

**The Center for Integrated Space Weather Modeling (CISM)  
An NSF Science and Technology Center**

**Strategic and Implementation Plan (Updated October, 2007<sup>1</sup>)**

**VISION AND MISSION**

As defined by the National Space Weather Program, "Space weather refers to conditions on the sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health." Space weather can cause satellites to fail, disrupt radio communications, cause navigation errors, overload electrical power distribution systems, and expose astronauts to dangerous levels of radiation. Mitigation of these effects requires both a better understanding of the space environment and developing the ability to predict and forecast conditions in space.

The Center for Integrated Space Weather Modeling (CISM) focuses its activities around building a comprehensive physics-based numerical simulation model suite that describes the space environment from the Sun to the Earth. This model will achieve three complementary goals: we will do fundamentally new science, increasing our understanding of the complex, closely coupled Sun-Earth system; in partnership with NOAA's Space Environment Center we will convert the results of our research into robust and operationally useful forecasting tools to be used by both civilian and military space weather forecasters; and in our education programs we will train the next generation space physicists in understanding the Sun and Earth as a system, and make the geospace environment accessible to understanding through models and visualization tools.

In order to achieve these goals we will need to:

- Foster interdisciplinary research between solar physicists, magnetospheric physicists, aeronomers, and computational scientists.
- Develop a better physical understanding of processes in the space environment.
- Develop the computational and analysis tools needed to couple models efficiently.
- Transfer our new understanding and the products of our research into useful forecasting and specification tools.
- Integrate research and education in order to effectively train the next generation of diverse space weather scientists.

---

<sup>1</sup> *The CISM Strategic and Implementation Plan was established in September 2003. The January 2006 revision refined the Center's plans as they had matured, and incorporated several detailed implementation plans that had been developed since 2003. This October 2007 revision provides updates to the January 2006 edition.*

## **CISM LEGACIES**

We foresee the legacies of the Center to be:

- The development of a new interdisciplinary science that views the Sun-Earth system as a single closely coupled system, and that erases the existing boundaries among space physicists.
- A new generation of well-trained space physicists from diverse backgrounds that is capable of using the tools of computational science to study the space environment and who approach problems from an interdisciplinary viewpoint.
- A new graduate program in space science at an historically black university.
- The introduction of community models into space physics and the use of numerical models as research tools by the broader research community.
- Advances in space science, particularly in our understanding of processes critical to the development of the global model.
- Advances in computer science brought about by our need to efficiently couple disparate numerical models and assimilate observational data.
- New models and understanding of the space environment that will lead to improved specification and forecasts at the nation's space weather operations centers.
- Ongoing community-directed model development after STC support ends that continues to improve and augment the CISM initiated models as community models.
- A suite of physics-based forecasting and specification tools.
- A better public understanding of the Sun and its affect on the Earth's space environment.

# RESEARCH PLAN

## Introduction

The overarching goal of CISM is to develop a reliable, well-validated, comprehensive, physics-based, numerical simulation model suite that describes the space environment from the Sun to the Earth. CISM's research goals are all directed towards achieving this overarching goal. This means that CISM's research plan must be considered as an integrated whole. Although, for the purposes of management, we have divided our research into components, our goals depend upon the interconnection and integration across the components, and the boundaries between them are necessarily flexible.

The core of the comprehensive CISM model suite consists of four fluid codes that form a chain from the Sun to the Earth. The magnetohydrodynamic (MHD) model of the solar corona developed by Jon Linker, Zoran Mikic, and others at SAIC describes solar corona dynamics from the base of the corona out to a radius at which the solar wind flow is entirely supersonic and superAlfvenic. The coronal model couples to the MHD model of the solar wind developed by Dusan Odstrcil at the University of Colorado, which is optimized for supersonic and superAlfvenic plasma flow. This code models the time dependent 3-D structure of flows and fields in the solar wind to well beyond the orbit of earth. We use the code developed by Lyon, Fedder, and Mobarry (LFM) to model the global dynamics of the magnetosphere to a distance far enough down the geomagnetic tail ( $300 R_E$ ) that all flow is again supersonic away from Earth. The LFM code can be driven either with results from the solar wind code or from solar wind data obtained from *in situ* spacecraft such as WIND and ACE, which allows the model chain to be easily split in two at the solar wind-magnetosphere boundary for the purposes of validation and testing. The magnetosphere is strongly coupled to the ionosphere and upper neutral atmosphere (thermosphere and mesosphere, or collectively ITM). The core ITM model is the National Center for Atmospheric Research (NCAR) Thermosphere-Ionosphere Electrodynamics General Circulation Model (TIEGCM). The coupling between the magnetosphere and ionosphere is by far the most complicated of the core model couplings, as it acts in both directions and involves many processes that are not well described by fluid (MHD) physics.

There are several regions and particle populations in the space environment whose physics is not well described by fluid codes. Therefore other models must be coupled to the core fluid codes in order to properly include the needed physics in the comprehensive model. All these regions and populations either have important space weather effects or have a direct influence on particle populations that do have space weather effects. Some of these models are very well developed, including the Rice Convection Model (RCM) which models the inner magnetosphere and ring current. The more energetic particles trapped in the radiation belts are described by the radiation belt model developed by Mary

Hudson and others at Dartmouth. Other important components of the comprehensive model, such as the solar energetic particle (SEP) module, are being developed as part of CISM's research program.

The research required to build the comprehensive model involves space science, model development and computational science. This work is organized into six research thrusts: three space science thrusts, model coupling, validation and metrics, and forecast modeling.

The three space science thrusts - Solar/Heliospheric Physics, Magnetospheric Physics, and Ionosphere/Thermosphere/Mesosphere Physics - are responsible for the targeted research required to bring our understanding of the fundamental physics to the level required for the comprehensive CISM model, and for developing the component models that will incorporate this physics into the comprehensive model. The areas of physics currently recognized as needing work include particle acceleration, CME initiation, magnetic reconnection, and magnetosphere-ionosphere coupling. These thrusts also study the processes responsible for coupling regions of the environment, such as the photospheric control of chromospheric and coronal process, and the thermospheric control of ionospheric and magnetospheric processes, so that these processes can be appropriately included in the comprehensive model.

The code coupling thrust is responsible for identifying and developing the computational science tools needed for efficiently coupling the component models together and then applying these tools to coupling the models to produce the comprehensive CISM model.

The validation and metrics thrust is charged with testing and validating the functioning models. This thrust performs both validation and metric or skill tests, that is, it both compares detailed model output against measurement data sets in order to evaluate the model against reality (validation) and makes standardized comparisons between model output parameters and a few selected operationally available baselines (metrics) that allow a direct comparison between the effectiveness of different models or prediction schemes. This latter allows progress between generations of models to be evaluated. It couples intellectually to the science thrusts in that studying the model outputs is one way of exploring the science questions being addressed by those thrusts. This thrust also feeds back to the others by pointing out where the models most need improvement.

The forecast modeling thrust is responsible for developing forecast and specification versions of our models. Initially this comprised various empirical or data-based models coupled together to provide an end-to-end model. Future versions will incorporate physics-based components in place of empirical components as they are ready, for example the coupled WSA-ENLIL solar-heliosphere and the CMIT geospace models. This research thrust is closely integrated with the CISM effort in knowledge transfer to the space weather

forecasting community as the forecast models are those most likely to be transitioned into operational models.

Working together the six research thrusts will develop a series of increasingly capable comprehensive models, with improvements arising from multiple sources: increased component model capability, improved representation of physical coupling between component regions, additional physics in new modules, increased computational capability, and feedback from validation testing.

## **Space Science Goals**

Space science goals are driven both by modeling needs, which require us to develop scientific understanding in order to develop certain models, and by modeling capabilities, which allow us to study quantitatively for the first time the effects of the various interactions of the components of the solar-terrestrial system. Hence science goals are intimately coupled to the progress of model development. In this section we list the space science goals and plans under broad topics.

**CME Initiation:** Coronal Mass Ejections (CMEs) are transient solar phenomena that drive some of the most intense space weather events. Although the mechanism(s) for eruption are not yet fully understood, CISM's modeling approach aims to incorporate the required physics for sophisticated event simulations and to lay the groundwork for routine physics-based simulations when the appropriate observable drivers become available. To develop a realistic active region model (where fast CMEs typically originate) the global MAS coronal model will include the thermodynamics of energy transport processes (radiation, coronal heating, thermal conduction). This thermodynamic model will ultimately be driven time-dependently by a flux evolution model.

**Particle Acceleration:** Solar Energetic Particles (SEP), and the energetic particles trapped in the Earth's radiation belts are two of the most important space weather hazards. In the solar-terrestrial system particles are accelerated: in solar flares; at shocks in the corona, in the solar wind, and standing upstream of planets; at magnetic reconnection sites and similar current sheets; by Fermi and betatron acceleration in radiation belts; and by wave-particle interactions. We are focusing on particle acceleration at coronal and interplanetary shocks with the goal of developing parameterized models for the production of SEP within the global solar and solar wind models. In the global models these particles will then be transported from their shock sources to predict their distribution in geospace. Radiation belt electron modeling and SEP transport and trapping will be incorporated with the LFM code to advance guiding center test particle and Lorentz trajectories of respective source populations, and where

the effects of ULF and VLF waves will be modeled. We will incorporate the effects of SEPs on the upper atmosphere.

**Solar Wind Physics:** The solar wind stream structure is responsible for quiet to moderate space weather conditions, and also affects the propagation, evolution, and geoeffectiveness of CMEs. We will include important thermodynamic processes to more accurately model solar wind structure and parameters (velocity, density, magnetic field) based on solar magnetic field observations, and simulate its effects on our model CMEs. The shock waves generated by the CMEs in the corona and solar wind in these simulations will be used as the foundation for the solar energetic particle (SEP) model. Observational tests of the solar wind/CME/SEP model will be carried out using L1 monitor observations. Solar wind interactions with geospace will be simulated with the comprehensive coupled model.

**Magnetic Reconnection:** Reconnection occurs under different circumstances and in three distinct places in the sun-earth system: at the sun where it causes solar flares, it could well be the cause of CMEs, and may contribute to coronal heating; at the magnetopause where it controls the energy transfer from the solar wind into the magnetosphere; and in the geomagnetic tail where its energy conversion powers substorms. In order to include reconnection processes in the global models, we will use our expertise in reconnection physics to develop appropriate techniques, such as including the Hall term in the LFM magnetospheric model to determine the local reconnection rate.

**Outer-Inner Magnetosphere Coupling:** Important new science goals can be accomplished when the physics of the inner magnetosphere, as represented by the drift physics in the RCM, is embedded in the global MHD magnetospheric code. The magnetospheric component of the comprehensive physics-based CISM code will be able to generate ring current and region 2 currents and associated shielding of the low-latitude ionosphere from high-latitude convection electric fields. This code will be able to resolve long-standing issues in magnetospheric physics by examining the time-dependent response and topology of the region 1 and region 2 current systems and its dependence on the interplanetary magnetic field.

**Magnetosphere/Ionosphere Coupling:** The first order goal is to determine the role and impact of MI coupling on the establishment and maintenance of the basic state of the ionosphere and magnetosphere. Our studies will shed light on the causes of the variability seen and the limitations of predictability. With the LFM code coupled to the thermosphere-ionosphere electrodynamic general circulation model (TIEGCM), a host of important science studies can be undertaken. At high latitudes, the global thermospheric response to magnetospherically driven Joule heating and energetic electron precipitation will be determined, including changes in ion and neutral composition, convection, ionization, and neutral, ion and electron heating. The evolution and spatial

distribution of the auroral electrojet during storms and substorms will be simulated. Inclusion of field-aligned plasma flows, initially via empirical parameterized models, and, ultimately, using physical transport models, will enable studies of dynamic density stratification in the ionosphere and low-altitude magnetosphere and the effects of ionospheric outflow on the global magnetospheric system. Precipitation-induced ionization and ionospheric outflows are significantly enhanced by collisionless ion and electron energization processes that occur in the lower magnetospheric region between the upper boundary of the TIEGCM and the lower boundary of the LFM. Empirical and physical transport models of these processes will be developed and included in the low-altitude LFM boundary conditions. The global electrodynamic interaction between the thermospheric winds and magnetospheric convection and, in particular, the “flywheel” feedback of thermospheric winds on magnetospheric convection will be characterized.

**Thermosphere/Ionosphere Physics:** The global interaction between ionization and heating induced by solar EUV and X-rays and the effects produced by M/I coupling will be determined. This interaction will have immediate applications to forecasting atmospheric drag on satellites, especially during storm-time conditions. The effects on ionospheric structuring, variations in ionospheric content along specified slant paths, and the evolution of geomagnetic induced currents affecting ground-based electrical transmission systems will be investigated. At low latitudes, where interhemispheric flows arise, studies of penetration electric fields on plasmaspheric structure and the role of light ions at and above the exobase will also be enabled with the RCM coupled to the LFM and TIEGCM models as described above.

**Magnetic Storms:** Magnetic storms are the premier space weather events, and the cause of many catastrophic space weather incidents. Magnetospheric behavior during magnetic storms is not well understood both because it is poorly sampled since storms are relatively rare, and because the coupling between the solar wind, magnetosphere, and ionosphere is much stronger, and perhaps of different character, during storms. CISM models will let us explore this coupling under extreme conditions in ways that are just not possible presently. Determining the role of the convection electric field on the storm-time ring current is a problem of central importance to understanding magnetic storms. We will investigate the phenomenon of “undershielding” which happens when the solar wind electric field changes suddenly thereby exposing the low-latitude ionosphere to electric fields from high latitudes and modifying the ionosphere’s radio propagation properties. This is very important for understanding the erosion of the plasmasphere during storms and the location of the auroral electrojet. These are enabling issues to make substantive advances in treating storm conditions.

## Model Development and Computational Science Goals

Model development will both lead to better scientific understanding of the space environment and, in turn, be enabled by our better understanding. Ongoing improvement of the comprehensive model derives from several areas, typically proceeding in parallel. Continued development of the individual component models will add physics and more accurate representations in response to experience with, and validation of, the individual and coupled models. More sophisticated coupling (both physics and computational) will link the components in ways that improve the performance of the comprehensive model. Refined treatment of model input data (e.g. solar magnetogram processing) will more accurately define the critical model drivers. Additional model components will be added to represent important processes. Finally, computational improvements will enable the models to run with high resolution and efficiency.

The sequence and priorities for component and comprehensive model development are established by the model developers and executive committee and reviewed on an ongoing basis, in response to the results of individual and coupled model results. The development sequence is documented in the *CISM Model Development Roadmap* and *Model Development Timeline*.

**Empirical and Forecast Models:** The first CISM forecast models were built using existing empirical and semi-empirical models as components. This suite of models provides the benchmark for metric and skill scores for all subsequent forecast and specification models as well as a benchmark to measure the performance of the physics-based comprehensive model. Future versions of the forecast model suite will incorporate physics-based components in place of empirical components as they are ready.

**Coupling Technology:** The first generation physics-based comprehensive model coupled the existing codes on an ad hoc basis, providing important experience with the issues and requirements for a more general “coupling framework” and with the capabilities of the coupled model.

After assessing available options, CISM has adopted a coupling framework based on two software packages, *InterComm* (developed at U. Maryland) for program control and communication, and *Overture* (developed at the Lawrence Livermore National Laboratory) for building couplers that include grid interpolation and data manipulation. This technology provides CISM with a flexible framework that allows coupled models to run as separate executables and provides a well defined basis for substituting or introducing model components. At this time, this coupling approach is the best choice for CISM’s coupling requirements. We will continue to closely monitor and coordinate as appropriate with other coupling architecture developers, such as the Earth Systems Modeling Frameworks.

**Validation and Metrics:** Each generation of model will undergo a period of up to a year of validation and assessment using observational data and metrics. The metrics that have been established include some selected from among those adopted by the National Space Weather Program and others developed specifically by CISM. We will perform both validation and metric tests, that is, both compare detailed model output against research data sets in order to evaluate the model against reality (validation) and make standardized comparisons between model output parameters and selected operationally available measurements (metrics) that allow a direct comparison between the effectiveness of different models or prediction schemes. These metrics studies will be used to measure the progress of model development. Validation couples intellectually to the space science goals in that studying the model outputs is one way of exploring the science questions being addressed. The results of validation studies will also guide further modeling efforts by pointing out where the models most need improvement.

**Data Assimilation and Input Data Processing:** CISM is developing and exploiting a variety of techniques for ingesting observational data in its numerical models. These include techniques of data assimilation, such as are routinely used in the meteorological community, as well as other techniques that are needed for the modeling regimes and measurement availability in the space weather system. Our goal is to identify and apply those techniques for using measured data that most effectively advance the models' characterizations of the system. CISM's approaches and priorities for using measurement data are set forth in the CISM *Data Assimilation Plan*, which is available on the CISM web site.

## **EDUCATION PLAN**

The *CISM Education Plan*, which is part of the Strategic and Implementation Plan, is maintained as a separate document. The Education Plan defines the education mission, objectives with desired outcomes, and program elements. Several quantitative assessments are specified for each outcome, and these assessments are part of the *CISM Performance Indicators*. The *Education Plan* is available on the CISM web site.

## **DIVERSITY PLAN**

The *CISM Diversity Plan*, which is part of the Strategic and Implementation Plan, is maintained as a separate document. The *Diversity Plan* defines our diversity mission, objectives and program elements. Several quantitative assessments are specified for each objective, and these assessments constitute part of the *CISM Performance Indicators*. The *Diversity Plan* is available on the CISM web site.

## **ETHICS TRAINING PLAN**

*CISM has developed an Ethics Training Plan*, which is part of the Strategic and Implementation Plan, and is maintained as a separate document. The Ethics Training Plan establishes the process by which all scientists and students who participate in CISM research undergo training in the ethical conduct of research within the context of CISM. This includes discussion of the ownership of research and ideas and the roles and responsibilities regarding intellectual property. The *Ethics Training Plan* is available on the CISM web site.

## KNOWLEDGE TRANSFER PLAN

The CISM knowledge transfer thrust will promote the exchange of information, tools, and techniques between CISM and other communities, particularly the broader space science research community, the space weather specification and forecasting operational community, and the aerospace engineering and other user communities. The plan has three distinct objectives: provision of models and forecasting tools to NOAA/SEC and the Air Force; providing models and visualization tools to the wider scientific community; and training and interaction with CISM's partners in the aerospace industry, government labs and agencies. These objectives are supported by five program elements, involving key partnerships and targeted CISM KT activities. The relationship between CISM's knowledge transfer objectives and program elements is summarized in the matrix following this section.

**Forecasting and Specification Tools:** The development and transition of specification and forecasting tools is a major component of the overall CISM plan. This goal benefits CISM in that it serves to focus research into areas most relevant to society's space weather needs. This goal is facilitated through the close partnership between CISM and the NOAA Space Environment Center (SEC).

A CISM-supported scientist is based at NOAA/SEC and serves as the on-site liaison between SEC and CISM. CISM also supports a software engineer resident at SEC. SEC and CISM recognize that model transfer can only be effected by a close working partnership between the scientist(s) who developed the model and the operators who will use it. The CISM liaison and software engineer provide this connection, becoming integral members of the SEC Rapid Prototyping Center (RPC) team, aiding the transfer of CISM-generated models into SEC operations, and consulting daily with the SEC forecasters, programmers, and scientists. By working closely with SEC personnel, the CISM personnel maintain a direct understanding and insight into the pressing needs of SEC and its customers. The liaison transfers this knowledge to CISM team members and also transfers knowledge about model development within CISM to SEC.

**Knowledge Transfer within the Space Physics Community:** The integrated models developed by CISM can be used to test new ideas and explore the complex space environment in ways not possible using only observations. Visualization of a global model provides the best way of understanding the complex 3-D structure and dynamics of the space environment. In partnership with the Community Coordinated Modeling Center (CCMC) CISM will make these models available to the space physics community.

**Industrial and Government Partners:** Interactions with industrial and government partners occur in a variety of ways, including participation in the annual CISM summer school, CISM presence at NOAA's Space Weather

Workshop, and close research links, especially with NOAA/SEC, AFRL, and NRL. CISM also offers a two-day short course, presented at partners' facilities, that includes a review of space weather and training in the use and interpretation of state-of-the-art CISM models and visualization tools.

<b>KT Program Elements:</b>	<b>AFRL Partnership</b>	<b>CCMC Partnership</b>	<b>SEC Partnership</b>	<b>Short Course</b>	<b>Case-by-Case Interactions</b>
<b><i>KT Objectives:</i></b>					
<i>Facilitate model transfers to operational environment.</i>	<p>Assess and prioritize USAF needs and potential model impact.</p> <p>Collaborate in model development toward operational needs.</p> <p>Identify appropriate areas for direct model transitions to USAF agencies.</p>	<p>Support transitions to operations through CCMC independent metrics evaluations, real-time test runs, and installation support.</p>	<p>Evaluate and prioritize models for operational impact.</p> <p>Transition and validate models for SEC operational environment.</p> <p>Support development of forecast products from CISM models.</p>	<p>Clarify operational needs of space weather product end-users.</p>	<p>Identify appropriate areas for direct model transitions, e.g. to AFWA, AFSPC.</p> <p>Support direct model transitions in high impact areas.</p>
<i>Provide models &amp; visualization tools to research community.</i>	<p>Provide models for AFRL research and for collaborative development of specialized models.</p>	<p>Provide model runs-on-request and visualizations for research (and operational) community.</p> <p>Obtain feedback on model use and validations by CCMC and community.</p>			<p>Provide CISM_DX to the community.</p>
<i>Train and interact with government agencies, aerospace industry and others who cope with space weather.</i>	<p>Explore AFRL as a USAF conduit for transmitting user needs and model capabilities.</p>	<p>Provide model runs for retrospective analyses of operational anomalies and to evaluate model capabilities.</p>	<p>Use extensive SEC interactions with government &amp; industry customers to assess diverse operational needs and prioritize CISM-based forecast products.</p>	<p>Interact directly with diverse end-users on modeling needs and future developments.</p> <p>Train in modeling capabilities, tools, and plans; and in available space weather resources.</p> <p>Provide CISM_DX and training with hands-on computer labs.</p> <p>Train in using specific forecast models.</p>	

## MANAGEMENT PLAN

The CISM management structure is designed to address the challenges of running a multi-institutional center which has clear project oriented goals and timelines. To achieve these goals requires close communication, cooperation, and collaboration between institutions and research groups. The CISM management structure, described in the CISM Organizational Chart, is designed to achieve these goals.

**Management Structure:** CISM's central administration consists of Director Jeffrey Hughes, Executive Director Jack Quinn, and Assistant Director Kathryn Nottingham. Jeffrey Hughes, as the Director of CISM, is ultimately responsible for the direction and management of CISM. Hughes meets regularly with the Dean of Arts and Sciences, Virginia Sapiro, to whom he reports. Quinn, as executive director, works closely with the director to manage the daily activities of CISM. Assistant director Kathryn Nottingham, who reports directly to the director, is responsible for all administrative functions, including budget management, overseeing the collection of management data, and maintaining the databases required for evaluation and to monitor progress.

The Center is divided into eight management areas, or "thrusts", each led by a co-director. The research efforts in solar, magnetospheric, and ionosphere/thermosphere/mesosphere physics are the responsibility of co-directors Janet Luhmann, Mary Hudson, and Stan Solomon. Charles Goodrich is responsible for code coupling technology and its application in coupling models. Harlan Spence is responsible for model validation. Ramon Lopez and Nick Gross are co-directors for Diversity and Education, respectively. Daniel Baker is responsible for Knowledge Transfer and the forecast model component. Whereas there is significant overlap in these areas, each has a distinctly different role to play in the development of the CISM comprehensive model, in its use and dissemination, and in the Center's broader objectives.

At each CISM site, the local principal investigator is responsible for managing activities and finances at that site and for coordinating with the appropriate co-directors to ensure that local activities are aligned with the overall CISM plan. Designated administrative contacts at each site interact directly with Assistant Director Kathryn Nottingham on all administrative and reporting issues, with Ms Maureen Rodgers (BU Office of Sponsored Programs) regarding contractual issues, and with the BU Office of Grant and Contract Accounting regarding fiscal reporting issues.

**The CISM Executive Committee**, CISM's principal executive body, consists of the CISM director, executive director, the co-directors who lead the eight thrusts, and three senior modelers. The executive committee confers bi-weekly by means of a telephone conference call, and meets several times a year in person, either at scientific meetings that we all attend, or in conjunction with other CISM

meetings. The Executive Committee develops the strategic policies of CISM including definition of tasks and time lines, monitors progress against these goals, and resolves conflicts arising within CISM. The director, in consultation with the Executive Committee, is responsible for the allocation of resources between areas and tasks. Implementation of CISM policies and the day-to-day management of CISM is the responsibility of the director and executive director

**The CISM Advisory Council** provides independent guidance to the CISM director. The Advisory Council is chaired by Gregory Ginet (AFRL). Its charter and current membership are provided on the CISM web site. The Council meets annually in the early spring to review the activities of CISM, and to provide guidance, advice, and oversight of Center management and all Center objectives. Individual members of the Advisory Council occasionally provide advice or guidance between meetings. Hughes confers with Ginet on a regular basis, and Ginet usually attends CISM's annual NSF Site Visit and All-Hands Meeting.

**Communication within CISM:** Frequent, efficient, and productive interaction of CISM personnel is critical to achieving our research, education, diversity, and knowledge transfer goals and to our smooth operation as a Center. For this reason we have developed a flexible set of communication methods that consist of periodic in-person meetings supplemented with a variety of electronic communications.

The annual CISM All-Hands Meeting, held in September each year, is the principal management tool by which the full CISM team discusses as a whole, refines, and adopts goals and plans. The meeting is typically attended by 75-80 team members and consists of a series of plenary meetings together with many splinter meetings of the different groups and thrusts within CISM each led by a co-director. While the plenary meetings allow for feedback and exchange within the whole group, most of the detailed work of refining milestones and developing plans is done in the splinter sessions. One product of the all-hands meeting is a Center-wide review of the milestones and underlying plans of the CISM Model Development Roadmap.

The annual CISM calendar is punctuated by a series of regular meetings. These include the annual Advisory Council Meeting in March and the annual NSF Site Visit in May or June. In addition CISM has a large presence at Space Weather Workshop, which is organized by NOAA/SEC, usually in April, and brings together space weather researchers, forecasters and end-users. CISM also participates in the annual SHINE, GEM, and CEDAR workshops each June or July, and in the two AGU meetings (December and May). Each of these meetings provides an opportunity for meetings of the CISM Executive Committee and/or other specialized CISM groups such as the solar, magnetospheric, or ITM teams at SHINE, GEM, CEDAR, and the annual "SolarCISM" meeting. Finally the CISM Summer School brings together many CISM participants each summer.

Physical meetings cannot be held often enough nor include all the appropriate CISM members to provide the desired level of close communication in support of the integrated activities of the Center. Thus much of our communication and interaction must be done electronically. We use three forms of electronic communication: real-time video conferencing via the AccessGrid, telephone conferencing, and e-mail including a large number of topical mailing lists. The executive committee and various groups within CISM have regular meetings via these means. The CISM science seminar series, held on the AccessGrid during the academic year, provides a Center-wide forum to present and discuss key scientific issues.

**The CISM Performance Indicators** are a diverse summary set of measures, both objective and subjective, by which CISM's performance can be assessed. The *Performance Indicators* cover five areas: research, education, diversity, knowledge transfer, and performance as a center. Within each of these areas a number of key performance objectives are identified, which include meeting the goals and milestones established in CISM's *Milestones* document. The Center's performance towards each of these objectives is measured by one or more performance indicators. The information required to assess CISM's performance by means of the *Performance Indicators* is compiled annually, and most of it is included in the CISM Annual Report. The document describing the CISM Performance Indicators is maintained on the CISM web site.

## REACHING THE POST-STC VISION

During its first five years, CISM developed a vision for continuing key center-enabled elements after its life as an STC. This vision is that the development, distribution, and use of CISM models, together with other models, will continue under community-wide guidance post-STC. To achieve this goal several elements that are currently a part of CISM will need to continue in a different, ongoing form (see following table). In addition to sustaining these elements, a successful community modeling effort must also ensure that participation in the community effort is attractive to the broad research community. Early in its second five years CISM will initiate a number of activities to engage the community to help design and build the structures that will enable this transformation. These initiatives include holding a workshop or series of workshops to explore the various options for community model development drawing on the experience of other disciplines, e.g. climate modeling; establishing a community-based model development advisory committee that could eventually become the community model steering committee that decides the model development path; and inviting non-CISM modelers to couple their models into the CISM framework to demonstrate interchangeability and develop working relationships.

The following table outlines the transition to community modeling. Key elements needed for sustained coupled model development are listed in the left column.

The center column lists responsibility for these elements within CISM. The right column suggests responsibility under a community modeling program, to be refined through the community discussions noted above. While many activities of community model development can be performed readily in a distributed fashion, some more centralized, integrative functions are needed to sustain development of a coupled model. The organizational and/or institutional form of this remains to be defined; we note it in the table as “TBD Integrator”.

<b>Responsibilities for:</b>	<b>CISM Models (during STC)</b>	<b>A Community Model (post-STC)</b>
Component Model Development	CISM developers	Any model developers
Develop Coupling Technology	CISM Code Coupling	Use existing technology or ?
Implement Model Coupling	CISM Code Coupling and Developers, CCMC	Model developers, <i>TBD Integrator</i> , CCMC, .....
Validation/Skill Scores	CISM Validation augmented by CCMC	Community, <i>TBD Integrator</i> , CCMC, operational users, ??
Archive of Model Runs	CISM, CCMC	<i>TBD Integrator</i> , CCMC
Steering of Model Priorities, Component Choices, Coupling Technologies	CISM	Community Steering Committee
Develop Visualization Tools (CISM_DX)	CISM	Community
Custodian of Development Models	CISM Developers to CISM Repository	Community Developers to <i>TBD Integrator</i> Repository
Custodian of Community Models	CCMC	CCMC
Custodian of Operational Models	SEC, ...	SEC, ...
Transitioning models to Community and Operational Users	CISM KT, CCMC, CISM Developers, User Institutions	<i>TBD Integrator</i> , CCMC, Community Developers, User Institutions
<b>Funding for:</b>		
Component Development	CISM + leveraged funding	NSF/NASA/NOAA/AF/ONR?
Developer support for coupling, validation, transition	CISM + leveraged funding	NSF/NASA/NOAA/AF/ONR?
Support for <i>integrator</i> tasks	CISM	NSF/NASA/NOAA/AF/ONR?

## **STC RAMP-DOWN**

As CISM approaches its end as an STC, the executive committee and institutional PIs will ensure that there is a clearly communicated plan for task completion and phase-out that is consistent with the ramping down Center support levels. This will be reviewed at the All-Hands meetings beginning in CISM Year-8.

Supervisors at all member institutions will ensure that the transition for graduate students and post-doctoral scientists is smooth. Normally, graduate students who will not complete their degrees during CISM will transition to other grant support under the same advisor.

## Implementation Plans

The following implementation and assessment plans, maintained as separate documents, are part of the CISM Strategic and Implementation Plan.

### *Advisory Council Charter*

<http://www.bu.edu/cism/Participants/advisorycouncil.html>

### *Data Assimilation Plan*

<http://www.bu.edu/cism/Publications/documents.html>

### *Diversity Plan*

<http://www.bu.edu/cism/Publications/documents.html>

### *Education Plan*

<http://www.bu.edu/cism/Publications/documents.html>

### *Ethics Training Plan*

<http://www.bu.edu/cism/Publications/documents.html>

### *Model Development Roadmap*

<http://www.bu.edu/cism/Publications/documents.html>

### *Model Development Timeline*

<http://www.bu.edu/cism/Publications/documents.html>

### *Model Release and Version Control Plan*

<http://www.bu.edu/cism/Publications/documents.html>

### *Performance Indicators*

<http://www.bu.edu/cism/Publications/documents.html>

### *Second 5-Year Goals & Milestones*

<http://www.bu.edu/cism/Publications/documents.html>