sensitive compilation and prototyping, collaborative science portals, data-intensive computing in high energy and nuclear physics. The number of alternatives a researcher must choose between in selecting a physical model, an algorithm or a parallel processing strategy is becoming increasingly larger. While having choices is desirable, having to implement the choices can be cumbersome. The problem solving or prototyping environment will relieve the researcher of the mundane tasks involved in the implementation of these alternatives as they are selected through a high-level language and the environment takes care of producing the low-level code, running the simulation and preparing the results for human interpretation. Synergistically with this effort is a major effort in Educational Technology linking CSIT research with FSU's initiative in practical use of distributed and distance learning. A hallmark of the School will the use of the very best technology to create productive learning environments.

The programming environments efforts specifically focus on parallel and distributed programs based on Java with data parallelism that can be implemented with either threads or message passing interface (MPI).

In true synergistic fashion, research in these CISE core technology areas is proceeding in close collaboration with research in the application areas which employ the core technologies. A unique feature of this proposal is the manner in which the School of Computational Science and Information Technology provides a structure already in existence for the facilitation of cross-disciplinary research between CISE core technology research areas and the application research areas that they benefit. Through the management and operation of the requested infrastructure by the School, technology transfer between different applications, as well as between the core technologies and the applications (in both directions) will take place with an ease that would be difficult if not impossible in a more traditional academic setting. The School is constituted in such a fashion as to encourage and promote multidisciplinary interaction necessary for the success of the proposed research effort, and the brief overview of the organization and management of the School provided at the end perhaps makes it clear.

We have chosen four application areas – i) high-performance computational models of coupled atmosphere-land-ocean systems, ii) rapid virtual prototyping and optimization for liquid composite molding process, iii) turbulent flows and radiated noise, and iv) general earthquake models computational infrastructure. FSU's expertise in the first three areas is highly regarded. Geoffrey Fox brings with him the collaborative arrangement in the fourth area involving experts across the nation. These projects are only a few of the many research projects conducted in the vigorous research environment at FSU.

In the first project, a team of computer scientists, mathematicians and preeminent geophysical modelers proposes to i) effect modeling and algorithmic improvements to the state of the art in simulating global circulation with passive and active transport, and ii) adapt full application codes (from input to output, not just kernels) to global distributed memory, local hierarchical memory environments; and iii) develop and demonstrate global circulation software and broadly applicable partitioning and load balancing tools, and a problem solving environment hospitable to geophysics research in general, and weather and climate prediction in particular. Successful completion of this project will push the weather and climate prediction capability to the next level, whose value can not be overemphasized.

The second project is concerned with composite materials, specifically liquid composite molding (LCM) process modeling and design optimization. In current LCM applications, computer simulations tools have been used to predict LCM process behavior. Design cycle simulations based on such tools become prohibitively expensive and extremely time-consuming to be useful. Thus, there is a need to develop simulations models and solution algorithms which are both efficient and accurate to conduct LCM process design in a rapid real-time fashion. This is precisely the intent of the project. A multidisciplinary team of computer scientists, mathematical modelers, materials scientists and industrial engineers propose to exploit the results of the core technology, and build a robust and problem solving environment for rapid virtual prototyping and optimization of LCM process. Its impact on reducing the design cycle time will be significant.

The third project area is concerned with noise production by turbulent flows, particularly those associated with jet engines. The goal of this work is to minimize jet noise without significantly reducing engine thrust. The solution of this problem involves both the analysis of the turbulent flow field – an extraordinarily difficult problem in itself due to its enormous range of scales – and the analysis of the production and propagation of the sound waves. Scientists at FSU with decades of experience in turbulence and acoustic problems are working together to develop models for subgrid scale phenomena and exploit advanced algorithms of high-order accuracy and their efficient implementation on high-performance platforms (resulting from core research). The fourth project (which Geoffrey Fox brings to FSU) pertains to providing computational infrastructure to general earthquake models.

It is but proper to provide here an overview of the School of Computational Science and Information Technology to demonstrate that FSU has committed significant new resources to this initiative. The School spans three colleges – College of Arts and Sciences, College of Social Sciences and College of Engineering. The School comprises a dozen departments including Computer Science and Mathematics. The mission of the School is to i) perform basic research in core areas of applied computer science, mathematics (including numerical modeling) and areas of overlap between different disciplines, ii) to foster an interdisciplinary research environment conducive to the participation of scientists from industries, national laboratories and academia, high-performance computing, iii) develop a curriculum incorporating the latest research techniques and results, iv) acquire and maintain state-of-the-art computing, communication and visuaization facilities, and v) adopt a pro-active education outreach policy. Core CSIT courses consistent with the mission are being planned and implemented. FSU has committed significant resources including thirty new faculty positions in recognition of the fact that interdisciplinary computational faculty are critical to any university aspiring to intellectual and educational leadership in the twenty-first century. Presently, the scope of its interdisciplinary research is broadly categorized into applied and engineering sciences, biosciences, geosciences and social sciences. These projects involve researchers in the College of Engineering, a joint venture with Florida A & M University which is a historically minority-oriented university.

The proposal makes clear that FSU has sufficient expertise, leadership, programmatic resources, and is committed to engage additional faculty on which to found this effort. In order to execute a rather ambitious research agenda that overlaps with CISE interests, it now seeks NSF funds for infrastructure support with required matching commitments. Note that FSU as part of the launching of the School, has committed to the allocation of $4M to $8M for the the purchase of a massively parallel supercomputer that will achieve over a Teraflop of processing power over the next two years. A request for proposals will be sent out at the end of January 2000, and the system is scheduled for installation by the end of October of this year. Here we ask for the additional infrastructure to enable the computer science research that that will create the multidisciplinary environment linking applications and computing research. We propose infrastructure of three distinct types which will enhance the raw computing power of the central system and allow research in distributed systems and cross architecture algorithms spanning mobile devices through parallel machines with shared and distributed memory architectures. This research infrastructure purchase involves a further $1M matching from FSU and is spread over 5 years. There is a commodity cluster architecture aimed at the computer science distributed system work and algorithmic research for such systems which are of growing importance. We are proposing a clustered shared memory system to be used in architecture comparisons and for application/algorithm development for the large supercomputer. The shared memory will enable thread parallelim research for our Java based research. The remaining infrastructure with database and mobile technology will be used extensively – especially in our education and problem solving environment research.

1 Summary of Requested Experimental Facilities

In this section we list the facilities requested under this grant. They are separated into three categories that clearly map into three different classes of research and educational activities. They are the Scalable Cluster Machine (SCM), the Experimental Parallel Machine, and the Information and Pervasive Infrastructure. In the following sections, we first describe the infrastructure we are requesting, followed by a five year time schedule over which the equipment will be acquired.

1.0.1 Scalable Cluster Machine (SCM)

A very high performance effective computer cluster will be purchased with the following characteristics:

1. 32 to 48 processors,
2. 1/2 Gbyte of memory per processor,
3. Peak speed of 1-3 Gflops per cpu,
4. An interconnect bandwidth of at least 1 Gigabit/sec.
5. An L2 cache of 1 to 4 Mbytes for each processor.
6. A 1/2 Terabyte of disk.

To illustrate the above requirements, we briefly describe the current and future technologies offered by SGI who has recently announced a cluster machine based on the new Merced chip from Intel and running Linux. We have received quotes from Compaq and IBM, but their systems do not run linux which we consider to be a requirement. We contrast the offering from SGI with that of a system built from current off the shelf components, in this particular case with components priced from a reputable vendor: PCNut based in New Jersey. The price will be lowered by constructing the cluster ourselves.

SGI: In June 2000, SGI will announce the first 64 bit Linux cluster based on the latest chip from Intel: the IA-64, code named Merced. Each chip will be part of a 4-way node, each with 1 Gbyte ram, and 9 Gbytes local disk. Each cpu has 4 Mbytes of secondary cache. The peak single precision performance is 6 Gflops and the peak performance in double precision is 3 Gflops. 32 processors are estimated to cost $420,000 with a 50 percent discount. This corresponds to a peak performance of 180 Gflops. The price includes 1/4 Terabyte of Fibrechannel disk and maintenance.

Commodity components: A single module has the following pieces: a motherboard (a Xeon III chip with 512 kbytes cache running at 600 Mhz ($600), 1/2 Gbyte of memory ($512), 27 Gigabyte disk ($300), CPU board ($200), Myranet card ($1500), with miscellaneous items including software ($500). The cost for a module running at a peak rate of 600 Mflops is $3600. To reach 50 Gflops requies 100 modules or approximately $360,000. Note that the cost of the CPU doubles for a 1 Mbyte cache, and doubles again for a 2 Mbyte cache. Thus the cost per module for a system with a 4 Mbyte cache will be approximately $4,800, and each CPU then costs $7,800 consistent with the cost proposed by Compaq and IBM for their ES40 and Power 3 nodes. A 50 Gflop system then costs $468,000. This is on the same order as the estimate provide by SGI for a prebuilt, and more advanced system based on technology not yet commonly available but one that already has the support of a wide number of vendors: the Merced chip based on the IA-64. Note that the system from SGI has at 3 times the peak performance of the Xeon chip at equivalent cost. Since we can expect Compaq and IBM to have similar offerings to SGI within the next 1-2 years, we defer a particular system choice until after the award is granted.

1.0.2 Experimental Parallel Machine (EPM)

A machine aimed at algorithm development will be purchased and upgraded within 24 months. This system will in all likelihood be a 64-way SMP system, or a distributed system of 16 nodes with at least 4 processors per node with CPUS in the range of 366 Mhz to 600 Mhz. The most probably candidate vendors will be Compaq, IBM, or SGI, given their track record, proposed chip architectures over the next several years, and low cost. The system will have the following characteristics:

1. 16 to 24 nodes
2. 1/2 Gbyte of memory per processor
3. Peak speed of 1-3 Gflops per cpu,
4. a switching infrastructure with an aggregate bandwidth of at least 2 Gbytes/sec.
5. An L2 cache of at least 4 Mbytes per processor.
6. A 1/2 Terabyte of disk.

The above configuration will be purchased in year 2, with an upgrade that consists of replacement of the chips by the next generation processors in year 3. We anticipate a factor 5 improvement in sustained floating point performance over this period, regardless of the architecture chosen.

We have found that although Compaq is the leader in absolute peak performance, that both SGI and IBM had technologies on the horizons which make the clear leader uncertain at this time. We have compared configurations from Compaq, IBM, and SGI to establish that within a 30 percent range, the cost/performance ratio is the same.

Compaq offers a distributed system with 4 cpus per node, enclosed in their Wildfire system. Each processor has 1 Gigabyte of memory, and the nodes are connected through their 16-way Quadrics switch. The bandwidth between nodes will be 800 Mbits/sec. IBM proposes a similar system based on their own technology which are the Power 3 soon to become Power 4 (within the next 24 months). SGI offers a true single system image system that is Linux-based with 64 Intel IA-64 CPUs, 64 GB of ram, and 540 GB of Fiberchannel JBOD storage. The price performance is about half that of their cluster. The advantage of getting two SGI machines is naturally the ability to compare radically different architectures, while keeping the operating system, compilers, libraries pretty much intact. Comparisons between the architectures thus become much cleaner.

1.1 Information and Pervasive Infrastructure

Pervasive infrastructure refers to equipment that does not fit in the above two categories. This equipment will support mostly the core technologies and the educational components of this proposal. They are classified into three sections: visualization and user interfaces, mobile support, and information infrastructure. Technology is evolving at a very fast pace and it is difficult to predict with any reliability the availability, quality, and pricing of almost all hardware devices. All that is certain, based on current trends, is that for a given technology, prices will continue to plummet downwards. Thus, we will purchase equipment in this category distributed evenly over the 5 year period. The amount spent in each category will remain approximately constant over the 5 year period.

1.1.1 Visualization and user interfaces (VUI)

We will purchase two raster managers for our SGI Onyx 2 visualization machine to feed our second pipe (year 2). These will support video broadcast for dissemination of presentations, workshops and tutorials to the desk. Several high quality digital video recorders, digital cameras, scanners, MPEG encoders/decoders are also necessary to support this activity. New input devices will be purchased and integrated into the visualization research. These consist of haptic devices from Sensable Technology, head trackers, and head mounted displays. We will track the technology and upgrade our components at least once every two years.

1.1.2 Mobile Support (MS)

To support research in education and in the core technologies, we require the purchase of equipment capable of communicating between computers using broadband. We will purchase PCI cards for hand held palm pilots (or equivalent PDAs) and laptop computers that enable researchers to interact remotely with their simulations, debuggers, problem solving environments, etc. We anticipate that the PCI cards will become available within the next twelve months, so the first purchases will occur in year 2. We expect continued improvement in transmission quality, broadcast distance, protocols, etc. To keep abreast of this anticipated evolution, we will purchase equipment upgrades every two years. It is clear that laptops, palmtops, pdas, cell phones are all converging into a single integrated system whose final form is yet to be determined. However, by allocating equal resources on a yearly basis for this class of equipment, we anticipate buying a device of fixed physical size (with increasing powers) at approximately fixed or decreasing cost. Java Virtual Machines will play an integral role in development applications for these devices.

Recently, Transmeta has announced a 700 Mhz Crusoe chip that has a decreased transistor count, and thus lower power requirements. In addition, novel software allows the power consumption to vary according to the actual use of the processor, keyboard, etc. The initial impact on handheld systems appears to be substantial, allowing much longer usage without the need to recharge. This development underscores the need to avoid premature decisions regarding a particular path of equipment acquisition to avoid getting locked into a particular and outdated technology.

1.1.3 Information Infrastructure (II)

We will purchase an Oracle database in year 1 to support storage of simulation data, metadata, input files, etc. Upgrades to the database and support tools will be acquired in years 2 and beyond.

Fox brings to FSU (from Syracuse) several Oracle Databases. Theses will be upgraded in year 3 with enhancements to support the new technologies used for education and research (video on demand, xml interfaces, objects, cube structures, etc.). He also brings several sun servers to support research in information technology and education. After they are integrated into our current environment, we will evaluate the need to add new hardware support in the form of more powerful servers.

1.2 Storage

Near term storage systems are requested to store simulation data, database data, video data, course files, etc. Some disk will hang off of servers. However, the majority of the disk space will be attached to the two larger parallel computers. To accommodate the high frequency of file storage and the large files produced by the simulations, we will install disk between 1/2 and 1 Terabyte purchased from IBM, SGI, or Compaq. Commodity disks will be purchased to attach to the cluster with a SCSI interface.

While there is a need for an archival storage system, we will leverage the 100+ Terabyte system purchased with the large Teraflop machine (TFM). We anticipate the system will be in place by October 2000 with 60 Terabytes of initial storage capacity. Additional storage will added within the following 18 months simultaneously with a major system upgrade.

The archival system (of which IBM's is typical) has a sustained rate between 7 and 12 Megabytes/sec from the disk subsystem. A one Gigabyte file can therefore be retrieved in its entirety in less than 2 minutes which is sufficient for batch postprocessing of many time-dependent datasets over a period of hours.

1.3 Software

The requested software are the compilers, profilers, and performance enhancement tools necessary to maximize the efficiency of the application programs. Compilers for C/C++/Fortran and Java are requested. The cost of software is dominated by the parallel environment which are low level OS routines to manage the parallel system. Finally, Automatic Data Storage Management tools (ADSM) are necessary to provide a high degree of flexibility and automation in the area of data storage and retrieval. This software can also be used to backup both the SP system as well as other computers on the network to the archival tape system. This class of software is available from all vendors. The operating system on the SCM will be Linux which gives access to a large variety of open source software. We anticipate collaborative agreements with computer vendors to help enhance their software in the areas of high performance code tuning, and Gigabit (and beyond) networking.

2 Resource Allocation

2.1 Current Research Equipment

Our current computational resources are distributed between the School of Computational Science and Information Technology, the acoustics research group in the Department of Mathematics, the Department of Industrial Engineering, the National High Energy Magnet Laboratory, and the Department of Meteorology.

The equipment breakdown is listed below.

School of Computational Science & Information Technology (CSIT).
CSIT hosts

1. 5 four R10000 processor Origin 200s (180 Mhz), each with 1 Gigabyte memory and 27 Gigabytes of disk, one single 180 Mhz CPU Origin 200 (xterminal server) one SGI maximum impact with one Gigabyte memory, and several SGI O2 workstations each with 1 Gigabyte memory.

2. A 30 Pentium Pro cluster with dual processors (400 Mhz), 256 Mbytes memory and 18 Gbytes disk per CPU, and a 100 Mbit/sec ethernet network. The cluster supports the activities in physics in collaboration with Jefferson Labs in Newport News, VA.

3. A 16-processor IBM SP2: 8 wide nodes, each with 1 gigabyte RAM, 12 gigabyte disk and 1024 Mbytes of memory, 8 thin nodes each with 256 Mbytes RAM and 12 gigabytes disk.

4. A second 30 Pentium Pro cluster with dual processors (450 Mhz), 256 Mbytes memory and 18 Gbytes disk per CPU is on order for research in Physics.

5. Two ES40 Compaq machines with 8 Gbytes of physical memory and 4 CPUs each.

6. An assortment of older heterogeneous clusters comprised of HPs, IBM RS/6000s, and Alpha Stations.

Department of Meteorology. They possess one 8 node IBM SP2 with 10 Gigabytes memory and 60 Gigabytes disk, one SGI power Challenge server, one SGI Origin 200 server, and 5 SGI workstations.

Department of Computer Science. They possess one 8 node IBM SP2 with 10 Gigabytes memory and 60 Gigabytes disk, one SGI power Challenge server, one SGI Origin 200 server, and 5 SGI workstations.

COAPS. The Center for Ocean-Atmosphere Prediction provides access to a 16 processor SGI Origin 2000 with 4.6 Gigabytes of memory and 320 Gigabytes of disk. In addition, the system possesses a 6 Terabyte archival system. This machine is a university-wide resource, and is not amenable to the types of computation envisioned herein.

The above equipment is supplemented by printing and backup facilities in the various groups. The research we propose in each area is very computationally intensive and must be integrated with advanced pre- and post-processing facilities. Research will focus on the development of tools which can semi-automatically generate highly efficient parallel code in several applied disciplines. The requested infrastructure will have a peak performance of at least one order of magnitude faster than the the fastest machine available on campus, with more disk, and more memory. This computer will allow tuning of codes with a view towards executing them on much larger supercomputers (e.g. those used by the Accelerated Strategic Computing Initiative (ASCI)) while retaining optimal scaling properties.

Description of Requested Equipment.
We will purchase equipment in three categories: 1) one cluster architecture (SCM) constructed from commodity components (those used now or in the near future by consumers), 2) one experimental parallel system (EPS) (distributed or single image), and 3) Information and Pervasive Infrastructure. While we have determined the categories, it is not realistic to make a decision on a particular vendor. To better understand the relationship between price and performance characteristics, we have elicited quotes for both the cluster and the EPM from Compaq, IBM, and SGI. Only SGI presented us with a cluster with a Linux operating system, yet based on the yet to be announced Merced chips. The Merced chip is based on the IA-64, that will be supported by most major vendors. We expect that within 6 months that other vendors will provide linux-based cluster solutions based Merced.

Equipment. We anticipate in year 1 the installation of the workstation cluster, with a Gbit backbone. The cost will be approximately $600,000, including 2 years maintenance. The cluster processors will be upgraded in year 3 and a slightly lesser cost ($550,000). In year 2, we will install the 32 cpu EPM at an estimated cost of $600,000. with an upgrade in year for at a cost of $550,000.

Peak performance of both commodity (IA-64) and proprietary (EV67, Powerx) chips are projected to increase by a factor 2 to 3 yearly to satisfy the requirements of ASCI. Depending on our purchase, we will replace IBM power 3 chips with IBM Power 4 chips, Compaq EV67 chips with EV7 chips, and SGI Merced IA-64 chips with McKinley chips. A specific upgrade program that permits the replacement of chips will be negotiated with the vendor when the system is purchased.

To support the effort in the core technologies and the integration of research and education, we will purchase a variety of smaller hardware that includes mobile palm tops and mobile laptops with associated PCI cards (they will become available within the next year), file and database servers, video servers, and trackers. The technology is continuosly changing, so we have allocated between $100,000 and $150,000 yearly for the purchase of this equipment.

The majority of the purchases will be coverered at a cost of 2/3 from NSF funds, and 1/3 from FSU funds.

Software. Software requirements includes operating systems, compilers, parallelization tools, and visualization tools. The hardware dominates the infrastructure cost. Florida State University has agreements with SGI and IBM that substantially reduces the cost of software (together, software components provided by the vendors will cost less than $50,000). This includes compilers for C, C++, Fortran 77 and Fortran 90. An additional cost of $25,000 to $50,000 for the managed system is anticipated for third party software in the areas of performance optimization and debugging. Packages include TotalView and VAMPIR. Parallel software environments for multinode systems are available from IBM and Compaq. SGI will provide a completely Linux solution, even on its single system image, also based on IA-64 components.

Maintenance. Maintenance on the compute hardware is estimated to cost between 7 and 10 percent of total cost on a yearly basis (based on an average of IBM, SGI, and Compaq pricing). Although maintenance is included the first year, we have negotiated a price with the vendors that includes maintenance for two years. After two years of maintenance, the machines will be upgraded at a cost that once again includes two years of maintenance. There will be no upgrades to the computing infrastructure in the 5th year at which point, we expect CSIT students to maintain (at least) the cluster. The exact specifications of the maintenance contracts will be negotiated upon award of this proposal. We will demand onsite service within 24 hours of failure.

Technical Support. CSIT currently has 3 1/2 system administrators who are responsible for the daily upkeep of CSIT resources, software upgrades, troubleshooting, helping users, and performing backups. The EPM requires direct management to insure that it maintains a high degree of availability. The algorithmic development on these machines is not conducive to low level experimentation. On the other hand, the SCM will be maintained by students and postdoctoral researchers active in the improvement of system tools, operating systems, and other low level development. CSIT system administrators will remain available to provide help as needed. In the first year, some effort will be expended to become familiar with the latest cluster tools, and extend, if necessary, existing scripts at automating system administrative chores. We do not anticipate an increased administrative load once the machines are upgraded, except for a brief period when low level parameters will be readjusted to compensate for various architectural changes.

2.2 Rationale

Equipment. We are proposing infrastructure to support an innovative new multidisciplinary school of Computational Science and Information Technology in the areas of research and education, and their integration in particular. The strongly multidisciplinary nature of the school leads to a strong interaction between computer science activities (for which clusters are a better environment), and computational and application science, for which a more integrated system, more akin to the big teraflop machine (to be used as a production machine) to be ordered and one that tracks ASCI, is best.

Core technology research described in this proposal supports efforts in the areas of coupled-ocean atmosphere modeling, materials science, manufacturing, acoustics, and the modeling of aquifers. In all cases, we will develop highly accurate numerical methods based on the newest implicit algorithms. These algorithms demand large memory sizes, and large caches to maximize their efficiency. The availability of a mixed mode programming model (a distributed set of n-way nodes) will lead to algorithms suitable for the next generation of supercomputers. Indeed, IBM will be announcing 32-way Power 4 chips within the next 1-3 years. Already commodity chips (Xeon III) have 4 processors per node. The algorithm development demands a computer with high availability, low down time, easy maintenance, and very high performance characteristics in terms of communication bandwidth, memory bandwidth and latencies. This leads to the requirement of what we refer to as a "managed system", a system on which students will not have access to the lowest levels of the operating system for experimentation. This machine will primarily be used for algorithm development, which is a substantial component of the proposed research.

Among the remaining core technology considered in this proposal, problem solving environments parallel Java, and the handling of large databases demand a combination of clustered computing and computing on a more integrated system. Problem solving environments are best built on a three tier system (client, server, cluster), which can accommodate many processes (handled by the cluster) and the interaction of many simultaneous users (clients). In most cases, the system is dominated by computational requirements, not communication bandwidth (the ideal situation for clusters). Throughput is not the primary concern of a problem solving environment. Users can wait 30 percent longer to have the system automate their code generation in a period of hours (as compared to months of labor of hand-coding is necessary). The research on HPJava leads to both a thread and an MPI implementation. The former requires a moderate size SMP or xUMA (UMA,ccNUMA, or NUMA) machine while the latter is best implemented on a cluster. In particular, research on Jini, meant to support the dynamic invocation of parallel codes is best performed on a cluster architecture. Applications of this technology includes roaming agents, computational steering, and geographically distributed computing to name a few. We anticipate installing beta versions of GSN running at 6.4 Gbits/sec under the ST protocol through a partnership with SGI. The SGI linux cluster was showcased at Supercomputing '99. Networks of this speed and beyond will be deployed nationally within the next decade. Experiments with a Gigabit or Gigabyte backbone will serve to predict and correct problems that might arise when many users interact on a wide area network at these speeds.

Both the SCM and the EPM will serve as learning tools for CSIT students. These two machines will complement each other and provide several programming paradigms for students to experiments with (OpenMP, MPI and a combination of the two). Students will have the opportunity to access the SCM to make kernel modifications for system tuning. This will not be possible on the EPM due to the need to low availability (i.e., single point of failure) of this class of computer. Science portals developed in the next several years will support both research and education and will be strongly dependent on general information and pervasive computer infrastructure such as mobile computing (hand held and laptop), database servers, video servers, etc. From previous work, the portals will emphasize web-based interaction with tools such as XML, MML, DHTML, and will require the acquisition of a variety of general purposes servers and storage to accomodate the expected growth in the data made available to the outside community.

We are requesting computer infrastructure in three distinct classes. The first is a cluster of workstations, based on the latest commodity chips, with a switched network of at least one Gigabit/sec, 1/2 to 1 Gigabyte of memory, and at least 1/2 Terabytes of disk space. The second system will be a Numa or SMP system. Except for the interconnect, the machine characteristics per prcessor are expected to be identical, as will the disk. We refer to the latter computer as a managed system (that requires formal system administrator, and cannot be experimented on at a low level by students or researchers). Recognizing that for algorithmic development, it is not important to have the largest possible system, we have allocated equal funds for both machines, to be purchased in two installments staggered at two year intervals. We expect the cluster to have twice the peak performance of the managed system. The funds allocated in years 1 and 2 for these machines are larger than the cost to upgrade. This is justified by the continued expected strong increase in the price/performance ratio. A slightly reduced cost for the system upgrade will degrade only slightly the potential performance characteristics of the machine, while still providing a substantial boost in performance.

Archival storage is not required in this proposal since at least 60 Terabytes will come online as part of the TFM.

Software. Requested software includes the tools necessary for compilation in C, C++, Fortran 77, Fortran 90, and Java, along with performance analysis tools to help optimize parallel software. The SCM will be linux-based and most of the software is free. open source.

Maintenance. Rather than pay maintenance for equipment on a yearly basis for the duration of the proposal, we will instead negotiate with the vendors to include a two year maintenance contract into the quipment at the time it is purchased. Upon upgrade, a similar contract will be negotiated. To reduce the cost, we will request service within 24 hours of failure. Given the high availability of a cluster (does not have a single point of failure), it is not necessary to obtain service quite as fast.

2.3 User access

The campus network provides access to a number of regional, national, and world-wide networks including ESnet, NSFnet, HEPnet, BITnet, FIRN and SURAnet. In addition, two T1 connections to ESnet via the University of Texas at Austin and Oak Ridge National Labs exist. The campus backbone is a 1 Gigabit FDDI ring that connects the individual research groups involved in this effort. The TFM is will be located at Innovation park (outside the main campus). Current access to the CSIT machine room (main campus) is at 100 Mbit/sec. However, we anticipate a 1 Gbit/sec upgrade that will allow high bandwidth between the TFM and the smaller EPM/SCM at CSIT. Florida State University is a member of Internet 2.

Off-campus connectivity is available via 28.8k or 56k modems. The Academic Computing & Network Services which provides computer-related services to the university, has new hardware for 576 lines with v.90 capability.

2.4 Space for Equipment

A typical footprint for a single frame (in which nodes are housed) 76"H $\times$ 36"W $\times$ 51"D with a weight of 2000 lbs fully configured with processors, I/O and peripherals. Each tall frame holds a maximum of 16 nodes (32 to 64 processors). We require a total of 1-2 frames for a total surface area of 57 ft^2. In addition, space is required for the disk farm (the archival tape unit will reside at Innvotion Park) . Lastly, a prototypical configuration for the 1 Terabyte disk subsystem is a 4 Model D40's (from IBM) that reside in a rack of dimensions 60"H $\times$ 19"W $\times$ 28"D ($\approx$ 4 ft^2). A spacing of 3ft around every cabinet/rack should be left unused for maintenance. No funding from the university is requested.

2.5 Institutional cost-sharing

The Florida State University has agreed to provide matching funds in the amount of $1,000,000 to support the purchase of equipment to support the research and education activities proposed by the School of Computational Science & Information Technology.

Spefically, Florida State University funds will be responsible for the purchase of the Experimental Parallel System (EPS), to be mostly used for research in core information technology and education. This system will also serve as a testing platform prior to the transfer of application simulation codes to the larger Teraflop Machine (TFM).

Florida State University is committed to the allocation of 5 to 8 million dollars to the the purchase of a massively parallel supercomputer that will achieve over a Teraflop of processing power over the next two years. A request for proposals will be sent out at the end of January, and the system is scheduled for installation by the end of October of this year. We estimate that upwards of 512 processors, each with a peak performance of 2 Gflops, 1 Gigabyte of memory, will provide computing cycles for university researchers to conduct production runs. About 10 percent of the machine will be reserved for computational science activities such as benchmarking, scalability testing etc.

3 Management Structure

The School of Computational Science and Information Technology has three arms – research, education and an infrastructure to support the research and education agenda. The infrastructure is called the Computational and Information Science Laboratory (CISL). This Laboratory is managed by the Associate Director, Geoffrey Fox. The high-performance computing infrastructure which the present proposal addresses will be in CISL.

3.1 Organizational Structure

Director: The Director is responsible for accomplishing the School's goals and objectives (its vision and mission) and for making budgetary and operational decisions. He relies on the steering committee (which includes the Associate Directors of Research, Education and Computational and Information Science Laboratory) and other formal and informal mechanisms for input and advice.

Advisory Board : The School's operation is overseen by the Advisory Board which consists of the deans of the participating colleges and schools and other distinguished leaders in the field. They are appointed by the Provost who chairs the Board. The Board sets the direction of the School, provides broad guidance and advice, and oversees financial management. It meets quarterly or as necessary to review the School's adherence to the policies and procedures set by the Board, and review the observations and recommendations of the Review Board. The current members of the Advisory Board are Jim Chang (ARO, Jack Crow (NHMFL), Douglas Dwoyer (NASA), Sid Karin (UCSD), Peter Lax, Courant Institute), and Robert Schrieffer (FSU).

Review Board: The members of the Review Board are drawn from industry, national labs and academia. They are appointed by the Provost at the recommendation of the Director. The review Board i) advises the Director in implementing the directives set by the Advisory Board and in selecting the science projects, ii) monitors fast-breaking scientific opportunities and iii) evaluates the School's performance and makes recommendations for the future. It meets biannually or as deemed necessary. However, in between meetings regular e-mail and/or telephone discussions will take place. The current members of the Review Board are Richard Hirsh (NSF), Spiro Lekoudis (ONR), Lyle Schwartz (AFOSR), Horst Simon (LBNL), Steven Ashby (LLNL), andThomas Zacharia (ORNL).

Steering Committee: The Steering Committee is composed of the three Associate Directors for research, education and infrastructure and other distinguished members of the faculty with interests relevant to the School. This committee is appointed by the Director who also chairs it. It assists the Director in all functions of School management such as maintaining interdisciplinary high-performance computing focus, facilitating technology transfer, raising and allocating resources, continuously assessing performance and planning future activities.

User Committee: This committee is appointed by the Associate Director of CISL to assist him in establishing appropriate management and resource allocation policies as well as ensuring that hardware and software remain state-of-the-art.

Administrative and Support Staff: To ensure the smooth operation of the School and to maintain a working environment conducive to the conduct of cutting-edge research, there is initially an office manager, a senior accountant, a budget coordinator and a secretary. CISL has now four technical staff – a systems administrator, two assistant systems administrators and a network specialist. There are a few software professionals. Additional permanent and temporary staff may be hired as warranted.

4 Prior NSF Support

M.Y. Hussaini
Interactive Concurrent Visualization of Unsteady Flows on Parallel Architectures, NSF9872140

We have developed and implemented a reduced order model capable of very high data compression rates that will ultimately allow the visualization of data concurrently with the executing program. The technique, based on an incremental proper orthogonal decomposition algorithm was implemented and tested on analytical two-dimensional time-dependent velocity fields. We found that a velocity field generated by several moving point vortices can be effectively decomposed using 10 Karhune-Loeve basis functions without visual degradation, of both the streamlines and the critical point locations and type. The required number of basis functions can be reduced further by decomposing the physical domain into several subdomains and applying the decomposition on each subdomain separately. While the total number of degrees of freedom is increased, the memory storage is constant, as is the visual reconstruction of the data.

Concurrently with this effort, we have developed a novel algorithm that addresses the display of time-dependent vector fields. We have generalized the line-integral convolution algorithm by blurring trajectories along a pathline. Our methodology differs from current practice in that we track specific particles in time, thus achieving a high temporal correlation.

This project involves personnel from the School of Computational Science & Information Technology (M.Y. Hussaini, PI, G. Erlebacher, K. Gallivan, S. Woodruff), and a postdoctoral researcher (B. Jobard). The grant period extends from Jan. 1999 to Dec. 2001 (award amount: $291,085).

Journal Publications

Gallivan, K. and Vandooren, P., "Reduced order models," In preparation.

Jobard, B., Erlebacher, G., and Hussaini, M. Y., "Time-dependent line integral convolution," In preparation.

Geoffrey Fox
Work in this proposal is related to previous NSF awards including activities in CRPC (the Center for Research in Parallel Computation) an NSF Science and Technology Center led by Ken Kennedy from Rice University; an NSF MRA grant Integration of Information Age Networking and Parallel Supercomputing Simulations into University General Science and K12 Curricula; ongoing work on education and problem solving environments in the NSF PACI program funded through NCSA; research grant in Data Parallel SPMD Programming Models from Fortran to Java from the Division of Advanced Computational Infrastructure and Research. The latter two are ongoing and will transfer to Florida State and are part of the research activities benefiting from this infrastructure grant. We chose to describe the last grant, which involves work on development of new approaches to parallelism in Java where Fox is P.I. Grant: 9872125, Total Award $346,827 over period: 09/01/98-08/31/01, Data Parallel SPMD Programming Models from Fortran to Java

This involves senior personnel Fox and Carpenter, who with two students on this project will be moving from Syracuse to Florida State. The project focuses on the use of Java for data parallel programming but the methods are generally applicable. Collaborator Professor Xiaoming Li from Peking University is investigating applications to traditional scientific languages especially Fortran. We have published several papers on this subject where the detailed ideas are described. The HPJava model is less ambitious than systems like High Performance Fortran (HPF) and aims to support an SPMD model intermediate between basic message passing (MPI) and HPF. One can incorporate pure MPI code but also array based computation with automatic decomposition with a user specified mapping in the spirit of HPF. An essential idea capability is a unified support of the successful data parallel libraries like ScaLAPACK, PetSc, Kelp, Global Array Toolkit, PARTI/CHAOS and Adlib. So far we have developed an operational HPJava translator and linked to Global Arrays and Adlib. As part of our collaboration we have prepared and given in China, a tutorial on HPJava and related approaches at www.npac.syr.edu/projects/pcrc/HPJava/beijing.html www.npac.syr.edu/projects/pcrc/HPJava/beijing.html. As part of the pure MPI work, we have developed an MPI Java binding which is available for download (www.npac.syr.edu/projects/pcrc/HPJava, www.npac.syr.edu/projects/pcrc/HPJava) and is a reference implementation used by the Java Grande MPI subgroup. We have developed an interesting research thrust looking at MPI style messaging which is natural for languages like Java. The derived types of current MPI can be replaced by concepts of object based messages and serialization. We organized the Java Grande Forum (www.javagrande.org , www.javagrande.org0 to address all the issues connected with the use of Java in scientific computing and both the working groups and associated conferences (now sponsored by ACM) have been quite successful. HPJava ideas have greatly benefited from contacts in this arena. As well as publications given below, Sung Ko will complete his Ph.D. in this area during this semester.

Journal Publications

Bryan Carpenter and Geoffrey Fox and Sung Hoon Ko and Sang Lim, “Object Serialization for Marshalling Data in a Java Interface to MPI”, ACM 1999 Java Grande Conference, ACM Press 1999.)

Mark Baker and Bryan Carpenter and Geoffrey Fox and Sung Hoon Ko and Sang Lim, “mpiJava: An Object-Oriented Java interface to MPI”, International Workshop on Java for Parallel and Distributed Computing, IPPS/SPDP ’99 San Juan, Puerto Rico, April 1999.

Jarek Nieplocha and Bryan Carpenter, “ARMCI: A Portable Remote Memory Copy Library for Distributed Array Libraries and Compiler Run-time Systems”, 3rd Workshop on Runtime Systems for Parallel Programming (RTSPP), IPPS/SPDP ’99, San Juan, Puerto Rico, April 1999.

Guansong Zhang and Bryan Carpenter and Geoffrey Fox and Xinying Li and Yuhong Wen, “The HPspmd model and its Java Binding”, chapter in book. Rajkumar Buyya editor: High Performance Cluster Computing, Volume 2, Prentice Hall, 1999.

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For font size and page formatting specifications, see GPG section II.C.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal, however, the entire proposal must be paginated. Complete both columns only if the proposal is numbered consecutively.

Research Description

1 Introduction

We will address problems from grand challenge applications that require high-performance algorithm/architecture combinations and supporting software infrastructure. We will develop state-of-the-art numerical algorithms for simulations in such areas as climate dynamics, composite manufacturing processes, turbulence and acoustics and geodynamics. Well-conditioned, high-order methods will be employed to discretize spatial and temporal operators to maximize accuracy per degree of freedom. The solver engine will be an architecturally driven, solution-adaptive, domain decomposition-based iteration.

High performance implementations on a distributed memory machine or a scalable shared memory machine will be analyzed and their limits identified relative to the interaction of the architecture and system software with the simulation algorithm. Scalability will come from keeping communication complexity of lower order than computational complexity, and maintaining load balance despite adaptive resolution and inhomogeneous source-term activity, by means of both dynamic local and periodic global balancing.

We will build integrated environments for simulation and visualization which are both portable and robust in the hands of users who are not experts in numerics but in the physical processes. Its symbolic processing component will provide a natural language for the manipulation of differential equations, numerical algorithms, input/output data, processes and associated visualization. It will further include symbolic processing necessary to support multiple structured/unstructured subdomains and interfacial boundary conditions associated with higher-order discretizations. Other capabilities will include powerful collaboration techniques, customizability for each user with an architecture that will allow the environment to be used in both research and education.

Our work in programming environments will focus on the development of parallel and distributed programs built around Java as a core scientific language with high performance. We have proposed an elegant expression of data parallelism which can be implemented with either threads or classic message passing (MPI). This research should lead to more productive scientific programming environments that can both express complex scalable algorithms and link to the rich Internet infrastructure.

Upon completion, this work will have significantly advanced the state of the art in core areas of CISE interest – advanced parallel algorithms, high-performance computing, scientific visualization, programming and problem-solving environments and tools. Apart from enabling the solution of the Grand Challenge problems discussed in the Multidisciplinary Applications section, this core technology will create many software solutions that are transferable to other partial-differential-equations-based applications of interest to the nation.

2 Core Technology

2.1 High-Order Numerical Methods for Parallel Architectures

Investigators: G. Erlebacher, K. Gallivan, M. Hussaini, D. Keyes, M. Sussman, S. Woodruff. The primary application areas that will benefit from the requested infrastructure share a basis in fluid mechanics, and, from a mathematical standpoint, a basis in partial differential evolution equations. As such, the numerical difficulties encountered in these applications and the algorithms developed to surmount these difficulties have important similarities. Below are discussed aspects of spatial discretization, grids and iteration strategies which are being addressed by innovative new algorithms in the applications areas. In all the applications, efforts are being made to transfer algorithm technology between fields and to develop algorithms with the target architecture in mind.

Discretization Techniques and Algorithm Development. The equations describing the flow in climate dynamics or in liquid composite molding process will be spatially discretized by spectral discretization techniques (Canuto et al. 1987). In this way, maximum resolving power per grid point will be achieved and memory requirements will be reduced. The increased accuracy per grid point more than compensates for the increased cost per iteration.

High-order spectral methods are adaptable to complex geometries through spectral-element formulations (Kopriva 1998), where, like finite-element methods, the solution domain is divided into elements that accommodate the arbitrarily complex geometry. The solution within the elements is then approximated spectrally to the desired accuracy. The discontinuous spectral Galerkin or spectral collocation formulation (Lesaint and Raviart 1974) is currently being developed by the proposers. Combining high accuracy with the ability to handle material discontinuities (Kopriva et al. 1999) and a strong potential for effective parallelization (Biswas et al. 1994), this technique has been effectively applied to flow problems (Warburton et al. 1997, Rasetarinera et al. 1998, 1999) and electromagnetic scattering problems (Kopriva et al. 1999). This technique will be coupled with the Level Set procedures (Sussman 1999) that are being investigated for tracking solution discontinuities such as shocks and other singular surfaces (Hussaini and Sussman 2000) to track weather fronts or the air-resin interfaces.

Consistent with the numerical methodology, we propose to construct surrogate models based on the proper orthogonal decomposition (POD) or the singular value decomposition (SVD) of data obtained from high-resolution numerical simulations of the original model. Basis functions are generated based on a collection of flow snapshots via the singular value decomposition of the snapshots (Sirovich 1987). These snapshots can cover several complete simulations, or several snapshots in time from a single simulation. We will combine the POD/SVD viewpoint with the Krylov subspace theory of surrogate models (Grimme 1997) to derive highly efficient parallel surrogate production algorithms and demonstrate their effective use. The proposed numerical methodology enables efficient construction of such surrogate models (with a priori error estimates) by employing the tangent linear operator and its adjoint.

New implicit time-advancement algorithms permitting computations for unsteady problems to proceed with efficient time steps will be developed. Newton-Krylov techniques (such as the Arnoldi method (Saad 1981) and GMRES (Saad and Schultz 1986)) and Krylov-Schwartz preconditioners (such as the additive-Schwartz techniques that are natural with domain-decomposition parallelization strategies (Keyes 1999)) at the focus of the proposed research will accomplish these goals both through the efficiency of the algorithms themselves and the effectiveness with which they may be parallelized. EN-like methods (Yang 1995, Yang and Gallivan 1995) are a new class of methods which subsume methods like GMRES and allow adaptation of the form of the algorithm to a particular computational platform, including parallel platforms. These methods have been demonstrated to be competitive and often superior to methods such as GMRES.

2.2 Visualization

Investigators: D. Banks, G. Erlebacher, M. Hussaini, B. Jobard, S. Woodruff. Rapid advances in computer performance have produced an explosion of large scale numerical simulations to solve grand challenge problems in many areas of science and engineering. These simulations are generally governed by a system of nonlinear, time-dependent partial differential equations. They often produce extremely large datasets which must be post-processed to extract relevant information necessary both to test current theoretical concepts and to develop new models. Examples of large-scale simulations are provided by the applications-driven research in this proposal: coupled ocean-atmosphere modeling including 4-D variational assimilation, simulations in the geosciences, computational manufacturing, and jet acoustics.

In order to effectively visualize time-dependent data, it is necessary to store the data at a temporal granularity fine enough to accurately reconstruct the data at any desired time level. Unfortunately, this is not possible with the simulations we envision. For example, on a 24 Gigabyte computer, the largest possible simulation of a compressible flow would have 256^3 grid points assuming 20 arrays of storage with a restart file of about 5 Gigabytes. Therefore, a 1 Terabyte disk can only hold 200 restart files, which is clearly insufficient for temporal post-processing at interactive rates.

We are currently developing reduced models of the time-dependent equations that permit a full temporal solution to be reconstructed from the equivalent of 30-50 time snapshots. Efficient data access techniques based on these models will allow users to interact with their data and visualize time-dependent phenomena without recomputing the flow (Gallivan and Van Dooren 2000). Instead of saving the full dataset prior to data reduction, the model is computed during the simulation. Based on these models, visualization tools are under development to allow users to interact with the data as it is produced by the computation. Concurrent visualization/simulation involves flow visualization in two distinct time intervals. First, the data produced up to the current time is reduced. This is essentially an interpolation and flow-feature extraction task. The second time interval extends from the last simulated time frame to any future time of interest to the user. The emphasis is on the extrapolation of flow features from the available data while retaining a respectable fidelity to the underlying physics. In both time intervals, the number of degrees of freedom must be minimized along with the time it takes to extract characteristic features of the flow. As a first step, the reduced basis functions will be based on a Karhunen-Loeve decomposition computed incrementally. A discontinuous Galerkin method, built from the original governing equations, is used to compute the reduced set of unknown coefficients.

Research in parallel feature extraction is necessary to identify the salient features of the data which will help guide the visualization process and suggest alternate means of efficiently accessing relevant data. On large-scale datasets, parallelism provides a substantial boost to interactive visualization. Examples of features include critical point and vortex cores which have proven to be invaluable in the fluid dynamics community.

The most promising flow visualization techniques to emerge from the research community during the past 6 years are to automatically place flow lines (such as streamlines or particle paths) in a dataset (Turk and Banks 1996, Jobard and Lefer 1997), animate a texture on them (Cabral 1993, Kiu and Banks 1996, Stalling et al. 1997) and illuminate them using a physically-based model derived for 1-dimensional fibers (Banks 1994, Zoeckler et al. 1997). Thus far, each of these elements has been demonstrated in isolation on research projects. We will integrate them into a complete tool, which promises to provide superior display of time-varying 3D flows.

Our recent installation of an 8-foot by 16-foot display (the "powerwall") creates an opportunity to investigate advanced techniques in human-computer interaction for visualization of time-varying simulations. We will develop 3D interaction tools ("widgets") to permit scientists to query both qualitative and quantitative information from the scene in an immersive keyboard-free 3D environment. Previous work demonstrated that immersive visualization, with tools for querying data, provided benefit to a flow physicist comparing experimental and numerical data for a turbulent flow (Banks et al. 1994, Banks and Singer, 1994, Crockett et al. 1996). The concurrent visualization system will provide users with the tools needed to manipulate their data as easily in the time domain as they currently do in the spatial domain (Jobard et al. 2000). Given the ability to store a full temporal data set on a local disk with only moderate sacrifice of accuracy, a new set of visual tools will be developed geared towards temporal analysis.

2.3 Problem Solving Environments

2.3.1 Application-sensitive compilation and prototyping

Investigators: R. Van Engelen, K. Gallivan, D. Whalley. Two recent projects addressed the need for practical software development environments that consider numerical algorithm specification, implementation, and restructuring at the algebraic/algorithmic level. These projects resulted in two operational environments: CTADEL (Van Engelen, Wolters, and Cats, 1997) developed at Leiden University and the Royal Netherlands Meteorological Institute, and FALCON (De Rose *et al.* 1996) developed by DeRose, Gallivan, Gallopoulos, Marsolf, and Padua at the University of Illinois at Urbana-Champaign. These software systems are complementary: CTADEL involves the generation of efficient serial, vector, and parallel Fortran codes for non-linear hyperbolic partial-differential equations governing atmospheric models , while FALCON is a tool aimed at code generation and optimization of MATLAB specifications of numerical solvers involved in numerical library prototyping and development.

The projects adopt a similar approach: the employment of a high-level problem specification language and an algebraic environment to transform the problem into code by using application-specific information and target hardware specifications. Application-sensitive compilation attempts to unify high-level application-specific algorithm specifications with lower-level compiler technology to obtain a practical algorithm prototyping and software development environment. This application-sensitive approach addresses the difficulties associated with the inevitable loss of crucial semantic information that arises after implementing a particular application solution in a high-level programming language. Loss of semantic information appears to occur on the choice of data structures (structured, unstructured, semi-structured, and sparse matrix representations) and the choice of solvers (direct, iterative, etc.) (van Engelen 1997) . These choices can have a profound impact on the effectiveness of the parallelization of the application. The CTADEL and FALCON projects demonstrated that lifting the abstraction level of the problem specification enables the underlying transformation system to algebraically restructure the algorithms and data structures thereby improving run-time performance and scalability of the codes.

We will exploit the CTADEL and FALCON technology and develop a problem-solving environment (PSE) that includes application-sensitive compilation techniques to facilitate the prototyping of algorithms based on the core algorithm technology for the application projects. In this respect, the PSE differs from the mainstream technologies (ELLPACK for example).

Recently we integrated CTADEL with the VPO compiler in an NSF funded project for the automatic validation of code improving transformations (van Engelen, Whalley, Yuan, 1999). VPO provides a base for performing data-flow analysis, traditional low-level code-improving transformations, and code generation. VPO is the compiler used by Zephyr, which is part of the National Compiler Infrastructure project that is funded by DARPA and NSF. The strengths of VPO include fairly easy retargetability and a variety of machine-independent code-improving transformations that can be applied on a machine-specific program representation. VPO is also integrated with a measurement system called EASE that provides a variety of measurements, including frequency and number of instructions executed, memory hierarchy, pipeline simulation, branch prediction, etc. The integration potentially enables powerful low-level optimization capabilities and static performance analysis of the generated codes by our PSE.

The benchmarks typically used in experimental studies have included only small to moderately sized programs. However, with the increasing complexity of applications and the use of modular design, programs are increasing in size and rely heavily on the use of procedures. Indications from industry are that for large application programs, many of today's optimization techniques are too costly to apply or are not effective. The goal of a current project funded by NSF and conducted by Whalley at FSU is to develop and experimentally verify a scalable approach to compiler optimizations. In particular, by employing techniques that limit the scope of optimizations. Program path selection for the scope of the optimization will be based on execution profiles and resource demand profiles, as the most effective optimizations are those that are applied on frequently executed paths as long as the resources needed are available.

Application of the PSE in climate modeling alleviates the difficult to implement coordination of numerical simulations of the atmospheric, oceanographic, geologic, and other sub-models and the sub-model boundary interface interactions involved. The PSE will include a workbench for interactive experimentation of parameter settings for each sub-model to relieve model designers from the burden of application (re)development. The workbench provides application scientists the ability to rapidly test new physical models, new numerical algorithms, or any combination of these applied to their particular problem and available computing platforms. Parameter selections include choices of mathematical models, numerical methods, discretization methods, discretization densities, data structures, boundary interaction methods, geographic features to be modeled, modeling scenarios, simulation visualization techniques, target serial, vector, and parallel machine descriptions, cache, memory, and interconnection network characteristics. The selection and composition of algorithm templates from a database is orchestrated by a knowledge-based system exploiting methods for case-based reasoning on the properties of the algorithms, model, and hardware. For example, optimal discretization methods are determined by the target hardware architecture (eg. shared or distributed memory system), memory latencies, network latencies, and cache/memory sizes. Further, sub-model integration requires compatible data structures to enable effective data interchange. The workbench aims to automate the method selection, the optimization, and the code generation aspects of a climate model to a high degree.

We are addressing the challanging problem of developing a unified analytical and computational PSE framework for designing products made of advanced fiber-reinforced materials. Advanced composites represent an important class of materials for a wide array of applications, such as marine structures, automobiles, and aerospace. Liquid composite molding (LCM) is an important composite manufacturing process for high volume production of large fiber-embedded structures with complex geometries. Accurate simulations of the LCM process are critical to the characterization of the macroscopic properties of the material being produced and in the optimization of the manufacturing process itself. For the simulation of the convection-diffusion equations intrinsic to the mold-filling and resin-curing processes, highly accurate space-discretization techniques and time-advancement algorithms need to be adapted and enhanced by the latest iteration acceleration techniques of the Newton-Krylov type. The development efforts are relieved by the PSE's algebraic restructuring and library generation capabilities.

We will explore a PSE infrastructure with network-based computing to support our work on MDO which requires resources from geographically distributed systems. Two technologies currently dominate network-based computing: component-based software and mobile agents. We will leverage the rapidly evolving component-based research at the DOE labs: Globus (Foster and Kesselmann (1997)), academia: NetSolve (Casanova and Dongarra 1997), MetaChaos (Edjlali *et al.* 1997), PSEware (Gannon *et al.* 1998) and the commercial sector: JavaStudio, Corba/OpenDoc, ActiveX, and Java Voyager. Mobile agents are an exciting technology which promises to revolutionize the approach taken towards data analysis, input/output, data mining, visualization, and computation. These are self-contained programs which are capable of executing on a local processor, transport themselves to a different environment, and resume execution elsewhere. Applications of this technology include decentralized load balancing, intelligent I/O, distributed database queries, automatic metadata generation from legacy data, and many more yet undiscovered.

2.3.2 Collaborative Science Portals

Investigator: G. Fox (with collaboration with NCSA team led by Dennis Gannon). While at Syracuse, Fox has built substantial experience in building both collaboration systems and web-based problem solving environments (PSE). The base technologies are built around distributed objects with the collaboration system Tango Interactive, using custom shared Java and JavaScript shared objects and the PSE's being built with both CORBA and custom Java servers. This work will continue after his move to Florida State but this move allows one an opportunity to rethink the architectures and implementation from scratch. We will also integrate the existing CSIT expertise in PSE's (van Engelen) and Visualization (Banks, Erlebacher) into our new approach. For the latter, we will build on some initial work at Syracuse on collaborative visualization and use these ideas to integrate the CSIT Powerwall collaboratively into portals.

Problem Solving Environments have been pursued for many years with the work at Purdue pioneering many important concepts. The increasing power of computers and the increasing capability of distributed object and web technologies are making this approach increasingly attractive for users and system builders.

One uses the Object Web (CORBA, COM, Java, XML etc.) and a browser based user interface to provide a single integrated view or portal to the resources and tools needed by the scientist. In his research at CSIT, Fox will start with the successful Gateway and WebFlow systems developed at Syracuse and applied to several DoD and NSF projects. These have a classic three-tier architecture with client, brokers/servers and services in the three layers. High performance is obtained even while using Java and CORBA in the middle tier, by careful separation of control and data. The middle tier provides a flexible control layer implemented with proxies and traditional high performance mechanisms such as Globus and MPI are used for data transfer in the backend. This WebFlow distributed object technology has a powerful dataflow and coarse grain object computing model with all interfaces defined in XML and compatible with community activities. For the future, we intend to work in the approach of the NCSA Alliance where a PSE is viewed as a Portal which has a set of services that combine those of well known web sites (such as Yahoo) with classic Scientific PSE's.

Further user customization allows one to support different views of the information and services and support both computational science and education uses. Systematic use of XML with well-defined interfaces for both client/broker and broker/back end service seems key. Further relevant community standards are being set by the Grid Forum and the computing portals spin-off from the Java Grande Forum. We will implement early prototypes of the new portal approach on Gateway but expect that one can better use one of the emerging set of Object Web operating systems such as E-Speak or Ninja as the basic framework.

We have been quite successful with using collaboration technologies in educational applications but have yet to develop collaborative computing applications, which are both robust, and of compelling value. We will use the existing collaboration systems in early experiments but we intend to build much of the collaborative infrastructure from scratch replacing custom protocols and services by more robust systems developed for large-scale application areas like e-commerce. We will use commercial products or the ANL/NCSA Alliance Access Grid project for audio-video conferencing. The collaboration service in science portals must support both asynchronous interactions, and real-time synchronous collaboration and mixtures thereof. Our web-based PSE approach implies that collaboration is a service that shares web-based distributed objects. However we also need to support several collaborative modes: shared display and both collaboration-aware and collaboration-unaware shared event models. Previous systems such as Tango Interactive have focused on one of these mechanisms and have not been able to support the needed range of collaboration. We will develop a new integrated system CPW (Collaborative Portal on the Web) based on a shared queued event service with XML used to define the details of the collaboration.

The multi-tier structure of Science Portals fits well with the proposed resources to be obtained as part of this proposal. We need multiple back end compute servers (Teraflop machine, cluster and experimental parallel machine) represented by the brokered Java/CORBA servers which are naturally implemented on the Information Infrastructure. Collaborative visualization and mobile user support is an important aspect of portals and this part of the proposed resource will enable such research.

2.3.3 Data Intensive Computing in High Energy and Nuclear Physics

Investigators: G. Fox (in collaboration with the High Energy and Nuclear Energy Physics groups at FSU). FSU has active High Energy and Nuclear Physics groups involved in major experiments at CERN, Fermilab and the Jefferson Lab. These experimental programs are generating hundreds of terabytes yearly and this production rate will grow to many petabytes of data annually. Our ability to work effectively with enormous data sets and to mine the data for the required information will determine the rate of progress in these fields.

There are several problems we wish to solve, of which the following are the most pressing: 1) To create a software system capable of running simulations, in parallel, on hundreds of computer nodes by possibly dozens of scientists at a time, who may be scattered across the globe; 2) To create a software system that provides an easy interface to both real and simulated data, not only for FSU scientists but for our colleagues world-wide and; 3) To create an analysis environment that makes it possible to manipulate and visualize multiple data sets as if they were a single entity; 4) Support both advanced neural network and probabilistic methods of data analysis.

We have considerable experience from our current experiments in dealing with large data volumes and widely distributed computations on computer clusters. For example, the Jefferson Lab experiments generate nearly a terabyte of acquired and simulated data on a good day. The simulations essential for using this data take place on computer clusters at several universities, including the 32-processor Linux cluster at FSU. As the data volume from experiments and computations explodes, one will require integrated problem solving environments to effectively conduct, track, combine and compare the results of thousands to hundreds of thousands of related, but independently conducted computations. Without such tools scientists will spend an inordinate amount of time simply keeping track of what computations they have done and where their data is stored.

There have been some projects in this area including the NILE project and more recently the National Scalable Cluster Project but technologies are changing rapidly and a modern infrastructure built around XML databases and interactive (Java) datamining tools appears very promising. Note even though this field has large data volumes, the analysis is compute not I/O bound. Thus it is attractive to build more flexible powerful information management schemes. Note that although Fox's current emphasis is computer science, while on the faculty at Caltech he built and used the data analysis system for several successful physics experiments at Fermilab.

2.4 Programming Environments: Java Grande and HPJava

Investigators: B. Carpenter, G.Fox. Following a workshop organized by Fox in December 1996, there has been growing interest in the use of Java and its associated technologies in large-scale computation. The workshop series is popular and now well established with ACM sponsorship. Further, the Java Grande Forum (www.javagrande.org) established in March 1998, has divided the issues into two broad areas: Numerics and Concurrency. Clearly Java can be used client side for nifty animations and its use for modern servers is well established in both industry and academia. However can Java be effective in your basic parallel algorithm? Satisfying this goal brings up issues such as floating point performance, convenient expression of complex variables and efficient array constructs. Already the Java Grande Forum, coordinated by Fox, has had significant impact on Sun Microsystems.

On the research side, our work on Java-based data parallel programming is a collaboration with Professor Xiaoming Li from Peking University. The HPJava model is less ambitious than systems like High Performance Fortran (HPF) and aims to support an SPMD model intermediate between basic message passing (MPI) and HPF. We call the generalization to languages like Fortran and C++ HPspmd but at Florida State we focus on Java. HPJava can be implemented as either threads or distributed MPI and we would be early users of both the proposed major parallel architectures (in the research infrastructure) to compare the effectiveness of these two paradigms. Currently HPJava has a few key concepts: distributed arrays, data-parallel arrays and a few special control constructs. Currently we are testing the first HPJava compiler (really just a translator) but we will then take some ab-initio application codes (such as those in our GEM Earthquake activity) and see if the new language can produce good code in a practical case.

As part of the pure MPI syntax for HPJava, we have developed an MPI Java binding which is available for download (www.npac.syr.edu/projects/pcrc/HPJava, www.npac.syr.edu/projects/-pcrc/HPJava) and is a reference implementation used by the Java Grande MPI subgroup. We are developing an interesting research thrust looking at MPI style messaging which is natural for languages like Java. This involves rather obviously serialized object based messaging replacing derived types in MPI. However, more interesting is links to technology like Jini to support dynamic invocation of parallel codes on cluster architectures. We hope this will be a major thrust on the proposed cluster resource.

3 Multidisciplinary Applications

The following application areas have in common the features of being significant concentrations of interest at FSU, of being capable of using unlimited computational resources and of making full use of the core technologies. All the areas have been long-standing strengths of FSU and it is intended that the proposed infrastructure will play a significant role in keeping these areas strong in the new century.

The areas described here are all fluid-mechanics related, and thus, of necessity, must deal with turbulent flows. This is the primary area of expertise of the Principal Investigator and his group, and it provides a rigorous test for the developing core technologies.

3.1 High Performance Computational Models for Ocean-Atmosphere Systems

Investigators: W. Dewar, M. Hussaini, T. Krishnamurti, I. Navon, J. O'Brien. The ongoing research program at the Florida State University in the area of the coupled ocean-atmosphere-land surface system involves a critical mass of well-known faculty, postdoctoral fellows and students and is preeminent in the world. This program includes major thrusts in physics, dynamics, and data and computational issues. Current work, which concentrates on the prediction of tropical activity, deals with the issues of storm frequencies (tropical storms, hurricanes and typhoons) and periods and locations of their ocean basin preferences, given seasonal forecasts of the atmosphere and ocean. On shorter time-scale forecasting (from one to ten days), FSU has been engaged in major model and data refinement efforts using a high-resolution global model implemented on a parallel computer platform. Basic issues in model development have also been under consideration by FSU faculty, and methods for advancing model physics have already been articulated.

To take the weather and climate prediction capability to a new level, the principal investigator has now assembled a team of geophysicists expert in atmospheric and oceanic sciences (Krishnamurti, O'Brien, Dewar, Navon, Chassignet, Busalacchi), computer scientists expert in parallel systems software, parallel algorithms, problem solving environments (Fox, Gallivan, Keyes, Mehrotra, van Engelen) and applied mathematicians expert in numerical methods and fluid physics (Erlebacher, Kopriva, Woodruff, Sussman) to attempt influential strides in the simulation of coupled models. This research program proposes to draw upon the expertise at the Laboratory for Hydrospheric Processes at the Goddard Space Flight Center, the atmospheric and climate sciences research at Los Alamos National Laboratory, and the computer science research at the Institute for Computer Applications in Science and Engineering at NASA Langley Research Center.

The objectives of our investigation reflect the diversity of the research team and the complexity of the scientific task, and include: i) modeling, particularly with regards to turbulent mixing; ii) discretization in space and time, with both p-type and h-type adaptivity, in a locally structured framework; iii) implicit coupling mechanisms, recognizing that there is little value in improving the accuracy of oceanic and atmospheric models within their individual thin domains if the results are dominated by either modeling or numerical errors committed along their vast common interface; iv) efficient parallel implicit solution algorithms, motivated by the multi-scale nature of the global circulation and the frequent desire to focus selectively on coarser scale features, and rendered challenging by the load imbalance caused by adaptivity and the all-to-all coupling which is formally present in any mathematical description of the inverse action of the implicit operator; v) cache-conscious and page-conscious programming implementations, given the pronounced sensitivity of the fastest processors to cache-residency and page-residency and the relative lack of programmer control over the details of interlevel memory mappings; vi) portable, scalable, message-passing implementations, given the volatility of individual hardware platforms (within the context of relatively converged general architectural characteristics); vii) parallel data base management, looking towards the use of the simulation capability we plan to develop in production mode, where the sizes of the input and output are comparable to the workingset size of the application itself.

In pursuit of high performance on the coupled ocean-atmosphere models, we will exploit three forms of parallelism: (1) an outer task parallelism, permitting the atmospheric and oceanic domains to be processed concurrently, except for synchronization to enforce interfacial compatibility, (2) parallelism within each domain, based on domain decomposition, and (3) inner task parallelism, derived from lightweight threads and as automated by compilers for multifunctional unit processors. The outer task parallelism has a granularity of just two, and appears at the level of the ocean-atmosphere coupling. The inner task parallelism is likewise of small granularity, and does not enter the discussion on distributed implementation except insofar as it will permit the overlap of communication with useful computation whenever the hardware support exists. The most interesting parallelism is the parallelism within the atmospheric and oceanic domains, in which each processor is responsible for applying essentially *all* of the operations to *part* of the data. This paradigm can be applied at almost any granularity.

It is clear that successful demonstration of a coupled ocean-atmosphere circulation model in a high performance environment will place a tool in the hands of the geophysical community that will permit revolutionary advances in our ability to understand and to predict our complex, ever-changing environment. In addition, the effort will create many software solutions that are transferable to other partial-differential-equations-based Grand Challenge applications of interest to the nation.

3.2 LCM Process Modeling and Design Optimization

Investigators: G. Erlebacher, H. Garmestani, M. Hussaini, B. Wang, S. Woodruff, C. Zhang. In current LCM applications, computer simulation tools have been used to predict LCM process behavior (Lee et al. 1994, Liu et al. 1996, Phelan 1997, Jiang et al. 1998, Zhang et al. 1999, Han et al. 2000). Design cycle simulation based on such tools become prohibitively expensive and too time-consuming to be useful. Thus, there is a need to develop simulation models and solution algorithms which are both efficient and accurate to conduct LCM process design in a rapid and real-time fashion. This is the intent of the current proposal.

Fluid Flow Modeling In an LCM process, three phases are involved: resin flow, heat transfer and chemical kinetics. Accurate simulation of these phases are critical to the characterization of the composite material as well as the optimization of the manufacturing process itself. We will develop a sophisticated and realistic three-dimensional non-isothermal simulation model that couples flow, thermal-kinetic physics and cure, taking further into account such considerations as race tracking, dry spot formation, pressure and temperature profiles, and curing degree. However, we will initially deal with the particular cases of the general formalism, which are the simplest possible realistic representations of the LCM process (surrogate models). Formally second-order methods are the state of the art for the solution of the current simulation models. We propose to develop well-conditioned high-order methods, which are inherently amenable to parallel computation. Such methods are desirable to resolve the physical complexity of multiscale phenomena with relatively fewer nodes and to take advantage of the continuing lag in memory speed relative to processor speed. Furthermore, these methods described below will also consistently apply to the material characterization relating microstructure evolution to macroscopic properties of the composite.

The LCM design space in which we wish to find an optimum can never be thoroughly explored by full simulations because of prohibitively excessive computational requirements. Consequently, a new class of surrogate models will be developed and integrated into the full-scale simulation codes. This will permit better sampling of parameter space, albeit with decreased accuracy. There are essentially two types of surrogate models. The first is based on physical approximations where the governing equations themselves are reduced and simplified in some fashion. The second is based on numerical approximation where the dimensions of the approximation space is significantly reduced through an appropriate choice of basis functions. This is further explained where the numerical methodology is discussed.

The outputs of the molding process simulations will be the total mold-filling time (a quantity to be minimized in the overall optimization procedure) and the details of the intermediate and final states such as resin flow pattern, pressure-velocity-temperature profiles and degree of cure at a specific point of time during an LCM process. It is these latter details of the processing state that will provide inputs for the material characterization problem discussed next.

Materials Characterization. Different input parameters to the mold-filling process will lead to different void distributions and to a complete or partial cure, producing a polymer structure with different combinations of monomers and polymers that can affect mass or molecular weight distributions. This information, provided by the LCM simulations, will be used to predict the mechanical properties of the composite. Experimental and computational investigations will be undertaken to establish the effects of voids, microvoids, dry spots, cure cycle, temperature gradient and fiber distribution on mechanical properties.

The effective properties of the composite material manufactured using LCM will be calculated from the fiber preform structure, resin flow pattern, and the void content/distribution output from the mold-filling simulation and experiments (Spoerre et al. 1998). The approach employed here for characterizing the inhomogeneity (Lin et al. 1998) employs correlation functions (Corson, 1974) provided by the LCM process simulation. The void distribution will be incorporated in the formulation to give three phases: the polymer matrix, the fiber reinforcement and the voids.

Novel approaches to modeling and simulation of material microstructure will borrow ideas from the statistical theories of fluid-mechanical turbulence and from its direct numerical simulation. This interdisciplinary cross-fertilization of ideas will lead to the adaptation of the intrinsically nonlinear models of turbulence to materials characterization to avoid the severe assumptions of linearity in current materials practice. The application of theoretical concepts from, for example, the Direct Interaction Approximation (Rubinstein and Erlebacher 1997), Renormalization Group Theory (Gatski et al. 1996, Smith and Woodruff 1998) and the Eddy-Damped Quasi-Normal Markovian (EDQNM) theory (Orszag 1977), and of techniques from the direct numerical simulation and large-eddy simulation (Hussaini 1998) of turbulence, to the analogous multiscale phenomena in materials characterization will result in important theoretical and practical advances in the subject.

Design Optimization. The optimization emphasis will be on Multidisciplinary Design Optimization (MDO), and in particular, development of powerful optimization algorithms of general applicability. Typical questions that the research program will be designed to answer (Alexandrov and Hussaini 1997) include: What guarantee is there that when one goes around the design loop in a multidisciplinary analysis in which each discipline changes the geometry, that a fixed point, rather than a limit cycle, exists? In recent years, sensitivity analysis has come to be widely used in many disciplines (Li and Navon 1998). How can the relatively high cost of sensitivity analysis for nonlinear problems solved by iteration be reduced? How may a high-fidelity optimum be sought by exploiting low-fidelity methods (simple physics, coarse grids, formal approximations) in a systematic search process that only occasionally employs the expensive, high-fidelity methods?

Optimizers specially suited to MDO will be developed (Cramer et al. 1993), since conventional optimizers wrapped around a standard multidisciplinary analysis have rarely proven to be computationally or organizationally feasible. Multi-level schemes permit the exploitation of disciplinary sub-optimizations and can lead to greater efficiency along with greater acceptance by design organizations. Mathematical issues include demonstrating the equivalence of the multi-level formulation (Alexandrov and Dennis 1994, 1999) with the original formulation, determining the optimum multi-level strategy and developing optimization strategies that take uncertainties in manufacturing and in the operating environment into account.

A successful demonstration of rapid virtual prototyping and optimization for liquid composite molding process in a problem-solving-environment will place a tool in the hands of the industrial engineering community that will permit advances in multidisciplinary design optimization and simulation-based design. This will lead to a reduction in product design-cylce time, a critical factor in global economic competitiveness.

3.3 Acoustics

Investigators: G. Erlebacher, M. Hussaini, C. Tam, S. Woodruff. The prediction and control of the sound generated by turbulent flows is a complex and difficult subject, entailing both the problem of the prediction of the turbulent flow and the prediction of the acoustic field generated by that flow. There is a significant concentration of expertise in both these endeavors at FSU, concentrated in several research groups; all have a pronounced need for the requested infrastructure. As a complex flow phenomenon, acoustics requires for its understanding and prediction significant input from the core technologies of visualization, numerical algorithms and advanced prototyping environments.

The acoustics work at FSU has four parts. The first part is concerned with improvements to the acoustic-source modeling of the industry-standard MGB noise-prediction code, which predicts the acoustic field based on previously computed aerodynamic and turbulence data. Further work in this area will employ the more computationally intensive but more accurate linear Euler equations for the prediction of the acoustic field. The second part is the assessment of the performance of state-of-the-art turbulence modeling for the prediction of the aerodynamic data that provides data to the MGB computation. Numerical results using two-equation, algebraic-stress and other models in two separate aerodynamic codes are computed, and comparisons of centerline and radial data with experiment are made (Woodruff, et al., 1998a.) The third part is concerned with performing large-eddy simulations of jets for noise prediction. This involves the development of new concepts in sub-grid-scale modeling, the assessment of the best numerical techniques and other developments in the relatively uncharted field of compressible-flow large-eddy simulation in order to produce accurate and detailed predictions of the turbulence statistics to be used in noise prediction (Woodruff, et al., 1998b.) The fourth part is concerned with the optimal control of jet acoustics. Active and passive control schemes may yield significant jet noise reductions and so are both an active area of interest in industry and NASA. Sophisticated new techniques from optimization theory, particularly surrogate modeling, are employed to make possible the efficient optimization of problems that were formally too complex for optimization to be practical.

In all these acoustical researches, the dramatic disparity between the length and time scales of the object generating the turbulence (and thus the sound), of the turbulence itself and of the acoustic waves leads to a truly formidable simulation problem. Even the most severe of those physical modeling approximations that are still reasonable lead to computational tasks which tax the largest modern computers; the need for the requested infrastructure, aided by the core technologies in making effective use of that infrastructure, is particularly acute here. Only with the combined aid of new visualization techniques for understanding the turbulence sound-generation phenomenon and the propagation of acoustic waves in turbulent fields, new numerical algorithms for resolving the wide range of length scales accurately and rapidly, and new prototyping environments to permit rapid experimentation to arrive at the best combination of algorithm, model and architecture, can the requested infrastructure be used to its fullest potential and lead to significant advances in this area.

The work performed with the two target architectures requested in this infrastructure proposal will be especially valuable because it will provide direct comparisons of the efficiency of various core-technology algorithms on the architectures for this type of simulations activity. The problem-solving environment will be tuned using this information to provide the most effective algorithm for a given target architecture. Once successful algorithms have been developed on the requested infrastructure, production runs will be performed on larger machines off-site.

3.4 GEM (Earthquake Science) Computational Infrastructure

Investigator: G.Fox (with Group of Computer and Earth Scientists from Academia and Government). Over the last three years, Fox has worked with a team of computer and earthquake scientists from academia and government to initiate a program GEM "General Earthquake Models" aimed at applying the latest computational technology in this area. This thrust contributes to the nationally identified importance of developing new approaches to Geoscience involving advanced instrumentation (EarthScope) and computing. The GEM group includes representatives of over a dozen universities, multiple government agencies and laboratories (DoE, NASA, NSF, USGS) and is coordinated with the major NSF Southern California Earthquake Center (SCEC). Fox leads the design of the computational infrastructure GEMCI for this effort and we will use the proposed CSIT resources as the site of an experimental system on which to test GEMCI without the limiting requirements (for computer science research) of production use. We note that as Fox's move to FSU is still in progress, we have not integrated many existing CSIT faculty capabilities into GEMCI and we will naturally work on this during the next months. CSIT expertise in Problem Solving Environments, data assimilation, visualization and basic numerical algorithms are all relevant to GEMCI.

The work of the earth scientists has been divided into three application area timeframes characterized by time scales of hours (post earthquake analysis), 6-12 months (data assimilation and development of new earthquake forecasting approaches) and ten years (fundamental theory). GEMCI work is divided into five thrust areas which must support the different needs of these application areas: distributed collaborative (shared) scientific objects, HPCC simulations, multi-sensor metadata, data and simulation visualization, and interactive scientific datamining for earthquake pattern analysis. Fox's initial activities focused on use of fast multipole techniques, where GEM shows interesting differences from previous applications areas such as astrophysics and CFD. Now we are concentrating on prototype science portals and work on collaborative systems to support this range of application requirements. Further, as mentioned in the parallel Java discussion, much of the code for this field can be developed from scratch and we expect to experiment with the use of Java as the coding language. GEMCI will make use of the full range of proposed resources in this proposal. As well as central simulation engines, we need to support hand-held devices for workers in the field and experts on call for real-time participation in analysis of an earthquake in process. Further, as indicated by our list of thrust areas, visualization resources will be an important capability.

4 Integration of Research and Education

4.1 Introduction

The proposed computational resource will be used in two synergistic but very different ways to support education. These are the use of the proposed computational resources to enhance courses given in CSIT and the support of research in new technology to enable virtual classrooms for distance and distributed learning. We describe these in order after first briefly describing CSIT's academic degrees and courses, which are still being discussed and have yet to complete the full approval process. Nevertheless, the overall structure and resource needs are clear.

4.2 CSIT Degrees and Courses

An important feature of CSIT is that it integrates applications and technologies from both simulation and information based fields. For example it includes both parallel and distributed computing but with the practical emphasis required for use in applications. CSIT will offer stand-alone degrees at the masters and Ph.D. level as well as minors and attractive courses to students in other majors. The latter include not only the expected computer science and science majors but also three courses aimed at preparing education majors to use computational science and information technology in their teaching careers. Degrees will be offered that have a required set of core courses, plus electives to support specializations in areas like computational biology or computer science. Approximately 15 core courses (independent of any specialization) are initially planned, covering topics such as Foundations of Computational Science, Foundations of Information Technology, Scientific and Information Visualization and Parallel Computing. To these we will add discipline-oriented courses covering topics such as Computational Physics or Optimizing Compilers. The design of these courses includes lessons from the Internetics programs developed at Syracuse and Peking Universities by Fox and Xiaoming Li which showed clearly that one could link Information technology curricula with conventional computational science and science programs. (www.npac.syr.edu/users/gcf/internetics2/.

4.3 Use of Proposed Resource in Courses

After many years when computers did not realize their early promise to dramatically improve learning environments, we believe that the situation is changing rapidly with many demonstrations of the advantages of integrating both computers and computing into courses. Here we include the value of electronic classrooms as described below as part of our educational technology discussion. However, especially valuable in the CSIT curricula will be the integration of research technologies and computational results into education. We will use the proposed enhanced visualization capabilities to develop visual enhancements to the teaching of science and computer science. We will use the NCSA Alliance concept of a Computational Science Education Portal to develop Science portals that have two faces

4.4 Research and Education

Exactly how to do this is a subject of ongoing research among the PACI sites and their EOT (Education Outreach and Training) partners. We will experiment with the use of mobile computers (hand-held and laptop) in classes. This will use technology, which is derived from our distance education work, where collaborative environments allow one to link students and teachers to interactive programs (at the simplest, Java applets and more generally visual displays from computational servers). We will of course use other tools besides those developed by our in-house education technology research. In fact, FSU itself has substantial experience with the interesting commercial Blackboard product and, with Joe Thompson of MSU, we are investigating SURA-wide initiatives to evaluate and use new technologies in open source courseware. We will reserve a fraction of the proposed compute resources for use in classes both to drive interactive visualizations and for student use in programming laboratories. The proposed information infrastructure will support courses which use or teach the use of database and object servers. Fox has substantial experience with this at Syracuse where for the Internetics courses, both on-campus and distant students use the Syracuse machines for both Information (e.g. experiment with Web-linked databases) or Simulation (MPI) homework.

4.5 Education Technology Research and Distance Education

Investigators: L. Dennis, G. Fox, C. Lacher. Fox has developed a significant activity in technology to support education and training as part of his work at Syracuse and this thrust will also be a major research focus in CSIT. We will work with the FSU Office of Distributed and Distance Learning (ODDL) led by Chris Lacher, which has institutional responsibility for implementing an aggressive high quality program in distance education. The combination of CSIT and ODDL allows a synergistic partnership between deployment and research in this exciting area. The establishment of three state-funded positions to enable this cooperation and jump-start the research program in CSIT indicates FSU's commitment to new learning environments. Fox hopes to continue his work with the DoD PET program and its program of course exchange with Historically Black Colleges and Universities (HBCU). It will be natural to add FAMU (also in Tallahassee) to our collaboration with Jackson State and Morgan State where at least one course has been taught every semester for last three years between Syracuse and these HBCU's. This technology has important synergies with the problem solving environments discussed earlier, with a Virtual University being considered as an education portal in contrast to a PSE as a computational science portal. In particular collaboration technologies like Tango Interactive from Syracuse can be used to support either the interaction between teacher, mentors and students or between collaborating researchers.

We intend to build a new research education infrastructure with the same advanced infrastructure as our science portals. On top of this general infrastructure one implements a set of special services to support education and training. These must support the special collaborative needs of education and distinctive services such as assessment, performance (grading) support, annotation. There are also distinctive educational objects (quizzes, homework, glossaries) as well as the curriculum pages with appropriate hierarchical structure. We need to pay attention to support for key capabilities such as displaying mathematics on the Web and standards for graphics where we hope to integrate the Power Wall. This new distributed object based system will be designed to support curriculum material built in any web authoring system and specified either statically or dynamically (from a database). We will implement collaboration (needed in particular for synchronous lectures or support of office-hours at a distance) using the ideas briefly described for science portals. Assessment will be a particular focus where we build on the experience of ODDL and two recent Ph.D. theses from Syracuse. The technologies described here will be tested in three distinct ways: use in CSIT courses, use by ODDL at FSU and finally use in outside collaborations such as those with NCSA Alliance and the HBCU network. This research thrust will, as described above, make extensive use of the proposed pervasive infrastructure.

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EXPERIENCE:

1996 to date	Director, School of Computational Science and Information Technology TMC Chair in Computational Science & Engineering Eminent Scholar Chair in Mathematics
1992-1996	Director, Institute for Computer Applications in Science & Engineering (ICASE)
1986-1992	Chief Scientist, ICASE NASA Langley Research Center, Hampton, Virginia
1978-1986	Research Scientist; Senior Staff Scientist, ICASE NASA Langley Research Center, Hampton, Virginia
1976-1978	National Academy of Sciences - National Research Council Senior Research Fellow NASA Ames Research Center, Moffett Field, California
1970-1976	Group Chief, Flow Fields; Assistant Division Head Acting Division Head, Aerodynamics Division Indian Space Research Organization, India

MEMBERSHIPS:
Member, Society for Industrial Applied Mathematics
Fellow, American Physical Society

AWARDS:

- NASA Medal for Exceptional Scientific Achievement - for his many pioneering studies of boundary layer transition physics and development of highly accurate computational methods for conducting such studies (1988)
- NASA Group Achievement Award - Member of Hypersonic Boundary-Layer Transition Team (1989)
- NASA Recognition of Outstanding Publication within the Aeronautics Directorate (co-author): Mixing Augmentation Technique for Hypervelocity Scramjet (1990).
- NASA Public Service Group Achievement Award - for pioneering developments in advanced numerical analysis and computational algorithms which have formed the foundation of modern computational fluid dynamics - Member of ICASE Numerical Analysis and Algorithms Group (1992)
- NASA Group Achievement Award - for important contributions in fluid mechanics and theoretical analyses which have led to major advances in flow prediction and control, including laminar flow control - Member of ICASE Fluid Mechanics Group (1994)

JOURNAL EDITORSHIP:
- Applied Numerical Mathematics; Editor; North Holland
- SIAM Journal of Scientific & Statistical Computing; Associate Editor 1988-91
- Theoretical & Computational Fluid Dynamics; Editor-in-Chief; Springer-Verlag

BOOK SERIES EDITORSHIP:
- Computational & Applied Mathematical Physics; Editor-in-Chief; American Institute of Physics
- Engineering Science; Editor; Oxford University Press
- Computational Physics; Editor; Springer-Verlag

PUBLICATIONS (over 150 publications):
1. "Interaction of an Entropy Spot with a Shock," with G. Erlebacher, *AIAA Journal*, Vol. 37, No. 3, pp. 346-356, 1999.
2. "Analysis of the Discontinuous Galerkin Method for Wave Propagation Problems," with F. Q. Hu and P. Rasetarinera, *Journal of Comp. Physics*, Vol. 151, 1999, pp. 921-946.
3. "A Self-Contained, Automated Methodology for Optimal Flow Control Validated for Transition Delay," with Ronald D. Joslin, Max D. Gunzburger, R. A. Nicolaides, and Gordon Erlebacher, *AIAA Journal*, Vol. 35, No. 5, 1997, pp. 816-24.
4. "Low-Dissipation and -Dispersion Runge-Kutta Schemes for Computational Acoustics," with F. Q. Hu and J. Manthey, *Journal of Comp. Physics*, Vol. 124, 1996, pp. 177-191.
5. Multidisciplinary Design Optimization: State of the Art, N. Alexandrov and M. Y. Hussaini, eds., Philadelphia, 1997, Society for Industrial and Applied Mathematics.

COLLABORATORS SINCE 1992:
Alexandrov (LaRC), P. W. Duck (U. Manchester UK), G. Erlebacher (FSU), T. Gatski (LaRC), C. Grosch (ODU), M. D. Gunsburger (CMU), J. Hardin (LaRC), F. Q. Hu (ODU), T. L. Jackson (U. Illinois), R. D. Joslin (LaRC), H. O. Kreiss (UCLA), D. G. Lasseigne (ODU), Lumley (Cornell), J. Manthey (LaRC), J. Morrison (LaRC), M. Macaraeg (LaRC), R. A. Nicolaides (CMU), S. Sarkar (UCSD), J. Seiner (LaRC), C. W. Shu (Brown U.), C. G. Speziale, deceased, (Boston U.), B. van Leer (U. Michigan), J. van Rosendale (NSF), S. L. Woodruff (FSU), T. A. Zang (LaRC)

STUDENTS:
Z. Ding (Florida State University)

POSTDOCS:
P. Rasetarinera and S. Yesilyurt (Florida State University)

01/05/99

Geoffrey Charles Fox

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Education:

B.A. in Mathematics from Cambridge Univ., Cambridge, England (1961-1964)
Ph.D. in Theoretical Physics from Cambridge University (1964-1967)
M.A. from Cambridge University (1968)

Professional Experience:

2000-	Professor of Computer Science, Florida State University
1990-	Professor of Computer Science, Syracuse University
1990-	Professor of Physics, Syracuse University
1990-2000	Director of Northeast Parallel Architectures Center
1979-1990	Professor of Physics, California Inst. of Tech.
1986-1988	Associate Provost for Computing, California Inst. of Tech.
1983-1985	Dean for Educational Computing, California Inst. of Tech.
1981-1983	Executive Officer of Physics, California Inst. of Tech.
1974-1979	Associate Professor of Physics, California Inst. of Tech.
1971-1974	Assistant Professor of Physics, California Inst. of Tech.
1970-1971	Millikan Research Fellow in Theoretical Physics, Caltech
1970	Visiting Scientist (April-May), Brookhaven National Laboratory
1969-1970	Research Fellow at Peterhouse College, Cavendish Lab.,Cambridge
1968-1969	Research Scientist, Lawrence Berkeley Lab., Berkeley, Calif.
1967-1968	Member of School of Natural Science, Inst. for Advanced Study, Princeton, New Jersey

Five Selected Publications

1) Fox, G. C., Messina, P., Williams, R., Parallel Computing Works!, Morgan Kaufmann, San Mateo Ca, 1994.
2) Akarsu E., Fox, G.C., Furmanski W., Haupt T., "WebFlow -- High-level Programming environment and Visual Authoring Toolkit for High Performance Distributed Computing" in Proceedings of SC98, Orlando, November 1998.
3) Erol Akarsu, Geoffrey Fox, Tomasz Haupt, Alexey Kalinichenko, Kang-Seok Kim, Praveen Sheethaalnath, and Choon-Han Youn , "Using Gateway System to Provide a Desktop Access to High Performance Computational Resources", Proceedings of HPDC-8 Conference, Redondo Beach Ca., Aug 3-6, 1999, IEEE Press.
4) Fox G.C., Furmanski W., "Computing on the Web,New Approaches to Parallel Processing,Petaop and Exaop Performance in the Year 2007”, IEEE Internet Computing 1:2,38-46, 1997

Five Selected Publications, continued:

5) Fox G.C., and Podgorny M, "Real Time Training and Integration of Simulation and Planning using the TangoInteractive Collaborative System", in Proceedings of International Test and Evaluation Workshop on High Performance Computing, July 1998, Aberdeen Maryland.

David C. Banks
Associate Professor, Computer Science
Florida State University
Tallahassee, FL 32306
850/644-0183

Education

PhD	Computer Science	UNC Chapel Hill	1993	DEC Visualization Fellowship
MS	Computer Science	UNC Chapel Hill	1988	
MS	Mathematics	UNC Chapel Hill	1987	
BS	Mathematics	Davidson College	1982	National Merit Scholar

Positions

Associate Professor	Florida State University	1999-	*Co-director, Visualization Lab.*
Assistant Professor	Mississippi State University	1995-1999	*NSF CAREER Award. Hearin-Hess Award. ASEE Instructional Award. Hardin Technology Award.*
Post-doc	ICASE (NASA Langley)	1993-1995	*Co-chair, 1995 Symposium on Visualizing Time-Varying Data. ACM SIGGRAPH VROOM demo: visualization in a CAVE.*
3D Graphics Developer	Data General (RTP, NC)	1990-1993	*Implemented commercial graphics libraries (AviEW, PEX).*

Selected Refereed Publications

Kiril Vidimce, John T. Foley, David C. Banks, Yong-Tze Chi, and Taha Mzoghi, "WebTOP: Interactive 3D Optics on the Web," ACM Web3D/VRML 2000 Symposium (to appear), Monterey, California, USA, February 21-24, 2000 .

Chris Weigle and David C. Banks, "Extracting Iso-Valued Features in 4-Dimensional Scalar Fields," IEEE Symposium on Volume Visualization 98, pp. 103-110.

David C. Banks, John T. Foley, Kiril Vidimce, Ming-Hoe Kiu, and Jay Brown, "Interactive 3D Visualization of Optical Phenomena," *IEEE Computer Graphics & Applications*, Vol. 18, No. 4 (July/August 1998), IEEE Computer Society, pp. 66-69.

David C. Banks, "Screen-Parallel Determination of Intersection Curves," *Parallel Computing*, Vol. 23, No. 7 (July 14, 1997), Pergamon Press, pp. 943-952.

David C. Banks, "The ImageSwitcher: A Design for Reducing VR Lag via Parallel

Image Generation," *Computers and Graphics*, Vol. 21, No. 2 (March/April 1997), Pergamon Press, pp. 171-178.

Greg Turk and David C. Banks, "Image-Guided Streamline Placement," Proccedings of SIGGRAPH 96 (New Orleans, LA), Computer Graphics, In Computer Graphics Proceedings, Annual Conference Series, ACM SIGGRAPH, 1996, pp. 453-460.

Chris Weigle and David C. Banks, "Complex-Valued Contour Meshing," Proceedings of IEEE Visualization 96 (San Francisco, CA), pp. 173-180.

David C. Banks and Bart A. Singer, "Vortex Visualization of an Unsteady Flow." *IEEE Transactions on Visualization and Computer Graphics*, Vol. 1, No. 2 (July 1995), pp. 151-163.

David C. Banks, "Illumination in Diverse Codimensions," Proceedings of SIGGRAPH 94 (Orlando, Florida, July 24-29, 1994). In Computer Graphics Proceedings, Annual Conference Series, ACM SIGGRAPH, 1994, pp. 327-334.

David C. Banks, "Interaction and Manipulation of Two-Dimensional Surfaces in Four-Dimensional Space." 1992 Symposium on Interactive 3D Graphics (Providence, RI), pp. 197-207.

Additional Collaborators
John Foley, Bernd Hamann, Dinesh Manocha, Robert Moorhead, Raghu Machiraju, Matthew Haines, Tyler Jarvis, Ioana Banicescu, Lois Boggess, Julian Boggess, Susan Bridges, Bradley Carter, Donald Dearholt, Anthony Skjellum, Greg Turk.

Graduate Students Advised
PhD: Po-Yu Tsai. Masters: Paul Brewster, Shannon Booth, Viktor Miladinov, Lance Burton, Warren Couvillion, Chris Weigle.

Graduate and Postdoctoral Advisors
Yousuff Houssaini (Post-doc), Stephen Pizer (PhD), Ladnor Geissinger (MS).

WILLIAM KURT DEWAR

A. Vitae

PERSONAL

Date of Birth: May 10, 1955
Citizenship: US
Social Security #: 283-50-2999

EDUCATIONAL BACKGROUND

1983 Ph.D. in Physical Oceanography, the Massachusetts Institute of Technology - Woods Hole Oceanographic Institution Joint Program in Oceanography

1980 M.S. in Physical Oceanography, the Massachusetts Institute of Technology

1977 B.S. in Physics, Minor in Mathematics, the Ohio State University

PROFESSIONAL EXPERIENCE

August 1995 - Present: Professor, Department of Oceanography, Geophysical Fluid Dynamics Institute and Supercomputer Computations Research Institute, Florida State University, Tallahassee, Florida.

August 1990 - August 1995: Associate Professor, Department of Oceanography, Geophysical Fluid Dynamics Institute and Supercomputer Computations Research Institute, Florida State University, Tallahassee, Florida.

December 1985 - August 1990: Assistant Professor, Department of Oceanography, Geophysical Fluid Dynamics Institute and Supercomputer Computations Research Institute, Florida State University, Tallahassee, Florida.

Jan. 1, 1985 - Dec. 31, 1985: Assistant Professor, Research Faculty, the University of North Carolina, Chapel Hill, North Carolina.

1983 - 1984: Postdoctoral Research Associate, the University of North Carolina, Curriculum in Marine Sciences, Chapel Hill, NC.

B. Publications

Related to Proposal

Dewar, W.K., On the potential vorticity structure of weakly ventilated isopycnals: A theory of subtropical mode water maintenance, ***Journal of Physical Oceanography, 16,*** 1986, 1204-1216.

Dewar, W.K., Topography and barotropic transport control by bottom friction, ***Journal of Marine Research*,** in press.

Dewar, W.K., On "too-fast" baroclinic planetary waves in the general circulation, ***Journal of Physical Oceanography*,** in press.

Miranda, A., B. Barnier and W.K. Dewar, On the dynamics of the Zapiola Anticyclone, ***Journal of Geophysical Research***, submitted.

McDougall, T.J. and W.K. Dewar, Vertical mixing, cabbeling and thermobaricity in layered models, ***Journal of Physical Oceanography***, in press.

Other

Dewar, W.K., Spontaneous shocks, ***Journal of Physical Oceanography***, ***22***, 1992, 505-522.

Dewar, W.K. and T.J. McDougall, On the solution of one dimensional advection-diffusion equation in layered coordinates, ***Journal of Physical Oceanography***, submitted.

Miranda, A., B. Barnier and W.K. Dewar, Mode waters and subduction rates in a high-resolution South Atlantic simulation, ***Journal of Marine Research***, submitted.

Dewar, W.K., Y. Hsueh, T.J. McDougall and D. Yuan, Calculation of pressure in ocean simulations, ***Journal of Physical Oceanography***, 28, 1998, 577-588.

Kravtsov, S. and W.K. Dewar, Sea ice and climate. Part I: Model formulation and steady states, ***Journal of Climate***, submitted.

C. List of Collaborators

Dr. E. Chassignet, University of Miami
Dr. J. Elsner, FSU
Dr. Y.M. Hussaini, FSU
Dr. R. Krishnamurti, FSU
Dr. S.P. Meacham, FSU
Dr. T. McDougall, CSIRO
Dr. D. Nof, FSU
Dr. J.J. O'Brien, FSU
Dr. E. Smith, FSU
Dr. D. Yuan, FSU

D. Graduate Students

Ms. Huan Meng, M.S. student. (Degree received August, 1993)
Major Advisor for Ms. Katharine White M.S. student; Mr. Sergei Kravtsov; Ph.D. student and Mr. Sebastian Bigorre, Ph. D. student. (currently enrolled)

Total Number of Graduate Students Advised: 6

E. Graduate and postdoctoral advisors:

Prof. John Bane
University of North Carolina
Chapel Hill, NC 27514

Prof. Glenn Flierl
MIT 54-1712
Cambridge, MA 02139

Gordon Erlebacher

- Program in Computational Science & Engineering,
- Florida State University, Tallahassee 32306-4120
- Tel. (904) 644-7196
- E-mail: erlebach@cse.fsu.edu

Education:

B.Sc., Free University of Brussels: 1974-1978
M.Sc., Free University of Brussels, 1979
Ph.D, Columbia University, 1979-1983

Experience:

1996-present, Program in Computational Science & Engineering, FSU

- Associate Professor, Department of Mathematics
- Associate Editor ASME Journal of Fluids Engineering

1989-1996, Institute for Computer Applications in Science and Engineering

- Physics of compressible isotropic and homogeneous shear flow turbulence (theory and direct simulations)
- Physics of shock/vortex interaction
- Parallelization of DNS turbulence codes on Paragon, SP-1, KSR, CRAY, and CM-5

1983-1989, NASA Langley Research Center

- Direct numerical simulations of supersonic transition and elucidation of physical mechanisms.
- Developed advanced flow visualization software tools on local workstations and remote supercomputing systems. Made use of distributed computing concepts. Applications to transition and turbulence diagnostics.

Awards:

- 1993 NASA Achievement Award for work on Parallelization of Transition code on Flex-32
- 1994 ICASE Fluid Mechanics Group Achievement Award presented by NASA Langley Research Center
- 1996 ICASE Milton E. Rose Research Fellow Award

Professional Societies:

- Member of the American Physical Society
- Member of the American Institute of Aeronautics & Astonautics
- Member of Society of Industrial and Applied Mathematics.

Books Edited:

- Wavelets: Numerical Methods and Applications, (Shortcourse). Eds.: G. Erlebacher, M.Y. Hussaini, L. Jameson. Oxford University Press, 1994.

Collaborators

K. Gallivan and S. L. Woodruff (Florida State University), R. Rubinstein (ICASE), C. W. Shu (Brown), R. D. Joslin (NASA Langley), M. D. Gunzburger (Iowa State University), R. A. Nicolaides (Carnegie-Mellon), S. A. Berger (Berkeley), M. M. Rai (NASA Ames), T. B. Gatski (NASA Langley)

Graduate Students and Postdoctoral Scholars

None

Relevant Publications:

Erlebacher, G.; Bokhari, S.; and Hussaini, M.Y.: "Parallelization of a Three-Dimensional Compressible Transition Code." AIAA Journal, Vol. 28, No. 1, 1990.

Erlebacher, G.; and Sarkar, S.: Statistical Analysis of the Rate of Strain Tensor in Compressible Homogeneous Turbulence. Phys. Fluids A, No. 5(12), (1994).

Eidson, T.M.; and Erlebacher, G.: "Implementation of a Fully-balanced Periodic Tridiagonal Solver on a Parallel Distributed Memory Architecture. ICASE Rept. 94-37. *Concurrency Practices & Experience* **7**, No 4, 273-302, (1995).

Joslin, R.D., Gunzburger, M.D., Nicolaides, R.A., Erlebacher, G., Hussaini, M.Y.: "A Self-Contained, Automated Methodology for Optimal Flow Control Validated for Transition Delay," ICASE Report 95-64, 1995. Accepted AIAA Journal.

Rubinstein, R., and Erlebacher, G.: Transport Coefficients in Weakly Compressible Turbulence. ICASE Report No. 96-52. Submitted *Phys. Fluids* **9**, No. 10, 1997, 3037–3057.

David Jon Furbish

Correspondence

Department of Geological Sciences
Florida State University
Tallahassee, Florida 32306-4100
(850)644-5892 (Phone)
(850)644-4214 (Fax)
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Degrees

Ph.D. (1985) University of Colorado, Boulder; Department of Geological Sciences and Institute of Arctic and Alpine Research.
M.S. (1981) California State University, Humboldt; Department of Watershed Management.
B.S. (1978) University of North Carolina, Chapel Hill; Department of Geology.

Positions at Florida State University

Director (1999-present) Computational Hydrology/Surface Processes Program, School of Computational Science and Information Technology
Professor (1997-present); Chair (1998-01) Department of Geological Sciences.
Associate (1990-present) Geophysical Fluid Dynamics Institute.
Associate Professor (1992-97) Department of Geological Sciences.
Assistant Professor (1987-92) Department of Geological Sciences.

Five Relevant Publications

Byrd, T.C., Furbish, D.J. and Warburton, J. 1999. Estimating depth-averaged velocities in rough channels. *Earth Surface Processes and Landforms*, 24. (*in press*)
Byrd, T.C. and Furbish, D.J. 1999. Magnitude of deviatoric terms in vertically-averaged flow equations. *Earth Surface Processes and Landforms*, 24. (*in press*)
Furbish, D.J. 1998. Irregular bed forms in steep, rough channels: 1. Stability analysis. *Water Resources Research*, 34, 3635-3648.
Furbish, D.J., Thorne, S.D., Byrd, T.C., Warburton, J., Cudney, J.J. and Handel, R.W. 1998. Irregular bed forms in steep, rough channels: 2. Field observations. *Water Resources Research*, 34, 3649-3659.
Furbish, D.J. 1997. *Fluid physics in geology: An introduction to fluid motions on Earth's surface and within its crust*. New York: Oxford University Press, 476 pp.

Research Collaborators

Anthony Arnold
William Dietrich
Sergio Fagherazzi
Peter Haff
M. Yousuff Hussaini
David Loper
Stephen Thorne
Jeff Warburton

Recent Graduate Students

- Tracy Byrd
- Rick Copeland
- Joseph Cudney
- William Evans
- Robert Handel
- Aaron Mango
- William Pendexter
- Nikki Strong
- Hongbing Sun
- Stephen Thorne
- Christopher Werner

Total Students

M.S. students: 12 (3 current)
Ph.D. students: 4

Graduate Advisors

T.Nelson Caine
Raymond Rice

Biographical Sketch: Kyle A. Gallivan

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Florida State University - Tallahassee, Florida 32306-4120
Telephone (850) 645-0306, FAX (850) 645-0300
E-mail: gallivan@cse.fsu.edu

EDUCATION:

* Ph.D., Computer Science; 1983, University of Ilinois, Urbana, Illinois
* M.S., Computer Science; 1981, University of Ilinois, Urbana, Illinois
* B.A., Mathematics and Computer Science with high honors; 1979, Lewis University, Romeoville, Illinois

FIVE RELATED PUBLICATIONS

1. "The Interactive Restructuring of MATLAB Programs Using the FALCON Environment," B. Marsolf, K. Gallivan, and E. Gallopoulos, In: Innovative Architecture for Future Generation High-Performance Processors and Systems, A. Veidenbaum and K. Joe, Eds., IEEE Computer Society Press, 1998, pp. 3--12.

2. "A Rational Lanczos Algorithm for Model Reduction," K. A. Gallivan, E. Grimme, and P. Van Dooren, Numerical Algorithms, Vol. 12, pp. 33--63, 1996.

3. "Model reduction of large-scale systems: rational Krylov versus balancing techniques," K. A. Gallivan and P. Van Dooren, In: Error Control and Adaptivity in Scientific Computing, Kluwer, Amsterdam, 1999, pp. 177--190.

4. "Rational approximations of prefiltered transfer functions via the Lanczos algorithm," K. A. Gallivan and P. Van Dooren, Numerical Algorithms. In press.

5. "A Method for Generating Rational Interpolant Reduced Order Models of Two Parameter Systems," D. S. Weile and E. Michielssen and E. Grimme and K. Gallivan. Applied Mathematics Letters. Vol. 12, pp. 93--102, 1999.

Curriculum Vita
Tiruvalam N. Krishnamurti

(Revised March, 1999)

U.S. citizen

Professor, Department of Meteorology, The Florida State University, Tallahassee, FL. 32306-4520

Telephone: (850) 644-2210 FAX: (850) 644-9642 E-mail: tnk@met.fsu.edu

Recognition & Awards:

Professorial Excellence Program Award, Florida State University, April 1997

International Meteorological Organization Prize, June 1996. Awarded by the World Meteorological Organization. The award is the most prestigious international award in the field of meteorology and includes a gold medal, certificate and cash award.

Director NOAA/FSU Cooperative Institute of Tropical Meteorology (CITM).

Science Team Member NASA TRACE'A' (Transport and Atmospheric Chemistry Near the Equator - Atlantic) (1992 - continuing)

Science Team Member NASA LAWS (Laser Atmospheric Wind Sounder) (1991 -continuing)

Science Team Member NASA TRMM (Tropical Rainfall Measurement Mission) (1991 - continuing)

Co-Chief Editor, Monthly Weather Review (1991-1994)

Member National Academy Board on Atmosphere and Climate (1989 - 1991)

Member UCAR climate advisory (CCM) (1983 - 1987)

Florida Scientist of the Year Award (1986)

Robert O. Lawton Distinguished Professor Award (1985). The highest honor the University can confer upon its faculty.

Carl Gustaf Rossby Research Medal (1985). The highest award of the American Meteorological Society.

Program Chairman FGGE Tropics seminar WMO (1983)

Fellow: Royal Meteorological Society and American Meteorological Society.

Councilor, American Meteorological Society, 1979-1982

Creativity Awards (1981). The National Science Foundation selected my group for a creativity award in the amount of $400,000 towards our research during 1981-1983. This was the first time this award was offered in Atmospheric Sciences and the only award made during 1981.

Publications:

1999: (with Zhang, Z.) Adaptive observations for hurricane predictions. Submitted to *Tellus*.

1999: (with D. Bachiochi) Enhanced low-level stratus in the FSU coupled ocean-atmosphere model. Submitted to *Journal of Climate*.

1999: (with D. Bachiochi, T. LaRow, B. Jha, M. Tewari, D. Chakraborty, R. Correa-Torres, and D. Oosterhof). Coupled Atmosphere-Ocean Modeling of the El-Niño of 1997-98. Accepted for publication, *Journal of Climate*.

1999: (with C.M. Kishtawal). A pronounced continental scale diurnal mode of the Asian summer monsoon. Accepted for publication, *Monthly Weather Review*.

1999: (with D.W. Shin) Improving precipitation forecasts over the global tropical belt. Accepted for publication, *Meteorology and Atmospheric Physics*.

1999: (with B. Jha) Diabatic effects on potential vorticity over the global tropics. Accepted for publication, *Monthly Weather Review*.

1999: (with B. Jha) A note on resolution dependence for monsoon rainfall forecasts. Accepted for publication, *J. Climate*.

1999: (with Zhang, Z.) A perturbation method for hurricane ensemble predictions. *Monthly Weather Review*, February issue.

1999: (with M. Tewari, D.R. Chakraborty, J. Marengo, P.S. Dias and P. Satyamurty). Downstream Amplification: A possible precursor to major freeze events over Southeastern Brazil, *Weather and Forecasting*, February issue.

1998: (with H.S. Bedi and V. Hardiker). Introduction to Global Spectral Modeling, Oxford University Press, New York, 253 pp. Textbook.

1998: (with Zhang, Z.) On Ensemble Forecasting of Hurricane Tracks, *Bull. Amer. Meteor. Soc.* **78**, 2785-2796.

1998: (with W. Han, B. Jha and H.S. Bedi). Numerical Prediction of Hurricane Opal. *Monthly Weather Review* **126,** 1347-1363**.**

1998: (with B. Jha, J.M. Prospero, A. Jayaraman and V. Ramanathan). Aerosol and pollutant transport over the tropical Indian Ocean during the January-February 1996 pre-INDOEX cruise, *Tellus* **50B**, 521-542.

1998: (with M.C. Sinha, B. Jha and U.C. Mohanty). A study of south Asian monsoon energetics. *J. Atmos. Sci.* **55**, 2530-2548.

1998: (with R.C. Torres, M. Latif and G. Daughenbaugh). The impact of current and possible future sea surface temperature anomalies on the fequency of Atlantic hurricanes. *Tellus* **50A**, 186-210.

1998: (with LaRow, T.E.). Seasonal Prediction using a Coupled Ocean- Atmospheric Model with Data Assimilation, *Tellus* **50A,** 76-94.

1998: (with Mohalfi, Saad, H.S. Bedi and S. Cocke). Sensitivity of Synoptic Systems and Diurnal Change to Dust Aerosols over the Region of Saudi Arabia, *Monthly Weather Review*, **126**, 3153-3168.

1998: (with W. Han and D. Oosterhof). Sensitivity of Hurricane Intensity Forecasts to Physical Initialization, *Meteorology and Atmospheric Physics* **65**, 171-181.

1998: (with Williford, C.E. and R.C. Torres). A Note on Tropical Cyclone Forecasts Made with the FSU Global Spectral Model. *Monthly Weather Review* **126**, 1332-1336.

1998: (with H.S. Bedi and W. Han). Organization of Convection and Monsoon Forecasting. *Meteorology and Atmospheric Physics*, **67**, 117-134.

Short Biography of

JAMES J. O'BRIEN

PRESENT POSITION: Secretary of Navy Professor in Meteorology and Oceanography
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DEGREES: Texas A&M University, Ph.D., Meteorology, 1966
Texas A&M University, MS., Meteorology, 1964
Rutgers University, BS., Chemistry, 1957

HONORARY AND PROFESSIONAL SOCIETIES:

AAAS, AGU, AMS, RMS, OSJ, SIAM, SX

HONORS: Medal of Honor, Liege University, Belgium, 1978
Fellow, American Meteorological Society, 1981
Fellow, Royal Meteorological Society, 1983
Secretary of Navy Professor in Oceanography, 1985
Sverdrup Gold Medal in Air-Sea Interaction, 1987
ONR Distinguished Ocean Educator, 1989
Fellow, American Geophysical Union, 1987
Fellow, AAAS, 1998
Distinguished Research Professor, FSU, 1991
Foreign Fellow, Russian Academy of Natural Science, 1994
Medal of Honor, Ocean University of Quindao, China, 1999

RECENT PROFESSIONAL AND SERVICE ACTIVITIES:

State of Florida Climatologist, 1999-
Robert O. Lawton Distinguished Professor, FSU, 1999
Florida Commission on Hurricane Loss Projection Methodology, 1999-
International Climate Institute, Modelling Advisory Committee, 1998 -
NASULGC, Chair, Board on Oceans and Atmospheres, 1997-1999
AAAS, President, Atmospheric and Hydrological Science, 1995 - 1998
NASA GSFC Advisory Panel for Data Assimilation Office, 1992 -
Board of Advisors, Naval Postgraduate School, CA, 1990 - 1995
NAS, Board on Atmospheric Sciences and Climate, Member, 1989 -1993
NAS, Ocean Studies Board, Member, 1988 -1991
NAS, Committee on Ocean's Role in Global Change, Chairman, 1989 - 1991
NAS, Committee on International Ocean Affairs, Member, 1989 -1991
Editor, *Journal of Geophysical Research: Oceans*, 1984 - 1988, 1988 - 1990
IAPSO, President, 1987 - 1991
Associate Editor, *Monthly Weather Review*, 1992 - 1998
Associate Editor, *Continental Shelf Research*, 1986 - 1998
Associate Editor, *International J. Math and Computer Modeling*, 1984 -
President, Oceanography Section, American Geophysical Union (AGU), 1980-1982

PH.D. STUDENTS

1. Dr. Jacob Padro
2. Dr. John Lee
3. Dr. Harley Hurlburt
4. Dr. J. Dana Thompson
5. Dr. John Kindle
6. Dr. Joseph Wroblewski
7. Dr. Richard Grotjahn
8. Dr. B. Cushman-Rosin
9. Dr. George Hepburn
10. Dr. Alex Camerengo
11. Dr. Antonio J. Busalacchi
12. Dr. Richard Rood
13. Dr. Sirpa Hakkinen
14. Dr. Ruth Preller
15. Dr. Germana Peggion
16. Dr. Bernard Barnier
17. Dr. Alejandro Pares-Sierra
18. Dr. Ole Martin Smedstad
19. Dr. Tommy Jensen
20. Dr. John McCalpin
21. Dr. Jiayan Yang
22. Dr. David Legler
23. Dr. Brian Kelly
24. Dr. Lisan Yu
25. Dr. Jay Shriver
26. Dr. Ming Liu
27. Dr. Mark Verschell
28. Dr. Rodrigo Nuñez
29. Dr. Steve Morey

TEN RELEVANT SCIENTIFIC PUBLICATIONS (Total over 115)

1994 Kamachi, M., and J.J. O'Brien. **Continuous data assimilation of drifting buoy trajectory into an equatorial Pacific Ocean model.** ***J.of Marine Sys., 6,*** **pp. 159 - 178.**

1995 Adams, R. A., K.H. Bryant, B.A. Mc Carl, D. Legler, A.Solow and R. Weiher, and J.J. O'Brien. **The value of improved long-range weather information: Southeastern U.S. ENSO forecasts as they influence U.S. agriculture.** ***Contemporary Economic Policy, 13,*** **pp. 10 - 19.**

1995 Jones, C.S., D.M. Legler and J.J. O'Brien. **Variability of surface fluxes over the Indian Ocean: 1960-1989.** ***The Global Atmos.and Ocean Sys., 3,*** **pp. 249 - 272.**

1995 Shriver, J.F., and J.J. O'Brien. **Low frequency variability of the equatorial Pacific Ocean using a new pseudo-stress data set: 1930-1989.** ***J.Clim.8 (11).***

1995 L. Yu, and J.J. O'Brien. **Variational data assimilation for determining the seasonal net surface heat flux using a tropical Pacific Ocean model.** ***J. Phys. Oceanogr., 25 (10),*** **pp. 2,319 - 2,343.**

1996 Meyers, S.D., M.A. Johnson, M. Liu and J.L. Spiesberger, and J.J. O'Brien. **Interdecadal variability in a numerical model of the Northeast Pacific Ocean: 1970.** ***J.of Phys. Oceanogr., 26,*** **pp. 2,635 - 2,652.**

1996 Richards, T. and J.J. O'Brien. **The effect of El Niño on U.S. landfalling hurricanes.** ***Bull. Amer. Meteorol. Soc.,*** **pp. 77,773 - 77,774.**

1998 Bourassa, M.A., D.M. Legler, and J.J. O'Brien. **The use of significant wave height to improve the accuracy of wind derived stress and wave characteristics.** ***J. Atmos. Sci.***, (in press).

1998 Legler, D.M., K.G. Bryant, and J.J. O'Brien. **Impact of ENSO related climate anomalies on crop yields in the U.S**., *Climatic Change,* **42 (2), pp. 351-375.**

1998 Siefridt, L., B. Barnier, D. M. Legler, and J.J. O'Brien. **5-day average winds over the North-West Atlantic from ERS1 using a variational analysis.** ***The Global Atmos. and Ocean Sys.5,*** **pp. 317 - 344.**

Biographical Sketch

Hans J. Schneider-Muntau

BIOGRAPHICAL INFORMATION

Address: National High Magnetic Field laboratory
Florida State University
1800 E. Paul Dirac Drive
Tallahassee, FL 32310

Telephone: 850-644-0863
FAX: 850-644-9462
Citizenship: Germany
Permanent Resident: USA

EDUCATION

Ph.D., Electrical Engineering, University of Munich, Munich, GERMANY (1967)
M.S., Electrical Engineering, University of Stuttgart, Stuttgart, GERMANY (1962)
B.S., Electrical Engineering, University of Stuttgart, Stuttgart, GERMANY (1958)

RESEARCH INTERESTS

Advancement of magnet technology and magnet materials; development of state-of-the-art magnet systems; laboratory management; industrial application of high magnetic fields; multi-institutional and international cooperation.

PROFESSIONAL EXPERIENCE

Deputy Director of the National High Magnetic Field Laboratory, and Professor of Mechanical Engineering, College of Engineering, Florida State University/Florida A&M University, Tallahassee, Florida (1991-Present)

Director, Magnet Science & Technology Department, National High Magnetic Field Laboratory, and Professor of Mechanical Engineering, College of Engineering, Florida State University/Florida A&M University, Tallahassee, Florida (1991-1997)

Chief Engineer, High-Field Magnet-Laboratory, Grenoble, FRANCE, Max-Planck-Institut für Festkörperforschung, Stuttgart, GERMANY (1972-1991)

Head of Development Laboratory, European Space Research Institute, Frascati, Italy (1967-1972)

Scientist, Institut für Plasmaphysik, Garching, Max-Planck-Gesellschaft, Munich, Germany (1962-1967)

PROFESSIONAL HONORS

Fellow, American Physical Society (1998)

RECENT PROFESSIONAL ACTIVITIES

Chair, 16th International Conference on Magnet Technology, National High Magnetic Field Laboratory (NHMFL), Tallahassee, FL (1998-1999)
Chair, VIIIth International Conference on Megagauss Magnetic Field Generation and Related Topics, National High Magnetic Field Laboratory (NHMFL), Tallahassee, FL (1997-1998)
Chair, International Workshop on High Magnetic Fields; Industry, Materials and Technology, National High Magnetic Field Laboratory (NHMFL), Tallahassee, FL (1996)

TOTAL NUMBER OF INVITED PRESENTATIONS AND PUBLICATIONS: In excess of 100

PUBLICATIONS

1. Vaghar, M., Wirth, S., Neu, V., Xiong, P., von Molnár, S., L. Li, and Schneider-Muntau, H., "Feasibility of Micro-Coils" to be published in Proceedings of Megagauss Conference, NHMFL, Tallahassee, FL, Oct. 18-23, 1998.
2. B., Gao, Schneider-Muntau, H., Pernambuco-Wise, P., Eyssa, y., "Mechanical analysis of poly-layer reinforcement schemes for pulse magnets," Physica B: Condensed Matter, 246-247, p. 341-45, May 1998.
3. Pernambuco-Wise, P., Lesch, B., Schneider-Muntau, H., Intrator, T., Fonck, R., Winz, G., "Wisconsin Pegasus Solenoid," Physica B: Condensed Matter, 246-247, p. 350-52, May 1998.
4. Pernambuco-Wise, P., Lesch, B., Schneider-Muntau, H., "Systematic failure testing of carbon composite reinforced pulse magnets," Physica B: Condensed Matter, 246-247, p.346-49, May 1998.
5. Schneider-Muntau, H., "High Field NMR Magnets," Magnetic Resonance, 9, 1, p. 61-71, Nov. 1997.
6. Sakai, Y., Schneider-Muntau, H., "Ultra-high strength, high conductivity Cu-Ag allow wires," Acta Materialia, 45, 3, pp 1017-1023, Pergamon Press, Great Britain, Mar. 1997.

7. Eyssa, Y., Schneider-Muntau, H., Pernambuco-Wise, P., Van Cleemput, M., and Jones, H., "Comparative analysis of micro-composite and macro-composite conductors for pulse magnets," IEEE Transactions on Magnetics, 32, 4, p. 2462-2465, July 1996.
8. Hascicek, Y., Pernambuco-Wise, P., Mignosi, C., Schneider-Muntau, H., Fellers, T., "Microstructure of wound conductors for high field pulsed magnets," IEEE Transactions on Magnetics, 32, 4, pt. 1, p. 2530-2533, July 1996.
9. Markiewicz, W., Dixon, I., Eyes, y., Schwartz, J., Swenson, C., Van Sciver, S., Schneider-Muntau, H., "25 T high resolution NMR magnet program and technology," IEEE Transactions on Magnetics, 32, 4, pt. 1, p. 2586-2589, July 1996.
10. Van Cleemput, M., Jones, H., van der Burgt, M., Barrau, J., Lee, J., Eyssa, Y., Schneider-Muntau, H., "Copper/Stainless steel conductor for high field pulsed magnets," Physica B, Condensed Matter, 216, 3-4, 226-229, Elsevier Science B.V., Jan. 1996

Christopher K.W. Tam

Address

Department of Mathematics
Florida State University
Tallahassee, FL 32306-4510
Phone: (850) 644-2455, Fax (850) 644-4053, Email tam@math.fsu.edu

Education

1962 B. Eng., McGill University, Canada
1963 M. Sc., California Institute of Technology
1966 Ph.D., California Institute of Technology

Academic Positions

Research Fellow, California Institute of Technology, 1966–1967
Assistant Professor, Massachusetts Institute of Technology, 1967–1971
Associate Professor, Florida State University, 1971–1976
Professor of Mathematics, Florida State University, 1976–present
Distinguished Research Professor of Mathematics, 1991– present

Scientific and Professional Societies

Fellow, the American Physical Society
Fellow, the Acoustical Society of America
Associate Fellow, the American Institute of Aeronautics and Astronautics
Member, the Society for Industrial and Applied Mathematics

Awards

Lockheed Aircraft Company Disclosure of Invention Award, 1981
NASA Technology Utilization and Application Office Award, 1982
AIAA Space Shuttle Flag Plaque Award (The American Institute of Aeronautics and Astronautics), 1984
AIAA Aeroacoustics Award (The American Institute of Aeronautics and Astronautics), 1987
Florida State University Distinguished Research Professor Award, 1991
Arnold Engineering Development Center Technical Achievement Award and the AEDC Annual Technology Achievement Award, 1993

Journal Editorial Board

Journal of Computational Acoustics

PUBLICATIONS

1. A study of the short wave components in computational acoustics (with J.C. Webb and Z. Dong), Journal of Computational Acoustics, **1**, 1–30, 1993.
2. Dispersion-Relation-Preserving finite difference scheme for computational acoustics (with J.C. Webb), Journal of Computational Physics, **107**, 262–281, 1993.
3. Wall boundary conditions for high order finite difference schemes in computational aeroacoustics (with Z. Dong). Journal of Theoretical and Computational Fluid Dynamics, **6**, 303–322, 1994.
4. Supersonic jet noise, Annual Review of Fluid Mech., **27**, 17–43, 1995.
5. Computational Aeroacoustics: Issues and Methods, AIAA Journal, **33**, 1788–1796, 1995.
6. Radiation and outflow boundary conditions for direct computation of acoustic and flow disturbances in a nonuniform mean flow (with Z. Dong), Journal of Computational Acoustics, **4**, 175–202, 1996.
7. Screech tones of supersonic jets from bevelled rectangular nozzles (with H. Shen and G. Raman), AIAA Journal, **35**. 1119–1125, 1997.
8. Jet noise: Since 1952, Theoretical and Computational Fluid Dynamics, **10**, 393–405, 1998.
9. Nonhomogeneous radiation and outflow boundary conditions simulating incoming acoustic and vorticity waves for exterior computational aeroacoustics problems (with J. Fang and K.A. Kurbatskii), International Journal for Numerical Methods in Fluids, **26**, 1107–1123, 1998.
10. Perfectly matched layer as an absorbing boundary condition for the linearized Euler equations in open and ducted domains (with L. Auriault and F. Cambuli), Journal of Computational Physics, **144**, 213–234, 1998.

COLLABORATORS SINCE 1993

T. Norum (LaRC), J.M. Seiner (LaRC), K.K. Ahuja (GTRI), R.R. Jones (AEDC), N.N. Reddy (LMAS), G. Raman (LeRC), K. Zaman (LeRC), F. Cambuli (Univ. Cagliari, Italy)

STUDENTS (1993–present)

J.C. Webb, Z. Du, Z. Dong, A.T. Thies, K.A. Kurbatskii, H. Shen, L. Auriault. (Total number of Ph.D. students advised: 12)

POSTDOCS

Drs. K.A. Kurbatskii, H. Shen

BEN WANG, PH.D.

Education

Ph.D. Industrial Engineering, Pennsylvania State University, 1986
M.S. Industrial Engineering, Pennsylvania State University, 1985
B. S. Industrial Engineering, Tunghai University, 1976

Professional Experience

8/93-present US DOE Massie Chair and Chairman, Ind. Engg., FAMU-FSU College of Engineering
8/90-7/93 Associate Professor, Ind. Engg., University of Iowa
1/87-7/90 Assistant Professor, Ind. Engg., State University of New York at Buffalo

Honors and Awards

1993 Tau Beta Pi Outstanding Professor Award
1992 Institute of Ind. Engr. (IIE) Joint Publishers Book-of-the-Year Award
1992 Society of Mfg. Engr. (SME) Eugene Merchant Manufacturing Textbook Award
1991 The University of Iowa Old Gold Iowa Research Award
1990 Society of Mfg. Engr. (SME) Outstanding Young Manufacturing Engineer Award
1989 Third Prize Winner of Shingo Award for Manufacturing Excellence
1987 Improvement of Undergraduate Education Award, New York

Publication Summary

80 Journal Papers 5 Books 15 Book Chapters 45 Conference Papers

Mailing Address

Department of Industrial Engineering
FAMU-FSU College of Engineering
2525 Pottsdamer St.
Tallahassee, FL 32310-6046
Tel: (850) 410-6339; Fax: (850) 410-6342; Email: indwang1@eng.fsu.edu

Funded Research Summary

$4,500,000 in the past eight years

Graduate Student Supervision Summary

11 PhD's 30 MS's

Other Professional Experience

Editorial board member of six journals in design and manufacturing

Editor of three special issues on IPPD, CAPP, CIM and predictive maintenance

Paper referee for more than 25 technical journals

Three U.S. patents

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Florida State University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Mohammed Y Hussaini**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Mohammed Y Hussaini - PI	0.00	0.00	0.00	$ 0	$
2. David Banks	0.00	0.00	0.00	0	
3. William Dewar	0.00	0.00	0.00	0	
4. Gordon Erlebacher	0.00	0.00	0.00	0	
5. Geoffrey C Fox - Co-PI	0.00	0.00	0.00	0	
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Scable Cluster Machine (SCM) $ 400,000					
TOTAL EQUIPMENT				400,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
(0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				400,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 46.5000, Base: 0)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				400,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 400,000	$

M. COST SHARING PROPOSED LEVEL $ 350,000	AGREED LEVEL IF DIFFERENT $	
PI / PD TYPED NAME & SIGNATURE* **Mohammed Y Hussaini**	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date Of Rate Sheet / Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Furbish, David -	**0.00**	**0.00**	**0.00**	**0**
Gallivan, Kyle -	**0.00**	**0.00**	**0.00**	**0**
Krishnamurti, T N -	**0.00**	**0.00**	**0.00**	**0**
O'Brien, James -	**0.00**	**0.00**	**0.00**	**0**
Schneider-Muntau, Hans -	**0.00**	**0.00**	**0.00**	**0**
Tam, Christopher -	**0.00**	**0.00**	**0.00**	**0**
Wang, Ben -	**0.00**	**0.00**	**0.00**	**0**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Florida State University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Mohammed Y Hussaini**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Mohammed Y Hussaini - PI**	0.00	0.00	0.00	$ 0	$
2. **David Banks**	0.00	0.00	0.00	0	
3. **William Dewar**	0.00	0.00	0.00	0	
4. **Gordon Erlebacher**	0.00	0.00	0.00	0	
5. **Geoffrey C Fox - Co-PI**	0.00	0.00	0.00	0	
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Experimental Parallel Machine(EPM)** $ 400,000					
TOTAL EQUIPMENT				400,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
(0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				400,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **% of MTDC (Rate: 46.5000, Base: 0)**					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				400,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 400,000	$

M. COST SHARING PROPOSED LEVEL $ 350,000	AGREED LEVEL IF DIFFERENT $	
PI / PD TYPED NAME & SIGNATURE* **Mohammed Y Hussaini**	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date Of Rate Sheet / Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Furbish, David -	0.00	0.00	0.00	0
Gallivan, Kyle -	0.00	0.00	0.00	0
Krishnamurti, T N -	0.00	0.00	0.00	0
O'Brien, James -	0.00	0.00	0.00	0
Schneider-Muntau, Hans -	0.00	0.00	0.00	0
Tam, Christopher -	0.00	0.00	0.00	0
Wang, Ben -	0.00	0.00	0.00	0

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION: **Florida State University**				FOR NSF USE ONLY		
				PROPOSAL NO.	DURATION (months)	
					Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Mohammed Y Hussaini**				AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Mohammed Y Hussaini - PI	0.00	0.00	0.00	$ 0	$
2. David Banks	0.00	0.00	0.00	0	
3. William Dewar	0.00	0.00	0.00	0	
4. Gordon Erlebacher	0.00	0.00	0.00	0	
5. Geoffrey C Fox - CO-PI	0.00	0.00	0.00	0	
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) SCM Upgrade $ 550,000					
TOTAL EQUIPMENT				550,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
(0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				550,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 46.5000, Base: 0)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				550,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 550,000	$

M. COST SHARING PROPOSED LEVEL $ 150,000	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* Mohammed Y Hussaini	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Furbish, David -	**0.00**	**0.00**	**0.00**	**0**
Gallivan, Kyle -	**0.00**	**0.00**	**0.00**	**0**
Krishnamurti, T N -	**0.00**	**0.00**	**0.00**	**0**
O'Brien, James -	**0.00**	**0.00**	**0.00**	**0**
Schneider-Muntau, Hans -	**0.00**	**0.00**	**0.00**	**0**
Tam, Christopher -	**0.00**	**0.00**	**0.00**	**0**
Wang, Ben -	**0.00**	**0.00**	**0.00**	**0**

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION **Florida State University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Mohammed Y Hussaini**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Mohammed Y Hussaini - PI	0.00	0.00	0.00	$ 0	$	
2. David Banks	0.00	0.00	0.00	0		
3. William Dewar	0.00	0.00	0.00	0		
4. Gordon Erlebacher	0.00	0.00	0.00	0		
5. Geoffrey C Fox - CO-PI	0.00	0.00	0.00	0		
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				0		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) EPM Upgrade $ 500,000						
TOTAL EQUIPMENT				500,000		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
(0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				0		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				0		
H. TOTAL DIRECT COSTS (A THROUGH G)				500,000		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 46.5000, Base: 0)						
TOTAL INDIRECT COSTS (F&A)				0		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				500,000		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 500,000	$	
M. COST SHARING PROPOSED LEVEL $ 150,000	AGREED LEVEL IF DIFFERENT $					

PI / PD TYPED NAME & SIGNATURE* **Mohammed Y Hussaini**	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 4

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Furbish, David -	0.00	0.00	0.00	0
Gallivan, Kyle -	0.00	0.00	0.00	0
Krishnamurti, T N -	0.00	0.00	0.00	0
O'Brien, James -	0.00	0.00	0.00	0
Schneider-Muntau, Hans -	0.00	0.00	0.00	0
Tam, Christopher -	0.00	0.00	0.00	0
Wang, Ben -	0.00	0.00	0.00	0

SUMMARY PROPOSAL BUDGET

YEAR 5

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Florida State University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Mohammed Y Hussaini**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Mohammed Y Hussaini - PI	0.00	0.00	0.00	$ 0	$
2. David Banks	0.00	0.00	0.00	0	
3. William Dewar	0.00	0.00	0.00	0	
4. Gordon Erlebacher	0.00	0.00	0.00	0	
5. Geoffrey C Fox - CO-PI	0.00	0.00	0.00	0	
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Pervasive infrastructure $ 100,000					
TOTAL EQUIPMENT				100,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
(0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				100,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) % of MTDC (Rate: 46.5000, Base: 0)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				100,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 100,000	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Mohammed Y Hussaini		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 5

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Furbish, David -	0.00	0.00	0.00	0
Gallivan, Kyle -	0.00	0.00	0.00	0
Krishnamurti, T N -	0.00	0.00	0.00	0
O’Brien, James -	0.00	0.00	0.00	0
Schneider-Muntau, Hans -	0.00	0.00	0.00	0
Tam, Christopher -	0.00	0.00	0.00	0
Wang, Ben -	0.00	0.00	0.00	0

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: **Florida State University**				FOR NSF USE ONLY	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Mohammed Y Hussaini**				PROPOSAL NO. / AWARD NO.	DURATION (months): Proposed / Granted

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Mohammed Y Hussaini - PI	0.00	0.00	0.00	$ 0	$
2. David Banks	0.00	0.00	0.00	0	
3. William Dewar	0.00	0.00	0.00	0	
4. Gordon Erlebacher	0.00	0.00	0.00	0	
5. Geoffrey C Fox - CO-PI	0.00	0.00	0.00	0	
6. (7) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (12) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 1,950,000					
TOTAL EQUIPMENT				1,950,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				0	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
(0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,950,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,950,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,950,000	$
M. COST SHARING PROPOSED LEVEL $ 1,000,000	AGREED LEVEL IF DIFFERENT $				

PI / PD TYPED NAME & SIGNATURE*: **Mohammed Y Hussaini**	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

Itemized Spreadsheet detailing requested purchases

Cost is in thousands of dollars

	Yr1		Yr2		Yr3		Yr4		Yr5		Total	Total
	NSF	**FSU**	**NSF**	**FSU**	**NSF**	**FSU**	**NSF**	**FSU**	**NSF**	**FSU**	**NSF**	**FSU**
Compute Cluster												
32 cpus 1 Gbyte/cpu	400	200	0	0	400	150	0	0	0	0	800	350
0.5 to 1 Tbyte disk	0	0	0	0	0	0	0	0	0	0	0	0
Total	**400**	**200**	**0**	**0**	**400**	**150**	**0**	**0**	**0**	**0**	**800**	**350**
Managed System												
32 cpus 1 Gbyte/cpu	0	0	400	200	0	0	400	150	0	0	800	350
0.5 to 1 Tbyte disk	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**400**	**200**	**0**	**0**	**400**	**150**	**0**	**0**	**800**	**350**
Information and Pervasive Infrastructure												
Miscellaneous	0	150		150		150		100		100	0	650
(viz,mobile,palm,input devices,	0	0	0	0	0	0	0	0	0	0	0	0
visualization, video servers)	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**150**	**0**	**150**	**150**	**0**	**100**	**0**	**100**	**0**	**350**	**300**
Grand Total (per year)	**400**	**350**	**400**	**350**	**550**	**150**	**500**	**150**	**100**	**0**	**1950**	**1000**

A two year maintenance is negotiated into all prices for the large parallel machines.

Current and Pending Support - Page 1 of 2

Investigator: **M. Y. Hussaini**

Support**: Current (PI)**
Project/Proposal Title: **Prediction of Compressible Jet Flow Fields and Aerodynamic Sound Fields**

Source of Support: **NASA Langley Research Center**
Total Award Amount: $ **434,507** Total Award Period Covered: **05/01/96 - 12/31/99**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: **1.20**

Support**: Current (Co-PI)**
Project/Proposal Title: **Research Collaborative in Materials Research and Education (CIRE)**

Source of Support: **National Science Foundation**
Total Award Amount: $ **1,500,000** Total Award Period Covered: **09/99 - 08/02**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: **.05**

Support**: Current (PI)**
Project/Proposal Title: **Interactive Concurrent Visualization of Unsteady Flows on Parallel Architectures**

Source of Support: **National Science Foundation**
Total Award Amount: $ **291,085** Total Award Period Covered: **01/01/99 - 12/31/01**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: **.05**

Support: **Pending (Co-PI)**
Project/Proposal Title: **Computational and Information Science Laboratory Infrastructure Support**

Source of Support: **Department of Energy**
Total Award Amount: **$26,951,448.** Total Award Period Covered: **01/01/2000-12/31/2005**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: .50

Support: **Pending (PI)**
Project/Proposal Title: **Development and Analysis of Discontinuous Spectral Element Methods for Computational Electrodynamics.**

Source of Support: **Air Force (AFOSR)**
Total Award Amount: **$162,668** Total Award Period Covered: **09/01/99-08/31/02**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: .05

Support: **Pending (PI)**
Project/Proposal Title: **Theoretical, Computational and Experimental Studies of Mass Conservation and Transport in Complex Particle Systems.**

Source of Support: **NSF**
Total Award Amount: **$317,932.** Total Award Period Covered: **06/01/00-05/31/03**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: .05

Investigator: M. Y. Hussaini

Support: **Pending (Co-PI)**
Project/Proposal Title: **Modeling of Karstic Aquifers**
Source of Support: **NSF**
Total Award Amount: **$502,060.** Total Award Period Covered: **07/01/00-06/30/01**
Location of Project: **Florida State University - Tallahassee, Florida**
Person-Months Per Year Committed to the Project. Cal: .05

Updated: 11/29/99

Current and Pending Support - Page 1 of 1

Investigator: **Geoffrey C. Fox**
Support**: Current** Project/Proposal Title: **Education Technology and Science Portals** Source of Support: **University of Illinois (NCSA)** Total Award Amount: $225,000. Location of Project: Florida State University Period covered: 10/01/99 - 09/30/00 Person-Months Per Year Committed to the Project. Cal: **0.25**
Support**: Current** Project/Proposal Title: **Performance Estimation for Large Scale Applications** Source of Support: **University of Maryland** Total Award Amount: $477,312. Period Covered: 10/01/93 - 05/27/00 Location of Project: Syracuse University Person-Months Per Year Committed to the Project. Cal: **0.25**
Support**: Current** Project/Proposal Title: **Programming Models from Fortran to JAVA** Source of Support: **National Science Foundation** Total Award Amount: $346,827. Period Covered: 09/01/98 - 08/31/01 Location of Project: Syracuse University and Florida State University Person-Months Per Year Committed to the Project. Cal: **0.25**
Support**: Current** Project/Proposal Title: **CEWES Computing Modernization** Source of Support: **Nichols Research Corporation** Total Award Amount: $1,735,073. Period Covered: 04/01/96 - 03/17/01 Location of Project: Syracuse University Person-Months Per Year Committed to the Project. Cal: **0.50**
Support**: Current** Project/Proposal Title: **DOD/HPC Modernization** Source of Support: **Nichols Research Corporation** Total Award Amount: $566,734. Period Covered: 07/08/96 - 05/12/01 Location of Project: Syracuse University Person-Months Per Year Committed to the Project. Cal: **0.50**
Support**: Current** Project/Proposal Title: **E-Systems** Source of Support: **Raytheon E-Systems** Total Award Amount: $736,253. Period Covered: 08/20/98 - 08/19/01 Location of Project: Syracuse University Person-Months Per Year Committed to the Project. Cal: **0.25**
Support**: Pending** Project/Proposal Title: **General Earthquake Model Computational Challenge** Source of Support: **NASA JPL** Total Award Amount: $20,000. Period Covered: 05/01/00 - 12/31/00 Location of Project: Florida State University Person-Months Per Year Committed to the Project. Cal: **0.50**

Current and Pending Support - Page 1 of 1

Investigator: **D. Banks**
Support**: current** Project/Proposal Title: **Vector field Visualization with Engineering Applications** Source of Support: **National Science Foundation** Total Award Amount: $200,000 Location of Project: Mississippi State University: Period covered: 06/01/96-05/31/2000 Person-Months Per Year Committed to the Project. Cal:
Support**: Current** Project/Proposal Title: **Learning Optics on the Web: 3D Interactive Graphics, Session Logging, and Collaboration** Source of Support: **National Science Foundation** Total Award Amount: $269,413 Period Covered: 05/16/99 – 05/15/2002 Location of Project: NSF MSU Engineering Research Center Person-Months Per Year Committed to the Project. Cal: 0, Acad: 0.9, Sumr: 1.0
Support**:** Project/Proposal Title: Source of Support: Total Award Amount: Location of Project: Person-Months Per Year Committed to the Project. Cal:
Support**:** Project/Proposal Title: Source of Support: Total Award Amount: Location of Project: Person-Months Per Year Committed to the Project. Cal:

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: W.K. DEWAR	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Thermodynamics in Layered Models

Source of Support: NASA

Total Award Amount: $265,419 Total Award Period Covered: 1/1/99-12/31/2001

Location of Project: FSU

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

s

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project: FSU

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support - Page 1 of 1

Investigator: **G. Erlebacher**
Support**: Current** Project/Proposal Title:**A comparison between a C++ and Java implementation of a scientifically relevant weather modeling code.** Source of Support: **IBM** Total Award Amount: $20,000 Location of Project: Florida State University Period Covered: 08/01/99-08/01/2000 Person-Months Per Year Committed to the Project. Cal: **0**
Support**:** Project/Proposal Title: Source of Support: Total Award Amount: Location of Project: Person-Months Per Year Committed to the Project. Cal:
Support**:** Project/Proposal Title: Source of Support: Total Award Amount: Location of Project: Person-Months Per Year Committed to the Project. Cal:

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: David Jon Furbish

Other agencies (including NSF) to which this proposal has been/will be submit-

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Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Theoretical, computational and experimental studies of mass conservation and transport in complex particle systems

Source of Support: NSF

Total Award Amount: $317,932 Total Award Period Covered: 01 June 2000 to 31 May 2003

Location of Project: Florida State University

Person-Months Per Year Committed to the Project. Cal: Acad: 2 Sumr: 1

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Land-cover and land-use controls on C storage and turnover in soils (with Y. Wang, PI, and P. Gong)

Source of Support: NASA

Total Award Amount: $336,786 Total Award Period Covered: June 2000 to June 2003

Location of Project: Florida State University

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Modeling of karstic aquifers (with David Loper, PI)

Source of Support: National Science Foundation

Total Award Amount: $502,060 Total Award Period Covered: 01 June 2000 to 31 May 2003

Location of Project: Florida State University

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration ofthis proposal.

Investigator: **Kyle A. Gallivan**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **High performance computing for large scale dynamical systems**

Source of Support: **National Science Foundation**

Award Amount (or Annual Rate): $ **130,000** Period Covered: **02/14/97 - 01/31/00**

Location of Project: **Florida State University**

Person-Months Committed to the Project. Cal: Acad: Summ: **2**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support: **IBM Faculty Partnership**

Award Amount (or Annual Rate): $ **20,000** Period Covered: **09/01/97 - 12/31/98**

Location of Project: **Florida State University**

Person-Months Committed to the Project. Cal: Acad: Summ: **1**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Interactive Concurrent Visualization of Unsteady Flow on Parallel Architectures**

Source of Support: **National Science Foundation**

Award Amount (or Annual Rate): $ **450,566** Period Covered: **06/01/98 - 05/31/00**

Location of Project: **Florida State University**

Person-Months Committed to the Project. Cal: Acad: Summ: **0.5**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **High Order Methodology for Composite Manufacturing Processes**

Source of Support: **National Science Foundation**

Award Amount (or Annual Rate): $ **2,090,956** Period Covered: **10/01/98 - 09/30/01**

Location of Project: **Florida State University**

Person-Months Committed to the Project. Cal: Acad: Summ: **1**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **A Comprehensive Retargetable Embedded System Software Development Environment**

Source of Support: **National Science Foundation**

Award Amount (or Annual Rate): $ **1,014,895** Period Covered: **06/01/99 - 05/31/04**

Location of Project: **Florida State University**

Person-Months Committed to the Project. Cal: Acad: Summ: **10**

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: T.N. Krishnamurti

Other agencies (including NSF) to which this proposal has been/will be

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Meteorological Support for the Indian Ocean Experiment (INDOEX)

Source of Support: NSF (ATM-9612894)
Total Award Amount: $200,000.00 Total Award Period Covered: 09/01/97 - 08/31/2000
Location of Project: Florida State University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Modeling of the North American Monsoon

Source of Support: NOAA
Total Award Amount: $170,638.00 Total Award Period Covered: 05/01/1999 - 04/30/2002
Location of Project: Florida State University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Comprehensive Observational and Modeling Study of the Mississippi Floods of 1993
Source of Support: NOAA
Total Award Amount: $131,668.00 Total Award Period Covered: 05/01/1999 - 04/30/2001
Location of Project: Florida State University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

CURRENT & PENDING SUPPORT
for Dr. James J. O'Brien

Source of Support	Project Title	Period Covered	Award Amt.	O'Brien support (months)
NASA	Advanced Data Assimilation in Ocean Models	5/1/99 - 4/30/02	$641,000	1/year
NASA	Anomalous Heat Budgets in the Pacific	5/1/98 - 4/30/01	$164,000	-
NASA	Graduate Fellowship for Alan Leonardi	9/1/98 - 8/31/00	$44,000	-
ONR	Secretary of the Navy Chair	10/1/85 - 12/31/04	$3,562,958	1.5/year
SCEEE/DOD	Graduate Fellowship for Charles Tilburg	8/7/97 - 8/31/00	$70,452	-
JPL	QuikSCAT Principal Investigator	2/22/99 - 2/29/00	$230,000	-
JPL	JASON and TOPEX/POSEIDON altimetry	7/1/98 - 6/30/01	$470,000	.5/year
NRL	Graduate Program in Physical Oceanography and Meteorology	7/1/90 - 12/31/00	$482,240	-
NSF	WOCE DAC/SAC for Surface Fluxes	2/1/94 - 2/28/02	$1,215,000	.5/year
NOAA	Regional Assessment of ENSO Impact in SSA/SNA	9/1/97 - 7/31/00	$1,534,925	2/year
NOAA/WHOI	Qualifying Underway IMET Data	8/1/98 - 7/31/00	$41,600	-
Scripps/NOAA	Flux Variability of the Pacific Ocean	1/1/98 - 12/31/01	$172,500	-
U Miami/NOAA	Application of Climate Forecasts to Agriculture	11/1/97 - 12/31/99	$200,000	.5/year
OSU	Oregon State Univ. SEAWINDS Project	9/15/95 - 12/31/00	$579,000	.5/year
FL Power Corp.	State of Florida Climate Ctr. Project	12/15/99 - 12/31/00	$35,000	-
TOTAL CURRENT SUPPORT:			**$9,442,675**	
Risk Pred. Initiative	Assembly/Quality Control of Temp. Records	1/1/00 - 12/31/00	$50,000	-
NASA	Analysis Modelling & Science for NSCAT	2/1/00 - 1/31/04	$975,000	1/year
U Miami	Application of Climate Forecasts to Agriculture	7/1/99 - 6/30/01	$264,000	.5/year
OSU	Oregon State Univ. SEAWINDS Project	1/1/00 - 12/31/03	$1,329,500	1/year
Willis Faber N.A.	WeatherTrax Climate Database & Forecast	7/26/99 - 7/25/00	$43,000	-
TOTAL PENDING SUPPORT:			**$2,661,500**	
TOTAL CURRENT & PENDING SUPPORT:			**$12,104,175**	

Revised 1/00

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Hans J. Schneider-Muntau

Other agencies (including NSF) to which this proposal has been/will be submitted.
none

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposed Title: Development of Micro-Coils

Source of Support: In-House Research Program

Award Amount (or Annual Rate): $ 190,100 Period Covered: 3/1/99-2/28/01

Location of Research: NHMFL

Person-Months or % of Effort Committed to the Project. Cal: .015 Acad: Summ:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project Proposed Title:

Source of Support:

Award Amount (or Annual Rate): $ Period Covered:

Location of Research:

Person-Months or % of Effort Committed to the Project. Cal: Acad: Summ:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project Proposed Title:

Source of Support:

Award Amount (or Annual Rate): $ Period Covered:

Location of Research:

Person-Months or % of Effort Committed to the Project. Cal: Acad: Summ:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project Proposed Title:

Source of Support:

Award Amount (or Annual Rate): $ Period Covered:

Location of Research:

Person-Months or % of Effort Committed to the Project. Cal: .015 Acad: Summ:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project Proposed Title:

Source of Support:

Award Amount (or Annual Rate): $ Period Covered:

Location of Research:

Person-Months or % of Effort Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

Investigator: **C.K.W. Tam**

Support: **Current**
Project/Proposal Title: **Jet Aeroacoustics: Noise Generation Mechanism and Prediction**
Source of Support: **NASA Langley Research Center**
Total Award Amount: $255,000
Total Award Period Covered: 01 / 01 / 1996–12 / 31 / 1998
Location of Project: Florida State University – Tallahassee, Florida
Person–Months Per Year Committed to the Project. Summ.: 0.80

Support: **Current**
Project/Proposal Title: **Numerical Simulation of Screech Tones from Supersonic Jets: Physics & Predictions**
Source of Support: **NASA Lewis Research Center**
Total Award Amount: $245,500
Total Award Period Covered: 12 / 01 / 1997–11 / 30 / 2000
Location of Project: Florida State University – Tallahassee, Florida
Person–Months Per Year Committed to the Project. Summ.: 1.00

Support: **Current**
Project/Proposal Title: **Advanced CAA Method for Airframe Noise Prediction and Simulation**
Source of Support: **NASA Langley Research Center**
Total Award Amount: $30,000
Total Award Period Covered: 12 / 08 / 1997–12 / 07 / 1998
Location of Project: Florida State University – Tallahassee, Florida
Person–Months Per Year Committed to the Project. Summ.: 0.20

Support: **Current**
Project/Proposal Title: **Micro- and Macro-Fluid Dynamics and Acoustics of Resonant Liners**
Source of Support: **NASA Langley Research Center**
Total Award Amount: $150,000
Total Award Period Covered: 01 / 01 / 1998–09 / 30 / 1999
Location of Project: Florida State University – Tallahassee, Florida
Person–Months Per Year Committed to the Project. Summ.: 1.00

Support: **Pending**
Project/Proposal Title: **Airframe – Jet Engine Integration Noise**
Source of Support: **NASA Langley Research Center**
Total Award Amount: $300,000
Total Award Period Covered: 11 / 01 / 1998–10 / 30 / 2001
Location of Project: Florida State University – Tallahassee, Florida
Person–Months Per Year Committed to the Project. Summ.: 1.00

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Ben Wang

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Design, Fabrication and Testing of Low-Cost Composite Tailkit

Source of Support: AFRL

Total Award Amount: $800,000 Total Award Period Covered: 9/1/97-8/31/99

Location of Project: FAMU-FSU College of Engineering

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0 Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Integrated Manufacturing and Quality System for Composite Fabrication

Source of Support: AFOSR

Total Award Amount: $400,000 Total Award Period Covered: 10/1/97-10/31/99

Location of Project: FAMU-FSU College of Engineering

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0 Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Characterization of Flow with Permeable Boundary Using Nuclear Magnetic Resonance (NMR) Imaging

Source of Support: NSF

Total Award Amount: $151,778 Total Award Period Covered: 5/1/97-4/30/99

Location of Project: FSU & NHMFL

Person-Months Per Year Committed to the Project. Cal: 0 Acad: 0 Sumr: 0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Design for Environmentally Conscious Manufacturing

Source of Support: Department of Energy

Total Award Amount: $1,600,000 Total Award Period Covered: 10/94-9/99

Location of Project: FAMU-FSU College of Engineering

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.75

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.