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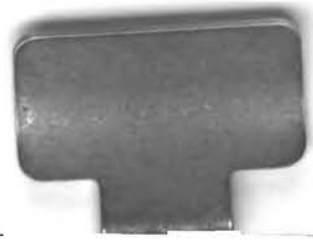

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IDENTIFICATION OF CRITICAL AND STRATEGIC MATERIALS FOR NAVAL COMBAT SYSTEMS

Report of the

Panel on Identification of Critical and Strategic Materials for Naval Combat Systems

of the

Committee on Technical Aspects of Critical and Strategic Materials

NATIONAL MATERIALS ADVISORY BOARD
Commission on Sociotechnical Systems
National Research Council

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The report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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The National Materials Advisory Board is a unit of the Commission on Sociotechnical Systems of the National Research Council. Organized in 1951 as the Metallurgical Advisory Board, through a series of changes and expansion of scope, it became the National Materials Advisory Board in 1969. Its general purpose is the advancement of materials science and engineering in the national interest. It fulfills that purpose by providing advice and assistance to government agencies and private organizations on matters of materials science and technology affecting the national interest, by focusing attention on the materials aspects of national problems and opportunities, and by making appropriate recommendations for the solution of such problems and the exploitation of the opportunities.

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ABSTRACT

The Panel on Identification of Critical and Strategic Materials for Naval Combat Systems was charged to "critically examine the Navy's needs for a data base regarding the quantity of critical and strategic materials it will require for the next generation and future Naval Combat Systems." To this end the panel reviewed current practices in government and industry. It was concluded that the Navy's needs are, to a considerable degree, common with those of the general U.S. military and industrial economy. Therefore, no special Navy-oriented system is needed. The Navy's specific requirements are included in the existing FEMA monitoring system and require only continuing liaison to assure currency of needs. In developing these needs the panel concluded that a "top-down" approach where experts make estimates using various supply and demand sources is preferable to the costly "bottoms-up" approach requiring scrutiny of every piece part. The panel also advises the inclusion of upgraded forms of materials and finished components if bottlenecks under "surge" production are to be avoided.

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An additional contribution was made, at one of the panel meetings, by Preston N. Shamer, Manager, Advanced Naval Programs, Government Systems Division, RCA, Inc. His discussion covered the important area of electronic materials.

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CONTENTS

CHAPTER 1

BACKGROUND

The Panel on Identification of Critical and Strategic Materials for Naval Combat Systems of the National Materials Advisory Board Committee on Technical Aspects of Critical and Strategic Materials was appointed to respond to the Department of the Navy concerns regarding the availability of materials for future combat systems. Panel members from a variety of backgrounds and different types of organizations were selected to provide the broad range of expertise needed to conduct a truly multidisciplinary study.

The panel was initially charged to "critically examine the Navy's needs for a data base regarding the quantity of critical and strategic materials it will require for the next generation and future Naval combat systems."

The panel approached this task by collecting and analyzing information on past and current efforts directed toward the development of materials monitoring systems. In addition, at panel meetings, 13 representatives of industry and government described their experiences in developing or operating materials monitoring systems. All of this information, as well as the experience and judgment of the panel members, formed the basis for this report.

The report pulls together in capsule form major findings from the panel's many discussions and interactions with numerous interested parties. It presents a consensus of a number of important issues brought to its

attention in the course of its deliberation. The panel acknowledges the efforts of all those who participated in the study, and the close interaction of the sponsor's representatives.

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

The early efforts of the Panel on Identification of Critical and Strategic Materials for Naval Combat Systems were devoted primarily to clarifying its charge and to broadening the scope of the study to encompass the wide range of factors that have an impact on materials availability. As a result of these efforts, the panel focused primarily on the need for a materials availability base, the uses to which such a data base might be put, the various types of data base that might be developed, the materials and material forms that might be covered, and the success or failure of previous attempts to develop such data bases.

Two vastly different approaches to materials monitoring have been used: top-down and bottom-up. The top-down approach starts at a global level by determining, through various supply and demand sources, total U.S. consumption of materials likely to become in short supply and that are likely to be consumed by the Navy. The bottom-up approach requires the collection of detailed bills of materials through all manufacturing levels and from all vendors and the subsequent identification and compilation of the types and quantities of materials involved.

The top-down analysis first identifies the critical and strategic materials upon which the economy and the defense of the United States rely; information available to the panel indicates that the most serious materials problems are already well known. The second step is to indicate which of these materials are being used by the Navy, as well as those likely to be used in the future. A direct consequence of this approach is to identify those materials likely to have availability problems so that the Navy can implement appropriate corrective action.

The bottom-up approach requires an extended effort to examine the bills of materials, even if limited to only the most important systems used by the Navy. Aside from the lengthy time and massive size of this effort, the level of accuracy would tend to be low. Moreover, there is no mechanism for identifying new and potentially critical materials not currently used.

The issues raised by the panel make it obvious that the Navy's planning and long-range procurement staff must be given the proper authority to act and have the flexibility to alter their course of action in response to changes forecast by a dynamic system. In a coordinated action, the responsible agency must have a technically competent staff that works closely with market analysts and life-cycle costing experts to identify and recommend the most appropriate alternatives available. Only in this way can the Navy make the most effective use of a system that clearly identifies the problem areas and points to the most promising approach.

The panel's major conclusions and recommendations are presented and discussed briefly below. Additional issues raised by the panel are presented following the conclusions and recommendations. Although these latter topics are somewhat beyond the scope of the panel's efforts, the group concluded that they represent matters that should be considered by the Navy.

CONCLUSIONS

The panel concluded that the Navy's materials availability problems are real, will continue, and should be addressed. It is generally accepted that the cornucopia of materials once available on demand to the United States no longer exists and that delays in the completion of weapon systems frequently result because materials or forms of materials are unavailable when needed. The nation's dependence on foreign sources for many critical and strategic materials makes it particularly vulnerable to supply disruptions that occur with little or no warning. An elaboration of this point is provided in the Appendix.

The technology used in combat systems is rapidly developing, and this can result in significant changes in demand patterns that quickly lead to unacceptable supply-demand imbalances. It also must be noted that the Navy competes with other demand sectors for available materials, and this competition is intensifying continuously.

An effective materials availability monitoring system obviously would play an essential role in such contingency planning; however, the panel concluded that the Navy need not develop a special system for its own use--primarily because its needs are very similar to those of the other military services and of the public sector of the economy.

The panel identified various materials monitoring systems currently used by government agencies and their contractors and subcontractors. Each is designed to meet the specific needs of its developer and none is oriented to monitor the availability of the broad spectrum of material forms specifically related to the weapon system needs of the Navy and the other military services. The panel concluded, however, that many of these existing systems could provide data that would serve as the basis for the comprehensive system deemed desirable. One system, developed by the Federal Emergency Management Agency (FEMA), appears to be a good core system into which components of the various other systems could be integrated to form a comprehensive system.

The FEMA system, currently used to determine the supply and demand situation for materials in the nation's critical and strategic stockpile, does not cover the highly upgraded or fabricated forms of materials for which the Navy must plan. The system appears to provide, however, a logical framework within which the availability and use of the elemental forms of basic raw materials can be considered. It does estimate in a reasonable

fashion the sensitivity of total consumption to military mobilization and those civilian uses that could be constrained without essentially damaging the country's military capabilities. The panel recognized the fact that the FEMA system makes no attempt to identify the critical semifinished or finished components for systems that were used by the agencies to generate their materials. These too are part of the total critical and strategic materials picture that could be considered for stockpiling. Nonetheless, this information-gathering system already in place contains adequate estimated data on supply and demand relevant to the top-down approach, especially for many basic raw materials needed for military consumption.

After examining prior attempts at materials monitoring, the panel has concluded that the effort required in the bottom-up approach, even if limited to only the most important systems, raises serious doubts about its feasibility or appropriateness, since literally millions of entries from thousands of suppliers and their many tiers of vendors would be required. In addition, the level of accuracy would tend to be extremely low, and new and potentially critical materials that are not currently used would not necessarily be identified.

The panel has concluded that the monitoring must recognize that the duration of availability problems varies (e.g., short-term shortages might result from a labor shortage, fire, or other uncontrollable event at a major supplying site; intermediate-term shortages might result because of the emergence of new technology that causes a severe demand on particular

materials; long-term shortages might result when demand and supply become imbalanced and are likely to remain so for many years). The Appendix reviews the causes of shortages and some of the actions that can be taken to mitigate the effects of such shortages.

There are numerous causes of materials availability problems (e.g., geopolitical, obsolescence, rapid technological changes, lack of manufacturing capacity, excessive lead times, price escalation, single-source suppliers, skilled labor shortages, and physical depletion), and information on each must be included.

RECOMMENDATIONS

The panel believes that the Navy could use its resources most effectively by cooperating in the development of a comprehensive national materials availability monitoring system that would serve a broad range of materials users by:

1. Establishing a task force composed of technically competent staff to further examine the FEMA system and formulating a plan of action for broadening it to serve the needs of the Navy and others.

2. Having FEMA require from agencies that employ other monitoring methodologies a listing of the critical components or systems that were the basis for their inputs of calculations for needed materials.

3. Working closely with market and life-cycle costing experts to identify the options applicable and recommend appropriate alternatives for selecting the Navy's critical semifinished or finished components or systems.

4. Using the "top-down" approach if any future attempts are made to develop a system. The number of critical and strategic materials at the elemental or raw materials level is likely to be small. Indeed, information available to the panel indicates that the most serious materials problems are well defined.

5. Identifying critical and strategic materials currently used, as well as those likely to be used in the future by a particular sector or for a particular application (e.g., a ship or plane). This can be performed by specialists who would be asked to estimate the materials required on the basis of several agreed-on scenarios.

Combining recommendations 4 and 5 would result in the identification of the materials that are likely to have availability problems. With this information, appropriate corrective actions could be implemented.

RELATED ISSUES

The panel believes that some related but very basic questions must be considered before any further effort is made to develop a monitoring system that forecasts impending problems:

1. Does the Navy have agencies in place that are able to make suitable response to a system that forecasts impending problems?

2. Although there are numerous possible responses (e.g., the use of substitute materials, the utilization of stockpiled materials, implementation of multiyear buying policies, and use of the authority of the Defense Production Act to divert material from nonmilitary uses), could the monitoring system's forecasts identify the most appropriate option, and could they do so early enough to permit implementation of the appropriate action?

3. Does the Navy, or any other government organization that would use the system, possess the expertise necessary for initiating and managing the prescribed action?

4. Would the costs required for implementing such a monitoring system be justified by the benefits obtained?

APPENDIX

CAUSES OF AND RESPONSES TO MATERIAL SHORTAGES

The causes of critical material shortages are numerous and complex and can affect any stage in the supply chain from the raw material to the end component or system. The most frequently cited causes of material shortages are discussed below.

Geopolitical

There has been much public discussion of the real impact of geopolitical considerations on availability of essential defense materials to the United States. It has been argued that no really serious impacts have been felt, that there has been no proven international foreign action taken to create shortages of materials essential to U.S. defense needs, and that potential enemies are driven only by economic necessity to provide the United States with needed materials. All of this is somewhat insignificant, since the nation cannot permit itself to be put into a position where crippling actions can be taken, whether or not there is any current intention to do so. The fact remains that the United States is import-dependent for many materials and, in a large number of cases, imports exceed 90 percent of total use. This condition must not be allowed to continue without strong countervailing policies, such as stockpiling.

Obsolescence

Much of the U.S. production capacity, particularly in the steel and aluminum industries, has become essentially obsolete. Economic conditions have brought about closing due to this obsolescence and low operating efficiency. Although some new updated facilities have been built, it has become increasingly expensive to do so because of inflation, rising interest rates, and the cost of meeting new environmental regulations.

Rapid Technological Change

New developments can easily strain the capacity of processors of certain critical materials. For example, heavy conversion to use of aluminum in U.S. auto production could well create major shortages of that metal (and a surplus of steel). On the other hand, the development of a new, lightweight, inexpensive container for liquids could strain the capacity of the substitute metal or plastic and at the same time create a surplus capacity of aluminum.

Lack of Manufacturing Capacity

A lack of manufacturing capacity may be created by a series of factors, including obsolescence of plants and equipment, the high cost of capital investments, and uncertain markets, which casts doubt on a manufacturer's ability to recover investments. The result, of course, is shortages of certain materials.

Excessive Lead Time

Excessive lead times are now required for various items, including forgings, castings, connectors, and semiconductors. This situation seems to have resulted from a combination of capacity limitations, high costs of expansion, and increasing levels of orders.

Price Escalation

Certain material prices have proved to be exceptionally volatile; recent notable examples are cobalt, tantalum, and the precious metals. Escalation rates on these materials have on occasion been several times the average rate of inflation and during severe supply disruptions could be many times greater. The panel believes that this factor needs to be considered in the government funding of weapon systems and could possibly be used to favorably influence government investment in research leading to alternate materials or methods for minimizing utilization of these products. In any event, a healthy R&D effort toward seeking substitutions for or reduced use of strategic materials would help provide alternative actions for implementation when the unexpected occurs.

Single-Source Suppliers

Often only one supplier has the technological or production capability to provide a given product. In some cases, this is due to patent protection of inventions (and properly so), but more often it is caused by the high

investment or technological development required to achieve a competitive position in a limited market. Although the existence of a single source for a given product can lead to shortage situations, the panel does not believe the government should assist in developing additional suppliers except when it is necessary to ensure that defense needs are met.

Skilled Labor Shortages

Materials shortages also can occur because of a lack of skilled labor. This has become more prevalent in recent years as many retiring skilled workers have not been replaced. New entrants to the workforce appear to be attracted to the high-technology areas (e.g., management, engineering, computer sciences) and the service occupations (e.g., teaching, counseling, and the social sciences), not the basic materials area. Until this trend can be reversed, shortages can be expected.

Physical Depletion

Most forecasts of impending physical depletion of raw materials on a worldwide basis over the past 50 years have proved to be inaccurate, but this does not lessen long-range concern since known economically exploited reserves and resources of several critical materials are at dangerously low levels. Although additional resources may be identified and new processing methods may be developed to better utilize low-grade or alternate ores, it nevertheless appears inevitable that there will be periods when demand cannot be readily met by the available supply.

RESPONSES

The response to critical material shortages are as numerous and complex as the causes. The most popular actions are reviewed below.

Conservation

Reduced consumption of critical materials is the most obvious and most direct action that can be taken when a shortage occurs. Thus, the panel believes the government should be in the position to identify potential critical materials and should judiciously fund conservation research in these areas, as well as initiate drives to encourage conservation and salvage.

Recycling

Large quantities of materials go to waste because recycling often is not economical. The panel believes that more research is needed to develop economical methods that will provide the incentive for firms and individuals to collect and segregate materials for efficient recycling.

Reclamation

Some strategic materials are unsuitable for recycling because of contamination and because of the forms in which they exist (e.g., mixed wet

grinding dust in the superalloy industry cannot be recycled into the superalloy product stream but must be treated chemically to recover the strategic elements in elemental form). Suitable economical reclamation processes have not yet been developed, and the panel believes further research and development is needed.

Substitution

Economic and availability considerations will of themselves create the most effective incentives for substitution of materials. Nevertheless, the panel believes that government research funding could efficiently be invested in developing substitute materials for potentially critical materials and processes.

Redesign

Recent titanium shortages caused much of the aircraft industry to conduct redesign efforts to reduce use of titanium. This has provided considerable relief and has improved the supply and economic situation to the point to where it soon may be practical to reverse some of those decisions. The panel believes that it might be wise for the government to encourage continuing redesign activity to eliminate or minimize the use of critical materials during the development of new weapon systems.

Stockpiling

The panel believes that government stockpiling of critical materials should be continued and expanded into additional materials and forms when practical to do so. In many cases, however, the materials deteriorate with age, or technological changes makes them obsolete. Thus, the panel encourages the continuing examination of the existing stockpile for its suitability in the current and future marketplace.

Standardization

Further development of common standards, both by the government and by industry, would be helpful from a materials availability as well as an economic viewpoint. The panel believes that existing differences in standards impose some limitations on the development of improved products. Generating and adopting common standards should be pursued, particularly with respect to those materials and products that are identified as potentially critical.

Intelligent Use

In those rare instances where market forces do not lead to an efficient allocation of resources, critical materials can be limited to the most essential applications; if necessary, the government can establish priorities for their use. Again, however, the panel believes it is essential that such regulatory interference by the government be limited to those situations in which the nation's security is imperiled.

Government Incentives

The panel believes that government incentives should be considered that would encourage industry to increase production capacity, develop substitutions, increase conservation efforts, recycle materials, etc. When possible, these incentives should be applied in a manner that allows the normal economic processes to create the desired effect with a minimum of government interference.