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INDUSTRIAL USE OF AEROSPACE TECHNOLOGY

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Early in its program, the National Aeronautics and Space Administration (NASA), established efforts for the transfer of technology. Management recognized that NASA and its contractors would necessarily develop very large amounts of new technology, and it was believed that the technology would have broad application outside the aerospace field. Also, the Space Act of 1958 which established NASA requires that NASA provide wide dissemination of the new knowledge resulting from its various activities.

At the time, this belief that aerospace technology would have many other uses was not universally accepted. A considerable skepticism was expressed by many. In addition, there was very little or no established technical communication between the aerospace and non-aerospace communities. As a consequence of these things, NASA found it necessary to establish necessary communication links, to pursue efforts to explain and illustrate the nature and diversity of its technology, to make the technology fully available, and to use various mechanisms to encourage technology transfer. All of these activites have been conducted as a part of the NASA Technology Utilization (T.U.) Program.

Lewis Research Center (Lewis), located in Cleveland, Ohio, is a major field Center of NASA with about 3300 employees. Lewis is responsible for advanced research and development in propulsion and power generation, and is program manager for the Centaur high energy launch vehicle. Lewis, as a part of NASA, has participated strongly in the T.U. program.

Partly as a result of the NASA T.U. Program, the original skepticism has been largely overcome. It is now widely recognized that aerospace-related new technology does have many valuable non-aerospace uses. A few selected examples of technology transfer are given below. They are only representative of several hundreds of documented transfers which have served to demonstrate widespread industrial use of aerospace-related new technology.

In November, 1964, Lewis held a two-day "Conference on New Technology". At this Conference, Lewis staff members reviewed current aerospace technology in a variety of selected areas: fabrication, materials, lubrication, instrumentation and control, etc. The invitational audience consisted of about 400 industry management and technical executives. An example of the positive results of this Conference is the case of Bardens and Oliver, Inc.

The Chairman of this machine tool company attended and first learned from a conference presentation of the technology of fluidic control systems. As a result, his company adapted the technology to develop the first commercial fluidic-controlled turret lathe. Quoting, by permission, from a subsequent letter from Bardens and Oliver, Inc.: "These fluidically controlled Automatic Turret Lathes are now contributing greatly to our dollar volume and profit".

In December, 1965, Lewis presented a two-day "Conference on Selected Technology for the Petroleum Industry". These special T.U. conferences for a specific industry provide surveys of selected technical areas and are organized as a report to industry executives. Both content and the method of presentation are designed to transfer an awareness of certain new technology in a form inviting further examination. They involve extensive interraction with industry executives for a considerable period before the conference and are a productive mechanism with multiple benefits - including the stimulation of technology transfer. A full description of the process is not possible in this short paper. At this petroleum technology conference, essentially all major domestic petroleum companies along with many smaller companies and industry suppliers were represented in the some 400 industry executives in attendance. Subject matter covered advanced aerospace technology in: combustion; heat transfer; surface physics and chemistry; lubricants, bearings and seals; storage and handling of cryogenic fluids; etc. Among the positive results from this conference was a substantially expanded participation by the petroleum industry in the NASA T.U. Program. Also, companies like Ashland Oil and Refining Company subsequently made repeated use of Lewis technology (e.g., their design of an induction heated pyrolysis reactor incorporated technology from the unsteady state hydrogen heater used for rocket engine research at the Lewis Plum Brook Facility).

Similarly, in September, 1968, Lewis held a two-day T.U. "Conference on Selected Technology for the Electric Power Industry". About 50 percent of the electric utility generating capacity of the country was represented by conference attendees. Among these many utility people attending were several employees of the Cleveland Electric Illuminating Company (CEI). They were particularly interested in the conference presentation on Automatic Checkout and Control. We later discussed the area further with them and also arranged for their inspection of the NASA Manned Space Flight Mission Control Center near Houston. All of this, including CEI use of the NASA aerospace contractor, resulted in a major technology transfer. The transfer was recently described as:

> "The interactive computerized display and control center developed for the NASA Apollo program has been adapted by the Cleveland Electric Illuminating Company to an electric utility

system. The computerized system operation center (SOC) is linked via a communication system to 4 power plants, controlled by mini computers, and 28 transmission stations. The SOC is a closely integrated man-computer complex which will monitor and control a complete power generation and transmission system either manually by an interactive operator or automatically by the on-line central computer".

In the 5 years since the Conference, several aerospace and electric utility companies have cooperated in technology transfer. The efforts have not been limited to computerized control systems but include other areas (e.g., experimental application of rocket engine type combustors as efficient, very compact heat sources for steam generation). It appears that aerospace-related technology and expertise may be able to make substantial contributions to ground based electric power systems.

These special T.U. briefing conference are continuing. Others have been held at Lewis and at various other NASA Centers. Lewis is now considering such a conference effort with the Gas Industry. These conferences are, of course, only one of the several mechanisms employed by NASA to stimulate technology transfer.

Now, however, let us briefly examine several industrial uses of aerospace technology without particular regard as to how the transfer was achieved.

Both the Atomic Energy Commission (fundamental developments have come from the Sandia Corporation in Albuquerque, New Mexico) and NASA have contributed substantially to the development of clean room technology. Our interests have been to reduce and control contamination to provide a nearly particle free environment for various aerospace precision equipment activities. This clean room technology is now increasingly employed in the surgical field including the use of "space-suit" type apparel with ventilated helmets for the surgical team. NASA special publications, "Clean Room Technology" (SP 5074) and "Contamination Control Handbook (SP 5076) have helped transfer this technology not only to the medical-surgical area, but to a variety of industrial applications. It is reported that of the $200,000,000 spent by industry for contamination control in 1970 about $75,000,000 was for the installation of new clean rooms.

The aerospace program need for long term storage, handling and use of cryogenic fluids led to the technology of super-insulations having very low heat loss. These insulations incorporated a highly reflective aluminized plastic film, originated by the National Research Corporation and later widely developed into a variety of aerospace uses in cryogenic tanks, spacecraft components, astronaut suits, etc. The technology has transferred widely to the commercial

market and has been adapted to uses in sportsmen blankets, lightweight sleeping bags, ski parkas, jump suits, etc. Sales are substantial; "space blankets", for example, which offer the reflective coating on several different fabrics, have been produced at about one-half million annually.

The NASA Structural Analysis (Nastran) computer program is an extraordinarily powerful finite element structures program. It was originally developed under the direction of Goddard Space Flight Center and is continuously updated and extended by Langley Research Center, both NASA field centers. Intended for use in the analysis and design of complex aerospace structures like the Space Shuttle, it was made generally available in November, 1970. It is becoming widely used by industrial firms, universities, computer service bureaus, consulting laboratories and other government agencies. Representative uses include: automobile frames and other components, high speed railroad tracks, turbine engines, aircraft assemblies, machine tools, power plants, buildings, etc. A brief review reported in February, 1972, showed 185 then current applications with 55 more pending. A computer service bureau in Chicago, Illinois, reports some 300 customers for the program. It is expected that long term impact of the Nastran program will be very large.

Additional examples of industrial uses of aerospace technology are varied and numerous; glancing quickly at a few, we see:

Heat pipe technology developed by the Atomic Energy Commission and NASA is now being applied to several non-aerospace uses, including improved domestic heating plants and to the continuous cooling of motorcycle lubricating oil.

A Lewis developed fluoride-metal composite material which is self lubricating at temperatures from 1000° - 1500° F has recently been licensed for commercial sale.

The technology developed for making large diameter, solid propellant rocket engines from fibre glass reinforced plastic has been applied to making commercial water pipe for underground installation. The pipe is available in diameters up to four feet, and is being successfully sold in competition with traditional steel or concrete pipe.

The preceding cases of industrial use of aerospace-related technology are examples of an increasingly widespread impact of this technology on various industries. In order to examine such impact in an organized way, NASA contracted with the Denver Research Institute (DRI) of the University of Denver to conduct several studies. These studies have been reported in a series of Technology Transfer Profiles entitled: "Applications of Aerospace Technology to Industry". These Profiles cover such areas as:

Cryogenics: Patient Monitoring, Food Technology, Welding, Contamination Control and Lubrication. They provide an overview of the field and document the aerospace technology transfers and impact. The "profile Highlights" from the cryogenics report reads as follows:

> "In the process of meeting its own needs for large quantities of efficient rocket fuels and life support systems, the American space program has affected the development of almost every dimension of the cryogenics field. Among its many contributions, NASA called into being large liquefier and storage facilities and fostered the development of new equipment and measurement techniques. The space agency's most significant contribution to this rapidly growing field, however, has been to systematically enlarge the foundations of cryogenics technology through the study of the low-temperature behavior of materials. NASA-generated technology has found its way into a wide variety of non-aerospace applications. For example, improved types of insulation now make possible more efficient transport of liquefied natural gas, and new knowledge of the physical properties of cryogenic materials has improved the performance of industrial processing facilities through cost savings and greater production.
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> The broad range of contributions support an emerging field in which improbable phenomena are harnessed to improve our lives. Fast freezing of food using liquid nitrogen helps preserve flavor, color and vitamin content. Cryogenic surgery has been used to treat Parkinson's disease, remove tumors and cataracts, and for bloodless tonsillectomies. Super conductivity, which is characterized by the abrupt disappearance of electrical resistivity, signals a new generation of motors, computer memory cores, power transformers, magnets and transmission lines".

These DRI reports provide useful insights in the several fields studied.

Taken together, individual transfer examples and summaries like these by DRI make clear the important economic role being played by aerospace-related new technology.