

Project Plan 2010-2015

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1 Summary

In this *Project Plan* we describe the nature, structure, goals, activities, funding, and evaluation of the Earth System Modeling Framework (ESMF) project from 2010-2015. It is distinguished from the ESMF Strategic Plan in that it focuses on principles of operation rather than strategy. It includes terms of reference for all project bodies and designated positions. The *Plan* is intended to serve as a vehicle for coordination and as a reference for collaborators, sponsors, customers, and others with an interest in ESMF. This is the second major revision of the *Project Plan*; the first *Plan* was created for the period 2005-2010.

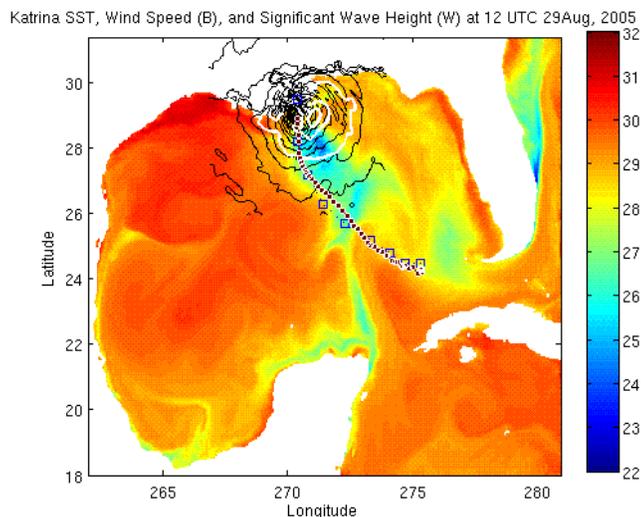
The ESMF website is mentioned frequently as a source of information; it is <http://www.earthsystemmodeling.org>. The Project Plan is posted there under the **Management** tab. For brevity we expand only acronyms likely to be unfamiliar, and provide a full listing in Appendix D.

2 Introduction

The ESMF collaboration [1,2] is a national effort to produce shareable software for climate, weather, and related applications. ESMF increases the interoperability, reuse, ease of use, and performance portability of models by introducing standard component interfaces and software infrastructure for common modeling functions. It includes tools for building applications from multiple science components, for data decomposition and communication on parallel computers, and for functions such as calculation of interpolation weights, time management and message logging.

Development and deployment of the ESMF is a far-reaching endeavor that requires the coordination and contributions of many participants, both technical and scientific, from programmer to program director, to be successful. Staff from modeling centers supported by DoD, DOE, NASA, NOAA, and NSF, as well as numerous universities, have contributed requirements, feedback, and software to ESMF. Figure 1 shows the results of a regional wave-ocean-atmosphere system coupled using ESMF. It was developed as part of the Battlespace Environments Institute (BEI), a large application initiative that is built on ESMF infrastructure.

Figure 1
The Naval Research Laboratory Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) is the first limited area model to adopt the Earth System Modeling Framework (ESMF) technology for use in the air-sea coupling problem. The image at right shows a COAMPS 48-hour simulation of hurricane Katrina. The three-way coupling between COAMPS, the Navy Coastal Ocean Model (NCOM), and the Simulating WAVes Nearshore (SWAN) model is achieved through ESMF.



At the time of this writing, ESMF is beginning its third funding and development cycle. The initial development cycle, which began in 2002, was a three-year project funded by NASA with additional support from the NSF. The second cycle, which began in 2005, was a five year multi-agency effort that broadened participation to include sponsorship and major application projects from NOAA and the Department of Defense.

ESMF development over the period from 2002 to 2010 is summarized in Figure 2. It shows the five major releases of ESMF during this period. The last release, version 5, is the culmination of a standardization process that is ensuring consistency across software interfaces and behaviors. Releases after 2010 are expected to have interfaces that are backwards compatible.

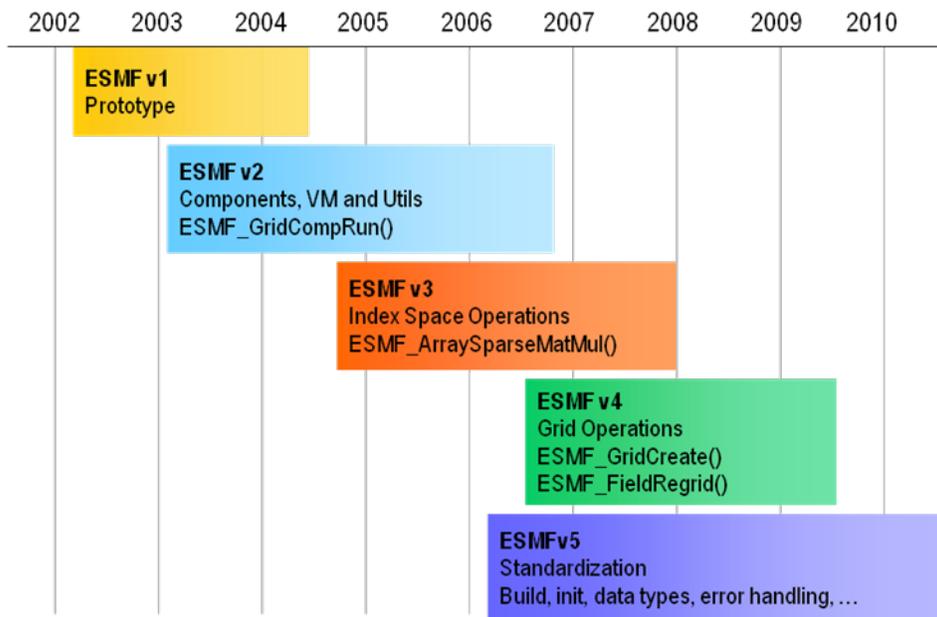


Figure 2 ESMF release plan for 2002-2010. The chart shows the timescales of the five major releases, the major capability that each represents, and some a canonical operations.

This *Project Plan* addresses the next five years of the ESMF effort, from 2010 to 2015. At the start of this period, the core development team of the project moved from the National Center for Atmospheric Research (NCAR) to the NOAA Earth Systems Research Laboratory (ESRL), which is expected to be its long-term home. NSF, NASA, DoD, and NOAA are expected to continue as project participants and sponsors. Some major application integration efforts based on ESMF, such as the Battlespace Environments Institute and the development of the GEOS-5 atmospheric general circulation model, are finishing active periods of development.

ESMF will continue to maintain and support these efforts, and to continue incremental development as needed for new scientific and technical requirements. Other groups are initiating new ESMF-based applications, such as the National Unified Operational Prediction Capability (NUOPC). NUOPC is a collaboration of the Air Force, Navy, and NOAA (collectively referred to as the Tri-Agency). The overall goal of NUOPC is to accelerate the rate of improvement in the U.S. national environmental prediction capability at its operational centers, focusing initially on the global model enterprise. This will include a multi-model ensemble for U.S. operational weather prediction.

In addition to new and continuing application projects, ESMF has also partnered with other infrastructure projects such as the DOE-funded Earth System Grid portal, which distributes climate model data, and the European Union’s METAFOR project, which is developing standard metadata to describe climate models. One of the long terms goals of ESMF is to facilitate end-to-end modeling and analysis, by working towards greater integration with data archives and science gateways. The white paper entitled *Future Directions for the Earth System Modeling Framework* [3] outlines a collective vision of that future. The Curator project, funded by the NSF and NASA, is beginning to implement this vision. In collaboration with the Earth System Grid, GFDL, the Georgia Institute of Technology and others, members of the ESMF project have been building combined modeling and data services in support of workshops and major international campaigns such as the Intergovernmental Panel on Climate Change Assessments.

The *Plan* is a living document, responsive to the many factors in technology, science, and society that can influence ESMF. Nonetheless, we expect the basic project structure described to persist. It is based on, and extends, organizational bodies and strategies that have proven effective in ESMF to date.

3 Definitions

Like many undertakings, ESMF can be viewed as both a project (or set of projects) and a product. As a community infrastructure effort, ESMF also aspires to be recognized as a standard. As the ESMF effort matures, we have also seen the emergence of a need for conventions, templates, and usage constraints designed to achieve increased interoperability for a set of ESMF components. These are collected into “usability layers.” In this section we clarify what is meant by each of these terms in the *Plan*.

3.1 ESMF as a Standard Interface

ESMF was conceived as an infrastructure standardization effort. As such, the project aims to produce a specification for an application programming interface (API) that is stable, consistent, distinct from the implementation, and recognized by some set of bodies as a common convention or standard. In theory, the API could be implemented by more than one group, or the underlying implementation might change substantially over time. Some successful examples of standardization projects that have adopted this approach in the high performance computing arena are MPI [4] and VSIPL [5].

In practice, except for a couple of implementations of the ESMF time manager library, there is only one group that is implementing the ESMF software - a funded Core Team. The code that this group produces is referred to here as the reference implementation. It has proven difficult to specify the API prior to or separate from the reference implementation, since requirements are often established by iterating on working code with users. As a result, the interface has evolved considerably over the course of development. Due to the many contributors to ESMF (and despite best efforts to follow coding and naming conventions), parts of the software are inconsistent in calling interface and behavior in the current version, ESMF version 4.

As shown in Figure 2, the second cycle of the project concludes with a period whose aim is standardization. In this context, standardization means that the development team enforces consistency across framework code. The intent is to produce a final version that is consistent in interfaces and behavior across the framework. After 2010 (ESMF version 5), the ESMF API is expected to be highly stable, and the ESMF team has committed to backwards compatibility for

future versions. After this time, the ESMF may seek recognition as a standardized interface by bodies such as the NASA Earth Science Standards Process Group.

3.2 ESMF as Product and Project

The **ESMF Product** is defined as the ESMF application interface, reference implementation and documentation; associated maintenance and testing; support and training; and a web-based collaboration environment that allows ESMF staff, sponsors, and customers to archive and exchange information. It does not include the full set of applications that have adopted or will adopt ESMF. Figure 3 shows a schematic of the ESMF Product.

ESMF target applications typically have life spans on the order of decades - large geophysical codes are too difficult to develop, tune, and validate to make frequent fundamental changes. The ESMF Product must be maintained on a comparable time scale in order to support these codes, and requires continuity in staff and management in order to do so effectively.¹ This means that the notion of an **ESMF Project** must exist beyond the confines of a three to five year funding cycle.

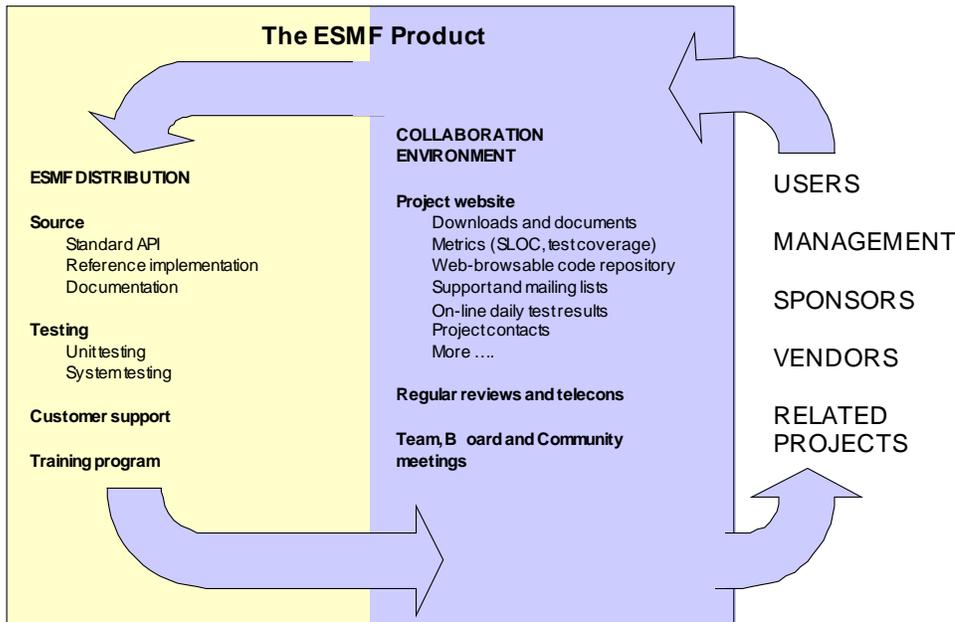


Figure 3
The ESMF Product includes both a source distribution and the collaboration environment necessary to develop and deploy it.

During ESMF's first NASA-funded phase, the definition of the ESMF Project was relatively clear; its scope was defined by a set of three interlinked NASA Cooperative Agreements, and its goals were laid out as a set of milestones [6]. NASA provided most of the funds for development of a reference implementation by a team located at NCAR, and funds for deployment of the framework in fifteen applications, among them GFDL models [7], new NASA GMAO models

¹ The paper *Future Directions for the ESMF* [3] provides a more detailed rationale for continued maintenance and persistent management.

and data assimilation systems, and the NCEP forecast system [8].

However, since 2005, ESMF has had multiple sponsors, each with their own milestones, reporting requirements, and mission. The activities of core framework development and the deployment activity are distinct. For example, the Battlespace Environments Institute (BEI) is a DoD effort to incorporate ESMF into a set of defense applications, with most funding going to application development. Similarly, through its Modeling, Analysis and Prediction (MAP) Climate Variability and Change Program [9], NASA is funding the development of a set of ESMF compliant applications and a “MAP modeling environment.” We term activities such as BEI and the MAP environment, in which groups integrate ESMF into applications, **Application Integration Projects**. Groups engaging in Application Integration Projects may have existed before ESMF; for example, the Community Climate System Model (CCSM) Software Engineering Group (CSEG) is participating in the integration of ESMF into their climate modeling software.

In addition to Application Integration Projects, there is community interest in providing software additions to the ESMF reference implementation. These additions may include extensions to the ESMF functionality or application domain, advanced user interfaces, optimization, porting, or other contributions. We refer to projects of this nature as **Development Plug-Ins**.

A centralized core framework development team is funded by multiple agencies, and Application Integration Projects and Development Plug-Ins contribute funds to the core effort for development, assimilation of contributions, testing, and support staff. See Section 6 for further details on this strategy.

Within this context, we define the ESMF Project as *the body responsible for developing and managing the ESMF Product*. It receives funding from multiple sponsors. It has two main parts, a **Working Project** that handles day-to-day operations and an **Executive Management**. It includes a support and outreach function, but does not include all of the applications that are integrating ESMF. So, for example, the ESMF Project does not subsume the BEI Application Integration Project; they are separate entities with their own structure and management. Connections between BEI and ESMF are established through BEI participation in the appropriate ESMF organizational bodies, and vice versa. Figure 4 shows the co-existence of the ESMF Project with various Application Integration Projects and Development Plug-Ins.

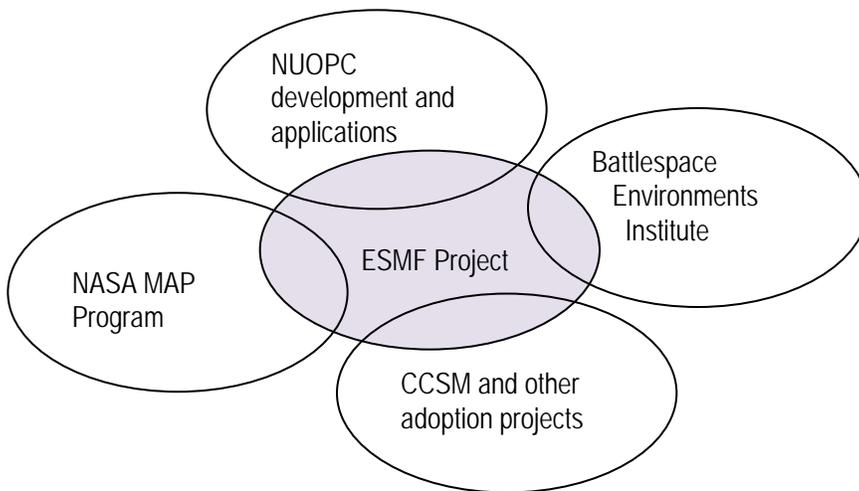


Figure 4
The ESMF Project and its relation to Application Integration Projects and Development Plug-Ins.

3.3 Usability Layers

ESMF interfaces offer multiple options for representation of the same quantity, and multiple interpretations of some of their arguments. Although this increases the flexibility of the framework and has encouraged a broad user base, it makes it difficult to achieve interoperability without the disambiguation provided by additional metadata and usage conventions. The NASA Goddard group that developed the GEOS-5 model addressed this issue early on by developing the Modeling, Analysis and Prediction Program Layer (MAPL), which sits on top of ESMF. It introduces a specific, hierarchical architecture and the templates and conventions to support it. Similarly, the NUOPC Common Model Architecture (CMA) committee has proposed the creation of a *NUOPC Interoperability Layer* that will specify, through conventions, metadata, and code templates, how NUOPC applications will implement ESMF. While this may not make components within NUOPC “plug-and-play,” it will enable NUOPC components to achieve a target level of interoperability. Some or all elements of the NUOPC Interoperability Layer may become part of the main ESMF distribution in order to increase interoperability across a broader community. The ESMF Core Team is charged with examining if and how MAPL can be merged with the NUOPC Layer, and with the main ESMF distribution.

4 Goals

The overriding goals of the ESMF are to

1. increase the scientific productivity of researchers in the Earth system domain by enabling them to use and reuse common modeling infrastructure; and
2. promote new scientific opportunities through community building and increased interoperability of codes.

The first goal is achieved mainly through the delivery of the ESMF Product. It offers the coupling tools, data structures, and utilities that modelers require. They can build models quickly, reuse existing software rather than reinventing it, and exchange and introduce new modeling components in a systematic way.

The second is achieved mainly through the ongoing activities of the ESMF Project. The collaboration required by ESMF, the standards-building activities, and the community outreach that the Project continually engages in are breaking down barriers in the modeling community and enabling new collaborations to be forged.

4.1 Key Organizational Strategies

The ESMF organization reflects the diversity of its customers and the ambition of its goals, and it is complex. However, there are number of key strategies that underlie its structure, and help to explain the choices made. These are:

1. *Recognition that the key relationship in the ESMF Project is between the ESMF Product and the science customer, and that the practical goal of the ESMF effort is to enhance the capabilities of a limited set of working research and operational codes.* This recognition encourages the formulation of appropriate test and validation strategies, milestones, and success metrics.
2. *A close and continuous relationship between the developers of the software and users of the software, encompassing requirements management, interface specification, short- and long-term reviews, and evaluation.* A close relationship ensures that the product delivered is the product needed.
3. *A core development and support team under direct line management.* We have found that a dedicated Core Team promotes responsive, high quality development and support, and provides necessary assimilation services for code contributions from other sources.
4. *A set of dispersed, science-knowledgeable coordinators working with each other, the development team, and application groups to organize outreach efforts, develop training materials, and encourage adoption of the framework.* It has been our experience that one of the best ways to promote ESMF adoption is to have scientists advocate the product to their peers.
5. *Clear, consensually decided upon mechanisms for setting implementation priorities and for making technical decisions.* These mechanisms are required in order to avoid perceptions of unfairness, and to keep development moving along a focused and timely path.
6. *Maintenance of an openly accessible web-based collaboration environment that provides comprehensive and pertinent information, including metrics, task lists, documents, regression test results, links to common repositories, and more.* The communication infrastructure together with frequent regular telecons, community meetings, and a network of informal cross-collaborator communications are the lifeblood of the project.

4.2 Overview of the ESMF Organization

The persistent ESMF organizational structure incorporates the elements above. We introduce the concept of a **Working Project**, defined as the team of customers and developers who collaborate day-to-day to build the ESMF Product. The Working Project consists of three parts:

1. a line-managed **Core Team** responsible for implementing the ESMF software, including unit and system testing, maintenance, support, and oversight of a web-based collaboration environment;
2. a **Content Standards Committee**, introduced in 2010, responsible for developing metadata, usage, and other conventions to enhance interoperability through

- standardization and a NUOPC Interoperability Layer for the Tri-Agency operational centers;
3. a group of active users called the **Joint Specification Team (JST)** that interact with the Core Team and broader community, providing requirements, feedback, and a standards track; and
 4. a **Change Review Board (CRB)** that integrates and prioritizes the requirements from multiple users and sponsors.

The Working Project is funded, guided and evaluated by its **Executive Management**. The Executive Management of ESMF is comprised of several bodies. These are:

1. an **Executive Board** charged with scientific and technical leadership;
2. a **Review Committee** that promotes relationships with the broader community;
3. an **Interagency Working Group (IAWG)** that coordinates funding.

Both the ESMF Executive Management and the Working Project interact with the Earth system modeling and related communities, including the computer science community and the vendor community. Figure 5 shows the ESMF Project and its interactions with outside communities.

The ESMF organization is how the ESMF Project coordinates across milestones, missions, reporting requirements and agencies. Coordination across the ESMF must be addressed by the entire Project structure, so that sponsors can coordinate with other sponsors, hands-on staff can communicate with their peers, and prioritization of multi-agency requirements can be mediated at the appropriate level. Also, the coordination must be dynamic and ongoing; it cannot be accomplished through infrequent events. Interactions occur at a range of different time scales, from days to years. In this document we focus on defining the mechanisms through which coordination will take place and how decisions will be made, rather than what those decisions will be.

The remainder of this section defines in greater detail the elements and associated roles within the ESMF Working Project and Executive Management, the broader community that ESMF serves, and the interactions amongst all of these. Figure 5 shows a diagram of the ESMF organization, and the timescales at which different bodies operate.

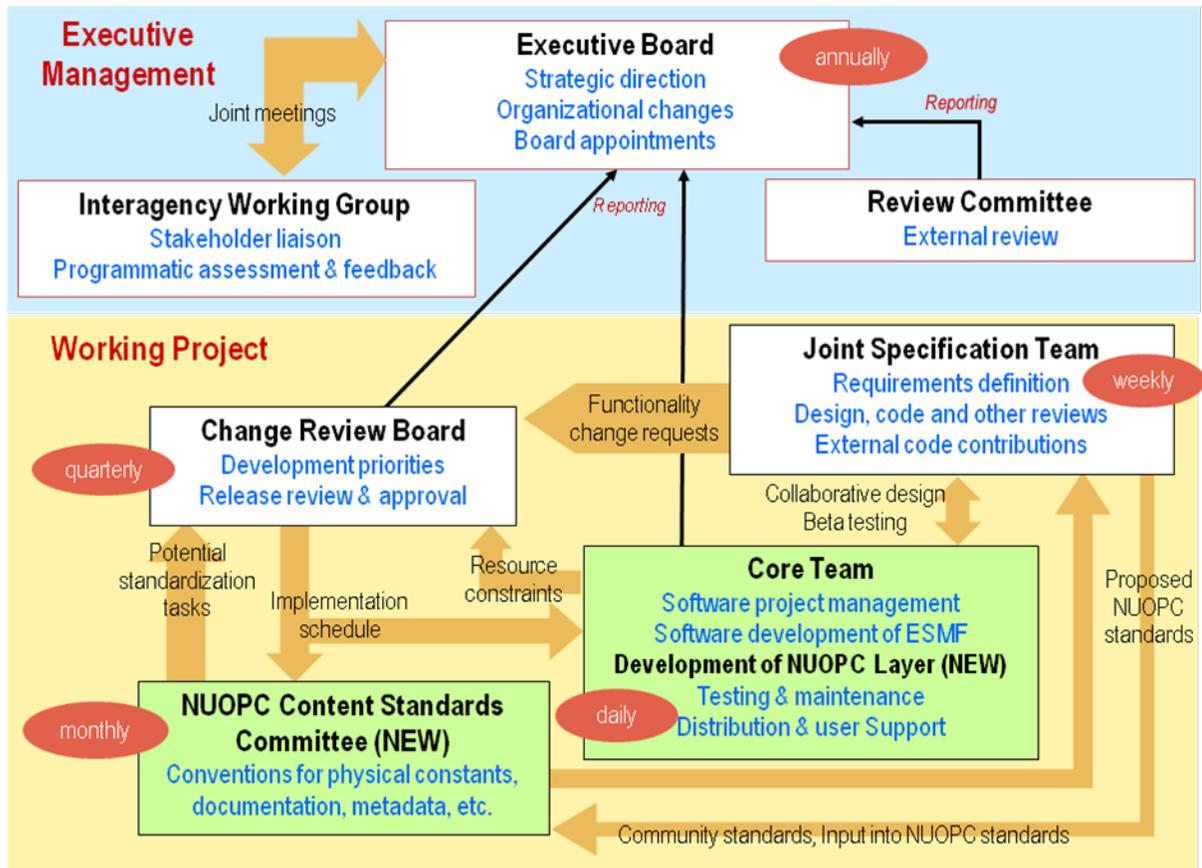


Figure 5
 The ESMF is comprised of a Working Project and Executive Management. A new element in the organization is the Content Standards Committee, which coordinates with the Core Team and receives priorities from the Change Review Board. Typical timescales of interaction are noted in the red ovals.

4.3 The Working Project

We refer to the organizational structure that is responsible for implementing the ESMF Product day-to-day as the Working Project. The Working Project is a balance between three bodies: a Joint Specification Team, a Core Team, and a Change Review Board. In simplest terms, the Core Team is responsible for implementing the software, the Joint Specification Team is responsible for communicating functional requirements and design preferences, and the Change Review Board is responsible for determining cross-agency priorities for software development and for creating development schedules. Beginning in 2010, the Working Project will also include the NUOPC Content Standards Committee, charged with developing usage and other conventions to improve interoperability. The Working Project has established paths of interaction with the Earth science user community, vendors, the computer science community, and ESMF Executive Management.

The Working Project is accountable to the Interagency Working Group for satisfying programmatic goals, and to the Executive Board for satisfying functional requirements. It receives direction from both of these bodies.

4.3.1 The Core Team

The Core Team is the part of the ESMF project responsible for implementing the framework software and maintaining the collaboration environment. The Core Team is the main point of contact for users and is responsible for archiving and resolving support requests, feature requests, and bug reports.

Starting in 2010, the ESMF Core Team will be responsible for implementing the NUOPC Interoperability Layer above the present ESMF architecture for the NUOPC operational centers and participating organizations. The Core Team will develop the software necessary to achieve the desired level of interoperability for NUOPC applications. This NUOPC Interoperability Layer is expected to be distinct from the ESMF main distribution. The Core Team will also participate in the coordination of development between the NUOPC Interoperability Layer and the existing NASA MAPL interoperability layer.

The Core Team receives framework requirements and design input from the Joint Specification Team (JST). It receives implementation priorities from the Change Review Board (CRB), and direction from the Executive Board and the Interagency Working Group (IAWG).

The Core Team is not responsible for prioritizing development tasks; that is the role of the Change Review Board. However, the Core Team Manager is an *ex officio* member of the Change Review Board, and can offer integrated effort, risk, and dependency assessments that may factor into the prioritization process.

The Core Team will receive guidance from the Content Standards Committee (CSC) on how to implement the NUOPC Interoperability Layer. The Core Team Manager or a designated proxy is an *ex officio* member of the CSC and is expected to work closely with that body on the NUOPC Interoperability Layer implementation. Core Team members should be able to meet with and advise people from the Tri-Agency operational centers and development laboratories as necessary. The Chair of the NUOPC Content Standards Committee will monitor the Core Team and attend relevant activities such as design and code reviews.

The Core Team is subdivided into several groups: a Development Group, a Support Group, a Test Group, and a Web Group. Each of these has a leader who may or may not have supervisory responsibilities. There is some overlap between staff in the Development and Support Groups, since an advanced user with a support issue may require interaction with a primary developer.

The Development Group is responsible for design, implementation, maintenance and documentation of the reference implementation. Details of the ESMF development process are described in the *ESMF Developer's Guide* [10].

The Test Group is responsible for unit and system testing of the software. Areas covered include functionality testing, regression testing, performance testing, use test cases, and portability testing. The Test Group also tracks bug reports and is responsible for verifying bug fixes. Details of the ESMF testing process are described in the *ESMF Developer's Guide* [10] and on the *Test and Validation* page of the ESMF website.

The Support Group is responsible for moderating the ESMF support mailing list and resolving and tracking support requests. The Support Group creates training materials in conjunction with members of the Joint Specification Team, and provides training classes.

The Web Group is responsible for maintaining the ESMF collaboration environment and for identifying and creating new tools to enhance it.

There is also a non-trivial administrative function associated with the ESMF project. ESMF administrative tasks include organizing the Annual Community Meeting, managing Board appointments, and coordinating meetings of Executive Management.

MEMBERS and MEETINGS The Core Team consists of software developers, testers, administrative staff, user support and training staff, web developers, and the Core Team Manager. The Core Team manager is responsible for staffing. Development meetings are held weekly, and ticket review meetings (for support requests, feature requests, and bug reports) are held monthly.

CHARGE and REPORTING

- Collect, archive, and track requirements.
- Implement requirements in software for the framework and NUOPC Interoperability Layer.
- Assimilate non-Core development activities.
- Perform maintenance and bug fixes.
- Track bugs, feature requests, and support requests.
- Unit and system test.
- Provide user documentation, design documentation, and a Developer's Guide.
- Provide user support and training.
- Liaise with vendors.
- Liaise with other projects (shared responsibility with other ESMF bodies).
- Develop and maintain the ESMF collaboration environment.

The Core Team reports to the Executive Board and receives priorities from the Change Review Board.

4.3.2 The Joint Specification Team

The Joint Specification Team (JST) is a group of active users that interact with the Core Team and the broader community, providing requirements, feedback, and a community standards track. Membership is open and communication is mainly through telecons.

Since the JST is comprised mainly of Earth science application developers who have experience using ESMF, it is the body best equipped to review and refine the ESMF Application Programming Interface (API). JST members may provide interface specifications along with requirements, or may review interfaces after prototypes have been developed by the Core Team. The balance between the JST and Core Team is fundamental to the ESMF organizational structure.

The JST will also function as a means to bring community input into the CSC standardization activity, and to disseminate CSC standards to the broader community. The CSC Chair will be responsible for requesting input into standards from the JST. Members of the JST who are also involved in the CSC will be responsible for advancing CSC standards in the broader community.

The JST interface review and standards activity places an important aspect of ESMF development in the hands of users, thereby promoting community ownership. This longer-term review function is the first step in transforming ESMF into a standard API.

MEMBERS and MEETINGS The JST is comprised of members of the ESMF user community, meeting jointly with members of the Core Team. It holds telecons weekly or as necessary to discuss priorities, meeting agendas, design and implementation issues, and other relevant topics. Membership is open.

CHARGE and REPORTING

- Generate functional requirements.
- Confirm implemented requirements.
- Participate in design and code reviews.
- Provide general feedback.
- Submit support requests, feature requests, and bug reports.
- Provide code contributions.
- Promote and develop the ESMF API as an interface standard.
- Interact with the CSC to develop and promote content standards.
- Liaise with other projects (shared responsibility with other ESMF bodies).

The Joint Specification Team reports to the Executive Board.

4.3.3 The Change Review Board

The Change Review Board prioritizes tasks and prepares a Core Team development schedule, and plans, authorizes, and reviews the content of ESMF releases. It provides guidance on priorities to the Content Standards Committee and ensures coordination of this body and the Core Team.

CRB members meet on a quarterly basis to review and revise development priorities, and prepare a development and release schedule for the Core Team. Proposals for new requirements or changes to existing requirements, and the concomitant development of new functionality, or changes to existing functionality, are communicated to the CRB from the JST via the ESMF support mailing list. The Board reviews all updates to requirements and prioritizes the implementation of new requests among the outstanding development tasks on the Core Team schedule. Prioritization takes into account the immediate needs of the agencies funding ESMF development. The release schedule prepared by the CRB specifies development tasks on a per-release basis for releases about a year into the future. The CRB reviews releases for conformance to planned contents prior to release.

The CRB receives potential standardization tasks from the Content Standards Committee and prioritizes them in accordance with strategic objectives, JST application priorities and Core Team activities.

MEMBERS and MEETINGS The CRB is populated with application developers representing agency and institutional stakeholders in the ESMF project. A typical CRB member controls the scientific and technical development of a set of ESMF-compliant applications. The Core Team Manager, the Content Standards Committee Chair, and the ESMF Program Coordinator are *ex officio* members of the CRB. The Core Team Manager advises the CRB on the capabilities of the Core Team and the scheduling of development activities. The ESMF Program Coordinator leads and mediates CRB meetings. Simultaneous membership on both the CRB and Executive Board is discouraged, except for *ex officio* members.

Members are appointed by the Executive Board and serve renewable one-year terms. CRB discussions are mediated by the Program Coordinator. The CRB meets quarterly and sends minutes and implementation schedules to the Executive Board for review within one month of meeting.

CHARGE and REPORTING

- Review and authorize changes to the reference implementation maintained by the Core Team.
- Review potential standardization tasks and provide development priorities to the Content Standards Committee.
- Coordinate the activities of the Core Team and the Content Standards Committee.
- Update the development and release schedules, and submit them quarterly to the Executive Board for review.
- Review and approve the content of ESMF releases to assure that development tasks are completed prior to release.

The CRB reports to the Executive Board.

4.3.4 The Content Standards Committee

The NUOPC Content Standards Committee (CSC) is the primary committee responsible for evolving and expanding interoperability standards for the NUOPC partners. The CSC will have responsibility for selecting or developing conventions for metadata, documentation, physical constants and other areas that require mutually agreed on values and formats. The CSC will not be responsible for the design of software or software interfaces. However, its work will need to be coordinated with the ESMF Core Team, since software will be required to support implementation of some of the conventions.

CSC recommendations relating to ESMF will be submitted to the Joint Specification Team (JST) for comment and review in the same manner that those recommendations of the Core Development Team are now addressed through the CDT – JST telecons. Serious objections by the JST will be considered by the CSC with final decisions made by the CRB if resolution is required. Additional standards not related to ESMF will be passed by the CSC to the JST for information and comment.

It is expected that the CSC will work in close collaboration with the ESMF Core Team. The Core Team will provide input to the CSC on standards from an implementation perspective, and ensure that the NUOPC software supports them. For this reason, there should be some individuals who are members of both committees.

The CSC and Core Team will receive priorities from the ESMF Change Review Board. NUOPC will act through the CSC to provide a list of potential tasks to the CRB, along with input on priorities, for final prioritization and coordination with the tasks on the ESMF development team schedule.

The Change Review Board will be responsible for ensuring that the CSC and Core Team activities are synchronized.

The CSC will also interact with the NUOPC Common Model Architecture Committee to evolve standards suitable for future global model systems.

The chair of the Content Standards Committee will also be a member of the ESMF Change Review Board. The CSC committee will be composed of members from the NUOPC participating operational centers, from the developmental organizations of the Tri-Agency (Air Force, Navy, and NOAA), from other U.S. government agencies (NASA, DOE and FAA), NCAR, and, as appropriate, university groups.

The CSC will meet as required to complete definition of the initial NUOPC standards and then at least quarterly thereafter, by teleconference and/or internet with periodic face-to-face meetings.

MEMBERS and MEETINGS The CSC consists of members from the three NUOPC operational centers, their development organizations, NASA and NCAR and other interested organizations and individuals. The CSC will meet quarterly or as determined by the CSC Chair.

CHARGE and REPORTING

- Develop metadata, physical constant, and other content standards for NUOPC, taking into account existing community standards and input from the JST.

The CSC reports to the NUOPC Common Model Architecture Committee.

4.3.5 Working Project Management

Working Project management is responsible for the day-to-day oversight of ESMF development and support. Different styles of management are appropriate for different Working Project functions. We have found that direct line management of the Core Team allows for rapid development. A line manager can be more effective than a principle investigator trying to direct a project member who he or she does not supervise and who may be located at another institution.

The Change Review Board and Content Standards Committee require mediation among peers. The Program Coordinator, who is ideally in a neutral position with respect to multi-agency development priorities, negotiates prioritization decisions with CRB members. The CSC Chair mediates among members of the NUOPC community.

The JST extends across multiple institutions and has relatively diffuse goals; members can organize and coordinate activities, but cannot line manage across group or institutional bounds.

4.3.5.1 Program Coordinator

The Program Coordinator maintains and conveys a high-level view of ESMF capabilities and priorities to sponsors and others. The person in this position is responsible for negotiating agreements on the CRB and for helping to track and facilitate the cross-agency transfer of capabilities. It is, at least initially, a part-time position.

CHARGE and REPORTING

- Serve as a representative of the ESMF project at conferences and other public events, and to ESMF sponsors.
- Organize and chair the Change Review Board, and lead the discussions and negotiations of that body.
- Ensure that the Change Review Board meets on a regular schedule and in a fashion satisfactory to members.
- Ensure that the Change Review Board provides development priorities to the Core Team, and that these are posted in a clear, public, and timely manner.

- Facilitate cross-agency activities and the cross-agency transfer of capabilities and ideas.
- Work with JST Coordinators, CSC, and the Core Team Manager to schedule and plan Interagency Working Group activities.

The Program Coordinator reports to the Executive Board.

4.3.5.2 Core Team Manager

The Core Team manager is responsible for directing ESMF development. It is a full-time position.

CHARGE and REPORTING

- Supervise and direct the activities of members of the Core Team.
- Perform Core Team administrative functions as required by NCAR management and contractual obligations.
- Direct the development and maintenance of the collaboration environment, and assure that it satisfies the needs of project members, sponsors, and customers.
- Provide technical direction for the reference implementation and NUOPC Layer.
- Assure that the support team is responding effectively to customer needs.
- Take responsibility for ensuring that adequate testing of the reference implementation is performed and that releases proceed in a satisfactory and timely fashion.
- Serve as an *ex officio* member of the Change Review Board, and work with other members of the Board to set the development schedule.
- Assure that development proceeds along implementation schedules set by the Change Review Board.
- Represent the Core Team to other project bodies and the outside community, including vendors.
- Mediate with other project bodies and the outside community on issues regarding core team activities such as support, training, and collaboration environment. The Core Team Manager does not, however, mediate with other project bodies regarding development priorities outside of the CRB.
- Work with JST coordinators, CSC, and the Program Coordinator to schedule and plan Interagency Working Group activities.

The Core Team Manager reports to the Executive Board.

4.3.5.3 Content Standards Committee Chair

The Chair of the Content Standards Committee organizes and leads standards-related activities.

CHARGE and REPORTING

- Promote standards that improve interoperability, accessibility, and ease of maintenance, and organize reviews and meetings to that end.
- The Chair of the CSC will be a member of the ESMF Change Review Board.

The Standards Coordinator reports to the NUOPC Executive Committees and the ESMF Executive Board.

4.4 Executive Management

The main ESMF management bodies are an Interagency Working Group, which determines funding levels, and an Executive Board, which provides overall scientific and technical guidance. An Outreach Committee helps to establishing relationships with related projects. An Interagency Working Group discusses ESMF activities at the sponsor level.

4.4.1 The Interagency Working Group

The IAWG provides a forum for ESMF stakeholder agencies to interact on a regular basis regarding the vision, goals, and progress of the ESMF effort as they relate to each agency's mission and plans. Agency representatives work with the ESMF Executive Board to articulate ESMF goals and formulate metrics that reflect programmatic requirements. Members of the IAWG annually assess the success of the ESMF in satisfying these requirements. Insofar as it is possible, members of the IAWG coordinate funding and funding opportunities so that the Working Project has adequate and appropriate resources to meet requirements. The IAWG receives reports from the Executive Board on the status of ESMF development, adoption, and collaborations, and offers guidance as warranted. Members of the IAWG coordinate the messages carried back to higher level agency management regarding ESMF progress and value.

MEMBERS and MEETINGS The IAWG consists of program executives from federal agencies that have a stake in the progress of the ESMF. The Working Group may invite other members to join and members are confirmed by consensus of standing members. The Working Group designates a Chairperson to coordinate the timing and location of meetings, reviews, and meeting agendas. The IAWG meets twice a year, or as directed by the Chairperson. An executive secretary will be responsible for meeting minutes, reports, schedules, and the Chairperson's business.

CHARGE and REPORTING

- Communicate agency objectives and constraints to the Executive Board and confer with the Board to ensure that they are reflected in ESMF goals and vision;
- Review and concur on ESMF programmatic metrics proposed by the Executive Board, and changes to those metrics as may be necessary from time to time.
- Assess progress against programmatic metrics on an annual basis, and communicate results and recommendations to the Executive Board.
- Coordinate reporting of ESMF reviews, accomplishments, status and plans, and agency impacts back to the member agencies.
- Report on agency perspectives and issues with respect to ESMF and discuss them with other members of the IAWG.
- Advise the Executive Board on funding issues and opportunities that may be relevant to continued progress, and, insofar as it is possible, work to coordinate funding and funding opportunities so that the Working Project has adequate and appropriate resources to meet requirements.
- Ensure all stakeholders are represented on the IAWG.
- Nominate agency representatives to serve on the ESMF Executive Board, and confirm the slate of members selected by Executive Board standing members. The Executive Board should be comprised of both agency representatives and members of the broader community.

4.4.2 The Executive Board

The Executive Board is the primary management body of the ESMF. It sets the goals, scope, and strategic direction of the Project as a whole, and provides technical and scientific guidance on practical matters as they arise.

The Executive Board is charged with ensuring that the ESMF organization works effectively. It is responsible for developing and approving changes to the Project Plan, which includes terms of reference for ESMF Project bodies and positions. The Executive Board is responsible for ensuring that the Project Plan is implemented, and it has the authority to make changes to the

ESMF organization in order to do so. The Executive Board is the body that represents the ESMF Project to the IAWG.

The Executive Board is informed by the Review Committee, whose members it selects. The Executive Board also selects members of the Change Review Board. Appointments to management and coordination positions, including the Program Coordinator and Core Team Manager, must be confirmed by the Executive Board.

MEMBERS and MEETINGS The ESMF Executive Board consists of leads from ESMF collaborating institutions. It should include members of the broader community. Candidates are nominated by members of the IAWG and a slate of members is selected by the standing members of the Executive Board. The slate is confirmed by the IAWG. Members serve renewable three year terms. The Executive Board Chairperson is selected by member consensus and serves a renewable three year term. The Program Coordinator and Core Team Manager are *ex officio* members of the Executive Board. Simultaneous membership on both the CRB and Executive Board is discouraged, except for *ex officio* members. The Executive Board meets twice yearly, or as directed by the Chairperson. An executive secretary will be responsible for meeting minutes, reports, schedules, and the Chairperson's business, and ensuring that the CRB quarterly reports are reviewed and acknowledged.

CHARGE and REPORTING

- Set the goals, scope, organizational structure and processes, functional metrics, and future directions of the ESMF Project.
- Represent the ESMF Project to the IAWG, and interact with the IAWG on any issues of interest or concern to that body.
- Propose programmatic metrics for review and acceptance by the IAWG.
- Provide information on the progress of the ESMF Project to the IAWG, the policy community, the Earth science community, and others.
- Promote the ESMF Project within the national and international Earth science and related communities.
- Periodically develop and approve updated versions of the ESMF Project Plan, and approve changes to the Project Plan.
- Track progress and ensure adherence to the ESMF Project Plan and direct any necessary corrective activities.
- Respond to information provided by the Review Committee in a timely manner, within three months from receipt.
- Review quarterly development schedules from the Change Review Board.
- Approve new ESMF Project bodies and positions.
- If necessary, terminate ESMF Project bodies or positions, or remove individuals from specific roles within the Project.
- Select members of the ESMF Review Committee and Change Review Board.
- Confirm management and coordination positions, including the Core Team Manager and the Program Coordinator.

The Executive Board receives reports from the Review Committee, and updates from the Change Review Board, JST, and Core Team. The Executive Board represents the ESMF Project to the IAWG.

4.4.3 The Review Committee

The purpose of the Review Committee is to review whether the activities of the ESMF project conform to standards and best practices in the broader community, and to review whether it is

fulfilling the project goals outlined in Section 3. The committee will provide synopses of its discussions.

MEMBERS and MEETINGS Members are drawn from related efforts both nationally and internationally. They are selected by the Executive Board and have renewable three year terms. The Review Committee Chairperson is selected by the Executive Board and serves a renewable three year term. The Review Committee meets once yearly.

CHARGE and REPORTING

- Review the ESMF project for conformance with standards and best practices in the broader community, and for progress towards project goals.
- Provide synopses of discussions in a timely manner, within two months of meeting.

The Review Committee reports to the Executive Board.

4.5 Interactions with Vendors

The HPC environment changes rapidly, and, as with the switch from vector to microprocessor based computer architectures, the changes can have profound effects on the way codes are structured. ESMF initiated the Industry Partners Forum (IPF) at SuperComputing 2003 in order to give vendor representatives, ESMF developers, and project leads a forum for interaction. It was discontinued when it was found that it was more productive to establish vendor relationships one-on-one. Vendor interactions are now coordinated and tracked through the Core Team.

4.6 Interactions with Related Computer Science and Infrastructure Projects

The ESMF Project interacts with many other technical and infrastructure projects on a routine basis, through the activities of both the Working Project and Executive Management. Strategies for interaction with the most significant of these projects are described here. Other projects will be added as the need arises.

4.6.1 METAFOR

The European Community has undertaken a number of climate infrastructure and integration programs. The METAFOR (Common Metadata for Climate Model Digital Repositories, <http://metaforclimate.eu>) project was funded in 2007 and involves participants from numerous European countries. METAFOR is developing a Common Information Model that will be used in the 5th Coupled Model Intercomparison Project (CMIP5), a basis for the 5th IPCC Assessment Report. ESMF has incorporated METAFOR metadata into its metadata Attribute class, and works regularly and frequently with the collaboration through the Curator project (<http://www.earthsystemcurator.org>), which is implementing displays of model metadata into the Earth System Grid data distribution.

4.6.2 Common Component Architecture

The Common Component Architecture (CCA) [11] is a DOE project that is developing software toolkits for structuring high performance computing applications in a fashion similar to the component-based commercial standard CORBA [12]. Working together, CCA and ESMF staff prototyped interoperability of ESMF components with CCA components at SuperComputing 2003.

ESMF tracks the activities of CCA through the participation of Core Team and JST members on

the CCA mailing list. In 2009, CCA funding was terminated by the DOE and the future of CCA software development is unclear.

5 Processes

Here we describe a number of routine events that generate flows of activity through the ESMF organization. This section defines what the appropriate contacts and paths are for these events. It also shows how the structure described in Section 3.2 can operate with reasonable efficiency for a large, complicated community effort! However, the section does not include an exhaustive description of ESMF development processes and conventions. These details are provided in the *ESMF Developer's Guide* [10].

5.1 Points of Contact

5.1.1 Support Requests

Support requests should be sent to esmf_support@list.woc.noaa.gov. The archives of this list are accessible from the ESMF website.

5.1.2 New Requirements

Some of the ways new requirements may enter the ESMF Project are: through JST weekly telecons, through Community or other project meetings, or through support requests.

5.1.3 New Users

Many new users encounter the ESMF website before any other contact, so it is important that documentation and downloads be easy to find. The redesign of the project website in 2007 expanded introductory pages (e.g., Features, Vision, Values) and introduced Frequently Asked Questions and Getting Started pages. Another initial means of contact is often the support mailing list, as people have questions about installing or porting the framework.

5.1.4 New Code Contributions

We define two types of contributions, **drop** and **assimilated**. Drop contributions can be placed at any time in a contributions repository accessible from the ESMF website. These contributions are unmonitored, publicly available, and unsupported by the ESMF Core Team. The only prerequisite is that the contributor must register with the service that provides the contributions repository, which can be done by contacting esmf_support@list.woc.noaa.gov.

Assimilated contributions are those that the contributor has proposed or agreed will become part of the reference implementation. These contributions must satisfy ESMF conventions and standards in terms of interfaces, documentation, portability, error handling, and so on, and will be fully supported by the ESMF Core Team. Potential contributors are encouraged to first contact the Core Team manager to discuss the nature and implications of the contribution. The Core Team Manager is obligated to share information about potential contributors in a timely manner with other project bodies. Code contributions may be proposed and discussed at JST telecons or at Community or other project meetings.

Following initial discussions, the contributor may choose to have the Core Team Manager, Program Coordinator or other representative on the CRB add assimilation of the code to the proposed tasks list for the next CRB meeting. At the CRB meeting the code assimilation task

will be discussed and prioritized.

5.1.5 New Sponsors

Potential sponsors of ESMF-related projects are encouraged to contact the Chair of the Interagency Working Group and attend IAWG meetings to facilitate coordination. The IAWG Chair is obligated to share information about new sponsors in a timely manner with other ESMF Project bodies.

5.2 Software Implementation

Requests for bug fixes, maintenance (e.g., a port to a new architecture), assimilation of contributed code, implementation of new capabilities, and interface standardization all require changes to the reference implementation. One can imagine that the time scales associated with each type of task may differ. The small bug fix might be made and sent out quickly in a patch. The new functionality must be recorded as a requirement, prioritized with respect to other requirements, time for design and implementation scheduled, and the new code distributed in a release. Interface standardization often requires lengthy discussion and coordination with other projects, which can take months or even years. In this section we describe the various development paths in ESMF. Figure 6 illustrates timescales associated with development tasks.

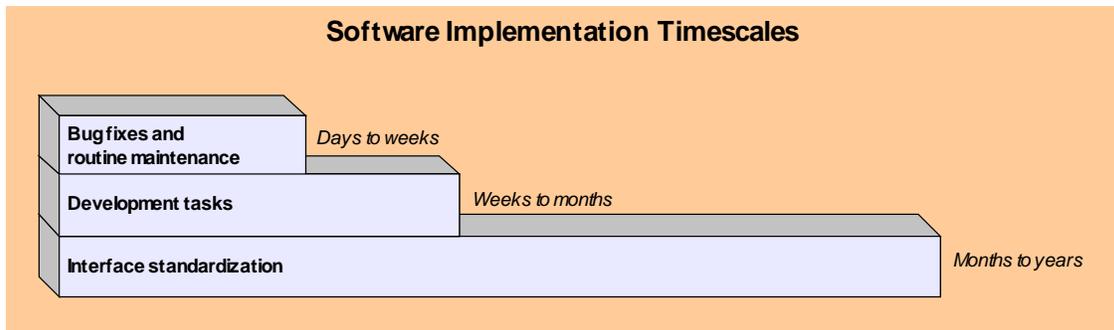


Figure 6

Software implementation happens at different timescales – such as fast bug fixes, scheduled development, and longer interface standardization.

5.2.1 Bug Fixes and Routine Maintenance – the Fast Path

We recognize the necessity of providing a fast path to responding to support requests, implementing bug fixes, and performing routine maintenance. 20% of the Core Team members' time is reserved for this type of activity.

The support process is as follows. Users with support requests write the `esmf_support@list.woc.noaa.gov` mailing list with questions, bug reports, and requests for ports and enhancement. All requests are archived, categorized, and tracked. Support requests requiring significant time and effort (more than two FTE-weeks) are normally prioritized by the CRB. However, if a request is identified as high priority, it may be addressed within the Core Team time reserved for support activities. \

5.2.2 The Development Path

Requests for significant development take longer than simple bug fixes to complete. Development tasks originate with requirements, which enter the ESMF Project via any of the routes described in Section 4.1.2. A list of proposed development tasks is reviewed at each CRB meeting. During the meeting the items are discussed and prioritized, and may be scheduled for implementation. The Development Group in the Core Team confirms the feasibility of the schedule before it is finalized. Typically one can expect development tasks to take on the order of months to be scheduled, completed, tested, and released.

5.2.3 The Standardization Path

The development of a consistent interface standard is a lengthy, collaborative process that requires meticulous attention to detail. An exhaustive review of the full ESMF API will occur before public release version 5. The emergence of the ESMF API as an interface standard has taken about eight years.

5.3 Assimilation of Contributions

Contributions from the JST and the broader community are an integral part of ESMF development. As described in Section 4.1.4, we define two types of contributions: drop contributions, which are dropped into a public repository for anyone to use, with minimal involvement by the ESMF team, and assimilated contributions, which become part of the reference implementation.

For example, in ESMF Version 2.0, the I/O package, Configuration Attributes class, and regridding software used in ESMF are all based on outside sources: WRF [13], the GMAO package INPACK, and the LANL SCRIP software [14], respectively. These packages were all modified to a significant degree in order to satisfy ESMF requirements, with the work either done entirely by the Core Team or split between the Core Team and the contributor. It is difficult to anticipate in advance what balance will make sense for a particular contribution; different approaches are appropriate for different capabilities.

Section 4.1.4 describes the points of contact and outlines the process for introducing a new code contribution.

5.4 Software Engineering Plan

The *ESMF Developer's Guide* [10] contains the processes, practices, and conventions recommended for the ESMF Core Team and for developers integrating the framework into applications. The *Developer's Guide* is a living document maintained by the Core Team. The document was significantly modified at the end of the first three years of ESMF development in order to reflect the new multi-agency organizational structure and processes.

6 Activities

The following are specific tasks that the ESMF Project must accomplish over the period from 2010 to 2015. The immediate focus is on creating viable, easy-to-use modeling applications, and increasing the level of real interoperability within the Earth science modeling community. Key activities include:

- support the existing customer base in implementing and running ESMF within their codes;
- complete the standardization of the ESMF API;
- update the software as required for additional platforms and capabilities as required by application integration projects;
- develop and integrate the MAPL and NUOPC usability layers;
- assimilate contributions into the ESMF software as required by applications;
- create an effective training program, with in-person and on-line materials;
- expand the program of collaboration with modeling and data infrastructure projects that represent other functions, domains, and agencies

A longer-term goal is to realize a vision of integrated community software infrastructure that spans data services, modeling, and governance and collaboration environments.

6.1 Support and Training

ESMF has a well-established user support function. All support requests are tracked and publicly archived on the ESMF website. Support requests go to a distributed group of developers and managers to ensure that service continues uninterrupted through vacations, absences, etc. The ESMF support team offers users help and advice with questions about the framework as well as advice about how to restructure applications. However, the support team does not currently offer scientific advice or long-term mentoring for large applications seeking staff for weeks or months of uninterrupted development time. These services should come from dedicated staff on Application Integration Teams.

ESMF training materials require significant effort and development. Early training courses still need to be adapted for the grid and data structure redesign that happened during the framework's second development phase. A renewed focus on real applications and ease of use is needed. Significant effort is expected in this area after the release of ESMF version 4.

7 Funding

ESMF funding for the Working Project is a combination of two parts. There is a base level of funding that represents a critical mass of staff necessary to deliver and support ESMF for some minimal set of customers. This base level of staffing for ESMF in 2009 was about nine FTEs (including manager, tester, admin/web staff, and developers/support staff) on the Core Team, plus a part-time Program Coordinator. In addition to the base there are funding contributions to the ESMF Core Team commensurate with the extent of Application Integration and Development Plug-in activities. This is necessary because Plug-Ins require support, development, and code assimilation services from the Core Team. Figure 7 illustrates these concepts.

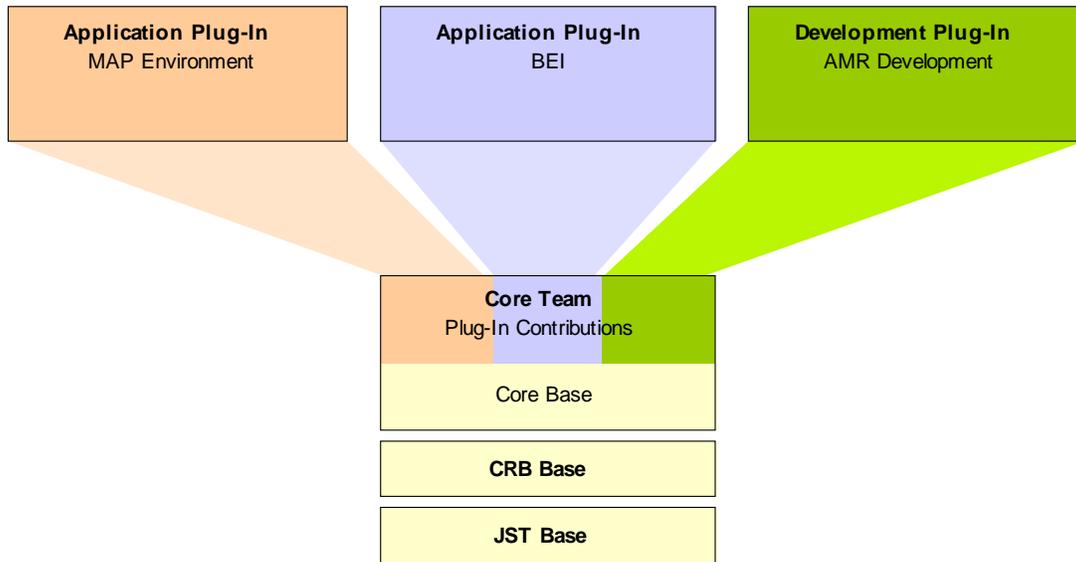


Figure 7

Funding model for the Working Project, in which a base level of support is supplemented by support from Application and Development Plug-In projects.

8 Evaluation

The ESMF Executive Bodies evaluate the progress of the ESMF Project as part of their charge. In addition, individual sponsors may conduct their own evaluation activities. We consider two types of evaluation: a metrics-based evaluation that focuses on the ESMF Product, and a science impacts evaluation.

8.1 Product Evaluation

The success of the ESMF Product can be evaluated partly through adoption, quality, usability, performance, portability, and other software metrics. It is important to establish adequacy in these areas for two reasons. First, some of the goals of ESMF are expressed directly through these metrics; for example, software reuse is expressed through adoption metrics. Second, a usable product is a prerequisite for achieving the science goals of the ESMF.

A sample of product evaluation metrics follows:

ADOPTION METRICS:

- Number of groups running ESMF in a production (research, operational) system
- Number of groups running ESMF in any system
- Number of multi-user computers with ESMF installed as a system library
- Number of downloads and number of international downloads
- Number of subscribers to ESMF mailing lists

QUALITY METRICS:

- Test coverage
- Number of unit and system tests
- Number of bugs reported by users; number of bugs closed

USABILITY METRICS

- Number of support requests; number of support requests closed
- Availability and quality of documentation

PERFORMANCE AND PORTABILITY METRICS

- Number of platforms supported
- % overhead in time to completion

In 2007 ESMF introduced a **Metrics** page on its website that captures many of the metrics cited above. In general, metrics are posted to the website monthly.

8.2 Science Impacts Evaluation

The science goals expressed in Section 3 concern increased collaboration across the community, and the freer exchange of code and ideas. How do we measure if the ESMF has been successful in reaching those goals? It isn't an easy question. It also isn't clear when the appropriate time is in the ESMF Project lifecycle to ask the question. The ESMF Product must reach a level of maturity, usability, and ubiquity before it can routinely facilitate new interactions. Once it is established, it can still take months or years to create science teams around new questions, tune coupled systems, and validate them scientifically. It may be that the best indicator here, for the time being, is how many real codes have evaluated and adopted ESMF. In the long run, it may be more telling to look at how many science teams have formed around new applications based on ESMF components.

Appendix A: Glossary

Application Integration Project A team of developers working with one or more applications to implement and test science and other capabilities, assimilate ESMF, and optimize for performance. As appropriate, these teams may also develop and optimize application-specific capabilities within the ESMF software and assist with framework validation. There are multiple Application Integration Projects associated with ESMF, each managed by an Application Integration Project Lead or Manager.

Application Integration Project Lead An individual tasked with coordinating or managing the development and validation of one or more ESMF-based science applications.

Application Programming Interface (API) The set of method names and corresponding arguments that form the user interface to a software package.

assimilated contribution Code contribution that is incorporated into the ESMF reference implementation. Assimilated contributions must satisfy ESMF requirements and are supported by the Core Team.

Change Review Board (CRB) The interagency group that sets development priorities for the ESMF implementation being developed by the Core Team. Part of the ESMF Working Project.

Content Standards Committee (CSC) A NUOPC organization that creates metadata, physical constant, and other content standards for ESMF users at U.S. operational numerical weather prediction centers. Part of the ESMF Working Project.

Core Team The Core Team is comprised of the development effort at NOAA ESRL/CIRES, plus others who can be line managed by the Core Team Manager. Core Team responsibilities include requirements management, design, implementation, testing, user support and training, and maintenance of the ESMF software and associated collaboration infrastructure, such as the ESMF website and central repository. Part of the ESMF Working Project.

Core Team Manager Line manager of the Core Team, located at NOAA ESRL/CIRES.

Development Plug-In Research effort external to the Core Team that contributes to development of the framework.

drop contribution Code contribution that is “dropped” into the ESMF contributions repository and made publicly available. Drop contributions are minimally supervised and not supported by the Core Team.

ESMF Project The entity that develops and manages the ESMF Product.

ESMF Product The ESMF Product includes the ESMF application interface, reference implementation and documentation; associated maintenance and testing, support and training; and a web-based collaboration environment that allows ESMF staff, sponsors, and customers to archive and exchange information.

Executive Board The ESMF Executive Board is the body responsible for directing the ESMF project and maintaining the ESMF organization. Part of ESMF Executive Management.

Executive Management ESMF Executive Management provides high-level scientific and technical guidance, advocacy, and evaluation. It is comprised of the Executive Board, Outreach Committee, Interagency Working Group, and Review Committee.

Industry Partners Forum (IPF) A working group consisting of vendor representatives and members of the Joint Specification and Core Teams. The IPF is charged with communicating ESMF requirements and issues to the vendor community, and with conveying technical advances and directions back to the ESMF collaborators.

Interagency Working Group (IAWG) ESMF body that consists of sponsors and other stakeholders. Part of ESMF Executive Management.

Joint Specification Team (JST) The group of hands-on science developers who interact closely with the Core Team to define requirements, develop a viable framework implementation and specification, and evaluate and provide feedback on the ESMF software. Multiple Application Integration Teams are represented on the JST. Application Integration Team Leads or Managers are represented on the Change Review Board. Part of the ESMF Working Project.

management overhead Overhead (staff and resources) required for ESMF project oversight and administration, including salary for Program Coordinator.

Program Coordinator Individual responsible for overall coordination of the ESMF effort, including mediation of the Change Review Board, interaction with agency leads, and representation of the project at national and international meetings.

reference implementation The ESMF API implementation developed by the Core Team. There may be other implementations of the API.

Review Committee An ESMF committee focused on external review of the ESMF project. Part of ESMF Executive Management.

Standards Coordinator The individual responsible for leading the development of standards within ESMF and serving as ESMF's primary liaison to other standardization efforts.

Working Project Management The level of management of the ESMF Project that provides day-to-day oversight of development and user support.

Appendix B: Status of ESMF Project Bodies and Positions

ESMF BODY OR POSITION	STATUS	POSITION CURRENTLY HELD BY
Working Project		
Core Team	Active since 2/2002.	
Joint Specification Team	Active since 2/2002.	
Change Review Board	Active since 9/2005.	
Working Project Management		
Core Team Manager	Initiated 2/2002.	Cecelia DeLuca (NCAR) since 2/2002.
Development Group Lead	Initiated 2/2002.	Gerhard Theurich (SGI) since 1/2005.
Support Group Lead	Initiated 2/2002.	Sylvia Murphy (NCAR) since 8/2006.
Test Group Lead	Initiated 5/2002.	Silverio Vasquez (NCAR) since 5/2002.
Web Lead	Initiated 2/2002.	Sylvia Murphy (NCAR) since 8/2006.
Administrative Lead	Introduced 7/2007 (prior to that handled by by the Core Team Manager).	Jennifer Bell (CIRES) since 11/2009.
Program Coordinator	Initiated 9/2005.	Robert Ferraro (NASA JPL) since 9/2005.
JST Coordinators	Initiated at ESMF inception, 2/2002, deprecated after 2005.	

ESMF BODY OR POSITION	STATUS	POSITION CURRENTLY HELD BY
Executive Management		
Executive Board	Active since project inception, it initially consisted of the set of Co-Investigators on the linked proposals to NASA. ²	
Advisory Board	Active since ESMF inception, 2/2002. Terminated in 2009.	
Review Committee	Formed in 2009 to establish an external review process	
Interagency Working Group	Active since December 17, 2003.	
Content Standards Committee	Active since January 2010.	
Liaisons		
Liaison to PRISM/METAFOR		Very active collaboration with lead V. Balaji (GFDL).
Other bodies		
Industry Partners Forum	The first meetings of this group (starting 2003) were not well-attended by vendors and were discontinued. The Core Team currently manages vendor relationships.	

² Not all Co-Is were included, since the intent was to give all institutions equal representation on the Executive Board.

Appendix C: Schedule of Meetings

MEETING	PERIOD	LOCATION
Community Meeting	Until 2008, in late spring and various locations; now coincident with Fall AGU in San Francisco, CA or AMS meeting	Varies
Executive Board	Annually in conjunction with Community Meeting, with telecons as needed	Varies
Review Committee	Annually in conjunction with Community Meeting, with telecons as needed	Varies
Interagency Working Group Team Meeting	Annually As of 2005, no longer distinguished from Community Meeting	Varies
Change Review Board	Quarterly	Telecon
Content Standards Committee	Quarterly or as needed	Telecon
Core Team Developers	Weekly	NOAA ESRL/Telecon
Core Team Ticket Review	Monthly	NOAA ESRL/Telecon

Appendix D: Acronyms

API Application Programming Interface
CCA DOE Common Component Architecture
CCSM Community Climate System Model
CISL NCAR Computing and Information Systems Laboratory
CORBA Common Object Request Broker Architecture
CSEG CCSM Software Engineering Group
CRB Change Review Board
CSC Content Standards Committee
DARPA Defense Advanced Research Projects Agency
DoD Department of Defense
DOE Department of Energy
ESMF Earth System Modeling Framework
ESKE Earth System Knowledge Environment
ESRL Earth System Research Laboratory
GFDL NOAA Geophysical Fluid Dynamics Laboratory
HPC High Performance Computing
HPCS High Productivity Computer Systems
IPF Industry Partners Forum
IAWG ESMF Interagency Working Group
JPL NASA Jet Propulsion Laboratory
LANL Los Alamos National Laboratory
METAFOR Common Metadata for Climate Modelling Digital Repositories
MIT Massachusetts Institute of Technology
NASA National Aeronautics and Space Administration
NCAR National Center for Atmospheric Research
NCEP NOAA National Centers for Environmental Prediction
NOAA National Oceanic and Atmospheric Administration
NSF National Science Foundation
NUOPC National Unified Operational Prediction Capability
SCRIP Spherical Coordinate Remapping and Interpolation Package
WRF Weather Research and Forecasting Model

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