Chapter V

OPTIONS FOR ACHIEVING THE INTEGRATED CAPABILITIES

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There are a number of options available to Congress and the President for improving materials information and analysis in accordance with the needs previously identified in Chapters I-IV. These options range from no direct action, to hearings, executive orders, and finally to legislation.

In illustrating the implementation possibilities of the last option, three alternative systems approaches for achieving the integrated capabilities were examined.

- **Approach A would employ an interagency committee or congressionally authorized group to coordinate the existing materials information systems;**
- **Approach B would create a full-time organization which would make step-by-step improvements in the existing information systems and add new supplementary capabilities as required;**
- **Approach C would create a central program management office which would first design the improved capabilities from the "top-down," then would decide what, if any, portions of the existing information systems could be utilized in the new design.**

The relative merits of the three approaches are compared and their order-of-magnitude costs are developed.

A. INTRODUCTION

A number of options are available to Congress and the President as a means of improving current Government materials information systems in accordance with the needs previously described in chapters I-IV. These options range from no direct action, to hearings, oversight, executive order, and finally to legislation. The options focus particularly on executive and/or legislative actions to provide integrated materials information capabilities in support of policy-level decision making.

The analysis in earlier chapters strongly suggests that, without direct and concerted action, the legislative/executive branch needs for improved materials information in support of public policymaking are unlikely to be met through the natural evolution of existing materials information systems. However, the analysis also indicates that increased Federal commitment to such improvement through one or more of the possible legislative/executive options will not by itself insure that existing systems evolve to meet priority needs. Regardless of the level of commitment, additional organization and integration seems essential.

B. LEGISLATIVE AND EXECUTIVE IMPLEMENTING OPTIONS

A **number** of options are available to Congress and the President for the provision of improved materials information and analysis in accordance with the needs previously identified. This section describes the range of legislative/executive options and discusses the major advantages and disadvantages of each. The focus is on executive and/or legislative action to provide improved materials information and analysis in supporting policy-level decisionmaking. However, some actions include an important role for the private sector, and some if not most of the improved information and analysis could be useful to the private sector.

1. Evolution of Current Systems Without Direct Action

A materials information "system" does currently exist, at least in a loose sense, as indicated by the survey and interviews. Many kinds of materials data are collected by numerous public and private sector entities with varying reliability and completeness. Based on these data, certain kinds of materials information (summaries, analyses, and forecasts) are available, although not always readily accessible and frequently in noncompatible formats. Nonetheless, a system of sorts does exist, especially for the handful of experts and specialists who know the parts of the system well and can pull things together, at least in their own minds.

The first option available to Congress and the President is to do nothing, that is, to let the current systems continue to evolve without direct intervention. The essential question, of course, is whether the current systems will improve quickly enough to achieve the capabilities.

a. Evolving Systems in the Federal Government. The survey of Federal Government systems reveals that efforts are underway in several agencies to improve or upgrade existing systems. However, the rate of progress appears to be quite slow. For example, the Department of the Interior's Bureau of Mines has a Minerals Availability System (MAS) in early stages of development. The system now includes data on only a few commodities and is therefore not extensively used, although the 5-year plan for MAS includes 32 minerals, In the Forest Service, Department of Agriculture, existing data bases and analysis techniques are being integrated into a forestry information system, which is expected to provide more effective support for the Forest and Rangeland Renewable Resources Act of 1974, Likewise, in the Department of the Interior, a Mineral Analysis and Policy System (MAPS) is under development to expand data collection, analysis, and forecasting activities in minerals-related areas, The Department of Commerce, Bureau of Domestic Commerce, is in the process of developing and implementing an Early Warning System designed to (1) forecast possible supply dislocations, (2) analyze the impacts of such dislocations, and (3) recommend policy options to avert or mitigate such dislocations.

But despite these signs of progress, major problems are identified in the survey of existing systems presented earlier. Overall, the natural evolution of Federal Government systems can be expected to lead to gradual improvement within agencies. However, little improvement can be expected with regard to the lack of effective integration of materials supply and utilization information which must cross agency lines.

b. Evolving Systems in State Government and the 'Private Sector. A few States (including Alaska, California, Illinois, and Oregon) are developing fairly comprehensive information systems on some materials for parts of the materials cycle, Yet in general, materials information systems at the State level are currently not as well developed as at the Federal level and by comparison are evolving slowly.

Survey results indicate that in the private sector many of the larger firms in materials-related industries have developed their own information system on some parts of the materials cycle. Many also have statistical and analytical capabilities with regard to basic materials trends affecting their own activities. By comparison, smaller firms generally cannot afford a substantial in-house effort. Some of the larger firms are making efforts toward upgrading their systems and introducing additional capabilities. But progress appears to be slow, in part due to lack of confidence in forecasting. inadequate conceptual frameworks for handling exogenous variables, incomplete data, and legal and competitive barriers to cooperation.

A few small private sector information service firms (e. g.. Battelle Memorial Institute, Data Resources, Inc., and Chase Econometrics. Inc.) provide technical data, as well as referral modelling and forecasting services. These firms thus fill some of the gaps in the information systems of materials-related companies. However, the natural evolution suggests a centinuing mismatch between the information needs of the private firms (and Government agencies) and the data collection and analysis techniques developed by the information service firms, universities, and "think tanks. "

The evolution of current systems is unlikely to 1) promote the most efficient and effective governmental and private sector responses to materials problems; 2) provide adequate data and analysis for public and private sector materials policy makers; and 3) solve the problems of interagency information transfer within the Federal Government and integration of materials supply and utilization information. Coordination and planning of materials information activities between the Federal and State governments and the private sector are unlikely to improve substantially.

2. Legislative Branch Options Short of New Authorizing Legislation

Congress has available a number of possible options short of legislation to provide various kinds of improved materials information.

a. Congressional Options To Provide Improved Materials Information Within the Legislative Branch. Congress can act through existing congressional offices and agencies which already have a general mandate compatible, at least in part, with the needs for improved materials information. The major possibilities here lie with the Congressional Budget Office, the General Accounting Office. the Congressional Research Service, and the Office of Technology Assessment, all supported by the evolving congressional information system. These offices, along with the congressional committees, serve an important function in filtering and translating data and information into a policy analytical format consistent with the needs of members of Congress.

The first possibility is action through the Congressional Budget Office (CBO). The CBO was established by the Congressional Budget and Impoundment Act of 1974 to provide Congress with high-level analytical capability in reference to the Federal budget and the relationships between allocations of resources (through the budget) on the one hand, and national priorities and quality of life on the other, The Act requires CBO to develop "a detailed structure of national needs which shall be used to reference all agency missions and programs, " and to study proposals for " improving analytical and systematic evaluation of the effectiveness of existing programs, and developing techniques of noneconomic as well as economic evaluation measures. "

The second possibility is action by the General Accounting Office. While CBO has continuous responsibility for analysis of matters involving the budget, the GAO generally becomes involved only at the specific request of Congress, However, because of the high priority of the energy -environment-resources area, and the large number of related requests from Congress, the GAO could assume an expanded role—particularly with regard to the monitoring and validation of materials data. Under the Legislative Reorganization Act of 1970, GAO is given the general responsibility to review and analyze Government programs, "including the making of cost-benefit studies, " which can be a useful technique in the materials area.

Two other congressional agencies, the Congressional Research Service (CRS) and the Office of Technology Assessment (OTA), may also carry out activities related to new or improved materials information. The CRS maintains a group of materials specialists for briefing Congress on materials issues, keeping track of materials-related legislation and reports, and performing research in selected materials area. Consistent with the Legislative Reorganization Act of 1970, CRS is empowered to provide improved information support to Congress, and could serve as a location for an expanded materials analytical capability and/or a materials referral service,

The Office of Technology Assessment could itself maintain a continuing role in the materials information area, building on the expertise developed through this and other materials assessments. In establishing OTA, Congress recognized that "the present mechanisms of the Congress do not and are not designed to provide the legislative branch with (adequate) information" on the "consequences of technological applications and emerging national problems. " Materials appears to be a national problem area to which OTA can justifiably give a degree of continuing attention for some time to come.

Support of materials-related activities of the offices described above can be provided by the evolving congressional information systems. Provision of computerized information support to Congress is shared primarily between the House Administration Committee, the Senate Rules and Administration Committee, and the Library of Congress. As yet there is no single unified system, but development has progressed to the point that improvements in CBO, GAO, CRS, and/or OTA materials-related analytical capabilities can likely be supported via the evolving congressional information systems. Computer terminals are already available in a number of committee and member offices, with further expansion expected. Efforts are underway to gradually enlarge the range of computer-based support services available to Congress for the provision of information in a wide range of areas, including materials.

Possible advantages and disadvantages of congressional actions to provide improved materials information with in the legislative branch are summarized in table V-1. While all materials in format ion needs cannot realistically be met within Congress, improvements within the legislative branch will strengthen congressional capabilities and independence in materials policymaking, regardless of actions taken by the executive branch,

b. Congressional Options To Provide Improved Materials Information Via the Executive Branch. Congress has several options, short of new authorizing legislation, in seeking to provide improved materials information via the executive branch. The most important of these options includes the use of congressional hearings, the exercise of oversight and investigative powers, and the possibility of congressional resolutions.

Through the hearing process—both substantive and appropriations—congressional committees with relevant jurisdiction can encourage Federal executive agencies to take actions to provide improved materials information, e.g., with respect to data base discipline and compatibility, improved forecasting capability, and better coordination and integration.

Problem areas, such as materials information transfer within a particular agency or between two agencies, can become a focus for special attention through oversight by congressional committees with relevant jurisdiction. An even stronger measure might involve the use of the congressional investigative power to obtain executive information as to the inadequacies of the present materials data and analysis, or (in an extreme case) to compel

Table V-1.—Possible Advantages and Disadvantages of Legislative Branch Options Short of New Authorizing Legislation

Advantages	Disadvantages
Congressional Options to Provide Improved Materials information Within the Legislative Branch	
Will strengthen congressional capabilities in the materials area, regardless of actions taken by the executive branch.	May spread thin the resources of congressional offices.
Will afford Congress a somewhat higher degree of independence in materials policymaking.	Will not be sufficient for meeting all materials information needs, some of which require ongoing administrative functions which are outside the capabilities and role of Congress.
May generate greater congressional confidence in materials data and analysis since information will be screened and interpreted by congressional offices instead of or in addition to the executive agencies.	
Congressional Options To Provide Improved Materials Information Via the Executive Branch	
Will encourage or place pressure upon the executive branch to improve materials data and analysis.	Will not normally be legally binding on the executive branch.
Will bypass the difficult process of enacting new authorizing legislation.	May not ensure an effective executive response,
May at least to some extent increase the responsiveness of established materials agencies.	
Congressional Options To Provide Improved Materials Information Via the Private Sector	
May encourage the private sector to improve materials information.	May not be taken seriously by the private sector.
May help give greater priority to materials information activities in the private sector.	May not ensure a private sector response sufficlent to meet priority information needs.
May help increase private sector involvement in and support for improving materials information.	

attendance of witnesses or submission of documents deemed pertinent to these inadequacies. Such investigations may be justified under congressional rules for holding administrative agencies accountable for their activities or to lay the informational basis for legislation.

Finally, short of legislation, Congress can also express its strong concerns about having better materials information and analysis through a resolution, directed toward the executive branch. However, since bills are preferred over resolutions in important matters, new authorizing legislation seems more appropriate here. House, Senate, and joint resolutions can additionally be used to implement improvements in legislative branch materials information, that is, to state what the internal policy of Congress shall be with regard to the materials information area.

Possible advantages and disadvantages of congressional options, short of new authorizing legislation, to provide improved materials information via the executive branch are summarized in table V-1. While such options will encourage the executive to improve materials information and bypass the difficult legislative process, they will not normally be legally binding and may not ensure an effective executive response.

c. **Congressional Options To Provide Improved Materials Information Via the Private Sector.** Policy statements by individual members of Congress and groups of Members can help stimulate private sector efforts toward provision of improved materials information, without enacting new authorizing legislation, Beyond that, through hearings and oversight in materials-related areas, Congress can encourage Federal agencies to allocate their resources flowing to the private sector in accordance with the need for improved materials information, under existing legislation in a wide range of materials-related areas, Greater priority can be given to improving materials information activities in the private sector, including the establishment of centers and institutes for materials information research, development, and demonstration,

Possible advantages and disadvantages are summarized in table V-1. While these options may to some extent encourage the private sector to improve materials information and increase private sector involvement, they may not insure a private sector response sufficient to meet priority information needs.

3. Executive Branch Options Short of New Authorizing Legislation

Another option is executive action, short of new authorizing legislation but more than the evolution of current systems, to provide improved materials information.

First, a Presidential proclamation or policy statement—while not having the force of law-can set an overall direction or thrust to improving materials in formation. Next, although the President's power to issue executive orders has been restricted by Congress, especially in regard to reorganization plans, some materials information needs can be met through executive and/or agency order. Examples include a materials referral service and perhaps data base standardization. Third, various specific improvements in current materials information systems could be implemented via an OMB directive or bulletin.

Table V-2.—Possible Advantages and Disadvantages of Executive Branch Options Short of New Authorizing Legislation

Executive Options to Provide Improved Materials Information	
Advantages	Disadvantages
May promote the greatest cooperation of executive agencies while minimizing organizational disruptions.	May not stimulate the public debate necessary to focus attention on materials information.
May promote the involvement of business and Industry.	May not provide an effective solution to materials information problems due to limitations on executive actions.
May draw upon the expertise of the private sector in materials data collection and analysis.	May not generate sufficient congressional support.

Finally, a somewhat different approach would involve grants and contracts to the private sector without further legislation. Federally supported materials research, development, and demonstration support programs, including energy conservation, environmental, and land use planning activities, in the private sector could be adjusted through executive action to aid in improving materials information. Such adjustments could relate to: (a) materials forecasting/modelling capabilities. (b) clearinghouse/referral capabilities in specialized areas of materials i n formation, and (c) statistical/analytical capabilities with respect to the cycle of materials supply and utilization.

Possible advantages and disadvantages are summarized in table V-2. Executive branch actions taken alone may promote cooperation among executive agencies and the involvement of the private sector, but may not stimulate the public debate and generate the congressional support needed to focus sufficient attention and resources on materials information problems.

4. Options Through Legislation

Up to this point, the legislative/executive options discussed would be accomplished within the existing systems and institutions, However, any actions to implement a major program from the standpoint of institutional changes and/or substantial expenditure of funds over an extended period of time will generally require legislation in view of the legal requirements, the level of resources involved, and political considerations, among other factors. Legislation could be designed to make current information systems more effective and efficient, and to implement the integrated capabilities by building on some or all of the systems now scattered throughout the Federal Government,

Possible advantages and disadvantages of implementing the integrated capabi1ities through Legislation are summarized in table V-3. Legislation will permit a more comprehensive approach, will allow interested parties to develop alternatives, and will help assure wider participation in decision process.

Table V-3. Possible Advantages and Disadvantages of Options Through Legislation

Advantages	Disadvantages
Will permit a more comprehensive appreach than executive or congressional action short of legislation.	May take longer than executive action due to delays in the legislative process.
Will allow many interested groups and organizations to develop alternative plans for consideration by Congress.	May stimulate a divisive political debate.
Will help assure wider participation in the decision whether or not to create a new or improved system.	May cause greater disruption in the Federal bureaucracy and potential resistance to change.
Will generate wider public awareness and interest in materials information and related areas.	May raise expectations to unrealistic levels.
Will permit a more focused congressional statement of purpose.	
May actually speed up action if a sense of urgency and widespread consensus is established on the need and priority for a new or improved system.	

If a sense of urgency and widespread consensus is established, legislation may speed up action, However, legislation could take longer, since one function of political debate is to bring out a wide range of views and opinions.

C. ALTERNATIVE INFORMATION SYSTEMS APPROACHES

In order to illustrate how the last option, aetions requiring new authorizing legislation, might be implemented to improve the current Federal materials information systems, three alternative information systems approaches were identified, The social, political, and other impacts of the approaches are discussed in chapter VII. All three approaches can achieve the integrated capabilities, but with differing degrees of effectiveness and at differing costs,

Consideration of the range of options for improving current Federal materials information systems led to the identification of three basic approaches for meeting the needs discussed in chapter III.

- Approach A—Coordinated Systems Evolution. This approach centers on the use of a coordinating group to organize activities of the current Federal systems as they exist and are expected to develop within the context of current 5 year plans, Solely through coordination, an attempt would be made to achieve the desired integrated capabilities. The various agencies would continue in their present directions, but the coordinating function would encourage increased communication and cooperation among them to promote greater effectiveness, This approach involves only minimum, if any, organizational change. Existing agencies would be assigned responsibility for functional requirements not now being performed, including the collection of data required for the improvements, These activities are also essential requirements for approaches B and C.

- Approach B—Directed, Step-By-Step Upgrading of Existing Information Systems. This approach is also based on the use of Federal systems as they exist and are expected to develop, but it would have an oversight function assigned to a directing office, which may be an existing or new agency. This office would closely follow the development of all Federal materials information systems and direct and focus activity toward achieving the desired integrated capabilities. The oversight office would determine the resources needed, compare them with existing capabilities, and fill the gaps by assuming responsibility itself or by assigning it to other agencies, This approach could be implemented in numerous ways. To illustrate its flexibility, a development encompassing three sequential steps is discussed.

- Approach C—New Information System. In contrast to the other approaches, this approach envisions developing the integrated capabilities from the top down. A strong centralized management group would be established to direct the program, It would determine what facilities and services were needed and how they should be implemented, making use of existing systems only where they clearly met ultimate requirements.

  To the extent that existing facilities met requirements of the top-down plan, they would be used. But, as compared with approaches A and B, there would be greater prerogative to acquire new facilities and less mandate to stay with existing systems of marginal use.

Table V-4 lists the major characteristics of each approach.

In examining alternative approaches, there are few basic options from which to choose:

Table V-4.—Summary of Alternative Systems Approaches

Approach Characteristics	Approach 1	Approach 2 Step 1	Approach 2 Step 2	Approach 2 Step 3	Approach 3
Supports improved capabilities	Yes	Yes	Yes	Yes	Yes
Meets materials information policy needs	Partially	Partially	Partially	Yes	Yes
Design philosophy	Coordinated evolvement of existing systems	Directed improvements to upgrade existing systems			Top-down, requirements design-driven to establish needed system
Uses existing* Federal materials information systems	Yes	Yes	Yes	Yes	Partially
Creates organization to oversee operation of existing systems	(Coordination group only)	Yes	Yes	Yes	No
Creates organization to establish new* information systems	No	No	No	No	Yes
Provides the following new* services:					
Referral	Maybe	Yes	Yes	Yes	Yes
Clearinghouse	Maybe	No	Yes	Yes	Yes
Query management	Maybe	No	No	Yes	Yes
Information exchange (including standards)	Maybe	Yes	Yes	Yes	Yes
Summary data base	No	No	No	Yes†	Yes‡
Statistical services	No	No	No	Yes†	Yes‡
Modeling services	No	No	No	Yes†	Yes‡

Notes:

* "Existing" includes planned growth or normal evolution; "new" involves improvements beyond that.

† New summary data base and analytical services to supplement detailed data bases, statistical analyses, and forecasts of existing system for critical materials and to-aid in the exchange of information among components of the existing system.

‡ All needed data collected, validated, and stored as part of new information system; necessary analytical services for system concept provided.

(a) one can improve cirtical parts of the present systems; (b) one can improve major parts and add new parts to achieve the desired level of performance; (c) or one can design a totally new system to replace the existing systems.

Analysis of the existing information systems shows that doing nothing is unlikely to achieve the desired capabilities, Some of the needed functional requirements are not met at all and need to be added. Others need to be improved because materials information is not managed so that it is sufficiently complete, accurate, current, standardized, and accessible. Moreover, even if these individual deficiencies were corrected, overall performance would still be inadequate without substantial improvement. As noted in chapter III, the functional requirements are highly interrelated, and there is a clear need to integrate these functions so that data on supply and utilization could be more readily exchanged and analyzed.

In implementing the integrated capabilities described in chapter 111, actions must be taken to provide a range of necessary services. Prospective users must have an awareness of what data exists and how it can be accessed; and they must have assurance that data obtained from different sources are consistently standardized. They need to know what standards apply. They also need to know what models are being used and what constraints exist in using them. In short, they need to know how to specify and obtain the "outputs" they require. In theory, the components that perform these services—locating data, establishing standards, handling queries, etc--coould all be implemented at the same time; moreover, they could be completely integrated and highly automated. In practice, however, it is more likely that the integrated capabilities will be added over time, and the desired level of services will be attained in steps. Initially, many steps will be accomplished manually, e.g., assisting users in locating information. Later, these services might be accomplished using more sophisticated, automated techniques.

Considering the broad range of uses to which the integrated capabilities could be applied, the following set of basic information services have been identified. All three systems approaches provide the services; however, they achieve them in different ways, on different time schedules. and to different levels of performance:

- Materials Referral Service.—This service would provide visibility and accessibility to needed information for policy makers.
- Materials Information Exchange Service.—This service would apply standards within the entire Federal information system, ranging from the development of a common vocabulary to be used in the select ion, analysis, and reporting of materials information to the development of common data formats and data handling procedures to be incorporated within each existing Federal information system. Such materials information exchange service, interfacing with all components of the existing Federal information system, would facilitate data exchange and would accomplish the meaningful interchange of data inherent to the integrated capabilities envisioned.
- Clearinghouse Service,—This service would be utilized to help users obtain answers to clear-cut, factual questions. The Clearinghouse would not provide analytical support. It would only obtain necessary serial publications and reports from the existing Federal materials information systems and forward them to the user.
- Summary Data Base Service.—This service would collect required information on supply and utilization at the appropriate level of aggregation from the existing Federal information systems. It would also handle any format conversions and data translations that were required to include the information in the summary data base.
- Query Management Service.—This service would help users obtain answers to more complex questions. It would access the summary data base for data, prepare statistical summaries showing historical trends, and possibly even run models on selected data. It would be staffed with materials specialists and economists who would work with users to help interpret their questions and obtain answers.
- Routine Statistical Services, -These services would be responsive to both periodic and one-time user requests, possibly issuing a semiannual or annual publication of summary statistics for all critical materials. They might also include the capability for analyzing summary historical data to answer specific questions, such as "What trends are developing in the domestic use of copper?" These kinds of services are needed to interpret and

display trends in critical materials to alert policy makers to potential scarcity situations.

- •Modeling Services.-These services would address "what if" type questions in response to user requests. They might include issuing a semiannual or annual forecast of potential shortages using the index of scarcity concept discussed in chapter 111. They might also provide answers to special requests for running appropriate models on materials situations. These analytical services would be particularly needed by users who do not have their own facilities, for example, Congress. The interpretation of the data, the setting of assumptions, the selection of parameters. etc. would be performed by the user's own staff.

These services are not independent but are supportive of each other, For example. establishment of the materials information exchange service would facilitate the establishment of materials referral service; establishment of the summary data base service would facilitate statistical services,

The following sections further detail each approach, not as a recommended evolution, but as illustrative of the ways they might reasonably be implemented.

1. Approach A: Coordinated Systems Evolution

This approach permits the current materials information systems to continue to evolve without a central group having direct authority over them, However. a coordinating group, probably comprised of representatives of the institutions now operating the systems, would guide the evolution. The coordinating group would establish common objectives and clearly delineate gaps and overlaps in institutional responsibilities, which could be corrected through executive directives (perhaps also with new legislation), Clear and separate responsibilities for information management of a particular class of materials to achieve specific functional requirements could thus be sought. However. without a central group with a measure of direct authority overseeing the improvements (as included in approaches B and C), this evolution could vary in degree by functional requirements or by class of materials, since the evolution would likely be driven by the latest perceived problems (for example, new fuel shortages) or other external influences,

This approach is most susceptible to redirection of institutional resources to address the short-range problems pertaining to a particular agency's mission. This could adversely impact the ability of existing systems to achieve the basic and supplemental functional requirements within reasonable time. It is important to note that current institutions have recognized the information management problems within the purview of their own institutional missions and have initiated plans to improve their information systems. Both short and long-range improvement plans are in place to upgrade information systems. Thus, there is a substantial base from which development evolution could start. Some of the plans upon which this approach could be based are described as follows.

a. Department of Interior. The Department of the Interior's Minerals Analysis and Policy System (MAPS), announced in September 1974, has two projects related directly to the management of materials information:

- Expanded data collection and analysis of domestic and international sources of critical minerals and materials, including appraisal of existing and potential ore deposits, processing facilities, transportation systems, labor supplies, and a variety of geologic, economic, and institutional data on operating mines which produce key mineral commodities. Paramarginal mineral deposits will be included to assess supplies at various price levels. Hypothetical resources will be considered to ensure identification of materials presently convertible to reserves.

- Expansion of the Department of the Interior's forecasting capabilities, as an improved guide to informed U.S. Government decisionmaking on both domestic and world mineral markets. Several different forecasting methods will be used in order that one will serve as an accuracy check on others in making appropriate long- and short-term forecasts which can assist in the orderly functioning of the market system.

The Office of Minerals Policy Development (OMPD). the U.S. Geological Survey (USGS), and the Bureau of Mines (BOM) were assigned major roles in this effort. The OMPD Report, Critical Materials: Commodity Action Analyses (March 1975), is an analysis of four supply/demand problems in critical imported materials. This study did not use data directly from an automated data base of supply/demand; however, as mineral reserves data are added to the Minerals Availability System (M AS). this capability is planned.

b. Department of Agriculture. The Forest Service is developing a long-term plan under the Forest and Rangeland Renewable Resources Planning Act of **1974** (P.L. **93-378)** that will consolidate and develop its use of data bases both to manage the national forests and provide supply and demand information on timber on public and private lands. including:

- Resource estimates of timber;
- Trends in consumption and prices;
- Prospective demand. supply, and price outlook to 2020; and
- International trade and resources.

Further development of the already advanced Forest Service Information System will consolidate and standardize the timber data banks and provide more extensive statistics, referrals, and reports.

c. Federal Energy Administration. The Integrated Petroleum Reporting System Task Force, with representation from the major FEA offices currently operating or using petroleum reporting systems, was formed to improve petroleum reporting systems in order to meet requirements imposed as a result of new legislation, Specifically, its goals were to minimize the gaps and remove redundancies and inconsistencies in data and to establish a cost-effective way to alleviate the reporting burden on the industry. As a result, the implementation of the Petroleum Reporting System Phase I (PRS) has recently been initiated within the constraint of using existing data elements. Further upgrading of this system is planned.

FEA has also established the National Energy Information Center (NEIC) in response to a requirement for a national clearinghouse for energy information, The Center serves all sectors of the materials community by:

- Responding to inquiries;
- Referring to data sources;
- Providing information analysis and research;
- Maintaining an energy library; and
- Producing indexes, bibliographies, periodic and special technical reports.

FEA is developing a computerized Federal Energy Information Locator System (FEILS) to provide information on the existence, location, and characteristics of energy or energy-related data to a detailed element level. At the present time the system contains entries of the **260** energy programs identified by an interagency task force. Summaries of data programs have been validated by source agencies for completeness and accuracy.

Once the user finds the location of the information that he desires, he can then request the assistance of the National Energy Information Center to obtain that information.

These activities are illustrative of those taking place which will significantly improve materia1s inform at i on m a n age m en t capabilities to address the basic functions and, ultimately. the supplemental functions.

There are two types of deficiencies that need to be corrected if the existing materials information systems are to accomplish the basic functions. First, some functions being addressed by some institutions are not being performed adequately; they could be corrected by directing each responsible agency to perform the needed function (such as improving resources and reserves estimation) in the manner required. The second deficiency involves developing a capability for basic functions which are not currently being performed, such as monitoring recoverable materials and assessing price impacts.

In approach A a coordinating group would evaluate which basic functions are already being performed by each institution and would assess the capability to perform the functions in the manner required, Institutional agreements would result in new directives within each agency to remove its own inadequacies, without disrupting other missions being performed. Also to be considered by the coordinating group would be the question of what agencies were best equipped to carry out or develop the missing functions. For example, the Bureau of Mines already monitors information on the materials cycle for the nonfuel minerals class. While an agency could be established or missioned in the Department of Commerce to collect missing elements, responsibility for monitoring of all these pieces might also be considered a BOM mission. Because of the economic considerations involved in the basic functions, particularly the supply/demand analysis leading to a calculation of an index of scarcity and its subsequent price impacts, the Office of Minerals Policy Development might also be involved in BOM in integrating these functions for that class of nonfuel minerals.

This logic could also be applied to other classes of critical materials, and a single existing institution could be given the integration responsibility for that material or class of materials. In this manner, a coordinator might be established for each critical material or class of materials to ensure that the required system interconnections between functions were achieved. For example, the Department of Agriculture might continue to be responsible for both the forest products/paper materials class and the nonfood agricultural materials class. In order to do so, it might obtain some needed data from the Department of Commerce. The Federal Energy Administration might be responsible for integrating the mineral fuel class of materials, obtaining needed data from both the Bureau of Mines and the Department of Commerce. In fact. its relationship with BOM for mineral fuels might be similar in some respects to its relationship with OMPD for nonfuel minerals. Other classes representative of processed materials might be handled by the Department of Commerce. These assignments would be very similar to current institutional responsibilities for these materials,

Basic information services such as the materials referral service and clearinghouse service could also be implemented within this approach. By mutual agreement. an existing office or agency would take on the responsibility. Once again, these services could be subdivided by class of material so that possibly five or more such services would be provided. (FE A already runs a referra1 a n d clearinghouse service for energy.) However. it might be more difficult to fully accomplish the services (particularly the clearinghouse service) in this approach because access to data would cross institutional boundaries and would require close cooperation among the existing institutions and users, Approach A could, in time, achieve the improved capabilities that might meet several of the needs identified in chapter III and might well improve the data available in regular publications. However, it probably would not meet all the needs of decisionmakers who want timely access to comprehensive, aggregated materials information presented in convenient, easy-to-understand formats.

2. Approach B: Directed, Step-by-Step Upgrading of Existing Information Systems

Approach B, which also makes extensive use of the existing materials information systems, has two characteristics which distinguish it from approach A: (1) oversight authority by a single agency, and (2) a step-by-step development philosophy involving a continuous evolution and reevaluation of ultimate objectives.

In approach B. a specific agency would be given oversight authority for all existing Federal materials information systems. This agency would be charged to understand the operations of all information systems and would be given authority to ensure that the systems supported established government-wide objectives, improving them as required. Various, alternatives for the location of this agency and its authority are discussed in chapter VI. At a minimum, it would have permanent staff, budgets, and authority to access the existing systems, understand their operations, establish plans and budgets for needed improvements, and ensure their implementation. The authority could be increased, depending on the institutional arrangement selected, to cover budget control and organizational control over the existing systems.

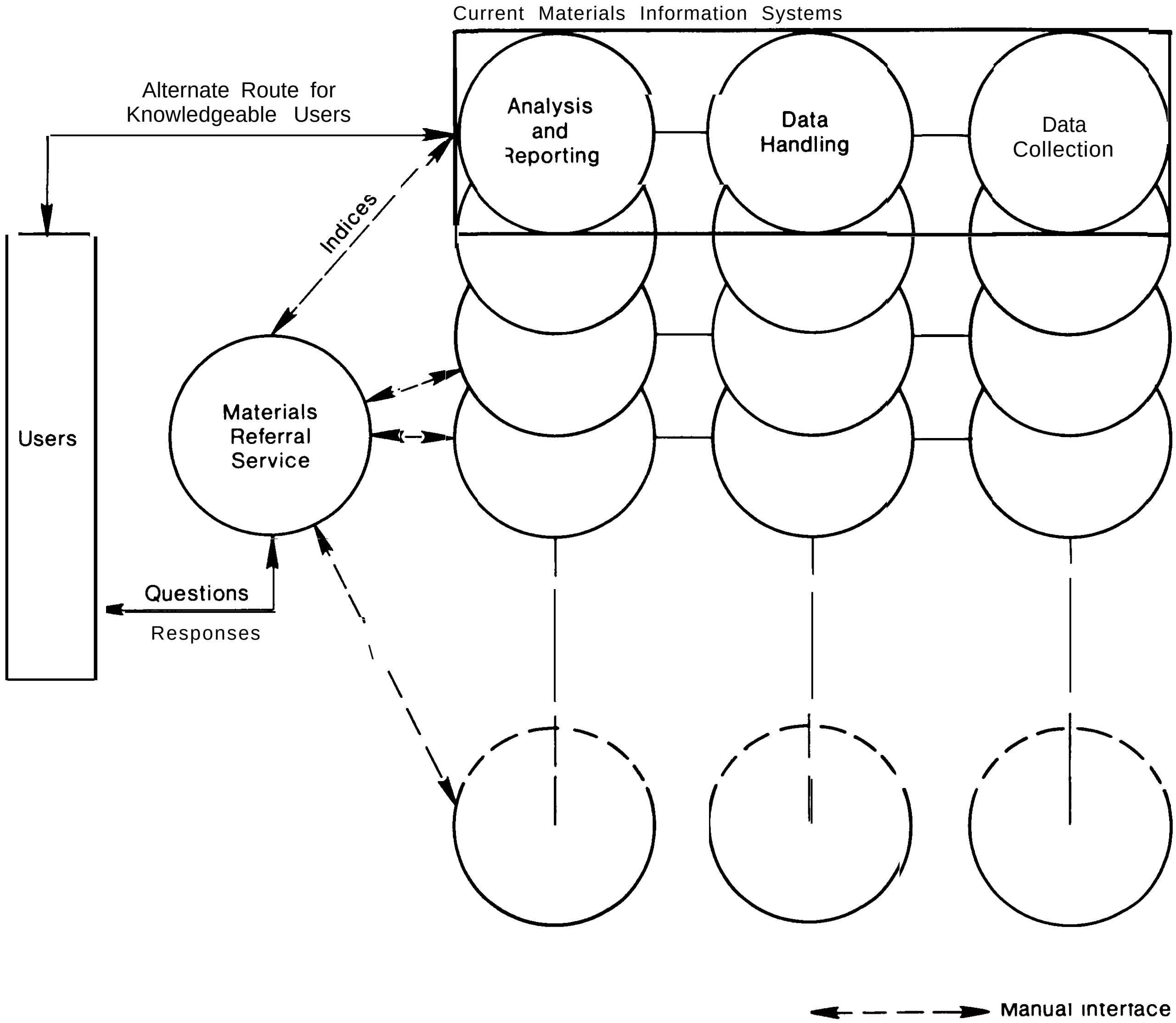
The intent of approach B is to utilize, and upgrade as necessary, the existing information systems to provide the functional requirements. However, the functional requirements do not have to be used initially, and additional functions may be determined in the future. This approach would establish an intermediate set of functional requirements, ensuring that the final set was not precluded in any way. For example, the functional requirements dealing with basic supply and utilization could be initially limited to domestic data, and later expanded to international data as it became more available. The existing systems would be upgraded to handle these requirements in the manner required, but they would be built to allow for expansion to include international data and disaggregated data at lower levels when the data was available. In this manner, the decision to proceed toward implementing the integrated capabilities could be reevaluated in the light of implementation experience, modifying plans based on interactions with the users and reexamining the costs/benefits. Once the immediate functional requirements were identified, their implementation could be accomplished in discrete steps so that tangible, useful support would be given to the users as soon as possible, concurrent with the existing materials information systems services.

Similarity, the basic information services delineated early in this chapter could be implemented in a series of steps, some at the outset and others added later. There is great flexibility in approach B; moreover, the final decisions do not have to be made at the outset, Congress could decide which services it would like to see in the first step; the oversight organization could then implement them, monitor their operations, and recommend services to be provided in the second step. Based on that review, some of the services could be discontinued, and new ones established in the third step, etc.

As an example of how approach B might evolve, a sequential three-step implementation of the basic services is described below, Clearly this is illustrative only, and many variations are possible,

a. Step 1: Materials Referral Service (MRS). Step 1 would establish the oversight

Figure V–1. Approach B, Step I—Materials Referral Service



agency to move existing systems in the direction of realizing the integrated capabilities. This agency would establish (1) the materials referral service to make existing information sources and services visible and accessible, and (2) the materials information exchange service o develop a materials thesaurus. data element dictionary, and master directory for establishing standardization throughout the materials community. The materials referral service (MRS) would be a focal point for developing and retaining information on the existing materials data and analytical services, the key people and organizations involved in the materials field, the kinds of information required, and the spectrum of materials problems being addressed. Figure V-1 is a simplified diagram of this step.

The principal responsibility of the MRS would be to respond to requests for ma terials information. Its initial response would be to direct the user to the individual or organization most likely able to provide the answers or develop the required information. Subsequently, MRS could direct the user to a known

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source of the data or advise him that the data does not exist. For complex requests, there could be more than one individual or organization involved in developing the answers. The MRS analyst would work with the user to structure the request into component parts which could be handled by each separate source selected, In addition, the user's analysis of the results, when obtained, could initiate a new request to MRS to identify an expert to assist in interpreting the results.

In support of this principal responsibility, several major activities could be performed by the MRS. It would:

- Create and maintain files on existing information systems, their data bases and analytical services, and key people involved in the materials community. The output of the activity would be a materials master directory;
- Retrieve and produce results from these secondary files in response to user requests;
- Maintain a controlled set of materials keywords as a standard means of identifying primary sources and individuals. The output of this activity would be a materials thesaurus;
- Develop and compile statistical information concerning the types of questions asked, the most frequently referenced data and individuals, and the adequacies of the results as expressed by the users of the service. This feedback to improve the referrals would also prove useful in determining the requirements for steps 2 and 3; and
- Produce a periodic report to the materials community which would list the information contained in existing information systems. This would result in feedback on new developments, additional capabilities in existing organizations or services, and correction of the existing information. The output of this activity would be a materials catalog which would be the principal means of keeping the MRS reference information files updated.

The main activity of the MRS would be to use the secondary information collected in the materials directory to answer user's questions by directing them to the proper source. For example, the question of how much coal was provided in the continental United States in 1974 might be answered directly from a published report, Using the materials directory, a MRS analyst would direct the user to this report. In many instances, the MRS analyst would have to provide assistance to users to ensure that their questions are processed as intended. For example, if a question on 1974 domestic coal production were asked in January 1975, the MRS analyst would not yet have had the pertinent published report and would have directed the user to consult various periodic reports for each of the States and to add the production figures himself. If the December 1974 report were not published and the figures for that month were available only in a particular office, the MRS analyst would have directed the user to call an individual to obtain them. A record of all requests and questions, whether answered or not, would be kept for use in analyzing MRS responsiveness. If possible, a feedback loop would be established to begin to evaluate whether the user was satisfied. A feedback from the cited references would also be useful to assist in determining whether they could respond adequately.

The MRS would monitor its interactions with users to determine:

- The kinds of questions asked most frequently,
- The staff skills required to obtain satisfactory answers to user queries,
- The types of questions which remained unanswered,
- The specific materials most frequently referenced,
- The distribution of queries across the

user groups (executive, legislative, general public), and

- The existing agencies or facilities with unique competence or superior data sources in various fields relating to materials,

This information would be used to determine primary data needed for the MRS reference files. Once users found the required source of information, they would return directly to that source as needed. However, new users with the same questions would use the MRS. as would past users for new queries.

The MRS might evolve through several stages of automation as its data files grew and the number of users and materials sources increased. First, a manual operation could be used to collect all published indexes to materials data, qualified people, published thesauri, and keyword lists to assist in providing the references needed, Analysts answering telephone inquiries might work mostly from printed reference sources, such as lists. technical publications and reports, and abstracts, but would also draw on their knowledge of the materials field. Each MRS analyst would be responsible for maintaining awareness of publications, existing data, and experts in his area of interest.

A master directory to materials data sources would serve as the principal new reference tool for the MRS. Producing this directory, promulgating its use, and keeping track of its usefulness to MRS users would be a continuing MRS responsibility. The master directory might be developed using off-line batch operations at an established computer center with text processing capabilities. The directory would be published and distributed throughout the materials community for feedback to assist in upgrading existing entries and adding new sources of data and expertise. The master directory would provide the following information:

- The various data sources in existence,
- Their locations.
- The people who maintain them and control access to them.
- How they can be contacted,
- The form in which information derived from these data sources is disseminated.
- The currency of the data.
- The reliability y of the data, and
- Any special analytical functions performed on the data at the particular location.

In compiling this directory, use would be made of the many indexes to data sources already in existence, such as the Federal Energy Administration's index of energy materials. Information already available in existing directories and indexes would be incorporated in the MRS materials directory. Other information would be obtained by new surveys. This compilation of data sources would be followed by an analysis to identify data duplications, omissions. and terminological differences.

It should be noted that duplication of data or data resources is not always undesirable in information systems; it can be used to advantage in maintaining validity and accuracy (through cross-checking) and also in providing alternative access to data.

Following compilation and analysis. the information in the master directory would be formatted to meet the requirements of MRS users, with uniform terminology and cross-references for specific materials (e. g., aluminum), classes of materials (e. g., nonferrous metals), and phases in the materials cycle (e.g., extraction, recycling). Careful control would have to be exercised over any changes to terminology and arrangement: without such control the usefulness of the directory would diminish rapidly. This formatting could be handled manually or with computer support, using time available at an existing computer facility,

The types of activities involved in assembling a master directory also constitute the first phase in the development of a materials thesaurus to establish a uniform vocabulary for the materials community. The usefulness of the thesaurus would be enhanced if the data sources and terminology used by trade associations, private industry, and the universities were reflected in its compilation. The analysts in MRS would consolidate separately published thesauri and keyword lists as a materials thesaurus. This would be published for use in the materials community, with periodic revisions planned.

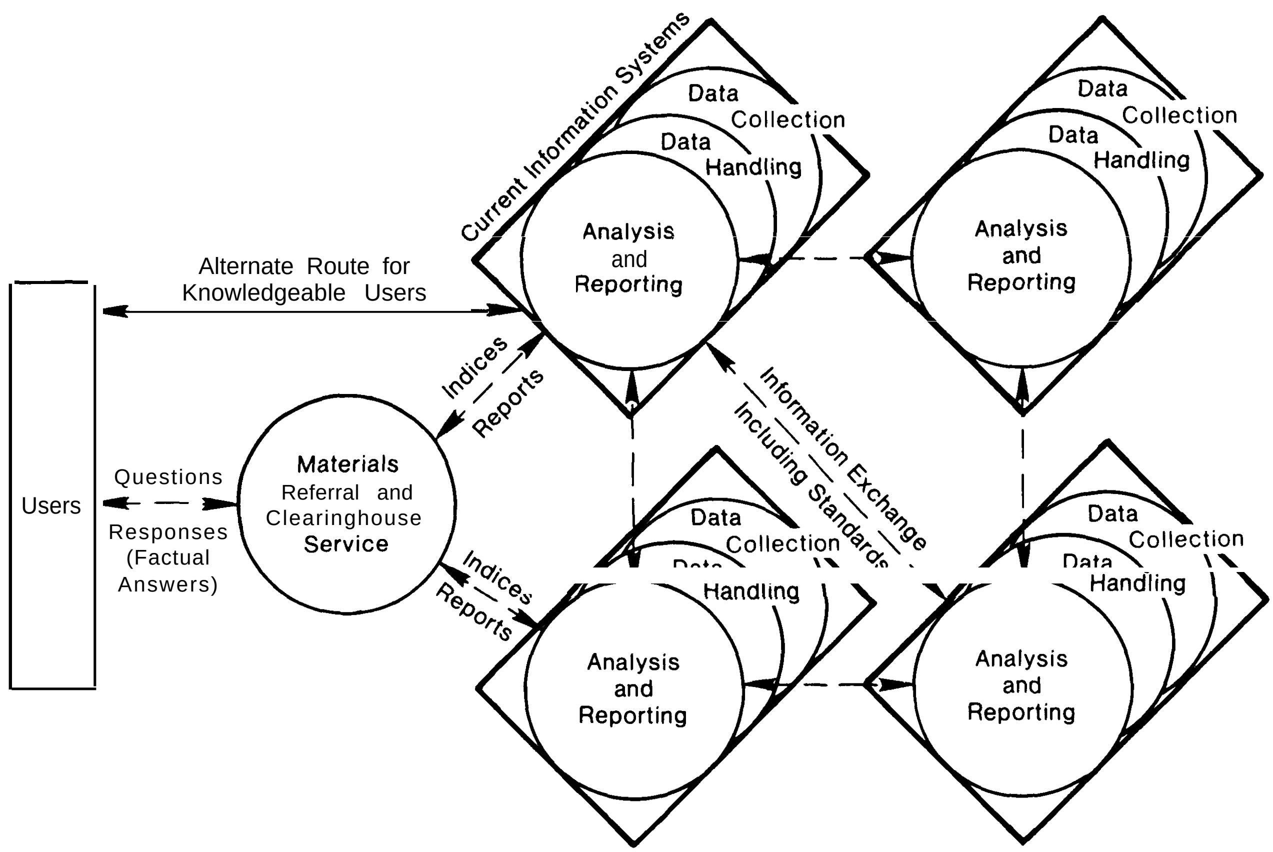
The MRS analysts would then be working from their two major sources, the master directory and the materials thesaurus supported by the MRS internal data on queries and references cited. At this point, after more information on data sources had become available in the MRS and secondary data collection had taken place, it might become necessary to compile a dictionary of primary data elements occurring in the many data bases maintained by the existing institutional agencies. The dictionary would include the names of the data elements, the larger context in which they are used, their format, source, validity, and status. The data element dictionary on the data processing level would be linked to the materials thesaurus on the human level.

As reliance on the MRS grew, it is likely that more complex queries would be asked and more sophisticated responses required. The master directory would be updated with additional references as more critical materials were added to the list to be covered. Updating the indexes and bibliographic references would continue by processing changes and additions to the secondary files at a computer service center. The retrieval of these references and production of responses, however, could then be performed at a video terminal. This would improve response time and allow analysts to browse through the secondary files for more accurate references. The consolidated thesaurus might be available on line to assist in developing more comprehensive searches for the users and in selecting keywords for indexing new material data sources, organizations, and individuals. Statistics on terminology and references would be produced automatically as a byproduct of the terminal sessions, There would still be a requirement, however, to have the users and referenced individuals feed back their evaluation of the query results.

At this stage the computer would likely be filling a major role in the operation of the MRS, relieving the MRS staff of many laborious tasks and allowing them to handle more thorough searches of voluminous files with shorter response time, It is in this stage of development that the MRS would be somewhat different from the referral capabilities available within existing Federal information systems. The current referral services can direct the requester to an organization or an individual who will have data of a generic type, such as for petroleum; it might even be able to tell him that FEA has production statistics on petroleum. However, the MRS would be able to tell the requester that FEA has an automated data base on petroleum called PRS which contains the specific data element such as producer, name, location, amount refined, amount stored, etc. It is this capability that would make the materials referral service so beneficial to all users.

b. Step z: Clearinghouse Service and Materials Information Exchange Service. Step 2 in this illustrative sequence would establish the clearinghouse service to index and abstract needed and unavailable materials information and to provide dissemination capabilities to users. The development of the materials information exchange service would continue. The materials thesaurus, data element dictionary, and master directory would be needed for both the materials referral service and clearinghouse service to identify the sources of materials information, the types of data contained in those sources, and the vocabulary to be used in indexing this information for search and retrieval. A secondary use would be to encourage their adoption throughout the Federal system and the private

Figure V–2. Approach B, Step 2—Clearinghouse and Materials Information Exchange Services



sector to facilitate data exchange and usage. The standardization of data formats and data handling procedures is a formidable and lengthy task; it need not be completed before proceeding to step 3. Figure V–2 is a simplified block diagram of this step.

The clearinghouse service is an extension of the materials referral service. In addition to keeping indexesor references to existing sources of materials information and analytical sources, it would collect, abstract, and index primary materials data in order to be responsive to user requests. The use of this service might be restricted to those reports of interest to policy makers which were not available in other retrievable information systems. For example, there are indications that reports developed in response to one-time requests, serial publications, and R&D reports do not appear in searchable data files or take too long to get there. The clearinghouse service could be designed to address this problem immediately. A knowledgeable staff member could review the report and prepare a special bibliographic record (reference). possibly accompanied by a description or abstract which would serve as a pointer or index to the full results. In this manner, the clearinghouse staff members could attempt to answer simple factual questions by providing the user with data, the abstract or the full publication, acting as the connection between the user and the source. The following activities would be added to those covered under materials referral service:

- An indexing and abstracting activity for materials information not currently covered by available commercial or Government services, and

- The development and maintenance of a materials information dissemination activity,

Another activity of the clearinghouse service would be to keep track of what specific data were located to answer a user's question, These results would aid in determining the appropriate aggregation level for the data being collected.

There are various stages of development or sophistication that the clearinghouse service might attain. Each would offer policy makers varying degrees of responsiveness. In stage 1, the staff could handle the abstracting, indexing, and searching activities using the computer, as in the advanced stage of MRS. It could have computer support in organizing and listing the references, abstracts, and keywords (thesaurus), as well as in searching for and retrieving the correct reference or abstract for display on a video terminal. With the increased volume of references and the addition of abstracts, the computer might be essential to maintain responsiveness. Preparation of the references and abstracts could be a manual operation. Later, an interactive, online indexing and abstracting capability could be added to the the basic retrieval and production function of the MRS. This capability would assist the staff analyst in preparing changes and additions to the secondary files, allowing him to handle a larger volume more efficiently. In addition. the analyst could be able to use the video terminal to gain access to other online materials bibliographic/abstract data bases—such as the National Technical Information Service (NTIS), Defense Documentation Center (DDC), and Smithsonian Scientific Information Exchange (SSIE)-either by subscription or by permission. The analyst could then browse through data bases to see what appropriate information was available for reference purposes. (The National Energy Information Center has access to 30 different energy-related data bases which can be searched by terminal,) In this manner, the clearinghouse analyst would have access to all major reference/abstract sources pertinent to materials. Use of the computer could allow him to search these sources quickly and thoroughly for references in answer to a user's question.

Step 2 might also address the problem of data compatibility among components of the existing information systems. Standardized data attributes and terminology relating to specific classes of materials could be imposed in order to improve data flow and communication among the many organizations collecting, disseminating. and analyzing materials information. This discipline would be imposed by directives by the oversight organization and monitored to ensure compliance. Standardization could involve some or all of the following:

- Data descriptions,
- Data formats,
- Classification designations,
- Data attributes,
- Data collection techniques,
- Technical terminology, and
- Units of measure.

To enhance compatibility, inconsistencies would also have to be resolved with respect to insufficient knowledge of data accuracy and validity, The data elements dictionary and the materials thesaurus (started in step 1) would be the basic instruments for recording the varying data standards within the existing system. Analysis of the uses would yield criteria for determining the appropriate scope of the standardization effort. Once the standards have been established, all agencies responsible for collection, management, analysis, or output of materials information would be required to adhere to them.

Two major considerations apply to such a standardization effort, increasing compatibility while minimizing disruption, Theoretically, one could require that scientists and technicians in the field adopt a new technical vocabulary, as well as new methods of data collecting and reporting. Such an approach, however, would likely be needlessly disruptive. Every effort would be made to resolve ambiguities and inconsistencies through the judicious use of computerized translation or conversion programs. Indeed, just recording the different uses of the same data among the components of existing systems would go a long way toward helping users and managers of materials information.

The standardization effort envisioned would require an implementation plan that would have to cover:

- Information collection.
- Definition and review,
- Development and installation,
- Operations and maintenance.
- Feedback and modification, and
- Audit and control.

A multidisciplined team, preferably including representation from the private sector, might be set up to develop specific procedures and an overall plan and organization to ensure orderly development. Information regarding requirements, current exchange problems, current data flow, and current standards and conventions would have to be collected and analyzed. Priorities would then be set, and an interactive definition and review cycle begun. Organization impacts would be assessed and the necessary organizational support acquired. In a similar undertaking the Canadian Department of Energy, Mines, and Resources began a project to identify sources of geoscience data (i.e., original observations and measurements). Because of the large number of documents involved, their wide physical distribution, and heterogeneous organization and reporting structures, a decentralized, cooperative approach was adopted. Canadian geoscience agencies were asked to voluntarily index documents published or held by each agency, with the results to be incorporated into a computer-based index by the Canada Center for Geoscience Data. Over 40,000 titles from 10 agencies have been indexed in detail and consolidated into the Canadian Index to Geoscience Data, Consistency and vocabulary control are maintained through a thesaurus of over 5,000 geology keywords under direction of a committee of the contributing agencies. After years of work, good coverage now exists for Ontario, Saskatchewan, Quebec, Newfoundland, Yukon, and Northwest Territories. Completion of Federal and Provincial Government documents is expected to take about 4 more years, It should be emphasized that this effort involved only the data for resources.

Many activities normally carried out by the referral and clearinghouse services would derive benefits from the improved compatibility introduced into the information system. The staff could use video or hard-copy terminals to review pertinent sections of the materials thesaurus and data element dictionary (both of which would have been standardized and cross-referenced appropriately), They could also review the master directory, as well as other secondary files created by the referral and clearinghouse services. This, in turn, could provide faster and more comprehensive searches for users. Dissemination of materials information could then be carried out systematically on the basis of user profiles submitted to the MRS specifically for that purpose. Regular (batch) searches could be made on new primary and secondary materials data and the results forwarded to users in hardcopy form.

The enhanced information capabilities of both the referral and clearinghouse services could also enable the staff to produce and update special indexes to its growing data sources. Very likely these indexes would be specifically designed to allow quick answers to frequently asked questions. With the growing emphasis on in-house information processing capability, there might well be an increasing need for information specialists who could perform and direct the indexing and abstracting tasks essential to the whole process of transforming and transferring information. As the volume of incoming materials data increased, the information specialists would implement automatic indexing procedures coupled with automated (batch or online) retrieval. Similar procedures have been implemented in existing systems, but their effectiveness depends greatly on control over vocabulary; improved effectiveness could be achieved through the standardized materials thesaurus. Effectiveness would also depend greatly on the competence of the designers who would approximate complex semantic relationships through very simple data processing techniques. Fortunately, considerable experience has already been gained with retrieval methods of this kind that have been used successfully in systems dealing with scientific and technical information. Furthermore, this simple (essentially unformatted) approach to text retrieval is not incompatible with a natural English language query,

c. **Step 3: Summary Data Base and Statistical Services.** Step 3 in the illustrative sequence would establish the summary data base service. Pertinent data, as identified through experience with users in steps 1 and 2, might be requested from each information system and placed into a centralized data base. The existing systems would have to convert the data to the prescribed format and send it to the oversight organization on a periodic basis to keep it current. Statistical services could be added to supplement the statistics prepared by the existing information systems. As envisioned they would be aimed at providing summary information to the Congress and the public on the status of critical materials. The centralized data base would also be available to support specific analyses by an authorized user, Congress, the executive branch, and the public.

Having established the materials referral service, expanded it to include a clearinghouse service, and introduced a level of standardization procedures, the existing services might then be further augmented through aggregation of data and additional data processing support. Major attention in this third step is seen to be centered on access to analytical tools. Whereas the efforts of steps 1 and 2 would have concentrated on identifying and analyzing data sources, step 3 would provide a summary data base comprising the inventory and economics data on the most frequently referenced critical materials. With this summary data, users could apply their own analytical capabilities to study the effects of policy alternatives. The summary data base would be built from data currently available within existing information systems, Having established data compatibility, chances of misuse or misrepresentation of data collected for the summary data base would be reduced, and new opportunities for effective interagency data exchange would be created. Improved data processing support would allow users to take full advantage of these opportunities, Figure V–3 is a simplified diagram of this step,

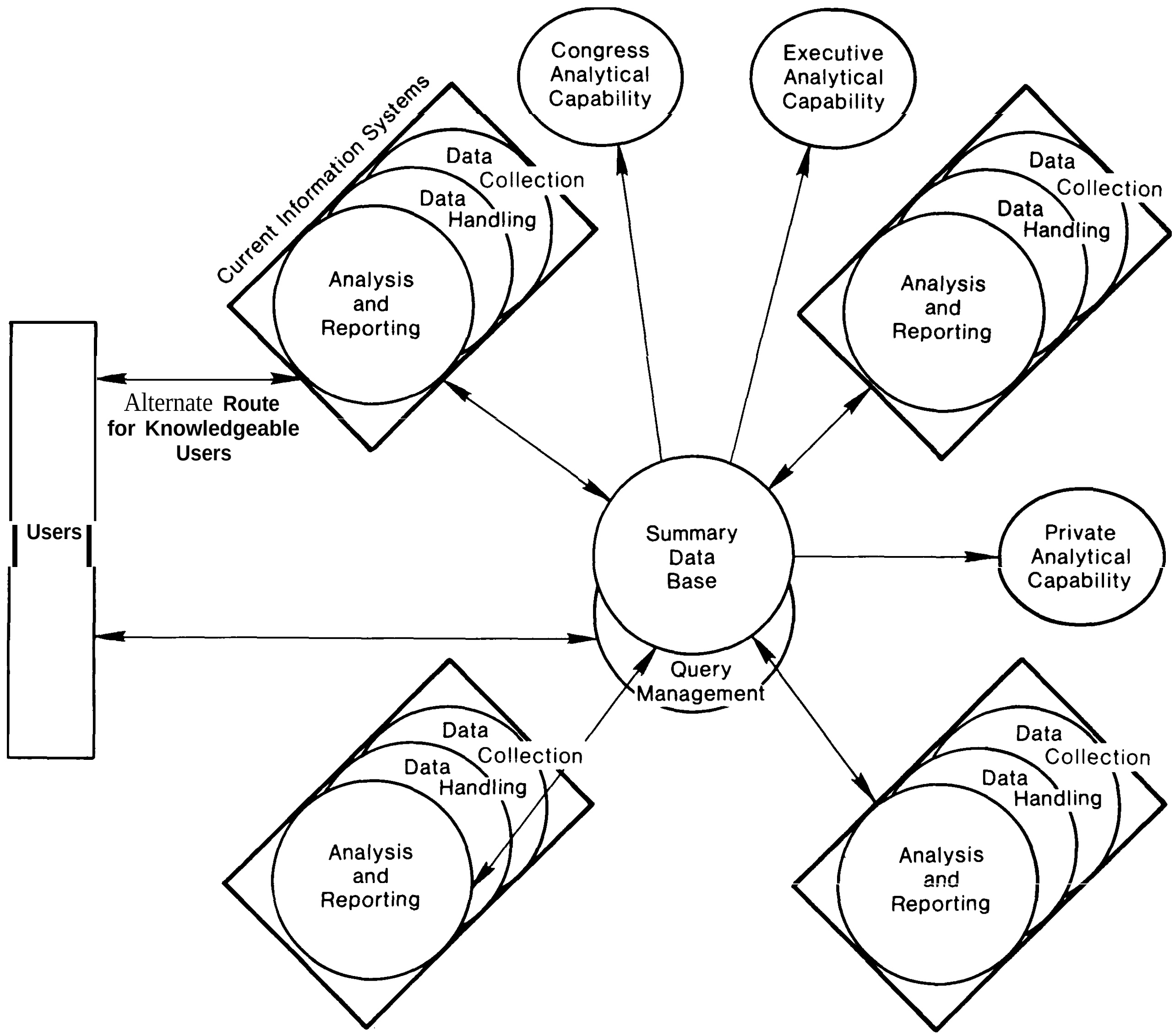
The materials referral service and clearinghouse service described in steps 1 and 2 would be expanded to provide a full query management service. The summary data bank and the secondary indexes would be available for analytical use by executive, congressional, or private organizations. Alternatively, an analytical capability, in the form of support tools such as statistical analysis packages, might be developed as part of the center's own organization.

Step 3 thus provides for the following additional services:

- Query management service,
- Summary data-base service,
- Statistical services and optional modeling services, and
- Data processing support services,

The query management service would be an extension of the clearinghouse service to enable it to handle complex user requests for the

Figure V–3. Approach B, Step &Summary Data Base and Statistical Services



summary data base service and statistical service. A staff of specialists knowledgeable in economics and materials-related areas would be needed to assist the staff information analysts in analyzing and answering user requests.

Based on the experience gained in monitoring the operation of steps **1** and 2, the oversight organization, having overall responsibility for accomplishing the upgrading of existing systems, would know the most frequently asked questions, referenced sources, levels of data aggregation, other user requirements, and user satisfaction with the referenced sources. Were a decision made to proceed to step 3. the oversight organization could then use this information to structure the summary data base that would be operated under its control, Participating institutions would be directed to send specified data in specified formats for inclusion in this data base. They would also be charged to periodically update the data by forwarding changes. As the illustrative evolution of approach 2 is here envisioned, this should not be a significant burden on the agencies since they would have information management systems with the capability to produce special files. If they did not, a program would have to be developed to accomplish the conversion.

The summary data base is not intended to hold detailed data. Provisions would have to be made to prevent it from growing too large. Explicit purging provisions could be established to ensure that obsolete or unused data were removed from the data base. In fact, the design of this summary data base would involve a trade-off between too much data at the summary level and too many accesses to the detailed data bases. Since no practical summary data base could contain all the data that a policy maker might need, continued access to the existing individual Federal information systems would still be required.

In terms of the staffing required to operate the illustrative summary data base and statistical services, commodity specialists, subject matter analysts, economists, and information analysts would work together to produce both periodic and special reports requested by users. Query management specialists would work with these specialists to develop the form of the report, the resources required, and the schedule for completion, Depending on the user, there might be a fee for these services. If existing procedures or models were available within the existing information systems to perform the required processing in support of the analysis, then the analyst would schedule the processing. He would check to see whether the correct data were available for the run. If it were not, he would obtain the needed data from the summary data base or the existing information source, whichever was appropriate, and forward it to the organization that had the model. This transfer of data would be accomplished via hard copy or computer media (magnetic tape, card deck). If new procedures or models were needed, the analyst would see what resources were needed to develop these items. He might then schedule this activity through direct contact with either the private sector or Government institutions. It is also possible that standard, available statistical packages or modeling languages would allow the MRS analyst to develop the tool himself and then process the appropriate data.

The data processing services, to support these activities, would involve the operation and maintenance of all digital computing equipment, keyboarding devices, terminals, and other media devices (microfiche, transmission equipment, graphics equipment) needed to support the other services described. This responsibility would include the following software used by the analysts and programmers:

. Operating system,

. Data base system,

. Data communications system,

. High-level programming languages,

. Utility support package,

. Scientific and statistical support packages,

. Modeling languages (optional),

. Materials and economic models (optional),

. Text processing system, and

. Online interactive terminal languages.

Detailed statistics would be obtained for all activities. Gathering these statistics would likely require little additional effort by the staff since the data would be generated and collected as a byproduct of the various processing activities and stored as part of the summary data base, Management could then view specific items by request. Exceptional and unusual activities in any part of the system would be noted and reported immediately to the data and/or security manager, The routines used for materials data analysis would also be used to support internal management and security.

In summary, the enhanced services accomplished through approach B would provide several benefits for users and participating agencies:

- Existing agencies would find it easier to obtain needed data from other agencies using the new services to facilitate the exchange.
- Users in Congress and the private sector would have their questions answered more promptly and would have broader control over the form in which the answers were presented. For example, it would be feasible to rapidly generate plots of data developed through the use of analytical models. Such plots or graphs could be transmitted in hard-copy form to the user. This offers more than just another way of viewing results; it constitutes an opportunity to reduce significantly the physical bulk of responses offered to policy makers. Rather than merely produce large volumes of data. the new capability would provide information (in the form of trends, extreme-value reports, summaries, graphic comparisons, etc.).
- The improved information services would make it possible to alert users immediately to the existence of new data and information through an expanded information dissemination service.
- In processing queries, the referral staff would be able to engage in a dialog with both the user (via telephone) and the center's data bases (via computer and online terminal). Responses obtained from the online system could be verified or alternatives discussed while the user was still on the telephone,
- In some cases, it might be able to process an entire complex query in-house, This could include running a simulation of one or more analytical models on aggregated data available in the central data base.
- Many of the standard analytical tools would be available within the center, However, analytical capability would remain in the agencies, with a small group of experts also at the center. The agencies would honor requests for aggregated data from the oversight organization by transmitting the data to the summary data base in magnetic or punched-card form. In this way, the center would be able to serve as a data storage and analysis center for the most critical materials data in aggregated form. Since it would not normally carry out any primary data collection activities, it would rely on the agencies to supply current and valid data,
- The center would provide query management capability, including the capability to assess bibliographic and abstract data available in agencies' data bases. Information specialists working from video terminals could accomplish this by first determining what data would be needed for a particular problem, then querying the data directory to determine the 1ocation of the desired data, and finally obtaining access to the data itself via a telephone or correspondence, depending on its urgency,
- The MRS could handle "what if" type queries. These queries might explore the impact of proposed legislative or executive actions in particular aspects of materials management. This would normally require selection and use of a suitable simulation model (by the agency that maintained the particular model). The center staff would play a role in selecting the appropriate model, making the user aware of its assumptions, and interpreting the results for him. (Alternatively. the center could suggest to the user one or more experts who could assist him in interpreting the results.) Depending on how it might be implemented, the output resulting from the simulation exercise might not be forwarded to the user at all; instead, the center staff could act as interpreters of the technical data for the users they serve, Operating in this manner, the center staff would assume

responsibility for determining the user's intent, processing whatever questions were implicit in his intent, coordinating the results, and communicating the final answers to the users,

3. Approach C: New Information System

Approach C is based on the development of a new materials information system designed and built from the top-down. The design would begin with a set of carefully defined requirements, the results of a design requirements study, and would be based on use of up-to-date technology. The desired integrated capabilities would be realized without undue regard to existing information systems. The existing information systems would influence the implementation planning in that parallel operation and phaseover of capabilities would have to be addressed, but the new program development plan would be largely free from the constraints of existing operating systems.

It should be emphasized that the new "system" implied by approach C does not imply total centralization of data and processing functions. Rather, what is envisioned is a distributed system operating in the various agencies as well as in a newly established information center. However, the authority for directing this approach would be legislated or assigned by executive order to an existing or new authority. This authority would provide greater control over the existing institutional materials information systems than in approaches A and B. Accordingly, this approach represents a more significant break with the past and, as such, implies greater changes to current activities and larger initial outlay of funds. The base requirements of this approach would be accomplished at the price of one-time development costs and possible disruption to ongoing activities during phaseover.

Rarely does the opportunity arise to exercise hindsight in system design. Since this approach, in effect, is to "start over, " it provides just that opportunity and should be evaluated as a candidate option for achieving the improved capabilities. As presented here, approach C would likely take longer to implement than the other approaches, However, should short-range capabilities be needed, there is a measure of flexibility in the approach to attain results earlier.

a. Approach C Development. Approach C would involve four steps:

- Step I—Define the program plans, controls, and measurement functions and organization with which to manage the system's orderly development and implementation. The organization would manage the numerous project tasks and provide continuity throughout the project life cycle. It would provide a central control to ensure that the enhanced array of information services being developed would:

  —Support the legislated mission;
  —Be flexible enough to respond to impacts of external sources and events;
  —Maintain data security, integrity, and timeliness;
  —Maintain uniform data base and coding structures, compatible software systems and telecommunications; and
  —Be within the resource and cost limitations imposed,

  The organization would assume responsibilities for overall thesaurus control and would examine the applicability of existing thesauri for this purpose.

- Step 2—With the information plans, controls, and measurements organization in place, the detailed requirements for the integrated facilities would be defined, based on the studies completed to date and a detailed survey of all users. When the required output and processes to achieve it were specified, an inventory of data sources would be prepared to determine what data were usable and what new data must be collected to support the data base. The data requirements specified during this activity would be used to begin collecting pertinent data while the "system" development process continued.

- Step 3—The requirements definition would be used to develop design and performance requirements. Hardware and soft ware, including a complete data management system, would be selected and procured based on the requirements and system design, Trade-offs would be analyzed to determine the plan for implementation of the design, such as where to start and how to phase over. Factors such as cost and disruption would be weighed against the need for function in deriving this plan. Part of this planning would involve analyzing requirements against off-the-shelf software products such as data base/data communications software,
- Step 4—After hardware and software components were selected, the initial applications could be developed and tested, and the operation could begin, Parallel with this activity, staffing would begin and training, procedures, and operations would be developed. In initial and subsequent application developments. current data bases would be examined to determine applicability to the new system environment.

Implementation of the integrated capabilities would be accomplished in phases, determined by priorities in the plan developed by the control group established in step 1. Therefore, step 4 might be repeated several times. Similarly, perhaps less frequently, steps 2 and 3 might also have to be repeated. The implementation plan would thus have to be flexible enough to respond to unforeseen circumstances during the development cycle, such as the requirements changing as major changes occurred in the system's intended operating environment. The planning group would have to control the project and maintain measurements and audits throughout the development cycle, so that change could be accommodated and with minimum impact on schedule.

As the evolution of approach C might be accomplished, the need to attain short-range results might take the form of installing an MRS (as described in approach B) between steps 1 and 2 of this approach. at the point where thesaurus and data inventories were identified. A variation of this approach might be directed at implementation of all of the integrated capabilities for a single material, instead of all or even one class of materials. Experience gained from providing support for the one material could then be applied to adding coverage for the additional materials. This procedure would be less disruptive and less costly, as the reiterations would be simpler to accomplish for one material. Still another variation might result in the establishment of an analysis group quite early in the development cycle. This group could begin to correlate supply and demand data by using whatever data were available for rough estimates. Their experiences could then be incorporated into the orderly planning cycle. Approach C provides great flexibility in building the new information services on a "learn and go" basis.

b. The Changing Relationship of User Needs and Capabilities. Approach C would provide a complete, detailed distributed data base to meet user needs. If a data item were needed, the data would be made available either from a reliable source or by assigning a qualified organization to collect it,. Analytical functional requirements not already available would either be developed as needed, Procedures to new functional requirements that may be only imperfectly specified now would be provided; for example, ways to accommodate information on materials selection (See appendix A,)

Any information "system" is of course designed and implemented to attain a definite set of goals, and after some period of operation it is frequently found to be deficient for new objectives, This same pitfall awaits the "system" that might evolve from this approach; care must be taken to avoid it, One tactic is to devote a large portion of the total design effort to the definition of functional requirements. While experience shows that this increased emphasis is desirable, it will not necessarily avoid all the pitfalls, The fact is that functional and performance requirements change over time. It is probable, therefore, that significant changes will have taken place between the time of the requirements definition and the time the system processes its first data.

What is needed, then, is an adaptive approach which will enable users to respond to change. The degree to which such an approach may be realized has bearing on the weight to be placed on the costs and disruption incurred in developing it. If a one-time cost and a one-time disruption can eliminate future repetitive expenditures and disruptions of operations, then they may well be justified. A "system" designed to recognize the requirement for change and to enhance the ability of incorporating new functions to meet change has certain characteristics which differentiate it from other systems. Such an adaptive system may be considered as having two components—a data processing component and an evolution component (see figure V–4). The data processing component would offer standard production data processing to its user; the user would make a request for processing and receive results. This data processing component would be preconditioned for the requests based on the requirements definition. A discussion of the kind of structure currently envisioned for this component is presented in the next section. The other evolution component would be totally committed to increasing the responsiveness of the system to change and crises. The work performed by the evolution component can be grouped as follows:

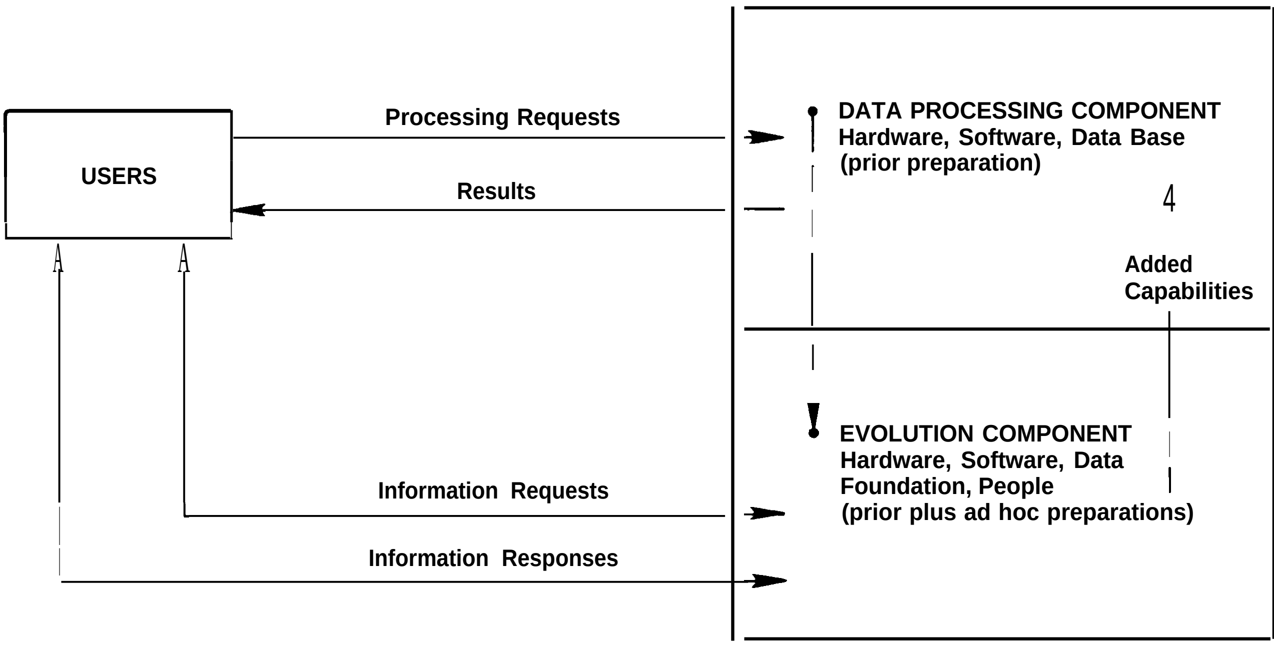
- Formal Semantic Dictionaries.—Within the evolution components, dictionaries would be compiled and maintained containing definitions of terms and concepts appropriate to the new system and its community of users.
- Information Clearinghouse,—The system would serve as a clearinghouse for exchange of information about itself.
- Program and Data Archives.—In addition to program documentation, programs would be collected and stored in libraries by the system.
- Readiness Management.—Efforts would be made to ensure that the permanently assigned staff is ready when a new requirement emerges.

c. Concept of Operation. In approach C, an information center would be used as the primary interface for policy makers seeking information. The materials information center would contain data, analytical tools, and resources sufficient to respond directly to many of the requests of policy makers. In addition, the information center would function as its own referral service to enable it to gather information from other points within the system or to levy new requirements where appropriate.

The other points in the system would be the existing institutions and agencies which currently process materials information. Their missions would not necessarily change, but might be realigned to avoid duplication or expanded to implement new functions, Existing institutions would continue to collect data and process it in support of their own missions. They would have the added responsibility of responding to requirements levied by the information center; in turn, they would benefit by being able to make use of the center and its capabilities,

The imposition of compatible information systems would offer a high degree of physical and logical data interchangeability. Data files could be moved from one location to another, and data access for one location could be triggered by another. This would facilitate data communication for access to and correlation of data from multiple stores across different agencies. Note that the capability for interchange would greatly increase the need for

Figure V-4. Adaptive System



adequate data security controls. Before such standards were imposed. the increased costs that would arise if agencies either replaced their current systems or made parts of them compatible with the new system would have to be carefully considered.

There is an opportunity when developing a new "system" to establish standardization among all operating locations. Since these operating locations have separate missions and are primarily responsible for supporting separate organizations. there will likely be a tendency over several years for redundancy, inconsistency, and ambiguity to creep in. Data redundancy—practically unavoidable and sometimes beneficial-could cause problems in updating. If redundant data are all updated whenever a single data item is updated. a penalty must be paid in performance. More important, there is normally a lack of awareness of the existence of the redundant data. During the updating process, the new system should be capable of managing redundant data so that an update transaction to one data item will trigger subsequent updates of redundant data wherever it exists within the system. This is a large task, but one which could be accomplished by careful file structuring or by periodically scheduled batch updating.

Inconsistency presents a similar situation as redundancy except that here actual stored values at different locations differ. One method of dealing with this problem would be to bring apparent inconsistencies to the attention of the information center to be resolved as appropriate. Ambiguity is the most significant obstacle to direct data interchange (machine -to-machine). Different meanings for like-named data elements are prevalent and difficult to discover in existing data bases. In addition to format, the meaning of the data must be understood by the particular organization in order to effectively process its data, but the meaning is not always apparent to outside organizations. those not possessing a day-to-day working knowledge of the data. The semantics of the data differ among data bases, programs, and personnel at various locations. Combining these factors would be essential to obtaining interpreted and correct results.

When the information center had determined that the information required to respond to a query existed within the system but in several different locations, it would consider a search strategy to gather the data. Normally, with any complex search involving multiple data bases there would be multiple paths which could be followed to get to desired data. Selection of a search strategy is defined as the choice of a path by the human information specialist, using the computer to assist but not to make the selection, Multiplicity of paths and the strategy options which result occur primarily because of redundancy. Redundant data permits correlation from different data bases. It offers the "glue" by which records are attached to other records, to extend the scope of linked data across data bases. Therefore, although redundancy creates problems for updating, it permits increased search capability,

As envisioned, the tactics of information searching would be the responsibility of the individual operating agencies themselves. That is, once the search strategy had been chosen by the information center, the involved organizations would be asked to conduct the searches. This approach offers advantages over that of direct access to the data to overcome ambiguity problems. Reliance on the personnel in those organizations using their own programs to search their data bases would likely yield more accurate and better interpreted results. Some searching might be done in parallel. The information center could initiate operations at multiple locations at one time. It might also be necessary, in some cases, to retrieve data from one organization's data base prior to directing that a search be performed at another location in another organization's data base.

The concept envisioned here would thus be a network operation in which large files would not be transferred across communications lines and direct searching in another organization's data base would be avoided. Rather, emphasis would be on individual agencies performing searches as requested. Output available to the information center, would be of low volume since the data would have been analyzed, evaluated, and interpreted by the agency's personnel. Conversational interaction of the decisionmaker and the information processing system is seen to be a key feature of approach C.

d. Information Center Functional Components. The information center is envisioned to encompass the following services:

- Query management,
- Materials analysis management,
- Data base management,
- Data collection management, and
- Clearinghouse and referral management.

The center would have a capability for infrequent ad hoc queries. Routing and periodic reports could be planned, controlled, or produced as needed. This is one aspect of query management. Short response time for immediate action queries, however, represents another requirement for this system, Whenever possible, the query specialists would have direct access to data and /or knowledge. This data would be dynamically maintained in response to changing situations. If unable to respond using the information center, the query specialist would be able to establish a task force of experts, using the online indexes to find and contact the right people and data to respond to the query or world situation.

In addition to using existing models, improved models to forecast supply and demand of various materials classes and to compute first and second order effects of alternative materials policies would be developed. A complete statistical, analytical, online system capability would be available for use by the analysts to verify the data collected, analyze the trends, support the periodic reports, and respond to the ad hoc queries, It is not anticipated that the analytical and forecasting services provided by the center would necessarily obviate the need for similar capabilities in major departments or agencies, Congress, or the private sector. The existence of independent analytical capabilities supporting decisionmakers in all such groups but drawing data and seeking the assistance from the center would be quite compatible with this approach.

The information center would contain its own data management function which would be used to define, create, maintain, modify, and retrieve data from data bases. Data can be lost, stolen, altered, distorted, and destroyed, The particular data to be maintained at the information center, as opposed to that held by other agencies, would initially be determined in the requirements analysis and would be constantly altered as needs evolved during operation. Its management must be planned, budgeted, and controlled to ensure the availability, integrity, and security of the data to both the sources and users,

The data collection requirements for the information center would be determined by the extensive study that would precede the design and development of the information "system". The means of collecting data are many-questionnaires, surveys, forms. machine-readable data, (cards, tape, etc.), and online interactive questions and answers. Similarly, the data can be formatted many ways. How this mass of data is collected, validated, and entered into the data bases would be determined in coordination with the data base manager. Data collection would be done by professionals and monitored by statistical validation programs to check the data and to normalize statistical samples.

The clearinghouse and referral management function would provide the following services:

- Development, publication, and maintenance of a materials thesaurus:
- Indexing and abstracting service for all materials information;
- Development and maintenance of a materials information dissemination and publication service; and
- Creation and maintenance of directories of experts and organizations in the many categories in the materials world.

In its full operation the information center would have to address problems of consolidation, summarization, and aggregation of data; many of these could be in detail after the basic information system was operational. In this way these more advanced information processing capabilities could be defined based on actual experience with the information center.

D. COST ESTIMATES

In assessing costs, the way in which the integrated capabilities are achieved is very important. The feasible combinations and permutations within each systems approach as well as within combinations of these approaches (such as A and B) are quite numerous, For example. an information system which applies the basic functions only to timber (forest products/paper class of materials) is easier to implement, less costly. and can be done faster than an information system which applies the same functions to the entire nonfuel minerals class of materials. The former involves principally one material, one institution, one already automated information system and one principal location: the latter involves many institutions (BOM, USGS, BLM. OMPD, Bureau of Census. DIBA, ERDA, GSA), and many manual and partially automated information systems with differing capabilities,

The number of users and the specific purposes served by an information system must also be considered. An information system that collects supply and utilization data to build a comprehensive, current data base to be used for monitoring and identifying potential materials shortages (early warning) is simpler and less expensive than one that collects the same data for use for both early warning and assistance to design engineering, The former might need materials inventory and economic data aggregated only to the regional level.

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whereas the latter might also require detailed materials properties data. An information service with simple statistical support capabilities based on extrapolation of past historical data and summaries is simpler and less costly than one with sophisticated modeling and forecasting support capabilities. The former involves standard programs that are available off-the-shelf and operate on the types of data in current materials data bases; the latter requires developing complicated programs which operate on the types of data in the current materials data bases and on many other exogenous factors, thus requiring additional data collection. As a final example of the influence of the scope of capabilities on cost, an information system that produces such periodic output as summaries and statistical trends on particular materials and that sometimes provides aggregated information upon request is simpler and less expensive than one that performs complicated policy analysis and impact assessments for policy makers.

Cost is also impacted by the implementation time schedule and by any acceleration or deceleration to support changing national, institutional, or materials priorities.

The estimates provided here indicate, to a general degree, the costs of resources in terms of manpower and automation requirements to develop and operate the facilities required. As indicated above, the estimates depend on many variables whose values cannot now be specified. Notwithstanding these recognized limitations, the estimates are useful in developing an appreciation of the relative investments that might be required for the three approaches. Quite clearly, the cost estimates should not be used for any other purpose.

There are four types of costs involved with each of the three approaches:

- Costs for data collection and validation for the selected materials,
- One-time, nonrecurring development costs consisting of personnel to perform requirements definition, design, development, and implementation. These costs include those efforts associated with new services as well as improvements to existing systems.
- Automation costs consisting of purchase and/or lease of necessary facilities to provide computer support, communications support, and special equipment such as plotters, displays, etc. The Government can either purchase these facilities at the outset and amortize the costs over some time period, or lease the facilities and pay the costs on an annual basis or utilize existing facilities by sharing the usage and costs. For purposes of this comparison, these costs will be considered recurring on an annual basis.
- Operational costs consisting of personnel for management and administration, operations, and information system support such as librarians, information system analysts, subject matter specialists, computer operators, programmers, and statisticians, These costs are recurring in that they will be needed for each year of operation. They include those efforts associated with operating the new information services as well as operating the existing information systems.

The cost estimates were based on the following assumptions:

- Man-year cost estimated at $40,000 per year to include salary, benefits, and overhead (facilities, space, supplies, travel, etc.);
- Computer time estimated at $400 per hour;
- Fees from use by private organizations would partially offset recurring costs. However, since such use was not examined during the study, no estimate of these potential revenues is included;
- No inflation factor included; and

- Only the incremental costs, over and above currently planned budgets, have been considered.

With these assumptions, the annual costs, averaged over 5 years, are on the order of:

	Millions of Dollars
Data collection and validation:	
For 5 materials	2
For 50 materials	20
Development, Automation, and Operation:	
Approach A	2
Approach B	17
Approach C	19

As noted, these cost estimates are considered to be rough at best because of the uncertainty in many of the numerous variables. It is conceivable that the estimates could be off perhaps by as much as an order of magnitude (factor of 10), For realistic situations, the estimates are expected to be accurate within a factor of about 5. It is expected that the relative cost ordering of the approaches would remain the same. Approach C appears to contain the greatest potential for cost escalation. The difference between approaches B and C are negligible considering the accuracy involved in the estimates, Approach C is very close to approach B because it was assumed that a high utilization of existing systems would be possible.

The elements of these cost estimates are described in the following subsections.

1. Data Collection Costs

Approaches A and B are premised on the assumption that the existing information systems (including planned improvements underway) form the basis for the required integrated capabilities. Approach C also will use data collected by the existing information systems, although the degree of utilization of existing information systems cannot be accurately estimated at this time. It is this factor that gives approach C the greatest risk for cost escalation, If the existing information systems are not used to any great extent (for example, if new automated support is required to replace existing support), then the collection costs could be greater than discussed here. Maximum usage of existing systems has been assumed. Existing deficiencies which would have to be addressed, such as lack of needed functions or incomplete functions, would be corrected within the existing information systems. Estimation of these costs is tenuous at best because of the difficulty of establishing the incremental cost increases to existing budgets. However, it is likely that the largest part involved will be those associated with completing the collection and validation of the detailed data for the required materials, Assuming that these required materials will be primarily from mineral fuels and nonfuel minerals classes, and that they may number no more than 50 or 60 in total (including both critical and potentially critical), then an estimate of costs can be based on plans of the Minerals Availability System (MAS) of the Bureau of Mines. The 5-year plan of the Bureau of Mines envisions an increase of MAS coverage to 35 minerals at an estimated cost of $29 million, mostly in personnel. It is thus reasonable to conclude that implementing a more aggressive plan to complete the data collection for about 50 to 60 materials might increase this cost to well over $50 million during the 5-year plan period.

Other costs associated with this activity, such as automation support and communications equipment, should be considerably lower since the basic systems already exist. Extending the coverage to more minerals would not necessarily cause a linear increase for each additional mineral, since these support facilities will already exist for the 35 minerals, Some cost increase is likely, however. due to the larger volume of information to be handled, This increase might be on the order of $1 million for additional storage; substantiation of this cost is the Bureau of Labor Statistics cost of $1.2 million for improving one data item, the price of imports/exports.

The Bureau of Census has allotted in the 1977 budget $3.7 million to prepare for taking, compiling, and publishing the censuses of business, transportation, manufacturers, and mineral industries. The budget for both preparation and conduct of the economic census in 1972 over 3 years was $24 million. Applying these cost yardsticks to the other institutions involved (Bureau of Census, Federal Energy Administration, etc.) for 50 materials might yield an average data collection cost increment over 5 years on the order of $2o million to bring the needed data to the point that it was complete and validated. For five materials we have assumed that these costs are assumed to vary proportionally, i.e., $2 million, Some experts believe, however, that a $4 to $5 million estimate is more realistic.

These data collection costs are applicable to all three approaches. The development, automat ion, and operation costs, however, vary with each approach.

2. Approach A: Development, Automation, and Operation Costs

While the major cost increment in this approach would be for the data collection previously discussed, the increased demand by users to process this data, coupled with increased requirements for processing and analysis support to provide improved services from existing referral and clearinghouse capabilities would increase the development costs of the agencies. These increased costs are estimated to be on the order of $2 million annually over the 5-year period. The operational cost increases are particularly difficult to assess since the present personnel may be able to handle all or a portion of the additional workload of new tasks. In the absence of better information, this assumption was made here; no additional cost for operations is included.

In summary, approach A would involve additional annual costs, over the 5-year plan, on the order of $2 million to $2o million to complete the collection and validation of needed data, and added annual development costs on the order of $2 million. These estimates are based on the assumption that the existing information systems are used and the additional operating costs of new services are absorbed within existing agency manpower budgets,

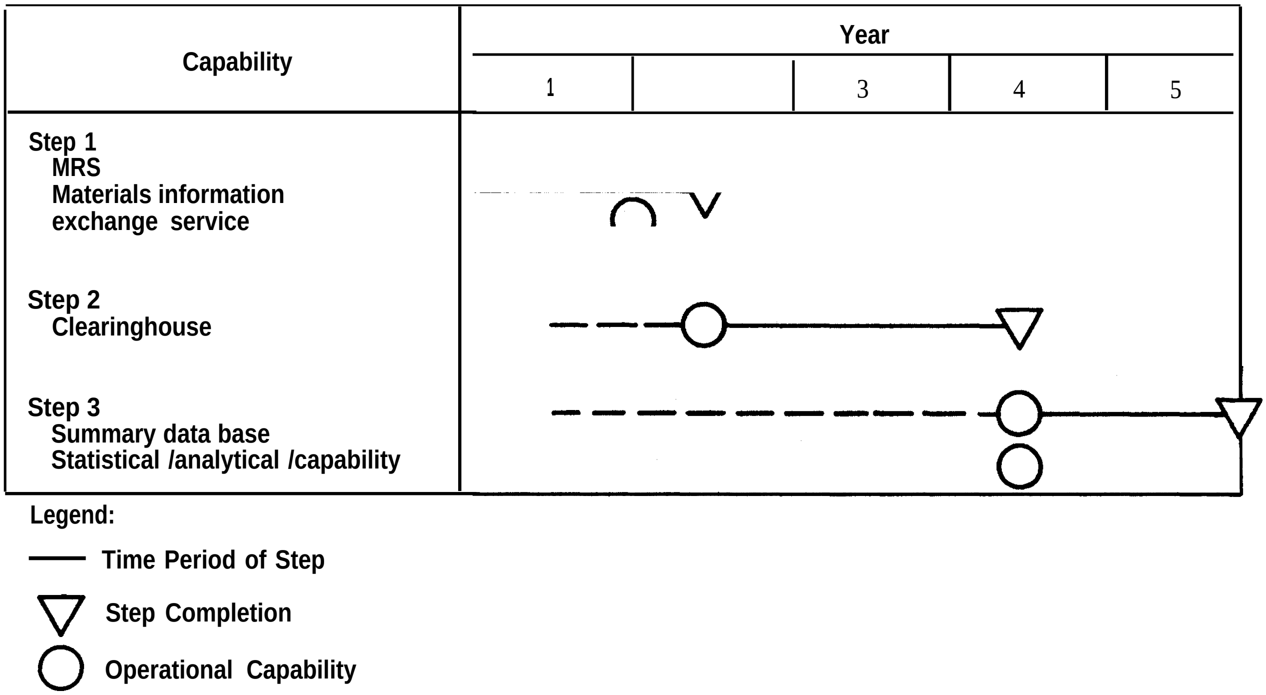
3. Approach B: Development, Automation, and Operation Costs

Cost estimates for this approach are dependent to a great extent on detailed decisions that must precede each step. It is impractical to postulate a 5-year plan posing costs for each possible alternative. The illustrative 5-year plan projected in table V–5 assumes that the evolution of approach B will begin with the materials referral service (MRS) and proceed to full statistical/analytical operations on materials information supplied by the existing agencies and placed in a summary data base.

For step 1, personnel costs are the major element. The numbers of people involved will vary during the step; however, implementation of this approach assumes an evolution of the MRS to provide continually increasing capabilities. For this reason, the costs of this step are shown for an 18-month plan.

The function of the MRS is to refer requesters to data sources. As such, the MRS staff would comprise primarily librarians and indexing specialists. However, the MRS would need broader knowledge of materials information to develop the basic data required for upgrading or evolving to steps 2 and 3, creating the need for information analysts and subject matter specialists. The initial task of the MRS during the first 6 months is envisioned to identification of the reference materials required and creation of the indexes to those materials. Having accomplished this, the MRS staff would then be supplemented with the information specialists and additional subject matter specialists to be operational during the last 6 months. Additional clerical/administrative support would also be required at this time in order to start compilation activities in preparation for step 2, Computer costs for the MRS

Table V-5.—Approach B Development Schedule



during this early phase of the approach are seen to be negligible because it is assumed that automated support, including online computer support, would be provided by the existing agencies.

For step 2, at the end of 18 months, an initial clearinghouse capability would be operational; support provided in addition to expansion of the MRS function would include indexing and abstracting plus the completion of a materials thesaurus, master directory, and data element dictionary. Feedback and utilization statistics would be accumulated to provide a basis for systems improvements. In addition to skills already established in step 1, commodity specialists, information systems analysts. systems and applications programmers and computer operations personnel would be added to the staff. An in-house computer might be requi red to provide the requisite support.

In step 3, the requirements for summary data bases would be established and implemented in such a manner as to provide an initial operational capability for selected materials within a 3.5 year time frame of the 5-year plan. It should be noted that the time period and resources to develop this capability would be significantly less than those required in approach 3. Considerable experience would have been obtained from the MRS and clearinghouse development. and information provided would, to a great extent, be prepared by the agencies. In addition, service would be limited in this approach to those questions which can be measured with the analytical capabilities available within the expanded MRS. Requests for data outside the purview of the MRS would be referred to the appropriate agency. New skills required to support this function would include subject matter specialists, systems engineers, data base/data communications experts, increased programming and computer operations staff and, in particular, experts in the fields of materials modeling, statistics, and analysis. Computer utilization would be expected to increase during this period to meet user requests as well as to provide system development support,

Table V-8 presents the average costs for approach B over 5 years, In addition to the costs

Table V-6.—Approach B Costs

Item	Cost per year ($ million)					Average Yearly Costs ($ million)
	1	2	3	4	5	
Development personnel (number) ...	(15)	(30)	(40)	(30)	—	
Development costs	$1	$2	$2	$2	—	$2
Operational personnel (number).....	(85)	(160)	(210)	(260)	(280)	
Operational costs..................	$4	$7	$9	$11	$15	$9
Automation costs	$1	$2	$5	$6	$6	$4
Total cost	$6	$11	$16	$19	$21	$15

Note: Costs are for the oversight organization and its new services. An additional $2 million may be needed annually to modify existing information systems to conform with this approach. This estimate is based on the assumption that some of the existing information systems would be utilized.

associated with the development and operation of the additional capabilities, there would be modification costs for the existing agencies to support the referral and clearinghouse services. It is estimated that this cost would average an additional $2 million annually for 5 years. As with approach A, the increased data collection costs would average $2o million annually over the same period.

4. Approach C: Development, Automation, and Operation Costs

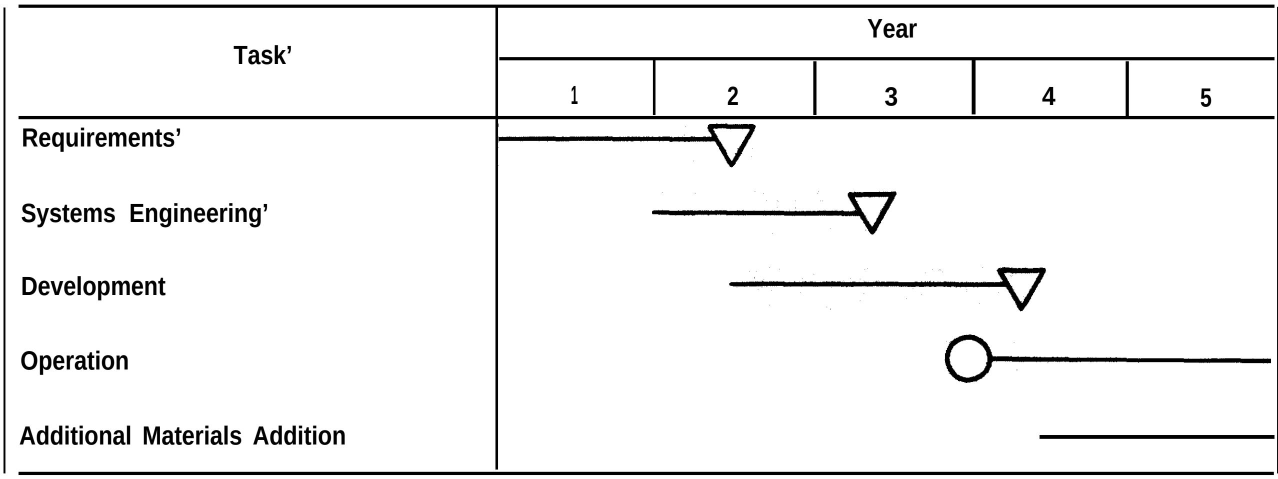
An accurate estimate of the investment required for this approach must be preceded by a detailed analysis of requirements and of existing information systems, to establish which could be utilized as part of the new information "system" developed.

The development of the required integrated capabilities by this approach would certainly impact existing information systems. However, the magnitude of the impact is difficult to estimate because it is a function of numerous variables, such as conversion costs, to interface with the new system, the degree of data aggregation/disaggregation, and the extent of disruption of existing information system operations and consequent need to provide backup. In the absence of a detailed analysis, a very rough estimate of $10 million was made; this is based on the assumption that the existing information systems are used to a large extent.

Approach C envisions the development of the integrated capabilities to be spearheaded by a few agencies, such as the Bureau of Mines and Department of Commerce, which would develop a prototype system to provide full functional support for a limited number of commodities. Such an approach is cost effective because the prototype development would be an early product of the overall system development activity and, at the same time, would provide the benefit of an early, limited operational capability with negligible increased cost. This would allow identification of required refinements, which could then be added since only a few materials would make up the data base. Additional commodities could be added on an incremental basis after the refinements were made. Further, since this approach provides the framework upon which additional commodities can be added, it is conceivable that the remaining commodities could be added without disruptions. In that case, the cost impact would be reduced and the workload might be accommodated by the permanent staff with only minor nonrecurring costs.

The overall development schedule for this approach is shown in table V–7. Work tasks

Table V-7.—Approach C Development Schedule



● Overlap of these tasks provides for refinement or requirement

Legend:

▽ Completion of Task

O Initial Operational Capability

during the first 2 years of systems development would be focused on requirements definition and overall systems engineering. Computer time would be negligible in the first year and would not start building up until the latter half of the second year when development would begin. In the third year development activity would peak and increased computer utilization would require nearly full-time support. Initial prototype system development test would be performed by connecting the new information system to one or more existing information systems late in the third year. This would further increase the workload so that by early in the fourth year full-time computer support would be required. Although new development activities are seen to decline in the fourth year, support to cover new commodities and more requests for information would continue to keep computer utilization at a peak level through the last year of the plan period. The average estimates of costs for this approach over 5 years are presented in table V–8.

In summary, approach C would average annual costs on the order of $2 to $20 million over the 5-year period to complete data collection and validation and would involve annual costs on the order of $17 milIion, averaged over 5 years, to establish the new information system capabilities needed, It would use the existing information systems to a large extent, and the increased costs, averaged over 5 years, in connecting these systems would be on the order of $2 million annually. If it developed that existing systems could not be extensively used, the increased costs could be substantially more.

E. SUMMARY

This section summarizes the strengths and weaknesses of the three illustrative approaches from an information system standpoint; in chapter VII their social, political, legal, and other impacts are analyzed. It is assumed in this comparison that the integrated capabilities are designed and implemented to support policy makers concerned with shortages in developing long-range contingency plans and short-range responses to crisis situations. It is also assumed that the particular critical material(s) will already have been

Table V-8_Approach C Costs

Item	Costs per year ($ million)					Average Yearly Cos s ($million)
	1	2	3	4	5	
Development personnel (number) . . .	(50)	(90)	(1 10)	(75)	(50)	
Development costs	$2	$4	$5	$3	$2	$3
Operational personnel (number)	(50)	(1 50)	(250)	(340)	(450)	
Operational costs	$2	$6	$10	$14	$18	$10
Automation costs	—	$1	$4	$6	$6	$4
Total cost	$4	$11	$19	$23	$26	$17

Note: Costs are for the new organization and its information system. An additional $2 million maybe needed annually to modify existing information systems to conform with this approach. This estimate is based on the assumption that the existing information systems would be utilized.

selected. The following characteristics were used as yardsticks to compare the approaches:

- Time to Achieve Operational Readiness.—The scale is marked in weeks, months, and years.
- Technical Application Constraints.—This refers to the amount of work required to convert technical knowledge into routine operating practice. The scale is marked as none, small, and large.
- Constraints on Access to Needed and Expertise.—This refers to the problems which will arise in carrying out the approach in having access to needed expertise to solve the problems. This scale is marked in none, few, and many.
- Administrative Authority .—This refers to the degree with which the assigned agency or group can ensure that the information plan is carried out. The scale is marked in weak, strong, and total.
- Budget Control.—This refers to the ability of an assigned agency or group head to control the money needed to implement the approach. This scale is also marked in weak, strong, and total.
- Continuity—This refers to the combined effect of management attention and the availability of staff to carry out the work on a sustained basis. This scale is marked ad hoc, periodic, and steady,
- Incremental Cost.—This refers to the relative size of additional expenditures required to set up and operate the approach (over and above the estimated initial data collection cost of $2o million which is common to all three approaches). This scale is marked low, medium, and high.

1. Approach A

The strengths of approach A are:

- The incremental cost could be relatively low, As developed in the cost analysis, about $10 million could be spent over 5 years. Approach A would use existing information systems and operating personnel, as well as planned improvements presently underway.
- Initial operational readiness could be achieved in a short time, possibly in a matter of weeks, assuming the needed data are already available. When Congress or another authority decided that a specific material or group of materials needed attention, the coordinating group

could form a task force of experts from within the existing agencies. If the material of interest is one that was already identified as such, it may have already been studied extensively by the materials management systems now in place, In other words, the job could be handled by a knowledgeable task force as it has been in the past. However, if the material in question had not been foreseen as potentially important, it might take months and even years to obtain the needed data.

- There could be essentially no technical application constraints. Routine operating practices of the existing information systems would remain the same.
- Problems in access to needed expertise could be none or few. Existing channels of communication between agencies and between public and private sector could be used.

The weaknesses of approach A are:

- Administrative authority could be weak, The coordinating group established to collect the data would have to do so via committees, task forces, or similar administrative devices. Such devices maintain their authority base for a short term in response to crisis situations, but over the long term, authority dissipates rapidly as the crisis passes. In general, this lack of authority could likely impose serious limits on the extent to which many problems involving interagency aspects of the information system could be solved (data transfer, standardization, etc.).
- Budget control could be weak. The coordinating agency could find it difficult to ensure that performing agencies allocate the money needed to be fully responsive to the coordinating group's requests.
- The ad hoc procedures and ad hoc staff could seriously impact continuity, When the need arose to restudy a specific material's shortage potential at various time intervals, it could likely be necessary to rebuild a coordinating mechanism each time.

The overall appraisal of approach A indicates that it would be well suited to those circumstances where the materials information needed to provide early warning of a shortage, including the probable effects of alternative policy responses, already exists in the Government. Unfortunately, this assessment has found few circumstances where these conditions exist.

2. Approach B

The strengths of approach B are:

- Continuity could be steady. It could be possible to set up a management measurement system and to monitor results against objectives, as well as to maintain visibility of critical materials in the intervals between formal reviews.
- The technical application constraints could be small. The work needed could consist in large part of setting up interfaces between existing information systems and the new information services being established such as referral and clearinghouse. The existing information systems could continue to operate and collect the needed data,
- The time to achieve operational readiness could be measured in months because of the step-by-step approach, Significant delays could arise primarily from obtaining initial authorization to establish the oversight organization. Once this was done, the approach could likely show tangible results in a matter of months.
- Administrative authority could be strong, at least, in the short term. Precautions could be needed, however, to ensure that the oversight organization retained its initial authority over the long term. The

step-by-step approach could permit flexibility in controlling and attaining development priorities as new needs were identified.

- The incremental cost could range from low to high, depending upon how far the step-by-step approach was carried. Initial costs for the first step could be low, approximately those of approach A. If all the steps were added incrementally, the total incremental cost of this approach could be high, approximately equal to approach C. A key cost consideration in this approach is that Congress could have the opportunity to review the results of each step before it appropriated extensions.

The weaknesses of approach B are:

- Budget control could be weak. The oversight organization could have the opportunity (and the responsibility) to advise on the funding levels needed by the various participating agencies to perform their assigned tasks. Such intervention could be made annually as budgets were prepared. However, the control over actual expenditures could remain with the various agencies.
- Access to needed expertise could involve many problems. Some could arise from uncertainties in the private sector over the system's ability to protect proprietary information. Others might result from evasive actions by individual Federal agencies to safeguard the autonomy of their missions, and from resistance to rules suggested by the oversight organization to minimize interface problems.

Approach B is especially attractive in its flexibility and adaptability to unforeseen circumstances. The step-by-step nature of the approach could ensure feedback before each major commitment was made. It may also be the best approach because of its high utilization of the significant investment in existing information systems.

3. Approach C

The strengths of approach C are:

- Administrative authority could be very strong. The agency responsible for the new system could be able to exercise a span of management measurement and control across the entire range of the objectives authorized by Congress.
- Budget control could be total. Funds could flow directly from Congress to the responsible agency through the established authorization and appropriation process. Transfer of funds to the performing agencies could be at the discretion of the responsible agency.
- Continuity could be steady. The management and staff could be in place for the long term to design, install, operate, and modify the new information system to meet new problems.

The weaknesses of approach 3:

- The time to operational readiness could be years. This approach is a long-term solution. The primary time delays could arise from the processes by which legislation is formulated and passed and the building of an effective organization. *
- The incremental cost could be relatively large. Further, this cost could vary significantly depending upon the extent of utilization of existing systems. Congress would likely have to commit to the whole incremental cost for this approach before initial work could be undertaken with confidence.

The access to needed expertise could encounter many problems. In addition to

*There may be no direct analogies in the physical sciences, but the timetable for the Lister Hill Center for Biomedical Communications in HEW is indicative. It was more than 2.5 years from the time it was formally proposed until P.L. 90-456 authorized its establishment, and another 2.5 to 3 years before funding, staff, and facilities were in place to begin meeting its objectives, those problems noted in approach 2, additional problems may arise as the agency responsible for the new information system hired knowledgeable people from the existing information systems and thereby reduced their capacity to participate effectively. New staff would also have to be built up to establish new interfaces with industry, a time-consuming process,

- Technical application constraints could be large. While approach C offers the opportunity to design a system from the start using the latest techniques, there are two classes of problems that could require continuing trade-offs in the new information system design. The first class of problems could arise from the fact that no one has yet designed an information system of this scope, especially when the supplementary functions are considered, The second could arise from the efforts that would be made to get maximum use of the existing information systems; it could be necessary to modify their internal operations to achieve system compatibility. This may impact their ability to perform their assigned functions.

Although, in principle, the advantages of approach C outweigh the limitations, it is based on the assumption that decision makers can fully define their system requirements and that false starts can be minimized. Recognizing the uncertainties in the ability to define the materials problem, and keeping in mind the pace of change in relevant information technologies, this approach may represent an unacceptably high risk.