



# Project Summary

## EMAP Information Management Strategic Plan: 1993 – 1997

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**The Information Management (IM) Strategic Plan for the Environmental Monitoring and Assessment Program (EMAP) describes how EMAP information will be managed from field sampling through the delivery of products to the user. This plan cuts across the entire EMAP and explains the process for developing an information management infrastructure that will enable EMAP to achieve its long-term objectives. This plan provides a strategy for meeting hardware, software, documentation support, and system designs that will meet EMAP Resource and Coordinating Group requirements. Users of EMAP data and information are discussed in the Plan as well as the process and technology with which they can access EMAP data and other data sources.**

*This Project Summary was developed by EPA's Environmental Monitoring and Assessment Program, Washington, DC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### EMAP Commitment

The EMAP represents a long-term commitment by the U.S. Environmental Protection Agency (EPA) to assess and periodically document the status and condition of the Nation's ecological resources. EMAP's goal is to monitor and assess the condition of those resources and to contribute to decisions on environmental protection and management.<sup>1</sup> EMAP will monitor indicators of the condition of our Nation's ecological resources to respond to the growing demand for information

characterizing the condition of our environment and the type and location of environmental changes. The EMAP project, when implemented, will provide the ability to integrate information from multiple sources across environmental media within the context of the National Information Infrastructure<sup>2</sup> and provide assessments of environmental impacts across ecological resource categories.

### Strategic Plan

The EMAP IM Strategic Plan outlines the implementation approach for development of workable information systems that will meet the requirements of EMAP scientists, information managers, and government decision makers. The Plan provides EPA management with the scope, the foundation of requirements and guiding principles, the management and technical approach, and resource requirements for EMAP information systems development. The Plan also provides EPA environmental scientists and collaborators with a common set of expectations and the EPA information management staff with a systems engineering road map that can be used to direct activities over the next 5 years.

### EMAP IM Vision

By 1997, EMAP is expected to monitor and assess the current status and geographic distribution of such ecological resources as estuaries, lakes, streams, wetlands, forests, grasslands, and deserts. By integrating information from several government agencies, assessments and reports will become available on the proportions of these resources that are degrading or improving, their location and extent, and their rate of change. Reported

ecological conditions and geographical coverage will be available with known confidence.

By 2002, EMAP plans to expand its monitoring and assessment capability to include information from virtually all applicable federal sources. Degrading and improving trends will be identified through specific indicators of how adversely affected ecosystems are responding to control and mitigation programs.

By 2012, EMAP should be a focused, mature program that is integrated with scientific information from key national and international sources. Trending information of all ecosystems will be available for use in making decisions concerning national and international environmental management and economic development.

## EMAP IM

EMAP IM is the vehicle with which the total EMAP manages data and information. EMAP objectives and corresponding EMAP IM objectives are shown in Figure 1. Specifically, EMAP IM will provide effective and extensible information management systems for assessing and reporting on the condition of the Nation's ecological resources. IM will provide the tools for turning raw scientific measurements (data) into useful information products that will serve to guide actions to improve the quality of our environment.

EMAP IM will be an environmental "information highway" allowing analysis of EMAP data across heterogeneous networks of personal and scientific computers by 1997. EMAP IM systems will provide interfaces for new analysis methods and integration of related scientific information across a "national information infrastructure." Scientists will have access to data distributed across a national network<sup>2</sup> and the computational tools needed to facilitate analyses. EMAP IM systems will provide access to data, metadata, and processed information for a diverse set of users through a network of dispersed databases.

## The EMAP Enterprise

The technical and management approaches discussed in the Plan require an explanation of the term "enterprise." The EMAP Enterprise, when fully developed, will include Resource Groups, Coordinating Groups, EPA and non-EPA related programs, and administrative activities that support the program. Collectively, EMAP as an enterprise is made up of these user groups, each of which has differing but complementary missions to perform in order for EMAP to accomplish its objectives. EMAP IM will eventually involve all these users and will consider their differ-

ing requirements for information management systems.

EMAP is and will continue to be an evolving enterprise with diverse user requirements. Currently, the Resource Groups are the most "mature" group of users. For several years the Resource Groups have been actively engaged in indicator research, collecting data, analyzing data, and publishing results within their ecological areas of responsibility. Conversely, the aspect of the EMAP Enterprise least developed is the relationship of EMAP to other EPA and non-EPA programs. For example, such questions as "What information does EMAP have that would assist NASA in accomplishing the objectives of the Earth Observing System Program?" are difficult to answer at this stage of EMAP development.

## Enterprise Components

The size and diversity of the collective EMAP user group and the evolving nature of EMAP require a systems engineering approach that is stratified by groups comprised of similar users, with similar missions, and in similar stages of development. These user groups are aggregated into four components by level of maturity. Figure 2 shows these user group components with the phased IM processes that are applicable to each component. The cells within this map depict the level of user involvement. The "Enterprise Components" of EMAP are

- *Planning, Research, Monitoring, and Assessment* - includes indicator research, collection and analysis of data, and distribution of data and information related to an ecological area of responsibility. This component is comprised of Resource Group users.
- *Integration and Assessment* - provides direction on the composition of EMAP information products that are derived from data available within individual Resource Groups, as well as information products derived from multiple Resource Groups. This component includes Coordinating Groups supporting assessment activity by EMAP Central.
- *EMAP National Program* component within EPA - defines the relationship of EMAP to other relevant EPA programs. These programs include the Great Lakes National Program, The Gulf of Mexico Program, the STORET Modernization within the Office of Water, the Gateway/Envirofacts program within the Office of Information Resource Management and others. This component also includes con-

nections to appropriate EPA administrative programs.

- *EMAP as partner in an Interagency Federation* - defines the relationship of EMAP to relevant programs outside of EPA that are not already included in other EMAP Enterprise components by virtue of their cooperative partner status. Examples of the types of programs targeted are NASA's EOS/DIS and the Global Change Research Program.

Each EMAP IM process includes an execution of the systems development life cycle (SDLC) and results with an operational information management system for the designated user. For example, Forests and Estuaries, as well as the EMAP Center, will have operational systems upon completion of the Proof-of-Concept (POC). An operational system is the computer hardware, software, databases, and communications links that are required to share data, metadata, and information among users.

## EMAP Users

The collective EMAP user community is reflected in Figure 3. The first category—and highest priority EMAP user from a strategic and implementation perspective—is the scientific community actively participating in EMAP. These principal users will be scientists in the EMAP Resource and Coordinating Groups, other EPA scientists, and such EMAP Cooperative Partners as the National Oceanographic and Atmospheric Administration (NOAA) and the U.S. Forest Service (USFS). These users have primary responsibility for planning, designing, collecting, managing, researching, validating, analyzing, and interpreting environmental data for a multitude of purposes.

The second user category includes other EMAP participants such as public and private sector scientists and researchers working on behalf of government, academic, and commercial interests; policy makers and government managers who use EMAP information to determine policy and guidance; and the general public and media, all of whom may use EMAP information as an ecological report card.

Eventually, users of EMAP data and information will range from scientists who will extract crosscutting data sets for detailed quantitative analyses to members of Congress, the general public, and the news media who require qualitative information products. A histogram at Figure 4 depicts relative differences in user involvement by EMAP Enterprise components. The makeup of the groups representing

Program Objectives	IM Objectives
Estimate the current status, trends, and changes in selected indicators of the condition of the Nation's ecological resources on a regional basis with known confidence.	<ul style="list-style-type: none"> <li>Assist in structuring, developing, maintaining, operating, and/or deploying:               <ul style="list-style-type: none"> <li>Resource Group databases for research, monitoring, and analysis;</li> <li>Access mechanisms to the databases;</li> <li>Manipulation mechanisms (algorithms); and</li> <li>Display mechanisms required for research, monitoring, and analysis.</li> </ul> </li> </ul>
Estimate the geographic coverage and extent of the Nation's ecological resources with known confidence.	<ul style="list-style-type: none"> <li>Assist in structuring, developing, maintaining, operating, or deploying:               <ul style="list-style-type: none"> <li>Access mechanism to EMAP Geographic Reference Data (GRD);</li> <li>Manipulation mechanisms (algorithms); and</li> <li>Display mechanisms required to analyze this information.</li> </ul> </li> </ul>
Seek associations between indicators of natural and anthropogenic stresses and indicators of condition of ecological resources.	<ul style="list-style-type: none"> <li>Ensure a distributed database structure that allows integration of information internally, and with external sources allowing responsibility for the data to reside with the "owners."</li> <li>Assist in the development, maintenance, operation, and deployment of crosscutting tools.</li> </ul>
Provide annual statistical summaries and periodic assessments of the Nation's ecological resources.	<ul style="list-style-type: none"> <li>Ensure that all data, metadata, and information required to meet the objective are available, in some cases by leveraging the central node of the database system.</li> <li>Assist in the development, maintenance, operation, and deployment of access mechanisms and display mechanisms useful in meeting this objective.</li> </ul>

Figure 1. EMAP IM objectives.

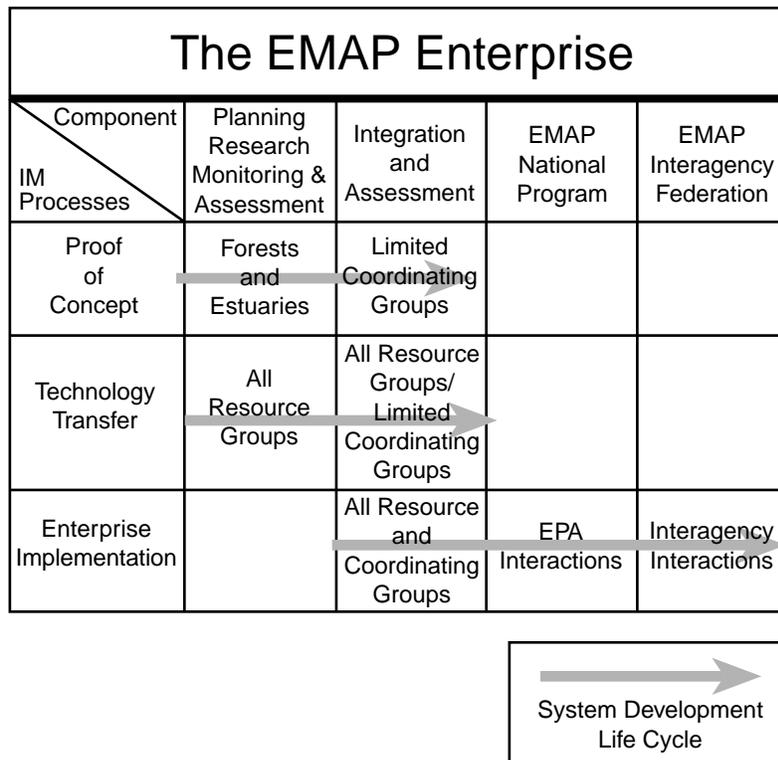


Figure 2. The EMAP enterprise.

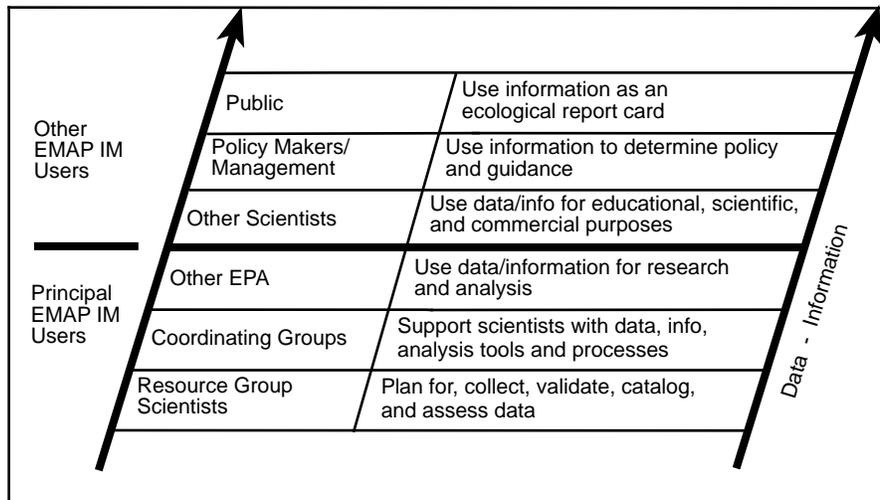


Figure 3. EMAP IM users.

the requirements of an EMAP Enterprise component has been structured to exert a leveling effect on the requirements gathering process. For example, although the POC is primarily driven by EMAP scientists, some policy makers and other scientists are involved in the process.

### EMAP Products

EMAP will provide three products that the EMAP IM system must support during the Plan period:

- Databases and derived information;
- Annual statistical summaries; and
- Integration and assessment reports.

Additionally, EMAP IM is designed to provide for administrative products that will be important to support EMAP as a National Program within EPA (Figure 5).

### EMAP IM Technical Guidelines

The technical approach used to define EMAP IM system development and implementation will be based on these guidelines:

- Use existing national infrastructure and standards whenever possible;
- Concentrate on integration engineering rather than new system development;
- Use a systems engineering approach based on a formal design process incorporating functional pilots and prototypes; and
- Use emerging technology whenever possible in meeting user needs.

### Evolutionary Approach

EMAP IM is designed to use an “evolutionary” systems engineering approach that adapts to emerging user needs and technology. This approach will permit ongoing use of operational systems while the development process continues. The distinguishing difference between the EMAP evolutionary approach and more traditional system engineering approaches is EMAP’s greater involvement of users throughout the SDLC. The SDLC elements include *concept, analysis, design, development, test, and operation*. Activities during each element of the SDLC will take into account current and projected user needs and technology and incorporate user feedback and new technology into the system development process.

### EMAP IM Framework

To assist in system development, EMAP IM uses the Zachman Framework<sup>3</sup> as an architectural guide during the Enterprise process. This framework allows for an orderly approach for designing and building systems. It provides system developers a complete template against which to map sequential and/or parallel steps for carrying out development of technical and management solutions.

The Zachman Framework stresses that the information system development process requires several architectures. Figure 6 depicts the Framework architectures: *Data, Function, Network, People, Time, and Motivation*. The levels of each architecture in the Framework are *Scope, Enterprise Model, Information System*

*Model, Technology Model, Components, and Functioning System*.

Each Framework architecture (e.g., data) develops as the process progresses through the Framework’s life cycle from *Scope* through *Functioning System*. This process development life cycle is applied to each architecture within the Framework. This iterative process will be applied to each subsequent Enterprise component during the three IM implementation processes: *POC, Technology Transfer, and Enterprise Implementation*.

Using such a checklist ensures that all aspects of the system are addressed from an “enterprise approach” and that all participants in the development and implementation of the Enterprise have a common reference. (This framework has been adopted for use by the EPA Office of Information Resources Management [OIRM] as a basis for all EPA systems.) The Framework also provides a technology-independent model to accommodate emerging hardware development and software changes.

### EMAP IM Architecture

Another view of the EMAP architecture is provided by the seven layer model depicted in Figure 7. (It should be noted that these architecture functions will be provided, to varying degrees, by dispersed systems at multiple nodes.) Forming the foundation of the architecture is the canonical data layer. It is comprised of databases and data sets that can be accessed by tools from the tool set layer.

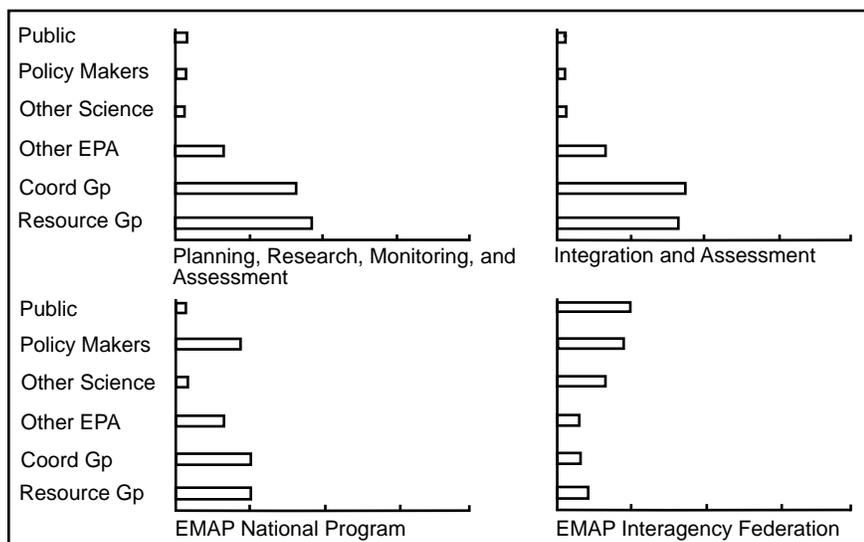


Figure 4. Relative user involvement by EMAP IM component.

Note that the software back plane connects at this level and that access is provided to users of the back plane through the Virtual Repository. A user entering through the tool set layer has the option of directory or catalog access, or access through the flexible set of tools that are provided to the user community to facilitate their use of the data. The inter-process communication layer allows the individual tools to communicate by passing data from one to another for processing. Finally, the user interface layer provides easy invocation of the various tools available as part of the EMAP suite and other tools available on the client platform.

### EMAP IM Management

The EMAP Director has overall program responsibility. The Director of the EMAP Center directs eight Coordinating Groups and is responsible to the EMAP Director. The Coordinator of Information Management, who heads one of the eight Coordinating Groups, is responsible for EMAP IM. The IM Coordinator relies on members of the eight Resource Group IM teams for coordination and implementation of EMAP IM.

EMAP IM is using an adaptation of an IBM Corporation information systems management process model<sup>4</sup> as the basis for project management as shown in Figure 8. This model has strategic, tactical, and operational levels that are sectioned into development, management, and service missions. The evolutionary approach of EMAP IM engages all levels and missions virtually simultaneously since operation implementation must continue to occur within the Resource Groups while tactical and strategic events are evolving.

The EMAP IM functional organization consists of teams focused on systems architecture, science direction, user interaction and planning, interagency data interchange, advanced technology evaluation, systems engineering, and systems support and operations. Each of these teams has specific roles within the management structure (Figure 9). Additionally, ongoing coordination is required with federal and EPA information resources management programs and offices.

### EMAP IM Implementation Processes

EMAP IM development and implementation consist of three IM process phases. First is the POC process that identifies and applies standards, policies, tools, and procedures to the For-

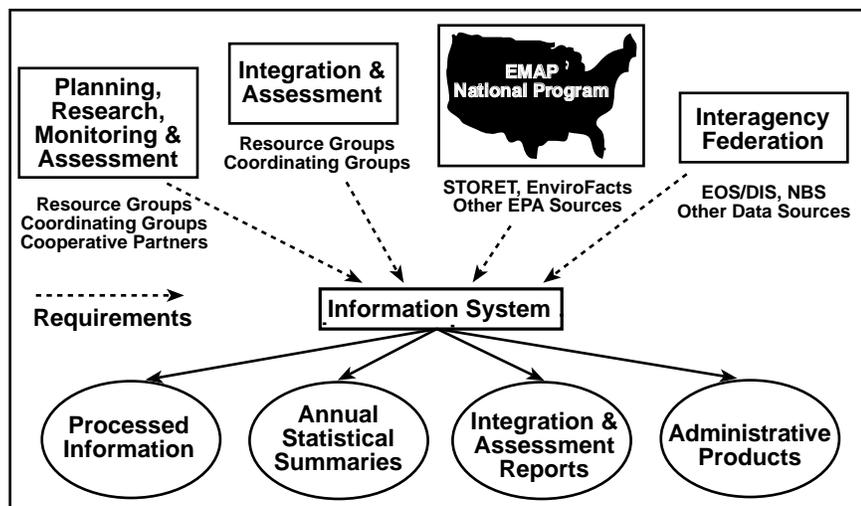


Figure 5. EMAP enterprise products.

Above the database layer is the Virtual Repository layer. The components of the Virtual Repository are model management tools, Computer Aided Software Engineering (CASE) tools, configuration management tools, the data dictionary, the directory, and catalog. The first three tools mentioned in this layer and the data dictionary pertain to computer science metadata that describe data stored in a relational database structure. The directory and catalog components of the Virtual Repository layer contain scientific

metadata that describe data sets and documents.

The security layer provides a means for EMAP to ensure the long-term integrity of its collection by controlling access. Security procedures, in practice, can apply at the user interface layer, the communications access layer, and the canonical data layer.

The communications and user access layer represents the means by which data may be entered and retrieved from the data layer using the Virtual Repository.

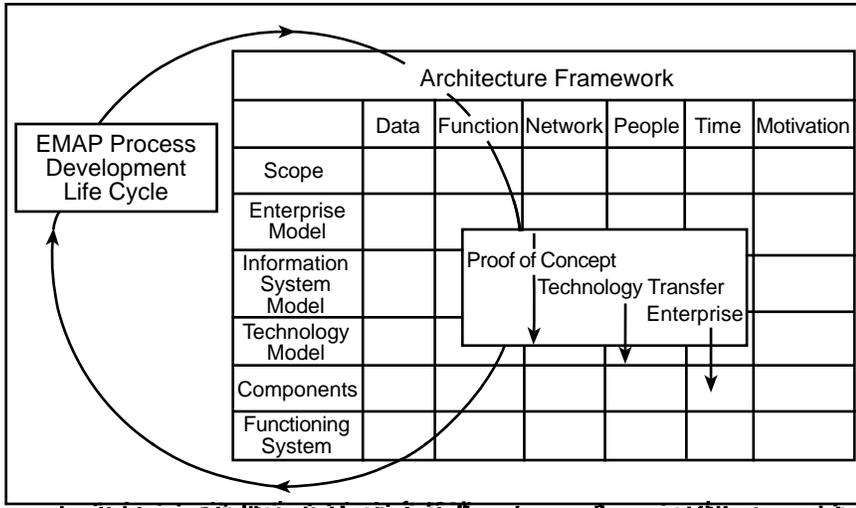


Figure 6. EMAP architecture framework.

gram function into general SDLC categories titled Initiation/Concept, Definition & Design, and Implementation/Operation. Each of these categories then lists IM functional areas and planned deliverables. It is important to note that each step of the implementation process includes participation from other user categories. For example, all Resource and Coordinating Groups have been observing the *Planning, Research, Monitoring, and Assessment* POC in order to facilitate their role in the Technology Transfer process.

### EMAP Schedule (1993 – 1997)

The schedules discussed below are based on the assumption that required resources will be available as depicted in Figure 13. If, however, constraints are placed on EMAP IM resources, the technical and management approaches specified in the Plan are sufficiently flexible to permit implementation to occur, but over a longer period of time. Also, it should be noted that capabilities scheduled for completion in the “out-years” are already in development to varying degrees. For example, the Virtual Repository, Geographic Information Systems (GIS), and user interface capabilities commenced with the 1993 POC.

1993—*Research, Monitoring, and Assessment* POC. This demonstration was designed to enable two Resource Groups to collect, manage, and share distributed data.

1994—*Planning, Research, Monitoring, and Assessment* Technology Transfer. This process will share the activities and technology from the POC with the other Resource Groups and Coordinating Groups. The system will include the initial data dictionary, perform basic analysis, provide initial user interface, provide GIS and initial report generation tools, and perform internal data exchange adhering to established OIRM data standards.

1995—*Integration and Assessment* Enterprise Implementation. This system should provide improved data verification, integration of improved data acquisition tools, a fully capable model manager, enhanced user interface with visualization, limited reporting across EMAP’s ecological resources, survey analysis methods and interfaces, and internal data transformation methods.

1996—*EMAP National Program within EPA* Enterprise Implementation. The system will provide interoperability with other EPA programs. This should include enhanced data acquisition tools, accessible metadata and methods using a Virtual Repository, enhanced analysis and aggregation methods, a common user inter-

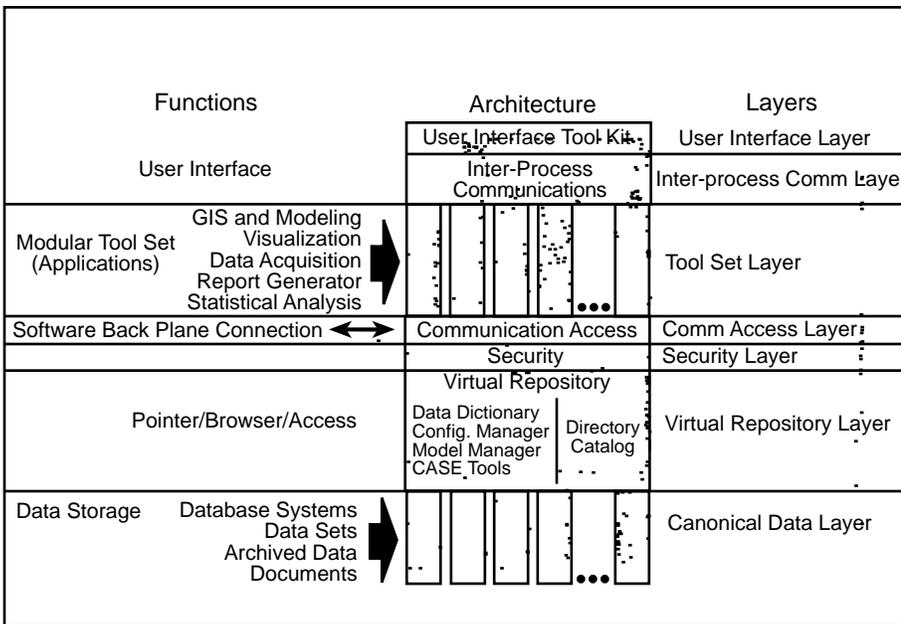


Figure 7. EMAP IM architecture.

est and Estuaries Resource Groups and limited Coordinating Groups. The Technology Transfer phase consists of extending the environment validated during the POC to the remaining Resource Groups and an increasing number of Coordinating Groups. The third process is Enterprise Implementation, which en-

gages other EPA and non-EPA programs in the systems development process. This phase re-engineers preceding implementation activities from an enterprise perspective.

The implementation schedules for each process are shown in Figures 10, 11, and 12. The schedules are arranged by pro-

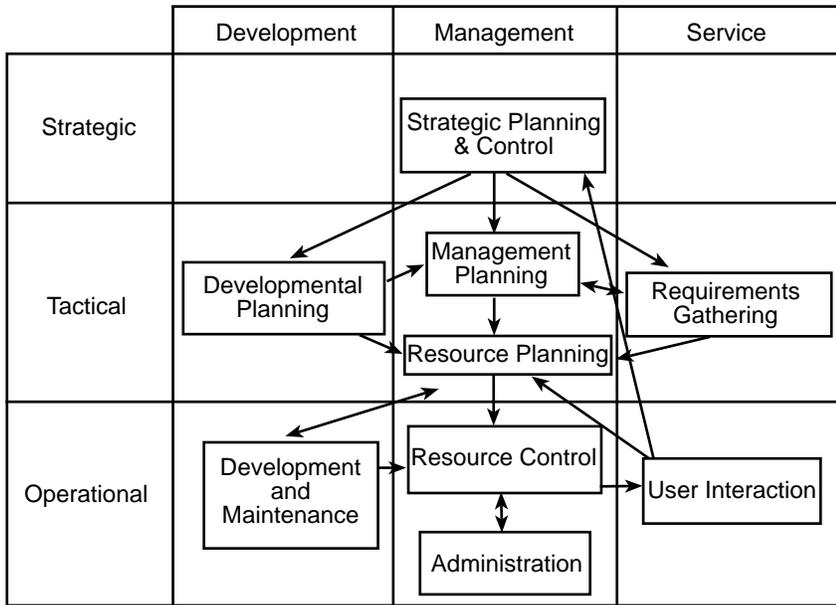


Figure 8. EMAP IM structure.

	Development	Management	Service
Strategic		<ul style="list-style-type: none"> <li>•IM Coordinator</li> <li>•Coordinating Groups</li> <li>•Science Direction</li> </ul>	
Tactical	<ul style="list-style-type: none"> <li>•User Interaction &amp; Planning</li> <li>•Resource Groups</li> </ul>	<ul style="list-style-type: none"> <li>•IM Coordinator</li> <li>•System Architecture</li> <li>•Technology Evaluation</li> <li>•Coordinating Groups</li> <li>•Resource Groups</li> </ul>	<ul style="list-style-type: none"> <li>•User Interaction &amp; Planning</li> <li>•Interagency Data Interchange</li> <li>•Resource Groups</li> </ul>
Operational	<ul style="list-style-type: none"> <li>•GIS</li> <li>•Systems Engineering</li> <li>•System Support &amp; Operations</li> <li>•Coordinating Groups</li> <li>•Resource Groups</li> </ul>	<ul style="list-style-type: none"> <li>•IM Coordinator</li> <li>•Coordinating Groups</li> <li>•Resource Groups</li> </ul>	<ul style="list-style-type: none"> <li>•User Interaction &amp; Planning</li> <li>•Coordinating Groups</li> <li>•Resource Groups</li> </ul>

Figure 9. EMAP IM functions.

face across many EPA platforms, an enhanced user interface featuring multimedia, and mechanisms for initial intra-agency data exchange.

1997—EMAP Interagency Federation Enterprise Implementation. System interoperability among EMAP, EPA and other agencies should provide external data exchange.

### EMAP IM Budget (1993 – 1997)

The budget estimates provided in this Plan include requirements for Resource Group

field support teams, support for the IM Coordinator and EMAP Central, and hardware and software costs. Using FY 93 as a baseline, the figures for FY 94 - FY 97 include resources anticipated for EMAP from all supporting Cooperative Partners and other federal agencies.

### Summary

The scope of this Plan extends from FY 93 through FY 97. However, EMAP IM systems will continue to operate beyond

1997 as the user base expands. These users will impose increasingly demanding requirements that will become more pronounced as EMAP enters the EMAP Interagency Federation.

With the assimilation of increasing data and information from other national and international ecology-related programs, EMAP IM is designed to become an “information highway.” It will serve as a powerful instrument for aggregating key environmental information to assist policy makers and managers at all levels in effecting the positive changes necessary to preserve the global environment.

### References

1. Environmental Monitoring and Assessment Program: Program Guide, June 1993.
2. *The National Information Infrastructure: Agenda for Action*, September 15, 1993.
3. Zachman, J.A., *A Framework for Information Systems Architecture*, IBM Systems Journal, Vol. 26, No. 3, 1987.
4. *IBM: A Management System for the Information Business, Vol. 1 — Management Overview*, GE 20-0662-1, 1984.

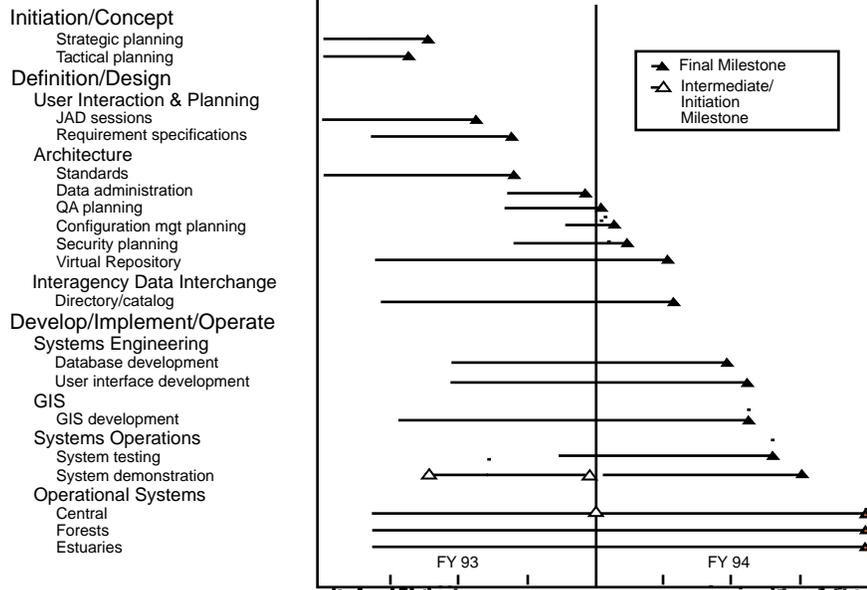


Figure 10. EMAP IM implementation schedule - POC.

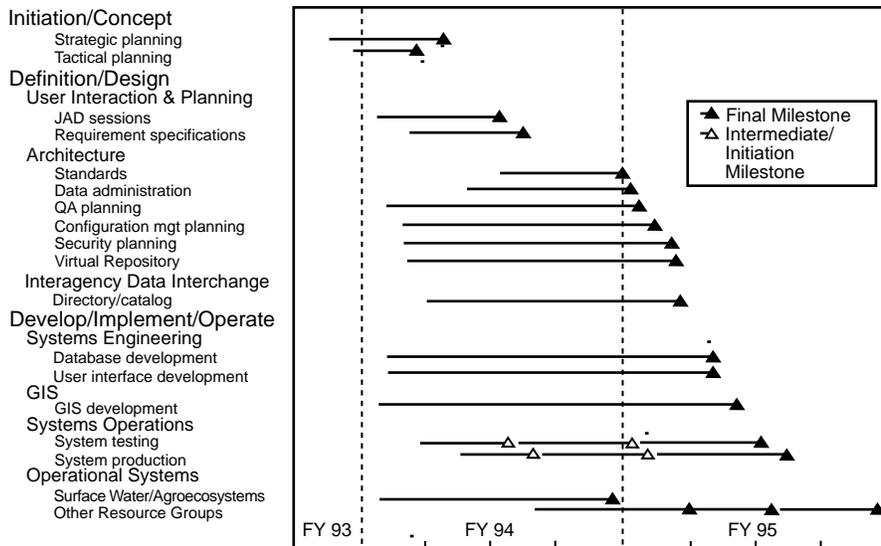


Figure 11. EMAP IM implementation schedule - Technology Transfer.

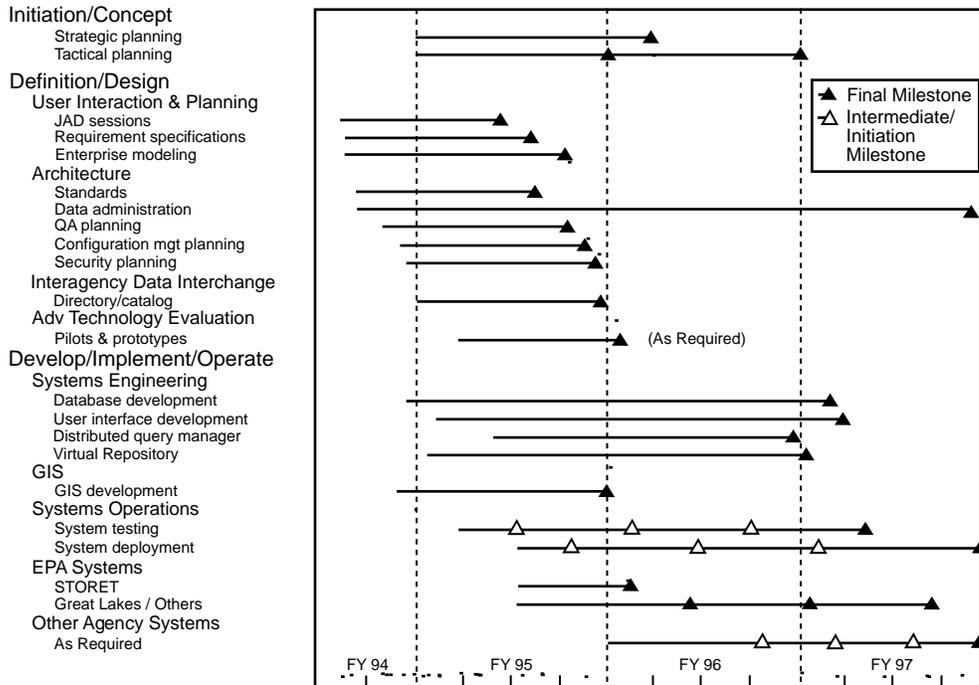


Figure 12. EMAP IM implementation schedule - Enterprise.

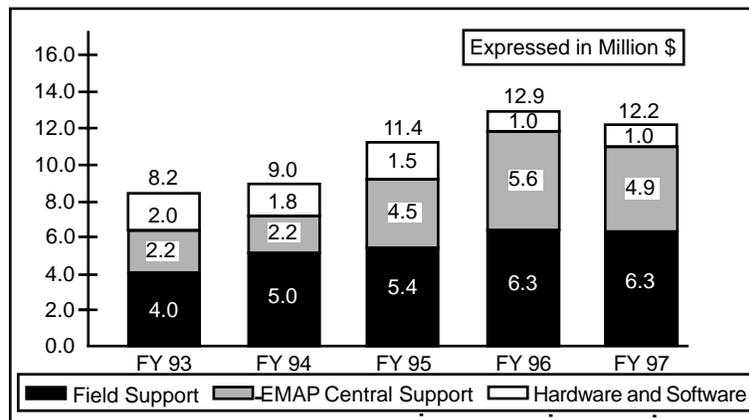


Figure 13. EMAP IM required budget.

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The complete report, entitled "EMAP Information Management Strategic Plan: 1993 – 1997," (Order No. PB94-176823, Cost: \$27.00, subject to change) will be available only from:

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5285 Port Royal Road  
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