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THE UTILIZATION OF TECHNOLOGICAL RESOURCES

by James E. Burnett
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Cleveland, Ohio

TECHNICAL PAPER proposed for presentation at 1967 Automotive Engineering Congress and Exposition sponsored by the Society of Automotive Engineers, Detroit, Michigan, January 9-13, 1967

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ABSTRACT

The skillful use of new technology has long been a factor in industrial growth, and in recent years it has become the controlling variable determining competitive success.

An unusual communication experiment between NASA and the petroleum industry clearly demonstrates the fact that aerospace-related new technology has a substantial content of industrial value. A number of examples are given illustrating this fact.

The entire body of aerospace-related technology is now fully and selectively available to industry on a regular working basis through special NASA programs. As a consequence, the technological resources for considered use by any interested company are very large and of demonstrated value.

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THE UTILIZATION OF TECHNOLOGICAL RESOURCES

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Technology is the fundamental tool with which man shapes his material progress.

The kind of technological resources available - and the ability to understand and apply them - are critical factors in any society. They directly determine the form of those activities basic to all societies: transportation, communication, agriculture, manufacturing... .

Never has the vital role of technology in the affairs of nations been more visible than it is today. Competition between nations, both friendly and not so friendly, is largely a technological struggle. And cooperation between nations, the effort to help the low income countries is essentially based on the application of technology to force economic growth.

This vital role of technology was recognized by Congress in the Congressional Space Act of 1958, establishing the National Aeronautics and Space Administration. The Act requires that NASA provide the widest possible dissemination of information about its activities and the results thereof. NASA in turn established the Technology Utilization (T. U.) Program.

The NASA T. U. Program is <u>a planned, continuing effort to locate aerospace-related innovations, new scientific knowledge and new</u>

technical skills and to make them broadly available to industry and the public for non-aerospace uses.

WHY SUCH A PROGRAM?

A practical and obvious question is: "Why such a program?" The answer is this:

1. Industry and commerce are based on technology - technology applied to the development of products and services and to the methods of manufacture and distribution.

2. Growth of the individual company and of the national economy depend greatly on new technology - new technology applied to help generate sales, profits, and new enterprises.

3. New scientific knowledge and new engineering skills are coming from aerospace research and development. The flights of our nation's spacecraft are visible evidence of a large and rapidly growing body of new technology.

4. These new skills and knowledge, however, are largely isolated, both corporately and geographically, from many possible users. Further, the volume of information is both tremendous and growing.

5. Traditional ways of transferring technology are no longer alone adequate to cope with these problems of isolation and volume.

The skillful use of new technology has long been a factor in industrial growth, and, in recent years, it has become the controlling variable determining competetive success.

The "Charpie Report" (1)* illustrates this quite dramatically. The Report shows, for example, that television, jet travel and digital computers from nothing in 1945, contributed in 1965 more than $13 billion to the Gross National Product and an estimated 900,000 jobs. The report also cites a few examples of technologically innovative companies (Polaroid, 3M, IBM, Xerox) which from 1945 to 1965 had a combined average 16.8 percent annual sales growth (compared to 2.5 percent for G.N.P).

Application of aerospace-related new technology in the general economy requires that it be so communicated as to be truly available on a regular, working basis and that it be in such form and context as to aid the process of examination and understanding. There is urgent need for effective new ways in which to communicate technology as the "Weinberg Report" (2) clearly outlines. The T. U. Program may accurately be considered a broad experimental effort in this area and seeks to develop new communication methods of lasting value.

There is an underlying and essential premise involved here, of course, and the premise is: Aerospace-related new technology does have a substantial content of value of non-aerospace uses. This premise was tested in some depth recently during a novel communication experiment between NASA and the petroleum industry.

A COMMUNICATION EXPERIMENT

BACKGROUND - As a part of the T. U. Program at Lewis Research Center, we decided to undertake a mission-oriented communication

*Numbers in parentheses designate References at end of paper.

experiment, that is, an effort to communicate in depth with a single identifiable industry. As we set forth desired objectives and considered how to best structure the effort, it became obvious that active industry cooperation would be required.

Several industries were considered, and the petroleum industry was finally selected. Important factors in the selection were size and economic importance of the industry, the number of major competitive companies, the existence of an active, mature industry association (the American Petroleum Institute) and the industry's general technical sophistication and level of activity.

Independently of the Lewis considerations, and during the same period, the Esso Research and Engineering Company, an affiliate of Standard Oil Company (New Jersey), expressed to NASA a general interest in the T. U. Program and a specific interest in comparing selected petroleum industry problems with appropriate aerospace technology. This E.R. and E. expression of related interests, and their recognized competence in petroleum technology were additional factors in selection of the petroleum industry.

OBJECTIVES AND GROUND RULES - The objectives of the experiment were: first, to selectively examine current aerospace-related technology in order to identify common areas of space and petroleum technical interests; second, to reduce these common areas to just those (if any) in which the aerospace technology contained new knowledge of real interest and value to the industry.

The second of these objectives is, of course, the critical one. We could, without much "experimentation" predict some obvious areas of common interest - as, for example, lubrication research - and suspected that careful examination would turn up other, much more subtle, areas. Subtle or obvious, however, our critical objective was to edit these common interest areas down to a hard core where aerospace research and development had produced new technology genuinely of interest and value to the petroleum industry.

The final objective, provided the search identified technology of petroleum value, was to communicate to the industry a clear awareness of the existence of such technology.

Only three, quite simple, ground rules were involved:

1. A purely voluntary, non-reimbursed cooperative effort would be undertaken, i.e., a customary government-government contractor relationship would specifically <u>not</u> be involved.

2. Any and all productive results of the search would be made fully and equally available to the industry.

3. No classified (government) or proprietary (corporate) information would be included in the search either directly or by reference.

The agreement to undertake a cooperative effort with the stated objectives and ground rules required only two exploratory meetings, a few weeks of consideration-time, and a single exchange of letters between Lewis and E.R. and E.

THE SEARCH AND THE RESULTS - The experiment involved a great deal of technical administrative effort in identifying key counterpart personnel, and led to the formation of several teams selectively combining aerospace and petroleum technical people.

The initial discussions were held in September 1964; individual technical meetings took place in December 1964 and June 1965. Information exchange, review and evaluation were conducted during this full period (sandwiched in with normal work) and in July E.R. and E. submitted a detailed report of their findings and conclusions.

The E.R. and E. findings were highly positive; that is, new technology of interest and use to the petroleum industry was repeatedly identified. The technology was not bits and pieces, was most definitely not trivial, and was identified in significant quantity. The following list, as summarized from the E.R. and E. report helps illustrate the results of the search and evaluation. This list covers those areas, and only those areas, which did, in fact, contain specific new technology of interest.

(1) Heat Transfer; (2) High Temperature Combustion and Kinetics; (3) Mathematical Methods and Computer Programs and Techniques in the preceding areas; (4) Turbines-Compressors, Pumps; (5) Lubrication-Bearings; (6) Cryogenics; (7) Catalyst "Related" Areas, e.g., ultra clean surface physics and chemistry; (8) Energy Conversion; (9) Fluidics; (10) Materials; and (11) Novel Instrumentation Techniques.

CONFIRMATION AND AN INDUSTRY BRIEFING - A Lewis report was written reviewing the experiment, outlining the search and evaluation process and detailing the E.R. and E. findings and conclusions. We then, in company with E.R. and E., met with executives of the American Petroleum

Institute and discussed the matter at some length. Following this, API furnished copies of the complete Lewis report to twenty large petroleum companies and asked for their comments and recommendations. The comments were consistently favorable and overwhelmingly recommended proceeding with an industry briefing.

A two-day invitational Conference on Selected Technology for the Petroleum Industry was held at Lewis Research Center on December 8 and 9, 1965. Senior representatives were present from the major petroleum companies and from a number of smaller petroleum companies and major industry suppliers. The American Petroleum Institute provided much valuable cooperation in the conference effort, particularly in identifying and encouraging the attendance of senior petroleum industry people. For those who would like specific information on the technology evaluated and selected in the communication experiment, Proceedings (3) covering the conference are available.

We can gain some measure of the petroleum industry reaction to the experiment and the Conference by noting that the number of petroleum companies directly participating in the NASA, T. U. Program has increased from four (pre-conference) to fourteen (post-conference), and eight others have indicated "more than casual interest."

We can justifiably conclude that the premise has been realistically tested and verified. AEROSPACE RELATED NEW TECHNOLOGY DOES HAVE A SUBSTANTIAL CONTENT OF VALUE FOR NON-AEROSPACE APPLICATIONS. The test and verification was, of course, for one particular industry, but it would seem difficult to maintain that the petroleum industry was unique in this regard. Indeed, I suspect that quite the contrary is true. Petroleum is a technologically sophisticated industry with good information resources and communication skills; as such, it provided a relatively stringent test of the premise.

EXAMPLES

To illustrate and emphasize this point, that aerospace-related new technology has many other potential uses, let us look at just a few specific examples. The first four of the following examples were a part of the material identified and selected during the petroleum industry communication experiment.

1. Computer Program, Chemical Equilibrium Computations (4). - A highly flexible, general computer program and associated thermodynamic data have been developed markedly simplifying chemical equilibrium computations - flame temperatures, equilibrium properties, gaseous detonations, etc. The program can perform thermodynamic computations for a system containing up to 15 different chemical elements, and it can accomodate as many as 90 different reaction products.

2. The "Cold Surface" Solidification Process (5). - Many heat transfer systems involve water as the working fluid, but little was known about the transient energy process that governs solidification (ice formation) at the cold radiator surface. This transient energy equation covering solidification, equilibrium under varying flow rates and temperatures and heat transfer rates through the ice layer has now been established and solved.

3. Increased Ball and Roller Bearing Life (6). - Research on the influence of hardness parameters on bearing relative life has shown that maximum life is achieved by establishing a specific hardness differential between the balls and race. The increase in relative life based on this technique can be in the order of 500 percent.

4. Improved Bearing Metals and Alloys (7). - Research in the atomic structure of metals and alloys has shown that the crystal lattice markedly influences friction and wear characteristics. Metals and alloys with a hexagonal crystal lattice have much lower friction and wear rates (up to 100 times lower wear, for example) than do those with a cubic crystal lattice. The desired lattice form can be achieved and stabilized by appropriate metallurgical techniques and will yield bearing metals and alloys with greatly improved resistance to catastrophic failure when lubricant surface films are lost.

5. Spray Gun, External Mixing (8). - A spray gun has been developed that has two reservoirs and two nozzles. The nozzles are so designed as to provide external mixing of the two streams so that a single, well-mixed stream impacts the workpiece. A simple valve control permits variation of the percentage flow from the two reservoirs. This spray gun provides obvious flexibility and advantages in spraying either paints (vehicle plus pigment) or plastics (resin plus hardner).

6. Boltless Attachment (9). - A technique for fastening two members together has been developed that provides a strong, sealed joint and is either permanent or separable and reusable as desired. The technique is based on one member having a projecting, "T" shaped fin and the other

member a re-entry cavity. The members are placed together, and the cavity filled with a liquid that (a) expands on solidifying (if a sealed joint is desired) and (b) has a melting temperature below that of the members to be fastened. The technique shows potential use and advantages in many applications.

7. Magnetic Forming (10). - Forming of metals (the metal needs only to be an electrical conductor) is achieved without physical contact by subjecting the metal to a high intensity, shaped magnetic field formed by discharging a capacitor bank through a solenoid coil adjacent to or surrounding the workpiece(s). The technique has been further extended to piercing, punching, fastening, removal of welding deformations, etc. It works equally well for large or small workpieces, and has decided advantages in certain applications (e.g., no surface marring, high strain rates, minimum metallurgical disturbance, etc.).

8. Tire Hydroplaning (11). - Aircraft takeoff and landing operations on wet runways have obvious hazards. "Simple" skidding is a possibility under certain conditions, but loss of steering control is a more serious threat. Research into the factors that influence loss of steering control revealed a specific tire-hydroplaning mechanism, much like that involved in water skiing or stepped-hull speedboats. Tire hydroplaning results in either reduced, or completely eliminated contact between the tire and road surface (high speed films show, for example, the slow down and finally complete stop of wheel rotation while the vehicle continues to move). The point at which hydroplaning will occur is a function of vehicle speed, water depth and tire pressure.

And now, for variety, let's make our last two examples of a different nature from the preceeding.

9. Magnetomers and Archeology. - The Science News Letter, issue of December 5, 1964, reported the use of a rubidium magnetometer by a group of American and Italian archeologists. The instrument, first used in the space program for detecting very small variations in the earth's magnetic field, was used by the archeologists to locate and then to map the long buried, half legendary city of Sybaris. Interestingly enough, use of the magnetometer spelled success for a search which had been underway in an 80 square mile area since 1878.

10. Artificial Heart Research (12). - Clinical reasearch in the development of a human artificial heart is being conducted by Dr. Kolff and his associates at the Cleveland Clinic. Development of the associated pneumatic control system has drawn heavily on aerospace technology and the consulting advice of several people on the Lewis Research Center staff. The control system must faithfully duplicate the changing pressure and flow dynamics of the normal human system under widely varying physical activity and emotional stress conditions.

The application of aerospace technology to artificial heart research is just one example of many direct medical-biological applications from the space program: astronaut condition monitoring sensors and techniques now used in hospitals; ultra-small cryogenic thermocouples now used in brain and eye cryo-surgery; a proposed lunar terrain vehicle scaled down and adapted to provide a highly mobile "walker" for multiple parapalegics... . And so on and on and on.

The same is true of the other illustrations used; they are but a few representative items picked from an ever increasing flow of examples that aerospace-related new technology has many possible uses. All of the preceding examples are specific, factual illustrations of the many other than space uses of space-related technology. This is only a part of the story, however. The national space program is rapidly evolving a very broad, completely new technology of space operations. This operational capability will have tremendous impact on industry and commerce and on our total society. Consider:

1. Communication satellites will link the peoples of the world in instantaneous, reliable communication. The impact will be seen not only in the communication industry, but in transportation (a large part of all business travel is a form of communication), and our educational systems will be substantially revised by the use of satellite communication-instruction.

2. Weather satellites, now operational rather than experimental, with global coverage of weather data, will help lead to longer term, more accurate forecasting. Among the industries to feel the impact: agriculture, transportation, water resources management, recreation, entertainment, clothing, public utilities . . . .

3. Survey satellites, much like weather satellites, but adapted for ground-survey are already producing important early measurements data in broad areas of geology and ecology. Such satellites will undoubtedly become a regular operational tool leading to improved measurement and management of such resources as water, soil, mineral

deposits, timber, and crops. Again, we can recognize that many of our industries and public activities will be affected: petroleum, mining, lumber, agriculture, conservation . . . .

THE IMPLICATIONS

Perhaps our point, then, is adequately made, but, the point is most significant in context: New technology is vital for industrial growth and competitive success. New technology, highly diversified and in large quantity is coming from this nation's aerospace program. Aerospace-related new technology does have a substantial content of value for non-aerospace applications.

The implication is clear. A working access to aerospace-related new technology is eminently desirable for any organization which has a product or a service subject either to technological improvement or technological obsolescence.

It was recognized early in the T. U. Program that effective industrial access to the new technology implied much more than a passive library effort by NASA. A basic communication link was required, and it must provide a technology information service of continuing value. From these and other basic considerations, came the Regional Dissemination Center program.

NASA has established several university-based Regional Dissemination Centers (13) where a NASA, university, and industry three-way partnership speeds the flow of new technology. These Centers provide a regular, working access to aerospace-related technology for fee-paying member companies. Custom-tailored services by information and technical specialists and computerized information retrieval serve to make the total NASA collection of aerospace-related technology fully and selectively available to each company.

A more complete description of these Centers and their activities will be given in a following paper at this session.

A NEXT STEP

A Technology Utilization Office is located at NASA Headquarters and at each of the NASA field centers (14). For more information on the T. U. Program, its organization, seminars, special industrial publications, etc., contact any one of these offices. For those who would like to investigate and consider membership in one or other of the NASA Regional Dissemination Centers, contact any one of the Centers for information on services and membership fees.

In closing, let us take a very brief look backward - you often see more clearly in that direction, and it sometimes helps improve your forward perspective. The history of industry and commerce has many technological milestones. Technology and the change it brings spelled difficulty - or disaster - for some and great opportunity for others. The automobile replaced the carriage; the airplane took the railroad's passengers; nylon made silk stockings obsolete; synthetic fibers proved a more serious competition to a wool manufacturer than other wool manufacturers; the electric refrigerator replaced the ice truck.

And so it goes, but the pace of change is an ever quickening one. Consider, for example, the dramatically changing patterns in the communication industry with the advent of communication satellites. The understanding and skillful use of new technology begins to outweigh the other factors essential to industrial growth and survival.

The future promises more of the same, not less, and a working access to all pertinent new technology, no matter where or by whom it is generated, will be a critical factor in future industrial operations.

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Willem J. Kolff, M.D., "An Artificial Heart Inside the Body." Scientific American, Nov. 1965.

13. Regional Dissemination Centers:

Aerospace Research Applications Center
Indiana University
Bloomington, Indiana 47405

Center for Application of Sciences and Technology
Wayne State University
Detroit, Michigan 48202

Industrial Applications Office
University of Maryland
College Park, Maryland

Knowledge Availability Systems Center
University of Pittsburgh
Pittsburgh, Pennsylvania

Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

North Carolina Science and Technology Research Center
Raleigh, North Carolina

Technology Application Center
U. of New Mexico - Box 181
Albuquerque, New Mexico

Technology Use Studies Center
Southeastern State College
Durant, Oklahoma

14. Technology Utilization Offices:

National Aeronautics and Space Administration
Washington, D. C. 20546

NASA-Ames Research Center
Moffett Field
Mountain View, Calif. 94035

NASA-Electronics Research Center
575 Technology Square
Cambridge, Mass. 02139

NASA-Flight Research Center
Edwards, Calif. 93523

NASA-Goddard Space Flight Center
Greenbelt, Maryland 20771

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, Calif. 91103

NASA-Kennedy Space Center
Kennedy Space Center, Fla. 32899

NASA-Langley Research Center
Langley Station
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NASA-Manned Spacecraft Center
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