Chapter III

THE NEED FOR IMPROVING FEDERAL MATERIALS INFORMATION SYSTEMS CAPABILITIES

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The existing Federal materials information systems, designed for different purposes, are loosely connected and do not provide Government policy makers with adequate information to deal with current materials issues. In particular, they cannot be used to forecast possible shortages, judge their impacts and the market's ability to absorb them, or test the effectiveness of alternative policy responses.

The functional requirements needed to improve existing materials information systems capabilities were developed through a review of the literature and a series of interviews with a cross-section of policy makers. H was found that more comprehensive and integrated systems capabilities were needed to deal with current materials problems. It was also noted that these capabilities should include techniques for interrelating data regarding the principal supply and demand factors so as to illuminate their effects on materials flow.

A. INTRODUCTION

In responding to materials problems. (government policy makers rely on information obtained from industry, academic institutions. State and local governments, as well as from Federal agencies For years the loosely coupled system that assembled. organized. analyzed, and distributed this information worked reasonably well. On the whole, the problems policymakers confronted were limited in scope, and timeliness generally was not a critical factor. Thus for example, the ability of specialist at the National Aero-nautics and Space Administration (NASA) to obtain information needed to carry out space programs. such as the state of development of new advanced composites to replace titanium and other metals, was generally satisfsctory, Similarly, international trade analysts at the Departments of State and Commerce could rely almost entirely on import and export statistics assembled by the Bureau of the Census and the International Trade Commission.

Serious shortcomings in the ability of these materials information systems to deal with shortage induced crises were first spotlighted in 1973 and 1974. Then, faced with the need to determine quickly whether the effects of the wheat shortage and the oil embargo could be contained by the market or whether Government interaction would be required, policy makers found that their information systems were deficient, This portion of the assessment examined whether or not that condition was symptomatic of general shortcomings in the Government's materials information capability and, if so, whether and how it might be corrected.

The assessment consisted of a series of step-by-step analyses in which hypotheses were advanced, tested, and successively reshaped. The initial steps in this approach proceeded as follows:

- The literature on materials information was critically reviewed.
- Based on information gathered from the literature, a tentative thesis was advanced that a significantly improved system was needed, and a set of provisional functional requirements for it was tentatively postulated.
- These premises were checked against the perceived needs of experts, as expressed in earlier studies and pending congressional actions on materials information systems.
- The premises were further tested and sharpened through a series of interviews with materials policymakers and specialists,
- In addition, views of several foreign experts with relevant experience were obtained.

The results of these steps, described in this chapter, supported the hypothesis that improved capabilities were needed and provided the basis for subsequent analysis of how they might be implemented.

B. LITERATURE REVIEW

Over the past 25 years there have been at least four major studies of national materials policy, The first was by the President's Materials Policy Commission in 1951, The second was begun in 1970 with the establishment by Congress of the National Commission on Materials Policy. In that same year the National Academy of Sciences appointed the Committee on the Survey of Materials and Engineering (COSMAT) to conduct a comprehensive survey of materials science and engineering. Most recently, in 1974, Congress established the National Commission on Supplies and Shortages. The reports of the three completed studies refer to and, in varying degrees. make suggestions regarding the role of information in formulating and executing materials policy, These ideas were utilized in this assessment.

In addition, the assessment drew on several other studies which specifically focused on information aspects of materials. These included two surveys by the National Materials Advisory Board of the National Academy of Sciences (1959 and 1964), the U.S. General Accounting Office's review of the Government's machinery for dealing with commodity shortages (1974), and a survey of materials information systems conducted by the Federation of Materials Societies (1974). The findings of these earlier efforts that bear on materials information aspects are briefly summarized below:[1]

1. The President's Materials Policy Commission Report

The Paley Commission was established in 1951 in the aftermath of the major materials

[1] In addition to the cited reports. several others (ref. 1,2,3) are relevant for their development of a general economic theory of information. The absence to date of a theory for evaluating the role of information in shaping market forces may well have impealed the development of materials information systems.

disruptions and price rises of the Korean War. Not unlike the effects of the shortages of 1973-74, the Korean experience focused public attention for the first time on materials issues. The Commission examined all major aspects of the problem of insuring an adequate supply of production materials for meeting national long-range needs. In its 1952 report, Resources for Freedom: A Report by the President's Materials Policy (commission, the Commission noted the need to improve the Government's "machinery"for anticipating changes in the materials situation. Emphasizing the interrelated nature of materials issues, it held that:

> The task of broadening and improving Government analysis of materials problems would take many forms. Butt improving the various parts o f Goverment equipment dealing with the materials problem will not make the whole operation run as it should. For all its wide diversities the materials problem is indivisible. There must be somewhere, a mechanism for looking at the problem as a whole. for keeping track of changing stations and the interrelations of poicies and programs. This task must be performed by a Federal agency near the top of the administrative structure(ref. 4).

Among its many findings and recommendations, the Report recommended that the Department of the Interior strengthen its programs for gathering and analyzing minerals data. It cited several functions that an improved analysis capability required, among them up-to-date information on resources and reserves, stockpiles, and producer inventories. As a basis for its own work, the Commission developed a methodology for making long-range projections and applied it to predict (in 1952) the 1975 U.S. demand. It thereby provided an important stimulus to more deliberative, analytical use of data in formulating materials policy. [2]

2. The National Commission on Materials Policy Report

With emphasis primarily on minerals, the 1973 report of the National Commission on Materials Policy, Materials Needs and the Environment, 7'oday and Tomorrow (ref. 6), noted that "almost every aspect of policy work on this area is handicapped by inadequate, inaccurate, or inaccessible information. It recommended that improvements be instituted with regard to data collection, data handling. analysis, and reporting. The following paraphrased excerpts indicate the thrust of the findings:

- Data Collection. An adequate, accurate, and accessible data base is needed for materials, energy, and environmental policy development; available basic data is generally inadequate. There is a need for more complete and reliable data and for continuing data acquisition. Information on mineral reserves and resources is patchy, inaccurate, or obsolete; to be useful, the data must be accurate, timely. and complete before processing.
- Data Handling. Data banks now used in processing reports on mineral resources are limited in number and highly specialized in application: none permit a comprehensive evaluation of materials flow, An improved system must provide for testing the accuracy of the data and its adequacy for policy decisions. The system requires a staff to search for available data and issue periodic reports on significant materials developments. There needs to be user access to nonconfidential information from any file, A

[2] A critique of the Paley projections, comparing them with actual 1972 usage, was made by Cooper (ref. 5). He found that the Commission underestimated growth in population (by about 10 percent). and GNP (by about 23 percent). Notwithstanding, they overestimated the consumption of materials for 17 of 24 minerals examined. Cooper notes, among several other possible reasons for the errors, that the Commission erroneously assumed that relative prices of materials would remain constant. The projected scarcities may in fact have developed and forced prices to rise. thereby inhibiting demand. Cooper shows evidence of this effect. He also notes that the Commission grossly underestimated the level of investment that would be made in plant and equipment (by 100 percent). The higher than anticipated investments in technology may have increased the effectiveness with which materials were used and thus reduced demand.

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basic task would be to establish standard terms and parameters, methods of collecting data based on those standards, and systems for organizing or filing the data. The data should be in computerized storage to facilitate their utilization.

- Analysis. Techniques for supply and demand forecasting must be improved; essential to analysis are sound historical records.
- Reporting. Interpretations of analyses and evaluations should be "packaged" in such form as to assist all users of the system; they should be released periodically and on special demand.

The Commission concluded that it was feasible and desirable for the Federal Government to establish a national inventory and information center on minerals (including fuels). They saw the new information system servicing many activities, including problem solving, program development, decisionmaking, and policy formulation. To be organized under the Department of the Interior (pending establishment of a new Department of Natural Resources), it would make extensive use of computer technology and would draw on existing, unused computer capacity wherever possible.

3. The COSMAT Report

The National Academy of Sciences Committee on the Survey of Materials Science and Engineering (COSMAT) published its findings in summary form in 1974 under the title, Materials and Man Needs (ref. 7). In 1975, it issued a multivolume supplementary report detailing background information. Whereas the National Commission on Materials Policy tended to view materials as commodities with emphasis on their role in commerce, COSMAT emphasized the technological aspects of materials; it attempted to show how science and engineering could be marshaled to address materials problems. Their principal findings covered opportunities for materials research and development, Governmental and industrial roles in materials research, and recommendations for strengthening the base of technical manpower through improvement in materials education. While information systems, per se, were not considered in any detail, COSMAT did note the need of the multidisciplinary materials field for improvements in materials data and statistics gathering.

4. The National Materials Advisory Board Surveys

The National Materials Advisory Board (NMAB), a division of the National Academy of Sciences National Research Council, was probably the first group to examine materials information in detail. In 1959, at the request of the Department of Defense, the Board sought the opinions of users of materials information systems on their effectiveness, specifically to illuminate these issues:

- The seriousness of the problem of dissemination of materials information;
- The deficiencies existing in the present (1959) arrangement:
- Whether certain substantive areas had greater deficiencies than others; and
- What changes would best correct any existing deficiencies,

A questionnaire was sent to **3.500** people, and replies were received from approximately **2,000.** The results provided an important early insight to user needs and preferences (ref. 8).

From the 57-percent return (compared with 20 to 30 percent normally encountered in mail surveys), the Board concluded that respondents considered the subject of materials information systems to be very important; in fact. more than 60 percent of the respondents provided expanded, narrative opinions. Reflecting a population that was decidedly scientifically oriented, respondents considered dissemination of information on applied research to be of greatest importance, followed, in turn, by basic research. development, and application engineering. With regard to which areas were encountering deficiencies, basic research and applied research and development were cited most often.

Users indicated a need for improvements in all types of basic information services. in particular abstracts, interpretive summaries, annual reviews, document distribution. bibliographic lists, information collection, technical answering services, and accession lists. Administrators stressed the need for current information: engineers wanted individual service from a technical answering facility. While all areas of materials science and technology were considered as having information handling deficiencies, those concerned with high-temperature and high-strength materials, lightweight materials. plastics, and ceramics appeared to have greater shortcomings than others.

With regard to how information systems might be improved, more than 85 percent of the respondents favored the general idea of materials information analysis centers. About 60 percent of the respondents felt that evaluation of information for scientific soundness was a necessary function. On the role of Government in fostering improvements, 94 percent of the respondents considered such a role to be suitable (about 95 percent were then using existing Government systems): however. having the information services available from nonprofit institutions was considered even more suitable. Respondents were asked to specify which Government and nongovernment bodies should serve in a continuing advisory capacity (quite apart from administrative control) with respect to materials information: 1,359 respondents cited Government agencies. with the Department of Defense and the National Academy of Sciences leading the list: some 581 respondents listed nongovernment bodies.

As to which Government agency should take the lead in managing and upgrading the information system. should such a decision be made, about 40 percent of the respondents preferred the Department of Defense. An equal number preferred a civilian agency, the Department of Commerce being the first choice. Some 20 percent preferred nongovernment control, the National Academy of Sciences being the first choice. Only 4 percent saw industry assuming this role.

In the years following the NMAB study, the Department of Defense expanded its support of materials information analysis centers, In 1964, the NMAB undertook a follow-up survey, this time focusing on user's perceptions of 10 DOD-supported centers. To obtain a more complete response than could be obtained from a mailed questionnaire some 350 people from 43 organizations were personally interviewed.[3] Table III- 1 shows the centers covered and the distribution of persons interviewed. The findings (ref. 10) provided a detailed breakdown of who was using the centers and for what, Representative of these findings, figure III-1 illustrates how users rated information centers relative to other means of acquiring information. Figure 111-.2 shows the relative use of the centers by category of user. Interestingly. some 80 percent of industry, Government, and research institute people used the centers, but less than 50 percent of university people.

The overall finding of the review was that materials information analysis centers were filling an important need and should be encouraged, In the following years they did grow. with strong support from the Department of Defense, the National Bureau of Standards, and other agencies. In 1972, however. a major change occurred: the Department of Defense initiated a policy

[3] A principal shortcoming of surveys in this area—experienced in the NMAB surveys and others, including those conducted as part of this assessment—is the difficulty of obtaining uniform interpretation of questions. The problem is exacerbated because "most scientists and engineers use information services only sporadically; their awareness of what they could be using is very incomplete, and more seriously, they do not reflect on their own pattern of activities sufficiently to be able to describe it" (ref. 9).

Table III-1_National Materials Advisory Board Study of Information Analysis Centers

DOD Materials Information Centers and Collections

Mechanical Properties Data Center (MP) (Belfour Engineering Company, Suttons Bay, Michigan)
Binary Constitution Information Service (BINARY) (Illinois Institute of Technology Research Institute, Chicago, Illinois)
The Groth Institute (Groth) Florida Atlantic University, Boca Raton, Florida)
Thrmophysical Properties Research Center (TPRC) (Purdue University, West Lafayette, Indiana)
Electrical and Electronic Properties Information Center (EPIC) (Hughes Aircraft, Culver City, California)
Radiation Effects information Center (REIC) (Battelle Memorial Institute, Columbus, Ohio)
Ceramics and Graphite Information Center (C&G) (Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio)
Centralizing Activity for Shock, Vibration and Associated Environments (SHOCK) (Naval Research Laboratory, Washington, D.C.)
Defense Metals Information Center (DMIC) (Battelle Memorial Institute, Columbus, Ohio)
Plastics Technical Evaluation Center (PLASTEC) (Picatinny Arsenal, Dover, New Jersey)

Distribution of Persons Interviewed

Organization		Nature of Work		Materials Interest	
Industry	197	Basic Research	64	Metals	70
University	46	Applied Research	149	Ceramics	11
Government	87	Design Engineering	31	Composites	15
Research Institute	23	Administration	13	Organics	41
Total	353	Information Activity	72	Research Materials (High purity)	23
Nature of Responsibility		Other (Service activities, e.g., testing and analysis, pilot plant)	24	Materials (Across-the board or combinations of materials)	185
Administrator	24	Total	353	Total	353
Supervisor					
Specialist	181				
Total	353				

Source: National Materials Advisory Board, Dissemination of Information on Materials.

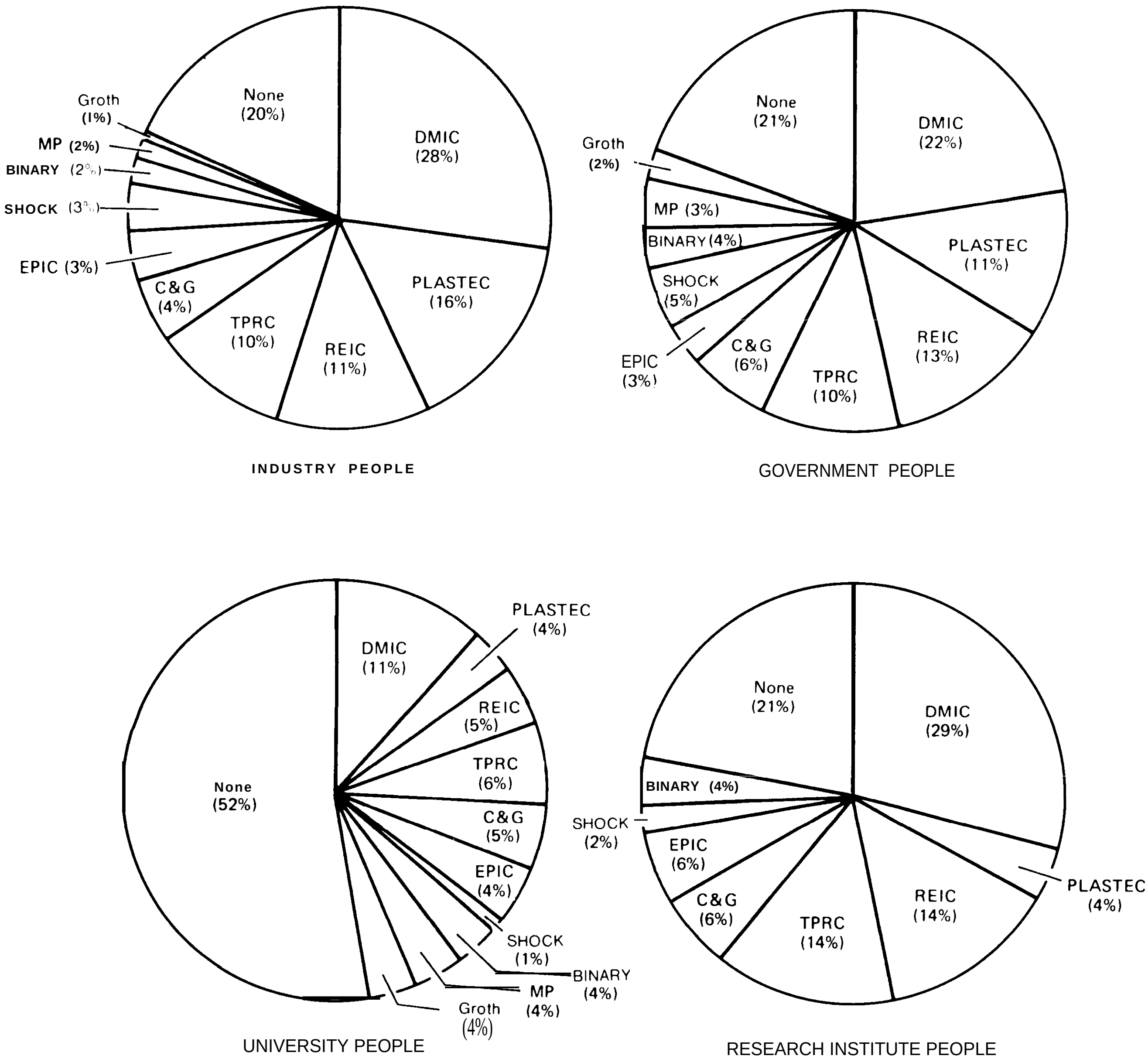
under which centers would charge users for services, Previously, the service was free to qualified Government and contractor personnel. Centers that could not become self-supporting would be closed. Indicative of the general problem of developing information services when the value of information is not clearly recognized—a condition that still exists—the views of the Department's spokesman are of interest:

> We repeatedly claim that technical information is a very valuable resource and that our technical information activities produce great benefits—yet to varying degrees we have failed to convince the people who control our resources that this is indeed true. Their quite logical response is—" OK. if it's so great, then the users certainly should be willing to foot the bill. " Frequently our response is—"Ah yes. but unfortunately the user and the people who control his resources do not realize how valuable our services are-and besides, they are not accustomed to paying for information services. " To me. the message is clear-if wc are to maintain viable information activities. we must do a better job of establishing the benefits of these activities. Se:rvice charges are one mechanism of establishing benefits which is clearly understandable to the people who have to make resource decisions for technical information activities (ref. 11),

5. GAO REPORT ON COMMODITY SHORTAGES

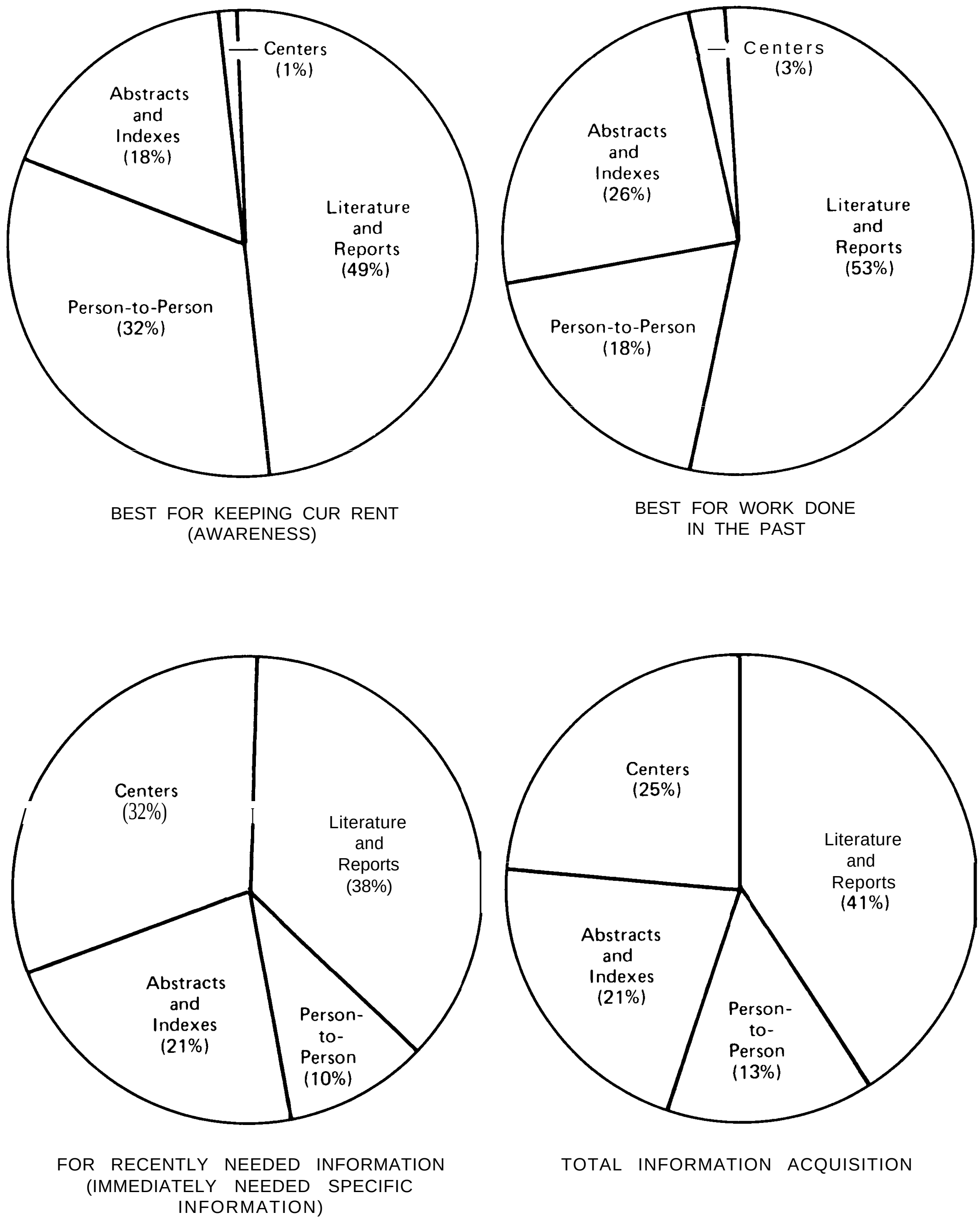
The General Accounting Office's (GAO) review, U.S. Actions Needed To Cope With Commodity Shortages (ref. 12), covered the performance of the Government's materials information system during the 1973–74 materials crises, The study found that the executive department agencies responsible for commodities . monitoring and forecasting lacked sufficient organizational or analytical

Figure Ill-1. DOD Materials Information Centers-Relative Use by Type of Organization.



Source: National Materials Advisory Board, *Dissemination of /formation on Materials.*
Note: See table Ill-1 for the names of centers.

Figure III-2. Tools or Techniques for Acquiring Information for Various Types of Needs



Source: National Materials Advisory Board, *Dissemination of /formation on Materials.*

resources to respond effectively to short supply situations that occur with little warning. Because short supply situations were long considered anomalies, coordinated procedures for analysis and decisionmaking had not evolved. and the existing methods were ad hoc and crisis-oriented. In large part. the problem resulted from the multiplicity of departments. agencies and councils involved in formulating policy.

In particular, the study confirmed a view of earl reviews: that unavailability of adequate corn mod it y information had hampered decision making, For some of the (commodities reviewed, necessary supply and demand in format ion was not available, incomplete, or in dispute. Because of fragmented information handling procedures. pertinent information, even when it was available. may not have been funneled to the people who needed it.

Many of these shortcomings also carried over to long-range commodity policy planning. Here, too. the study found that organization and coordination among the involved agencies needed improvement to clarify roles and missions. Throughout GAO's analysis. the importance of effective information systems was stressed:

> Commodity policy analysis. decisionmaking and planning can not be effective if adequate information is not available. Commodity policy decisions can have only limited utility. and may even be counterproductive, if they are' not guided by a set of established long-range policies and extensive data gathering has little value; if the data is not effectively used for analysis. Data gathering. analysis. forecasting. decisionmaking, and planning must be (considered together for the system to function properly (ref. 12).

The GAO study noted that the development of an information system for mineral commodities posed a more difficult challenge than for agricultural commodities. Among the complicating elements are the larger number of minerals for which the United States depends on foreign supply and the inherent difficulty in measuring and projecting resources within the earth (in contrast to those that are visible at the surface). Because of long-term efforts of the Department of Agriculture in developing crop forecasting systems (initially in support of production incentive programs), the in format ion systems for agricultural commodities are more advanced than for minerals. The GAO study concluded that for mineral commodities, "the quantity, quality. accessibility, and interchangeability of data is inadequate for the task of developing natural resources and environmental policies" (ref. 12).

The study emphasized the need for improvements in analytical techniques for interpreting and projecting the data. Citing certain exceptions, e.g., the Economic Research Service (ERS) within USDA. GAO observed that:

> Most of the research and analysis in commodity forecasting is a result of informed opinion rather than such scientific methods as partial simulation models embodying judgment and statistical relationships or fully computerizcd models. . . . Methods used arc generally selected in an ad hoc manner from a variety of sources not programmed by type of inquiry or analysis. The research is not based on a steady accumulation of data and analysis. Agencies. therefore. rely on an individual analyst's expertise. developed within the organizat ion on specific commodities.. and do not build a general data base that can be used as a permanent record. Relying on such commod i ty expertise hinders the development of stand ads of reliab i1ity and improved forecasting (ref. 12),

Looking to the future. the report noted the growing number of domestic and international factors that affect the severity and complexity of shortage situations and concluded that existing policymaking procedures did not adequately interrelate them.

6. The Federation of Materials Societies Survey

In contrast with the focus of the GAO study on Government systems, this review covered the entire spectrum of materials information systems. Conducted by the Federation of

Materials Societies at OTA'S request, its purpose was to obtain a quick hut comprehensive survey of the breadth and intensity of the materials information problems confronting users. As reported (ref. 13), a questionnaire was designed and sent to some 4,OOO professionals having evinced an interest in materials information. About 700 replies were received.[4] The distribution of respondents, shown in figure 111-3, indicates roughly equal representation from industry and universities. with less coverage of Government. Respondents' fields of speciality were predominantly in science and advanced engineering. with less coverage in practical design engineering, and still less in economic aspects. Table 111-2 presents selected results of the survey bearing on four points of particular interest to this assessment. namely:

- Importance of improved materials information systems;
- Perceived needs the improved systems should address;
- How such systems should be institutionalized; and
- How the costs should be borne.

Almost 9 out of 10 respondents judged materials information to be important or highly critical. Fewer than half regarded the present scope of information systems as good, with many noting needs not being served. Two-thirds spoke of deficiencies in quality. and almost half criticized the accessibility of information. The most frequently cited needs related to up-to-date, reliable compilations of data. A smaller number of respondents cited the need for more complete economic statistics and the problems introduced by the proprietary nature of much of this information. A striking point that emerged from the survey was the great diversity of the sources of information that users call on. Asked to name the top four specific sources of materials information that they use, the 688 respondents (not all of whom answered the question) cited 574 different sources. Recognizing the difficulties in satisfying this variety of needs, Westbrook commented "This great diversity of important sources is one of the root causes of materials information problems*' (ref. 13). With regard to improved services, the respondents divided about evenly as to whether they preferred a single national system or a pluralistic network of systems. More than half favored the sharing of the costs of information management among Government, users. and technical societies.

In addition to the responses to the formal questions, an unusually large number of respondents appended comments. Many covered the frustrations met in using the systems;[5] others contained thoughtful suggestions for improving it, Many of these additional comments were considered in this assessment.

7. Prospective Functional Requirements of an Improved System

Analysis of these studies led to the thesis that the Government's ability to deal effectively with shortages needs to be improved. and that such improvement should treat materials information in an integrated. systematic manner. That is, the problem demands a conceptual framework to interrelate the multitude of different factors; data to be collected on each of the factors; and all of it to be so organized. coupled, and analyzed as to display the inherent dynamics of the flow of materials.

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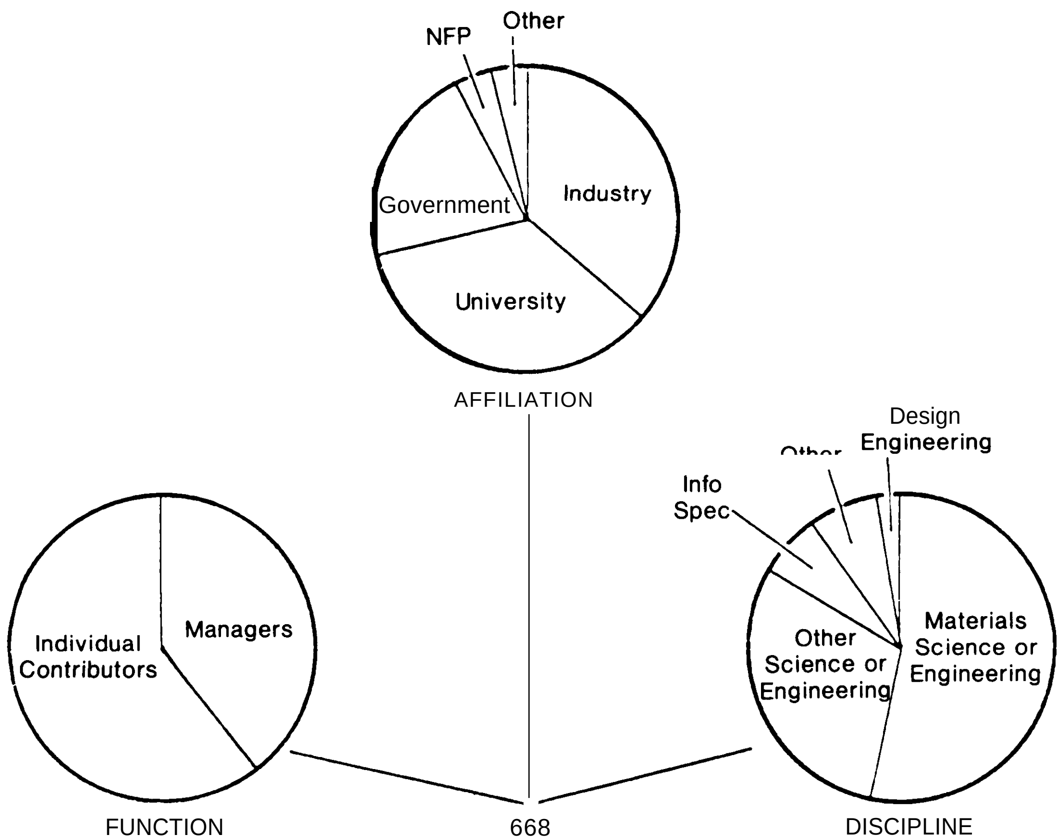
[4] An additional 300 replies received after ref. 13 was prepared were not reported in the analysis.

[5] In this connection, Westbrook's characterization is of interest:

> '*This (materials information) syndrome comprises bewilderment. apprehension. dismay. frustration. and outrage: *Bewilderment* with respect to the enormous volume and diversity of needed sources of information: A *pprehension* as to the quality and reliability y of those facts: *Dismay* at the redundancy. gaps. and lac k of coordination between information sources and systems: *Frustration* with the mechanics of search. retrieval and manipulation of information from the general store: and *Outrage* at the cost of seeking and locating needed information" (ref. 13).

Figure III-3. Distribution of Respondents to FMS Survey



Source: J. H. Westbrook, "Materials Information: An Examination of the Adequacy of Existing Systems".

Table ill-2.—Selected Results of FMS Survey

A — Importance of Improved Materials Information System

Assessment	
Highly critical	36.5%
Important	48.5
Satisfactory	11.6
Attention, selected area only	3.3

B — Perceived Need

Comprehensive, machine readable, continuously updated information system	111
Handbooks, reviews, compilations with critical evaluation and coordination	107
Lag in availability of information	47
Problem of proprietary information	46
Better economic statistics, supply/demand, etc.	42
Problems of coping with foreign information	29

C — Favored Objective

Comprehensive, integrated national system	44.070
Improved present pluralistic system	43.2
No change	12.8

D — Who Should Pay Costs?

Shared	54.270
Government mission agency	22.8
User	17.6
Professional societies	3.5
Other	1.9

Source: J. H. Westbrook, “Materials Information: An Examination of the Adequacy of Existing Systems”.

An initial set of prospective functional requirements needed for improving the materials information system was developed. These were then refined through the interview process and subsequent analysis, The functional requirements covered three general areas of materials flow: (1) factors directly affecting supply, (2) factors directly affecting utilization, and (3) factors which indirectly affect both. Table 111-3 indicates those prospective functional requirements cited or significantly implied in past materials studies.

C. REVIEW OF PENDING LEGISLATION

Reflecting considered analysis by Congressmen and their staffs, some 200 bills dealing directly with materials and materials information were introduced in the 93d and 94th Congresses. These bills indicate a recognition of the need for many of the prospective functional requirements, as shown in table 111-4. The bills reflect the view that information management problems such as coordination, compatibility, and dissemination are limiting effective analyses of materials shortages and related environmental problems. The proposed legislation include provisions for improving the collect ion, standardization, analysis, and reporting of materials information, covering information both on the long-term availability of critical materials and on associated environmental problems.

Comparison of the bills introduced in the 93d Congress with those of the 94th Congress indicates that the more recent bills show greater awareness of the need for the supply and utilization functions, It is interesting to note that in response to changing priorities, concern for incorporating an energy function increased. while interest in the environmental protection function leveled off,

D. INTERVIEWS WITH MATERIALS DECISIONMAKERS

The views of a sample of materials decisionmakers regarding the need for and the charac - teristics of improved information system capabilities were obtained through two sets of interviews. The first covered senior level ex - ecutives having policy responsibilities. The

Table 111-3.—Referenoes to Functional Requirements in Principal Materials Studies

Functional Requirements	President's Materials Policy Commission	National Commission on Materials Policy	COSMAT	GAO
supply				
Resources inventory	x	x		x
Reserves inventory		x		x
Industrial stocks	x	x		x
Strategic stockpiling	x			
Economic stockpiling	x			
Import levels		x		x
Recovery/recycle potential	x	x		x
Supply forecasting	x	x	x	x
Utilization				
Production rate		x		x
Production capacity		x		
Consumption rate/patterns	x	x		x
Export levels		x		x
Demand forecasting	x	x	x	x
Indirect				
Price		x		x
Research and development	x	x	x	x
Materials substitution		x	x	
Environment	x	x	x	
Energy		x		x
Investment capital		x		x
Transportation		x		x
Manpower			x	

second covered lower level materials managers concerned with a single. representative material-aluminum.

1. Senior Level Executives

Some 20 senior executives at the assistant secretary level in the Federal Government and 5 similarity placed industry executives were interviewed. Their affiliations and positions are shown in table III-5,

A formal questionnaire was designed and used to guide the discussions; however, the executives' views on all related issues were invited. To encourage the frankest expression of views, it was agreed that individual responses would not be attributed but would be aggregated for publication, Generally, the respondents described the policy questions they were called upon to answer. the information systems they used, and the strengths and shortcomings they experienced in using them, The discussion focused on two related questions: (1) To what extent did the executive see the need for improved materials information capabilities? and (2) What capabilities did they consider most important?

With respect to the nature of materials questions they confront, the majority of respondents cited requests from the department secretary or assistant secretary as being most common. Less frequent were lateral inquiries from other departments or Congress, There, the common pattern of information flow was vertical from the secretary through the specific assistant secretary through the appropriate policy or planning office responsible for preparing the response. In most cases, all information used in answering the request was developed from within the department; seldom did one department go to another for information,

Table III-4.—Prospective Functional Requirements Reflected in Legislation of 93d and 94th Congresses

Functional Requirements	93d Congress																		94th Congress																		
	Senate									House									Senate									House									
	S.424	S.1283	S.2296	S.2782	S.2806	S.2966	S.3625, 3467	S.3964	S.4061	H.R. 6547	H.R. 11694	H.R. 12936	H.R. 15781	H.R. 16006	H.Res. 907	H.Res. 1014	H.R. 9697	H.R. 9698	S.26	S.32, S.79	S.594	S.1410	S.1415	S.1798	S.1864	S.1869	S.2296	H.R. 966	H.R. 1832	H.R. 1668	H.R. 1847	H.R. 2363	H.R. 2386	H.R. 2736	H.R. 4971	H.R. 9212	H.Res. 31
Supply																																					
Resources inventory	x	x	x	x										x				x				x		x	x		x	x		x			x				
Reserves inventory				x							x			x								x			x			x			x		x				
Industrial stocks				x													x						x		x									x			
Strategic stockpiling																					x	x	x														
Economic stockpiling																	x				x	x	x			x											
Imports monitoring/control					x	x										x							x			x			x								
Recovery monitoring/ recycled materials								x				x					x																				
Supply forecasting			x			x											x	x				x	x	x			x	x					x				x
Utilization																																					
Production rate						x												x				x	x		x			x					x	x			
Production capacity						x																x	x		x			x						x			
Consumption rate/patterns			x		x	x								x				x				x	x		x			x				x	x	x			
Exports monitoring/control						x				x						x							x														
Demand forecasting (rate of materials demand)			x			x											x	x				x	x	x	x		x	x					x				
Indirect																																					
Price		x										x		x		x						x	x	x			x	x					x				
New technology		x			x	x			x									x		x		x	x				x	x					x			x	
Research and development		x	x		x		x		x			x	x						x	x			x	x			x	x		x			x	x		x	
Materials substitution																					x	x		x				x		x							
Environment	x		x	x		x	x	x	x									x	x			x	x				x	x					x		x		
Energy		x		x	x									x				x				x	x		x			x			x		x	x	x		
Investment capital		x	x		x																	x	x	x			x	x					x				
Transportation	x							x				x						x				x	x	x	x		x	x					x				
Manpower						x												x				x	x	x	x												
Consumer product safety/hazards																																			x		
Marketing																						x	x		x												

Table 111-5-Materials Executives Interviewed

Assistant Director for Research, U.S. Geological Survey, Department of the interior
Manager, Material Strategy Department, Ford Motor co.
Director, Federal Preparedness Agency, General Services Administration
Director, Office of Planning and Evacuation, Department of Agriculture
Director, OBRA, Department of Commerce
Senior Fellow, Resources for the Future, Inc.
Director, Bureau of Mines, Department of the Interior
Assistant Secretary for Economic and Business Affairs, Department of State
Assistant Secretary, Land and Water Resources, Bureau of Land Management, Department of the Interior
Former Deputy Director, Washington Environmental Research Center
Senior Specialist, Congressional Research Service, Library of Congress
Deputy Administrator, General Services Administration
Assistant Secretary for Economic Policy, Department of the Treasury
Deputy Assistant Secretary, International Resources and Food Policy, Department of State
Acting Assistant Attorney General, Department of Justice
Head, Energy and Materials Division, Resources for the Future, Inc.
Director, U. S. Geological Survey, Department of the interior
Associate Director, Mineral and Materials Supply/Demand Analysis, Bureau of Mines, Department of the Interior
Vice President, Government Relations; Director of Environmental Services, National Coal Association
Director, Agricultural Economics, Department of Agriculture
Deputy Assistant Administrator, Federal Energy Administration
President, Reynolds Metals Corporation
Former Administrator, Federal Energy Administration
Chief, Trade Resources Division, Department of State
Vice President, ALUMET

The nature of the questions varied greatly. Some recurred frequently; commonly, these concerned commodity reserves, current distribution, current prices, consumption, and the levels of stockpiles. A few respondents indicated that occasionally they are asked to provide specific materials plans, for example, a contingency plan for materials allocation or rationing.

Only a few respondents indicated that they had formalized information systems which they could use to assess policy questions. Some, as in the Bureau of Mines, could call on sophisticated, partially automated systems that were in development. Though it was too early to judge their overall performance, it was already clear that they would likely have some serious limitations, particularly with respect to inadequate data on foreign resources, reserves, production, and consumption. Most respondents indicated that their "systems" were based on commodity experts, who attempted to keep current on all developments in their fields by relying on serial publications of their own and other departments and contacts with industry sources.

About half the respondents, generally those who had need to exchange information outside their own agencies, felt that lateral transfer was inadequate. Sometimes the flow was restricted because, as one respondent said, "people do not want the information used against them. " Often, one agency is reluctant or unable to devote the time and effort required to answer a query from another. A majority of respondents, including those that had no quarrels with lateral transfer, were dissatisfied with the effectiveness of vertical transfer of information, The general opinion was that they received too much rather than too little information. Too much information was being sent forward without summarization or analysis. One executive said. "It takes time and effort and understanding to summarize. It is much easier to send up the complete report rather than extract the information necessary to answer the particular question. Moreover, it's safer. As a result, I'm swamped with reports when what I want is simple answers.

More than half the respondents felt that improved, systems-oriented information systems would enable them to formulate better materials policy. However several, mostly in industry, were troubled by the problems such a system might pose and did not endorse it. Of particular concern were questions on the privacy of information and the possibility that the system might lead to "undue" Government interference in the free market.

Most of the materials executives offered opinons on the functional requirements that ought to be included in an improved system, if it were implemented, These views are summarized in table 111-6,

Table III-6_Importance of Functional Objectives as Viewed by Materials Executives

Functional Requirements	Number of Reaponses (of 25)		
	Great Value	Substantial Value	Negligible Value
Supply			
Resources inventory	13	8	2
Reserves inventory	15	7	1
Resources/reserves prediction	7	0	0
Industrial stocks	5	0	0
Strategic stockpile	15	6	2
Economic stockpiles	5	0	0
Rate of imports monitoring	15	6	2
Recycling/potential rate of recycling	15	6	3
Overall supply forecast	8	2	0
Supply/demand monitoring	16	0	0
Utilization			
Rate of production-mining	14	7	3
Rate of production—extraction	14	6	4
Rate/level of production-fabrication	14	6	3
Rate of exports monitoring	15	7	2
Indirect			
Overall supply vs demand analysis capability	16	1	0
Price forecasting	7	0	0
Research end development monitoring	0	1	0
Residuals (pollutant) production	15	6	2
Land management-multiple use	2	0	0

2. Aluminum Specialists

The second step in the interview process covered 59 materials specialists in industry, academic institutions, and Government, In contrast with the senior executives surveyed in the first step, most of these respondents had more pragmatic, day-to-day management responsibilities. To bring greater focus to this survey, a single material (aluminum) was selected, and respondents were chosen for their familiarity with the aluminum materials cycle and the strengths, weaknesses, and needs of the information systems that support aluminum decision making,

Aluminum was chosen as the representative "test" material for several reasons. First, it is a major domestic commodity, accounting in 1972 for approximately $1.4 billion worth of primary aluminum products. Second, it displays complex dependencies on foreign sources: 90 percent of the ore (bauxite) is imported: also shortage-inducing actions of exporters, akin to those of OPEC, are of concern. (The International Bauxite Association was formed in 1974,) These conditions have resulted in a national awareness of aluminum shortages, As indicated by a 1974 survey conducted by the Senate Committee on Government Operations, nearly **30** percent of the respondents foresaw or were concerned with aluminum shortages, Unlike some materials for which the economy is totally dependent on foreign supplies, the United States has some domestic supplies of bauxite. Moreover, there are also supplies of alunite, anorthosite, dousinite, and kolonite which could be exploited in place of bauxite.

Aluminum also illustrates the range of options and interrelationships that derive from substitution of one material for another. Thus. copper can be substituted for aluminum in many applications, It is already so used in the electrical industry, But, illustrative of the complex interactions at work, this trend could be reversed as a result of increasing energy costs. Other aspects of aluminum that recommended it for the study are its use in Government stockpiles, and the fact that the industry includes an active recycling element.

While the aluminum cycle appears to encompass a large number of the issues of concern with materials generally. it is recognized that no single example is fully representative; follow-on study efforts would well consider additional detailed examples,

In the aluminum survey. respondents were asked about their use of existing materials information systems, the need they saw for an improved system, and the kinds of functions that should be included within such a system. As with the senior executive interviews, these interviews were conducted informally, often by telephone: a written questionnaire was used to set the general direction. but respondents were encouraged to volunteer opinions and percept ions, Table III-7 1ists the affiliation of the respondents, and the areas of emphasis in the interviews: it also summarizes the major characteristics of their materials information systems.

In the public sector of the aluminum community, these information systems are primarily concerned with supply and demand statistics: in the private sector, with technical information. The larger industrial firms have developed in-house information systems covering those aspects of the aluminum cycle of special relevance to their operations. Some, with sophisticated statistical and analytical capabilities. are used to develop economic forecasts. The smaller firms tend to rely on data obtained from the Federal Government and trade associations and do not have substantia1 in-house ana1ytia1 capabi1i ties. Several respondents noted that often Government data-base managers were not sufficiently aware of how private industry used their reports. A need exists for users to have more input in formulating the content and format of published reports.

The survey indicated that while some systems were automated, most were manual and in almost all cases the respondents relied on primary and secondary 1iterature and on person-to-person exchanges rather than on automated systems. In almost all cases. analysis and interpretation of data bases were performed manually. Several respondents noted that an arrangement of candid, sometimes unofficial, exchanges of information between industry representatives and their counterparts in Government has evolved over many years. They recommended that expansion of the present materials information system should take pains to avoid interrupting these valuable information channels.

The survey found it difficult to assess the quality of the aluminum information systems, There was little agreement on how to rate the systems; few respondents were in a position to assign meaningful quantitative measures, In an attempt to obtain a degree of uniformity in the appraisals, respondents were asked to consider how well their systems could provide answers to the series of very specific representative test questions listed in table 111-8, Using these as a frame of reference, the survey inquired about the completeness of aluminum data bases and their accuracy, Table III-9 summarizes the coverage of data bases as reported by respondents, The most comprehensive bases (covering the complete aluminum cycle) are maintained by the larger industrial firms. The most automated bases pertain to resources and reserves data. Considering the importance of foreign activities in the aluminum cycle, the incompleteness of foreign data is striking.

An appraisal of the accuracy of representative aluminum data bases was obtained from a subset of respondents, all in the public and academic sectors: the results are shown in table 111-10. On the whole, accuracy appears to be high. However, the techniques used to verify the survey are primitive and the estimates are thus only “best guesses. ” Also, as indicated by industrial respondents, errors as small as 5 percent or less can be important.

On the question of the need for a significantly improved information system, 52 percent of the respondents felt that such a system was required, 14 percent saw it as unnecessary

Table III-7.—Information Systems Used by Aluminum Survey Respondents

Company/ Agency Affiliation	Emphasis Interview	Information Systems in Use			
		General Type/Contents	Major Data	Accesibility	Analytical Capability
Industry					
Alumax	Complete aluminum Cycle	Conventional reference files		—	
Alumimum	Complete aluminum Cycle	Manual	Internal trade	Open	None
Aluminum Co. of America	Complete aluminum cycle	Automated; 10 years of industrywide data by quarters	Alcoa, DOI, DOC, Aluminum Assoc.	Proprietary	Statistical, econometric models make 5 and 10 year industrywide forecasts
Anaconda Casting company	Complete aluminum Cycle	Manual statistical	Aliminum Assoc.	Open	
Coors Inc..	Recycling, aluminum Cycle	Recycling statistics;Manual reference flies		—	
Earth Sciences	R&D	Manual	Internal	Proprietary	
Fairfield Aluminum	R&D	Manual	Trade association	Open	None
Foote Mineral Co.	R&D	Manual	Trade association	Open	None
Forest City Foundries	Complete aluminum cycle	Manaul	Trade association	Open	None
General Extrusion	Complete aluminum cycle	Manual	Trade association	Open	None
Howmet corporation	Complete aluminum cycle	Manual statistical system	Aluminum Assoc., DOI, DOC	Open	
Kagan - Dixon Wire Company	Manufacturing	Manual reference files		—	
Kaiser Aluminum & ChemicalCorp.	Manufacturing	Automated; worldwide data	Kaiser, DOI, DOC, Aluminum Assoc,. Foreign Sources	Proprietary	statistical and econo metric models
Norandex Inc	Manufacturing	Manual Industry files; automated company files-	Trade association	Open	None
Revere Brass and copper	Aluminum cycle	Manual statisatical system	Aluminum Assoc., DOI. DOC	Open	
Reynolds	Aluminum cycle	Automated; worldwide data	Reynolds, Dot, DOC, Aluminum Assoc., foreign-sources	Proprietary	Statistical, econometric models for forecasting and requirements
S-G Metals smelting & Refining Co.	Aluminum Cycle	Manual	Trade association	Open	None

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use: General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Southwire	Aluminum cycle	Automated company data; manual industry data	Company, DOI, DOC (Census), trade association	Limited access	Statistical summaries
U.S. Aluminum Corporation	Aluminum cycle	Manual	—	Open	None
Vulcan Materials Company	Aluminum cycle	Manual system on new and old scrap; refining	*American Metal Market, Iron Age;* customers and suppliers; trade journals	Proprietary	Forecasting by regression analysis on limited scale
Wabash Smelting	Aluminum cycle	Manual	—	—	—
Private					
McGraw-Hill — N.Y. (Information, subsidiary)	Financial information, metal prices	Library and automated bibliographies, reference sources	Industry, internal sources	Open	Abstracts, special reports
Oppenheimer & Company	Aluminum cycle, financial data	ADP, aluminum refining, smelting, other	Industry, government	Proprietary	Model outputs for financial use
Trade Association					
Aluminum Association of America	Aluminum cycle, R&D	Manual files	Industry, DOI, DOC, GSA	Proprietary	Statistics, forecasting; world supply and demand, short-term U.S. products
Aluminum Extruders Council	Aluminum cycle	Manual statistical files	—	—	—
Aluminum Recycling Association	Recycling	Manaual secondary industry statistics	Members	Proprietary	Statistics to members
American Diecasting Institute	Aluminum cycle	Manual statistical files	—	—	—
Forging Industry Association	Aluminum cycle	Manual statistical files	—	—	—
National Assoc. of Recycling Industries	Recycling, aluminum cycle	Manual statistical files	—	—	—
Professional society					
ASM Metals Information	R&D; aluminum cycle	Automated library system and abstracts	Trade and professional journals, industry, other societies	Open	Abstracts; special search reports

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Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use: General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
University					
Georgia—Institute of Technology	Substitute ores	Manual files on aluminum	U.S. DOI BOM, USGS and industrial contacts	Open	—
Montana School of mines State Bureau of Mines & Geology	Substitute ores	Developing a CRIB file on state minerals. USGS will keypunch and will enter in DOI CRIB system	—	—	—
University of Utah	Substitute ores	Manual	U.S. DOI BOM, USGS	Open	—
Not-for-profit					
Battelle Memorial Institute	Materials substitution and selection	Pilot automated materials properties system; various abstracting systems	Multiple literature sources	Limited	Various
State government					
Alaska	Minerals	Automated system on mines, petroleum, but no mineral files	State	Open	Selected file output
Arizona	Substitute ores	Automated system on land leases only	State	Open	Selected file output
Arkansas	Aluminum cycle	Conventional statistical files	U.S., DOI BOM, USGS	Open	—
California	Substitute ores	Conventional files on minerals and mines	—	—	—
Colorado	Substitute ores	Manual files only on resources	—	—	—
Georgia	Aluminum cycle, substitute ores	Conventional files	U.S., DOI BOM, USGS	Open	
Illinois State government N.E. Illinois Planning Comm. Chicago	Substitute ores, waste	Conventional files on natural resources	—	Open	—
Iowa	Substitute ores	Manual statistical files	—	Open	—
Maryland Management Information Systems Division	Substitute ores	Automated system on natural resources, but not for materials	Multiple	Open	Selected file output
Montana State Dept. of Natural Resources	Substitute ores	Automated system on land, river, dams, but no files on minerals	—	Open	
New Mexico	Substitute ores	Manual files on resources	—	Open	—

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use			
		General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Federal Government					
Department of Commerce	Aluminum cycle	Manual monthly statistics, metal stocks of domestic producers, etc.	DOC (Census); Bureau of Domestic Commerce	Open	Publications; commodity statistical reports
Department of Commerce, Bureau of Census, Foreign Trade Division	Aluminum cycle	Automated; all import-export commodity data on monthly basis; retained 3 years tape, then microfiche	DOT, Customs Bureau	Open	Monthly statistical reports
Department of Commerce, Bureau of Domestic Commerce	Aluminum cycle	Automated; monthly statistics from aluminum producers and importers	280 aluminum producers and importers	Proprietary	Monthly statistical reports, special reports to federal agencies trade associations, and universities
Department of Interior, Bureau of Mines (BOM)	Aluminum cycle, R&D	Comprehensive automated and conventional system	Industry, other agencies, in-house experts	Open	Serial publications; commodity reports
BOM Div. of Econ. Analysis	Aluminum cycle, R&D	Statistical files; relies upon BOM commodity specialists to supply required data	BOM commodity specialists	Open	Economic forecasts in response to staff requests
BOM, Import-Export	Aluminum cycle	Manual statistical files on bauxite imports and aluminum exports	DOC Bureau of Census, Foreign Trade Division	Open	Support to BOM commodity specialists
BOM, Office of Statistics	Aluminum cycle	Automated; data acquired by BOM commodity questionnaires – mineral industrial surveys on over 200 minerals and materials; in process of developing data file on worldwide aluminum plant capacity to include: source of power, source of bauxite, source of alumina plant production with 10-year projection	Questionnaire to selected industries: bauxite consumption (177-A); bauxite production (20-Q); alumina (30-A); aluminum (31-M); aluminum scrap (82-A)	Proprietary	Routine periodic and special purpose statistical support to BOM commodity specialists
BOM World Production Tech. Data Services	Aluminum cycle	Manual statistical files; world production of bauxite and aluminum ingots, etc.	U.S. Embassies, Dept. of State; foreign and domestic publications	Open	Annual reports
USGS	Aluminum cycle automated files	Worldwide data in report form, USGS bulletin 1228, 1968 is being updated; automated files; (CRIB), worldwide	Multiple sources	Open, limited access	Publications; CRIB file output; statistical output using STATPAC

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use			
		General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Environmental Protection Agency	Environment	Automated system on pollutants and energy production by point source	Industry	Open and proprietary	Statistical printouts
Federal Energy Administration	Energy	Automated system	Industry, DOI BOM	Open, limited access	In development
General Services Administration	Stockpiles	Semiannual report	Internal data	Open	Semiannual report to Congress and various agencies
National Science Foundation	R&D	Automated management information system; conventional files	Internal data; interagency exchange	Open	Publications

Table III-8_Representative Test Questions

Resources:	What are the national resources of bauxite (the primary ore of aluminum) or alunite, kaolin, anorthosite (substtute ores for bauxite)?
Reserves: (Primary Ore)	What are the reserves of bauxite in Jamica (in Arkansas) vs. price?
Reserve (Substitute Ore)	What are the reserves of kaolin in Georgia (alunite in Utah) vs. price?
Mining-Production:	Where are bauxite mining operations located and how much do they produce? How much bauxite is produced in the United States by Company and by state?
Refining:	How much alumina is refined by state and by what processes?
Production-Capacity:	How much aluminum is produced in the United States and by what companies? What capacity do the producing companies have? By state?
Fabricated Products:	How much of a particular fabricated product is produced by a given company or within a region? (Fabricated product here means castings, plate, sheet, rod, extrusions)
Consumer Products:	What consumer products are manufactured by type?
Value:	What is the value added at each (or any) stage of the aluminum cycle?
End Products:	What is the aluminum content of consumer end products?
Manpower:	What is the complement of personnel for various plants?
Capacity:	Is data available concerning plant capacity versus dollar investment and time to construct ?
Service Life:	What is the service life of various consumer products?
Material Selection:	For aluminum with given physical, mechanical, or chemical properties, what are the alternative metals?
Toxicity:	What are the toxic properties of any aluminum alloy?
Environment:	What quantities of residuals are produced in aluminum process (e.g., red mud from refining ?
Energy:	How much energy is consumed at each (or- any) stage of the cycle? How much energy is used to produce the giver! fabricated product [eg., casting, plate, or extrusions)?
R&D:	What aluminum-related R&D activities are in progress for each (or any) part of the aluminum cycle?
Recycling:	How much of the aluminum produced by a given company or within a given geographic area is from recycled material?
Recycling:	How much new scrap is produced by state ?
Transportation:	What is the availability of railroad transportation to a plant, deposit, etc.?

and/or undesirable. and 34 percent were undecided as shown in table 111-11. Respondents in the Federal sector showed the highest percentage favoring such a system, followed by respondents in academic institutions. More than two-thirds of the State government respondents were undecided; however, their principal concern was that the costs to implement and operate the system might exceed their available resources. Respondents from the business community were most equivocal: 35 percent saw no need and another 18 percent were undecided.

Almost all respondents were mindful of and concerned about the possibility that an improved materials information system might be misused to "manage" the American market system. They were similarly concerned about providing sensitive data to an overall open system.

Table III-12 summarizes the important functions of an improved system that were identified by the different categories of respondents. The most commonly stressed functions directly related to improving supply and

Table III-9.—Reported Coverage of Aluminum Data Bases by Component of the Materials Cycle

Contact	Resources	Reserves	Mining	Import Export	Refining	Smelting	Fabrication	Manufacturing	Consumption	Recovery	Stockpile	Inventory	Sample Size
Dept. of Commerce	–	–	–	A-D	–	A-D	A-D	A-D	A-D	A-D	–	A-D	3
Dept. of Interior	A-W/ M-W	A-W/ M-W	A-D/ M-W	– / M-D	A-D/ M-D	A-D/ M-D	A-D/ M-W	A-D/ M-W	A-D/ M-D	A-D/ M-D	– / M-D	A-D/ M-D	7
GSA	–	–	–	–	–	–	–	–	–	–	A-D	–	1
State agencies	–	–	–	–	–	–	–	–	–	–	–	–	12
Industry, large	–	A-W	A-W	A-W	A-W	A-W	A-W	A-W	A-W	A-W	–	A-W	4
Industry, small	–	–	–	–	–	A-D	A-D	A-D	–	A-D	–	–	20
Trade associations	–	–	M-W	M-D	M-D	M-D	M-W	M-W	M-W	M-W	–	–	7
Universities	–	–	–	–	–	–	–	–	–	–	–	–	8

M – Manual A – Automated D – Domestic W – Worldwide

Table III-10.—Accuracy of Aluminum Data Bases

Category	Estimated Accuracy (Ye)	Source of Estimate
Resources		
Alunite and Aluminum-bearing clays	50	DOI–USGS
Kaolin	60	Georgia Inst. of Technology
Reserves	Uncertain	DOI–BOM
	90	State of Georgia
Mining	90	DOI–BOM
Refining	90	DOI-BOM
Smelting	95+	DOC
Fabrication	95+	DOC
Manufacturing	95+	DOC
Consumption	95+	DOC
Recovery	95+	DOC
Stockpile	95+	GSA
Import–Export	95+	DOC
Worldwide Production & Trade	80	DOI–BOM
Energy	80	Battelle (for BOM)

demand projections. Like the senior level executives interviewed, they also saw the need for the indirect functions. Table 111-13 shows the comparative level of their concern, vis-a - v is those expressed by the senior executives.

E. FOREIGN MATERIALS INFORMATION SYSTEMS

An indication of the status of several foreign government materials information systems was obtained through limited discussions with system designers and planners in Canada, Japan, France, the Organisation for Economic Cooperation and Development. and the International Institute for Applied Systems Analysis. As in the United States. most of the foreign systems are oriented toward development of comprehensive data bases on materials properties and provision of 1ibrary -type abstracting and searching services, rather than toward support of such policy issues as shortages.

One of the most comprehensive systems is that operated by the Centre for Geoscience Data in the Canadian Department of Energy, Mines and Resources. The Centre is the focal point for inquiries and cooperation among

Table III-11.—Aluminum Community Perceived Need for an Improved Materials Information System

Segment of Aluminum Community	Anticipated Need for Improved System			Factors Cited Prompting No/Undecided Responses
	Yes	No	Undecided	
industry	10	8	4	Additional burden of complying with new reporting regulations. Additional cost would not justify small gain to business Concern for increased government involvement in business Trade association and government supply satisfactory data for present needs
Universities, not-for-profit	9	—	5	Undecided until service costs are established
State government	3	—	7	Lack of funds to utilize such a system
Federal Government	7		3	Concern that data bases might be taken from operating agencies

government, universities, and industry, It maintains an index of reports, maps, and data files which it publishes annually. It also attempts to monitor research and development. It has taken the lead in developing standards for reporting geoscience data on mineral and fuel deposits, In its current configuration, index entries are performed online through computer terminals which are located throughout the country. Future plans look to full online interactive access, for input and output. In addition, consideration is being given to expanding the coverage of mineral and fuel types.

In Japan, the country's heavy reliance on foreign raw materials has spurred development of materials analysis techniques. The principal agency responsible for monitoring industrial activities, forecasting industrial outlook, and developing industrial development plans is the Ministry of International Trade and Industry (MITI). Because of the traditionally high level of industry/government cooperation, MITI is able to acquire inventory and production statistics that are considered to be highly reliable, MITI is actively developing econometric models for interrelating production factors and making forecasts; however, it appears that much of this work is still in the experimental stage.

With regard to scientific and technical information, the Japan Information Center of Science and Technology acts as the central organization. The Center carries out collection, regulation, and dissemination of information. It selects important articles, records and classifies them, associates key words, and generates secondary information, The Center also acts as a channel for the exchange of scientific and technical information with other countries. To improve these operations in the face of growing volume, diversity, and demand for information, the Science and Technology Council has developed an approach for a new system called NIST, the National Information System of Scientific and Technical Information, NIST will systematically integrate various existing information collecting organizations into a nationwide network. Increasing emphasis will be placed on participation in international information exchange activities. As currently envisioned, NIST would comprise a central coordination function for the efficient operation of the system as a whole; a processing function to carry out specialized data collection and data processing; and a service function to handle contacts with users, i.e., receive various inputs and furnish information. The processing function, in

Table III-12.—Functional Requirements Cited by Aluminum Specialists

Functional Requirements	Segment of Aluminum Community															
	Industry							Academic		Government						
	Primary Producers	Secondary Industries	Small Business	Other Business	Industry R&D Fac.	Financial Institution	Trade Associations	University	Not-for-Profit	States	USGS	BOM	GSA	DOC	NSF	Federal Research Fac.
Supply																
Resources inventory	×						×			×	×	×				
Reserves inventory	×									×		×				
Strategic stockpiling	×	×					×						×			
Economic stockpiling	×	×				×	×						×			
Industrial stocks	×	×				×	×									
Imports monitoring/ control	×	×				×						×		×		
Recovery monitoring/ recycled materials	×	×		×	×		×					×	×			
Supply forecasting	×		×	×	×	×	×		×		×	×				
Utilization																
Production rate	×	×	×									×				
Production capacity	×	×	×									×				
Consumption rate/patterns	×	×	×	×										×		
Exports monitoring/ control	×	×	×											×		
Demand forecasting (rate of materials demand)	×	×	×	×	×	×	×		×			×				
Indirect																
Price	×			×								×	×	×		
New technology	×							×	×						×	×
Research and development	×	×			×		×	×	×	×	×	×			×	×
Materials substitution									×							
Environment	×				×		×		×	×		×				×
Energy	×				×				×	×	×	×				
Investment capital	×	×														
Producer inventory (location, etc.)					×	×	×							×		
Transportation Manpower	×			×	×	×	×					×				
Consumer product safety/hazards	×				×		×		×		×	×				
Marketing	×	×	×	×			×						×			

Table III-13.—Level of Concern for the Indirect Functional Requirements

Additional Functional Objective	Senior Policymakers (Government and Private)	Aluminum Materials Community (Government and Private)	Aluminum Business Community (Industry Only)
Price and forecasting	Critical	Critical	Critical
Research and development	Critical	Critical	Critical
Materials substitution	Serious	Serious	Serious
Energy	Critical	Critical	Serious
Environment	Critical	Serious	Serious
Capital investment	Serious	Serious	Critical
Transportation	Moderate	Serious	Critical
Manpower	Moderate	Serious	Moderate
Producer inventory	Serious	Moderate	Serious
Marketing	Moderate	Serious	Critical
Consumer product safety	Moderate	Moderate	Moderate

Notes:

Critical — functional objective must be addressed in improved system.

Serious – functional objective deserves strong consideration as an important part of an improved system.

Moderate — concern expressed by only a few respondents; deserves attention as functional objective after critical to serious functional objectives are addressed.

particular, would require high-level data processing methods using computers for collection, regulation, analysis, evaluation. and forecasting. The NIST plan is still under study by the Government.

In France, scientific information related to materials, particularly geological information, is collected, organized, and entered in a semiautomatic information system. In addition, much other technical information concerning materials (e.g., the engineering properties of materials, or data derived from original data in the data base) is already maintained in data banks. Data banks in some 50 technical centers are very detailed as far as engineering properties are concerned. The most complete is that developed for the building industry; it is fully automated and provides information on all the materials used in the building industry. As in Japan. because of the close relationship between industry and the Government, data for these data banks are easily obtained and is considered to be very reliable, Although much material based on this data is published, full access is restricted to individuals and organizations within the Government.

The Canadian, Japanese, and French representatives all expressed interest in an improved information system to address materials-related issues and expressed the view that such a system would fill important international and national needs. Its international aspect was echoed in the discussions held with the Organisation for Economic Cooperation and Development (OECD) and the International Institute for Applied Systems Analysis (IIASA). OECD representatives stressed the need to orient any improved system to user requirements, Because of the difficult technical problems in effectively coupling supply and demand data, they stressed that the information system concept should be limited in what it addressed, particularly in its early form. Further, they emphasized the need in fashioning such a system to build it top-down, demand-driven. Otherwise, those affected would be likely to maintain that change was unnecessary, un -

desirable, or impossible and would resist all innovation or modification. Currently. OECD collects materials data from many countries. catalogs it, and provides information and data (even copies of tapes) to countries requesting it. From time to time it has undertaken original studies relating to materials management (e. g.. Implications For industry of Changes in the Availablitity of Energy and Raw Materials and Their Prices, DSTI/IND/75-04 OECD).

The IIASA representative indicated that the international organization had need for a materials information system of the kind discussed, but that at present lacked funds for such a development. IIASA is planning to develop a model of world energy supply, demand, and use. IIASA considers that standardization of data as a means of interrelating relevant data held in diverse data banks ought to be a principal objective.

F. IMPROVED FUNCTIONAL REQUIREMENTS

Based on the composite findings of the literature review, the analysis of the interviews and, to a lesser extent on foreign contacts. a set of functional requirements that should be satisfied in an improved materials information capability was developed. Many of the functions were cited in these sources: others were newly identified. The set covered three kinds of factors: those that directly affect supply: those that directly affect utilization: and those that indirectly affect both.

1. Functional Requirements-Supply

These include:

- Ability to monitor and project inventories of resources.—Resources are the concentrations of natura11y occurring material deposits in or on the earth's crust. The principal data elements are the quantity of materials existing in specific deposits, their locations, grade of the ore, and site characteristics (overburden, deposit area. and thickness).
- Ability to monitor and project inventoric.s of reserves.-Reserves are those portions of the identified resources from which usable minerals and energy commodities can be economically and legally extracted at the time of the determination, Specific materials resources are classified as reserves if they are economically com - petitive with other materials in the marketplace. A controlling factor in determining reserves is the cost of extraction. Thus. a technological breakthrough that substantially reduces the extraction costs of an ore hitherto not considered economically minable could drastically change the quantity of reserves. Accordingly, the principal data elements of concern are those related to quantity and extract ion costs, i.e., basic reserves information for each material must be provided in terms of the current estimate of reserves at specified costs of extraction.
- Ability to monitor and project industrial stocks.-Stocks cover material in process and stored for normal future use, including both raw and finished products. Data elements are concerned with the quantities, types, and locations of inventories.
- Ability to monitor and project inventories of strategic stockpiles.—Stockpiling refers to the diversion (from any part of the materials cycle) and temporary storage of materials to maintain a supply that can be used to avert critical shortages caused by natural or man-made supply interruptions. In accordance with legislation, a strategic stockpile has been maintained by the General Services Administration to maintain sufficient supplies of materials that affect national defense. The data elements required for strategic stockpiles are the quantity of materials, their nature (ore, semifinished,

finished), and the rates at which they approach or depart from their objective levels.

- Ability to monitor and project inventories of economic stockpiles.-In contrast with strategic stockpiles, economic stockpiles seek to effect better materials distribution for peacetime public purposes. Although none has yet been implemented, the concept is under consideration. The data elements are similar to those of strategic stockpiles; however, since their effectiveness and operation are more intimately tied to price variations, they need to be monitored more frequently.
- Ability to monitor and project levels of imports.— Understanding the changing patterns of imports is clearly important to private and public materials managers. The key data elements are quantity of materials imported, their nature (ore, semifinished, finished), and rate of importation.
- Ability to monitor and project the level of recycled material s.—Material that is recovered (and recoverable) from discarded products is becoming increasingly important as a source of supply. Recovery occurs in many phases of the materials cycle. Runaround scrap is the intraplant recycling of scrap material in fabricating plants. New scrap is that material recycled to fabricating plants from manufacturing operations. This material is generally clean and can be readily used by primary mills; old (or dirty) scrap is that material recovered from used end products. The data elements necessary to monitory recovery include the product descriptor (item, material, the location of the scrap, by district and site), its quantity, and data on recovery costs.

  Potentially recoverable materials refers to that materials for which technology exists for separating specified materials from used end products, but for which costs preclude practical recovery at this time. Irrecoverable material is that material in end products for which a recovery technology does not exist. To determine the recycling potential of materials in current use and to analyze the impacts resulting from changes in recovery patterns, the required data elements are the recovery capability of materials by end product, by industry, and by geographical region.
- Ability to forecast total supply.—Total supply is the aggregate of materials in reserves, materials in stockpiles, materials being imported, and materials recovered after use. The reserves provide an indication of long-term supplies; imported and recovered materials together with stockpiled materials constitute short-term supplies. The ability to combine current and forecasted levels to achieve meaningful estimates of total supply depends on developing consistent units of measurement, taking into account possible temporal differences among them.

2. Functional Requirements-Utilization

These include:

- Ability to monitor levels of materials being produced and producible.—Production is the process of converting natural deposits into marketable products, i.e,, transforming primary ores to intermediate products to manufacturing of end products. Production capacity refers to the amount of materials that could be produced at each production step if the Nation's plants were fully utilized. Knowledge of available production capacity is needed to assess the ability of domestic production facilities to expand as needed.

  The required data elements vary with each stage of the materials cycle. For mining, for example, they cover location (to site level), characteristics of the products and byproducts, quantity of each product and byproduct, supplies used (energy and materials), resources needed to build. maintain, and operate the plant, and related economic data, For manufacturing, they cover the materials in end products, location (special districts and site level), capacity, quantity and types of byproducts, supplies used (energy and materials), resources required, and economic data,

- Ability to monitor levels of materials consumed in end products.-This refers to the rate of consumption of materials delivered to consumers. Of prospective concern is the amount of a specific material contained in each product, the product service life, and the manner in which the material is incorporated in the product. Although few such statistics are now available, they could be important for efficient recycling and product disposal. Data elements for the consumption component are the product (market category, Standard Industrial Classification, and item), location by special districts and site, and the quantity produced.
- Ability to monitor levels of exports. -As with imports. understanding patterns in materials exports is clearly important. The rate of exports reflects the ability of domestic firms to compete with other nations. Increasing exports of critical materials (as materials or products) is of concern to materials managers because of the possibility of domestic shortages and/or increased domestic prices. With effective monitoring and forecasting. suitable actions might be taken to minimize these potential impacts. The data elements needed for monitoring exports are similar to those for imports.
- Ability to forecast total demand-This refers to the ability to project total demand, aggregating future domestic requirements, and export opportunities. Although inherently difficult (the Paley Commission projections are a case in point), this capability is essential for anticipating potential shortage situations.

3. Functional Requirements-Supply/ Utilization

The initial set of prospectively useful functions also called out a series of other capabilities having to do with interrelateing price effects and several other factors. These include:

- Ability to merge separate supply and utilization information to forecast the impact of price on supply and demand.-Changes in the market price of a product clearly can change the supply available and the demand for it. In the past it was generally assumed that supplies of materials for products in demand would become available with suitable price increases. Recent events have shown that this may not hold under conditions of scarcity. Each material has a unique supply and demand price elasticity. whose range depends on a complex array of factors. Observing and recording changes in supplies, demands, and prices of critical materials could aid in developing improved methods for quantifying their relationships.
- Monitoring research and development programs. -This capability refers to improving the availability y of information on current materials research and development and maintaining data on new technology which might impact the availability of critical materials, A 1 ink between knowledge of the broad range of existing R&D programs and awareness of materials problems is essentia1 to materials management policy; often new R&D programs must be implemented and other programs redirected. A better information mechanism might increase the effectiveness of Government R&D programs by ensuring that they address critical materials problems, Data elements

for monitoring materials R&D activities include a registry of experts in materials science and engineering and the status of materials research programs.

- Aiding in selection of substitute materials.-This refers to the complex process by which users of materials select one material over another and modify their choices as a material comes into short supply. Materials policy planners, as well as engineers and producers, need to understand the options available for substitution. The process is fundamentally dependent on the availability of information,
- Monitoring environmental impact and energy use.—This capability refers to analyzing the consequences of implementing environmental protection programs, including the use, elimination, and replacement of specific materials, and to the analysis of the energy consumed by processes in the stages of the material cycle. Data elements for environmental monitoring include pollutant by type, amount per unit production, and media for disposal; for energy use, they include energy consumption by manufacturing process per unit production and by end product when used by the consumer,
- Monitoring availability of investment capita l.—As demonstrated by Cooper's analysis of the Paley Commission projections, the availability of investment capital is a fundamental variable in projecting future suppliers. Information elements on the relevant variables might be assembled which would enable analysts to get a better handle on this factor,
- Monitoring and projecting availability of transportation.—Transportation capabilities significantly affect materials supplies. Information on current and future capabilities are required.
- Monitoring and projecting availability of manpower.—Availability of a trained labor force can have direct bearing on materials policy options. Information on current and projected levels are needed.

G. INTEGRATION OF FUNCTIONAL REQUIREMENTS

Perhaps the most important finding of the literature review and the interviews was that materials decision makers need to interrelate more effectively the various elements of data available to them. They require an information system structure that displays the interaction of the many factors determining materials flow through the cycle, even more important than obtaining more complete data. In effect, the improved capabilities needs to be organized to illuminate the dynamic flow of material through the materials cycle. Such an organization could indicate the availability of a material at each stage in the materials cycle, By examining the flow pattern, i.e., by having information and analysis of conditions at each stage in the cycle, the Federal policy maker could determine the severity of a problem and, if it were sufficiently serious, how it might be averted or relieved and at what cost.

These operational characteristics are akin to those that occur in many physical control systems, In an electrical distribution system, for example, input disturbances (perhaps a sudden increase in demand caused by a summer heat spell) are continuously monitored and compared with system capacity. The difference is used to signal or trigger corrective actions, such as putting another generator online or drawing additional energy from another power pool. In dealing with dynamic, physical problems, one must first characterize the control system i.e., describe how the individual elements within the system affect each other, For example, how do weather conditions affect demand, or how does capacity vary with the number of generators online, These interrelationships are the so-called subsystem transfer functions, The control system is normally represented in the form of a func -

tional block diagram in which the blocks depict, in mathematically precise form, the action of each element in the physical system.

The dynamics of material flow and the control options for dealing with disturbances to normal flow are more complex than for most physical systems. Monitoring all the relevant variables is clearly more difficult, as is defining the various interrelationships in precise, mathematical form. Yet the principle is essentially the same, and the block diagram concept is useful for describing the way the individual functions can be usefully organized,

Figure III-4 is illustrative, The individual blocks in the diagram depict information requirements at each stage in the materials cycle and correspond to the functional requirements described earlier. The arrangement of the blocks and the way they affect each other simulate the overall behavior of the materials system. The level of detail required in such a functional block diagram depends on its intended use. For providing aid to Government policymaking, the data can be aggregated to a high level and the number of functional blocks and interrelationships can be kept to a relatively small number.

The simplified diagram describes the flow of a single material; in actual practice, it would comprise a similar set of interconnected functions for each critical material to be covered. The block diagram may be viewed as another way of depicting the flow of materials through the materials cycle: it simply superimposes on the physical flow of material the flow of the information that directs it.

The blocks are of three kinds: those that depict considerations affecting supply; those that depict utilization considerations; and those that treat their interrelationships.

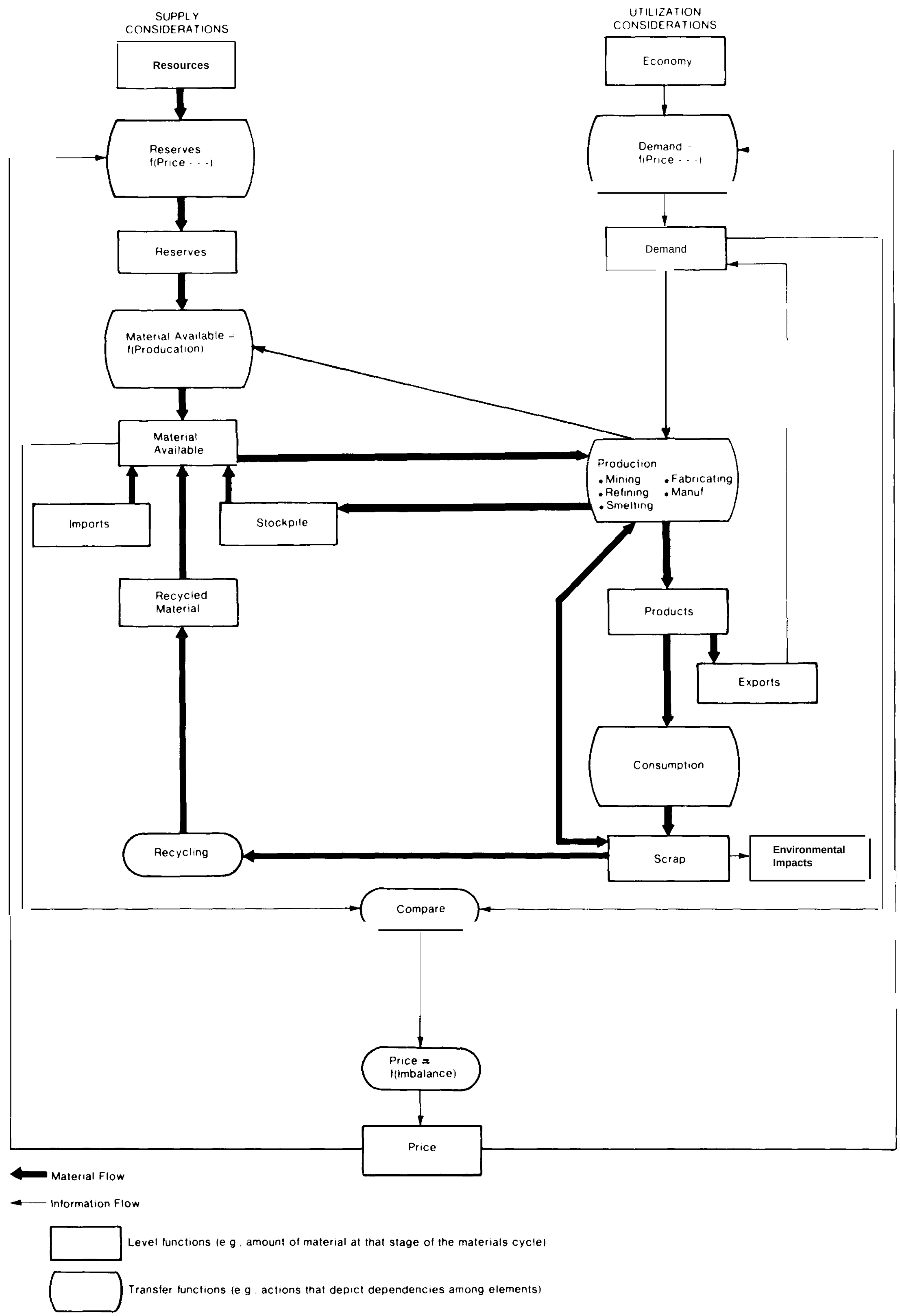
1. Supply Considerations

The first supply considerations shown in figure III-4 are the functional capabilities for monitoring and projecting levels of resources and reserves, As an improved set of in formation capabilities might be organized, this information might be collected and held in multiple, compatible data bases, As with other data bases implicit in this kind of framework, it is not required that all of this information be held in one place, only that it be so organized, standardized, and aggregated that all of it can be accessed when needed by authorized users. The framework also shows the capability to determine levels of materials made available through production processes, This function accounts for the levels of materials processed from reserves; these, in turn, depend on the level of plant capacity employed and other factors.

Other supply considerate ions, shown in figure III-4 include the capabilit y to monitor and project levels of normal industrial stocks and any strategic and economic stockpiles maintained by the Government, This information would be stored in appropriate standardized data bases. Similarly, the framework would monitor imports and incorporate techniques for projecting future foreign supplies. Such unpredictable perturbations as embargos might be handled by building in blocks corresponding to different sets of contingency scenarios. The framework would also monitor and project levels of materials that become available through recycling. All of these contributions to supply would be appropriately summed. The organization would thus continuously monitor and project total materials availability y.

Two functionally different kinds of supply blocks are shown in figure 111-4. The rectangles show the levels of supplies in their various forms, for example “resources”. The rounded rectangles represent transfer functions which depict the dependency of one element on another. Thus, the box marked “Reserves = f (Price. . .)” indicates that resources become reserves through the pricing mechanism: as prices increase, subeconomic resource become economic to mine and thus add to reserve levels.

Figure III-4.—Basic Framework for Interrelating Elements of Materials Information



2. Utilization Considerations

Figure III-4 also incorporates the capability to project the demand for a critical material. In general the demand is a function of the price of the material and a host of other factors, including the level of general economic activity. The demand for a material. covering both its domestic and export components. determines the productive capacity to bring that supply into being. The project ion transfer function merges information on alL phases of activity involved in transforming ores into useful products. Examples of information associated with the product ion function include (1) the quantity of the primary material at each stage of production: (2) other materials used or produced (including waste products and by-products): (3) employment; (4) existing plant capacity: (5) lead time and cost for construction of new capacity; (6) transportation requirements: and (7) energy requirements.

The output of the production function are products, i.e$_j$, the end-use item(s) designed to fill specific consumer needs. By organizing information monitoring and projecting the consumpt ion patterns of a product, such as the useful 1ife and recyclable material content, the in formational framework is able to monitor and predict the available amount o f recycled material. As indicated in figure III-4, recoverable material also flows in forms of scrap from wastes generated in the production process. On the negative side. waste disposal is conceptually depicted as presenting environmental impacts which, in turn, affect the production function, price, and ultimately demand.

3. Supply/Utilization Interrelationship and Management Actions

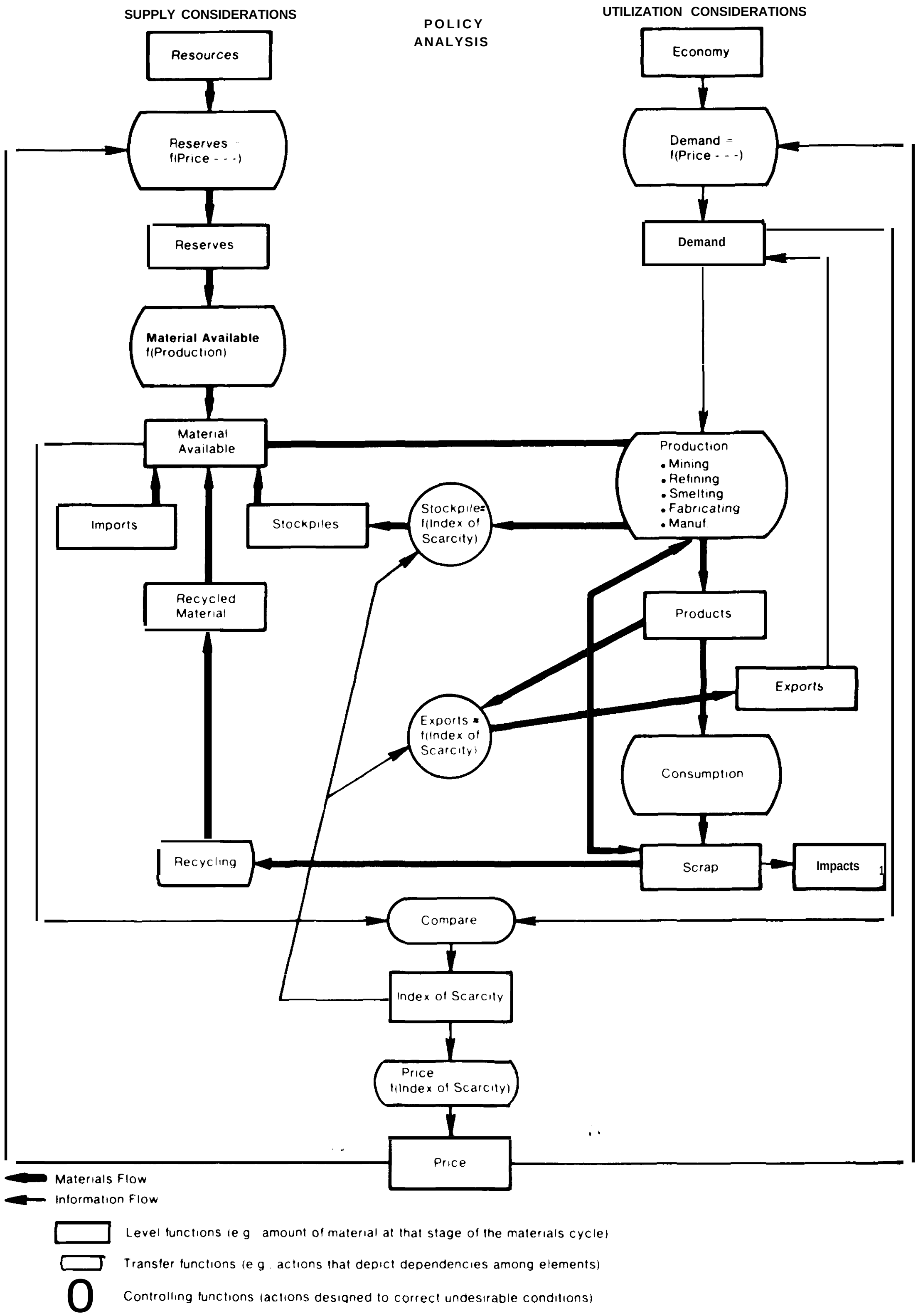
Also depicted in figure III-4 is the principal control act ion of the market system, the pricing mechanism. The framework compares material supplies with demand and adjusts price accordingly, feeding back the price incremen t to each block having a price sensitivity. Under normal conditions the pricing mechanism works to maintain a continuous flow of material through the cycle. However, if it does not, policy makers in the Government must decide whether or not action in the public interest is required. The improved functions and organizational framework would support this decisionmaking process by assessing the impacts of alternative policy options upon the flow of materials through the economic system.

Before using these improved capabilities, careful distinction should be made between three separate, though sequentially dependent, steps in the overall decisionmaking process: (1) data gathering and analysis, (2) policy analysis, and (3) policymaking. The improved capabilities might provide the capabilities to achieve the first two steps, but it would in no way attempt to achieve the third. Policy decisions would in all cases be the responsibility of the policy maker. The integrated framework would merely support his decisions. first. by collecting and analyzing data, and second, by using the data and analysis capability to address “what if” types of questions.

In depicting the internal control behavior of the market, as shown in figure 111-4, the framework would itself be an extremely useful analytical tool. However. its real value is its capability to provide information and analysis for policy makers to use in assessing the effectiveness of policy options the Government might take to relieve serious d islocations, Two examples of Government policy actions are shown in figure 111-5, One relates to Govern - ment stockpiles: the other. to the use of export controls as a means of addressing materials shortages,

In assessing whether a stockpile policy could avert or alleviate a shortage, Government policy makers could use the integrated capabilities —the individual functions and their organization along the lines of the framework—to test its effectiveness. The framework, in effect, provides the means for simulating its rippling effects on the materials system, By examining the benefits and costs of the stockpile policy, and by comparing this in-

Figure III-5.—Basic Informational Framework Showing Selected Policy Actions



formation with similar analyses of other relevan t policy options, the Goverment decision - maker could determine what policy, if any, might be required to solve the material problem. The analysis might well indicate that no Government action is required, and that the market system will self-correct.

The same kind of "testing" can be used for assessing Government actions with regard to export controls. also shown in figure III-5. Export embargos, an extreme form of export control, were implemented in the 1972–74 period, but for only short periods. They were hastily applied and hastily lifted, in part because their impacts, both positive and negative. on the materials flow pattern were imperfectly anticipated, By organizing all the relevant data and showing the interrelationships and feedback effects. the improved in formational capabilities could present a fuller picture of the impacts of such actions. The framework might enable more effective use of export controls; or it might show that the anticipated consequences are such that Government action is unnecessary.

In general. the need for any kind of Government action arises whenever an unacceptable condition occurs or is projected to occur in the material flow pattern. As envisioned in this framework, this condition will be signalled when a computed index of scarcity exceeds a prescribed level. The index of scarcity, as shown in figure 111-5, could take many forms. It might be a price threshold: if the projected price change is too high, for example, remedial act ion might be required. Another measure, particularly useful for long-range materials policy analysis, might be the "time-to-exhaustion" of the materials, In practice, a set of different, unique indices (trigger points) would be adopted for each critical material, reflecting the existing pattern of flow and the potential disturbances that might interrupt that pattern.

Indicative of the more complex forms of policy analyses to which the improved capab i 1 i t ies might be applied, figure III-6 shows how it might be conceptually structured to assist policy makers in analyzing the potential of material substitution to relieve shortage conditions. The key points of initial impact in the materials cycle are the material availability y and production functions. As shown in figure III–6, materials A–E represent the candidates for substitution. The framework could evaluate their impacts on other materials (F–I) utilizing the demand function as the transfer mechanism. The system would show changes in demand for each material (F–I) caused by each candidate substitute material (A–E): it would then evaluate the changes throughout the other materials cycles (F–I). This kind of information would enable the substitution analyst to determine which candidate material has the greatest potential for relieving the shortage. Of course, a host of factors not explicitly shown in the figure also affect the analysis and need to be factored in. e.g., the environ mental impact of each substitute would have to be evaluated. Other substitution considerations are discussed in appendix A,

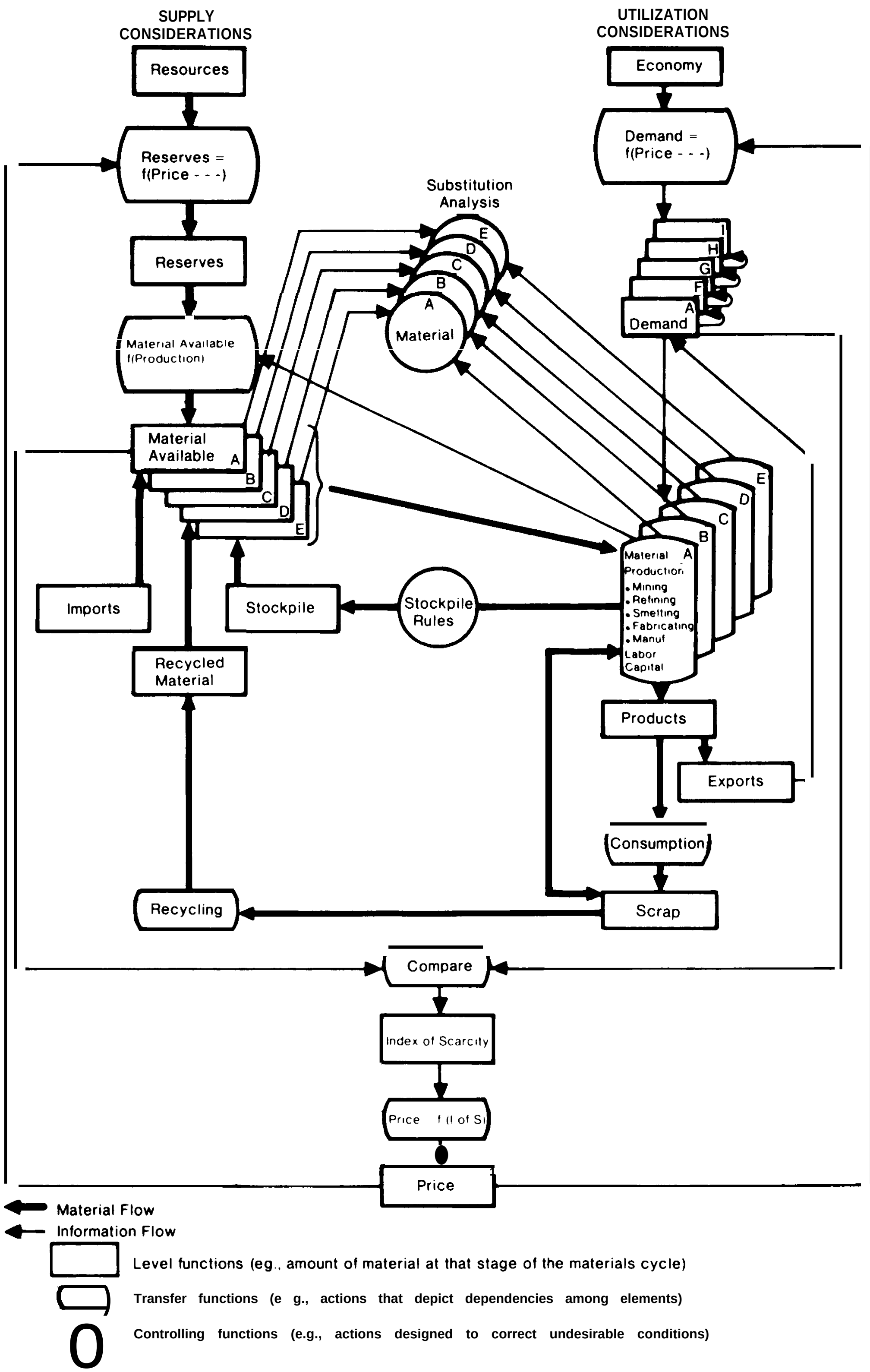
4. Evolution of Capabilities

It is important to recognize that it is not necessary to incorporate all of the individual functional requirements discussed in section F into the conceptual framework at one time. Rather, the framework could evolve, first incorporating the level functions and transfer functions that are best understood, and later adding other functions whose developments will take more time to perfect.

Considering (1) their relative importance in depicting materials flow, and (2) the state-of-the-art for obtaining the relevant data and defining the associated transfer functions, the assessment suggests that the following basic functional capabilities ought to be initiall y implemented:

- Monitor and project resource inventories,
- Monitor and project reserves inventories,
- Monitor and project industrial stocks,

Figure ill-6.-Basic Informational Framework Applied to Materials Substitution



- Monitor and project stockpiles (strategic and economic),
- Monitor and project imports,
- Monitor and project recycled materials.
- Forecast total supply,
- Monitor and project materials produced and production capacity,
- Monitor and project material consumed in end products,
- Monitor and project exports,
- Forecast total demand, and
- Forecast price impact on supply and demand.

If implemented within the integrated framework described here, these functions could provide substantial capability to assist policy makers in addressing such questions as:

- Will a shortage in a particular critical material occur, and when ?
- Where will the impact be felt most severely ?
- How might affected industries act to ease the resulting economic distortions?
- What other measures (conservation, stockpiling, expanding productive capacity) might be adopted?

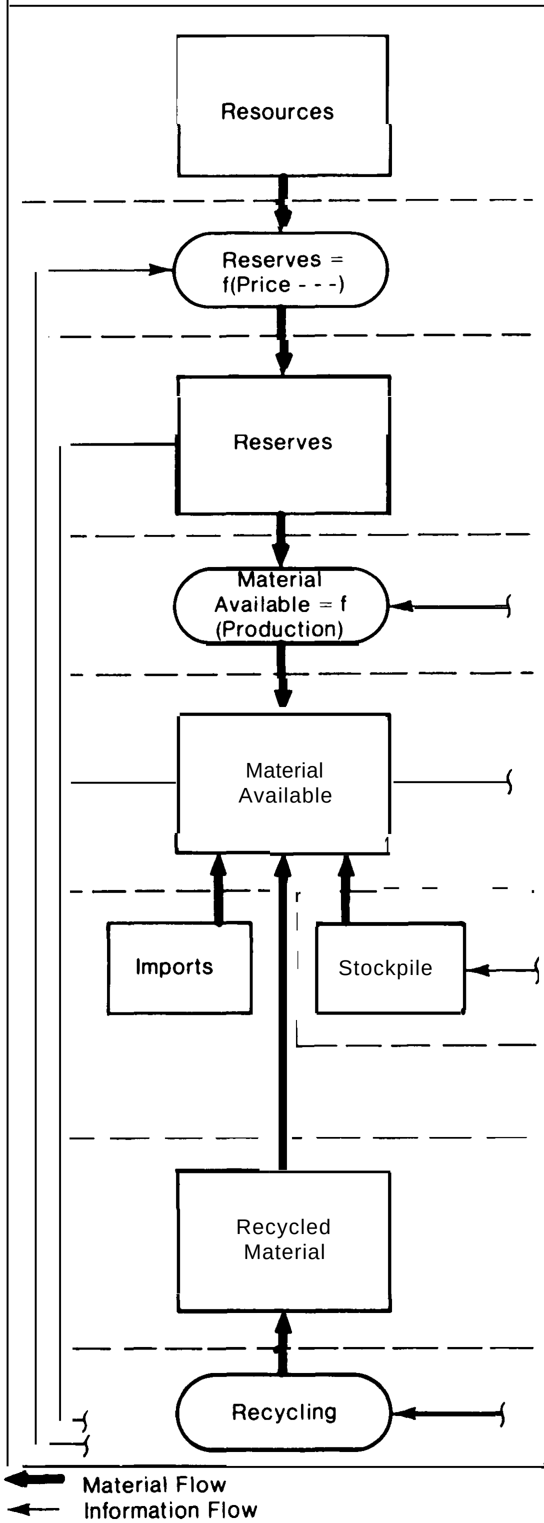
The basic functions are all deemed to be implementable within the current state-of-the-art. Acquiring all the necessary information will present problems, but much of it appears to be available, at least for certain materials, as indicated in figures III–7 and III–8 covering aluminum. (In this connection, it should be noted that the assessment did not attempt to select the specific materials that might be included within the conceptual framework. The number of materials covered might be of the order of 50. For comparison, the President's Council on International Economic Policy identified 19 materials as critical.)

The set of functional capabilities that might be added later to the basic set could enable policy makers to address more complex problems than would be possible with the basic set. The supplemental set might provide. for example. the capability for a more accurate and comprehensive impact assessment of policy alternatives. Thus, policy makers could address regional analysis, worldwide materials supply/use assessment. comprehensive intercommodity substitution analysis, and the implications of such operational considerations as transportation requirements. availability y of capital, and availability of trained manpower. Also, policy makers using a supplemental set of functional capabilities might be able to assess the potential impacts and restraints of national policies related to employment. protection of the environment, and conservation of energy.

The assessment identified the following functions which could be added to the basic set:

- Monitor and project foreign supply and utilization. This function would supplement the basic functions that monitor and project inventory of domestic resources/reserves and imports/exports. It would seek to acquire and utilize data on foreign resources and reserves and on trade between foreign countries to a greater extent in the equilibrium analyses.
- Monitor and project environmental impact and energy use. This function would acquire the necessary data on energy use throughout the materials cycle and would show the relationships and trade-offs among production, price, environmental impact, and conservation, among other variables.
- Project recycling potential. This function would supplement the basic function covering recycled material. Whereas the basic function covers the established recovery industry. this function accounts for the potential of additional recovery using advanced technologies not currently used. It also could be used to evaluate the effectiveness of incentives to encourage such advanced technologies.

Figure III-7.—Aluminum Information Sources for Supply Functions

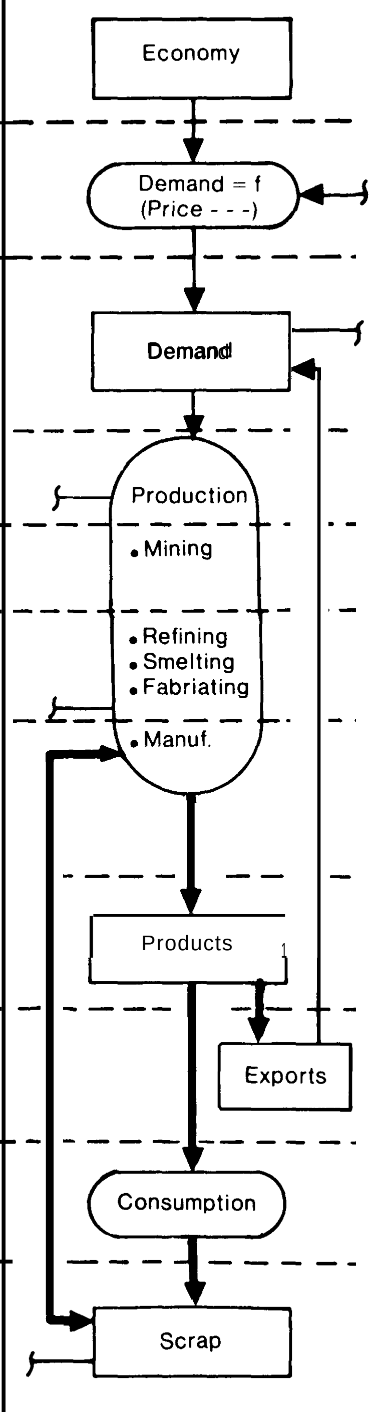


Information	Source: Government	Source: Private
Resource and Site Characteristics	GS DOA	
Reserves Classification	GS BOM	
Quantity of Reserves	GS BOM	Industry
Quantity Mined and Capacity of Mining	BOM	
Quantity of Material Available (Annual-Short and Long Term)	DOA DOM OMPD	
Inventory of Stocks	BOM GSA	Industry Aluminum Assoc.
Quantity Imported	Customs Census	Aluminum Assoc.
Quantity of Material from Scrap	BOM	Industry Aluminum Assoc. Aluminum Recycling Assoc.
Recycling Process		Industry

Figure III-8.—Aluminum Information Sources for Utilization Functions

Information	Source: Government	Source: Private
State of U.S. Economy (GNP, and Sectors)	DOC (Sic)	
Price Impact on Demand	DOC FEA EPA	
Quantity of Material Demand, Annual	DOC (Short term)	Aluminum Assoc. Industry
Mining Processes Quantities Mixed	BOM	Industry
Primary Material Production and Capacity	DIBA Bur. of Census	Aluminum Assoc. Industry
Manufacturing Processes, Production and Capacity	Bur. of Census DIBA	Industry
Annual Quantity of Material in Each Product	DOC	Industry
Material Exported, Annual	Bur. of Census	Aluminum Assoc. Industry
Useful Life of Products		Industry
Quantity of Material In Discarded Products		Industry

UTILIZATION



~ Material Flow

+- Information Flow

- Monitor research and development. This function would factor research and development information into the supply/utilization analysis, thereby improving its accuracy and realism. The tie-in between the R&D information systems and the economics-oriented system would also be useful in indicating objectives for improved technology. Thus, if the overall system indicated a materials shortage in say, nickel, R&D opportunities and programs could be evaluated in light of the seriousness of the threat. Data on results of current research, along with data on scientific manpower, such as availability and current research interests, would also aid in the formulation of R&D programs to address identified problem areas, The extended function might also provide a basis for better judging as to whether or not R&D could affect a perceived shortage within a given lead time.
- Determine substitutability. This function would enable analysts to consider more completely the effects of substitution of one material for another, Another possibility is to combine this function with an information system covering physical and chemical materials properties to achieve a computer-assisted materials selection system, This would enable planners and users to evaluate the merits of using one material in place of another, taking into account economic conditions as well as technical properties. As detailed in appendix A, it appears that much of the information needed for such a system is identical with that needed for a general purpose materials planning system.
- Monitor availability of investment capital, transportation, and trained labor. These factors all impact long-range supply. Elaborating the basic system to incorporate their effects increases the overall accuracy of solutions and would enable policy makers to address more detailed and more subtle aspects of materials flow.

H. SUMMARY

In establishing whether a need exists for significantly improved materials information capabilities, objective quantitative criteria are preferred. Unfortunately, this is not possible. Like other problems in the public policy area, analysis of information systems is hampered by the absence of a recognized, theoretical framework covering the economic value of information. In theory, to the extent that information provided by a materials information system reduces uncertainty, it contributes to more risk-free and, thus, more effective decisionmaking. In practice, however, the decisionmaking process, even in a relatively straightforward industrial situation, involves so many other factors blurring the contribution of the information element that attempts to quantify the value of information are rarely conclusive. They become even more clouded when attempted in the Government policymaking area.

In the absence of purely objective standards, this assessment drew on the experience of informed specialists, as expressed in reports of materials study groups, congressional activities, and a series of interviews with materials executives and managers. The overall conclusion to be drawn from this body of experience is that current systems are not adequate and that new improved capabilities would enable materials managers, particularly in Government, to do a better job,

The assessment also pointed to two other considerations. First, it emphasized the indispensable need to better interrelate the various factors bearing on materials supply and demand. Policy makers need to know where relevant data exists. They need to be able to compare the data on a consistent basis, regardless of the data sources, and they need to be able to merge data from different data bases for comprehensive materials-flow analyses. Second, the study confirmed the view that to achieve the needed. improved capabilities, a systematic view of the materials information problem is required. Individual information systems that currently deal with limited aspects of the overall materials problem must be seen in perspective as sub-systems, and improvements to each must be undertaken within the context of a coordi - nated, overall, plan.

The assessment developed a conceptual information framework that might serve as the basis for such improvements.

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