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Modernization and Unification: Strategic Goals for NASA STI PROGRAM

W. Blados and G. Cotter

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MODERNIZATION AND UNIFICATION: STRATEGIC GOALS FOR NASA STI PROGRAM

Abstract

Information is increasingly becoming a strategic resource in all societies and economies. The NASA Scientific and Technical Information (STI) Program has initiated a modernization program to address the strategic importance and changing characteristics of information. This modernization effort applies new technology to current processes to provide near-term benefits to the user. At the same time, we are developing a long-term modernization strategy designed to transition the program to a multimedia, global "library without walls."

Notwithstanding this modernization program, it is recognized that no one information center can hope to collect all the relevant data. We see information and information systems changing and becoming more international in scope. We are finding that many nations are expending resources on national systems which duplicate each other. At the same time that this duplication exists, many useful sources of aerospace information are not being collected because of resource limitations. If nations cooperate to develop an international aerospace information system, resources can be used efficiently to cover expanded sources of information.

We must consider forming a coalition to collect and provide access to disparate, multidisciplinary sources of information, and to develop standardized tools for documenting and manipulating this data and information. In view of recent technological developments in information science and technology, as well as the reality of scarce resources in all nations, it is time to explore the mutually beneficial possibilities offered by cooperation and international resource sharing. International resources need to be mobilized in a coordinated manner to move us towards this goal.

This paper reviews the NASA modernization program and raises for consideration new possibilities for unification of the various aerospace database efforts toward a cooperative international aerospace database initiative that can optimize the cost/benefit equation for all participants.

The Changing Environment of Information

1993...a reminder that we are fast approaching the end of the twentieth century, and finding ourselves living in a new society, a new age, a new environment - an information society, an information age, an environment which is creating new relationships and new opportunities as a result of the increased availability of information. We are now finding ourselves using new methods to do our work, as well as a new environment in which we carry out our work.

Information, increasingly, is becoming a strategic resource in all societies and economies. It is the basis on which most new jobs are being created, new wealth generated, and new productive activities started. It is a primary determinant of the competitive position of industry in the marketplace. It is the driving force behind the internationalization of the marketplace.

In societal terms, it is of growing significance, not only in the role it plays in our economic affairs, but in the way it influences how we live and the way we function as citizens.

Information itself is also changing in character:

- there is more of it.
- it is now treated as a commodity that is bought and sold.
- it is more becoming more international in nature with sources now global, rather than national or local.
- it is now more transient as a result of the increasing speed with which new information gets produced and the rapidity of its dissemination.
- it is now being presented in more diverse formats; the spoken and printed word has been augmented by electronic databases, television, video, CD-ROM, etc.
- the format and manner in which information is produced is changing, mainly as a result of improved computer and communications technology. In fact, it is this technology that is changing the character of information itself and the strategic role which it plays in the economy and society.

Given the strategic importance and the changing character and use of information, we have to reexamine our approach to the collection, storage, retrieval, preservation, and use of information. However, we are finding that our answers to questions are far more complex and difficult than they have ever been before. We find that this complexity and difficulty is no longer (if it ever was) merely a question of finding a technical solution. Now we are finding that in our search for answers we must factor economic, political, social, and cultural dimensions into the equation.

Scientific and Technical Information

Scientific and technical information (STI), which represents the results of large investments in research and development (R&D) and the expertise of a nation, is a valuable resource. It is the basis for a strong science and technology base which is a national necessity in a competitive world. Today's basic research efforts and investments establish the foundation to support tomorrow's capabilities and opportunities.

An integral part of the aerospace R&D process is the scientific and technical information (STI) associated with it. STI is both a raw material (input) and a product (output) of this process. The systems that support STI must be considered as part of the scientific and technical (S&T) infrastructure. The data or existing knowledge bases are a raw material necessary for the production of new findings and developments.

Information processing in aerospace R&D, as well as in any R&D activity, is viewed as an ongoing problem-solving cycle which involves each activity within the innovation process, as well as the larger organization to which it belongs, and the external world. For purposes of this paper, the innovation process is conceptualized as a process of related activities or units beginning with research on one end, and service and maintenance on the other. Figure 1 attempts to graphically portray this process.

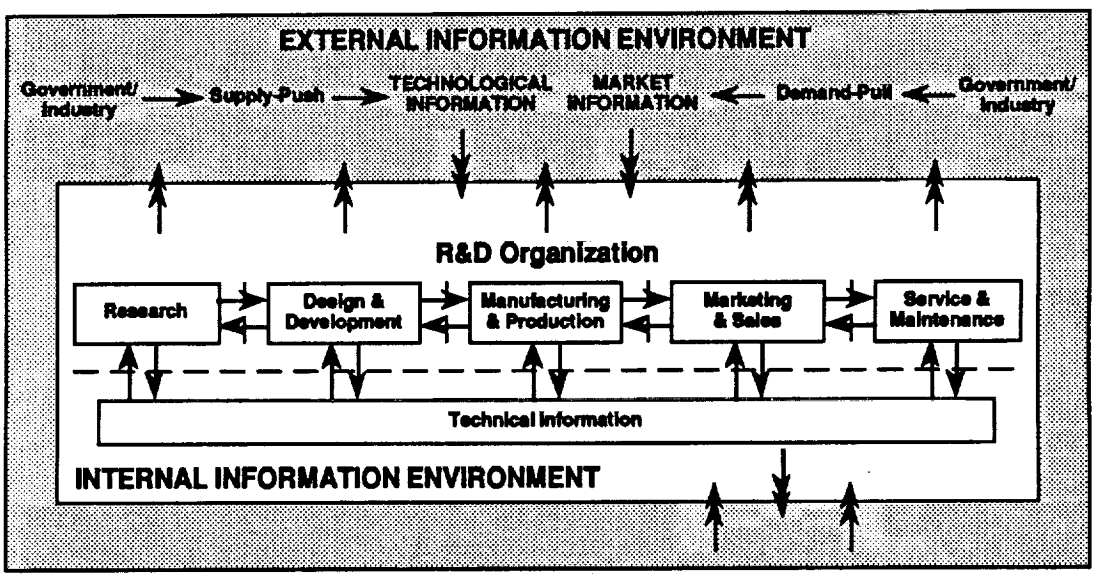

Figure 1. The Innovation Process as an Information Processing System

For any given task, each activity or unit within the innovation process must identify, gather, and assess scientific, technical and market information from the external information world. New (external) and established (internal inhouse) information must be effectively processed within the work area: decisions, solutions, and approaches must be worked on and coordinated within each activity and within the organization; and outputs, such as decisions, processes, products, and information, must be effectively transferred to the external environment. The outputs of this process create conditions for another set of activities, thereby initiating another information processing cycle. Numerous studies have found a strong relationship between successful innovation, idea formulation, and information external to the organization.

So, I think we can safely conclude that timely, accurate, and relevant STI is critical to the R&D process. It is an incredibly valuable resource that directly affects the cost of performing a technical task, the quality of the results, and productivity. Further, STI has value which may be exploited more widely than the purpose for which it was originally collected. It can serve as a critical link between R&D and the achievement of other national goals such as improving the education of scientists and engineers, the strengthening of the technology base, and fostering international cooperation on global problems. Even further, the diffusion of knowledge resulting from aerospace R&D is indispensable in maintaining the vitality and international competitiveness of the aerospace industry.

Current Factors Impacting the Use and Management of STI

The expanding use of information technology, the growth of interdisciplinary research, and an increase in international collaboration and development of international standards are having a significant impact on the conduct of science and the corollary management activities.

The expanding range of media and transmission alternatives, along with the continual increase in computing capacity and software building knowledge, are now removing barriers to the creativeness of scientists and engineers. Electronic mail expands the collegial campus, and electronic publishing improves the information transfer capability of documents.

We are now finding that computerized instruments gather data many orders of magnitude greater than previous methods. Data are available, not only in computerized databases, but also from sensing and other data-gathering instruments. New analytical approaches have been made possible through graphics, color enhancement, animation, and other visualization techniques.

These problems are further compounded by the growing internationalization of science. STI is being produced, enhanced, and stored around the globe. While single countries in some cases are acknowledged leaders in select scientific and technical disciplines, many of the major research efforts involve worldwide data collection. Many of the significant research challenges today are interdisciplinary in nature, which requires expanding the circle of collaborators and the range of information sources. Not only are a variety of disciplines involved, but scientists from around the world are participating in these efforts. The users in these projects are distant geographically as well.

All of these factors are changing traditional data management techniques and are creating pressures to change accepted information practices. Although we now have vast and large databases, the different methodologies, vocabularies, and cultures of individual disciplines create obstacles to efficient information exchange. Merging existing data collections from different fields to perform analyses creates new problems. It becomes extremely difficult to compare data that were derived using different techniques or approaches. Contributing to this problem is the lack of standards for data exchange formats which hamper the building of multidisciplinary and interdisciplinary databases.

The bottom line, however, is that we must be prepared to import external information to support the internal requirements, and to assure real-time delivery of information to support the transfer and transition of technology within the worldwide aerospace community.

In short, the pace of data collecting, the growth of international approaches to research, and the tendency to cross traditional disciplinary boundaries all cast a new perspective on earlier information issues, and raise new challenges for effectively providing critical information to the end user.

We now find that our customers want expanded subject coverage, not only national but international; they want to see more types of information such as numeric, factual, and multimedia; and they want rapid access to the full text of documents, along with improved systems of on-line bibliographic citations and delivery of documents.

These issues all fit into the theme of supporting the decision-making process. Researchers, scientists, engineers, program managers, and administrators need access to decision-supporting information regardless of the country of origin. They also need access to interdisciplinary information, not just to their own specialty.

Providing information in support of the aerospace, or any other global community would appear to be a formidable and overwhelming task. Especially so, when provision of information must take into account the vast array of multidisciplinary databases, the requirement to provide observation data, graphic representations of observation data, information available through personal contacts, as well as being able to supply complete reports of research on demand. The end users are a diverse group with many diverse needs. They require different types of data, different products, different services, and different user interfaces.

The NASA STI Program

The United States was a major and early entrant into the aerospace R&D arena through the creation of the National Advisory Committee on Aeronautics (NACA) in 1915, followed by the creation of the National Aeronautics and Space Administration (NASA) in 1958.

From the very beginning, the need for and role of a centralized scientific and technical information system was recognized. NASA's enabling legislation requires NASA to "provide for the widest practicable and appropriate dissemination of information concerning the activities and the results thereof."

The international nature of the mission was also recognized for NASA to conduct its activities "so as to continue to contribute materially to...cooperation by the United States with other nations and groups of nations in work pursuant to the Act and in the peaceful application of the results thereof."

This led to the early commitment and continued development of a NASA STI Program and a NASA aerospace database (NAD) consisting of world-wide information.

The NASA Scientific and Technical Information (STI) Program is a combination of systems, functions, products, services, and information professionals, with the common mission of providing for the widest practicable and appropriate dissemination of information concerning NASA activities and research results. The Program is geographically and organizationally dispersed across NASA Headquarters, each of the 13 NASA Research and Flight Centers, and service centers such as the Center for AeroSpace Information (CASI). The program provides interfaces to and from other U.S. government agencies engaged in the collection and dissemination of scientific and technical information and to and from international aerospace agencies such as the European Space Agency (ESA).

The Program's user community includes NASA scientists, engineers, and managers; NASA contractors; other US government agencies and their contractors; US industry and the academic community; and the international aerospace community. In total, over 7,000 entities are registered with the Program, but since many of these are actually registered at the intermediary and organizational level, the number of end users reach by the Program is much greater. For example, the number of registered international users in January 1992 was 700, although the potential end user population derived from these registrations could be as high as

40,000.

When developed in the 1960s, the NASA REsearch CONnection (RECON) online database positioned NASA as a leader in online dissemination of STI; the RECON retrieval engine became the basis for other commercial and government agency online system. In the intervening years, however, the NASA version of the system was only upgraded in minor ways.

Today, RECON remains a command-driven bibliographic retrieval system. However, users state that this capability is no longer sufficient. In addition to the capabilities that are now provided, they need online access to the full text of published and other STI, improved ways to search this information, and capabilities for integrating the results across diverse formats and sources. It became readily apparent that because of the highly distributed and diversified nature of the NASA user community, the Program had to start taking advantage of advances in computer systems networking in order to deliver STI directly to individual end users at the desktop.

With the reality of shrinking budgets, we knew we had to develop a strategy for streamlining our information products and delivering them more cost effectively. We needed to focus, for example, on replacing selected hard copy documents with electronic media in order to reduce production and users costs. In addition, we needed to enhance product accuracy, completeness, and the timeliness of delivery to avoid the high cost of research duplication and missed research opportunities.

Formulation of a Strategic Plan for Modernization

Beginning in late 1990, the NASA STIProgram developed a Strategic Plan. Among the many objectives defined in the Plan, four are key to Program modernization:

- enhance the quality of products and services
- enhance and improve access to STI resources
- increase the scope and access of foreign source materials
- improve current operations.

Our approach to modernization is characterized as one of evolutionary development, designed to reduce the risk and cost of new system acquisition through the cautious, incremental building of system components. Our approach emphasizes the use of already proven commercially available technology and other government developed or public domain products. We are also emphasizing the use of standards to ensure the lowest cost migration path for future enhancements and to support the greatest potential for interoperability among and between system components. Table 1 provides a summary of the modernization strategies, current projects and prototypes, and long term concepts.

MODERNIZATION STRATEGY	CURRENT PROJECTS	LONG TERM CONCEPTS
User Feedback/Outreach Functions	NASA STI Users Group, Bulletin Boards, Consolidated HELP Desk, User Surveys, Customer Satisfaction Metrics, STI Awareness Campaign	Permanent electronic-based NASA STI Users Group
GUI, Gateway Interfaces, Value-Added Search Tools	NAM Prototype	Enterprise-wide tailorable GUI, Gateway(s) to all required sources, both internal and external
Full Text Search/Multimedia	FTS Alternatives Evaluation; Nonprint Cataloging Project	RECON replacement/migration to FT/image document retrieval; Extended search capabilities
Electronic Publishing	Electronic Publishing Prototype; ASTRO/CD Prototype	Full life cycle electronic acquisitions, publishing, and dissemination; optical archiving
Expansion of Coverage	NTC Interface, Exchange agreement enhancements	Expanding sources; increased gateway access and shared processing
Worldwide Connectivity	Country-by-country connectivity for electronic document exchange	Global STI Network
Automatic Translation	SYSTRAN Evaluation Prototype	Full life cycle support for translations, minimizing human intervention
Support Systems Upgrade	Downsizing; selected operational upgrades and process improvements; OCR Prototype	Enterprise-wide MIS, Integration with operational processes

Table 1. NASA STI Modernization Strategies, Current Projects and Long Term Concepts

In our strategic plan for modernization, one important fact that we must take into consideration is that **no one information center can hope to collect all the relevant data in support of their aerospace community participants.** One strategy to cope with this problem is to form an international coalition, North and South, East and West to collect and provide access to disparate, multidisciplinary sources of information, and to develop standardized tools for documenting and manipulating this data and information. International resources must be mobilized in a coordinated manner to move us towards this goal.

Our goal at NASA is to meet the requirements of our customers and to establish as comprehensive and complete a database as possible. The most practical way to achieve this it to work with all the other organizations worldwide who share this goal, and to develop cooperative strategies to realize it. Development and use of gateway systems appear to have potential for the immediate solution of gaining access to the many databases available worldwide.

Recent advances in information retrieval systems have focused on developing and applying interface technology to create an environment where networking and interoperability strategies are possible on a global basis. One of these technologies is the development of gateways. Gateways allow users to interconnect with multiple, diverse information systems. In essence, gateways act as intelligent switches. Gateways are being designed and developed to operate in environments ranging from single-user microcomputers to multi-user, central processing mainframes. These gateways allow simple interconnections, registration into multiple systems, and provide telecommunication paths and protocols, and logon and logout procedures. More sophisticated gateway systems incorporate menus, common command language, data analysis routines, artificial intelligence, and related technology.

To date, we have found that access to online information sources of scientific and engineering data has been limited to a large extent by factors such as inadequate telecommunication systems, non-standard query language syntax, lack of standardization in the information, and lack of adequate tools to assist in searching.

The NASA STI Program has recently began testing a prototype gateway system, the NASA Access Mechanism (NAM), which offers a solution to these problems by providing the user with a set of tools that provide a graphical interface to remote, heterogeneous, and distributed information in a manner adaptable to both casual and expert users. The NAM will provide access to many Internet-based services such as electronic mail, the Wide Area Information Servers (WAIS) system, peer locating tools, and electronic bulletin boards.

One requirement of the future NAM is that the user interface be easily customized for specific user communities. Another requirement for the future is to provide for two- and three-dimensional visualization and rendering of datasets, both for user input and results output.

Using gateway technology, we can determine which relevant databases exist to solve an information query; from there we can learn how to access them, how to retrieve information from them, and how to manipulate the retrieved information. The NAM can provide a single, easy-to-use interface for identifying, accessing, interrogating, and post-processing information from numerous databases relevant to global change information needs.

In terms of peer locator databases, or "people bases," the NAM can be designed to answer questions such as what expertise is available on the network, how to communicate with the experts, and how to share information with colleagues. The system acts as an integrated information system that allows human experts, information users, and information resources to exist and interact in harmony.

In short, the NAM or any other gateway will help us ensure that the proper sources are used, and that relevant information is retrieved. Such systems can also help us avoid leaving out important sources of information and retrieving volumes of irrelevant data. Gateway technology will help us to:

- Maintain a constant alert for new databases/services.
- Register for, and maintain accounts with each of the services.
- Select the right service(s) for the query.
- Learn the diverse command structures associated within each of the services.
- Become knowledgeable regarding the terminology used in each database.
- Merge and analyze results from multiple sources.

The basic components of the NAM provide a directory of resources, subject searchable; a common method for accessing and searching diverse databases; tools for downloading and post-processing data; and tools for communicating with a network of experts and colleagues. **The NAM is still in its infancy, but it has the potential for extraordinary growth.**

Strategies for Cooperation

There are two strategies that can be implemented quickly to improve the availability of information to the worldwide aerospace communities.

One strategy is to build gateway connections between the existing databases of our worldwide aerospace partners. This will increase the availability of the existing databases, and create a base for establishing and promoting a global scientific and technical information network (STINET).

The second strategy would build upon the first, as a next step in this international cooperative effort. This strategy is to organize and establish an advisory group of representatives. The first action this advisory group might undertake would be the development of a comprehensive list of issues to be addressed, such as how can current existing exchange relationships form the basis for more cooperative international efforts. Other tasking for this group could include:

- Determining the types of agreements and relationships that will encourage involvement.

- Determining whether a formal group should be established to set policy and establish procedures for the sharing of existing international databases.

- Determining how to make the bibliographic database more comprehensive and timely, by identifying how information producers can be motivated to provide input, and how coverage of those parts of the world not participating in the effort might be accomplished.

- Addressing the issue of database availability. Who would be eligible for access, what should the pricing strategies be, and what is an appropriate network architecture?

- Identifying what strategies will be necessary to go beyond bibliographic cooperation into sharing of other kinds of data and information, including improvements in systems and technology for delivery and management of information, by determining how to reconcile the need on the part of participants in the international cooperative effort national for proprietary information.

- Providing oversight of a global STINET. This would require intellectual maintenance, in addition to the maintenance requirements associated with hardware and software. Some of the challenges for the advisory group would involve tracking changes instituted at remote resources to initiate appropriate modifications to preclude disruption of network harmony. Maintenance would also involve adding new resources to the network, and an appropriate task for the advisory group would be to determine what resources should be added to the network and in what priority order. Most importantly, the advisory group would be called upon to attest to the validity and reliability of data sources, ensuring that resources are credible.

- Developing policies concerning how nationally generated information will be controlled and validated. The use of incorrect information for decision making and planning could prove disastrous to an individual or to an organization.

- Examining strategies for an automatic translation facility. This would be useful in cases where pertinent information is stored in a language that is not native to the user. Automatic translation could make the information rapidly available in a useful format, and help eliminate the language barrier among users on the network. It could be used in conjunction with the "people bases."

- Addressing when to distribute resources on optical media for local use rather than making the resources available through telecommunications. Optical and video technology introduce us to the era of hypermedia, where conventional definitions of information systems and the data they contain must be redefined.

The task is not an easy one. During negotiations, there are other issues and problems that must be addressed:

- Information technology issues to address such things as advances in technology, next-generation information system problems and issues, the pace of technology development, development of computer networks, standards,military applications, and other technology issues.

- Policy, structural and institutional issues address changes in science, information policy issues, public/private sector roles and relationships, and relationships among text, numeric, and image providers.

- Legal and ethical issues to address intellectual property rights and other ethical issues.

- Economic/marketing/financial issues to deal with the increasing volume of information, storage and archiving, quality/comprehensiveness/currency of information content, access and dissemination, and security issues.

- Attitudinal and behavioral issues which concern the user community and the relationships with the information programs.

- Education and training issues are self evident. Given the pace of new technology development and the complexity of information systems and networks, education and training are a vital necessity to maintaining a strong sti program.

- International issues for information access which encompass such items as exchange of STI, transborder data flow, privacy/security, political/economic/social considerations, acquisitions and mergers of information companies, pricing/currencies, information to be exchanged/transferred/sold, language and translation, telecommunications, communicability, compatibility, standards and copyright and data rights.

So, the job of establishing an international program to deal with the burgeoning sources of information is a tremendous task, but given the proper planning, resources, and both fiscal and personnel support, it can be accomplished, and can provide an invaluable service to the worldwide aerospace user community.

The challenge of building a global scientific and technical information network will stretch far into the future. Network services will be added and deleted based on changes in technology and user requirements. The unchanging factor in successful development of the global network will be the partnership among end users, information specialists, and network developers. As long as this cooperative relationship continues, the STINET will continue to grow and expand.

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The NASA modernization program is reviewed and new possibilities for unification of the various aerospace database efforts are considered. The goal is to move toward a cooperative international aerospace database initiative that can optimize the cost/benefit equation for all participants. This modernization effort applies new technology to current processes to provide near-term benefits. NASA is developing a long-term modernization strategy designed to transition the program to a multimedia, global "library without walls." No one information center can hope to collect all the relevant data. Information and information systems are changing and becoming more international in scope. Many nations are expending resources on national systems which duplicate each other, while many useful sources of aerospace information are not being collected because of resource limitations. If nations cooperate to develop an international aerospace information system, resources can be used efficiently to cover expanded sources of information. We must consider forming a coalition to collect and provide access to disparate, multidisciplinary sources of information, and to develop standardized tools for documenting and manipulating this data and information. It is time to explore the mutually beneficial possibilities offered by cooperation and international resource sharing. International resources need to be mobilized to move us toward this goal.

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