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The Role of Databases in the Academic Environment

L. S. FLETCHER†
Mechanical Engineering Department, Texas A&M University, College Station, Texas 77843–3123, *U.S.A.*

Database systems have expanded dramatically over the past decade, as have the number of on-line services to access them. In view of the increasing number of database systems, the rapid increase in technology-based information, and the potential for image databases, the role of database systems in the academic environment is explored in terms of those database systems relevant to aerospace engineering. Potential database uses include such topic areas as enhancement of the undergraduate and graduate instructional and research programs, identification of colleagues with similar research interests, location of unique research capabilities and associated facilities, and tracking of research developments in selected topic areas as well as development of documentation for invention disclosures. Database systems are important to the academic environment, and with increased awareness and accessibility through reasonably priced on-line systems, could have an increasingly important role.

INTRODUCTION

OVER the past decade, the use of computer facilities has expanded dramatically, with many different applications from control systems, to information storage and retrieval, to data acquisition and processing systems. Peripheral support systems such as full text scan and optical character recognition capabilities have also improved, increasing the versatility of computers. Further, there has been a significant increase in the power and capability of personal computers, as well as their availability and affordability for personal use.

With the widespread use of computer facilities and the demand for more timely information, the quantity and quality of electronic database systems has improved. These database systems offer access to a wide variety of information, ranging from bibliographic citations with abstracts to full text state and federal laws. Each database system is generally developed around a central theme, endeavoring to incorporate information relevant to that theme. The scope of some databases has grown significantly, whereas others have maintained a focus on the primary theme. At present there is a wealth of material available to engineers and scientists in the form of electronically archived information.

With the rapid increase in the number of database systems available, there has been a concomitant increase in the number of on-line services available for accessing these databases. Some on-line services provide access to selected databases and deal with specific subjects or related groups of subjects, whereas other on-line services have incorporated a full spectrum of databases, all accessible through that on-line system.

For the past two decades, most libraries have offered some form of literature search services. Now libraries are beginning to offer a wider range of database services, considerably beyond the traditional literature search. These added services are being provided for two reasons: the wealth of information available through database systems, and the increasing importance of these systems to libraries and their users. At the same time, library shelf space is at a premium and the number of publications has increased substantially. Further, libraries are experiencing increased costs in acquiring and archiving library materials. In fact, the cost of journal publications has increased to the point that some second-line journals are being dropped from many library acquisition lists. Nevertheless, access to library materials continues to be as important as ever, if not more important, and new techniques for archiving and retrieval of such information must be explored [1].

In industry, database systems have been used for a wide range of purposes, from evaluation of trends in research and product development to assessing the progress of competitors. The use of database systems in the academic environment, however, has generally been limited to librarians, some graduate students, and a few research-oriented faculties. Faculty and staff as well as undergraduate and graduate engineering students are becoming more proficient with the use of computers, and an array of machines from mainframes to personal work stations are available to them. Faculty have computers in their offices, often hardwired to institutional mainframe computers. Further, many students have their own computers which may be

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† Thomas A. Dietz Professor.

connected through modems to the institutional computer systems. Clearly, the facilities to access databases are available.

The education of engineering students is increasingly important, and there have been numerous studies to assess the quality and content of engineering education programs. Engineering education programs could be enhanced through the integration of database systems into the educational process. Engineering curricula continue to be offered as four-year educational programs, and more and more material is being added to the curricula. With the increased depth and breadth of material in these programs, a large majority of the students find that it is increasingly difficult to complete their studies in four years.

The 1990s are the time of the 'information explosion', with printed technical material expanding more rapidly than the capability to archive and retrieve salient information. Technology is in a continuous state of change, and new technologies are developing. New concepts in database systems are being explored with increasing interest, and databases are being made available in different formats. Reference material and historical information are now available both on-line and on compact disc [2, 3], and the potential for image databases is developing. In fact, the use of image databases could play an extremely important role in the educational process in the not-too-distant future.

In view of the wealth of information available through databases, the wide range of on-line services available, and the need to make more efficient use of the educational process, it seems appropriate to explore in more depth the role that database systems might play in the academic environment. Inasmuch as database systems cover such a wide range of material, this paper will be restricted to those database systems and subjects relevant to aerospace engineering. This paper will suggest a number of ways in which database systems may be used in the academic environment and review some of the database systems appropriate to aerospace engineering along with the attendant on-line services.

POTENTIAL ACADEMIC APPLICATIONS

There are numerous opportunities in the academic environment for use of databases. These opportunities include the instructional program at both the undergraduate and graduate levels, as well as research activities. More specific uses of databases might include the identification of industries working in areas of student and faculty interest, identificatin of colleagues with similar interests, location of unique research facilities and capabilities, identification of institutions for graduate study, supporting information for invention disclosures, and tracking of research developments in specific topic areas.

Access to institutional computer capabilities is readily available, from mainframe computers to library holdings. Most institutions are also connected to various networks such as Internet or Bitnet, with the capability for world-wide electronic mail as well as access to many of the on-line services and their associated databases. Clearly, faculty now have access to a wide range of database systems.

In terms of the instructional program, databases may be used to provide timely information for lectures and project activities. Textbook material is often three to five years, or more, out of date. A brief search of the literature, and review of the associated abstracts will permit the inclusion of new material in lectures to supplement textbook background. While such supplementation often occurs at the graduate level due to the active research of the faculty, it is less likely to occur at the undergraduate level. Timely topics and current information would make undergraduate lectures more interesting and exciting, and strengthen the value of education to the student. There are many instances in instructional programs where the introduction of visual examples would facilitate student understanding, and the development of image databases is at the point where such visual instructional material may be a reality in the near future [4].

In graduate level courses, the use of timely information is essential, and it is assumed that faculty are current in the subject material. From time to time, however, it is necessary to teach graduate courses out of a faculty member's specific research area, necessitating extra effort to prepare for the graduate course. A database review would provide the latest in timely information which would strengthen the course content and provide the material needed to meet the goals of a quality graduate course. At the same time, such a database review could provide peripheral technology information.

It may also be appropriate to assign a part of the course material to various students in a graduate class, asking that they conduct a database search to bring recent developments to the class, either prepared in report form or as an oral presentation for the rest of the class. Such an approach stresses the importance of timely information in graduate coursework. The instructor might also assign current publications found in the database search to individual students, asking for their critical evaluation and review of the published materials. Such a technique strengthens the students' critical evaluation of material and their interest in current research.

The use of database searches is particularly important in both faculty and student research. It is essential that faculty and graduate students be aware of recent research developments in order that they might gauge their contribution to the published literature. Such searches may identify new theoretical and analytical approaches to the problem at hand, or perhaps identify new experimental data which could be used for comparison.

Database searches might also lead to thesis and dissertation topics, and potential research in the critical technologies [5].

Database searches of research areas might also permit the identification of other researchers in the field, as well as identification of new experimental facilities. These searches are essential for the identification of current research results, to assure advancement of the state of the art, as well as to make comparisons with published data to assure credibility of the research being conducted. The identification of industries actively involved in research projects of special interest can also be determined from database searches. Such identification would lead to potential contacts to explore co-operative research activities.

Occasionally, undergraduate and graduate students find topics of special interest in which they would like to pursue advanced study. Often these interest areas are receiving limited attention at their home institution, and the students would like to know which institutions have specific expertise in the area. A search of the appropriate databases might lead to identification of publications in the area along with the authors and their home organization. Such use of databases would provide opportunities for students to pursue in-depth studies in areas of personal interest which might not otherwise have been possible.

Graduate and undergraduate students might use the database search to identify potential job opportunities. A review of recent publications in topic areas of personal interest, noting the author's affiliation, would permit the identification of companies recently active in the field relevant to the students' interest. Such a review would also permit the students to be conversant with recent company achievements and be better prepared for employment interviews.

One of the areas particularly suited to database searches is the development of background material for invention disclosures. The productive use of patent information has been previously discussed [6]. Patent literature searches permit the identification of areas amenable to patent consideration as well as those that might be considered patent infringements. In 1977, approximately 70% of the patented technology was not documented in conference or journal publications. Clearly, the patent databases are essential to the patent search process and lead to more clearly defined invention disclosures.

DATABASES

There are a number of databases that could be relevant to the broad field of aerospace engineering, although only a few of these specifically include the aerospace field. These databases will be discussed briefly, providing an overall perspective on those most suitable for use in aerospace engineering education.

Abstracted information from significant literature in the field of engineering and technology is provided by the COMPENDEX*PLUS™ database. This database is the electronic version of *The Engineering Index*, which provides world-wide coverage of approximately 4,500 journals and selected government reports and books [3]. This database provides broad coverage of a wide range of engineering subjects from aerospace engineering to industrial robotics. The database also provides significant coverage of published proceedings of engineering and technical conferences.

The National Technical Information Service (NTIS) database covers a wide spectrum of subjects including administration and management, energy, materials science, military science, and transportation. This database is focused on government-sponsored research, development, and engineering [3]. The database includes unclassified material from the major agencies such as NASA, DOE, DOT, and the Department of Commerce as well as many other federal and state agencies.

The Institute for Scientific Information (SCISEARCH®) database contains records previously published in *Science Citation Index* (SCI®) and information from the *Current Contents* publication. All significant articles, reports, letters, editorials, and other relevant information are indexed to permit retrieval of newly published articles through subject relationships [3]. This database covers some aspect of almost every area of both the pure and the applied sciences.

One of the peripheral areas related to aerospace engineering includes the materials area. The Engineered Materials Abstracts (EMA®) database provides comprehensive coverage of polymers, ceramics, and composite materials for use in the design, construction, and operation of structures, equipment, and systems [3]. Composite materials coverage includes metallic materials with ceramic or polymer matrices. In addition, laminated and composite materials include primarily non-metallic materials, although metal flakes, fibers, or other forms of metal may occur in reinforcement. The ASM International and The Institute of Metals (London) provide the METADEX® database through the Materials Information Service. This database offers comprehensive coverage of literature related to the science and practice of metallurgy, specific metallic systems, as well as inter-metallic compounds [3]. Information is also available on the steel-producing and steel-using industries. Both the EMA® and METADEX® databases provide an opportunity to access materials applications related to aerospace engineering.

The Fluid Engineering Abstracts (FLUIDEX®) includes all aspects of fluid engineering, from theory to application. The database includes a wide variety of fluid mechanics abstracts from nearly 1,000 technical journals [3]. For purposes of aerospace engineering education, the coverage associated with aerodynamics, wind energy, fluid dynamics and the aspects of noise are particularly

relevant. Other areas include computational fluid mechanics, and flow measurement and instrumentation.

The DMS/FI databases deal with a comprehensive file of non-classified US government prime contract actions and contractors, and analyses of aerospace contract programs and others involved in the aerospace/defense industry. The data are organized to permit compilation and analysis of information by categories [3]. The Jane's Defense and Aerospace News Analysis provides articles that summarize, highlight, and interpret worldwide events in the aerospace industry. Information in the database includes new program starts, new contract awards, and other related information.

The PTS Aerospace/Defense Markets and Technology® (PTS A/DM&T®) provides details of products and technology as well as full-text articles and abstracts from aerospace and defense journals. This database is often used to locate information on new technologies developed for the aerospace field, to monitor government funding and contracts, and to identify new technologies with potential commercial applications [3].

The Institution of Electrical Engineers, London, manages the INSPEC database for physics, electronics, and computing. The database includes abstracts from *Physics Abstracts*, *Electrical and Electronics Abstracts*, and *Computer and Control Abstracts*, commencing publication in 1898. The database uses a single classification scheme for all abstract material to assist researchers in the identification of appropriate subject codes [3].

The Air Transport Research Information Service Abstracts are included in the TRIS database. This database includes transportation research information on air transport and details on regulations and legislation, maintenance, and air traffic control and communications. A number of transportation research information services contribute to this database, providing abstracts of documents and résumés of research projects [3].

Perhaps the most useful database for aerospace engineering education is the Aerospace Database. This database provides references, abstracts, and indexing of key scientific and technical documents covering aerospace research and development in over 40 countries, including Europe and the former Soviet Union. This database service is useful for both basic and applied research in aeronautics, astronautics, and the space sciences, as well as supporting fields such as communications and electronics [3]. The Aerospace Database incorporates two previous aerospace-related publications, *Scientific and Technical Aerospace Reports* (*STAR*), and *International Aerospace Abstracts* (*IAA*). The Aerospace Database is managed by the American Institute of Aeronautics and Astronautics. A summary of the Aerospace Database subject categories is provided in Table 1.

Clearly, there are a number of databases appropriate to science and technology, addressing specific topic areas. Some databases are more relevant to aerospace engineering education than others, but all provide information which might be useful. To access these databases, on-line services must be used and these will be discussed in more detail.

ON-LINE SERVICES

There are approximately 34 on-line database search services available at this time, covering a wide range of subject material from financial data to medical and legal information. While many of these services are directed toward specific subject areas, such as current news or financial management, several are directed toward topics which involve basic and applied technology. Based on a careful review of the scope and content of these on-line services, there appear to be five on-line services directed toward one or more aspects of technology as it relates to the aerospace field.

The INFOTRAK on-line service is a combination of the ORBIT and BRS services. The ORBIT service features approximately 75 databases which focus on science and technology. These databases include on-line patent references, including Japanese patents, information on modern engineering materials such as plastics and composites, and exclusive access to the complete range of Society for Automotive Engineers (SAE) publications and standards. In addition, the ORBIT system can access timely information of the innovative developments in Japan, as well as information pertaining to geography, geology, mineralology, and ecology. The BRS services provides menu-driven on-line access for physicians from over 150 different databases. Information is provided as bibliographic citations and/or abstracts, and some full-text information is provided. The INFOTRAK series of databases are directed toward business, medicine, and science and technology research [8].

The Mead Data Central on-line service specializes in full text information for lawyers (LEXIS), for medical researchers and doctors (MEDIS), and for business and financial professionals (NEXIS) [8]. The LEXIS database incorporates a comprehensive summary of legal information, including case law, both federal and state laws, as well as many state statutes. MEDIS provides full text information from the medical journals and special libraries, including the special cancer library. NEXIS incorporates a broad range of full text news information from magazines, newspapers, newsletters, and news wires. Other information includes brokerage house reports and research reports on major industries throughout the world. Some of the information included in the databases is relevant to aerospace engineering.

The Data-Star on-line service provides international information from business news to biotechnology, with access to over 250 databases [8]. One of the areas of focus is the European Community (EC) with over 25 European journal entries. Accessible information includes world-

Table 1. Aerospace Database subject categories*

AERONAUTICS
Aeronautics (general)
Aerodynamics
Air Transportation and Safety
Aircraft Communications and Navigation
Aircraft Design, Testing, and Performance
Aircraft Instrumentation
Aircraft Propulsion and Power
Aircraft Stability and Control
Research and Support Facilities

ASTRONAUTICS
Astronautics (general)
Astrodynamics
Ground Support Systems and Facilities (Space)
Launch Vehicles and Space Vehicles
Space Transportation
Space Communication, Spacecraft Communication, Command and Tracking
Spacecraft Design, Testing and Performance
Spacecraft Instrumentation
Spacecraft Propulsion and Power

CHEMISTRY & MATERIALS
Chemistry and Materials (general)
Composite Materials
Inorganic and Physical Chemistry
Metallic Materials
Nonmetallic Materials
Propellants and Fuels
Materials Processing

ENGINEERING
Engineering (general)
Communications and Radar
Electronics and Electrical Engineering
Fluid Mechanics and Heat Transfer
Instrumentation and Photography
Lasers and Masers
Mechanical Engineering
Quality Assurance and Reliability
Structural Mechanics

GEOSCIENCES
Geosciences (general)
Earth Resources and Remote Sensing
Energy Production and Conversion
Environment Pollution
Geophysics
Meteorology and Climatology
Oceanography

LIFE SCIENCES
Life Sciences (general)
Aerospace Medicine
Behavioral Sciences
Man/System Technology and Life Support
Space Biology

MATHEMATICAL & COMPUTER SCIENCES
Mathematical and Computer Sciences (general)
Computer Operations and Hardware
Computer Programming and Software
Computer Systems
Cybernetics
Numerical Analysis
Statistics and Probability
Systems Analysis
Theoretical Mathematics

PHYSICS
Physics (general)
Acoustics
Atomic and Molecular Physics
Nuclear and High-Energy Physics
Optics
Plasma Physics
Solid-State Physics
Thermodynamics and Statistical Physics

SOCIAL SCIENCES
Social Sciences (general)
Administration and Management
Documentation and Information Science
Economics and Cost Analysis
Law, Political Science and Space Policy
Urban Technology and Transportation

SPACE SCIENCES
Space Sciences (general)
Astronomy
Astrophysics
Lunar and Planetary Exploration
Solar Physics
Space Radiation

* Database Services, AIAA/TIS, New York, 1992.

wide import/export statistics on a wide range of products, broad coverage of the pharmaceutical industry, and such areas as health, nutrition, and fitness. Technology and chemical databases may be accessed along with information on trade shows and the automobile industry.

STN on-line service offers access to over 100 databases in chemistry, engineering, and the physical sciences, providing coverage on an international level. STN is managed by the American Chemical Society with production facilities at FIZ, Karlsruhe, Germany and JICST, the Japan Information Center of Science and Technology.

The DIALOG® on-line service is the largest, full spectrum service available at this time, with access to nearly 400 databases. DIALOG® may be used to access a wide variety of topics from art to finance, and medicine to law. There are over 200 databases related to science, technology, and business. The databases accessible through DIALOG® are divided into a number of search categories, facilitating searches across database boundaries [3]. The science category is of particular note, with several subcategories relevant to the aerospace industry, science and technology, patents and trademarks, energy and the environment, and computer technology. The Aerospace Database is included among the databases accessible through DIALOG®.

While the foregoing on-line services provide a wide range of opportunity for the individual user, not all services appear to be as useful to the academic community as might be expected. Nevertheless, access to a range of databases could significantly benefit the educational process.

RESEARCH TRENDS

Occasionally there is a desire to learn more about the level of interest in certain technology areas. A database search can identify the number of citations on a specific topic on a year-by-year basis, over a period of a few years. Such a search process provides interesting and timely information.

In order to demonstrate the trends in a few selected areas, the Aerospace Database was searched using DIALOG®. It should be noted that there is often a slight delay between publication and inclusion in a database; therefore, the data shown in Figs 1–4 for 1992 include citations up to November 1992. Topics selected for comparison are cold fusion, fuel cells, heat pipes, and aluminum graphite metal matrix composites.

Figure 1 demonstrates the rapid increase in conference/journal papers related to cold fusion. Prior to 1986, there appeared to be little interest in this area, with very few publications. With the announcement that cold fusion was observed at the University of Utah, academic interest in the subject increased dramatically. The publications are almost entirely from the academic community.

An overview of interest in fuel cells over the past few years is shown in Fig. 2. Work on fuel cells is being conducted in a variety of sectors: at some universities and national laboratories, at agencies

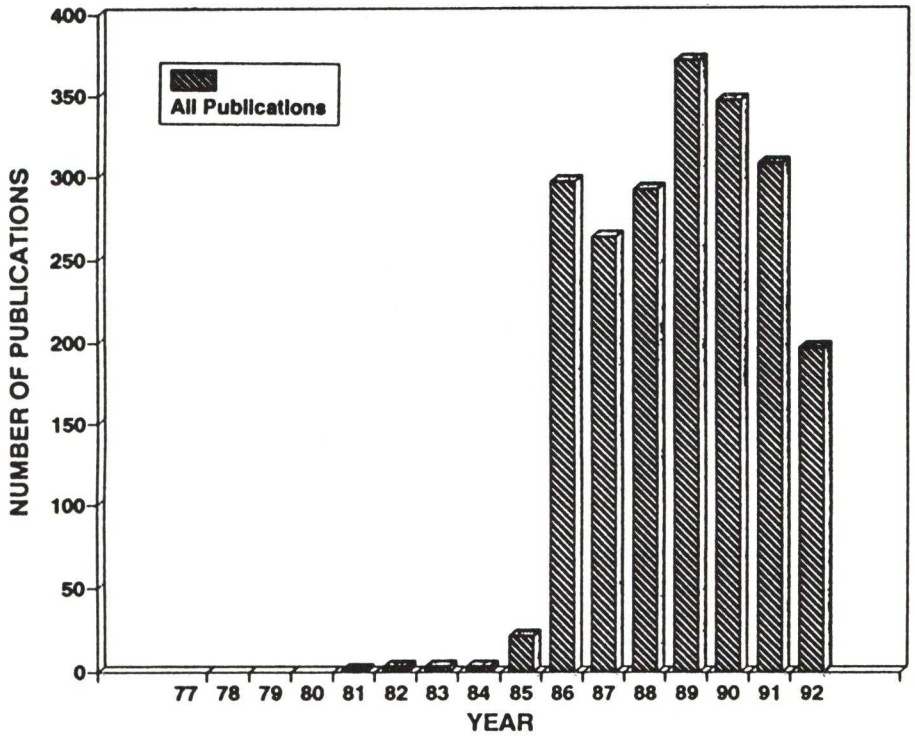

Fig. 1. Cold fusion conference and journal publications in the Aerospace Database as a function of year published.

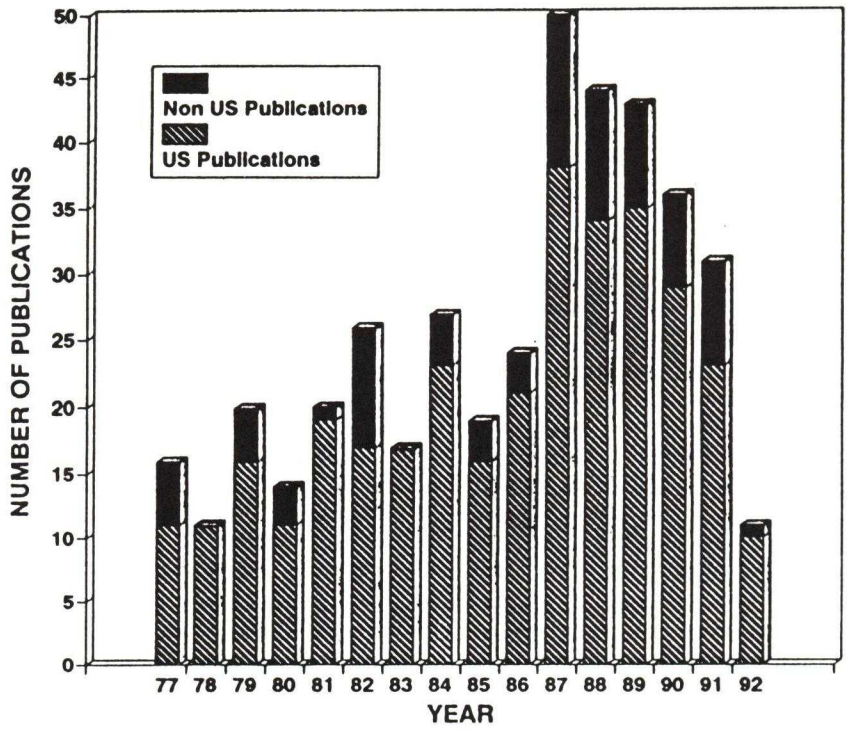

Fig. 2. Fuel cell conference and journal publications in the Aerospace Database as a function of year published.

of the federal government such as NASA and the Armed Services, as well as in the private sector. Often fuel cell findings are co-authored by individuals in two or more of these sectors. A review of the citations indicates that most fuel cell research is being done by individuals in the private sector, since author affiliation with industry exceeds academic affiliation by a factor of four.

With the advent of space exploration, interest in heat pipes has increased in both the space-related and domestic areas. Figure 3 demonstrates the increase in publications over the past few years. Of the non-US publications, a majority of the work is conducted by Japanese researchers, although a few of the publications have European authors.

The use of metal matrix composite materials has received considerable attention, with most of the work devoted to structural materials such as nickel alumide and silicon carbide. For heat transfer applications, both copper graphite and aluminum graphite materials are of interest. Figure 4 demonstrates the increased proportion of non-US publications dealing with aluminum graphite materials.

While it is possible to have database searches conducted by a second party on behalf of a researcher or research program, the benefits may be limited. The individual research process is both educational and informative, and permits a focus on areas peripheral to the specific topic in the search. It is the individual involvement in the search process which sparks new ideas and an understanding of trends in the literature. Information derived from individual searches can prove to be quite valuable for the initial objective of the search as well as for future reference [9].

CONCLUSIONS AND RECOMMENDATIONS

The relevance of database systems to the academic environment has been explored in terms of aerospace engineering, including instructional and research programs. Specific benefits include access to:

(1) more timely information for lectures and project activities;
(2) current analytical and theoretical developments as well as new experimental data;
(3) information on corporate and government research and development activities, perhaps leading to research collaborations or employment opportunities.

Database systems and on-line services have been considered in terms of availability of information relevant to aerospace engineering in the academic environment, and several databases have been identified. One or more of the on-line services is available at most academic institutions, providing accessibility to several of the database systems. Unfortunately, awareness of the usefulness of these database systems and the associated on-line services to the field of aerospace engineering seems to be limited.

Database systems are amenable to use in the academic environment and could play an increasingly important role provided there was increased awareness and accessibility through reasonably priced on-line services.

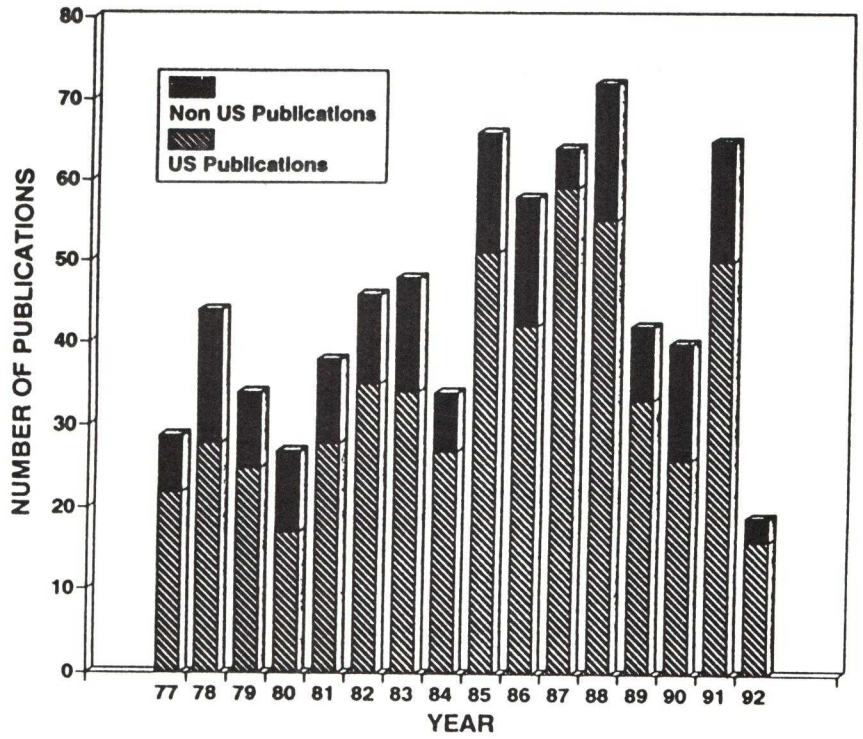

Fig. 3. Heat pipe conference and journal publications in the Aerospace Database as a function of year published.

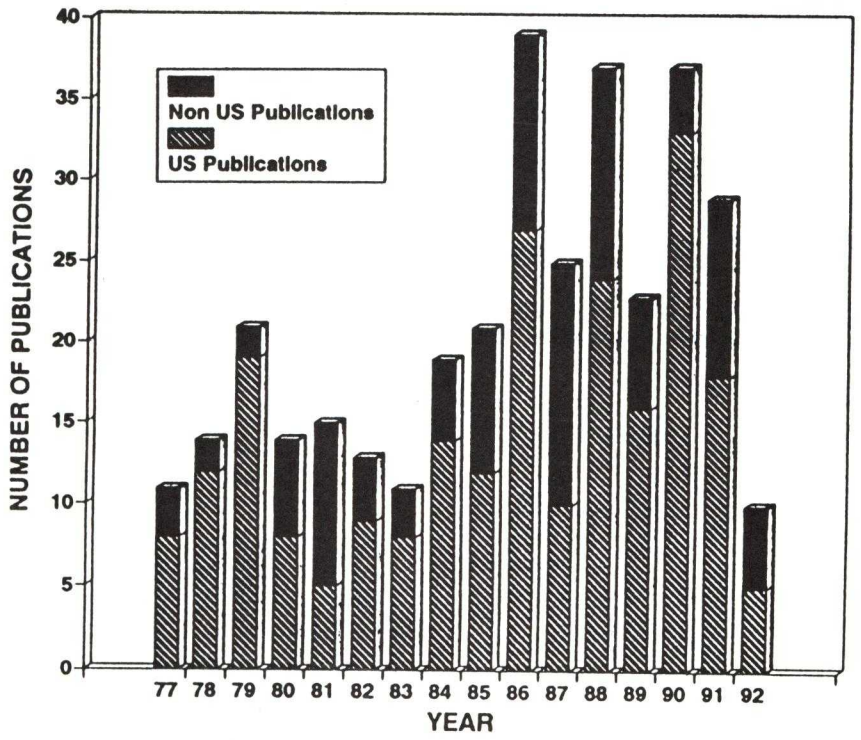

Fig. 4. Aluminum graphite metal matrix composite conference and journal publications in the Aerospace Database as a function of year published.

REFERENCES

1. B. Lawrence, Issues for effectiveness in scientific and technical information management, AIAA Paper 92-0798, AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 6–9 January (1992).
2. D. Oudard, An analysis of CD-ROM as a long-term archiving solution, AIAA Paper 92-0800, AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 6–9 January (1992).

3. DIALOG® Database Catalog, Dialog Information Services, Palo Alto, California, January (1992).
4. J. Alam, J. D. Bakos, Jr., and J. O'Leary, Applications of image databases in engineering education, *Int. J. Engng Ed.*, **8** (1), 76–80 (January 1992).
5. J. L. Porter, Critical technologies for transfer and exploitation, AIAA Paper 92-0803, AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 6–9 January (1992).
6. R. P. Cheslock, Technical and competitive value through productive use of patent information. AIAA Paper 92–0802, AIAA 30th Aerospace Sciences Meeting, Reno, Nevada, 6–9 January (1992).
7. J. Terapane, The uniqueness of patents as a technical resource, Eighth Technology Assessment and Forecast Report, Office of Technology Assessment and Forecast, US Patent Office, Washington, DC, December (1977).
8. Online Access Vendors, *Online Access*, **6** (4), 44–57 (1991).
9. P. Zarchan, How an engineer acquires and uses information through the dialog system, AIAA Paper 89-0851, AIAA 27th Aerospace Science Meeting, Reno, Nevada, 9–12 January (1989).