INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS

Submit only ONE copy of this form with your proposal. Attach it on top of the cover page of the copy of your proposal that bears the original signatures. Leave the back of the page blank. *Do not include this form with any of the other copies of your proposal, as this may compromise the confidentiality of the information.*

Please check the appropriate answers to each question for all principal investigator(s)/project director(s) listed on the cover page, using the same order in which they were listed there:

	Principal Investigator/ Project Director	First Additional PI/PD	Second Additional PI/PD	Third Additional PI/PD	Fourth Additional PI/PD
1. Is this person					
Female	☐	☐	☐	☐	☐
Male	☒	☐	☐	☐	☐
2. Is this person a					
U.S. Citizen	☒	☐	☐	☐	☐
Permanent Resident	☐	☐	☐	☐	☐
Other non-U.S. Citizen	☐	☐	☐	☐	☐
3. Which one of these categories best describes this person's ethnic/racial status? (If more than one category applies, use the category that most closely reflects the person's recognition in the community.)					
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Asian	☐	☐	☐	☐	☐
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No	☒	☐	☐	☐	☐
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AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

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HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

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*Disabled: A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of the proposed principal investigators/ project directors and co-principal investigators. To gather the information needed for this important task, you should submit a single copy of this form with each proposal; however, submission of the requested information is not mandatory and is not a precondition of award. Any individual not wishing to submit the information should check the box provided for this purpose. (The exception is information about previous Federal support, the last question above.)

Information from this form will be retained by Federal agencies as an integral part of their Privacy Act Systems of Records in accordance with the Privacy Act of 1974. These are confidential files accessible only to appropriate Federal agency personnel and will be treated as confidential to the extent permitted by law. Data submitted will be used in accordance with criteria established by the respective Federal agency for awarding grants for research and education, and in response to Public Law 99-383 and 42 USC 1885c.

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PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 98-2

NSF 98-55 05/12/98

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

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NSF PROPOSAL NUMBER

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION

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TITLE OF PROPOSED PROJECT **General Earthquake Models: A New Computational Challenge**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE
$ 2,776,858	36 months	10/01/98

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)
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- ☐ FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)
- ☐ RESEARCH OPPORTUNITY AWARD (GPG V.H)

PI/PD DEPARTMENT

CIRES

PI/PD FAX NUMBER

303-492-5070

PI/PD POSTAL ADDRESS

Campus Box 216, CIRES Bldg. 318
C4/CIRES
Boulder, CO 803090216
United States

NAMES (TYPED)	Social Security No.*	High Degree, Yr	Telephone Number	Electronic Mail Address
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CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

NOTE: THE FULLY SIGNED CERTIFICATION PAGE MUST BE SUBMITTED IMMEDIATELY FOLLOWING THIS COVER SHEET.

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE NSF INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

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	Date
PI/PD John B Rundle		
Co-PI/PD		
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 98-2. 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)		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
303-492-6221		303-492-6421

A. Project Summary:

Objectives: We plan to develop the computational capability to carry out large-scale numerical simulations of the physics of earthquakes in southern California and elsewhere. Our state-of-the-art problem solving environment will facilitate: 1) The construction of numerical and computational algorithms and specific environment(s) needed to carry out large simulations of these complex scale-invariant nonlinear physical processes over a geographically widely distributed, heterogeneous computing network; and 2) Development of computational infrastructure for understanding earthquake physics and potential “forecasting” methodologies that use modern distributed object and collaboration technologies with scalable systems, software and algorithms. We will integrate high performance simulations, real-time data, and interactive analysis systems to analyze the evolution of fault slip on complex, scale-invariant fault systems.

Method: We will base our work on currently available small scale workstation-class simulation codes as starting points to model the physics of earthquake fault systems in southern California. The problem solving environment will be developed from the best available parallel algorithms and emerging distributed object based systems. It will leverage state-of-the-art national HPCC activities in simulation of continuum, cellular automata, and large-scale particle systems. We will also develop techniques to calibrate and validate simulations with seismic, GPS and InSAR and other data, and to assimilate new data into the simulations.

Scientific and Computational Foci: We will focus on developing the capability to carry out large scale simulations of complex, multiple, interacting fault systems using a software environment adapted for rapid prototyping of new phenomenological models. The software environment will require: 1) Developing algorithms for solving computationally difficult nonlinear problems involving ("discontinuous") thresholds and nucleation events in a networked parallel (super) computing environment; 2) Adapting new “fast multipole” methods previously developed for general N-body problems; 3) Adapting existing modern Web and other commodity technologies to allow researchers to rapidly integrate simulation data with field and laboratory data (visually and quantitatively).

Significance of Anticipated Results: The GEM approach will allow the physics of large networks of earthquake faults to be analyzed within a general computational and theoretical framework for the first time. Using recent advances in space-time Pattern Dynamics analysis methods for complex nonlinear threshold systems, GEM may lead to several forecast methodologies similar to those now used for El Niño forecasts. The computational techniques developed by the project will find significant applications in many other computationally hard problems of great technological importance, for example, 1) simulating nonlinear threshold systems such as large neural networks with learning and cognition; 2) magnetic depinning transitions in superconductors and charge density wave systems; 3) growth of magentized domains in ferromagnets; and 4) statistical physics approaches to random field spin systems.

Investigator Team: Our team is internationally recognized in the three areas of 1) Earth science 2) statistical mechanics and complex systems and 3) computational science. The latter include world experts in the critical algorithms, software and both HPCC and commodity systems required. We plan a vigorous education and outreach program, so technology transfer to related projects, as well as educational benefits, will follow easily. Rundle will serve as Principal Investigator. The Investigators will participate in periodic workshops at which 1) results will discussed; and 2) specific research avenues will be formulated on a regular and timely basis. We will partner actively with scientists from the existing Southern California earthquake Center and the proposed California earthquake Research Center.

TABLE OF CONTENTS

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

*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.

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C. Project Description

C.1 Web References and Resources:

GEM Web Site: http://www.npac.syr.edu/projects/gem
(This site has information on the GEM team, scientific results, codes and plans)

ftp site: ftp://fractal.colorado.edu/pub/Viscocodes/Virtual_California

on host: fractal.colorado.edu
(This site has current versions of the basic numerical codes from *Rundle* [1988] upon which many of the initial GEM methods will be based, together with results from recent small scale model runs possible on current workstations)

C.2 Earthquake Science: Issues and Opportunities

Rationale for Earthquake Research: Earthquakes, even those significantly smaller than the largest magnitude events of about magnitude 9.5 (e.g., Chile, 1960), are capable of producing enormous damage today and in the future. The recent January 16, 1995 Kobe, Japan earthquake (magnitude ~ 7) was responsible for an estimated $200 billion in damages, accounting for lost economic income as well as direct structural damage. This event was a complete surprise, inasmuch as the immediate region had been relatively inactive in historic time (see, e.g., *Trans. AGU*, **76** Supp., 1995). It has also been estimated that a repeat of the 1933 Long Beach California earthquake, which had a maximum Modified Mercalli Intensity of IX, would today cause in excess of $500 billion in damages, rather than the $41 million loss that occurred in 1933 . These figures can be compared to the total assets of the US Property Insurance Industry, which is at present about $200 billion (*Insurance Institute for Property Loss Reduction*, pers. comm., 1997). Losses in a repetition of the 1906 San Francisco earthquake would be far larger. The magnitude of these potential losses, even in an economy the size of the United States in 1998, $1.7 trillion, clearly indicate the need to evolve approaches to understand, forecast, and mitigate the risk. The importance of developing techniques to eventually predict or forecast earthquakes has been underscored by the fact that an increasing proportion of the global population lives along active fault zones (*Bilham*, 1996).

Status of Earthquake Science: Although a great deal of data has accumulated about the phenomenology of earthquakes in recent years, these events remain one of the most destructive and poorly understood of the forces of nature (see e.g., *Reid*, 1908; *Richter*, 1958; *Scholz*, 1990; and the review by *Rundle and Klein*, 1995). In the last decade, a series of national policy decisions and programs have culminated in the establishment of the Southern California earthquake Center (SCEC) (http://www.scec.org/); and parallel efforts in other countries, e.g., (http://shake2.Earthsciences.uq.edu.au/ACES/). An even larger group of Universities have come together to propose the new California Earthquake Research Center, under the NSF Science and Technology Centers program, to succeed SCEC in the year 2001. Together with efforts initiated several decades ago by the United States Geological Survey (http://www.usgs.gov/themes/Earthqk.html), the accuracy, reliability, and availability of observational data for earthquakes, particularly in southern California, have increased enormously.

Despite this, the scientific community is unable to even approximately forecast the time, date, and magnitude of earthquakes. At the moment, the best that can be done is embodied in the Phase II report of earthquake probabilities published by the SCEC (*SCEC*, 1995; (http://www.scec.org/). These probabilities are based on “scenario earthquakes” and probabilistic assumptions about whether, for example, contiguous segments of faults (“characteristic earthquakes”) do or do not tend to rupture together to produce much larger events. Attempts to forecast large events based on recurrence intervals or physical precursory phenomena have been pursued since the 1970s without notable success.

Recent research indicates that earthquakes exhibit a wealth of complex phenomena over a very large range of spatial and temporal scales, including space-time clustering of events, self-organization and scaling (e.g., *Scholz*, 1990; *Turcotte*, 1992). It is has often been suggested that the most promising strategy for forecasting large earthquakes would be to learn how to recognize the space-time patterns of the smaller earthquakes that precede them. Several strategies have emerged ranging from pure pattern recognition techniques (*Keilis-Borok et al,* 1996; *Minster and Williams*, 1996; *Pepke et al*, 1994; *Ben Zion and Eneva*, 1996) to methods based on analogies with the statistical mechanics of critical phenomena (e.g. *Sornette, et al.,* 1996) to new Pattern Dynamics approaches (*Rundle et al*., 1998).

Why GEM, and Why Now? There is a growing consensus in the scientific community that the time has come to establish a feedback loop between observations, theory and computer simulations within the field of earthquake science similar to that which currently exists in the study of climate and atmospheric science. The goals of the General earthquake Model (GEM) project are similar to those of the GCM community: 1) to develop sophisticated computer simulations based upon the best available physics, with the goal of understanding the physical processes that determine the spatial and temporal distribution of earthquakes on active fault networks, and 2) to develop a model of the earthquake process that will allow current data to be projected forward in time, so that model predictions can be tested against future observations.

A “Pattern Dynamics” pattern recognition methodology has recently been developed for earthquakes (*Rundle and Klein,* 1988a). It is similar to the approach used in climate studies for El Niño predictions, which have made it possible to forecast these events 6 months to 1 year before onset, with an approximately ~ 70% success rate (e.g. *Barnston et al.*, 1994; *Chen et al.*, 1995; *Penland and Magorian,* 1993). The success of such El Niño investigations bodes well for earthquake studies since both problems involve nonlinear systems with structure developed on a wide range of scales.

The GEM project is a large, complicated, and expensive undertaking (by academic standards). It involves more than 40 scientists at about 20 institutions. Since the difficulty of the problem is comparable to numerical climate/weather forecasting, which today involves thousands of scientists at many institutions as well as entire federal agencies, the scale of the GEM project should not be surprising. Moreover, the functions described below, 1) modeling and analysis, 2) computations, 3) calibration / validation / assimilation, are the same as those for the climate/weather problem. Although earthquake modeling and simulation techniques have been the focus of small research projects for the past two decades, the various groups have not tended to work in the kind of large, collaborative modes that have become the norm in the climate/weather community. Rather, these activities have tended to remain small, disconnected, and relatively isolated from each other and from observational and laboratory seismologists.

However, there is growing suspicion that much larger numerical models of multiscale fault networks are required to simulate spatio-temporal patterns of seismicity, with sufficient veracity to be used in concert with real-time seismicity and geodetic data in a predictive mode. Specifically, such models must ultimately incorporate the physics of rupture on individual faults and the time dependent rheology of the crust between faults. Of greatest interest is the capability to study the space-time characteristics of large populations of earthquakes, rather than focusing on individual events. Other factors motivating the initiation of a large scale numerical simulation program at this time include the extremely rapid increase of computational capability within the last five years, the recent availability of extensive new data sources such as InSAR and GPS, and the even more rapid increase in the economic cost of earthquake disasters.

C.3 Computational Science: Issues and Opportunities

Computational Significance of GEM: While there are similarities to the weather/climate problem, the earthquake problem presents unique computational aspects implying that entirely new and novel algorithms will be needed. Specifically, the observational Gutenberg-Richter magnitude-frequency relation and the Omori aftershock law, both of which are scaling relations, indicate that the earthquake system is always operating in close proximity to a critical point (*e.g., Carlson et al.*, 1991; *Rundle and Klein*, 1994; *Sornette and Sammis*, 1995). Consequently, correlation lengths and correlation times will always be large. This is in contrast to large scale weather forecasting, which tends to focus on "forecastable" synoptic-scale problems and to neglect sub-grid scale turbulent processes. Earthquake simulations cannot afford this luxury. Scaling laws in fluid dynamics calculations such as the Kolmagorov five-thirds law (e.g., Frisch, 1995) are observed only intermittently in space and time, in strongly turbulent flows. This difference in "persistence" of the dynamics is the reason why weather and climate are clearly "forecastable" to some extent at present, and why earthquakes are not. For these reasons, the computational aspects of GEM will have important implications for simulation techniques used to model similar nonlinear threshold systems, including large neural networks (*Hertz et al.*, 1991; *Herz and Hopfield*, 1995), depinning transitions in driven superconductors and charge density wave materials (*Fisher*, 1985), driven foams (*Gopal and Durian*, 1995), magnetized domains in ferromagnets (*Urbach et al.*, 1995), sandpiles (*Bak et al*., 1987) and so forth. Many of these systems have considerable technological significance.

Why GEM is an HPC-class Problem: Current evidence indicates that forecasting the damaging earthquakes of magnitude ~ 6 and greater almost certainly depends upon understanding the space-time patterns displayed by smaller events, e.g., the magnitude 3's, 4's and 5's (*Sornette et al.*, 1996; *Keilis-Borok et al*, 1996; *Minster and Williams*, 1996). With at least 40,000 km^2 of fault area in southern California capable of participating in magnitude 6 and greater events, and needing a spatial resolution of about 100 m to eliminate grid-scale effects and to capture the physical processes of the magnitude 3 events, we arrive at the conclusion that as much as 10^6 grid sites will be necessary for a maximally realistic simulation. If grid sizes at the 10 m scale are used to capture the failure physics of the magnitude 3 events, then ~ 10^8 grid sites will be needed. Below we give run time estimates of several months for such a problem based upon current technology. This clearly puts the GEM problem into the HPC range.

The scientific establishment in Japan clearly recognizes these facts. Officials at the Japanese RIST funding agency recently announced (*H. Nakamura, Personal communication*, 1997) a funded program of some $400 million over the period 1996-2001 to construct a 32 TERAFLOP computer to be dedicated to weather and earthquake forecasting. At the present time, no such computer, and no such GEM-type program is even contemplated in the United States.

A significant feature of the GEM HPC challenge is the lack of major large “legacy” codes. This deficiency turns out to be an advantage, because we can immediately adopt modern distributed object-oriented technology from the outset. We have used initial computations to estimate that the simulation of a fault network containing 107 elements requires machines of 1 to 100 TERAFLOPs, in the same range as the machine announced by the Japanese. The uncertainty in our estimate reflects the currently unknown requirements stemming from needed accuracy in earthquake simulation. The development of a forecast/predictive capability will thus require enormous computational resources, which are comparable to those needed for the large-scale simulations of DOE's ASCI program. We expect such capabilities to be available from general facilities such as the Los Alamos Advanced Computing Laboratory (ACL), NPACI - San Diego, NCSA - Illinois, and the Boston University MARINER project. Eventually one might expect to set up dedicated resources for earthquake forecasting as planned in the major Japanese program in this area. Although these high-end machines may well have distributed shared memory architecture, our software should also support the increasingly popular clusters of PC hardware, which provide a cost-effective development environment. The many levels of complexity present in the current and future generations of New Computational Challenge simulations will call for an interactive team of Earth scientists, physicists and computational scientists working together.

GEM Computational Infrastructure: The GEMCI will involve the following elements:

User Interface
Non-local Equation Solver (Green’s functions)
Modules specifying local Physics and friction
Evaluation, Data analysis and Visualization
Data storage, indexing and access for experimental and computational information
Complex Systems and Pattern Dynamics Interactive Rapid Prototyping environment for developing new phenomenological models with their analysis and visualization.
Overall Integration of GEMCI into a problem solving environment

We will describe the details in sections C.7, C.8 and C.9 but here we summarize our overall approach. One important feature of GEM is that there are no major large “legacy” codes. This can be turned into an advantage, because we can adopt modern distributed object-oriented technology from the outset. There are ambitious high performance computing projects in this area: ***POOMA*** (http://www.acl.lanl.gov/PoomaFramework/; ***Nile*** (http://www.nile.utexas.edu/) and ***Legion*** (http://www.cs.virginia.edu/~legion/). We intend to adopt a simpler approach where we do not initially link distributed object and parallel computing concepts. We will use traditional Message Passing Interface (MPI) based parallel systems with extensive use of libraries so that for instance the fast multipole algorithm can be used by application programs from a high level interface that hides the details of its MPI implementation. Sequential or parallel programs will then be encapsulated as Common Object Broker Architecture (CORBA) objects which will allow us to link them together and with databases, visualization and collaboration tools with invocations that do not depend on the computing platform and module implementation. Early on, we intend to establish an overall ***Computational Seismic Framework***, which will allow the team to develop different modules separately, in such a way as to enable this integration. This involves effectively defining a "CORBA vertical facility" with the properties and methods of the GEM modules defined in terms of a specific IDL (Interface Definition Language) syntax. NPAC has substantial experience in this area with projects for the NCSA Alliance, DoD Modernization and ASCI. A new book *'Building Distributed Systems for the Pragmatic Object Web'* (http://www.npac.syr.edu/users/shrideep/book/) co-authored by Fox and his colleagues describes how other commodity technologies including Microsoft's COM and Java can be integrated with CORBA in the emerging object web.

As most of our software will be built from scratch, we expect that we can establish and enforce the uniform practices of a ***Computational Seismic Framework*** which will lead to a GEMCI consisting at a high level of a set of coarse grain “Distributed Scientific Objects.” These can be in any language (such as parallel C, C++ Java or Fortran) but with a uniform Javabean applet front end. Note, for instance, that cellular automata models are natural applications for Fortran or HPF, but the complex hierarchical data structures of the fast multipole method are much more naturally handled in C or C++. One can also anticipate using Java to directly develop some application modules as this is rapidly emerging as an attractive modeling language (http://www.npac.syr.edu/projects/javaforcse). The support of multiple paradigms will not lead to a chaotic environment because we will enforce uniformity at the module interfaces. Integration of these multi-paradigm coarse grain objects will rely either on commercial CORBA or COM object brokers or on custom technology such as NPAC's WebFlow/JWORB (which integrates Web CORBA and COM in a single Java Server.) NPAC has also already demonstrated (http://www.npac.syr.edu/users/gcf/alliance98/index.html) how one can use a multi-tier architecture to link Globus (http://www.globus.org) with CORBA and Web modules to achieve high-performance when necessary. This complication is only needed to enhance inter-module performance; we use conventional parallel computing approaches internally to each module.

We do not propose to assign significant resources to develop an overall computer science infrastructure: we will be using well established parallel computing techniques and impose a uniform overall design framework to allow commodity distributed object systems such as CORBA to manage the coarse grain structure of GEMCI. It is clear that a rich set of tools is quickly becoming available to support this approach. Our clear separation of parallel and object technologies is not the most ambitious approach possible but ensures an excellent system, which can adapt to inevitable change with a modest level of effort.

C.4 GEM Scientific Objectives

In previous sections we discussed the philosophy of the GEM simulations by drawing analogies with the GCM climate simulation project. There are scientific similarities as well. Both are extended non-linear systems which develop structures cascading over a wide range of scales and both require that as wide a range of scales as possible be included in the model. However there are significant differences. The physics of climate is governed by continuum mechanics and thermodynamics, for which appropriate partial differential equations (e.g. Navier-Stokes) have been identified and validated. In contrast, earthquakes are probably best described as threshold phenomena involving nucleation and rupture processes which are, themselves, not well understood. For seismicity simulations we must in principle deal with both the complexity of the individual events (rupture phenomenon) and the complexity of a population of events on a multi-scale network (patterns of events). A well constructed simulation technology should hold the promise of an iterative solution to both problems through a direct comparison of simulations with seismicity and geodetic data. In this context, specific **scientific objectives** of our research include :

Objective 1. Cataloguing and understanding the nature and configurations of space-time patterns of earthquakes and examining whether these are scale-dependent or scale-invariant in space and time (e.g., *Scholz*, 1990; *Ben-Zion & Rice*, 1993; 1995; 1996, 1997; *Ben-Zion*, 1996; *Eneva and Ben-Zion*, 1997a,b; *Lyakovsky et al.,* 1997; *Rundle et al.,* 1998). Correlated patterns may indicate whether a given event is a candidate foreshock. We want to study how patterns form and persist. One application will be to assess the validity of the "gap" and "antigap" models for earthquake forecasting (e.g., *Kagan and Jackson*, 1991; *Nishenko et al.*, 1993). Another will be to understand the physics of "correlation at a distance," and "time delayed triggering," which result in seismicity that seems correlated over larger distances and time intervals than previously thought (e.g. *Hill et al.,* 1993).

Objective 2. Identifying the key parameters that control the physical processes and space-time patterns. We want to understand how fault geometry, friction laws, and Earth rheology enter the physics of the process, and which of these are the controlling parameters.

Objective 3. Understanding the importance of inertia and seismic waves in determining details of space time patterns and slip evolution.

Objective 4. Understanding the role of sub-grid scale processes, and whether these might be parameterized in terms of uncorrelated or correlated noise.

Objective 5. Ascertaining the possible effects of unmodeled processes, including neglected, hidden or blind faults, lateral heterogeneity, variability in friction laws, nature of the tectonic forcing and Earth rheology.

Objective 6. Developing and testing potential earthquake forecast algorithms, based upon the use of space-time pattern dynamics (*Rundle et al.,* 1998) or other methods, such as log-periodic (*Sornette et al.*, 1996) and other algorithms (e.g. *Keilis-Borok et al,* 1996; *Minster and Williams,* 1996)**.**

C.5 Complexity, Nonlinearity, Space-Time Patterns and Scales

Approach: Credible, realistic earthquake simulations must be expected to display space-time complexity comparable to the real world. Simulations allow experiments to understand better the origin and stability of such complexity. For example: 1) Calculations can be repeated with different random initial conditions to study the influence of fluctuations and annealed noise; 2) Slightly different geometries and parameter families, with different grid scales can be adopted to determine the effects of quenched noise; 3) Parameters can be tuned to optimize or isolate selected effects, and so forth. While these and other numerical experiments can be carried out, there is also a need to use these simulations in order to develop analysis techniques that can be applied to natural seismic data and earthquake fault systems. We highlight below a sampling of current ideas and approaches.

Hierarchy of Spatial and Temporal Scales: The presence of hierarchies of spatial and temporal scales is a recurring theme in modern ideas about earthquakes. It is known, for example, that fault and crack systems within the Earth are distributed in a scale invariant manner over a wide range of scales (*Brown and Scholz*, 1985; *Power et al.,* 1988; *Scholz*, 1990; *Turcotte*, 1992). Moreover, the time intervals between characteristic earthquakes on this fractal system is known to form a scale invariant set (*Allègre et al.,* 1982, 1994 1996; *Smalley et al.*, 1985; 1987). Changes in scaling behavior have been observed at length scales corresponding to the thickness of the Earth's lithosphere, but the basic physics remains nevertheless similar over many length scales (e.g., *Rundle and Klein*, 1995). It is also known that nucleation and critical phenomena—which are now suspected to govern many earthquake-related phenomena—are associated with divergent length and time scales and long range correlations and coherence intervals (see, e.g., *Rundle and Klein*, 1995 for a literature review and discussion). Our philosophical approach to simulations will begin by focusing on the largest scales first, working down toward shorter scales as algorithms and techniques improve. Moreover, our practical interest is limited primarily to the largest faults in a region, and to the largest earthquakes that may occur. Therefore, focussing on quasistatic interactions and long wavelength interactions is the most logical initial strategy.

We plan to model smaller faults and events as a background "noise" in the simulations, as discussed in the proposed work. In this respect, we will have to address the issue of "cascades," —similar to cascades encountered in turbulence models—, and determine whether such cascades cause difficulties near the "Nyquist" wavelength of the grid.

Dynamics of Space-Time Patterns: Anecdotal evidence accumulated over many years indicates the existence of space-time patterns in seismicity data (*Scholz*, 1990; *Das et al.*, 1986; *Simpson and Richards,* 1981; *Rundle et al.,* 1996). The exact nature of these patterns, however, has so far eluded identification. Recent attempts to forecast seismic activity have been based upon several approaches. One of the oldest ones is exemplified by the M8 algorithm of *Keilis-Borok* and coworkers (*SCEC*, 1997): several seismic activity functions are tracked as functions of time. When these attain preset values, a "Time of Increased Probability" (TIP) is triggered, and remains in effect for several years. Another method relies on identification of a precursory "Active Zone" before the largest events that seems to be evident in a variety of numerical simulations (*Shaw et al.* 1992; *Pepke et al.,* 1994). Still another promising approach is the log-periodic time-to-failure method (e.g. *Sammis et al*., 1996) that relies on a characteristic signature arising from an earthquake failure process involving a discrete scale invariant hierarchy of smaller events. Finally, *Eneva and Ben-Zion* (1997a,b) have applied standard pattern recognition techniques to simulations in an effort to categorize the kinds of space-time patterns that may exist in real data. It should be noted that all of these approaches implicitly assume that space-time patterns do exist in the data and can be discovered through analytical techniques.

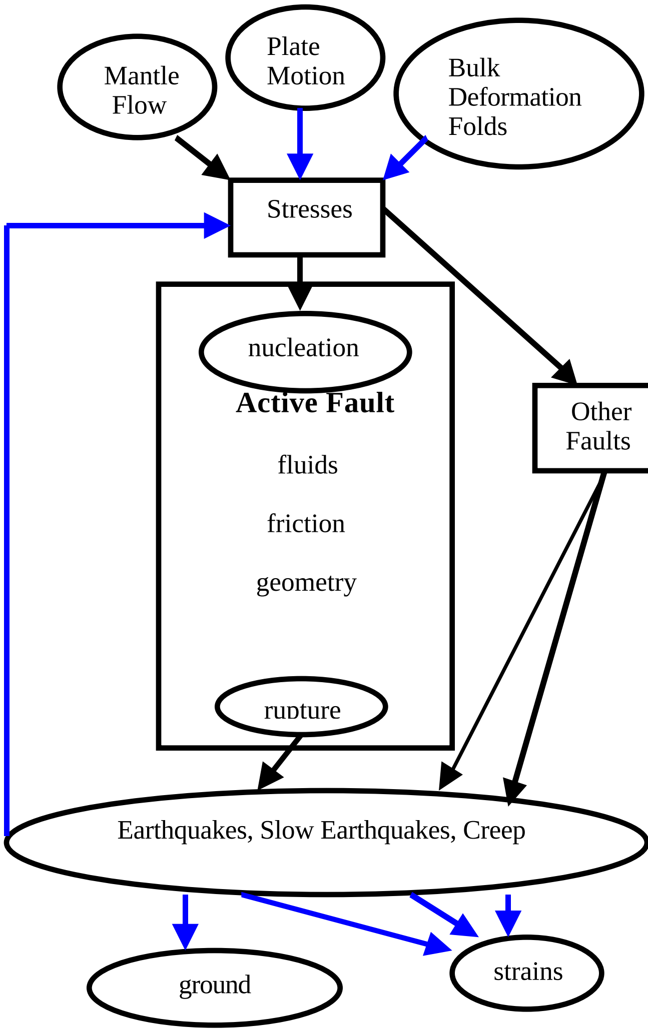
Quite recently, a new Pattern Dynamics approach has been devised, that holds the promise of identifying and classifying all possible space-time patterns that may exist for a given set of faults, together with the probabilistic master equation that governs their evolution (*Rundle and Klein,* 1998a).The patterns are represented by a complete set of orthonormal eigenfunctions (eigen-patterns) of an appropriately defined matrix operator that embodies the dynamics of the various fault segments. A pattern state evolution operator can be then constructed and used to propagate the pattern states probabilistically in time. Similar pattern state operators can be retrieved from real earthquake datasets, if one has a long enough time series of observations. Numerical simulations can be used to construct the pattern state evolution operators as long as the simulation captures the statistical characteristics of actual seismicity. These operators can then be used on real datasets 1) to identify in which eigen-pattern the real fault system currently resides, and 2) to forecast into which space-time pattern the real fault system is likely to evolve. A similar approach is currently used in El Niño forecasting with an approximately ~ 70% success rate (e.g. *Barnston et al.,* 1994; *Chen et al.,* 1995; *Penland and Magorian,* 1993).

C.6 Proposed Scientific Approach

Fundamental Equations: The basic problem to be solved in GEM is the following (e.g., *Rundle* 1988a): Given a network of faults embedded in an Earth with a given rheology, subject to loading by distant stresses, and neglecting elastic waves (see discussion below), evolution of the state of slip $\mathbf{s}(\mathbf{x},t)$ on a fault at $(\mathbf{x},t)$ is determined from the equilibrium of stresses according to Newton's Laws:

$$\frac{\partial \mathbf{s}(\mathbf{x},t)}{\partial t} = \Phi \left\{ \Sigma_i \left(\sigma_i \right) \right\} \tag{1}$$

where $\Phi\{\}$ is a nonlinear functional, and $\Sigma_i\ (\sigma_i)$ represents the sum of all stresses acting within the system. These stresses include 1) the interaction stress $\sigma_{int}[\mathbf{x},t;\ \mathbf{s}(\mathbf{x}',t');\ \mathbf{p}]$ provided by transmission of stress through the Earth's crust arising from background tractions $\mathbf{p}$, as well as stresses due to slip on other faults at other sites $\mathbf{x}'$ at times t'; 2) the cohesive fault frictional stress $\sigma_f[\mathbf{x},t;\ \mathbf{s}(\mathbf{x},t)]$ at the site $(\mathbf{x},t)$ associated with the state of slip $\mathbf{s}(\mathbf{x},t)$; and 3) other stresses such as those due to dynamic stress transmission and inertia. The transmission of stress through the Earth's crust involves both dynamic effects arising from the transient propagation of seismic waves, and from static effects that persist after wave motion has ceased. Rheologic models typically used for the Earth's crust between faults are all linear (e.g., *Rundle and Turcotte,* 1993) and include 1) a purely elastic material on both long and short



time scales; 2) a material whose instantaneous response is elastic but whose long term deformation involves bulk flow (viscoelastic); and 3) a material that is again elastic over short times, but whose long term response involves stress changes due to the flow of pore fluids through the rock matrix (poroelastic). In the adjacent figure, we show the basic conceptual "wiring diagram" for the model, which indicates the interplay between loading stresses, rupture, interactions with other faults, and relaxation processes following a major earthquake.

Green's Functions: Focusing on GEM models that assume a linear interaction rheology between the faults implies that the interaction stress can be expressed as a spatial and temporal convolution of a stress Green's function $\mathbf{T}_{ij}{}^{kl}$ $(\mathbf{x}\text{-}\mathbf{x}',t - t')$ with the slip deficit variable $\phi(\mathbf{x},t) = \mathbf{s}(\mathbf{x},t) - \mathbf{V}t$, where $\mathbf{V}$ is the long term rate of offset on the fault. Once the slip deficit is known, the displacement Green's function $\mathbf{G}_{ij}{}^{k}(\mathbf{x}\text{-}\mathbf{x}',t\text{-}t')$ can be used to compute, again by convolution, the deformation anywhere in the surrounding medium exterior to the fault surfaces (e.g. *Rundle* 1988a). We know of no approach other than a Green's function method that can be used in the context of specified fault geometries, realistic earth models and linear rheologies, and specified friction and failure laws, to quantitatively and numerically compute synthetic earthquake sequences, space-time stress and seismicity patterns, and surface deformation for direct comparison to observations (see for example *Scholz,* 1990; *Kostrov and Das,* 1988).

Seismic Waves: In the first implementation of GEM models, we will further specialize to the case of quasistatic interactions, even during the slip events. Although we plan to include elastic waves and inertia for synthetic earthquakes in the future (e.g., *Aki and Richards,* 1980; *Zheng et al.,* 1995; *Kanamori*, 1993; *Beroza*, 1995; *Jordan*, 1991; *Imhlé et al.*, 1993). Recent work (*Perrin and Rice*, 1995**;** *Shaw*, 1995**)**, has shown that many important features of earthquakes and slip evolution on faults can be reproduced without including waves (*Rundle*, 1988; *Rundle and Klein*, 1995a; *Ben-Zion and Rice*, 1993; 1995; 1997). Examples of these features include statistics (*Rundle and Jackson*, 1977; *Rundle and Klein*, 1993; 1995a,b; 1996; 1997; *Carlson and Langer*, 1989; 1991a,b; *Shaw*, 1992; 1995**;** *Fisher, et al.*, 1997), characteristics of source-time functions (*Rundle and Klein*, 1995a), and space-time slip patterns (*Rundle* 1988; *Rundle et al.*, 1998b). Observational evidence supports the hypothesis that simulations carried out without including inertia and waves will have substantial physical meaning. *Kanamori and Anderson* (1975) and *Kanamori et al.* (1998) estimated that the seismic efficiency η, which measures the fraction of energy in the earthquake lost to seismic radiation, is less than 5%-10%, implying that inertial effects in the dynamical evolution of slip in studying large populations of earthquakes will be of lesser importance for initial calculations. Elastic waves will be included in later simulations when errors arising from other effects are reduced to the 5%-10% level. At present, inclusion of these effects is severely limited by available computational capability, so we anticipate that it may be only practical to include only the longest wavelengths or largest spatial scales. This computational plan is consistent with our philosophical approach.

Inelastic Rheologies: In quasistatic interactions, the time dependence of the Green's function typically enters only implicitly through time dependence of the elastic moduli (e.g., *Lee*, 1955). Because of linearity, the fundamental problem is reduced to that of calculating the stress and deformation Green's function for the rheology of interest. For materials that are homogenous within horizontal layers, numerical methods to compute these Green's functions are well known (e.g., *Okada*, 1985, 1992; *Rundle*, 1982a,b, 1988; *Rice and Cleary*, 1976; *Cleary*, 1977; *Burridge and Varga*, 1979; *Maruyama*, 1994). Problems in heterogeneous media, especially media with a distribution of cracks too small and too numerous to model individually, are often solved by using effective medium approaches, self-consistency assumptions (*Hill*, 1965; *Berryman and Milton*, 1985; *Ivins*, 1995a,b), or damage models *Lyakovsky et al.* (1997). Suffice to say that a considerable amount of effort has gone into constructing quasistatic Green's functions for these types of media, and while the computational problems present certain challenges, the methods are straightforward as long as the problems are linear. In the proposed work, we will focus on elastic (with possible incorporation of damage parameters) and layered viscoelastic models only.

Friction Models: At the present time, six basic classes of friction laws have been incorporated into computational models.

1. Two basic classes of friction models arise from **laboratory experiments:**

Slip Weakening - This friction law (*Rabinowicz*, 1965; *Bowdon and Tabor*, 1950; *Beeler et al.*, 1996; *Stuart*, 1988; *Li*, 1987; *Rice*, 1993; *Stuart and Tullis*, 1995) assumes that the frictional stress at a site on the fault $\sigma_f = \sigma_f[\mathbf{s}(\mathbf{x},t)]$ is a functional of the state of slip. In general, $\sigma_f[\mathbf{s}(\mathbf{x},t)]$ is peaked at regular intervals. The current state of the system is found from enforcing the equality $\sigma_f[\mathbf{s}(\mathbf{x},t)] = \sigma_{int}[\mathbf{x},t;\ \mathbf{s}(\mathbf{x}',t');\ \mathbf{p}]$ prior to, and just after, a sliding event.

Rate and State - These friction laws are based on laboratory sliding experiments in which two frictional surfaces are slid over each other at varying velocities, usually without experiencing arrest (*Dieterich*, 1972; 1978; 1981; *Ruina*, 1983; *Rice and Ruina*, 1983; *Ben Zion and Rice*, 1993; 1995; 1997; *Rice*, 1993; *Rice and Ben Zion*, 1996). In these experiments, the laboratory apparatus is arranged so as to be much "stiffer" than the experimental "fault" surfaces. The rate dependence of these friction laws refers to a dependence on logarithm of sliding velocity, and the state dependence to one or more state variables $\theta_i(t)$, each of which follows an independent relaxation equation.

2. Two classes of models have been developed and used that are based on laboratory observations, but are **computationally simpler.**

Coulomb-Amontons - These are widely used because they are so simple (e.g., *Rundle and Jackson*, 1977; *Nakanishi*, 1991; *Brown et al.*, 1991; *Rundle and Brown*, 1991; *Rundle and Klein*, 1992; *Ben Zion and Rice*, 1993, 1995, 1997). A static failure threshold, or equivalently a coefficient of static friction μ^S is prescribed, along with a residual strength, or equivalently a dynamic coefficient of friction μ^D. When the stress at a site increases, either gradually or suddenly, to equal or exceed the static value, a sudden jump in slip (change of state) occurs, that takes the local stress down to the residual value. These models naturally lend themselves to a Cellular Automaton (CA) method of implementation.

Velocity Weakening - This model (*Burridge and Knopoff*, 1967; *Carlson and Langer*, 1989) is based on the observation that frictional strength diminishes as sliding proceeds. A constant static strength $\sigma_f = \sigma^F$ is used as above, after which the assumption is made that during sliding, frictional resistance must be inversely proportional to sliding velocity.

3. Two classes of models are based on the use of **statistical mechanics** involving the physical variables that characterize stress accumulation and failure. Their basic goal is to construct a series of nonlinear stochastic equations whose solutions can be approached by numerical means:

Traveling Density Wave - These models (*Rundle et al.*, 1996; *Gross et al.*, 1996) are based on the slip weakening model. The principle of evolution towards maximum stability is used to obtain a kinetic equation in which the rate of change of slip depends on the functional derivative of a Lyapunov functional potential. This model can be expected only to apply in the mean field regime of long range interactions, which is the regime of interest for elasticity in the Earth. Other models in this class include those of *Fisher et al* (1997) and *Dahmen et al* (1997).

Hierarchical Statistical Models - Examples include the models by *Allègre et al*. (1982, 1996); *Smalley et al.* (1985); *Blanter et al.* (1996); *Allègre and Le Mouel* (1994); *Heimpel* (1996); *Newman et al.* (1996); and *Gross* (1996). These are probabilistic models in which hierarchies of blocks or asperity sites are assigned probabilities of failure. As the level of external stress rises, probabilities of failure increase, and as a site fails, it influences the probability of failure of nearby sites.

C.7 Proposed Computational Approach

The GEM Computational Infrastructure (GEMCI) described in section C.3 requires several technological components. A major one is the detailed simulation modules for the variety of physics and numerical approaches discussed above. This includes the non-local equation solver and physics/friction modules (GEMCI.2,3). The fast multipole, statistical mechanics and cellular automata subsystems will need state of the art algorithms and parallel implementations. These will be built as straightforward MPI-based parallel systems, within the overall modular structure implied by our proposed *Seismic Framework*.

Estimate of Computational Resources Needed: A careful analysis reveals that the algorithms needed for large scale simulations are rather different from those used up to now. We base our analysis on simulations performed so far, which use 80 to 64,000 sites and various interaction laws. We also use the known results from the fast multipole approach to astrophysics simulations with 100 million particles. We estimate an execution time between 4 and 40 milliseconds for each segment and each GEM calculation step on a 300 MHz Pentium II processor. Thus, on a 128 node Origin2000, a large GEM simulation with 100 million segments (corresponding to 10 meter segment sizes) would take between 3 and 36 months. There are many natural ideas to alleviate the computational complexity, but, conversely, many physical effects that could increase needed computing resources. Our estimates suggest that TERAFLOP-class machines will be effective for the very large simulations envisioned for the future, even though we are still able to perform meaningful simulations on the machines available to us today.

Caltech, Colorado and Syracuse have already begun building the necessary high performance non-local equation solver modules. A starting point is the simulation technology developed by *Rundle* (1988), the source code for which is publicly available (anonymous ftp) on host: fractal.colorado.edu at: /pub/Viscocodes/Virtual_California. The Green's function approach in present and future computations will be formulated numerically as a long-range all-pairs interaction problem. We are parallelizing this aspect using well-known algorithms. However one cannot reach the required level of resolution without switching from an order N^2 ($O(N^2)$) to one of the $O(N)$ or $O(N \log N)$ approaches. As in other fields, this can be achieved by dropping or approximating the long-range components and implementing a neighbor-list based algorithm. However it is more attractive to formulate the problem as interacting dipoles and adapt existing fast-multipole technology developed for particle dynamics problems. We have already produced a prototype general purpose "fast multipole template code" by adapting the very successful work of *Salmon and Warren* (1994). These codes have already simulated over 300 million gravitating bodies on a large distributed memory system (a 4500-processor subset of the ASCI "Red" machine), so we expect these parallel algorithms to scale efficiently up to the problem sizes needed by GEM. If we make the conservative assumption that the GEM dipole-dipole Green's function evaluations are ten times as computationally expensive as the Newtonian Green's functions evaluated in Salmon and Warren's code, then a machine comparable to 1000 300Mhz Pentium II systems should be able to compute between 10 and 100 events per day. Notice that the target level of performance can be achieved through a combination of effective use of parallelism and evolution in the microprocessor market.

Multipolar Representation of Fault Systems: A primary key to a successful implementation of GEM models of faults systems will be to utilize computationally efficient algorithms for updating the interactions between fault segments. Converting the Green's function integrals to sums, without truncation or approximation, would require $O(N^2)$ operations between earthquakes, and possibly more for segments of faults experiencing an earthquake. For quasistatic interactions, the Green's functions $\mathbf{T}_{ij}^{kl}$ and $\mathbf{G}_{ij}^{k}$ for linear elasticity have a simple time dependence. Moreover, the Green's functions for linear viscoelasticity and for linear poroelasticity can be obtained from the elastic Green's functions using the correspondence principle (e.g., *Lee*, 1955; *Rundle* 1982a,b). These simplifications strongly suggest that multipole expansions (*Goil*, 1994; *Goil and Ranka*, 1995) will be computationally efficient algorithms.

The stress and displacement Green's functions $\mathbf{T}_{ij}^{kl}$ and $\mathbf{G}_{ij}^{k}$ represent the tensor stress and vector displacement at $\mathbf{x}$ due to a point double couple located at $\mathbf{x}'$ (*Steketee*, 1958). The orientation at $\mathbf{x}'$ of the equivalent fault surface normal vector, and of the vector displacement on that fault surface, are described by the indices i and j. Displacement and stress indices at the field point $\mathbf{x}$ are described by indices k and l. Integration of $\mathbf{T}_{ij}^{kl}$ and $\mathbf{G}_{ij}^{k}$ over the fault surface then corresponds to a distribution of double couples. For that reason, representation of the stress over segments of fault in terms of a multipole expansion is the natural basis to use for the GEM computational problem. In fact, the use of multipolar expansions to represent source fields in earthquake and explosion seismology was introduced by Archambeau (1968) and Archambeau and Minster (1978), and later revisited from a different perspective by Backus and Mulcahy (1976). Minster (1985) gives a review of these early representations.

Application of Fast Multipole Methods to GEM: In the gravitational N-body problem, each body interacts with every other one in the system according to the familiar law of gravitational attraction. Simply computing all pairs of interactions requires N(N-1)/2 separate evaluations of the interaction law. This formulation of the problem has some important advantages: it is easy to code, it is easy to vectorize and parallelize, it is readily expressible in HPF, and it is even amenable to special-purpose hardware [e.g. GRAPE]. Nevertheless, even today's fastest special-purpose systems, running in a dedicated mode for extended times at rates of nearly 1 TERAFLOP, cannot simulate systems larger than about 100,000 bodies.

Tremendous computational savings may be realized by combining bodies into “cells” and approximating their external field with a truncated multipole expansion. When this idea is applied systematically, the number of interactions may be reduced to O(N logN) (*Appel*, 1985; *Barnes and Hut*, 1986) or O(N) (*Greengard and Rokhlin*, 1987; *Anderson*, 1992). The cells are generally arranged in a tree, with the root of the tree representing the entire system, and descendants representing successively smaller regions of space. *Salmon and Warren* (1997) have demonstrated that such codes can run in parallel on thousands of processors and have simulated highly irregular cosmological systems of over 300 million bodies using ASCI facilities.

There is a direct analogy between the bodies in an astrophysical N-body system and the fault segments in a GEM. In both cases, there exists a pair-wise interaction that seems to require $O(N^2)$ interactions. But if we represent the distribution of sources in a region by a multipole expansion, the external field generated by a large number of bodies can be computed to any desired degree of accuracy in constant time. Thus, the GEM problem can also be reduced to O(NlogN) or O(N) total interactions, so that large calculations are tractable. On the other hand, although multipole methods can deliver large performance gains, they also require a considerable infrastructure. This is especially true of efficient parallel implementations. We will develop the multipole version of GEM using a library that has been abstracted from Salmon and Warren's successful astrophysical N-body codes. The continued development of this library, and in particular any new features needed to support GEM will be supported by the project. This new library is:

Modular **-** The “physics” is cleanly separated from the “computer science”, so that in principle, alternative physics modules such as the evaluation of the GEM Green's functions, can simply be "plugged in". The first non-gravitational demonstration was a vortex dynamics code written by *Winckelmans et al.* (1995). The interface to the physics modules is extremely flexible. A general decision-making function tells the treecode whether or not a multipole, or any other approximation, is adequate for a given field evaluation. Short-range interactions, which vanish outside a given radius, can be handled as well.

Tunable **-** Careful attention to analytical error bounds has led to significant speed-ups of the astrophysical codes, while retaining the same level of accuracy. Analytic error bounds may be characterized as quantifying the fact that the multipole formalism is more accurate when the interaction is weak: when the analytic form of the fundamental interaction is well-approximated by its lower derivatives; when the sources are distributed over a small region; when the field is evaluated near the center of a "local expansion"; when more terms in the multipole expansion are used, and when the truncated multipole moments are small. These issues are primarily the concern of the "physics" modules, but the library provides a sufficiently powerful interface to make these parameters adjustable. The formulation is general enough that the same library can be used to support evaluation of O(N), O(NlogN) and O(N^2) approximation strategies, simply by changing the decision criteria and interaction functions.

Adaptive **-** The tree automatically adapts to local variations in the density of sources. This can be important for GEM as it is expected that large earthquakes are the result of phenomena occurring over a wide range of length and time scales.

Scalable **-** The library has been successfully used on thousands of processors, and has sustained 170 Gflops aggregate performance on a distributed system of 4096 200Mhz PentiumPro processors.

Out of core **-** The library can construct trees, and facilitates use of data sets that do not fit in primary storage. This can allow one to invest hardware resources into processing rather than memory, resulting in more computations at constant resources.

Dynamically load balanced **-** The tree data structure can be dynamically load-balanced extremely rapidly by sorting bodies and cells according to an easily computed key.

Portable **-** The library uses a minimal set of MPI primitives and is written entirely in ANSI C. It has been ported to a wide variety of distributed memory systems - both 32-bit and 64-bit. Shared memory systems are, of course, also supported simply by use of an MPI library tuned to the shared memory environment.

Versatile **-** Early versions of the library have already been applied outside the astrophysics and molecular dynamics area. In particular the Caltech and Los Alamos groups have successfully used it for the vortex method in Computational Fluid Dynamics.

In the full GEM implementation, we have a situation similar to the conventional O(N^2) N-body problem but there are many important differences. For instance, the critical dynamics -- namely earthquakes -- are found by examining the stresses at each time step to see if the friction law implies that a slip event will occur. As discussed above, many different versions of the friction law have been proposed, and the computational system needs be flexible so we can compare results from different laws. Analogies with statistical physics are seen by noting that earthquakes correspond to large-scale space-time correlations including up to perhaps a million 10-to-100 meter segments slipping together. As in critical phenomena, clustering occurs at all length scales and we need to examine this effect computationally. However, we find differences with the classical molecular dynamics N-body problems not only in the dynamical criteria of importance but also in the dependence of the Green's function (i.e. "force" potential) on the independent variables. Another area of importance, which is still not well understood in current applications, will include use of spatially dependent time steps (with smaller values needed in active earthquake regions). An important difference between true particles and GEM is that in the latter case, fault positions are essentially fixed in space. Thus the N-body gravitational problem involves particles whose properties are time-invariant but whose positions change with time, while GEM involves "particles" whose positions are fixed in time, but whose properties change with the surrounding environment. Of course a major challenge in both cases is the issue of time-dependent "clustering" of "particles." It may be possible to exploit this in the case of GEM - for example by incrementally improving parallel load-balancing.

We believe a major contribution of this project will be an examination of the software and algorithmic issues in this area with the integration of data and computational modules. We will demonstrate that the use of fine grain algorithmic templates combined with a coarse-grained distributed object framework can allow a common framework across many disciplines.

C.8 GEM Computational Interface Software Environment

As a complement to our general approach described in Section C.3, we sketch here key features of the various components.

GEMCI.1: User Interface

This will include a Javabean applet to control execution of the computational modules. It will support the *Seismic Framework* by allowing the user to get values, set parameters, and invoke the distributed executable objects. NPACI has substantial experience with this technology, which provides a well-defined way of building seamless interoperable interfaces. The "front-end" will support an interactive 2D or 3D map on which one can specify individual faults. The system will support access to computational objects, data and visualization resources.

GEMCI.3: Local Physics

We propose to represent local physics modules in an object-oriented framework. This is possible if we adopt approaches such as Legion or POOMA but we believe a simpler approach may suffice. We will build equation solvers through templates where physics modules are interfaced through defined subroutine interfaces; this will allow us to use modules interchangeably. The *Seismic Framework* will specify interfaces that specify not only the modules to use but also the necessary parameters. These modules will be local and hence sequential and must achieve high performance. We expect therefore to use mature language (Fortran or C) to code them.

GEMCI.4: Evaluation, Data analysis and Visualization

As our simulations grow in fidelity, we expect to need increasingly sophisticated visualization capabilities and we will base these on the experience of other grand challenge projects. We must support both distributed low-level and high-performance workstation visualization as well as high-end capabilities at major sites such as Boston and NPACI (http://www.npaci.edu). Boston University has substantial expertise in simulation physics, acceleration algorithms, and visualization and display. Earth System Science (ESS) is one of four thrust areas within NPACI where major efforts are now underway in Multi-Scale, Multi-Resolution (MSMR) modeling (using climate change as the initial area of study.) The infrastructure developing under the MSMR activities will apply directly to GEM. In addition, the Data Intensive Computing Environments, and Interaction Environments technology thrusts of NPACI are working to expand data management and archival systems capabilities, as well as visualization support. Existing collaborations between the ESS and Technology thrusts of NPACI, in the areas of ecological and environmental modeling and remote sensing, will be brought to bear on the GEM project. This approach will naturally link the visualization and data storage/access components of GEMCI

Syracuse has developed a sophisticated collaborative environment dubbed ***TangoInteractive*** (http://trurl.npac.syr.edu/tango/). It will be available to support remote interactions among the GEM community. *TangoInteractive* can be considered as technology to share distributed objects within a rich interactive environment allowing shared text, white-boards and audio-video interactions. The *Seismic Framework* will of course draw on *TangoInteractive*. Furthermore, NCSA has developed a prototype collaborative visualization system using *TangoInteractive* and this will be available in production mode for the purposes of this proposal. Thus, one group using a high-end *ImmersaDesk* could share visualizations with a remote site running systems like *SciVis* (http://kopernik.npac.syr.edu:8888/scivis/index.html) on a PC. This will facilitate collaboration with GEM simulations.

GEMCI.5: Data storage, indexing and Access:

Growing repositories of geophysical data will be assimilated within the simulations to evaluate and calibrate them. Our approach will exploit the expertise of both NPACI and Syracuse who both are using *Persistent Distributed Objec*t models for such problems. This would be illustrated in the *Seismic Framework* through the use of standard relational databases together with JDBC (Java Database Connectivity) and CORBA (Enterprise Javabean) middleware. Such approaches will allow elegant user interfaces and data access using standard commercial technology. This part of GEMCI will need the development of specialized assimilation modules to support overlaying experimental and computational data. These will be the responsibility of the Colorado team.

GEMCI.6: Complex Systems (Pattern Dynamics) Environment
An important feature of GEM is that it will produce *ab initio* simulations and numerical systems with predictive characteristics, which link data and patterns abstracted from the simulations. An interactive Rapid Prototyping environment for developing new phenomenological models will help with their analysis and visualization. This aspect entails somewhat different trade-offs than the core simulations, in that interactivity is perhaps more critical than performance. We can then view the pattern dynamics module as another execution integrated into the same user interface, data access and visualization subsystems.

C.9 Calibration and Validation of Simulations: We plan to build on the data collection and archive activities of the Southern California Earthquake Center (SCEC) and the planned California Earthquake Research Center (CERC). From our perspective, data are viewed as a means of validating simulations. The GEM team expects, however, that recommendations for new data collection activities might emerge as a natural outgrowth of the simulations, and that an interesting new feedback loop will be initiated between observation seismologists and modelers as a result of the project.

Management of earthquake Data: Primary responsibility for earthquake data collection and archiving lies with the SCEC and CERC, as well as the Seismological Laboratory of the California Institute of Technology, and the Pasadena field office of the United States Geological Survey. Data in these archives include, 1) Broadband seismic data from the TERRASCOPE array; 2) Continuous (SCIGN) and "campaign style" geodetic data; 3) Paleoseismic data collected on the major faults of southern California; 4) Near field strong motion accelerograms of recent earthquakes; 5) Field structural geology of major active faults, 6) Other data including pore fluid pressure, *in situ* stress, and heat flow. These will be used, for example, to update the fault geometry models used by GEM, and to update fault slip histories used to validate earthquake models. Primary responsibility for interacting with elements of this database will be given to a committee chaired by Kanamori and Jordan.

A new and extremely promising type of geodetic data *is Synthetic Aperture Radar Interferometry* (InSAR), which permits "stress analysis of the Earth." A number of SAR missions are currently acquiring data over southern California, including the C-band (5.8 cm) European ERS 1/2 satellites and the L-band Japanese JERS satellite. These missions have already produced revolutionary images of the complete deformation fields associated with earthquakes in the United States and Japan (e.g., *Massonnet et al.*, 1993). These techniques rely on radar interferograms that represent the deformation field at a resolution of a few tens of meters over areas of tens of thousands of square kilometers, and over time intervals of weeks to years. We are now able to see essentially the complete surface deformation field due to an earthquake, and eventually, due to the interseismic strain accumulation processes.

Model Calibration/Validation/Data Assimilation: GPS, InSAR and broadband seismic (TERRASCOPE) data, together with archived and newly developed paleoseismic information in the SCEC database must be used in conjunction with our proposed simulation capabilities to establish the relevant model parameters. These parameters include the current geometry of faults; slip rates on any given segment; recurrence intervals and historic variations in slip during earthquakes—leading to estimates of frictional parameters; deformation data leading to estimates of elastic plate thickness and sub-crustal stress; relaxation times; poroelastic stress relaxation in the crust following earthquakes, leading to estimates of drained and undrained elastic moduli; and variations in seismicity, leading to estimates of the variable properties of friction and fault geometry at depth. Fits of models to data will be accomplished by standard techniques (e.g., *Menke*, 1989), including least squares, evolutionary programming, and simulated annealing (*Michalewicz*, 1996; *Holland*, 1975; *Rawlins*, 1991), among others. In addition, our purpose is to develop new methods so as to adapt models to assimilate new data as that becomes available, a concept that has served meteorological and climate studies extremely well. Self-adaptation techniques can be based on the same kinds of back-propagation methods that have been useful in analysis of neural network models (*Hertz et al.*, 1991). All of these methods pose unique problems, but all of them depend heavily on the use of data visualization methodologies of the type that have been discussed in C.9.

C.10 Role of Senior Investigators: (See also Organization/Management Plan)

Project Leadership:

Rundle	Colorado	Lead Earth Science -- Develop earthquake models, stat. mech approaches, validation of simulations (AL, PSE, AN, VA, SCEC)
Fox	Syracuse	Lead Computer Science -- Develop multipole algorithms and integrate projects internally and with external projects including HPCC and WWW communities (AL, PSE, AN))

Major Senior Investigators:

Andrews	USC/SCEC	Outreach organization, liaison with SCEC (O)
Ben-Zion	USC	Cellular Automata, space-time patterns, rate and state models, dynamic Green's functions (AL, AN)
Giles	Boston	Object oriented friction model algorithms, Cellular Automata computations (AL, AN, PSE)
Henyey	USC/SCEC	Outreach organization, liaison with SCEC (O)
Helly	UCSD/SDSC	Visualization methodologies (AL)
Jordan	MIT	Validating models with "slow earthquake" data (VA, SCEC)
Marone	MIT	Validating models with friction laboratory data (VA)
Kanamori	Caltech	Validating models with broadband earthquake source mechanism data (VA, SCEC)
Kellogg	UC Davis	Nature of driving stresses from mantle processes (AN)
Klein	Boston	Statistical mechanics analogies and methods: Langevin equations for fault systems dynamics, meanfield models (AL, AN)
Minster	UCSD	Validation with GPS & InSAR data (VA, SCEC))
Salmon	Caltech	Parallel multipole algorithms, linkage of model validation with simulation (AL, VA, PSE)
Sammis	USC	Pattern analysis, validation with seismicity (AN)
Shaw	Lamont	Inertial models, stat mech., stress transfer (AL)
Teng	USC	Stress transfer/wave modeling (AL)
Turcotte	Cornell	Nature of driving stresses from mantle processes (AN)
York	Northeastern	Cellular Automata, implementing computational approaches (AL, PSE)
Ward	UC Santa Cruz	Earthquake models, Green's functions, validation (AL, VA)

*Roles: AL) Algorithms; PSE) Problem Solving Environment; AN) Analysis by statistical mechanics/statistical mechanics; VA) Validation; SCEC) Interaction with SCEC/CalTech and other earthquake data bases; O) Outreach

Results from Prior NSF Funding for PI (J.B. Rundle):

John Rundle has been eligible for NSF funding only since he arrived at the University of Colorado at the end of 1993. Over the years, the overwhelming majority of his funding has originated from the Office of Basic Energy Sciences at the US Department of Energy, and from the Geodynamics/Natural Hazard Office of the National Aeronautics and Space Administration. The other investigators on this proposal however, have a much longer and very distinguished record of research supported by NSF. This is NOT summarized here. Nevertheless, we provide below a summary of results from NSF proposals upon which Rundle was Principal Investigator.

EAR-9318648, $11,305 to the Santa Fe Institute for the Study of Complexity for the period 1/1/94-6/30/95, WORKSHOP ON REDUCTION AND PREDICTABILITY OF NATURAL DISASTERS, J.B. Rundle (University of Colorado), W. Klein (Boston University), and D.L. Turcotte (Cornell University)

A workshop on Reduction and Predictability of Natural Disasters was held at the Santa Fe Institute on January 5-9, 1994, with funding generously provided by NASA, DOE, and NSF. The general theme of the meeting was the application of the techniques of statistical mechanics to problems in the earth sciences, and their use in forecasting and understanding natural disasters.

Publications resulting from grant:

1) Rundle, J.B., W. Klein, and D.L. Turcotte, Meeting report, workshop on reduction and predictability of natural disasters, *Trans. Am. Geophys. Un. EOS*, in press, 1994.

2) A book in the Santa Fe Institute series on the sciences of complexity, to be edited by Rundle, Turcotte and Klein, is being prepared for publication to appear in early spring, 1996. It will include the following papers by Rundle, Klein and Turcotte:

a) J.B. Rundle, W. Klein, D.L. Turcotte, and S. Gross, Observation of Boltzmann fluctuations in stochastic massless slider-block simulations.

b) J.B. Rundle and W. Klein, Rupture characteristics, recurrence, and predictability in a slider-block model for earthquakes.

c) W. Klein, C. Ferguson and J.B. Rundle, Spinodals and scaling in slider block models.

EAR-9526814, $110,000 to the University of Colorado at Boulder, "Clustering and Correlations in Seismicity", JB Rundle, S. Gross, V.K. Gupta (University of Colorado).

Work completed to date on this proposal is summarized below:

Rundle, J.B., W. Klein, S. Gross and C.D. Ferguson, The traveling density wave model for earthquakes and driven threshold systems, *Phys. Rev. E*, **56**, 293-302, 1997.

We discuss and interpret new simulation results from a recently proposed, physically-based earthquake model (``traveling density wave" model). This model produces a mixture of scaling and characteristic event ruptures. Stresses are transferred well beyond nearest neighbors in the two-dimensional lattice which represents the fault in the model. Cohesive forces due to small scale fault topography produce large scale friction, showing how friction is a function of length scale and why it is proportional to normal stress. Healing during rupture creates strongly irregular stress distributions, and displacement fields that have the statistical characteristics of a random walk. Strong cohesive forces introduce characteristic length scales into the size distributions. Event frequency statistics are in the range of those observed for natural seismicity.

Gross, S. and J.B. Rundle, A systematic test of time-to-failure analysis, *Geophys. J. Int.*, **133**, 57-64, 1997.

Time-to-Failure analysis is a technique for predicting earthquakes in which a failure function is fit to a time series of accumulated Benioff strain. Benioff strain is computed from regional seismicity in areas that may produce a large earthquake. We have tested the technique by fitting two functions, a power-law proposed by Bufe & Varnes (1993) and a log-periodic function proposed by Sornette & Sammis (1995). We compared predictions from the two time-to-failure models to observed activity and to predicted levels of activity based upon the Poisson model. Likelihood ratios show that the most successful model is Poisson, with the simple Poisson model four times as likely to be correct as the best time-to-failure model. The best time-failure model is a blend of 90% Poisson and 10% log-periodic predictions.

Gross, S.J., Repeating earthquakes on heterogeneous faults, *Bull. Seism. Soc. Am.*, in review, 1998.

Repeating earthquakes are defined to be events with hypocenters within one kilometer of one another having magnitudes within two tenths of a unit. A comparison of the observed number of repeated earthquakes with the number expected based upon the distribution of hypocenters has shown more repeating events than expected by chance in and near the creeping section of the San Andreas Fault. Areas with slower stress accumulation, such as the Landers and Northridge source regions, show no surplus of repeating earthquakes and little difference between the inter-event times of repeated earthquakes as compared to inter-event times of repeated events with dissimilar magnitudes. Studies of slider block models with and without structural heterogeneity support the interpretation that fault structure or strength heterogeneity plays an important role in determining rupture area and consequently the magnitudes of earthquakes.

Other papers in preparation:

Rundle, J.B.E. Preston, S. McGinnis, W. Klein, Why earthquakes stop: Growth and arrest in stochastic fields, to be submitted to *Phys. Rev. Lett.*, 1997.

According to classical Griffith theory, earthquakes nucleating in a homogeneous stress field will not stop until the boundaries of the fault are encountered. We show in this paper that when the stress field is heterogeneous, however, the roughness of the stress field determines whether the rupture will self arrest or spread over the entire fault. An associated stress difference field can be defined whose spectral characteristics determine whether the rupture arrests. If the stress field is characterized by red noise, the rupture will eventually arrest; if blue noise, the rupture cannot self arrest.

Rundle, J.B., W. Klein and K. Tiampo, Linear pattern dynamics in nonlinear threshold systems, to be submitted to *Phys. Rev. Lett.*, 1998.

Anecdotel evidence over many years indicates the existence of space time patterns in seismicity data. Complex nonlinear threshold systems such as earthquakes frequently show space-time behavior that is difficult to interpret. We describe a new technique that allows patterns to be understood as eigenstates of a suitably constructed Impulse Correlation Function (ICF). The dynamics can then be viewed as a progression through the pattern state space of the system. Temporal evolution of the normalized pattern vectors is governed by a Schroedinger equation. The ICF is the generator of motion of patterns states through state space.

Education, Outreach And
Institutional Resource Commitments

1. Outreach: Results of our work will of course be published in the most prestigious scientific journals, as has our research on similar topics in the past. *However, even the possibility of forecasting earthquakes would have a considerable impact on society. Therefore, the investigators feel that the GEM project should have a major component of education and outreach to the government agencies and the public at large.* Through the outreach staff of USC and the Southern California Earthquake Center, we will have access to a highly professional, dedicated, and effective outreach and education program that has a proven record of success over the last eight years. Tom Henyey, Director of SCEC, and the Director of Education and Outreach for USC/SCEC, Jill Andrews, will therefore play critical role in disseminating the results of our research to the public. We have therefore included funds in our budget for Tom and Jill to design and conduct an effective public education and outreach program. Following is a brief description of these plans.

An Earth Science Module -- World Wide Web Based Teaching and Learning Tools to Enhance Nationwide Middle School Earth Science Curricula:

Jill Andrews heads a results-oriented team that manages an array of activities consisting of workshops, publications, WWW sites, education modules, partnerships in industry and education, and database development and management, currently for USC and the Southern California Earthquake Center (SCEC). This group will be an effective broker of information between the academic community and practitioners, between earth scientists and engineers, between technical professionals and public officials, and between scientists and educators. The Center is already known for its effective partnerships with local, state, and national government entities, academic institutions, industry, and the media. The Southern California Earthquake Center Education program, a component of Center Outreach, focuses on earthquake-related education in the K-14 environments. We emphasize the importance of adhering to National Science Education Standards as we create educational materials and tools for use in the nation's classrooms. The General Earthquake Models (GEM) project provides a platform we can build on to characterize, through creation of a WWW-based education module, the use of high performance computing methods to reliably forecast earthquakes.

Because the education standards of today strongly encourage an inquiry-based, accessible approach to learning science, the SCEC-funded Web-based modules now under construction (see http://www.scecdc.scec.org/Module/module.html), "Investigating Earthquakes through Regional Seismicity", have met with enthusiastic acceptance among reviewers from the California Science Implementation Network. Partnership with the GEM principal investigators will enhance the material presented in the existing modules. The central themes in the first modules are earth sciences and the study of earthquake phenomena, and fit into middle school curricula. We propose creation of a mathematically-oriented Web-based module, using GEM as the illustrative example, to acquaint high school instructors and students with the concept of an integrated approach to solving computational challenges, and to lead them through an exercise to produce their own earthquake forecast (probability) models. Students using the first two science modules will have already become familiar with new technologies such as broad-band, high dynamic range digital seismometers, continuously recording GPS systems, and Interferometric Synthetic Aperture Radar (InSAR). The GEM module would build on the foundation and framework set by the first two modules. As in the first modules, animated graphics and links to other Web sites, a glossary of terms, and hands-on activities will be included. We will employ a Web author who will work under the supervision of Jill Andrews, SCEC Outreach Director. Andrews will assemble a special team of scientists and educators (representatives of the California Science Implementation Network) who will review the work in progress for scientific accuracy and who will align the product to the State and National Education Standards.

Institutional Resource Commitments:

GEM investigators all have access to state of the art computer workstation environments. A brief summary of these are given below. As Lead Investigator, and as Director of the Colorado Center for Chaos and Complexity, Rundle will make available all of the facilities of the Center, which has 2 full time staff assistants, over 2000 square feet of meeting space and offices, a network of 10 SUN, WINTEL, and other machines, and reading room/libraries. The Center also has access to all of the facilities of the Cooperative Institute for Research in Environmental Sciences, in which the C4 Center is housed. These include SUN multiprocessor computers, researchers, faculty and staff that number over 500 persons, and access to NOAA facilities and personnel. Since the GEM problem is so similar to El Nino forecasting, we are establishing collaborations with the Climate Diagnostic Center, a part of CIRES, to leverage their expertise.

A letter from Dr. Claudio Rebbi, Director of the MARINER node at Boston University, in which Giles and Klein have leading roles, authorizes 25,000 hours of supercomputer time on the SGI Power Challenge array during the first funded year of the proposal, and will consider an application for similar allotments in succeeding years. The San Diego Supercomputer Center will make available considerable expertise and machine resources to support the visualization requirements in the proposed work. The attached letter from Dr. Sid Karin also describes the previously established procedures that we shall follow for allocation of supercomputer resources at NPACI. The National Parallel Architectures Center at Syracuse University is directed by Geoffrey Fox. NPAC's infrastructure consists of clusters of PC's and many Sun and SGI servers with from 1 to 8 processors. They are interconnected by modern ATM and other networks. These systems will be sufficient for testing the computational software on significant problems but not very relevant as a production simulation resource. NPAC has excellent support for commercial databases and object brokers which will be used in initial implementations of the GEMCI environment. These servers will run on our Sun 4 processor systems and be transferred to larger facilities at Boston or SDSC when necessary. NPAC's system staff will provide professional support to these resources.

Jordan and Marone at the Massachusetts Institute of Technology will make available their network of SUN workstations for computation and data analysis. Together with graduate students they will use SparcUltra machines for calibration and testing of the GEM simulations. In addition, Marone's laboratory is available, which houses a biaxial loading frame for friction and fracture experiments and a triaxial apparatus for work involving fluid flow at higher temperatures. Each of these are servo-controlled and are capable of complex loading histories and a wide range of strain rates.

The Seismological Laboratory of the California Institute of Technology will contribute resources arising from its computer facilities, which include a SUN ULTRA-2 based workstation system, as well as data and processing facilities from its extensive network of 250 short-period seismic stations and 80 broadband TriNet stations operating throughout southern California.

Personnel from the Jet Propulsion Laboratory, although not funded by this proposal, are interested in working with us on various aspects of the proposed work, particularly on calibration and validation of codes using GPS/SCIGN and InSAR data. The attached letter from Diane Evans expresses their primary interest in developing techniques to process InSAR interferograms to develop large crustal deformation data sets for southern California. GEM models will also be a necessary prerequisite for both the LightSAR and ECHO satellite missions that are under development by JPL and NASA, as described in the letter.

The remaining investigators all are well equipped with a variety of UNIX workstations, and intend to use these extensively in support of the proposed work.

April 29, 1998

Dr. John B. Rundle
Department of Physics & CIRES
Colorado Center for Chaos & Complexity
University of Colorado, Boulder, CO

Dear Dr. Rundle,

I am writing in support of your proposal "General Earthquake Models: A New Computational Challenge." The Center for Computational Science at Boston will support the work in this proposal by providing the researchers access to advanced computer facilities described below together with support and applications consulting. In addition, we are at the center of an active community of users and developers of high performance parallel computing technology. As partners in the NCSA Alliance (a recent Partnerships for Advanced Computational Infrastructure Awardee), we are able to link this research effort with a large national community of applications scientists, developers, and resources.

Boston University has a long tradition of support for high performance computational research and has provided leading edge computational resources to its researchers on a university wide basis since the installation of its first massively parallel supercomputer in 1988. The recent installation of the SGI/Cray Origin2000 with 192 processors represents the fourth generation parallel supercomputing technology at the University. The high-end resources also include a 38 processor SGI POWER CHALLENGEarray, high performance graphics workstations, graphics and computational workstation laboratories, a virtual reality laboratory with RealityEngine II graphics and two ImmersaDesks, and high performance ATM and HIPPI based networking with a connection to the vBNS.

We will support the activities of GEM proposal at the level of 25,000 processor hours in the first year, based on your proposal to us for computer resources. We would normally expect that your future use at a comparable level would be approved.

Sincerely,

Claudio Rebbi
Director, Center for Computational Science
Boston University
3 Cummington Street
Boston, MA 02215

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April 24, 1998

Dr. John Rundle
Professor of Physics and Geophysics
Director, Colorado Center for Chaos & Complexity (C4)/CIRES
Campus Box 216
Boulder, CO 80309

Dear John:

We are pleased to team with you in pursuit of the National Science Foundation's Knowledge and Distributed Intelligence (KDI) funding opportunity (NSF9855). Our proposal, General Earthquake Models, is a clear example of the computationally challenging research envisioned by the Earth System Sciences thrust area of our National Partnership for Advanced Computing Infrastructure (NPACI). I will look to Dr. Helly, who is on your proposal team, to provide the liaison between the GEM effort and the NPACI community.

The computational, data, and visualization resource requirements described in this proposal are well within the scope of the NPACI and SDSC capabilities. Geologically realistic simulations will represent a true computational challenge, which our team shall endeavor to meet.

Although time on the HPCC resources within NPACI must be allocated through our competitive resource allocation process, I am confident that this project will fit well in the context of our Earth System Science objectives, and will amply justify the required computational resources.

We will be happy to support the additional efforts in visualization and data management within the scope of the KDI grant itself in conjunction with Dr. Helly and his research team.

Sincerely,

Sid Karin

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109-8099
(818) 354-4321

JPL

March 24, 1998

Dr. John Rundle,
Director
Center for Chaos & Complexity
University of Colorado at Boulder
Campus Box 216
Boulder, CO 80309-0216

Dear Dr. ~~Rundle~~ John:

As you know, both NASA and JPL are extremely interested in the proposed, "General Earthquake Models: A New Computational Challenge" activity. Efforts such as these are required to maximize the value of space based observations from the Global Positioning Satellites (GPS) and Synthetic Aperture Radar (SAR) interferometry. We currently have several internally funded activities that we believe we can contribute to your effort through the participation of Andrea Donnellan, Jay Parker, Ron Blom, Gilles Peltzer, Greg Lyzenga and Paul Rosen. Our particular interests are related to high performance processing of SAR interferograms and analysis of data from the South California Integrated GPS Network (SCIGN) Array. We plan to propose several additional complimentary activities to NASA over the course of the next year culminating with a proposal for a dedicated SAR Interferometry Mission in 2001, for which your model will be invaluable.

Please let me know if any of us can provide you further assistance with this effort.

Sincerely,

Diane L. Evans
Program Scientist for Earth Science
Space and Earth Science Programs Directorate

DLE/jrh
Ref. No. 730-98-014.DLE

Performance Goals

Year 1 Major Activities:

Earthquake Physics:

1. Level 0 simulations based on existing codes of Rundle (1988), with 3D geometry, viscoelastic rheology, algorithms for CA TDW, Rate & State friction interfaces
2. Establishment of basic specifications for GIS-type overlays of simulation outputs upon data
3. Use of existing data bases to establish the basic model parameters, including major fault geometries.
4. Analyzing fault interactions to understand effects of screening and frustration

Computational Science, Software Support & System Integration:

1. Quasistatic Green's functions for other kinds of faults, and establishment of their basic multipolar representations
2. Prototype the fast multipole method with changes needed for GEM
3. Prototype optimal approaches for CA - type, TDW and Rate & State computations
4. Develop Seismic Framework with initial user interface and visualization subsystems.

Year 2 Major Activities:

Earthquake Physics:

1. Level I simulations with evolving fault geometries, shear & tensional fractures
2. First calculations with inertia and waves
3. Pattern evaluation and analysis techniques using phase space reconstruction, and machine reconstruction, and other techniques
4. Systems analysis of faults, and analysis of nonplanar geometries

Computational Science, Software Support & System Integration:

1. Develop and use a simple brute force $O(N^2)$ TDW and Rate & State solution system with fixed time and variable spatial resolution, based on adaptive methods
2. Test initial parallel multipole schemes with machine benchmarking
3. Incorporate multipole solver on an ongoing basis with friction laws, multiresolution time steps.
4. Integrate simpler simulations and data access into operational Problem Solving Environment (GEMCI) supporting distributed simulations, data analysis & collaborative visualization
5. Design and prototype initial Pattern Dynamics interactive environment

Year 3 Major Activities:

Earthquake Physics:

1. Protocols for calibration and validation of full-up simulation capability, numerical benchmarking, scaling properties of models (with SCEC, PEER, CERC)
2. Protocols for assimilation of new data types into models (SCEC, PEER, CERC)
3. Further analysis and cataloguing of patterns, evaluation of limits on forecasting and predictability of simulations
4. Define requirements for future simulations, transfer technology to third parties, outreach to local, state, government agencies as appropriate

Computational Science, Software Support & System Integration:

1. Develop/implement operational Fast Multipole system in terms of full GEMCI
2. Investigate and prototype full time dependent multipole method
3. Fully integrated GEMCI supporting large scale simulations, data access and Pattern Dynamics analysis.

Organization/Management Plan

As described, the GEM undertaking is complex and expensive. We provide a guide to the personnel involved in the various activities, together with names of those responsible for leadership. We felt that in order to ensure success, the broadest participation possible is mandatory. Note that the persons listed below include all collaborators, funded and unfunded, not just major senior personnel.

GEM Team -- Investigator Roles:

Planning and Coordination: The Principal Investigator, Rundle, will be responsible for overall planning, coordination, and integration of the project. Henyey and McRaney will also assist in planning relating to logistics, with liaison to the Southern California Earthquake Center, and with other activities associated with outreach modules.

Modeling and Analysis: Includes Ben-Zion, Gross, Ivins, Kellogg, Klein, Lyzenga, Rundle, Sammis, Shaw, Teng, Turcotte, Ward. Leadership will be provided by Klein and Sammis.

Computations: Includes Bosl, Bradley, Fox, Giles, Helly, Salmon, York. Leadership will be provided by Fox.

Validation/Data Assimilation: Includes Blom, Donnellan, Kanamori, Jordan, Marone, Minster, Peltzer, Rosen. Leadership will be provided by Jordan and Kanomori.

Outreach/Information Dissemination: Although all scientists will participate in this activity, we will focus our efforts around Jill Andrews and John McRaney. Andrews will plan and lead several yearly workshops dedicated to disseminating our results to the public.

Project Management: Rundle, the PI, will have full authority and responsibility for making decisions as to appropriate directions for the GEM KDI project. In particular he will approve budgets and work plans by each contractor and subcontractor. These must be aligned with the general and specific team goals. The PI will be advised by an executive committee made up of a subset of the PI's representing the key subareas and institutions. This committee will meet approximately every 4 months in person and use the best available collaboration technologies for other discussions. The expectation is that the executive committee will operate on a consensus basis. Note that the goals of the KDI project are both Scientific (simulation of Earth Science phenomena) and Computational (development of an object based Problem Solving Environment). The needs of both goals will be respected in all planning processes and contributions in both areas will be respected and viewed as key parts for the mission of the project.

The executive committee will be expanded to a full technical committee comprising at least all the funded and unfunded investigators. The technical committee will be responsible for developing the GEM plan which will be discussed in detail at least every 12 months at the major annual meeting, probably coordinated with the SCEC annual meeting, that we intend to hold for scientists inside and outside this project. As well as this internal organization, we expect NSF may wish to set up an external review mechanism. However we suggest that a GEM external advisory committee consisting of leading Earth and Computer Scientists might be set up and that it will attend GEM briefings and advise the PI as to changes of direction and emphasis. At the present, no budget line is included for this activity.

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Bibliography (within last 5 years) related to proposed work:

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EDUCATION: M.I.T.; S.B. in Electrical Engineering (1983), S.M. in Computer Science (1986), Ph.D. in Electrical Engineering and Computer Science (1992). Abelson and Sussman, advisors.

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Assistant Professor, University of Colorado, Department of Computer Science and Department of Electrical and Computer Engineering, January 1993 to present.

Visiting Scholar, Harvard University, Division of Engineering and Applied Sciences, Spring 1997.

Associate Editor of the Annals of Mathematics of Artificial Intelligence, special issue on ``Reasoning About Functional Models," 1996. Program committee for AAAI '96 and AAAI '97.

RESEARCH/TEACHING INTERESTS: Nonlinear dynamics and chaos; artificial intelligence, specifically qualitative reasoning and qualitative physics; network theory and circuit design; classical mechanics.

AWARDS AND RECOGNITION:

Member, Eta Kappa Nu, Tau Beta Pi, Sigma Xi.

NSF National Young Investigator Award, 1993-1998.

Packard Fellowship in Science and Engineering, 1995-2000.

1988 Olympic Games, 5th Place, Rowing, Women's Four With Coxswain.

SELECTED PUBLICATIONS:

E. Bradley and J. Stuart, ``Using Chaos to Generate Variations on Movement Sequences," Chaos, in review. Preliminary version appeared in the Fourth Experimental Chaos Conference, August 1997.

E. Bradley, A. O'Gallagher, and J. Rogers, ``Global Solutions for Nonlinear Systems using Qualitative Reasoning," Annals of Mathematics and Artificial Intelligence, in press. Preliminary version appeared in the Eleventh International Workshop on Qualitative Reasoning about Physical Systems, Cortona, Italy, May 1997.

J. Dixon, E. Bradley, and Z. Popovic, ``Nonlinear Time-Domain Analysis of Injection-Locked Microwave MESFET Oscillators," IEEE Trans. on Microwave Theory and Technique, 45:1050-1057 (1997).

E. Bradley and D. Straub, ``Using Chaos to Improve the Capture Range of a Phase-Locked Loop: Experimental Verification," IEEE Transactions on Circuits and Systems, 43:914-922 (1996)

E. Bradley, ``Autonomous Exploration and Control of Chaotic Systems," Cybernetics and Systems 26:299-319 (1995).

E. Bradley, ``Causes and Effects of Chaos," Computers and Graphics 19:755-778 (1995).

E. Bradley, ``Using Chaos to Improve the Capture Range of a Phase-Locked Loop," IEEE Transactions on Circuits and Systems 40:808-818 (1993).

E. Bradley and F. Zhao, ``Phase Space Control System Design," IEEE Control Systems Magazine 13:39-46 (1993).

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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:

1990-	Professor of Computer Science, Syracuse University
1990-	Professor of Physics, Syracuse University
1990-	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

Awards and Honors
Senior Wrangler, Part III Mathematics, Cambridge (1964)
Alfred P. Sloan Foundation Fellowship (1973-75)
Fellow of the American Physical Society (1990)

Journal Editorships

Principal:	Concurrency: Practice and Experience (John Wiley, Inc.)
	Physics and Computers (International Journal of Modern Physics C - World Scientific)
Associate:	Journal of Supercomputing,

Selected List of Publications - Geoffrey C. Fox

1. Fox, G.C., Johnson, M.A., Lyzenga, G.A., Otto, S.W., Salmon, J.K., Walker, D.W., Solving Problems on Concurrent Processors, Vol. 1, Prentice-Hall, Inc. 1988; Vol. 2, 1990.
2. Fox, G. C., Messina, P., Williams, R., Parallel Computing Works!, Morgan Kaufmann, San Mateo Ca, 1994.
3. 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 39-46 March/April 1997
4. Fox G.C., Podgorny M, Cheng G. et al., "Web Technologies for Collaborative Visualization and Simulation", SIAM Parallel Processing Conference, March 1997
5. Fox G.C., Dincer K.,"Using Java and JavaScript in the Virtual Programming Laboratory: A Web-Based Parallel Programming Environment" Special Issue on Java, Concurrency:Practice and Experience 9:6 485-508, 1997.

Summary of Interests
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Fox is an internationally recognized expert in the use of parallel architectures and the development of concurrent software and algorithms. His activities include high performance Java and Fortran compilers and their runtime support. Fox has established a community activity to investigate value of Java in large scale networked computing. He is also a leading proponent for the development of computational science as an academic discipline and a scientific method. He has established at Syracuse University both graduate and undergraduate programs which cover both simulation and information technologies. All course have been made available on the Web and his research includes HPCC technology to support education at both K-12 and University level. His research on parallel computing has focused on development and use of this technology to solve large scale computational problems with recent application foci including numerical relativity, earthquake prediction and financial modeling. Fox directs InfoMall, which is focused on accelerating the introduction of high speed communications and parallel computing into New York State industry and developing the corresponding software and systems industry. Much of this activity is in educational area where Fox is leading developments of new K-12 curricula material built using VRML, Java and other new technology. A recent set of activities center on Web collaboration technology and its application to synchronous distance education

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Professional Employment

1985-Present	Associate Professor (tenured), Department of Electrical, Computer and Systems Engineering, College of Engineering, Boston University.
1979-1985	Assistant Professor, Department of Physics and Center for Theoretical Physics, Massachusetts Institute of Technology
1976-1978	Post-Doctoral Fellow, Center for Theoretical Physics, Massachusetts Institute of Technology.
1975-1976	Post-Doctoral Fellow, Theoretical Physics Group, Stanford Linear Accelerator Center (SLAC)

Education

Ph.D.,	Physics	Stanford University, 1975
M.S.,	Physics	Stanford University, 1973
B.A. Honors,	Physics	University of Chicago, 1970

Honors and Fellowships

Faculty Service Award, Boston University College of Engineering, 1996
DOE Undergraduate Computational Science Award, DOE, 1995
DOE Undergraduate Computational Science Award for "Introduction to Parallel Computing Course," 1994
Boston University Scholar–Teacher of the Year 1992-93.

Professional Activities

Deputy Director, Center for Computational Science, 1992–present.
Co-Director, MARINER Project, Boston University, 1995-present.
Member and Team Leader for Education, Outreach, & Training, National Computational Science Alliance Executive Committee, 1997-present.
Member, National Research Council NIST Assessment Board, Panel for Information Technology (NIST), 1997-present
Member, NSF-EHR Special Emphasis Panel on Evaluation, 1997-present
Member, External Advisory Committee, NSF/ARPA Graphics and Visualization Center, 1996-present
Member, Advisory Committee, DOE Computational Science and Engineering Graduate Fellowships Program, 1996-present
Member, Boston Public Schools Technology Planning Committee Advisory Board, 1995-present
Member, Boston Museum of Science Program Advisory Committee, 1995-Present
Co-Chair for SC97 Education Program, SC97 Conference Executive Committee, 1995-97
Member, Board of Directors, Fayerweather Street School, 1988-1995
Associate Chairman, Department of Electrical, Computer, and Systems Engineering, Boston University, 1993-1995.
Member, Organizing Committee for "Workshop on Increasing the Participation of Minorities in Computing Disciplines", 1995.

Professional and Research Interests

My research focuses on the application of high performance and parallel computing to physics and materials problems. I have been particularly active in developing computer simulations of materials. A major research focus has been the parallel simulation of the dynamics of magnetic materials, useful for recording applications, on a scale that has never been done before. We have used the computer to study mechanisms underlying the process of magnetization reversal. Results of this work help develop our understanding of the complex collective processes that underlie magnetic recording technology. I have also worked to develop short range molecular dynamics simulations for very large numbers of particles on a variety of parallel architectures.

I have also been active in the development and elaboration of computational science at Boston University, in the region, and in the Nation. As a cofounder of the Center for Computational Science and as its Deputy Director, I have actively promoted and developed applications of high performance parallel computing and have helped acquire and evaluate supercomputer hardware ranging from our first Connection Machine parallel supercomputer through our current SGI Origin2000. I have developed and taught a variety of graduate and undergraduate Engineering and Physics courses in areas including parallel computer architecture, programming, and electromagnetics. I am also particularly proud of our work developing undergraduate curriculum in parallel computing, supported by the National Science Foundation.

As a Director of our NSF sponsored MARINER outreach project, I worked to extend our educational and research activities in computational science to other University, Corporations, and Schools in the Northeast region. I am working with several schools and school systems to advise and support applications of advanced computer and communications technology in elementary and secondary education. As a member of the Boston Museum of Science Program Advisory Committee, I have helped advocate effective use of advanced information technologies in the museum. As a member of the Boston Public Schools Technology Committee Advisory Board, I have helped formulate policies and proposals for applications of computer technologies in education. I am currently Co-PI on an NSF sponsored project entitled "Teacher-Researcher Collaboration in Scientific Modeling…" which focuses on developing computational science in secondary schools supported by distributed high performance computing resources.

I am a member of the executive committee of the National Computational Science Alliance (NCSA), one of two national multi-institutional partnerships to be funded under the National Science Foundation's Partnerships for Advanced Computational Infrastructure program. This five year project began in October 1997. I coordinate the NCSA Education, Outreach, and Training activities and co-chair the overall National EOT coordinating committee.

I also advise various agencies and groups on computational science related issues. These include the NSF sponsored Graphics and Visualization Center and the National Research Council's Panel on Information Technology which oversees NIST programs.

I am also faculty advisor to the Minority Engineers' Society, a chapter of the National Society of Black Engineers and work in several capacities to help increase the level of participation of underepresented groups in science and computing. I was a Vice President of the Parents Association of the Cambridge School of Weston and have been a long-time member of the Board of Directors of the Fayerweather Street School, Cambridge MA.

Selected Publications

Daniel Reed, Roscoe Giles, Charles Catlett. "Distributed Data and Immersive Collaboration", Comm. ACM. **40**, p 39, 1997.

Elizabeth R. Jessup, Roscoe C. Giles, "Teach Computing in Context," Computational Science & Engineering, **3**, Fall 1996, p54.

Beazley, Lomhdal, Gronbech-Jensen, Giles, and Tamayo, "Parallel Algorithms for Short Range Molecular Dynamics," Annual Reviews in Computational Phyiscs, **3**, 1995.

H. Fu, R. Giles, M. Mansuripur, "Coercivity Mechanisms in Magneto-Optical Recording Media," Computers in Physics, 8, 80 (1994).

R. Giles and M. Mansuripur, "Computer Simulations of Magnetization Reversal Dynamics," Journal of the Magnetic Society of Japan 17 (Supplement S1), 255 (1993).

H. Fu, R. Giles, M. Mansuripur, G. Patterson, "Investigation of the Effects of Nanostructure on the Observable Behavior of Magnetic Thin Films using Large-Scale Computer Simulations" Computers in Physics, 6, 610 (1993).

R. Giles, P.S. Alexopoulos, and M. Mansuripur, "Micromagnetics of Thin Film Cobalt-Based Media for Magnetic Recording," Computers in Physics, 6, 53 (1992).

G. Patterson, R.C. Giles, and F.B. Humphrey, "A Numerical Investigation of Horizontal Bloch Line Motion in Thin Films with Perpendicular Anisotropy," IEEE Transactions on Magnetics, 27, 5498 (1991).

R. Giles and M. Mansuripur, "Micromagnetics of Thin--Film CoX Media for Longitudinal Magnetic Recording," J. Appl. Phys., 69, 4712 (1991).

M. Mansuripur and R. Giles, “Coercivity of Domain Wall Motion in Thin Films of Rare Earth–Transition Metal Alloys” J. Appl. Phys., 69, 4844 (1991).

A. De Rujula, R. Giles, R. Jaffe, “Unconfined Quarks and Gluons,” Phys. Rev. D17, 285 (1978).

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EDUCATION:

University of California, Los Angeles, CA	Ph.D. (Computer Science)	1984
University of California, Los Angeles, CA	MS (Biostatistics)	1978
Occidental College, Los Angeles, CA	MA/BA (Biology)	1975

EXPERIENCE

1995 – present	Senior Staff Scientist, San Diego Supercomputer Center
1994 – 1995	Principal Scientist, San Diego Supercomputer Center
1991 – 1994	Director, Data Management and Scientific Computing, MEC Analytical Systems, Carlsbad, CA
1988 – 1991	Senior Scientist and Manager, Database Technology, Hughes Space and Communications Group, El Segundo, CA
1982 – 1988	Systems Director, Advanced Projects, Space Flight Operations, Shuttle and Ground Control Systems, Shuttle Operations, The Aerospace Corporation, El Segundo, CA
1978 – 1981	Lecturer in Biochemistry, Department of Anesthesiology, UCLA Medical Center
1976 – 1981	Senior Statistician, Department of Anesthesiology, UCLA Medical Center
1977 – 1981	Statistical Consultant, Division of Thoracic Surgery, Department of Surgery, UCLA Medical Center
1976 – 1977	Statistician, Child Trauma Intervention Project, Neuropsychiatric Institute, UCLA Medical Center
1974 – 1975	Visiting Instructor in Biology, Occidental College, Los Angeles, CA

RELEVANT PUBLICATIONS

- Helly, J. J., Visualization of Ecological and Environmental Data, in Data and Information Management in Ecological Sciences: A Resource Guide, eds. W. Michener, J. H. Porter, S. Stafford, Univ. of New Mexico Press (to appear).
- Michener, W., J. Brunt, J. Helly, T. Kirchener, and S. Stafford. Non-geospatial metadata for ecology. *Ecological Applications*, February 1997
- Helly, J. J.and K. Herbinson. (1994). Visualization of a salinity plume from a coastal marine desalination plant, *Water Environ. Res.* Jul/August, 66(5) pp. 753-758.
- Helly, J. J. *Effects of Temperature and Thermal Distribution on Glycolysis on Two Rockfish Species (Sebastes)*, Marine Biology, 37,89-95
- Helly, J. J. and A. Carpenter. (1993). *Visualization of coastal marine water quality data using parallel coordinates*, SAS User Group Conference (SUGI '93 Conference paper).
- Helly, J. J. (1994). *An Ultra Low-Level Remote Sensing System (ULLRSS)*,.Proc. of Second Thematic Conf. Remote Sensing for Marine and Coastal Environments, Marine Spill Response Corp., U. S. EPA, ERIM, New Orleans.
- Deland, E., and J. J. Helly: Compartmental physiological models with chemical reactions, *Proceedings of IMACS,* Sorrento, Italy, pp. 333–338, 1980.
- Helly, J. J., and E. Deland: Complex system modeling with statistical methods, *Winter Simulation Conference Proceedings,* **v. 82,** pp. 611-615, 1981.

RECENT COLLABORATORS

James Brunt, University of New Mexico
Ted Case, University of California, San Diego
Frank Davis, University of California, Santa Barbara
James Gosz, University of New Mexico
Matt Jones, University of California, Santa Barbara
Simon Levin, Princeton University
William Michener, Jones Ecological Research Center
Scott Miller, Bishop Museum, Honolulu, Hawaii
Richard Olson, Oak Ridge National Laboratory
Cheri Pancake, Oregon State University
James Reichman, University of California, Santa Barbara
Mark Schildauer, University of California, Santa Barbara
Susan Stafford, Oregon State University
Steward Pickett, Institute for Ecosystem Studies
Robert Waide, University of New Mexico

GRADUATE ADVISOR

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SHORT RESUME OF THOMAS L. HENYEY

A. Personal Information

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B. Education

A.B. Geophysics, University of California, Berkeley, 1962
Ph.D. Geophysics, California Institute of Technology, 1968

C. Professional Experience

Research Assistant, Caltech, 1966-1967
Teaching Assistant, Caltech, 1967-1968
Assistant Professor of Geological Sciences, University of Southern California, 1968-1974
Associate Professor of Geological Sciences, University of Southern California, 1974-1981
Sabbatical leave, U.C. Santa Barbara, Spring, 1976
Professor of Geological Sciences, University of Southern California, 1981-present
Sabbatical leave, DSIR, New Zealand, Summer/Fall, 1982
Professor of Geological Sciences and Chairman, Department of Geological Sciences, University of Southern California, 1989-1991
Professor of Geological Sciences, University of Southern California and Executive Director, Southern California Earthquake Center, 1991-1996
Professor of Geological Sciences, University of Southern California and Director, Southern California Earthquake Center, 1996-present

D. Some Recent Publications

Li, Y.G., T.L. Teng, and T.L. Henyey, Shear Wave Splitting Observations and Implications for the Stress Regime in the Los Angeles Basin, Southern California, Bull. Seis. Soc. Amer., 84, 307-323, 1994.
Schiffries, C.M. and T. L. Henyey, A possible earthquake deficit in southern California, Geotimes, June, 1994.
Henyey, Tom, One shock leads to another, News and Views, Nature, 375, No.6258, p. 191, 1995.
Malin, P.E., E.D. Goodman, T.L. Henyey, Y.G. Li, D.A. Okaya, and J.B. Saleeby, Significance of seismic reflections beneath a tilted exposure of deep continental crust, Tehachapi Mountains, California, Jour. Geophys. Res., 100, 2069-2088, 1995.
Jackson, D., K. Aki, A. Cornell, J. Dieterich, T. Henyey, M, Mahdyiar, D. Schwartz, and S. Ward, Seismic hazards in southern California: Probable earthquakes, 1994-2024, Bull. Seis. Soc. Amer., 85, no. 2, 379-439, 1995.

E. Advisors, Collaborators, Graduate Students and Post-Doctoral Fellows

Graduate Advisors: Gerald Wasserburg, James Brune
Collaborators: S. Holbrook (Wyoming), N. Christensen (Wisconsin), T. McEvilly (UCB), R. Clayton (Caltech), G. Fuis (USGS), P. Davis (UCLA), G. Jiracek (SDSU), T Stern (Victoria, N.Z.), F. Davey (IGNS-N.Z.); Also, Scientists from the Southern California Earthquake Center and the publication list above.
Graduate Students and Post-Doctoral Fellows: Robert Clayton, Avijit Chakraborty, Mike Forrest, Ned Field, Rachel Abercrombie, Nicola Godfrey, Yong-Gang Li.

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Vitae

EDUCATION:
B.S., Geophysics, California Institute of Technology, 1969
M.S., Geophysics, California Institute of Technology, 1970
Ph.D., Geophysics and Applied Mathematics, California Institute of Technology, 1972

EMPLOYMENT:
1969-1972: Graduate Research Assistant, California Institute of Technology, Pasadena, California;
1972-1975: Assistant Professor, Princeton University, Princeton, New Jersey;
1975-1977: Assistant Professor, Scripps Institution of Oceanography, University of California, San Diego, California;
1977-1982: Associate Professor, Scripps Institution of Oceanography, University of California, San Diego, California;
1982-1984: Professor, Scripps Institution of Oceanography, University of California, San Diego, California;
1984-Present: Robert R. Shrock Professor of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Mass.;
1988-Present: Department Head, Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Mass.

HONORS & AWARDS:
National Merit Scholar, 1965-1969; Alfred P. Sloan Fellow in Physics, 1980-1982; Fellow, American Geophysical Union, 1983; James B. Macelwane Award, American Geophysical Union, 1983; Fellow, American Academy of Arts and Sciences, 1996.

Scientific Publications

1991 Jordan, T.H., Far-field detection of slow precursors to fast seismic ruptures, *Geophys. Res. Lett.*, **18**, 2019-2022.
1993 Ihmlé, P. F., P. Harabaglia, and T. H. Jordan, Teleseismic detection of a slow precursor to the great 1989 Macquarie Ridge earthquake, *Science*, **261**, 177-183.
1994 Ihmlé, P. F., and T. H. Jordan, Teleseismic search for slow precursors to large earthquakes, *Science*, **266**, 1547-1551.
1995 Ihmlé, P. F., and T. H. Jordan, Source time function of the great 1994 Bolivia deep earthquake by waveform and spectral inversion, *Geophys. Res. Lett.*, **22**, 2253-2256.
1996 McGuire, J. J., P. F. Ihmlé, and T. H. Jordan, Time-domain observations of a slow precursor to the 1994 Romanche Transform earthquake, *Science*, **274**, 82-85, 1996.
1986 Riedesel, M.A., T.H. Jordan, A. F. Sheehan, and P. G. Silver. Moment-tensor spectra of the 19 Sept 85 and 21 Sept 85 Michoacan, Mexico, earthquakes, *Geophys. Res. Lett.*, **13,** 609-612.
1989 Riedesel, M.A., and T.H. Jordan, Display and assessment of seismic moment tensors, *Bull. Seis. Soc. Am.*, **79**, 85-100.
1988 Jordan, T.H. Structure and formation of the continental tectosphere, *J. Petrol*, Special Lithosphere Issue, 11-37.
1990 Beroza, G.C., and T.H. Jordan, Searching for slow and silent earthquakes using free oscillations, *J. Geophys. Res.*, **95**, 2485-2510.
1991 Gee, L.S., and T.H. Jordan, Generalized seismological data functionals, *Geophys. J. Int.*, in press.

Recent Collaborators (last 48 months, exclusive of students)

J. Rundle, University of Colorado; D. Weidner, SUNY, Stoney Brook; Paul Silver, Carnegie Institution of Washington; David James, Carnegie Institution of Washington.

Doctoral Dissertations Supervised

1979 S. A. Sipkin, *Constraints on Earth Structure Determined from Observations of Multiple ScS*, UCSD.
1981 K. A. Sverdrup, *Seismotectonic Studies in the Pacific Ocean Basin*, UCSD.
1982 A. L. Lerner-Lam, *Linearized Estimation of Higher-Mode Surface Wave Dispersion*, UCSD.
P. G. Silver, *Optimal Estimation of Scalar Seismic Moment*, UCSD (Eckart Prize winner).
1984 K. C. Creager, *Geometry, Velocity Structure, and Penetration Depths of Descending Slabs in the Western Pacific*, UCSD.
1985 M. A. Riedesel, *Seismic Moment Tensor Recovery at Low Frequencies*, UCSD.
D. K. Smith, *The Statistics of Seamount Populations in the Pacific Ocean*, UCSD.
R. G. Adair, *Microseisms in the Deep Ocean: Observations and Theory*, UCSD.
1988 K. M. Fischer, *The Morphology and Dynamics of Subducting Lithosphere*, MIT.
1989 J. Sauber, *Geodetic Measurement of Deformation in California*, MIT.
J. S. Revenaugh, *The Nature of Mantle Layering from First-Order Reverberations*, MIT.
G. C. Beroza, *Near-Source Imaging of Seismic Rupture*, MIT.
1990 L. S. Gee, *New Techniques for Seismological Studies of Earth Structure*, MIT.
E. Lavely, *Theoretical Investigations in Helioseismology*, MIT.
J. A. Goff, *Stochastic Modeling of Seafloor Morphology*, MIT.
1991 M. H. Murray, *Global Positioning System Measurement of Crustal Deformation in Central California*, MIT.
1991 K. L. Feigl, *Geodetic Measurement of Tectonic Deformation in Central California*, MIT.
1994 P. F. Ihmlé, *Teleseismic Study of Earthquakes of Long Duration*, MIT.
1995 P. Puster, *The Characterization of Seismic Earth Structures and Numerical Mantle Convection Experiments Using Two-Point Correlation Functions*, MIT.
1995 J. G. Gaherty, *Structure and Anisotropy of the Upper Mantle*, MIT.
1998 R. Katzman, *Structure and Dynamics of the Pacific Mantle*, MIT.

Graduate and Postgraduate Advisors:

Ph.D. advisor: D. L. Anderson, Caltech
Postgraduate advisor: none

Hiroo Kanamori
California Institute of Technology

Born - 17 October 1936, Japan (Japanese citizen)

Education:

B. S. (Geophysics) Tokyo University, 1959
M. S. (Geophysics) Tokyo University, 1961
Ph.D. (Geophysics) Tokyo University, 1964

Professional Experience:

Research Associate, Geophysical Institute, Tokyo University, 1962-65
Research Fellow, California Institute of Technology, 1965-66
Associate Professor, Earthquake Research Institute, Tokyo University, 1966-69.
Visiting Associate Professor, Massachusetts Institute of Technology, 1969
Professor, Earthquake Research Institute, Tokyo University, 1970-72
Professor, California Institute of Technology, 1972-
Director, Seismological Laboratory, California Institute of Technology, 1990-

Bibliography:

Kanamori, H., and M. Kikuchi, The 1992 Nicaragua Earthquake: a slow tsu ami earthquake associated with subducted sediments, Nature, 361, 714-716, 1993.
Kanamori, H., J. Mori, E. Hauksson, T. H. Heaton, L. K. Hutton and L. M. Jones, 1993, Determination of Earthquake Energy Release and ML Using TERRAscope, Bull. Seismol. Soc. Am., 83, 330-346, 1993.
Kikuchi, M., and H. Kanamori, The mechanism of the deep Bolivia earthquake of June 9, 1994, Geophys. Res. Lett, 21, 2341-2344, 1994.
Huang, W., L. T. Silver, and H. Kanamori, Seismic Evidence for Detachment Structures in Southem Califomia, Geology, submitted 1995.
Kanamori, H., The Kobe (Hyogo-ken Nanbu), Japan, Earthquake of January 16, 1995, Seismol. Res. Lett., 66,, No. 2, p. 6-10, 1995.
Kikuchi, M., and H. Kanamori, Rupture process of the Kobe, Japan, earthquake of Jan. 17, 1995 determined from teleseismic body waves, J. of Physics of the Earth, submitted 1995.
Kikuchi, M., and H. Kanamori, The Shikotan Earthquake of October 4, 1994, a lithospheric earthquake, Geophys. Res. Lett, 22, 1025-1028, 1995.
Mori, J., and H. Kanamori, Initial rupture of earthquakes in the 1955 Ridgecrest, Califomia sequence, Geophys. Res. Lett., 23, 2437-2440, 1996.
Kanamori, H., D. L. Anderson, and T. H. Heaton, Frictional Melting During Faulting, Science, 279, 839-842, 1998.

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Education

Doctor of Philosophy	Geophysics, Cornell University, 1988
Master of Engineering	Engineering Physics, Cornell University, 1985
Bachelor of Science	Engineering Physics
Bachelor of Arts	Philosophy
	Cornell University, 1982 (Dual Degree Program)

Professional Experience

Associate Professor of Geology, University of California, Davis, 1993 - present.
Assistant Professor of Geology, University of California, Davis, 1990 - 1993.
Myron C. Bantrell Research Fellow in Geochemistry and Geophysics California Institute of Technology, 1988 - 1990.

Honors and Awards:

Presidential Faculty Fellowship, (National Science Foundation) 1992-1997.
Myron C. Bantrell Research Fellowship in Geochemistry and Geophysics, Caltech, 1988-1990.

10 Recent Publications:

E. Gamete, J. Revenaugh, Q. Williams, T. Lay, and L. H. Kellogg, Ultralow velocity zone at the core-mantle boundary, in press in the AGU monograph on the Core-Mantle Boundary, 1997.
T. Lay, E. J. Garnero, Q. Williams, R. Jeanloz, B. Romanowicz, L. Kellogg, and M. E. Wysession, Seismic wave anisotropy in the D" region and its implications, in press in the AGU monograph on the Core-Mantle Boundary, 1997.
W. S. Kiefer and L. H. Kellogg, Geoid anomalies and dynamic topography from timedependent, spherical, axisymmetric mantle convection, in press in Physics of the Earth and Planetary Interiors, 1997.
G. Bawden, A. Donnellan, L. H. Kellogg, D. Dong, and J. Rundle, Geodetic measurements of horizontal strain near the White Wolf fault, Kern County, California, 1926-1993, Journal of Geophysical Research, 102, 4957-4967, 1997.
L. H. Kellogg, Growing the Earth's D" layer: Effect of density variations at the core-mantle boundary, Geophysical Research Letters, 24, 2749-2752, 1997.
M. A, Feighner, L. H. Kellogg, and B. J. Travis, Numerical modeling of chemically buoyant mantle plumes at spreading centers, Geophysical Research Letters, 22, 715-718, 1995.
L. H. Kellogg and S. D. King, Effect of mantle plumes on the growth of D" by reaction between the core and mentle, Geophysical Reasearch, 20, 379-382, 1993
H. Kellogg, Chaotic Mantle Mixing, Advances in Geophysics, 34, 1-33, 1993.
L. H. Kellogg, Mixing in the Mantle, Annual Reviews of Earth and Space Sciences, 20, 365398, 1992.

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Experience

Senior Research Scientist 12/95 to present NPAC, Syracuse University, Syracuse

- Project Leader for four major computational research efforts:
- Binary Black Hole Grand Challenge (http://www.npac.syr.edu/projects/bh/). Team leader
- Rome Lab Weather Project (http://kopernik.npac.syr.edu:8888/weather/). Project leader
- Scientific Data Visualization (http://kopernik.npac.syr.edu:8888/weather/). Project leader
- Fnancial modeling (http://terminator.npac.syr.edu:4761/Demo/history2.html/). Involved with a collaboration of business people and academic people

Supervision of graduate/undergraduate students

Management and Supervision of graduate and undergraduate students: In the last 2 years at NPAC, I have supervised 3 undergraduates in the Research Experiences for Undergraduates in High Performance Computing at NPAC (http://www.npac.syr.edu/REU/). I have also supervised 1 Ph.D. student in physics, 1 Master's student in Computer Science, and 1 Ph.D. student in Computer Science. In addition I have supervised 4 other graduate student projects since I have been at Syracuse.

Post Doctorate Fellowship 09/94 to 12/95 University of Texas, Austin

Designed several numerical tools for the solution of large-scale PDE's including: A three-dimensional elliptic PDE solver for the initial value solution of the coalescence of two black holes. This code used state-of-the-art numerical techniques including: Multi Level Adaptive Techniques, Adaptive Mesh Refinement, Deferred Correction.

Research Associate 06/94 to 09/94 Center for Relativity, University of Texas, Austin

Designed a large scale PDE elliptic solver for the initial value problem for general relativity.

Research Associate, 09/89 to 06/94, Center for High Performance Computing, University of Texas,

Worked on visualizations for medical imaging including: Designed visualization techniques to show MRI's and CAT scans in three dimensions; and implemented a visualization technique to map from an abstract mathematical model, to the human body to display the spread of head and neck cancer.

Junior Physicist 1987,1988, Plasma Physics Laboratory, Diagnostics Division, Princeton University

Designed a large-scale computer system for the diagnostic spectroscopy group working on plasma physics, which is still in use today. Large portion of the coding went into the reliability and reusability of this code.

Education:
Ph.D., Physics, 1994, University of Texas, Austin (Supervisor: Dr. Richard Matzner)
B.S., Physics, 1989, Drexel University, Philadelphia, Computer Experience

Recent Publications

- "Schwarzschild-Perturbative gravitational wave extraction and outer boundary conditions (w./ Abrahams et. Al.), submitted to Phys. Rev. Letters 1997.
- "Moving a Black Hole" (w/ Huq et. Al.), submitted to Phys. Rev. Letters 1997.
- "The Binary Black Hole Grand Challenge ADM code", (w/ Huq et. Al.) sumitted to Phys. Rev. D, 1997.
- "Collaborative Scientific Visualization" (w/ B. Ki), Journal of Concurrent computing?", 1997.
- "Multigrid- An Approach in HPF" (w/ U. Dittmer)
- "Multigrid support with the DAGH package: Specifications and Applications" (w/ M. Choptuik et al.), Site report, 1995.
- "A Technique for Tracking Apparent Horizons," (w/ M. Huq et al.), Site Report 1996.
- "A Parallel Implementation of Multi-Grid in one dimension" (w/ R. Guenther), (Site report, 1994).
- "Visualizing Complex Patterns in the Spread of Head and Neck Cancers," (w/ L. Gray et al.), The International Journal of Supercomputer Applications 7, 167 (1993).
- "Three-dimensional initial data for the collision of two black holes," (w/ G. Cook et al.), Physical Review D47, 1471 (1993).

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EDUCATION

Ph.D. Temple University 1972, Physics
B.A. Temple University 1965, Physics

POSITIONS

Professor of Physics, Boston University, Sept. 1984–

Visiting Professor, Oersted Institute, University of Copenhagen July 1992–Jan. 1993

Professor, College of Engineering, Boston University, April 1992–

Associate Professor of Physics, Boston University, Sept. 1981–Sept. 1984

Visiting Scientist, IBM Zurich, August 1983

Assistant Professor of Physics, Boston University, Jan. 1977–Sept. 1981

Research Scientist, Institut für Theoretische Physik, Universität zu Köln, Sept. 1974–Sept. 1976

PostDoctoral Fellow, Mathematics Department, MIT, Sept. 1973–Sept. 1974

PostDoctoral Fellow, National Bureau of Standards, June 1972–Sept. 1973

Additional Activities

Consultant, Digital Equipment Corporation, 1984–1985

Consultant, Schlumberger-Doll, 1983–1985

Member, Editorial Board, Journal of Statistical Physics, January 1, 1991–December 31, 1993

PUBLICATIONS RELEVANT TO PROPOSAL

[1] J. B. Rundle and W. Klein, "Non-Classical Nucleation and Growth of Cohesive Tensile Cracks" Phys. rev. Lett. **63**, 171 (1989)

[2] J. Rundle and W. Klein, "Scaling and Critical Phenomena in a Class of Burridge-Knopoff Models for Earthquakes" J. Stat. Phys. **72** 405 (1993)

[3] W. Klein and J. B. Rundle, "Comment on 'Self Organized Criticality in a Continuous, Nonconservative Cellular Automaton Modelling Earthquakes" Phys. Rev. Lett. **71**, 1288 (1993)

[4] J. B. Rundle and W. Klein, "Dynamical Segmentation and Rupture Patterns in a 'Toy' Slider Block Model for Earthquakes" Non-Linear Proc. in Geophys. **2**, 61 (1995)

[5] J. B. Rundle, W. Klein, S. Gross and D. L. Turcotte, "Boltzmann Fluctuations in Simulations of Non-Equilibrium Threshold Systems" Phys. Rev. Lett. **75**, 1658 (1995)

ADDITIONAL PUBLICATIONS

[1] W. Klein, D. J. Wallace and R. P. K. Zia "Essential Singularities at First Order Phase Transitions" *Phys. Rev. Lett.* **37**, 639 (1976)

[2] P. J. Reynolds, W. Klein and H. E. Stanley "A Real Space Renormalization Group for Site and Bond Percolation" *J. Phys. C* **10**, L167 (1977)

[3] A. Coniglio and W. Klein "Correlated Site-Bond Percolation and Ising Critical Droplets" *J. Phys. A*, **13**, 2775 (1980)

[4] D. W. Heermann and W. Klein "Nucleation and Growth of Non-Classical Droplets" Phys. Rev. Lett. **50** 1062 (1983)

[5] W. Klein and F. Leyvraz "Crystalline Nucleation in Deeply Quenched Liquids" *Phys. Rev. Lett.* **57**, 2845 (1986)

Graduate Student and Post Doctoral Collaborators

Students

1. Leacir Lucena - University of Natal, Brazil
2. Dieter Heermann - University of Heidelberg
3. Christopher Unger - Texas Instrument
4. James Given - NIST
5. Tane Ray - University of Eastern Missouri
6. Pablo Tamayo - Thinking Machines Co.
7. Liza Monette - Exxon
8. John Ross - University of Southern Indiana
9. Iuval Clejan - Boston University
10. Nicolas Gross - University of Pittsburgh
11. Raphael Ramos - Florida State

Post Doctoral Collaborators

1. Francois Leyvraz - University of Mexico at Cuenavaca
2. Alan Brown - Address Unknown

Collaborators in the Last 4 years not on above lists 1. Raymond Mountain - NIST

2. Andrew Mel'cuk - Boston University
3. George Batrouni - KFA Jülich
4. Martin Zuckermann - McGill University
5. Lou Colonna-Romano - Clark University
6. Karl Ludwig - Boston University
7. Harvey Gould - Clark University

Thesis Advisor M. S. Green - Deceased

PostDoctoral Advisors

1. Eliot Lieb - Princeton University
2. J. Zittartz - University of Cologne

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Education

1989 Ph.D. Geophysics Columbia University.
Dissertation: *Experimental Studies of Simulated Fault Gouge: Frictional Behavior, Microstructures, and Stability of Sliding*.

1987 M. Phil. Geophysics Columbia University.

1984 M.A. Geophysics Columbia University.

1981 B.A. Geology State University of New York at Binghamton.

Honors

1993 Kerr-McGee Career Development Professorship, Massachusetts Institute of Technology.

1989-1990 Melbourne University, Postdoctoral Research Fellowship.

1982-1988 Columbia University/Lamont-Doherty Geological Observatory Faculty Fellowship.

Academic Appointments

1997-present *Associate Professor of Geophysics*, Massachusetts Institute of Technology.
1992-1997 *Assistant Professor of Geophysics*, MIT.
1991-1992 *Adjunct Assistant Professor*, University of California at Berkeley.
1989-1990 *Research Fellow*, Melbourne University and CSIRO Division of Geomechanics, Australia.
1982-1988 *Graduate Research Assistant*, Lamont-Doherty Geological Observatory of Columbia University.

Research Interests

Earthquake physics and fault mechanics, rock friction, fracture, scaling laws.

Recent Professional Activities

1998 Co-convener, *Amer. Geophys. Union* Meeting, Special Session in Seismology.
1997 Committee of Examiners, GRE Geology Test.
1996 Steering Committee, Physical Properties of Earth Materials, Amer. Geophys. Union
1996 Nominating Committee for the Seismological Society of America Board of Directors.

1996, 1997 Panel member, National Earthquake Hazards Reduction Program, External Research Program.
1996 Guest Co-Editor, *Tectonophysics*, Special issue on Earthquake Generation Processes.

Professional Affiliations

American Geophysical Union, Seismological Society of America

Colleagues, Collaborators, and Ph.D. Advisors

C. Barry Raleigh (Thesis Advisor), Chris Scholz (Thesis Advisor),
Mike Blanpied, John Vidale, Bill Ellsworth,

Graduate Student and Posdoctoral Associations

S. Karner, M. Roy, G. Chen, M. Liu, K. Mair, E. Richardson, L. Montesi.

Selected Recent Publications

Marone, C., and S. J. D. Cox, Scaling of rock friction constitutive parameters: the effects of surface roughness and cumulative offset on friction of gabbro, *Pure and Applied Geophysics, 143,* 359-386, 1994.

Vidale, J. E., W. Ellsworth, A. Cole, and C. Marone, Rupture variation with recurrence interval in eighteen cycles of a small earthquake, *Nature, 368,* 624-626, 1994.

Marone, C., Fault zone strength and failure criteria, *Geophysical Research Letters*, *22,* 723-726, 1995.

Marone, C., Vidale, J. E., and W. Ellsworth, Fault healing inferred from time dependent variations in source properties of repeating earthquakes, *Geophysical Research Letters*, *22, 3095-3098*, 1995.

Marone, C., Reply to comment on “Fault zone strength and failure criteria”, *Geophysical Research Letters*, *23*, 791-792, 1996.

Roy, M., and C. Marone, Earthquake nucleation on models faults with rate and state dependent friction: the effects of inertia, *Journal Geophysical Research, 101*, 13,919-13,932, 1996.

Karner, S. L, C. Marone, and B. Evans, Laboratory study of fault healing and lithification in simulated fault gouge under hydrothermal conditions, *Tectonophysics, 277,* 41-55, 1997.

Marone, C., and M. Liu, Transformation shear instability and the seismogenic zone for deep earthquakes, *Geophysical Research Letters*, *24,* 1,887-1,890, 1997.

Marone, C., On the rate of frictional healing and the constitutive law for time- and slip-dependent friction, *Int. J. Rock Mech. & Min. Sci. 34:3-4,* 1997.

Marone, C., The effect of loading rate on static friction and the rate of fault healing during the earthquake cycle, *Nature, 391,* 69-72, 1998.

Jean-Bernard Minster
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Position: Professor of Geophysics
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EDUCATION:

Ingénieur: Ingénieur Civil des Mines de Paris, 1969
Ingénieur: Ingénieur du Pétrole, Institut Francais du Pétrole, 1969
Ph.D.: Geophysics, California Institue of Technology, 1974
Doctorat d'État: Géophysique, Université de Paris VII, 1974

SELECTED RECENT PUBLICATIONS:

Baker, GE, JB Minster, G Zandt, and H Gurrola, Constraints on crustal structure and complex Moho topography beneath Piñon Flat, California, from teleseismic receiver functions, Bull. Seismol. Soc. Amer., 86, 1830-1844, 1996.

Calais, E, and JB Minster, GPS detection of ionospheric perturbations following a Space Shuttle ascent, Geophys. Res. Lett., 23, 1897-1900, 1996.

Ridgway, JR, JB Minster, N Williams, JL Bufton and WB Krabill, Airborne laser altimeter survey of Long Valley, California, Geophys. J. Int., 131, 267-280, 1997.

Calais, E, JB Minster, MA Hofton, and MAH Hedlin, Ionospheric signature of surface mine blasts from Global Positioning System measurements, Geophys. J. Int., 132, 191-202, 1998.

Hofton, MA, JB Blair, JB Minster, JR Ridgway, NP Williams, JL Bufton, and DL Rabine, Using laser altimetry to detect topographic change at Long Valley caldera, California, Earth Surface Remote Sensing, SPIE, 3222, 295-306, 1997.

Shkoller, S and JB Minster, Reduction of Dietrich-Ruina attractors to unimodal maps, Nonlinear Processes in Geophysics, 4, 63-69, 1997.

Xu, H, SM Day and JB Minster, Model for nonlinear wave propagation derived from rock hysteresis measurements, J. Geophys. Res., submitted, 1998

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Education B.S EECS: Massachusetts Institute of Technology, 1981
B.S. Physics: Massachusetts Institute of Technology, 1981.
M.S. Physics: U.C. Berkeley, 1983.
Ph.D. Physics: California Institute of Technology, 1991.

Awards
Gordon Bell Prize for Achievement in Large Scale Scientific Computing, 1992.
Intel Grand Challenge Computing Award, 1992.
Two Gordon Bell Prizes for Achievement in Large Scale Scientific Computing, 1997.

Publications

BOOKS

[1] Thomas Sterling, Don Becker, and John Salmon. How to build a Beowulf. MIT Press, Fall 1998. (in preparation.

[2] Geoffrey C. Fox, Mark A. Johnson, Gregory A. Lyzenga, Steven W. Otto, John K. Salmon, and David W. Walker. Solving Problems on Concurrent Processors. Prentice Hall, Englewood Cliffs, NJ, 1988.

REFEREED JOURNALS AND CONFERENCES

[1] Thomas Sterling, Tom Cwik, Don Becker, John Salmon, Mike Warren, and Bill Nitzberg. An assessment of Beowulf-class computing for NASA requirements: Initial findings from the first NASA workshop on Beowulf-class clustered computing. In IEEE Aerospace Conf. IEEE, 1998.

[2] David Pfitzner, John Salmon, and Thomas Sterling. Halo world: Tools for parallel cluster finding in astrophysical N-body simulations. J. of Data Mining and Knowledge Discovery, 2, 1998. special issue on scalable high-performance computing.

[3] Michael S. Warren, John K. Salmon, Donald J. Becker, M. Patrick Goda, Thomas Sterling, and Gr6goire S. Winckelmans. PentiumPro inside: I. a treecode at 430 Gflops on ASCI red, II. Price/performance of $50/Mflop on Loki and Hyglac. In Supercomputing '97, Los Alamitos, 1997. IEEE Comp. Soc.

[4] John K. Salmon and Michael S. Warren. Parallel out-of-core methods for N-body simulation. In Michael Heath, Virginia Torczon, et al., editors, Eight SIAM Conference on Parallel Processing for Scientific Computing. SIAM, 1997.

[5] Michael S. Warren, Donald J. Becker, M. Patrick Goda, John K. Salmon, and Thomas Sterling. Parallel supercomputing with commodity components. In H. Arabnia, editor, Intl. Conf. on Parallel and Distributed Processing Techniques and Applications (PDPTA97), pages 1372-1381. CSREA, 1997.

[6] David W. Pfitzner and John K. Salmon. Parallel halo finding in N-body cosmology simulations. In Evangelos Simoudis, Jiawei Han, and Usama Fayyad, editors, KDD-96 Proceedings: The Second International Conference on Knowledge Discovery & Data Mining, pages 26-31. AAAI Press, 1996.

Charles G. Sammis
University of Southern California

Present Position:

Professor of Geological and Materials Sciences, University of Southern California
Visiting Professor, University College London

Born: 1944, Huntington, New York

Education:

Brown University, Sc. B. (Cum Laude, with honors in Physics) 1965
California Institute of Technology, M.S. (Geophysics) 1968
California Institute of Technology, Ph.D., 1971

Previous Positions:

N.A.T.O. Postdoctoral Fellow in the School of Theoretical Chemistry at the University of Bristol, 1971-72
Assistant Professor of Geophysics, Department of Geosciences, The Pennsylvania State University, 1972-75
Associate Professor of Geophysics, Department of Geosciences, The Pennsylvania State University, 1975-77
Associate Professor of Geophysics, Department of Geological Sciences, University of Southern California, 1977-1987
Professor, Department of Geological Sciences, University of Southern California, 1987-

Academic Awards:

United Aircraft Scholarship, Brown University, 1961-1965.
Title IV Fellowship, Caltech, 1966-1970.
N.E.R.C. Visiting Scientist Fellowship, Cambridge, 1983-1984.
Burlington Resources Foundation Faculty Research Award, 1991.
USC Associates Award for Excellence in Teaching, 1994.

Professional Activity:

Department Chair:	Dept. of Earth Sciences, University of Southern California 1994-
Visiting Scholar:	Cambridge University Engineering Laboratory, 1983-1984
Visiting Professor:	Institut de Physique du Globe de Paris,
	Universite Pierre et Marie Curie, Summer, 1987.
	Institute for Theoretical Physics (U.C. Santa Barbara), Fall, 1992
Associate Editor:	Journal of Geophysical Research, 1984-1987
Associate Editor:	Reviews of Geophysics and Space Physics, 1984-1987
Member:	NASA Planetary Science Review Panel, 1980-1982

Member:	AGU Mineral Physics Committee, 1984-
Member:	AGU Publicity Committee , 1988-1991
Member:	Geomechanics Committee of the Am.Soc.Mech.Engineers, 1988-
U.S. Organizer:	U.S.-Japan Seminar on "Fracture, Form, and Fractals", NSF U.S.-Japan Cooperative Science Program, Lake Arrowhead, CA. 1989

FIVE SELECTED RELEVANT RECENT PUBLICATIONS

Huang, Y., H. Saleur, C. Sammis, and D. Sornette, Precursors, aftershocks, criticality and self-organized criticality, Europhys. Letters , 41, 43-48, 1998.

Saleur, H., C.G. Sammis, and D. Sornette, Discrete scale invariance, complex fractal dimensions, and log-periodic fluctuations in seismicity, J. Geophys. Res., 101, 17,661-17,677, 1996.

An, L-J., and C.G. Sammis, A cellular automaton for the growth of a network of shear fractures, Tectonopyhsics, 253, 247-270, 1996.

Robertson, M.C., C.G. Sammis, M. Sahimi, and A. Martin, The 3-D spatial distribution of earthquakes in southern California with a percolation theory interpretation, J. Geophys. Res., 100, 609-620, 1995.

Sornette, D., and C.G. Sammis, Complex critical exponents from renormalization group theory of earthquakes; implications for earthquake predictions, J. Phys.I France, 5, 607-619, 1995.

Bruce E. Shaw
Columbia University

Education:
A.B. Physics, magna cum laude, University of California, Berkeley 1984
Ph.D. Physics, supervised by Leo Kadanoff, University of Chicago 1989

Employment:
Teaching Assistant, University of Chicago 1984-85
Research Assistant, University of Chicago 1986-89
Postdoctoral Fellow, Institute for Theoretical Physics, UCSB 1989-92
Postdoctoral Scientist, Lamont Doherty Earth Observatory 1993-95
Associate Research Scientist, Lamont Doherty Earth Observatory 1995-
Summer Research Assistant, UC Irvine, 1981, 1982

Experience:
Summer Research Fellowship in Geophysics, Yale University 1983
Summer School: "Nonlinearities in Geophysics", UCLA 1988

Honors:
University of California, Berkeley Alumni Scholar 1980-84
Phi Beta Kappa, University of California, Berkeley 1984
Storke-Doherty Lectureship, Columbia University 1995

Related Publications:
Jean M. Carlson, James S. Langer, Bruce E. Shaw, and Chao Tang, Intrinsic Properties of a Burridge-Knopoff Model of an Earthquake Fault, Physical Review A, 44, 884, 1991.

Bruce E. Shaw, Jean M. Carlson, and James S. Langer, Patterns of Seismic Activity Preceding Large Earthquakes, Journal of Geophysical Research, 97, 479-88, 1992.

Bruce E. Shaw, Moment Spectra in a Simple Model of an Earthquake Fault, Geophysical Research Letters, 20, 643, 1993.

Bruce E. Shaw, Generalized Omori Law for Aftershocks and Foreshocks from a Simple Dynamics, Geophysical Research Letters, 20, 907, 1993.

Shirlev L. Pepke, Jean M. Carlson. and Bruce E. Shaw. Prediction of Large Events on a Dynamical Model of a Fault, Journal of Geophysical Research, 99, 6769, 1994.

Jean M. Carlson, James S. Langer, and Bruce E. Shaw, Dynamics of Earthquake Faults, Reviews of Modern Physics, 66 657, 1994.

Bruce E. Shaw, Complexity in a Spatially Uniform Continuum Fault Model, Geophysical Research Letters, 21, 1983, 1994.

Bruce E. Shaw, Frictional @Veakening and Slip Complexity in Earthquake Faults, Journal of Geophysical Research 100, 18239, 1995.

Christopher H. Myers, Bruce E. Shaw, and James S. Langer, Slip Complexity in a Two Dimensional Crustal Plane Model, Physical Review Letters, 77, 972 , 1996.

James S. Langer, Jean M. Carlson, Christopher H. Myers, and Bruce E. Shaw, Slip Complexity in Dynamical Models of Earthquake Faults, Proceedings of the National Academy of Sciences, 93, 3825 , 1996.

LEON TENG
University of Southern California

A. Education

B. S. (Geology) National Taiwan University, Taipei, Taiwan, China, 1959.

Ph.D. (Geophysics and Applied Mathematics), California Institute of Technology, 1966

B. Professional Experience

Professor of Seismology, University of Southern California, 1976 -.
Member of California Earthquake Prediction Evaluation Council, 1976-1982.
Member of Academia Sinica

C. Selected Recent Publications

Wang, J. and T.L. Teng (1993) Surface-wave profiling of the lithosphere beneath the Mojave desert using TERRAscope date, J. Geophys. Res., Vol. 99, No. B1, 743-750.

Qu, J. , T.L. Teng and J. Wang (1994) Modeling of short-period surface waves propagation in Southern California, Bull. Seis. Soc. Am., Vol. 84, No. 3, 596-612.

Qu, J. and T.L. Teng (1994) Recursive stochastic deconvolution in the estimation of earthquake source parameters: synthetic waveforms, to appear Phys. Earth Plan. Int., Vol. 86, 301-327.

Wang, J. and T.L. Teng (1995) Artificial neural network-based seismic detector, Bull. Seis. Soc. Am., Vol. 85, No.1, 308-319.

Huang, B.S., T.L. Teng, C.C. Liu, and T.C. Shin (1996) Excitation of short-period surface waves in Taiwan by the Hyogo-Ken Nanbu earthquake of January 17, 1995, Journal of Physics of the Earth, 44 (4), 419 - 427.

Teng, T.L., L. Wu, T.C. Shin, Y.B. Tsai, and W.H.K. Lee (1997) Development on Earthqyake Rapid Reporting: One Minute after: Intensity Map, Epicenter, and Magnitude, 1997 Proceedings of Maring Meteorology and Seismology, Central Weather Bureau of Taiwan, 781-792.

Teng, T.L., L. Wu, T.C. Shin, Y.B. Tsai, and W.H.K. Lee (1997) One Minute after: strong-motion map, effective epicenter, and effective magnitude, Bull. Seismo. Soc. Am., Vol. 87, No. 5, 1209-1219.

Wu, Y.M.,Shin, T.C., Chen, C.C.,Tsai, Y.B., Lee, W.H.K. and Teng, T.L. (1997) Taiwan rapid earthquake information release system, Seism. Res. Ltr., Vol. 68, No. 6, 931-943.

Wang, J. and T.L. Teng (1997) Identification and picking of S phase using artificial neural network, Bull. Seis. Soc. Am., Vol. 87, No.5, 1140-1149.

Donald L. Turcotte
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a. Donald L. Turcotte, is the Maxwell Upson Professor of Engineering in the Department of Geological Sciences, Cornell University, Ithaca, New York. He received B.S. and Ph. D. degrees from Caltech in 1954 and 1958 respectively and has been on the Faculty of Cornell University since 1959. He is author or co-author of 4 books and 251 papers. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences and has received the Day Medal of the Geological Society of America, the Wegener Medal of European Union of Geosciences, the Whitten Medal of the American Geophysical Union, and the Regents (New York State) Medal of Excellence.

Donald Turcotte has actively worked on fractals, chaos, self-organized criticality, and related topics for 15 years. His book (D.L. Turcotte, *Fractals and Chaos in Geology and Geophysics*, 2nd ed., Cambridge University Press, 1997) is the primary textbook and reference work in this area in the earth sciences. Recently he has also applied concepts of complexity to a variety of natural hazards including earthquakes, floods, forest fires, and landslides.

b. Five related publications:

B. Barriere and D.L. Turcotte, Seismicity and self-organized criticality, Phys. Rev. E49, 1151-1160, (1994).

W.I. Newman, D.L. Turcotte, and A.M. Gabrielov, Log-periodic behavior of a hierarchical failure model with applications to precursory seismic activatiion, Phys. Rev. E52, 4827-4835, (1995).

D.L. Turcotte, Earthquakes, fracture, complexity, in Nonlinear Analysis of Fracture, J.R. Willis, ed., pp. 163-175, Kluwer, Dordecht, 1997.

J.D. Morgan, D.L. Turcotte, and J.R. Ockendon, Models for earthquake rupture propagation, Tectonophys., 277, 209-217 (1997).

G. Morein, D.L. Turcotte, and A. Gabrielov, Statistical mechanics of distributed seismicity, Geophys. J. Int., in press, 1997.

Five other publications:

D.L. Turcotte and W.I. Newman, Symmetries in geology and geophysics, Proc. Natl. Acad. Sci. USA 93, 14,295-14,300, (1996).

B.D. Malamud, D.L. Turcotte, and C.C. Barton, The 1993 Mississippi River flood: A one hundred or a one thousand year event?, Environ. Eng. Geosci., 2, 479-486, (1996).

J.D. Pelletier, and D.L. Turcotte, Scale-invariant topography and porosity variations in fluvial sedimentary basins, J. Geophys. Res. 101, 28,165-28,175, (1996).

J. Lighthill, D.L. Turcotte, and K. Conrad, Large scale hazards - tropical cyclones, earthquakes, risk, mathematics, in ICIAM 95, K. Kirchgossner, O. Mahrenholtz, and R. Menuicken, eds., pp. 155-176, Akademic Verlag, Berlin (1996).

D.L. Turcotte, Fractals and Chaos in Geology and Geophysics, 2nd, ed. (Cambridge Univesity Press, 1997) 398.

c. Collaborators (last 48 months)

J. Arkani-Hamed, McGill
Chris Barton, USGS
Boris Bukchin, IIEPTMG. Moscow
Klaus Conrad, Munich Re
Andrei Gabrielov, Purdue University
Susanna Gross, Colorado
Vladimir Keilis-Borak, IIEPTMG, Moscow
William Klein, Boston University
Vladimir Kossobokov, IIEPTMG, Moscow
Alexander Lander, IIEPTMG, Moscow
Sir James Lighthill, University of London
George Molchan, IIEPTMG, Moscow
William Newman, UCLA
Lee Phoenix, Cornell
Vladilen Pisarenko, IIEPTMG, Moscow
Igor Primakov, IIEPTMG, Moscow
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John Rundle, Colorado
Peter Shebalin, IIEPTMG, Moscow
Michail Shnirman, IIEPTMG, Moscow
Alexander Soloviev, IIEPTMG, Moscow

d. Former graduate students (5 years)

Benoit Barriere, University of Paris
Richard Birchwood, City University of New York
Jie Huang, Exxon Production Research
Algis Kucinskas, JPL
John Morgan, Univesity of Oxford
Jon Pelletier, Caltech

(Total number of graduate students supervised 79, total number of postdoctoral scholars sponsored 6)

e. Present graduate students

Gleb Morein

Steven Neal Ward
Research Geophysicist
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Education:

B.S., Physics, 1974	Bucknell University, Lewisburg, Pennsylvania
M.A., Geophysics, 1976	Princeton University, Princeton, New Jersey
Ph.D., Geophysics, 1978	Princeton University, Princeton, New Jersey

Recent Experience:

7/86-Present	Research Geophysicist
1/84-6/86	Associate Research Geophysicist, University of California, Santa Cruz
10/80-12/83	Associate Research Geophysicist Harvard University

Service:

1992-Present: Board of Editors Geophysical Journal International
1990: Guest Co-Editor for the Geophysical Research Letters special issue on the 1989, Loma Prieta Earthquake.

Publications (5 most recent only):

Ward, S. N. and G. Valensise, 1996. Progressive growth of San Clemente Island, California, by blind thrust faulting: implications for fault slip partitioning in the California Continental Borderland, Geophys. Jour. Int., 126, 712-734.

Ward, S. N., 1996. A synthetic seismicity model for southern California: Cycles, Probabilities, Hazards, J. Geophys. Res., 101, 22,393-22,418.

Ward, S. N., 1997. Dogtails versus Rainbows: Synthetic earthquake rupture models as an aid in interpreting geological data, Bull. Seism. Soc. Am., 87, 1422-1441.

Ward, S. N., 1997. More on *M,.*, *Bull. Seism. Soc. Am.*, 87, 1199-1208.

Ward, S. N., 1998. On the consistency of earthquake rates, geological fault data, and space geodetic strain: The United States, *Geophys. Jour. Int.*, in press.

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Education:

Ph.D. University of Massachusetts - Amherst, Computer Science
M.S. University of Massachusetts - Amherst, Computer Science
S.M. Sloari School of Management, M.I.T., Management
A.B. Brandeis University, Waltham, MA, Mathematics

Professional Experience:

8/97 - Present-	Co-Director of Laboratory for Networking and Distributed Computing
9/91-Present:	Associate Professor and Research Director College of Computer Science, Northeastern University, Boston, MA
9/90-9/91	Program Director, CISE/CDA, National Science Foundation, Washington, DC 20550
9/90-8/91:	Visiting Research Scientist, Center for Computing and Applied Mathematics National Institute of Standards and Technology, Gaithersburg, MD 20899
1/86-8/91	Associate Professor (on leave 1990-91), Computer Science Department, Boston University, Boston, MA
6/84-1/86	Consulting Software Engineer, AI Technology Group, Digital Equipment Corporation, Hudson, MA
2/83-6/84	Principal Softwaxe Engineer, Al Technology Group, Digital Equipment Corporation, Hudson, MA
6/79-2/83	Research Staff member, Computer Science Dept, IBM Research Labs, San Jose, CA

Professional Societies: ACM, IEEE-CS, AAAI, AAAS, SIAM

Professional Service:
Member, National Science Foundation CISE Directorate Advisory Committee, 1992-1997
Member, ACM Education Board, 1991-1996
Member, ACM U. S. Public Policy Committee, 1992-present
ACM Eastern Regional Representative, 1996-1997
Chair, ACM Committee on Minorities, 1994-95
Minority mentor, New England Board of Higher Education, 1992-present
NSF panelist - 19@present (except 90-91)
NSF reviewer - 1989-present (except 90-91)
Member, Program Committee, Society and the Future of Computing 96, 1996
Co-Chair, Education Committee for Supercomputing 97 Conference, 1995 - 1997
Member Ph.D. Advisory Committee in Computer Science and Engineering, University of Puerto Rico, 1996 - 1998

Five Relevant Publications:

"The Ab-Initio Crystal Structure Solution of Proteins by Direct Methods. VI. Complete phasing up to derivative resolution", C. Giacovazzo, D, Siliqi, J. Platas, H-J. Hecht, G. Zanotti, B. W-York, Acta Cryst., (1996). D52. 813-825

“Transform Techniques for Parallel Promsing Analysis”, J. J. Rushanan and B.W. York, submitted to Networks, November 1995.

"On the Scalability of Parallel Triplet Generation for Protein Crystallography, S. Ramamurthy, B. W. York, and C. Giacovazzo, in Proc. of 1996 ACM Symposium on Experimental Computing and Applications Development (SAC 96), pp. 344-352, February 1996, Philadelphia.

“Matrix invenion in 0(log n) on a Scan-Enhanced Reconfigurable Mesh Computer", A. Moreira and B. W. York, in Proc. of 24th Annual ACM Computer Science Conference, pp. 67-75, February 1996, Philadelphia.

“Virtual Topology Embeddings on Networks of Workstations for High-Performance Computing, B. Yener,-B. W. York, Y- Ofek, and M. Yung, in Proc, of IEEE Third Workshop on the Architecture and Implementation of High Performance Communication Subsystems, pp192-195, Mystic, CT., August 1996.

Five Additional Publications:

“Constructing Permutation Representations for Matrix Groups, G, Cooperman, L. Finkelstein, M. Tselman, and D. W. York, to appear in Journal Of Symbolic Computation.

Discrete Wavelet Transforms on a Massively Parallel Platform”, J. Fridman, B. Manolskos and B. W. York, in Proc. of the International Conference on Signal Processing Applications and Technology (ICSPAT'95), pp. 1512-1516, Boston, MA., October 1995.

"Generalized Stone-Wales Transformations”, D. Babic, S. Bassoli, M. Casartelli, F. Cataldo, A. Graovac, 0. Ori, B. W. York, in Molecular Simulation, vol. 14, pp. 395-401.

"A Parallel Multi-Grid Algorithm for Percolation Clusters", R. Brower, P. Tamayo, and B. York, J. of Statistical Physics, vol. 63, no 1/2, pp. 73-88, April 1991.

“Some Performance Results for a Connection Machine Implementation of the Boundary Contour Systems”, B, York and M. Atkins, in the Proc. of the International Joint Conferences on Neural Networks, Vol I, pp 351-8, San Deigo, CA. June 1990.

Additional Collaborators in last 48 Months-. John Rundle, Bill Klein, Richard Tolimieri, Myoung An, Roscoe Giles, Geoffrey Fox

Ph.D. Thesis Advisor: Edward Riseman
Ph.D. Students: Alberto Moreira, Tony Sena

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION University of Colorado at Boulder	FOR NSF USE ONLY				
	PROPOSAL NO.	DURATION (months)			
		Proposed	Granted		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR John B Rundle	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. John B Rundle - none	0.00	0.00	1.00	$ 8,590	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	8,590	
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. (2) GRADUATE STUDENTS				41,760	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				50,350	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,210	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				54,560	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Sun Sparc Server $ 15,000					
TOTAL EQUIPMENT				15,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,500	
2. FOREIGN				6,750	
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				2,750	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				3,000	
5. SUBAWARDS				751,103	
6. OTHER				31,610	
TOTAL OTHER DIRECT COSTS				789,963	
H. TOTAL DIRECT COSTS (A THROUGH G)				870,773	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 45.5% of MTDC (Rate: 45.50, Base: 250310)					
TOTAL INDIRECT COSTS (F&A)				113,891	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				984,664	
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)				$ 984,664	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* John B Rundle	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 YEAR 2

ORGANIZATION University of Colorado at Boulder				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR John B Rundle				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. John B Rundle - none	0.00	0.00	1.00	$ 8,908	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	8,908		
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. (2) GRADUATE STUDENTS				43,310		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				52,218		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,315		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				56,533		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,658		
2. FOREIGN				6,986		
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				2,854		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				3,105		
5. SUBAWARDS				757,542		
6. OTHER				32,717		
TOTAL OTHER DIRECT COSTS				798,218		
H. TOTAL DIRECT COSTS (A THROUGH G)				866,395		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 45.5% of MTDC (Rate: 45.50, Base: 78466)						
TOTAL INDIRECT COSTS (F&A)				35,702		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				902,097		
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)				$ 902,097	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* John B Rundle	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

**** G-6 Other**
Tuition Remission: $30,388

SUMMARY PROPOSAL BUDGET

YEAR 3

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

ORGANIZATION
University of Colorado at Boulder

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
John B Rundle

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. John B Rundle - none	0.00	0.00	1.00	$ 9,238	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	9,238	
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. (2) GRADUATE STUDENTS				44,919	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				54,157	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,425	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				58,582	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,821	
2. FOREIGN				7,231	
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				2,961	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				3,214	
5. SUBAWARDS				764,983	
6. OTHER				9,350	
TOTAL OTHER DIRECT COSTS				782,508	
H. TOTAL DIRECT COSTS (A THROUGH G)				853,142	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 45.5% of MTDC (Rate: 45.50, Base: 81220)					
TOTAL INDIRECT COSTS (F&A)				36,955	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				890,097	
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)				$ 890,097	$

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

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

SUMMARY PROPOSAL BUDGET

Cumulative

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

ORGANIZATION
University of Colorado at Boulder

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
John B Rundle

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. John B Rundle - none	0.00	0.00	3.00	$ 26,736	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	3.00	26,736	
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. (6) GRADUATE STUDENTS				129,989	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				156,725	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				12,950	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				169,675	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 15,000					
TOTAL EQUIPMENT				15,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				13,979	
2. FOREIGN				20,967	
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				8,565	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				5,500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				9,319	
5. SUBAWARDS				2,273,628	
6. OTHER				73,677	
TOTAL OTHER DIRECT COSTS				2,370,689	
H. TOTAL DIRECT COSTS (A THROUGH G)				2,590,310	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				186,548	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				2,776,858	
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)				$ 2,776,858	$

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

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

SUMMARY PROPOSAL BUDGET — YEAR 1

ORGANIZATION: **Boston University**			FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **William Klein**			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. William Klein	0.00	0.00	1.00	$ 9,764	$
2. Roscoe Giles	0.00	0.00	1.00	9,268	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,032	
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. (1) GRADUATE STUDENTS				17,250	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				36,282	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,453	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,735	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,336	
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)				43,071	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63% of MTDC (Rate: 63.00, Base: 43072)					
TOTAL INDIRECT COSTS (F&A)				27,135	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				70,206	
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)				$ 70,206	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $	
PI / PD TYPED NAME & SIGNATURE* William Klein	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

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Boston University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **William Klein**				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. William Klein	0.00	0.00	1.00	$ 9,764	$
2. Roscoe Giles	0.00	0.00	1.00	9,268	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,032	
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. (1) GRADUATE STUDENTS				17,250	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				36,282	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,453	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,735	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,336	
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)				43,071	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63% of MTDC (Rate: 63.00, Base: 43072)					
TOTAL INDIRECT COSTS (F&A)				27,135	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				70,206	
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)				$ 70,206	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **William Klein**	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

YEAR 3

ORGANIZATION **Boston University**			FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **William Klein**			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. William Klein	0.00	0.00	1.00	$ 9,764	$
2. Roscoe Giles	0.00	0.00	1.00	9,268	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,032	
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. (1) GRADUATE STUDENTS				17,250	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				36,282	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,453	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,735	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,336	
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)				43,071	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63% of MTDC (Rate: 63.00, Base: 43072)					
TOTAL INDIRECT COSTS (F&A)				27,135	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				70,206	
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)				$ 70,206	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **William Klein**	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

Cumulative

	FOR NSF USE ONLY		
ORGANIZATION **Boston University**	PROPOSAL NO.	DURATION (months)	
		Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **William Klein**	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. William Klein	0.00	0.00	3.00	$ 29,292	$
2. Roscoe Giles	0.00	0.00	3.00	27,804	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	6.00	57,096	
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. (3) GRADUATE STUDENTS				51,750	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				108,846	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,359	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				122,205	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				7,008	
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)				129,213	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				81,406	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				210,619	
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)				$ 210,619	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **William Klein**	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

YEAR 1

ORGANIZATION: California Institute of Technology				FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Hiroo Kanamori				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. Hiroo Kanamori	0.24	0.00	0.00	$ 8,000	$	
2. John Salmon	0.00	0.00	0.00	22,838		
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.24	0.00	0.00	30,838		
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. (1) GRADUATE STUDENTS				14,717		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				45,555		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,710		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				53,265		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,447		
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				1,620		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				1,500		
5. SUBAWARDS				0		
6. OTHER				11,774		
TOTAL OTHER DIRECT COSTS				14,894		
H. TOTAL DIRECT COSTS (A THROUGH G)				72,606		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 59.5% of MTDC (Rate: 59.50, Base: 60832)						
TOTAL INDIRECT COSTS (F&A)				36,195		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				108,801		
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)				$ 108,801	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE*: Hiroo Kanamori	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

**** G-6 Other**
GRA Benefit (80% of GRA salary,IDC exempt)

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **California Institute of Technology**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Hiroo Kanamori**				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. Hiroo Kanamori	0.36	0.00	0.00	$ 8,240	$	
2. John Salmon	0.00	0.00	0.00	22,838		
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.36	0.00	0.00	31,078		
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. (1) GRADUATE STUDENTS				15,159		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				46,237		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,770		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				54,007		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,447		
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				1,620		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				1,500		
5. SUBAWARDS				0		
6. OTHER				12,127		
TOTAL OTHER DIRECT COSTS				15,247		
H. TOTAL DIRECT COSTS (A THROUGH G)				73,701		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **59.5% of MTDC (Rate: 59.50, Base: 61574)**						
TOTAL INDIRECT COSTS (F&A)				36,636		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				110,337		
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)				$ 110,337	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* **Hiroo Kanamori**	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
YEAR 3

ORGANIZATION **California Institute of Technology**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Hiroo Kanamori**				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. Hiroo Kanamori	0.36	0.00	0.00	$ 8,487	$	
2. John Salmon	0.00	0.00	0.00	22,838		
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.36	0.00	0.00	31,325		
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. (1) GRADUATE STUDENTS				15,614		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				46,939		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,832		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				54,771		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,447		
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				1,620		
3. CONSULTANT SERVICES				1,500		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				12,491		
TOTAL OTHER DIRECT COSTS				15,611		
H. TOTAL DIRECT COSTS (A THROUGH G)				74,829		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **59.5% of MTDC (Rate: 59.50, Base: 62338)**						
TOTAL INDIRECT COSTS (F&A)				37,091		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				111,920		
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)				$ 111,920	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* **Hiroo Kanamori**	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

**** G-6 Other**
GRA benefit $12,491, IDC exempt

SUMMARY PROPOSAL BUDGET — Cumulative

ORGANIZATION California Institute of Technology					FOR NSF USE ONLY PROPOSAL NO. / DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Hiroo Kanamori					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. Hiroo Kanamori	0.96	0.00	0.00	$ 24,727	$
2. John Salmon	0.00	0.00	0.00	68,514	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.96	0.00	0.00	93,241	
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. (3) GRADUATE STUDENTS				45,490	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				138,731	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				23,312	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				162,043	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				13,341	
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				4,860	
3. CONSULTANT SERVICES				1,500	
4. COMPUTER SERVICES				3,000	
5. SUBAWARDS				0	
6. OTHER				36,392	
TOTAL OTHER DIRECT COSTS				45,752	
H. TOTAL DIRECT COSTS (A THROUGH G)				221,136	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				109,922	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				331,058	
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)				$ 331,058	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				
PI / PD TYPED NAME & SIGNATURE* Hiroo Kanamori	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

YEAR 1

ORGANIZATION **Massachusetts Institute of Technology**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months)		
		Proposed	Granted	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Thomas H Jordan**	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. Thomas H Jordan	0.00	0.00	0.60	$ 8,875	$
2. Christopher J Marone	0.00	0.00	1.25	8,875	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.85	17,750	
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. (1) GRADUATE STUDENTS				8,946	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				26,696	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,970	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				31,666	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,400	
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				3,060	
5. SUBAWARDS				0	
6. OTHER				16,979	
TOTAL OTHER DIRECT COSTS				20,039	
H. TOTAL DIRECT COSTS (A THROUGH G)				54,105	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63.5% of MTDC on Campus (Rate: 63.50, Base: 23407) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				15,945	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				70,050	
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)				$ 70,050	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **Thomas H Jordan**	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

**** G-6 Other**
Tuition Remission $16,979
**** I- Indirect Costs**
9.6% of MTDC off Campus (Rate: 9.60, Base 11271)

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Massachusetts Institute of Technology**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Thomas H Jordan**				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. Thomas H Jordan	0.00	0.00	0.60	$ 9,319	$
2. Christopher J Marone	0.00	0.00	1.25	9,319	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.85	18,638	
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. (1) GRADUATE STUDENTS				9,215	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				27,853	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,218	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				33,071	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,400	
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				3,060	
5. SUBAWARDS				0	
6. OTHER				17,828	
TOTAL OTHER DIRECT COSTS				20,888	
H. TOTAL DIRECT COSTS (A THROUGH G)				56,359	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63.5% of MTDC on Campus (Rate: 63.50, Base: 24249) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				16,534	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				72,893	
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)				$ 72,893	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **Thomas H Jordan**	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

**** G-6 Other**
Tuition Remission $17,828
**** I- Indirect Costs**
9.6% of MTDC off Campus (Rate: 9.60, Base 11835)

SUMMARY PROPOSAL BUDGET — YEAR 3

ORGANIZATION: Massachusetts Institute of Technology			FOR NSF USE ONLY		
			PROPOSAL NO.	DURATION (months)	
				Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Thomas H Jordan			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. Thomas H Jordan	0.00	0.00	0.60	$ 9,785	$
2. Christopher J Marone	0.00	0.00	1.25	9,785	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.85	19,570	
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. (1) GRADUATE STUDENTS				9,215	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				28,785	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,480	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				34,265	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,400	
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				3,060	
5. SUBAWARDS				0	
6. OTHER				17,828	
TOTAL OTHER DIRECT COSTS				20,888	
H. TOTAL DIRECT COSTS (A THROUGH G)				57,553	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63.5% of MTDC on Campus (Rate: 63.50, Base: 24848) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				16,971	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				74,524	
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)				$ 74,524	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE*: Thomas H Jordan	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

**** G-6 Other**
Tuition Remission $17,828
**** I- Indirect Costs**
9.6% of MTDC off Campus (Rate: 9.60, Base 12427)

SUMMARY PROPOSAL BUDGET
Cumulative

ORGANIZATION Massachusetts Institute of Technology				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Thomas H Jordan				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. Thomas H Jordan	0.00	0.00	1.80	$ 27,979	$	
2. Christopher J Marone	0.00	0.00	3.75	27,979		
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.55	55,958		
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. (3) GRADUATE STUDENTS				27,376		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				83,334		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				15,668		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				99,002		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				7,200		
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				9,180		
5. SUBAWARDS				0		
6. OTHER				52,635		
TOTAL OTHER DIRECT COSTS				61,815		
H. TOTAL DIRECT COSTS (A THROUGH G)				168,017		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				49,451		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				217,468		
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)				$ 217,468	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* Thomas H Jordan	DATE			FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE			Date Checked	Date Of Rate Sheet	Initials - ORG

NSF Form 1030 (10/97) Supersedes all previous editions C*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Northeastern University**			FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Bryant York**			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. Bryant York	0.00	0.00	2.00	$ 17,062	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	17,062	
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)				17,062	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,324	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				22,386	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,000	
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)				24,386	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **56% of MTDC (Rate: 56.00, Base: 24385)**					
TOTAL INDIRECT COSTS (F&A)				13,655	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				38,041	
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)				$ 38,041	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI / PD TYPED NAME & SIGNATURE* **Bryant York**	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

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION Northeastern University				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Bryant York				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. Bryant York	0.00	0.00	2.00	$ 17,574	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	17,574	
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)				17,574	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,484	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				23,058	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,000	
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)				25,058	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 56% of MTDC (Rate: 56.00, Base: 25057)					
TOTAL INDIRECT COSTS (F&A)				14,031	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				39,089	
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)				$ 39,089	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* Bryant York	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

YEAR 3

ORGANIZATION **Northeastern University**	FOR NSF USE ONLY				
	PROPOSAL NO.	DURATION (months) Proposed	Granted		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Bryant York**	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. Bryant York	0.00	0.00	2.00	$ 18,101	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	18,101	
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)				18,101	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,648	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				23,749	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,000	
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)				25,749	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **56% of MTDC (Rate: 56.00, Base: 25749)**					
TOTAL INDIRECT COSTS (F&A)				14,419	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				40,168	
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)				$ 40,168	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* **Bryant York**	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

Cumulative

ORGANIZATION: Northeastern University				FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months): Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Bryant York				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. Bryant York	0.00	0.00	6.00	$ 52,737	$	
2.						
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	6.00	52,737		
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)				52,737		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				16,456		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				69,193		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000		
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)				75,193		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				42,106		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				117,299		
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)				$ 117,299	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE*: Bryant York	DATE			FOR NSF USE ONLY: INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE			Date Checked	Date Of Rate Sheet	Initials - ORG

NSF Form 1030 (10/97) Supersedes all previous editions C*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Syracuse University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Geoffrey Fox**				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. Geoffrey Fox	1.00	0.00	0.00	$ 17,208	$	
2. Scott Klasky	3.00	0.00	0.00	12,000		
3. TBA Researcher	3.00	0.00	0.00	8,250		
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	7.00	0.00	0.00	37,458		
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. (2) GRADUATE STUDENTS				26,782		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				64,240		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,010		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				77,250		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,700		
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				26,637		
TOTAL OTHER DIRECT COSTS				26,637		
H. TOTAL DIRECT COSTS (A THROUGH G)				106,587		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **54.3% of MTDC (Rate: 54.30, Base: 79951)**						
TOTAL INDIRECT COSTS (F&A)				43,413		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				150,000		
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)				$ 150,000	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* **Geoffrey Fox**	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

**** G-6 Other**
Tution remission $26,639
**** I- Indirect Costs**
TDC $106,590-$26,637

SUMMARY PROPOSAL BUDGET

YEAR 2

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

ORGANIZATION
Syracuse University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Geoffrey Fox

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. Geoffrey Fox	1.00	0.00	0.00	$ 17,208	$
2. Scott Klasky	3.00	0.00	0.00	12,000	
3. TBA Researcher	3.00	0.00	0.00	8,250	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	7.00	0.00	0.00	37,458	
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. (2) GRADUATE STUDENTS				26,782	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				64,240	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,010	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				77,250	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,700	
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				26,638	
TOTAL OTHER DIRECT COSTS				26,638	
H. TOTAL DIRECT COSTS (A THROUGH G)				106,588	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 54.3% of MTDC (Rate: 54.30, Base: 79950)					
TOTAL INDIRECT COSTS (F&A)				43,412	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				150,000	
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)				$ 150,000	$

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

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

SUMMARY PROPOSAL BUDGET   YEAR 3

	FOR NSF USE ONLY		
ORGANIZATION **Syracuse University**	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Geoffrey Fox**	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. Geoffrey Fox	1.00	0.00	0.00	$ 17,208	$
2. Scott Klasky	3.00	0.00	0.00	12,000	
3. TBA Researcher	3.00	0.00	0.00	8,250	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	7.00	0.00	0.00	37,458	
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. (2) GRADUATE STUDENTS				26,782	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				64,240	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,010	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				77,250	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				2,700	
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				26,638	
TOTAL OTHER DIRECT COSTS				26,638	
H. TOTAL DIRECT COSTS (A THROUGH G)				106,588	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 54.3% of MTDC (Rate: 54.30, Base: 79950)					
TOTAL INDIRECT COSTS (F&A)				43,412	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				150,000	
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)				$ 150,000	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI / PD TYPED NAME & SIGNATURE* **Geoffrey Fox**	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

**** G-6 Other**
Tuition remission $26,638
**** I- Indirect Costs**
MTDC $106,590-$26,638

SUMMARY PROPOSAL BUDGET

Cumulative

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

ORGANIZATION
Syracuse University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Geoffrey Fox

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. Geoffrey Fox	3.00	0.00	0.00	$ 51,624	$
2. Scott Klasky	9.00	0.00	0.00	36,000	
3. TBA Researcher	9.00	0.00	0.00	24,750	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	21.00	0.00	0.00	112,374	
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. (6) GRADUATE STUDENTS				80,346	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				192,720	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				39,030	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				231,750	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				8,100	
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				79,913	
TOTAL OTHER DIRECT COSTS				79,913	
H. TOTAL DIRECT COSTS (A THROUGH G)				319,763	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				130,239	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				450,002	
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)				$ 450,002	$

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

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

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION	FOR NSF USE ONLY		
University of California-San Diego Scripps Inst of Oceanography	PROPOSAL NO.	DURATION (months)	
		Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR	AWARD NO.		
Bernard Minster			

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. Bernard Minster	0.00	0.00	0.00	$ 0	$
2. John Helly	0.50	0.00	0.00	4,000	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.50	0.00	0.00	4,000	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1) POST DOCTORAL ASSOCIATES	1.50	0.00	0.00	4,533	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				17,241	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				25,774	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,692	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				27,466	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,800	
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				1,237	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				700	
5. SUBAWARDS				0	
6. OTHER				7,425	
TOTAL OTHER DIRECT COSTS				9,862	
H. TOTAL DIRECT COSTS (A THROUGH G)				42,128	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 51.5% of MTDC (Rate: 51.50, Base: 34703)					
TOTAL INDIRECT COSTS (F&A)				17,872	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				60,000	
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)				$ 60,000	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI / PD TYPED NAME & SIGNATURE* Bernard Minster	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

**** G-6 Other**
Tuition Remission $7425
**** I- Indirect Costs**
MTDC $42128-$7425

SUMMARY PROPOSAL BUDGET

YEAR 2

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

ORGANIZATION
University of California-San Diego Scripps Inst of Oceanography

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Bernard Minster

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. Bernard Minster	0.00	0.00	0.00	$ 0	$
2. John Helly	0.50	0.00	0.00	4,160	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.50	0.00	0.00	4,160	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1) POST DOCTORAL ASSOCIATES	1.50	0.00	0.00	4,623	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				17,584	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				26,367	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,739	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				28,106	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,800	
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				1,174	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				800	
5. SUBAWARDS				0	
6. OTHER				7,795	
TOTAL OTHER DIRECT COSTS				10,269	
H. TOTAL DIRECT COSTS (A THROUGH G)				43,175	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 51.5% of MTDC (Rate: 51.50, Base: 35380)					
TOTAL INDIRECT COSTS (F&A)				18,220	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				61,395	
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)				$ 61,395	$

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

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

SUMMARY PROPOSAL BUDGET

YEAR 3

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

ORGANIZATION
University of California-San Diego Scripps Inst of Oceanography

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Bernard Minster

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. Bernard Minster	0.00	0.00	0.00	$ 0	$
2. John Helly	0.50	0.00	0.00	4,325	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.50	0.00	0.00	4,325	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1) POST DOCTORAL ASSOCIATES	1.50	0.00	0.00	4,716	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				17,938	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				26,979	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,788	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				28,767	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,800	
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				1,186	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				500	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				800	
5. SUBAWARDS				0	
6. OTHER				8,182	
TOTAL OTHER DIRECT COSTS				10,668	
H. TOTAL DIRECT COSTS (A THROUGH G)				44,235	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 51.5% of MTDC (Rate: 51.50, Base: 36052)					
TOTAL INDIRECT COSTS (F&A)				18,566	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				62,801	
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)				$ 62,801	$

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

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

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

**** G-6 Other**
Tuition Remission $8182
**** I- Indirect Costs**
MTDC $44234-$8181

SUMMARY PROPOSAL BUDGET Cumulative

ORGANIZATION University of California-San Diego Scripps Inst of Oceanography				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Bernard Minster				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. Bernard Minster	0.00	0.00	0.00	$ 0	$	
2. John Helly	1.50	0.00	0.00	12,485		
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	1.50	0.00	0.00	12,485		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (3) POST DOCTORAL ASSOCIATES	4.50	0.00	0.00	13,872		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (3) GRADUATE STUDENTS				52,763		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				79,120		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,219		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				84,339		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				14,400		
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				3,597		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				1,500		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				2,300		
5. SUBAWARDS				0		
6. OTHER				23,402		
TOTAL OTHER DIRECT COSTS				30,799		
H. TOTAL DIRECT COSTS (A THROUGH G)				129,538		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				54,659		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				184,197		
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)				$ 184,197	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* Bernard Minster	DATE			FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE			Date Checked	Date Of Rate Sheet	Initials - ORG

NSF Form 1030 (10/97) Supersedes all previous editions C*SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)

SUMMARY PROPOSAL BUDGET — YEAR 1

	FOR NSF USE ONLY		
ORGANIZATION **University of Southern California**	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Thomas L Henyey**	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. Thomas L Henyey	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) 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. (1) OTHER				6,000	
TOTAL SALARIES AND WAGES (A + B)				6,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,890	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				7,890	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA 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				507	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				240,276	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				240,783	
H. TOTAL DIRECT COSTS (A THROUGH G)				248,673	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **63.5% of MTDC (Rate: 63.50, Base: 8397)**					
TOTAL INDIRECT COSTS (F&A)				5,332	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				254,005	
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)				$ 254,005	$

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

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

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION University of Southern California				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Thomas L Henyey				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. Thomas L Henyey	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) 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. (1) OTHER				6,000		
TOTAL SALARIES AND WAGES (A + B)				6,000		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,890		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				7,890		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA 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				500		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				239,905		
6. OTHER				0		
TOTAL OTHER DIRECT COSTS				240,405		
H. TOTAL DIRECT COSTS (A THROUGH G)				248,295		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63.5% of MTDC (Rate: 63.50, Base: 8390)						
TOTAL INDIRECT COSTS (F&A)				5,327		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				253,622		
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)				$ 253,622	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI / PD TYPED NAME & SIGNATURE* Thomas L Henyey	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

YEAR 3

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

ORGANIZATION
University of Southern California

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Thomas L Henyey

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. Thomas L Henyey	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) 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. (1) OTHER				6,000	
TOTAL SALARIES AND WAGES (A + B)				6,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,890	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				7,890	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA 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				499	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				241,668	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				242,167	
H. TOTAL DIRECT COSTS (A THROUGH G)				250,057	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 63.5% of MTDC (Rate: 63.50, Base: 8389)					
TOTAL INDIRECT COSTS (F&A)				5,327	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				255,384	
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)				$ 255,384	$

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

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

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION University of Southern California	FOR NSF USE ONLY				
	PROPOSAL NO.	DURATION (months) Proposed	Granted		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Thomas L Henyey	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. Thomas L Henyey	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) 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. (3) OTHER				18,000	
TOTAL SALARIES AND WAGES (A + B)				18,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,670	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				23,670	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA 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				1,506	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				721,849	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				723,355	
H. TOTAL DIRECT COSTS (A THROUGH G)				747,025	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				15,986	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				763,011	
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)				$ 763,011	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $			
PI / PD TYPED NAME & SIGNATURE* Thomas L Henyey	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date Of Rate Sheet	Initials - ORG

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: **John Rundle**

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: **Correlations and Clustering in Seismicity Observations**

Source of Support: **NSF Grant EAR-9526814**

Total Award Amount: $ **110,000** Total Award Period Covered: **08/01/96 - 07/31/98**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.45** Summ: **0.50**

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

Project/Proposal Title: **Collaborative Research: Scaling Theories of the 3-D Geometry and Flows of River Networks**

Source of Support: **NSF Grant EAR-9421755**

Total Award Amount: $ **221,850** Total Award Period Covered: **08/01/95 - 07/31/98**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.45** Summ:

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

Project/Proposal Title: **Collaborative Research: Airborne Laser Altimetric Monitoring of the Rapid Evoution of Topography in the Long Valley, CA Caldera**

Source of Support: **NASA Grant NAG5-3054**

Total Award Amount: $ **90,000** Total Award Period Covered: **09/01/95 - 08/31/98**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.45** Summ:

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

Project/Proposal Title: **Collaborative Research: Scaling Theories of the 3-D Geometry and Flows of River Networks**

Source of Support: **NASA Grant NAG5-3848**

Total Award Amount: $ **152,000** Total Award Period Covered: **10/01/96 - 09/30/98**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.45** Summ:

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

Project/Proposal Title: **An Interdisciplinary Graduate Education and Research Program I Hydrology**

Source of Support: **NSF Grant GER-9454093**

Total Award Amount: $ **562,500** Total Award Period Covered: **09/15/94 - 08/31/99**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.90** 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

(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: **John Rundle**

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: **Analysis of Time Dependent Fault Interactions and Stress Transfer in Southern California Using Viscoelastic Coulomb Failure Functions: Application to Data from Southern**

Source of Support: **NASA Grant NAG5-5168**

Total Award Amount: $ **236,453** Total Award Period Covered: **07/15/97 - 07/14/00**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.45** Summ: **1.00**

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

Project/Proposal Title: **Collaborative Research: Nonlinear Systems Approach to Understanding the Origin of Geodetic Crustal Strains**

Source of Support: **DOE**

Total Award Amount: $ **391,696** Total Award Period Covered: **11/15/97 - 11/14/00**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.45** Summ: **1.50**

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **2,776,858** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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: Summ:

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: Summ:

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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 of this proposal.

Investigator: **Jill Andrews**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **153,018** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **University of Southern California**
Person-Months Per Year Committed to the Project. Cal: **3.00** Acad: Summ:

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: Summ:

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: Summ:

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: Summ:

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: 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

(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: **Yehuda Ben-Zion**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **176,823** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **University of Southern California**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.50**

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: Summ:

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: Summ:

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: Summ:

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: Summ:

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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 of this proposal.

Investigator: **Elizabeth Bradley**

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: **New Approached to Engineering Design: Controlled Chaos and Computer Automation**

Source of Support: **NSF**

Total Award Amount: $ **290,931** Total Award Period Covered: **08/01/93 - 01/31/99**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **Automatic construction of Accurate Models of Physical Systems**

Source of Support:

Total Award Amount: $ **327,447** Total Award Period Covered: **04/01/96 - 03/31/99**

Location of Project: **University of Colorado**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **2.00**

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: Summ:

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: Summ:

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: 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

(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: **Geoffrey Fox**

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: **General Earthquake Models: A New Computational Challenge**

Source of Support: **NSF**
Total Award Amount: $ **450,000** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **Syracuse University**
Person-Months Per Year Committed to the Project. Cal:**3.00** Acad: Summ:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Retooling the Supercomputing Community for Scalable Parallelism**

Source of Support: **NSF**
Total Award Amount: $ **414,014** Total Award Period Covered: **10/01/94 - 09/30/98**
Location of Project: **Syracuse University**
Person-Months Per Year Committed to the Project. Cal:**0.50** Acad: Summ:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Common Runtime Support for High Performance Parallel Languages**

Source of Support: **hanscom AFB (ARPA)**
Total Award Amount: $ **1,952,902** Total Award Period Covered: **10/01/94 - 06/30/98**
Location of Project: **Syracuse University**
Person-Months Per Year Committed to the Project. Cal:**0.50** Acad: Summ:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **National High Performance Software Exchange**

Source of Support: **NASA**
Total Award Amount: $ **729,044** Total Award Period Covered: **10/01/94 - 03/31/99**
Location of Project: **Syracuse University**
Person-Months Per Year Committed to the Project. Cal:**0.25** Acad: Summ:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Black Hole Binaries: Coalescence and Gravitational Radiation**

Source of Support: **University of Texas/Austin (NSG Grand Challenge)**
Total Award Amount: $ **549,000** Total Award Period Covered: **10/01/93 - 08/31/98**
Location of Project: **Syracuse University**
Person-Months Per Year Committed to the Project. Cal:**0.25** 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

(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: **Geoffrey Fox**

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: **ASCI WebFlow-High Level Programming Envronmental and Visual Authoring Toolkit for HPCC**

Source of Support: **DOE**

Total Award Amount: $ **1,063,490** Total Award Period Covered:

Location of Project: **Syracuse University**

Person-Months Per Year Committed to the Project. Cal: **0.50** Acad: Summ:

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

Project/Proposal Title: **Webspace: A Web Windows Based Gateway to ANL LabSpace**

Source of Support: **US Department of Energy**

Total Award Amount: $ **424,063** Total Award Period Covered: **09/30/95 - 08/31/98**

Location of Project: **Syracue University**

Person-Months Per Year Committed to the Project. Cal: **0.25** Acad: Summ:

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

Project/Proposal Title: **Rortran Programming for CRPC**

Source of Support: **NSF**

Total Award Amount: $ **300,000** Total Award Period Covered: **01/01/98 - 12/31/98**

Location of Project: **Syracuse University**

Person-Months Per Year Committed to the Project. Cal: **0.50** Acad: Summ:

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: Summ:

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: Summ:

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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 of this proposal.

Investigator: **Roscoe Giles**

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: **Integrating High Performance Computing into Research: Molecular Dynamics Simulation in Chemistry, Physics and Engineering**

Source of Support: **NSF**

Total Award Amount: $ **450,000** Total Award Period Covered: **09/01/94 - 08/31/98**

Location of Project: **Boston University**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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

Project/Proposal Title: **CRLT: Teacher-Researcher Collaboration in Scientific Modeling: The High School Science Virtual Machine Laboratory**

Source of Support: **NSF**

Total Award Amount: $ **858,545** Total Award Period Covered: **10/01/96 - 09/30/99**

Location of Project: **Boston University**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **MARINER: Metacenter-Affiliated Resource in the New England Region**

Source of Support: **NSF**

Total Award Amount: $ **821,441** Total Award Period Covered: **11/01/95 - 10/31/98**

Location of Project: **Boston University**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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

Project/Proposal Title: **Partnerships for Advanced Computational Infrastructure (PACI): Regional Partners**

Source of Support: **NSF**

Total Award Amount: $ **270,018** Total Award Period Covered: **10/01/97 - 09/30/98**

Location of Project: **Boston University**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **Partnerships for Advanced Computational Infrastructure(PACI): Education, Outreach and Training(EOT)**

Source of Support: **NSF**

Total Award Amount: $ **94,979** Total Award Period Covered: **10/01/97 - 09/30/98**

Location of Project: **Boston University**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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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 of this proposal.

Investigator: **Roscoe Giles**

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: **Visual Tools for Modeling Parallel Processes (Subcontact via U. Massachusetts at Boston)**

Source of Support: **NSF**
Total Award Amount: $ **341,571** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **Boston University**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge (Subcontact via U. Colorado) This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **210,619** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **Boston University**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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: Summ:

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: Summ:

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: 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

(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: **John Helly**

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: **Web-based Data Management for Ecological Analysis and Synthesis**

Source of Support: **NSF**

Total Award Amount: $ **146,000** Total Award Period Covered: **10/01/97 - 09/30/98**

Location of Project: **SDSC**

Person-Months Per Year Committed to the Project. Cal:**2.00** Acad: Summ:

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

Project/Proposal Title: **LTER Network Office**

Source of Support: **NSF**

Total Award Amount: $ **200,000** Total Award Period Covered: **02/01/98 - 01/31/02**

Location of Project: **SDSC**

Person-Months Per Year Committed to the Project. Cal:**2.40** Acad: Summ:

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

Project/Proposal Title: **National Partnership for Advanced Computeing Infrastructure(NPACI)**

Source of Support: **NSF**

Total Award Amount: $ Total Award Period Covered: **10/01/98 - 09/30/02**

Location of Project: **SDSC**

Person-Months Per Year Committed to the Project. Cal:**4.00** Acad: Summ:

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

Project/Proposal Title: **Global Earthquake Modeling:**

Source of Support: **NSF**

Total Award Amount: $ **184,196** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **SDSC**

Person-Months Per Year Committed to the Project. Cal:**1.50** Acad: Summ:

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

Project/Proposal Title: **Ocean Observing System**

Source of Support: **ONR**

Total Award Amount: $ **200,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **SIO**

Person-Months Per Year Committed to the Project. Cal:**4.00** 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

(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: **Thomas Henyey**

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: **Southern California Earthquake Center**

Source of Support: **NSF**

Total Award Amount: $ **3,040,000** Total Award Period Covered: **02/01/97 - 01/31/98**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ: **2.00**

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

Project/Proposal Title: **Southern California Earthquake Center**

Source of Support: **NSF**

Total Award Amount: $ **1,150,000** Total Award Period Covered: **01/11/97 - 09/15/98**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ:

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

Project/Proposal Title: **Earthquake Hazard Research in the Greater Los Angeles Basin and its Offshore Area**

Source of Support: **United States Geological survey**

Total Award Amount: $ **324,800** Total Award Period Covered: **12/01/94 - 05/31/98**

Location of Project: **Los Angeles, California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.25** Summ:

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

Project/Proposal Title: **THUMS-Long Beach Seismic Monitoring System**

Source of Support: **THUMS Long Beach Company**

Total Award Amount: $ **141,000** Total Award Period Covered: **07/01/97 - 06/30/98**

Location of Project: **Long Beach, California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.25** Summ:

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

Project/Proposal Title: **SCEC Activities to Promote and Encourage the Understanding of Earthquakes**

Source of Support: **FEMA**

Total Award Amount: $ **25,000** Total Award Period Covered: **09/01/97 - 09/30/98**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.50** 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

(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: **Thomas Henyey**

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: **Geophysical Investigations of a Modern Continent-Continent Collisional Orogen: The Southern Alps, New Zealand**

Source of Support: **NSF**

Total Award Amount: $ **3,600,000** Total Award Period Covered: **03/01/95 - 02/28/99**

Location of Project: **New Zealand**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ:

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

Project/Proposal Title: **Acquisition of Continuous GPS Equipment for the Earth Sciences**

Source of Support: **NSF/OSTI**

Total Award Amount: $ **2,000,000** Total Award Period Covered: **09/01/96 - 08/31/99**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.10** Summ:

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

Project/Proposal Title: **W. M. Keck Foundation GPS Array for Earthquake Research**

Source of Support: **W. M. Keck Foundation**

Total Award Amount: $ **5,600,000** Total Award Period Covered: **12/15/96 - 12/31/99**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.10** Summ:

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

Project/Proposal Title: **California Earth Science Education 2000 (Cal-Earth Ed 2000)**

Source of Support: **NSF**

Total Award Amount: $ **82,894** Total Award Period Covered: **07/01/98 - 06/30/99**

Location of Project: **Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.20** Summ:

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

Project/Proposal Title: **Acquisition and Integration of Continuous GPS Instrumentation for Studying the Pacific-North America Plate Boundary Zone from Northern California to Southern Mexico**

Source of Support: **NSF**

Total Award Amount: $ **2,000,000** Total Award Period Covered: **09/01/98 - 08/31/01**

Location of Project: **Western North America**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.10** Summ:

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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 of this proposal.

Investigator: **Thomas Henyey**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **762,991** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **USC**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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: Summ:

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: Summ:

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: Summ:

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: 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

(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: **Thomas Jordan**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **217,467** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **Massachusetts Institute of Technology**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

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

Project/Proposal Title: **Functions of Nuclear Explosions from Inversion of IMS Data MIT fully supports Mr. Jordan's AY salary, but makes no specific commitment of time on salary to any individual**

Source of Support: **Defense Special Weapons Agency**
Total Award Amount: $ **59,927** Total Award Period Covered: **06/01/96 - 05/31/98**
Location of Project: **MIT**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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

Project/Proposal Title: **Imaging Mantle Structure of Australasia, Eastern Asia, and the Western Pacific**

Source of Support: **NSF**
Total Award Amount: $ **80,000** Total Award Period Covered: **09/01/97 - 08/31/98**
Location of Project: **MIT**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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

Project/Proposal Title: **CSEDI Collaborative Research: Testing Critical Hypotheses About Upper-Mantle Structure and Composition Using Seismological and Mineralogical Data**

Source of Support: **NSF**
Total Award Amount: $ **35,629** Total Award Period Covered: **09/01/97 - 08/31/98**
Location of Project: **MIT**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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

Project/Proposal Title: **Collaborative Research: The Anatomy of an Archean Craton: The Evolution of the South African Continental Lithosphere**

Source of Support: **NSF**
Total Award Amount: $ **100,030** Total Award Period Covered: **09/01/97 - 08/31/98**
Location of Project: **MIT, South Africa**
Person-Months Per Year 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

(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: **Thomas Jordan**

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: **Space-Time Imaging of large Earthquakes at Teleseismic Distances**

Source of Support: **NSF**

Total Award Amount: $ **87,153** Total Award Period Covered: **06/01/98 - 05/31/99**

Location of Project: **MIT**

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

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

Project/Proposal Title: **Fine Scale Structure of the Crust Mantle from IMS Data**

Source of Support: **Defense Special Weapons Agency**

Total Award Amount: $ **118,837** Total Award Period Covered: **07/01/98 - 06/30/99**

Location of Project: **MIT**

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

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

Project/Proposal Title: **Characterization of Natural and Huaman-Related Seismicity ifn South Africa**

Source of Support: **NSF**

Total Award Amount: $ **128,843** Total Award Period Covered: **07/01/98 - 06/30/99**

Location of Project: **MIT**

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

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

Project/Proposal Title: **Development of a Curriculum for a Master of Science Degree in Geosystems**

Source of Support: **NSF**

Total Award Amount: $ **44,773** Total Award Period Covered: **07/01/98 - 06/30/99**

Location of Project: **MIT**

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

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: 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

(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: **Hiroo Kanamori**

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: **Acquistion of 10 Broadband Seismographs for Enhancement of TERRAscope**

Source of Support: **NSF**

Total Award Amount: $ **45,000** Total Award Period Covered: **10/01/95 - 09/30/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: **0.24** Acad: Summ:

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

Project/Proposal Title: **Real-time Monitoring of Ground Motion for Development of Early Warning System**

Source of Support: **USGS**

Total Award Amount: $ **40,800** Total Award Period Covered: **03/01/97 - 05/28/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: **0.36** Acad: Summ:

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

Project/Proposal Title: **Earthquake and Seismicity Research Using TERRAscope**

Source of Support: **USGS**

Total Award Amount: $ **60,000** Total Award Period Covered: **12/01/96 - 05/30/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: **0.36** Acad: Summ:

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

Project/Proposal Title: **Initiation of Earthquake Rupture**

Source of Support: **USC**

Total Award Amount: $ **60,000** Total Award Period Covered: **04/01/91 - 01/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: **0.24** Acad: Summ:

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

Project/Proposal Title: **Determination of Slip Plane**

Source of Support: **USC**

Total Award Amount: $ **23,776** Total Award Period Covered: **02/01/98 - 01/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: **0.36** 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

(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: **Hiroo Kanamori**

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: **Characterization of Fault Plane Heterogeneitics with Wave-Form Correlation**

Source of Support: **USGS**
Total Award Amount: $ **115,655** Total Award Period Covered: **11/01/98 - 10/31/00**
Location of Project: **California**
Person-Months Per Year Committed to the Project. Cal: **0.36** Acad: Summ:

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

Project/Proposal Title: **Mitigation of Earthquake Losses Through Detection and Analysis of Ground Motion for Building Code Inprovement (TriNet)**

Source of Support: **Office of Emergency Services**
Total Award Amount: $ **7,426,000** Total Award Period Covered: **01/01/97 - 12/31/01**
Location of Project: **California**
Person-Months Per Year Committed to the Project. Cal: **0.60** Acad: Summ:

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

Project/Proposal Title: **Radiated Energy and State of Stress During Earthquake Rupture**

Source of Support: **USGS**
Total Award Amount: $ **131,605** Total Award Period Covered: **11/01/98 - 10/31/00**
Location of Project: **California**
Person-Months Per Year Committed to the Project. Cal: **0.72** Acad: Summ:

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

Project/Proposal Title: **Monitoring of Seismicity Near Hermosa Beach**

Source of Support: **Windward Assoc./MacPherson Oil Co.**
Total Award Amount: $ **221,376** Total Award Period Covered: **05/01/98 - 04/30/01**
Location of Project: **California**
Person-Months Per Year Committed to the Project. Cal: **0.12** Acad: Summ:

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**
Total Award Amount: $ **181,058** Total Award Period Covered: **10/01/98 - 09/30/01**
Location of Project: **California**
Person-Months Per Year Committed to the Project. Cal: **0.36** 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

(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: **Louise Kellogg**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **64,257** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **University of California, Davis**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.05**

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

Project/Proposal Title: **Determination of a regional velocity map for the region near the Big Bend segment of the San Andreas fault, Tejon Pass, southern California Modeling**

Source of Support: **SCEC**

Total Award Amount: $ **25,000** Total Award Period Covered: **07/01/97 - 05/30/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.05**

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

Project/Proposal Title: **Crustal deformation near the White Wolf Fault, Greater Los Angeles Region using global positioning system observations and viscoclastic model**

Source of Support: **NSF**

Total Award Amount: $ **93,095** Total Award Period Covered: **07/01/97 - 06/30/99**

Location of Project: **UC Davis**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.05**

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

Project/Proposal Title: **Three-dimensional models of crustal deformation along the San Andreas fault system**

Source of Support: **CULAR**

Total Award Amount: $ **22,173** Total Award Period Covered: **10/01/96 - 11/30/97**

Location of Project: **UC Davis**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.05**

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

Project/Proposal Title: **Presidental Faculty Fellowship**

Source of Support: **NSF**

Total Award Amount: $ **500,000** Total Award Period Covered: **09/01/92 - 08/31/98**

Location of Project: **UC Davis**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **2.00**

*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: **Scott Klasky**

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: **Black Hole Binaries: Coalescence and Gravitational Radiation**

Source of Support: **Rice University (NASA)**

Total Award Amount: $ **729,044** Total Award Period Covered: **10/01/94 - 03/31/99**

Location of Project: **Syracuse University, NY**

Person-Months Per Year Committed to the Project. Cal: **2.00** Acad: Summ:

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge**

Source of Support: **NSF**

Total Award Amount: $ **450,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **Syracuse University**

Person-Months Per Year Committed to the Project. Cal: **3.00** Acad: Summ:

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: Summ:

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: Summ:

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: Summ:

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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 of this proposal.

Investigator: **William Klein**

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: **The Physics of Glasses and the Glass Transition**

Source of Support: **NSF**

Total Award Amount: $ **400,100** Total Award Period Covered: **08/01/96 - 07/31/98**

Location of Project: **BU**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **Collaborative Research: Nonlinear systems Approach to Understanding the origin of Geodetic Crustal Strains**

Source of Support: **DOE**

Total Award Amount: $ **344,815** Total Award Period Covered: **11/15/94 - 11/14/98**

Location of Project: **BU**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **210,619** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **BU**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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: Summ:

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: 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

(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: **Christopher Marone**

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: **Laboratory Study Of Fault Healing And Friction Under Hydrothermal Seismogenic Conditions**

Source of Support: **NSF**

Total Award Amount: $ **276,000** Total Award Period Covered: **07/15/96 - 06/30/99**

Location of Project: **MIT**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.50**

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

Project/Proposal Title: **Fault Zone Properties: Laboratory Study of the Relationship Between Frictional Healing, Compaction, and Elastic Wave Velocity**

Source of Support: **Petroleum Research Foundation**

Total Award Amount: $ **58,560** Total Award Period Covered: **05/01/98 - 08/31/00**

Location of Project: **MIT**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **Friction of Rocks and Simulated Fault Gouge at Seismic Slip Velocities**

Source of Support: **NSF**

Total Award Amount: $ **105,000** Total Award Period Covered: **07/01/98 - 06/30/99**

Location of Project: **MIT**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.50**

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

Project/Proposal Title: **Laboratory Study of the Rheology of Brittle Faults: Implications for Fault Healing and Friction Constitutive Laws**

Source of Support: **USGS**

Total Award Amount: $ **168,172** Total Award Period Covered: **07/01/98 - 06/30/00**

Location of Project: **MIT**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **2.00**

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

Project/Proposal Title: **General Earthquake Models: A new Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **217,467** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **MIT**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **2.50**

*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: **Bernard Minster**

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: **Use of Evolutionary Strategles in Seismicity Pattern Analysis**

Source of Support: **USC**
Total Award Amount: $ **25,000** Total Award Period Covered: **01/11/98 - 01/10/99**
Location of Project: **SIO**
Person-Months Per Year Committed to the Project. Cal:**0.50** Acad: Summ:

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

Project/Proposal Title: **Research and Experiments in Support of the Geosciences Laser Altimeter System(GLAS)**

Source of Support: **NASA**
Total Award Amount: $ **669,752** Total Award Period Covered: **10/01/89 - 09/30/98**
Location of Project: **SIO**
Person-Months Per Year Committed to the Project. Cal:**1.00** Acad: Summ:

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

Project/Proposal Title: **Airborne Laser Altimeteric Minitoring of the Rapid Evolution of Topography in the Long Valley, California, Caldera**

Source of Support: **NASA**
Total Award Amount: $ **194,111** Total Award Period Covered: **08/01/95 - 07/31/98**
Location of Project: **SIO**
Person-Months Per Year Committed to the Project. Cal:**1.00** Acad: Summ:

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

Project/Proposal Title: **Estimation of the Ground Motion Exposure From Large Earthquakes at Four UC Campuses in Southern California**

Source of Support: **University of California Campus Laboratory Collaboration**
Total Award Amount: $ **240,540** Total Award Period Covered: **11/01/95 - 10/31/98**
Location of Project: **SIO**
Person-Months Per Year Committed to the Project. Cal:**0.50** Acad: Summ:

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

Project/Proposal Title: **Integration of Synthetic Aperture Radar Interferommetry, Continuous GPS, and GPS meterology for Crustal Deformation and Earthquake monitoring (with Bock, Sandwell, Agnew)**

Source of Support: **NSF**
Total Award Amount: $ **422,867** Total Award Period Covered: **10/01/97 - 09/30/00**
Location of Project: **SIO**
Person-Months Per Year Committed to the Project. Cal:**0.50** 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

(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: **Bernard Minster**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **184,196** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **SIO**

Person-Months Per Year Committed to the Project. Cal: **3.00** Acad: Summ:

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: Summ:

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: Summ:

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: Summ:

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: Summ:

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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 of this proposal.

Investigator: **John Salmon**

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: **Application of Beowulf Class Computing Systems to Data Management Tasks for the Very Large Telescope**

Source of Support: **ESO**

Total Award Amount: $ **165,000** Total Award Period Covered: **01/01/98 - 12/31/98**

Location of Project: **CIT**

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

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **165,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **CIT**

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

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: Summ:

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: Summ:

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: 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

(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: **Charles Sammis**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **176,823** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **University of Southern California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.50**

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

Project/Proposal Title: **A Renormalization Group Model for Observed Temporal Fluctuations in Regional Seismicity**

Source of Support: **NSF**

Total Award Amount: $ **113,000** Total Award Period Covered: **07/01/95 - 06/30/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.50** Summ: **0.50**

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

Project/Proposal Title: **A Damage Mechanics Model for Underground Nuclear Explosions**

Source of Support: **DASWA**

Total Award Amount: $ **224,569** Total Award Period Covered: **09/01/97 - 09/01/00**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ: **1.00**

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

Project/Proposal Title: **Gouge Turbulence: A possible Structural Signature of Low Friction?**

Source of Support: **SCEC**

Total Award Amount: $ **15,000** Total Award Period Covered: **02/01/98 - 01/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ:

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

Project/Proposal Title: **Monitoring the Approach to Criticality Using Regional Seismicity**

Source of Support: **NSF**

Total Award Amount: $ **119,887** Total Award Period Covered: **01/01/98 - 12/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

*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: **Bruce Shaw**

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: **Dynamic Models of Earthquakes, Fault Systems, and on Fault Systems**

Source of Support: **USGS**

Total Award Amount: $ **75,000** Total Award Period Covered: **02/15/97 - 02/14/99**

Location of Project: **LDEO**

Person-Months Per Year Committed to the Project. Cal: **4.00** Acad: Summ:

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

Project/Proposal Title: **Aftershocks and Beforeshocks in the Earthquake Cycle**

Source of Support: **Univ of So. CAl.**

Total Award Amount: $ **34,000** Total Award Period Covered: **02/01/93 - 01/31/99**

Location of Project: **LDEO**

Person-Months Per Year Committed to the Project. Cal: **2.50** Acad: Summ:

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

Project/Proposal Title: **Elastodynamic Modles of Earthquake Fault Systems**

Source of Support: **Univ. of So. Cal.**

Total Award Amount: $ **60,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **LDEO**

Person-Months Per Year Committed to the Project. Cal: **2.00** Acad: Summ:

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

Project/Proposal Title: **Renewal of USGS: Dynamic Models of Earthquakes, Fault Systems, and on Fault Systems**

Source of Support: **USGS**

Total Award Amount: $ **143,654** Total Award Period Covered: **02/15/99 - 02/14/01**

Location of Project: **LDEO**

Person-Months Per Year Committed to the Project. Cal: **7.00** Acad: Summ:

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **60,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **Lamont Doherty Earth Observatiory**

Person-Months Per Year Committed to the Project. Cal: **2.00** Acad: Summ:

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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 of this proposal.

Investigator: **Leon Teng**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **117,750** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **University of Southern California**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Summ: **0.00**

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

Project/Proposal Title: **Earthquake Hazard Research in the Greater Los Angeles Basin and its Offwhore Area**

Source of Support: **USGS**

Total Award Amount: $ **104,400** Total Award Period Covered: **12/01/94 - 05/31/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.50** Summ: **1.00**

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

Project/Proposal Title: **Seismic Monitoring Studies in the Long Beach Oilfield**

Source of Support: **THUMS**

Total Award Amount: $ **141,000** Total Award Period Covered: **07/01/97 - 06/30/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: **0.50** Summ: **1.00**

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

Project/Proposal Title: **Prototype Design and Construction of the CWB Earthquake Early Warning System and Implementation of the Strong Motion Instrumentation Program**

Source of Support: **Central Weather Bureau of Taiwan, ROC**

Total Award Amount: $ **145,000** Total Award Period Covered: **07/01/97 - 06/30/98**

Location of Project: **Taiwan and California**

Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ:

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: Summ:

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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 of this proposal.

Investigator: **Donald Turcotte**

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: **Complexity and Natural Hazards**

Source of Support: **NASA**
Total Award Amount: $ **185,000** Total Award Period Covered: **06/01/95 - 05/31/98**
Location of Project: **Ithaca,NY**
Person-Months Per Year Committed to the Project. Cal: Acad: **1.00** Summ:

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

Project/Proposal Title: **Implications of Episodic Subduction on Planetary Evolution**

Source of Support: **NASA**
Total Award Amount: $ **105,000** Total Award Period Covered: **04/01/97 - 03/31/00**
Location of Project: **Ithaca, NY**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.50**

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

Project/Proposal Title: **Self-organized Critacally and The Landslide Hazards**

Source of Support: **NASA**
Total Award Amount: $ **112,792** Total Award Period Covered: **07/01/98 - 06/30/01**
Location of Project: **Ithaca, NY**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.25**

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

Project/Proposal Title: **Applications of Dynamical Systems to Earthquake Prediction**

Source of Support: **NSF**
Total Award Amount: $ **372,812** Total Award Period Covered: **04/01/98 - 03/31/01**
Location of Project: **Ithaca/Moscow**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.50**

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

Project/Proposal Title: **Seismicity as Self-Organized Critical Phenomena**

Source of Support: **USGS**
Total Award Amount: $ **108,163** Total Award Period Covered: **11/01/98 - 10/31/00**
Location of Project: **Ithaca,NY**
Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **0.50**

*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: **Donald Turcotte**

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: **General Earthquake Models: A New Computational Challenge This Proposal**

Source of Support: **NSF**

Total Award Amount: $ **90,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **Cornell University**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.50**

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: Summ:

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: Summ:

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: Summ:

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: 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

(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: **Steven Ward**

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: **Southern California Seismic Hazard Models**

Source of Support: **Southern California Earthquake Center**

Total Award Amount: $ **24,000** Total Award Period Covered: **02/01/97 - 01/31/98**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

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

Project/Proposal Title: **A collaborative investigation of the Sumatran subduction zone**

Source of Support: **NSF**

Total Award Amount: $ **14,000** Total Award Period Covered: **02/01/96 - 01/31/99**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

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

Project/Proposal Title: **Earthquake Probabilities, Cycles, and Hazards in Northern California**

Source of Support: **USGS**

Total Award Amount: $ **25,000** Total Award Period Covered: **04/01/98 - 03/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **Synthetic Rupture Models as an aid in Interpreting Geological and Earthquake Recurrence Data**

Source of Support: **NSF**

Total Award Amount: $ **164,000** Total Award Period Covered: **02/01/98 - 01/31/01**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **A collaborative investigation of the Sumatran subduction zone-II**

Source of Support: **NSF**

Total Award Amount: $ **36,000** Total Award Period Covered: **06/01/98 - 05/31/99**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

*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: **Steven Ward**

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: **Southern California Seismic Hazards Models Continuation**

Source of Support: **Southern California Earthquake Center**

Total Award Amount: $ **34,000** Total Award Period Covered: **02/01/98 - 01/31/99**

Location of Project: **California**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

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

Project/Proposal Title: **Space Geodetic Input into National Earthquake Statistics**

Source of Support: **USGS**

Total Award Amount: $ **59,490** Total Award Period Covered: **03/01/99 - 02/28/01**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.00**

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

Project/Proposal Title: **UCSC participation in the GEM project**

Source of Support: **NSF**

Total Award Amount: $ **20,000** Total Award Period Covered: **03/01/99 - 02/28/01**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **1.20**

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

Project/Proposal Title: **General Earthquake Models: A New Computational Challenge This proposal**

Source of Support: **NSF**

Total Award Amount: $ **60,000** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **University of California, Santa Cruz**

Person-Months Per Year Committed to the Project. Cal: **1.33** Acad: Summ:

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: 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

(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: **Bryant York**

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: **General Earthquake Models: A New Computational Challenge**

Source of Support: **NSF**

Total Award Amount: $ **117,298** Total Award Period Covered: **10/01/98 - 09/30/01**

Location of Project: **Northeastern University**

Person-Months Per Year Committed to the Project. Cal: Acad: Summ: **6.00**

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

Project/Proposal Title: **Novel Mathematical/Computational Approaches to Image Exploitation**

Source of Support: **Air Force**

Total Award Amount: $ **100,000** Total Award Period Covered: **11/01/98 - 10/31/99**

Location of Project: **Northeastern University**

Person-Months Per Year Committed to the Project. Cal: **1.20** Acad: Summ:

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: Summ:

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: Summ:

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: Summ:

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

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory:

Clinical:

Animal:

Computer:

Office:

Other: ______________________

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.