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FEDERAL R&D REDUCTIONS, MARKET SHARE, AND AEROSPACE INFORMATION USAGE

JoAnne Rocker and George Roncaglia
NASA Langley Research Center
Hampton, VA

ABSTRACT

Reductions in federally funded research have a rippling effect over the entire aerospace industry. The decline in federal R&D spending in aerospace in recent years coincides with declines in U.S. aerospace market share. One of the lesser-understood factors in the declining U.S. market share may be the differing ways and intensity with which the U.S. and its competitors approach another trend, the increasing availability of large amounts of aerospace research information on the World Wide Web. The U.S. has been a pioneer in making research information available in electronic form, and the international community has long been a heavy consumer of that information. In essence, the U.S. contributes to the research efforts of its competitors, thus contributing to foreign aerospace consortiums efforts to gain market share in the aerospace industry. This may be a cautionary note to the U.S. aerospace industry to consider the use of R&D output in its own development and strategy because the foreign competition is using the U.S. scientific and technical literature.

INTRODUCTION

The aerospace industry faces both internal and external challenges. Over the past two decades, the federal support for aerospace research and development has had some fluctuations but overall has declined. The end of the Cold War lessened the federal funding for military research and consequently, the aerospace portion of the support fell as a result. During the same period of reduced federal spending for aerospace R&D, the U.S. global market share has fallen. The U.S. aerospace products and services industry remains a strong economic performer, however, foreign competitors continue to make gains in the marketplace.

FEDERAL R&D REDUCTIONS AND MARKET SHARE

Federal funding for aerospace research fluctuated dramatically during the last three administrations. During the Carter administration federal funding for aerospace R&D was 15%. This rose to over 20% during the Reagan administration, but reached a low of 8% in the Clinton administration. (AIA, 2000) The downward trend of federal funding corresponds to the steady decline of U.S. market share during the same period.

The National Research Council's Recent Trends in U.S. Aeronautics Research and Technology reports that the U.S. global market share fell from over 70% in the mid-1980s to 55% in 1997. The numbers of unit orders of large commercial transport aircraft to Europe show a descent from 73% in 1990 to 54% in 1998. (p. 7) Further evidence of the loss of U.S. aerospace market shares comes from the National Science Foundation (NSF) report, Science and Engineering Indicators 1998. In it the report states that the aerospace industry was the only high-tech industry that lost market share from 1990–1995. Computers, pharmaceuticals, and communications equipment all gained market share during the same period. (p. 6-2)

The once dominant U.S. aerospace industry is facing the daunting task of staying on par with its foreign competitors. Reductions in federal funding for aerospace research certainly do not work in the favor of U.S. competitiveness since companies take on the peril of doing high-risk, high-cost research projects once performed by the government. The far-reaching consequences of reduced federal funding remain to be seen.

The U.S. aerospace industry's present predicament of losing ground in the marketplace cannot be entirely blamed on fewer federal research dollars, however. It is a factor but not the sole cause of eroding U.S. prominence. Other factors like innovativeness, government intervention in the marketplace, and technical competence come into play when considering why foreign competitors like the Europeans are gaining market share.

If amounts spent on research were the only criteria for success, the Europeans would not be the threat that they currently are. It is important to note that the Europeans spend less on R&D than their U.S. counterparts. According to the National Science Foundation, the U.S. "… accounts for roughly 44% of the industrial world's R&D investment total and continues to outdistance, by more than 2 to 1, the total research investments made by Japan, the second largest performer." (NSF, p. 4-3) The U.S. spends more than any country in the world on R&D so why isn't the U.S. maintaining its place in the aerospace marketplace? Something else must account for the European ability to gain market share despite lower funding levels for research.

Europeans would seem to be a disadvantage with the U.S. when it comes to competing in a global market because of the different nationalities, languages, and cultures of the Airbus consortium members. Heterogeneity proves to work to the advantage of the Europeans, however. In the position paper, Aeronautical Research and Technology - A Strategic Imperative for Europe, the Confederation of European Aerospace Societies (CEAS) defines its strengths: (1) Diversity of members of European R&T community. Multiple nationalities in project groups creates positive competition which produces high quality products; (2) Strong collaborative ties among scientists and technologists. They know each other well and communicate often; (3) Researchers and technologists awareness and use of "pre-competitive" information available in scientific and conference literature; and (4) Highly skilled workers and cutting-edge research facilities. (CEAS, pp. 7–8)

Europeans maximize their strengths, their differences spurring innovation rather than killing it. Innovation is key to economic success. In Michael E. Porter's article on, "The Technological Dimension of Competitive Strategy", he describes how technology can shift the balance of power between competitors:

> What makes technology unique as a strategic variable is its considerable power to change the competitive rules of the game. Technological change can be a great equalizer that nullifies the advantages of incumbents and creates opportunities for newcomers and followers. Technological change is perhaps the single most important source of major market share changes among competitors for this reason, and is probably the most frequent cause of the demise of entrenched dominant firms. (Porter, p. 3)

INFORMATION USAGE

Europeans are closing the gap on the U.S. by being technically competitive; part of their success is attributable to their use of external information sources like research journals and conference proceedings. They stay abreast of the latest developments in science and technology. In a knowledge intensive industry like aerospace, scientific and technical information (STI) plays an important role in gaining advantage over competitors. The U.S. Office of Technology Assessment (OTA) states in its report, Helping America Compete, that, "Scientific and technical advancements are information-intensive, and those who know how to obtain and use STI will have a competitive edge-whether the competition is over market share or over intellectual leadership on global issues." (OTA, p. 8) In the past, economic success was due to superior manufacturing processes and physical resources. Now the world's economies are based on knowledge-based systems and services. The speed in which knowledge is "…created, diffused … and absorbed or utilized influences the rate of technical innovation and progress." (Pinelli et al., 1997, p. 87)

Europeans are very aware of that innovation and information go hand-in-hand as evident by their use of U.S. STI. The innovation process is contingent on infusing new kinds of information into an organization. In Kranzberg et al.'s (1977) analysis of information in the innovation process, they refer to incremental vs. discontinuous R&D efforts. The terms refer to the level of technological change in an organization's products or processes. Incremental improvements do not significantly alter a product or process. An organization can usually rely on in-house expertise to make changes. In a discontinuous effort, the results are new products or scientific or technical breakthroughs. They go beyond an organization level of experience and competence. Discontinuous efforts come about from an

infusion of external information. In the case of the Europeans and Airbus, they borrow from the U.S. STI efforts, incorporating that knowledge in their innovation process.

U.S. AIDS COMPETITORS

Ironically, U.S. foreign competitors are using U.S. produced STI to compete against the U.S. In this age of high-tech industries and competitive market place, the U.S. is a major contributor to the success of its competitors. The U.S. R&D infrastructure with its federal laboratories, university systems, and industrial research organizations outputs more STI than any other country in the world. In examining citation analysis of STI literature, countries cite more U.S. information sources than their own. (NSF, 5-46) It's evident that the U.S. sponsored research enables other countries in their own research efforts since they heavily cite U.S. sources. In a humanitarian sense, the U.S. research helps other countries that do not have the scientific infrastructure of the U.S. and this is a positive result. In an economic and competitive sense, the U.S. is fueling the success of its competitors by the accessibility of its STI. Obviously, there are other factors in addition to STI diffusion that account for the success of other countries; however, knowing that STI makes a difference should give U.S. aerospace industry members cause for concern. If the foreign competition is using U.S. generated STI than the U.S. should maximize its own use of domestic and international STI.

LIMITED USE OF STI

There are reasons that suggest that the U.S. is not fully utilizing it's STI. Studies of information usage by scientists and engineers found that engineers prefer informal modes of information gathering such as colleagues versus more formalized modes like consulting librarians for help in finding information. In Pinelli's study (1991) of the use of government technical reports by U.S. aerospace engineers and scientists in AIAA, respondents answered questions about using information sources. The engineers preferred using their own personal experiences or asking colleagues before going to the technical literature. This study confirmed earlier studies by Rosenbloom and Wolek (1970) that found that engineers relied more on internal information sources than external ones. (Pinelli, p. 99) Scientists, on the other hand, tend to use the professional literature more for their work. If the natural tendency for engineers is to rely first on internal knowledge rather than external knowledge than they need to be encouraged and educated in using STI.

Another reason for the under use of STI is its availability. Engineers choose information sources based upon accessibility. Kaufman's study (1983) of the Factors to the Use of Technical Information in Engineering Problem Solving, found that engineers rank technical quality or reliability before relevance; however, accessibility is the main selection criteria even if source is not useful. (Pinelli, 1991, p. 96)

Finally, the federal government makes its own case that the U.S. needs to make better use of its STI to compete in a global economy. In this instance, the government is responsible for the lack of STI usage. The Office of Technology Assessment's report, Helping America Compete, addresses the absence of an effective science and technology policy for the dissemination of STI. Information usage is impaired when government STI is difficult to find and use. There is no central oversight for government produced STI; rather, each agency has its own mandates for disseminating information. The lack of centralized authority gives rise to varying degrees of effective STI distribution. Four key areas need improvement in federal STI dissemination: implementing technical standards for databases and documents; indexing databases and documents for better retrieval of information; funding for STI activities in agency budgets to ensure appropriate storage and dissemination of STI; and including end-user involvement in the development of products and services. (OTA, p. 2) The report recommends the Office of Science and Technology Policy (OSTP) take a leadership role for governmental STI. OTA's report recommends ways to improve government STI dissemination thus improving the accessibility and usage of STI.

BARRIERS TO FINDING INFORMATION

STI is difficult and time-consuming to locate considering the multitude of sources available in print and on the web. For example, to find academic information, researchers must go to print or e-journals. In order to find government information, they have to go to all of the following for a comprehensive search: the Government Printing Office (GPO), National Technical Information Service (NTIS), and the individual agencies. Industry information usually is not publicly available because of trade secrets and intellectual property concerns.

The Internet, though a marvelous technological tool, compounds the problem of locating information. Search engines operate differently and results vary depending upon which search engine is used. Web search engines tend to rank hits by relevancy. Relevancy ranking uses algorithms to weigh word usage to come up with an order of importance. Relevancy may not find the most relevant hit however because the overall content of the site might make one result more relevant than another. Ranking by relevancy is not as accurate as one would be lead to believe.

The size of the web is enormous. Estimates place the size of the web at 800 million pages. There are a lot of out-dated and defunct pages. Current search engines do not index every page of the web. They index approximately 16% of the public pages so valuable information may not show up in a results set. Subject coverage breakdowns indicate 83% contain commercial content and 6% are scientific or educational. (Lawrence and Giles, 1999)

The impetus for better utilization of STI is clear but barriers exist in finding that information. More oversight and money will be necessary to create a better dissemination strategy by government agencies. The web is a great delivery tool but is not necessarily the best retrieval tool. More attention in helping researchers find and use STI is necessary on part of government, academia, and industry research organizations. In the meantime, aerospace information users have access to relevant sources for their research. First, they can consult their institutional libraries or information centers that organize and make accessible information sources for their use. Secondly, they have a number of federal web-enabled databases they can search for aerospace information. They can search: (1) NASA's ASAP-TRS for citations to NASA technical documents (http://www.sti.nasa.gov/ASAP/); (2) DOD's STINET site allows searching and ordering of DOD reports (http://www.dtic.mil/stinet/); and (3) NTIS is a general repository of documents from all the government agencies (http://ntis.gov/). Eventually, technology will shorten the time users have to expend on information retrieval. It is important that users invest time in technical intelligence activities because their foreign counterparts are.

CONCLUSIONS

The U.S. aerospace industry is in a struggle to maintain its market share. At risk is the U.S. technological and economic role as a global leader. Why the competition is making gains should be of concern to aerospace policy makers and industry leaders. Is it because the Europeans are spending more money than the U.S. on aerospace R&D? No, the U.S. still spends more than any other country on R&D. Europeans are able to effectively compete with the U.S. despite fewer dollars spent on R&D.

The level of expertise and quality of products of U.S. competitors accounts for the current situation. The foreign competition is catching up to the U.S. One reason they are so successful at competing is that they make effective use of aerospace STI. They seek out and utilize available STI literature most of which generate from the United States. The Europeans use technical intelligence to their advantage. Should not the U.S.

According to information usage studies and the federal government's own investigation of STI use, the U.S. has to make better use of its STI. A preemptive measure for the U.S. to take in lieu of reduced federal funding levels would be to be more aggressive in collecting and using aerospace technical intelligence. Competitors like Europe and Japan are known for their effective competitive intelligence programs. They actively seek STI like journal articles, technical reports, data sets, and patents. They have proven that they do not need a research base the size and scope of the U.S. to effectively compete in high-tech industries.

Foreign use of U.S. STI shows the value inherent in this information for they would not use it otherwise. The U.S. aerospace industry needs to make the same investment in STI especially in light of the steady decline of federal research monies. Maximizing the use of technical information can only help companies stay abreast of the market place and promote innovation. In the Competitiveness Policy Council's report, Building A Competitive America, it states, "America's competitive problem reflects slow erosion rather than sudden crisis … Pluralistic democratic societies such as ours - and perhaps especially ours - are not adept at responding to "termites in the woodwork." (p. 7) Aerospace products and services still provide the U.S. a positive balance of trade so perhaps that is why few feel the impending crisis awaiting the aerospace industry. The U.S. dominance in the aerospace industry is slowly eroding and its highly successful competitors are the termites in the woodwork.

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