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SPACE BENEFITS

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THE SECONDARY APPLICATION OF
AEROSPACE TECHNOLOGY IN OTHER
SECTORS OF THE ECONOMY

NASA - NOTEBOOK - 77-1

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National Aeronautics and
Space Administration

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NASA BENEFITS BRIEFING NOTEBOOK

- Prepared for -

The Technology Utilization Office
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National Aeronautics and Space Administration

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- Prepared by -

Program for Transfer Research and Impact Studies
Industrial Economics Division
Denver Research Institute
University of Denver

PREFACE

This "Benefits Briefing Notebook" has been prepared for the NASA Technology Utilization Office by the Denver Research Institute, "Program for Transfer Research and Impact Studies," to provide the Agency with accurate, convenient, and integrated resource information on the transfer of aerospace technology to other sectors of the U.S. economy. Portions of this notebook will be updated and/or expanded on a timely basis as new materials become available.

As of the September 1976 edition, the notebook contains 347 paragraphs that describe 515 examples of beneficial use for NASA technology by public and private organizations. These examples, selected on the basis of existing documentation, illustrate how NASA's mission-oriented programs affect technological progress in the U.S. Since only a fraction of the documentation process is complete, the results to date are not sufficient to estimate the full magnitude of such effects.

The contents of this notebook are divided into three sections: (1) Transfer Overview, (2) Benefit cases, and (3) Indexes. The benefits section is subdivided into nineteen subject areas; the Table of Contents identifies those areas. Each subsection presents one or more key issues of current interest, with discrete transfer cases related to each key issue. Additional transfer examples relevant to each subject area are then presented. Pertinent transfer data are given at the end of each example (viz., the communication link, the DRI Transfer Example File and individual case number(s), and the date of the latest information used).

The Transfer Overview section provides a general perspective for technology transfer from NASA to other organizations. In addition to a description of the basic transfer modes, the selection criteria for notebook examples and the kinds of benefit data they contain are also presented.

Transfer examples may be selected for speeches, articles, or other purposes on the basis of factors such as location, audience composition, or subject matter by using one or more of the four indexes.

Since we are evolving this document and plan to add and update its contents, a constructive critique would be beneficial.

Louis Mogavero, Director
Technology Utilization Office

NOTICE: Supporting documentation for the examples described in the notebook is available from the TU Services Department, NASA Scientific and Technical Information Facility, P.O. Box 8756, Baltimore/Washington International Airport, Maryland 21240. Telephone 301/796-5300, Ext. 212.

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TRANSFER OVERVIEW

TRANSFER OVERVIEW

New technology generated by NASA programs represents a major addition to the nation's total reservoir of technology. This section of the notebook presents an overview of the ways in which new technology is applied and, therefore, characterizes how the benefits presented in this notebook are derived from the use of NASA-generated technology.

Scope of Technical Innovations Reported

In-house and contractor R&D activities span more than 30 major technical disciplines in standard engineering fields. These activities have created a wide range of specific innovations including new equipment designs, techniques and technical capabilities. Some of these innovations were developed for direct applications in aircraft designs, weather forecasting, etc. Most of the R&D activity, however, has produced innovations for space applications which do not have direct analogs outside the space program and, therefore, require adaptation for each secondary application. NASA has also undertaken the development of selected secondary applications, the results of which often are innovations in their own right. All benefit examples from NASA innovations, regardless of why the innovation was developed, will be included in the notebook as these examples are identified and verified.

NASA has purchased off-the-shelf products for use in its programs. If this type of procurement activity did not cause product improvements or otherwise contribute to innovations in the product line, the product will not be included in the notebook.

Technology Utilization Modes

Benefits from NASA innovations occur when the technology is directly or indirectly used, rather than being potentially used. The technology may be applied, for example, in developing a new product which provides the manufacturer with increased sales and the customer with increased performance. The variety of applications and benefits is indicated by eight common modes that are used by organizations and individuals to acquire NASA technology:

Mode I: Diversification by firms producing for NASA programs through (a) shifts in production facilities and personnel to commercial product lines, or (b) implementation of formal organizational policies to apply mission-related expertise in commercial product development projects.

Mode II: General improvement of industrial production practice and product quality through NASA-initiated specifications and standards for mission hardware procurement.

Mode III: Development by industrial firms of new process or product technology, with NASA as the first market, and subsequent commercial production because additional markets and applications are recognized.

Mode IV: Relocation of skilled individuals from NASA-funded employment to employment in other economic sectors, resulting in the application of acquired skills to solve engineering or management problems encountered in the new sectors.

Mode V: Professional activities, including professional design code development, by researchers involved with NASA's basic and applied R&D programs.

Mode VI: Formal NASA programs that disseminate or adapt mission-generated technology for organizations in other economic sectors.

Mode VII: Direct access to NASA personnel or the Agency's scientific and technical information systems by other organizations as part of their normal information acquisition efforts.

Mode VIII: Interagency projects in which NASA adapts or develops technology for the needs of a second agency or the organizations that are aligned with the second agency.

This characterization provides a convenient context for understanding how NASA programs cause technological change in other economic sectors, as well as a basis for expanding the Agency's formal efforts to facilitate technology utilization. Continuing efforts by NASA to stimulate technology utilization have involved the deliberate use of Modes V through VIII.

Benefits Information

Economic benefits data are not presented in all of the notebook examples. These data are often proprietary. In general, however, individuals cannot estimate the proportion of organizational output that is attributable to the use of NASA technology. Economic data for individual examples rarely provide an accurate measure of the impact from NASA technical innovations. Therefore, each notebook example describes the technical impacts or benefits of NASA-developed technology, and specific economic data are included only when they are available.

The information contained in each example is verified and documented to assure reliability and accuracy on the date specified. Due to the time dependency of the data, the information will be periodically updated as appropriate to assure its current accuracy.

MANUFACTURING CONSUMER PRODUCTS

A. MANUFACTURING CONSUMER PRODUCTS

Key Issues

- a. Consumer product R&D: 1973 McGraw-Hill Economics Department survey of industrial R&D expenditures indicated continuing decline as % of sales (2.5% of sales in 1972, 2.4% in 1973, projected 2.3% by 1976) and significant shift from new product or process development to improving products or processes. 44% of manufacturers surveyed reported product improvement as main R&D goal and 73% did not anticipate a technological or basic research breakthrough by 1976. Previous 1972 survey indicated that new products would account for 18% of total sales in 1975, 1973 survey now indicates they will account for 13% in 1976. (A-1)
- b. Productivity: Average annual increase in output per man-hour was 3.1% (1955-1966), 1.7% (1967-1970), 3% (1971-1972). Bureau of Labor Statistics estimates that decrease of 0.1% in average productivity between 1970 and 1980 would cause GNP to be \$60 billion less than potential. Productivity expert Professor John Kendrick (George Washington University) stated that 1967-1970 slump was due to slow-down in government funding as % of GNP, which peaked in 1964, and since then "growth in the stock of knowledge has been decelerating." Upturn in 1971 attributed by Business Week (1/1/72, p. 36) to new worker hiring lag at beginning of business boom, only a short-term effect. (A-4)

A. MANUFACTURING CONSUMER PRODUCTS

- *A-1 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product purchased by B.F. Goodrich Co. (Ohio) and regularly used for consumer product R&D. . . . applications include analyzing tire designs and causes of tire fatigue, identifying tire design and construction flaws, and investigating how heat shortens service life for V-belts, shock mounts, brakes and rubber bearings. . . . scanner enables researchers to observe and record heat build-up during product testing so designs or production processes can be improved. . . . 1973 R&D funding by rubber products industry was about \$200 million (1.1% of sales), large part directed toward product improvement. (Customer/contractor, TEF 398, Case No. 70001, 8/74)
- A-2 Management method for R&D programs: developed for Marshall. . . . used by The Upjohn Co. (Michigan) to develop management method for its pharmaceutical research programs. . . . saved Upjohn substantial man-hours. (TB/TSP, TEF 452, Case No. 60860, 8/74)
- A-3 Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing composite products. . . . orders of nearly \$1 million in 1973. . . . products used in golf club shafts and business machines. (Trade journal/TSP, TEF 490, Case No. 87986, 2/74)
- *A-4 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Alabama). . . . integral part of industrial monitoring system developed by SCI. . . . entire industrial system similar to Saturn instrument monitoring system. . . . SCI system installed in most U.S. textile weaving mills built between 1968 and 1971, 17 installations by SCI in price range \$65,000 to \$100,000, at least 4 more installed by ex-SCI employees working for West Point-Pepperell, Inc. (Georgia). . . . product line sold to Swiss company in 1971, with same technology used in many new textile weaving mills worldwide (particularly, Poland, France, Belgium and U.S.). . . . system monitors loom operator performance and is wholly responsible for productivity increases over 1%, generally in 2-6% range. . . . annual national productivity increase was 1.7% between 1967 and 1970, 3% before and after that time period. (Contractor, TEF 119, Case No. 04793, 9/74)
- A-5 Contamination control handbook: compiled for Marshall. . . . used by Ortho Pharmaceutical Co. (New Jersey) to design better contamination control facilities for birth control pill production. . . . increased worker productivity used by Kentucky Electronics, Inc. (Kentucky) to improve two key production steps for consumer electronics (mainly color television components for RCA, Westinghouse and Zenith products), degreasing and drying operations now done with fluids and processes described in handbook. . . . improved product quality and productivity, with annual sales over \$7 million. (TB/TSP, TEF 262, Case Nos. 31286, 39662, 9/74)

* Denotes transfer case related to Key Issue.

A. MANUFACTURING CONSUMER PRODUCTS (CONT.)

- + A-6 Paragraph deleted, 9/76
- A-7 Optical alignment training manual: compiled by Marshall. . . . incorporated into standard operating procedures at Eastman Kodak Co. (New York) for aligning optical testing instruments. . . . accuracy improved. (TB/TSP, TEF 208, Case No. 32414, 8/74)
- A-8 Intumescent fire retardant coatings: developed by Ames. . . . used, under NASA license, by AVCO Corp. (Massachusetts) to develop commercial product line. . . . more than 50,000 sq. ft. of the intumescent sheeting product sold monthly to major manufacturer of hoses. . . . used as protective cover on fuel hoses for inboard pleasure boats. . . . AVCO working with Boating Industry Association and U.S. Coast Guard to develop additional intumescent coatings for pleasure boat applications such as fuel tanks and engine compartment walls. . . . improved fire safety for boating. (License, TEF 554, Case No. 108481, 2/75)
- A-9 Dry lubricant coating processes for metals: research need identified in quality control study conducted for Headquarters by General Magnaplate Corp. (New Jersey). . . . company developed and patented 4 processes to bond dry lubricants, such as Du Pont's Teflon, on metal surfaces for space applications many components for Apollo, Viking, Skylab, and Shuttle coated by General Magnaplate. . . . commercial coating services introduced; annual sales are \$1.8 million. . . . over 600 manufacturing clients include GE, IBM, RCA, Westinghouse, Polaroid, and ITT. . . . applications include production equipment for hundreds of household items such as molded plastic products, dog biscuits and birth control pills, as well as products such as computer components, office equipment, packaging machinery, turbines, valves and racing car components. . . . coated production equipment enables longer wear life, higher operating speeds, and cleaner operation. . . . increases productivity and lowers unit cost. . . . two Japanese companies, including Mitsubishi Corp., and one Israeli company licensed to use processes. (Contractor, TEF 575, Case No. 109338, 9/76).
- + A-10 Microbiological handbook: compiled for Marshall. . . . used by Eli Lilly and Co. (Indiana) as training manual in sterilization procedures for technical and professional employees. . . . resulted in improved procedures and \$15,000 annual savings in operating costs. . . . also used by designers of new Lilly facility for production of antibiotics. (Personal contact/TSP, TEF 402, Case No. 95114, 2/75)

A. MANUFACTURING CONSUMER PRODUCTS (CONT.)

- A-11 Black chrome coating properties for solar energy collectors: compiled by Lewis. . . . used by Chamberlain Manufacturing Corp. (Iowa) in selecting black chrome for its new solar collector product line. . . . approximate retail cost \$12 per square foot for residential collectors. . . . company has collector production capacity for 250,000 square feet annually in anticipation of an expanding solar collector market. (Conference/personal contact/TSP, TEF 600, Case No. 114859, 12/75)
- A-12 Computer modeling handbook for thermal analysis: prepared for Johnson by Grumman Aerospace Corp. (New York). . . . thermal analysis procedures for the Lunar Module. . . . the computer programs simulate and display the reactions of different materials and structures to the same thermal conditions. . . . company modified the computer programs to design a thermal analyzer system for testing solar collectors. . . . benefits of analyzer system include a savings of several years in engineering testing time during the development of a new commercial solar collector called Sunstream. . . . new product currently being distributed nationally. (Contractor, TEF 616, Case No. 117155, 3/76)
- A-13 Computer technique for financial analysis: developed for Marshall to provide financial evaluation of new equipment. . . . consists of 3 computer programs to calculate present value and return on investment. . . . used by Plough, Inc. (Tennessee) to evaluate alternative production equipment purchases. . . . technique enables company to make prepurchase comparisons based on a numerical rating. . . . reduced cost, time and uncertainty in making comparisons. . . . programs used 75 times and continued use expected. (TB/COSMIC, TEF 625, Case No. 117161, 4/76)
- A-14 Floating zone process for producing refractory material fibers: developed for Lewis advanced gas turbine program by Arthur D. Little, Inc. (Massachusetts) process uses a 400-watt laser heat source to produce high temperature aluminum oxide fibers for composite materials. . . . under same contract, ADL developed a prototype fiber-drawing machine to perform the process. . . . ADL obtained a patent waiver from NASA to use the process and fabricated a similar commercial machine for drawing out sapphire filaments. . . . ADL sold this machine and a license for the process to RCA, Inc. . . . RCA will use the process and machine to produce the sapphire stylus part for a new consumer product, a video-disc player. . . . ADL is also fabricating an automatic version of the machine for RCA for same use. . . . benefits to ADL include increased revenue from research activities and an expanded capacity to conduct new research. (Contractor, TEF 612, Case No. 117153, 3/76)
- A-15 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Walt Disney Productions, WED Enterprises Div. (California) to design the support structure for a Disney World (Florida) roller coaster ride called "Space Mountain" company accessed the program through a computer service to determine the size and strength of structural components. . . . benefits include cost savings of \$5,000 from not overstrengthening the track supports. . . . program also being used to design a similar ride for Disneyland. . . . benefits expected to continue. (Personal contact, TEF 410, Case No. 119307, 6/76)

A. MANUFACTURING CONSUMER PRODUCTS (CONT.)

- A-16 Carbide analysis to predict bearing fatigue life: developed by Lewis as part of a continuing program to advance mechanical components technology. . . . used by Walt Disney Productions, WED Enterprises Div. (California) to redesign faulty axles on its "Autopia" fun rides at Disneyland and Disney World. . . . 350 axles were replaced by axles containing more durable bearings material, selected on the basis of carbide analysis data. . . . new axles have operated without failure for approximately two years. . . . elimination of ride break-downs due to axle failure has saved \$30,000 in labor and materials costs. (TB/TSP, TEF 634, Case No. 119299, 5/76)
- + A-17 Fracture toughness tests: developed by Lewis. . . . used by Deere and Co. (Wisconsin) to improve safety and service life of snowmobile product line, Big John. . . . better alloys and quality control procedures reduced chance of fracture failure in snowmobile drive trains. . . . sales for 1976 expected to be 240,000 snowmobiles at \$1,200 to \$2,850 each. . . . Deere is third largest of 10 companies marketing snowmobiles. (Professional society, TEF 451, Case No. 101903, 9/76)

Other Relevant Examples:

B-9 (lubricant deposition process); B-16 (electronic components); B-19 (flammability tests of home furnishings); B-23 (spun metal fibers for web filters); B-24 (wire components); B-28 (sports stadium); B-31 (paint production); B-42 (process equipment seal); C-5 (fabric metallizing process); F-2 (product safety); F-13 (anti-fog); F-14 (food production); F-19 (food processing); H-11 (automobile fuel R&D); I-5 (home safety product); I-12 (performing arts hall); K-3, K-4, K-5 and K-6 (automobile design and production); K-7 (studless winter tires); Q-4 (lubrication handbook)

MANUFACTURING CAPITAL GOODS

B. MANUFACTURING CAPITAL GOODS

Key Issue

Balance of trade for capital goods: In 1973, U.S. exported capital goods worth \$21.5 billion and imported \$7.5 billion. Exports of electrical machinery and electronic components accounted for \$3.5 billion, more than any other classified capital goods. U.S. supplied over two-thirds of growing world market for microelectronic components. Market share maintained by continually advancing the state-of-the-art of microelectronic component production technology so that productivity is increased. Productivity depends on yield which is improved by reducing the percentage of components spoiled during production. (B-1)

B. MANUFACTURING CAPITAL GOODS

- *B-1 Microelectronics production quality assurance: NASA established reliability program and procurement standards for microelectronic products in 1964 to assure best manufacturing practices would be used by suppliers. . . . introduced concept of Certified Production Line (CPL) so that entire production lines, rather than products themselves, were certified for NASA procurement after vendor had established quality control practices and in-house evaluation methods to satisfy NASA inspection teams. . . . CPL approach later adopted by DOD which developed, with NASA, certification standards. . . . many major microelectronics manufacturers configured standard production lines to be certified for space or defense procurement and now produce commercial units from these lines. . . . widespread impact by increasing productivity for commercial products on world market. . . . one vendor increased yield by 20% after modifying production practices for certification (1-2% increases very valuable in the industry). . . . Marshall obtained one of first scanning electron microscopes (SEM) ever built and developed SEM inspection techniques to analyze failure modes for microelectronics. . . . provided failure analysis reports to microelectronic vendors and encouraged manufacturers to use SEM for same purpose. . . . SEM's now widely used in U.S. microelectronics industry. . . . largest producer of microelectronics, Texas Instruments (Texas), with annual sales over \$1 billion, is certified by NASA and used 3 SEM's for quality assurance and failure analysis. . . . NASA standards used in key production steps for all TI products. (Contractor, Industrial Products and Practices, DRI, 2/73)
- B-2 Infrared scanner and television display: operational unit developed for Marshall. . . . contractor employees founded Dynarad, Inc. (Massachusetts) to market unique product line of IR scanners. . . . units display heat picture on TV screen. . . . over \$2 million in total sales, unit price range \$6,500 to \$25,000. . . . customer applications include maintenance inspections, quality control, and research in several industries (steel, aluminum, petrochemical, rubber, nuclear fuels, aircraft and electric power), as well as medical diagnoses such as breast cancer. . . . product line sold to Inframetrics, Inc. (Massachusetts) in 1975. . . . production and sales continuing. . . . developing design improvements. (Personnel/contractor, Purchased product line, TEF 398, Case Nos. 70001, 112249, 9/75)
- + B-3 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over \$2 million in contracts to produce innovative NASA equipment in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed. . . . uses multiple transducers for significant improvement in speed and accuracy. . . . more than 25 manufacturers purchased between 1 and 100 Manipulators @ \$800. . . . larger number of firms fabricated in-house versions. . . . widely used for quality control inspection of aircraft components and steel pipe manufactured for petrochemical applications. . . . Automation has \$50 million annual sales of ultrasonic test equipment for quality control in steel, railroad, aircraft, nuclear reactor, automotive, and tubular products industries. (Contractor, TEF 387, Case No. 59201, 8/74)

* Denotes transfer case related to Key Issue.

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-4 Nondestructive testing handbook: developed by Marshall. . . . ultrasonic techniques in handbook provided 10-30% of input to development of in-house quality control procedures at Aluminum Company of America (Pennsylvania) ultrasonic testing routinely done for wrought aluminum products at Alcoa plants. . . . ultrasonics faster, better resolution than other NDT methods in finding flaws, very important link to fracture mechanics since brittle fracture can start at flaws left by fabrication process. (TUO conference, TEF 381, Case No. 57802, 8/74)
- B-5 Contamination control handbook: compiled for Marshall. . . . used at Xerox Data Systems (California) to improve contamination control in production of computer peripherals such as disc files. . . . reduced cost of contamination control and significantly reduced quality control failure rate caused by contamination. (TB/TSP, TEF 262, Case No. 33050, 10/72)
- B-6 Surface finishing method for nickel alloys: developed for Marshall. . . . standard process at Westinghouse Corp. (Pennsylvania) since 1970 to finish components for gas turbine electric generators. . . . turbines up to 100 megawatts. . . . significant time and cost savings over previous method. (TB/TSP, TEF 198, Case No. 29518, 8/74)
- B-7 Inert-gas welding enclosure: developed by Lewis. . . . used by Communications Satellite Corp. (District of Columbia) to fabricate microwave components for satellites and ground stations. . . . made it possible to use very lightweight metals for components and reduce production time tenfold. (TB/TSP, TEF 189, Case No. 19795, 8/74)
- B-8 Fluidic controls: developed by Lewis for rocket engines. . standard controller on automatic metalworking lathes produced by Bardons and Oliver, Inc. (Ohio) since 1967. . . . only fluidic-controlled lathes on market. . . . 125 sold in price range \$40,000 to \$80,000. . . . fluidic controls are half the cost of electric controls, also more reliable and maintainable. (TUO conference, TEF 193, Case No. 101902, 8/74)
- B-9 Lubricant deposition process: developed for Goddard by Ball Brothers Research Corp. (Colorado). . . . process commercialized by BBRC into VacKote line of several hundred lubricant products. . . . 1976 sales mainly derived from lubrication service. . . . company holds several patents on lubricant variations and receives license royalties. . . . applications: coating for glass industry molds increases production efficiency 5% and eliminates prior fire hazard; protective film coating for movie camera film cartridges improves performance and reduces film breakage; lubricant for electric motor brushes in vacuum cleaners, electric shavers and car air conditioners increases service life; and lubricant for computer peripheral equipment increases efficiency. (Contractor, TEF 201, Case No. 42849, 7/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-10 Fracture toughness tests: developed by Lewis. . . . used by Aluminum Company of America (Pennsylvania) to provide fracture toughness guarantee for high-strength alloy products. . . . critical design parameter for Alcoa customers who use these alloys to fabricate aircraft components, chemical processing equipment, or liquefied natural gas containers on ocean tankers. . . . reduces structural failures. (Professional society, TEF 451, Case No. 101901, 8/74)
- B-11 Thermal expansion properties handbook: compiled for Marshall. . . . used extensively at Eastman Kodak Co. chemical plant (Tennessee) in design and materials selection for new hydrogen production facility worth over \$500,000 saved 25% of design cost and significant amount of construction cost also used to select better materials for catalytic cracker and heat exchanger. (TB/TSP, TEF 321, Case No. 32416, 3/71)
- B-12 Weld strength prediction method: developed for Marshall. . . . used at Eastman Kodak Co. chemical plant (Tennessee) to improve safety at little cost. . . . eliminated hazard of rupturing pipes that contain chemicals. (TB/TSP, TEF 359, Case No. 41946, 3/71)
- B-13 Paragraph deleted, 1/76
- B-14 Mass flowmeters for low gas flow: developed to meet specifications of Johnson Apollo subcontractor by Tylan Corp. (California). . . . Tylan introduced gas flowmeter as commercial product in 1968. . . . product now used extensively in U.S., Europe, and Japan for process control and manufacture of semiconductors, as well as in petrochemical production, medical instrumentation, heat transfer devices and thermodynamic analysis. . . . since initial NASA market in 1965, growth in annual sales from \$300,000 to \$3,000,000, employment up from 20 to 80. . . . entire business based on fallout from Apollo Program. (Subcontractor specifications, TEF 563, Case No. 109332, 5/75)
- B-15 Technique for reducing noise in radio amplifiers: developed for Headquarters used by GTE Sylvania, Inc. (California) to improve rf amplifier product by lowering "electrical noise". . . . saved research time and reduced operating costs. . . . amplifiers used in high sensitivity, low noise military receivers. (TB/TSP, TEF 553, Case No. 58826, 3/75)
- B-16 Specification guidelines for hybrid microcircuits: compiled by Marshall. . . . used by Bell & Howell Co. (Connecticut) to develop new manufacturing process for epoxy mounting of semiconductors on substrates. . . . technique now used in part of company production line. . . . reduced operating and material costs used by General Electric Co. (Pennsylvania) to revise microcircuit manufacturing standards. . . . saved engineering time and increased product reliability. . . . microcircuits used in heart pacemakers and medical monitoring equipment. . . . used by Cutler-Hammer, Inc. (New York) to prepare microcircuit workmanship standards manual. . . . reduced operating costs. . . . microcircuits used in military and commercial aircraft instrument systems. . . . used by "R" Engineering (California) to solve problems in the production of solid state relays. . . . use of manual expected to continue. (Personal contact/TSP, TB/TSP, TEF 556, Case Nos. 83967, 87260, 87339, 91196, 7/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-17 Temperature and solvent resistant sealant: developed for Marshall. . . . used by Weed Instrument Co. (Texas) to develop new sensing component for temperature control product line. . . . product accuracy improved, contributing to substantial increase in company's annual sales. . . purchased by various industries to control temperature of plant process equipment (TB/TSP, TEF 541, Case No. 90086, 3/75)
- B-18 Guidelines for fabrication of hybrid microcircuits: compiled for Marshall used by Watkins-Johnson Co. (California), manufacturers of microwave communications systems, to improve processing techniques in assembly of microcircuits. . . . improved product quality and production yields; increased marketability and sales. . . . used by Harris Semiconductor Div. of Harris Corp. (Florida) in development of integrated circuit packages. . . . reduced operating costs. . . . packages sold to electronic equipment manufacturers for use in computer control and communication equipment. (TB/TSP, Trade show/TSP, TEF 501, Case Nos. 83756, 101726, 4/75)
- B-19 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . report used by Monsanto Co. (Missouri) to design flammability tests of fire retardant chemicals and other company products used in the construction industry. . . . also used by Owens-Corning Fiberglas Corp. (Ohio) to help in evaluating flammability data from in-house test program to develop new markets for company products used by Baychem Corp., Mobay Chemical Co. (Pennsylvania), to design fire tests and evaluate data for in-house program to improve fire resistance of polyurethane foams; major manufacturer of chemicals used to produce foams. (Contact/contractor, NTIS, TEF 539, Case Nos. 107043, 107044, 107046, 1/75)
- B-20 Electronic power dividers and switching components: developed for Johnson Apollo communications systems by Transco Products, Inc. (California). . . . developed into commercial products by Transco. . . . enabled design of compact, hermetically sealed, highly reliable electronic components. . . . applications in aerospace and nonaerospace microwave communications equipment. (Subcontractor, TEF 562, Case No. 109336, 5/75)
- B-21 Standards for material handling equipment testing: developed for Johnson regularly used by Goodyear Atomic Corp. (Ohio), ERDA contract operator of major uranium gaseous diffusion facility, during internal safety code inspections and safety report preparation. . . . provides more detailed information than safety code for some equipment. . . . only UF₆ diffusion in U.S.; occupies 3,000 acres, with 38 large buildings containing many units of material handling equipment. (TB/TSP, TEF 572, Case No. 58958, 4/75)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-22 Apollo Program management techniques: developed for Johnson by Rockwell International Corp., Space Div. . . . used by RI's Rockwell-Standard Div. (Michigan), major producer of truck and bus components such as axles and transmissions, to manage product design and development processes. . . . enabled significant improvements in personnel evaluation procedures, standardization of product and component test methods, task scheduling, design control procedures, and other management tasks. . . . initiated use of computerized management information system for product warranty payment data. . . . annual RI sales for automotive products about \$1 billion. (Personnel/contractor, TEF 573, Case No. 109337, 4/75)
- B-23 Spun metal fibers for web filters: identified by Marshall contractor as needing further development for space applications. . . . developed by Hydraulic Research and Manufacturing Co. (California) and supplied to Apollo Program contractors. . . . commercially available from HR since 1971. . . . annual sales over \$500,000; market expected to double in 5 years. . . . filter applications include chemical processes for photographic film and synthetic fibers, nuclear reactors, marine hydraulic systems, and subsurface blowout valve systems on offshore oil rigs. (Contractor report, TEF 564, Case No. 109330, 5/75)
- B-24 Lead oxide ceramic as high-temperature lubricant: developed by Lewis used by National Standard Co. (Michigan) to develop manufacturing process for aluminum coated wire. . . . wire product formerly supplied for telephone and other communications transmission lines. . . . National Standard process now licensed to Yazakai Corp. (Japan). . . . major supplier of auto instruments, wiring harnesses, and gas meters to Asian markets. (TB/TSP, TEF 337, Case No. 44293, 8/75)
- B-25 AC-to-DC converter: developed for NASA Pasadena Office. . . . used by Wer Industrial Corp. (New York) in design of new AC-to-DC converter, a component of electrical control system used in automatic sheet metal cutters. . . . total system sales of \$250,000 for 250 units. (TB/TSP, TEF 437, Case No. 45978, 8/75)
- B-26 Methods for using optical instruments: compiled by Marshall. . . . used by Farrand Optical Co., Inc. (New York) in design reviews to identify key user features of an alignment telescope. . . . identified need for two product modifications. . . . improved model recently introduced into marketplace, and company anticipates increased sales volume. (TB/TSP, TEF 529, Case No. 99316, 1/75)
- B-27 Microbiological handbook: compiled for Marshall to provide design information for planetary-landing spacecraft. . . . used by Continental Testing Laboratories, Inc. (Florida) to select the best method for testing fungus and nutritive properties of insulating materials. . . . significantly affected decision to subcontract biological testing. . . . handbook also used as a standard reference for understanding and communicating biological testing capabilities, limitations and requirements. (TB/TSP, TEF 402, Case No. 51951, 8/75)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- + B-28 Air flotation device: invented by General Motors. . . . first large-scale application as air bearing lift pad for moving Saturn V components during assembly at Marshall. . . . former GM employees formed Rolair Systems, Inc. (California) and received license from GM to produce and market the device for moving heavy objects. . . . \$3 million annual sales of flotation device product applications include assembly line movement of heavy components for Allis-Chalmers crawler tractors, caterpillar earthmover components and Boeing 747's, moving seats in Hawaiian stadium, and movement systems for Space Shuttle program, including the rocket engine and mating of the satellite company also offers several standard air pad components, for use in custom-designed moving systems. (Personnel/contractor, TEF 267, Case No. 44292, 9/76)
- + B-29 Visual simulation systems: developed for Johnson by General Electric Co. (Florida). . . . a computer-generated color TV display to simulate spacecraft docking, Space Shuttle landing and other space-related applications used by GE to develop a commercial system, IMAGE 100, for the analysis of multispectral remote sensor data. . . . processor accepts photographic and/or digitized images and displays output on a color video screen or records information with a printer/plotter or color film recorder. . . . user can control or modify the analysis process to extract desired thematic information. . . . applications include land use classification, urban and agricultural mapping from LANDSAT data, also in medicine for breast and skin cancer research. . . . ten systems sold to government agencies in the U.S. and foreign countries. . . . retail cost is approximately \$450,000. . . . also used by GE for a commercial service for data analysis. . . . IMAGE 100 users group formed in 1974, members exchange applications and service information. . . . software exchange program and library are available to users. (Contractor, TEF 389, Case No. 109340, 7/76)
- B-30 Limited life item management: developed for Marshall. . . . control plans, procedures, and complete specifications for the management of age-sensitive hardware. . . . used by the Tennant Co. (Minnesota) to establish inventory distribution control procedures to improve rubber component shelf life. . . . also used to educate customers on need for replacement schedule for age-sensitive components. . . . reduced production downtime for customers. (TB/TSP, TEF 457, Case No. 69356, 7/75)
- B-31 Motivation techniques: developed for Johnson to outline motivation techniques for reducing employee error. . . . document used by Waldom Electronics, Inc. (Illinois) to develop work performance standards for a computer assisted production analysis program. . . . saved many hours of planning time; increased productivity expected within a year. . . . used by Warth Paint Co. (Florida) to improve employee goal orientation and to develop error identification discussion topics on production of coatings saved \$12,000 in materials loss and industrial injury expense. . . . information also used by United Technologies Corp., Pratt & Whitney Aircraft Div., Florida Research and Development Center (Florida) to develop a staff motivation and development program, involving 8 engineers, to improve design and development capabilities on the F-100 engine. (TB/TSP, TEF 583, Case Nos. 105362, 105498, 105500, 9/75)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-32 Manpower planning techniques: developed for Johnson. . . . used by Universal Oil Products Corp., Wolverine Tube Div. (Alabama) to assist management with long-range manpower forecasting. . . . manpower planning techniques implemented in division's current 5-year plan. . . . estimated labor savings of 5,000 hours per year. . . . division produces components for air conditioners. (Personal contact/TSP, TEF 287, Case No. 33904, 7/75)
- B-33 Electronic power circuit design techniques: developed by Lewis for spacecraft instrumentation. . . . used by Inservco, Inc. (Ohio) in the design and production of temperature control instruments for chemical processing plants. . . . company modified instrument's circuit design to eliminate a calibration problem. . . . reduced production costs by \$15,000. (Personal contact/Lewis, TEF 601, Case No. 114864, 1/76)
- B-34 Connector seals for cryogenic fluid lines: developed by Goddard. . . . Cryolab, Inc. (California) acquired nonexclusive NASA license in 1965 to produce a line of connector seals in various sizes. . . . annual sales during the late 1960's averaged \$5,000 to \$6,000 before leveling off. . . . 1975 sales totaled \$3,000. . . . most seals now available by special order. (TB/TSP, TEF 354, Case No. 49067, 12/75)
- B-35 Die set for flared metal tubing: developed for NASA Western Operations Office. . . . patent rights waived to contractor who sold production rights to Dynaflare Industries, Inc. (California). . . . used to produce a four-model line of automated tube flaring machines. . . . retail cost ranges from \$8,000 to \$16,000 each. . . . machines purchased by government and industry manufacturers. . . . applications include component fabrication for heating, air conditioning, hydraulic and oxygen systems. . . . benefits for customers include 25% savings in labor, 20% savings in fabrication costs, and more reliable precision parts. (License/contractor, TEF 52, Case No. 114858, 12/75)
- B-36 Lathe chuck key: developed by Johnson to provide safety feature that prevents leaving key in chuck. . . . commercialized by Omex Corp. (California) for use in industrial lathes and power tools. . . . also, readily adaptable for household power tools. . . . retail cost is \$1.50 each. . . . 800 units sold to a large aerospace company and contract negotiations currently underway with a large retail merchandiser. . . . sales expected to increase as new markets are developed. . . . Omex assisted by Rockwell International minority business program. (Personal contact/TSP, TEF 589, Case No. 113676, 11/75)
- B-37 Eddy current nondestructive testing training manuals: developed for Marshall. . . . manuals published by contractor and distributed by American Society for Nondestructive Testing. . . . used by Pullman, Inc., Pullman Kellogg Div. (Texas) to train 50 welding inspectors in eddy current testing methods used during construction of chemical plants. . . . manuals also used for mechanical engineering recertification training. . . . benefits include reduced training costs, more rapid certification of welders, and improved quality assurance programs. (Professional society, TEF 14, Case No. 114855, 12/75)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-38 Combustion analysis computer program: developed by Lewis. . . . used by Ralph M. Parsons Co. (California) in the design of chemical processing plants. . . . applications include sulphur, coal gasification and petroleum processes. . . . also used to develop the Beavon process, a patented method to reduce gas emissions from sulphur plants. . . . principal customers are major oil companies. . . . company designs about 30 plants each year at engineering design costs ranging from \$100,000-\$400,000. (Personal contact, TEF 463, Case No. 104279, 1/76)
- B-39 Photodiode design methods: developed by Ames. . . . two methods used by Hewlett-Packard Co., Electro Optics Div. (California) to improve photodiode product line. . . . one method used to improve ultraviolet sensitivity in company's 4200 series PIN photodiodes. . . . product line has specialized customer applications, with several models sold on a special order basis. . . . second method used to expand knowledge of temperature characteristics for photodiode product line used in instruments. . . . benefits include a savings of engineering time, valuable marketing information, a significant increase in sales, increased capacity to meet customer requirements, and broader applications for photodiodes. (Personal contact/Ames, TEF 595, 604, Case Nos. 114471, 114472, 11/75)
- B-40 Magnetic properties of core materials for electrical transformers: developed by JPL to design lightweight, reliable transformers for Mariner spacecraft. . . . Spang Industries, Inc., Magnetics Div. (Pennsylvania) used test data and new air-gap design concept to develop new product line of cut core transformer materials. . . . data also used to produce company brochure on transformer materials selection. . . . increased sales by \$100,000 annually. . . . other benefits include wider range of market segments and enhanced reputation in transformer component market. (Personal Contact/JPL, TEF 597, Case No. 114474, 11/75)
- B-41 Subminiaturized gas chromatograph: developed by JPL to provide fast, efficient analysis of samples on spacecraft. . . . commercialized by former JPL employee under nonexclusive NASA license. . . . assets and technology purchased by Honeywell, Inc., Process Control Div. (Texas) to produce new line of gas chromatograph process analyzers for petroleum, chemical and fertilizer industries. . . . Honeywell also obtained a NASA license to use the basic invention. . . . product line features faster analysis time, greater reliability, simpler operation, and reduced maintenance. . . . company holds 20% of market share, with annual sales of \$1.5 million. . . . retail cost is \$6,000-\$30,000 each. . . . customer benefits include better use of utilities, improved quality and process controls, and reduced product waste. (Purchased product line, TEF 144, Case No. 114854, 12/75)
- B-42 Technique for suspending magnetic particles in fluid: developed by Lewis to control liquid propellants under zero gravity conditions. . . . former contractor employee obtained a NASA license to use the technology and formed Ferrofluidics Corp. (Massachusetts) to develop new product line of rotary shaft seals. . . . one product, called FERROMETIC Rotary Feedthrough, provides zero leakage, low maintenance, and easy installation on rotary shafts protruding into vacuum processing systems. . . . company's annual sales total \$750,000. . . . primary market is electronics industry. . . . customer applications include production of integrated circuits, computer memory discs, and home stereo loud speakers. (Personnel/contractor/TSP, TEF 607, Case No. 114870, 1/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-43 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Control Data Corp., Professional Services Div. (California and Florida) to convert customers' computer program codes for use on CDC's equipment. . . . reduced program conversion time; saved 30 hours in one application. . . . continued use expected in other program conversion efforts as part of customer services. (Trade Journal/TSP, TB/TSP, TEF 527, Case Nos. 102222, 102223, 9/75)
- B-44 Telecommunications systems analysis techniques: prepared for NASA Pasadena Office by JPL. . . . describes techniques for the design and analysis of deep-space telecommunications systems. . . . contains 10 sections related to the tracking, telemetry, antennae and command functions of the systems, as well as performance criteria charts, block diagrams and reference material used by Motorola, Inc., Government Electronics Div. (Arizona) as a reference source in a design review and reliability analysis of a proposed circuit for a satellite transponder. . . . customers are Lockheed (building satellites for the USAF) and General Electric Co. (building the NASDA satellite for the Japanese government). . . . saved approximately \$500 in research effort handbook will continue to be used as a reference source. (Personal contact/TSP, TEF 623, Case No. 112272, 4/76)
- B-45 In-house telephone system: developed by Johnson. . . . inexpensive, closed loop system accommodates 16 or more telephone or data units and 8 simultaneous 2-way conversations through 4 interconnecting wires; it uses fewer circuit components than existing systems and requires no central exchange control used by Cook Industries, Inc. (Tennessee), a major wholesale grain company, to design an in-house telephone system for its plants and facilities in the Memphis area. . . . company saved \$8,000 by adopting NASA design. . . . use of the system is expected to continue. (TB/TSP, TEF 618, Case No. 104504, 4/76)
- B-46 Comparison of chemical solvents for degreasing: prepared for Marshall. . . . outlines process specifications for Inhibited 1,1,1-Trichloroethane (TCE) to replace trichloroethylene for degreasing. . . . used by Dow Chemical Co. (California) as a reference source to answer a customer inquiry on the safety of using TCE in the degreasing of an aluminum part. . . . chlorinated solvent used for commercial clothing and metal cleaning. . . . use of information improved customer relations. . . . benefits expected to continue. (TB/TSP, TEF 619, Case No. 111778, 4/76)
- B-47 Fluid properties handbook (Revised Edition): compiled for Marshall to update and expand the existing Fluid Properties Handbook. . . . updated version contains quantitative data related to thermodynamic properties of specific cryogenic fluids and several metals. . . . original and revised versions used by Flow Dyne Engineering, Inc. (Texas) as a central reference for properties of liquids and gases. . . . information is essential in custom designed Venturi and critical flow nozzles which are fluid meters used for test purposes in research and development and for existing systems to measure rate and flow of fluids and gasses. . . . annual sales total 400 units at more than \$200 each. . . . customers include commercial and government users. . . . company estimates handbook used once every two weeks. . . . benefits include a 20% reduction in research effort and lowered engineering costs. (TB/TSP, TEF 246, Case No. 113832, 4/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-48 Coaxial cable stripper: developed by Ames. . . . patented by Ames employee. . . . hand tool simultaneously cuts shielding and insulation from a cable in order to attach connectors. . . . Western Electronics Products Co. (California) obtained an exclusive license from the inventor and produced the stripper in a slightly modified form for commercial sale. . . . to date, 10,000 units have been sold. . . . basic model retails for \$46.50. . . . cable stripper marketed through sales representatives and distributors. . . . customers include TV stations and citizen band radio manufacturers. (Personal contact/Ames, TEF 60, Case No. 52691, 5/76)
- B-49 Vinyl-coated nylon refuse bag: developed for Marshall service contractor by TRS Co. (Michigan) to reduce the costs of cleaning service at Marshall. . . . use of vinyl-coated material and welded seams eliminate mildew, stain and leakage problems. . . . new, inexpensive "Long-Life Bag" is fire retardant, washable, lasts 10 times longer than cotton duck bags, and can replace 1,000 disposable polyethylene liners. . . . company expanded sales to entire building service trade; sales so successful, TRS abandoned previous, less profitable product line to manufacture refuse bag exclusively. . . . customers include Holiday Inn, Sheraton Lodges, and many large janitorial contractors. (Subcontractor, TEF 615, Case No. 117156, 3/76)
- B-50 Precision grinding tool: developed by Marshall to fabricate precision components for Saturn V guidance and control system. . . new method for impregnating aluminum plates with diamond powder and hard-anodizing them to form grinding and polishing laps. . . . invention patented by NASA employee who formed Abernathy Laps Co. (Alabama) in 1966 to commercialize the laps. . . . company fills custom orders for laps in various sizes and shapes as well as diamond powder sizes. . . . unit prices range from \$170 to over \$500 and annual sales have been between \$20,000 and \$25,000. . . . sales expected to continue, with market expansion planned. . . . applications include fabrication of precision components and preparation of metallurgical specimens for analysis. (Former NASA employee, TEF 11, Case No. 119301, 5/76)
- B-51 High-temperature strain measurement system: developed for Dryden Flight Research Center by Boeing Aerospace Co., division of Boeing Co. . . . capacitive strain gage and signal conditioning system to measure stress-induced strain without thermal expansion strain. . . . Boeing obtained a patent waiver from NASA and issued an exclusive license to Hitec Corp. (Massachusetts) to commercialize the system. . . . company used thermal expansion strain cancellation design feature in developing new product, strain measurement gage with optional instrumentation package. . . . cost of gage alone is \$900; cost of complete system is \$1,200. . . . sales totalled \$250,000 in 1975. . . . used in electric power plants and oil refineries to monitor stress in boilers, pipes and valves. (License/contractor, TEF 637, Case No. 119304, 5/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-52 Differential temperature transducer: developed by Ames for an energy research project. . . . measured difference between inlet and outlet temperature for cooling water in an electric-arc heater. . . . patented by NASA. . . . Ames inventor obtained nonexclusive license and formed Delta-T Co. (California) in 1964 to commercialize the invention. . . . transducer produced in different sizes and sold for approximately \$430 each. . . . annual sales of \$40,000 in recent years, expected to be \$50,000 in 1976. . . . provides accurate, rapid measurement of temperature difference, a critical parameter for analyzing heat flux in energy conversion equipment. . . . primary applications are fusion and solar energy research projects in government and private laboratories. (Personnel/Ames/License, TEF 222, Case No. 119300, 5/76)
- B-53 Welding high-strength aluminum alloys: handbook compiled for Marshall. . . . integrates results from 19 research programs, including work done for Saturn V. . . . describes welding fabrication, aluminum alloy characteristics, weld defects and porosity, role of contaminants, weld thermal effects and residual stresses. . . . used by Reynolds Metals Co., Metallurgical Research Div. (Virginia) to improve welding techniques in its research activities. . . . specifically, the dry machining method of preparing surfaces for welding has become the standard technique used in precision welding and metallurgical research. (TB/TSP, TEF 626, Case No. 105576, 4/76)
- B-54 Nondestructive spot test procedure: compiled by Langley. . . . used by Fischer & Porter Co. (Pennsylvania) to test for cadmium in electronic components. . . . tests performed several times each year, primarily on equipment for ERDA's nuclear reactor program. . . . saved research time and approximately \$500 in outside laboratory testing costs. . . . also used by Ball Brothers Research Corp. (Colorado) to identify alloys and contaminants in metal and porcelain components for computer tape drive discs and brewery machinery. . . . in addition, used to verify aluminum alloy content in TV scanner cases produced for the U.S. Navy. . . . benefits include increased in-house materials testing capability and savings of \$1,000 in outside laboratory testing costs. (TB/TSP, Personal contact/TSP, TEF 378, Case Nos. 44734, 114830, 5/76)
- B-55 Electronic and electromechanical component reliability data: compiled for NASA Pasadena Office by JPL. . . . includes failure modes, screening requirements, derating factors and stress analysis. . . . used by Iomec, Inc. (California) to specify less costly quality assurance requirements and materials for the semiconductor components in its product line of computer peripheral equipment. . . . surface and burn-in specifications for some semiconductors were reduced from 160 hours to 90 hours. . . . also enabled company to substitute inexpensive plastics for ceramics in semiconductor chip packages; this saved \$.25 per chip. . . . estimated annual savings of \$300,000 include more precise specification of quality assurance requirements and reduced materials cost; benefits expected to continue. (Trade Journal/TSP, TEF 627, Case No. 112318, 5/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- B-56 Sonar locator system: U.S. Navy underwater search and locator system refined and further developed by Langley for use in recovering nose cones. . . . system uses a transmitter on object and receiver on surface craft or diver to locate underwater objects. . . . commercialized by Burnett Electronics Lab, Inc. (California) after completing Langley contract for receiver part company developed complete system for government users, mainly NASA and U.S. Navy. . . . two commercial models also produced: one for general purpose, the other for offshore oil rigs. . . . general purpose model costs approximately \$150; larger model approximately \$4,000. . . . principal customers include geological survey and oil exploration companies. . . . applications are exploring the ocean floor and locating equipment on it. . . . sales volume good and expected to remain high. . . . system also commercialized by Dukane Corp., Ultrasonics Div. (Illinois) after completing Langley contract for transmitter. . . . company produces several models of the transmitting element, called Pinger, and one model of the receiver. . . . Pinger is required on most commercial and government aircraft by the FAA. . . . Pinger supplied to 95% of the airline industry at \$395 each or less, depending upon quantity purchased. . . . since 1972, 8,000 transmitting elements sold. . . . sales expected to continue at present rate. (Contractor, TEF 4, Case Nos. 117158, 117159, 4/76)
- B-57 Broadband square-law detectors: developed for NASA Pasadena Office by JPL. . . . provide accuracy over a wide dynamic range, thermal stability and fast response time compatible with computers. . . . used by Buck Engineering Co., Inc. (New Jersey) as a reference source for basic principles of low level electronic signal detection applied in developing a circuit for a new radio frequency generator product. . . . to date, 12 units produced. . . . generator costs approximately \$300 and is used by technicians for signal detection when repairing and servicing electronic equipment. . . . benefits include reduced R&D costs by approximately \$100 and increased sales. . . . benefits expected to continue. . . . company products used mainly for teaching electronics in schools. (TB/TSP, TEF 629, Case No. 114740, 5/76)
- + B-58 Mass spectrometer: developed for Goddard, Johnson, Langley, Lewis, Marshall, JPL, by Perkin-Elmer Corp. (California). . . . design features included pre-set collectors and high reliability for various analyses; including atmosphere, pilot breath, spacecraft environment, Martian soil. . . . modified by company to develop commercial product line. . . . Model 1200 Multiple Gas Analyzer for industrial use has different packages for measuring various combinations of gasses. . . . over 15 units sold, price range \$25-30,000 each. . . . used in petrochemical and other industries for production of ethylene, ethelene oxide, vinyl chlorine, petrochloride and hydrogen. . . . market expected to expand. (Contractor, TEF 656, Case No. 121462, 9/76)
- + B-59 Optical data processing handbook: prepared by Goddard. . . . used by M7, International (Illinois) in designing photovoltaic paper tape reader product for computer input systems. . . . systems used by government, industry. . . . saved \$10,000 in development costs. (Trade journal/TSP, TEF 24, Case No. 78866, 7/76)

B. MANUFACTURING CAPITAL GOODS (CONT.)

- + B-60 Magnetics metric conversion data handbook: prepared for NASA Pasadena Office by JPL. . . . metric conversion data on design parameters for transformers, inductors. . . . used routinely by Endicott Coil Co., Inc. (New York) in design of less-than-50 watt transformers. . . . also used by Konigsberg instruments, Inc. (California) in design of an inductor for implantable telemeter for biomedical research on animals and in designing new product line of magnetic components. . . . company formed new division, Inductive Science, Inc. (California) in July 1975 to produce the small magnetic components such as filters, chokes, conductors, transformers. . . . approximately 7,500 custom-designed components sold to date for use in electronics, telemetry, research. (TB/TSP, Personal contact/TSP, TEF 547, Case Nos. 99844, 102704, 9/76)
- + B-61 Computer reliability improvement techniques: developed for Marshall. . . . modular design concepts to increase reliability by a factor of 10 for future computer needs. . . . used by Martin Marietta Corp., Orlando Div. (Florida) in designing communications controller, HICOM, for call processing by telephone companies. . . . provides parallel modules; if one fails, parallel unit takes over. . . . reduces downtime due to component failure. . . . technology reduced subsystem development costs substantially. (TB/TSP, TEF 645, Case No. 86548, 8/76)
- + B-62 Welder conversion circuit: developed for Marshall. . . . electronic package for converting continuous-dc TIG (tungsten-inert gas) welder to pulse-arc operation. . . . used by AMF, Inc., Potter and Brumfield Co. Div. (Indiana) to solve TIG welding problem. . . . company now welds small parts using modified TIG welder that eliminates heat deformation in electrical equipment products for government and industry. . . . enabled company to save 7 person-months in production and to adopt new weld procedures as standard shop practice. (TB/TSP, TEF 641, Case No. 119704, 12/75)
- + B-63 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Gardner Laboratory, Inc. (Maryland) to select lubricant applied in company product. . . . reduces customer maintenance. . . . product, a quality control Colorimeter, measures color for paint, plastics, food producers. . . . 100 to 200 units sold annually at \$5,000 to \$8,000 each. (TB/TSP, TEF 497, Case No. 93222, 9/76)
- + B-64 Graphite fluoride lubricant evaluation: developed by Lewis after initial discovery of lubricant properties by Rice University and U.S. Army. . . . established lubrication characteristics and advantages of new solid lubricant. . . . used by Ozark-Mahoning Co., Special Chemicals Div. (Oklahoma) to introduce new product line, Fluorographite. . . . applications include solid lubricant and cathode material in non-aqueous, high-energy batteries. . . . batteries used primarily by military, industry. . . . potential new use for electric car battery. . . . price is based on carbon/fluorine ratio; \$110 per pound for 1:1. . . . between 200 and 300 pounds sold in 1975. (TB/personal contact, TEF 333, Case No. 44077, 8/76)

B. MANUFACTURING CAPITAL GOOD (CONT.)

- + B-65 Materials flammability in oxygen environments: prepared by Marshall. . . . presents flame propagation rates and flammability ratings of 780 commercial materials in high oxygen environments. . . . used by Chemetron Corp., Fluid Controls Div. (Missouri) to select safe coatings and materials for new valve product line for chlorine gas environment. . . . sold to major chemical companies for use in production of ethylene glycol and polyvinyl chloride reduced R&D costs, time for new product line. (TB/TSP, TEF 659, Case No. 117369, 9/76)
- + B-66 Semiconductor processing capability: developed for Langley by University of Virginia, Electrical Engineering Dept. (Virginia) includes equipment and techniques for modifying solid state semiconductor materials. . . . used by department to develop fabrication process for Shottke barrier mixing diodes Shottke diodes produced by department are used in approximately 90% of all millimeter wave length radiotelescopes in U.S. and Western Europe department saves \$25,000 annually due to Langley-funded capabilities. (Contractor, TEF 657, Case No. 121464, 9/76)
- + B-67 Wing design concepts and propeller parametric performance data: developed by Langley. . . . used by Brod & McClung-Pace Co. (Oregon) in design of all household and industrial fan product lines. . . . industrial models used in air pollution control, venting, fruit drying. . . . Langley results described critical to company's design process. . . . annual sales of \$8 million, 150 employees. ([Unknown], TEF's 631, 639, Case Nos. 120515, 120516, 7/76)

Other Relevant Examples:

A-3 (office equipment); A-9 (production machinery lubrication); C-1 (energy conservation equipment); D-3 (dispatch computers, electric power); D-6 and D-11 (nuclear power plant equipment design); D-7 (steam turbine, steam generator and high temperature gas-cooled reactor design); D-9 (nuclear power plant design); E-12 (manufacturing contamination prevention); F-15 (waste water treatment product); F-2 (farm tractors and implements); F-15 (farm equipment); H-2 and I-6 (LNG storage and transfer facilities); I-18 (heating/cooling equipment); H-4 and H-5 (process control systems); H-6 (heat pipes); H-10 (gasoline vapor condenser); H-14 (oil refinery equipment); I-12 (elevator installation); J-5 (flat conductor cable); M-3 (production inspector training); M-14 (ball bearing design); M-17 (fabrication tools); N-5 (decontamination procedures); O-4 (soldering school); O-6 (R&QA training); O-7 (instrument training); Q-3 (electron tubes)

NEW CONSUMER PRODUCTS AND RETAILING

C. NEW CONSUMER PRODUCTS AND RETAILING

Key Issues

- a. New product introduction: New products have been a major source for corporate growth. Industrial trend is now toward introducing fewer new products and reducing production costs to maintain profitability (see Key Issue A-a). Booz, Allen and Hamilton estimates that only 2% of new product ideas are successfully commercialized. A recent study of 500 successful innovations showed 75% were based on market demand or production need, rather than technical feasibility. Even with market demand, a new consumer product may not be profitable if return on investment is inadequate. Dr. T. R. Hopkins, president of Gulf Research and Development Co., said in 1973 speech that product research is out-pricing itself since research costs are 10% of the investment to manufacture a new product. (C-1)
- b. Automation in department store sales: Retail sales by department stores were \$37.3 billion in 1970 and will be about \$55.5 billion in 1974; this represents 10% of total retail sales. Between 1970 and 1974 there was a 30% increase in department store sales per employee. One factor in this productivity increase is the rapid proliferation of computerized point of sale (POS) equipment such as cash register and credit authorization terminals. Over 250,000 POS terminals are being used by retailers. Many of the terminals are linked to approximately 75 major, on-line computer systems that have been installed by department store chains such as J.C. Penney and Montgomery Wards. POS equipment sold in 1973 had an estimated value of \$70 million; expected payback time for the equipment cost is 3 to 4 years. Advantages include reduced operating costs, improved inventory control, more detailed merchandising information, and faster, more accurate sales transactions. (C-9)

C. NEW CONSUMER PRODUCTS AND RETAILING

- *C-1 Heat pipe technology: developed for NASA by Los Alamos Scientific Labs and others. . . . based on availability of NASA R&D results from a Regional Dissemination Center, Isothermics, Inc. (New Jersey) was formed in 1971 to market heat pipe products. . . . five product lines introduced and successful \$700,000 sales in 1972, over \$1.5 million sales in 1974. . . . over half of sales are for Air-O-Space and Thermo-Coil, heat pipes that recover waste heat from furnace flue gas. . . . Air-O-Space for home furnaces, 10,000 sold in 1974 @ \$100. . . . Thermo-Coil for industrial furnaces, dryers, etc., just introduced, projected annual market doubling and \$2 million sales in 1976. . . . products increase heat efficiency by 8-10%, relevant to new consumer demand. . . . Isothermics capturing large market share early in trend toward energy conservation equipment. (RDC-TAC, TEF 197, Case No. 83601, 9/74)
- + C-2 Anti-fog compound: developed for Johnson. . . . prevents condensation fogging on transparent surfaces. . . . more than 60 NASA licenses issued. . . . sold by Western Fire Equipment Co. (California) for firefighters' face shields, air masks and for protective goggles. . . . annual sales total approximately 1,000 cases. . . . cost per case is \$20.50. . . . also sold by Younger Med-Optics (California) to optical supply companies and dentists. . . . 1975 sales estimated @ \$700,000. . . . marketed by others for divers' masks and ski goggles. (TB/TSP, Trade Journal/TSP, TEF 423, Case Nos. 81856, 81857, 7/76)
- C-3 Rogallo airfoil design: developed by Langley Research Center for rocket recovery. . . . used by Free Flight Systems (California) and others to design hang gliders. . . . Free Flight Systems is largest manufacturer of hang gliders. . . . 3,000 sold @ \$500. . . . rapidly growing sport. (Personal contact/JPL, TEF 499, Case No. 101900, 8/74)
- C-4 Battery-powered hand tools: developed for Johnson by Black and Decker (Maryland). . . . commercialized by B & D into line of 6 cordless power tools for home consumer (including 1/4" drill, 3 models of grass shears, 2 shrub and hedge trimmers). . . . direct improvement over previous line. . . . sales figures not available. (Subcontractor, TEF 300, Case No. 33607, 8/74)
- + C-5 Aluminized plastic film: basic patent by National Research Corp. in 1962. . . . first applications, Echo I, spacecraft, space suits, developed for Lewis commercial product, SPACE^R blanket, introduced by NRC in 1964 NRC acquired by Norton Co. in 1965 and renamed Metallized Products Division. . . . Division sold to King-Seeley Thermos Co. (Massachusetts) in 1971. . . . SPACE^R brand blankets retail \$2 to \$10 each. . . . coating sells for \$3 to \$5 per pound, depending on thickness. . . . used for food packaging by St. Regis Paper Co., Smuckers Co., coffee companies. . . . also used for home and commercial wall covering products by General Tire Co. and Columbus Coated Fabrics plant, Borden, Inc. . . . market for wall covering film over \$2 million. (Contractor, TEF 160, Case No. 37434, 9/76)

* Denotes transfer case related to Key Issue

C. NEW CONSUMER PRODUCTS AND RETAILING (CONT.)

- C-6 Active filter circuit design method: developed for Marshall. . . . circuitry and design procedures utilized by Computer Image Corp. (Colorado) in development of its Scanimate computer. . . . contributed to unit cost reduction from \$350,000 to \$300,000 each. . . . 1973 sales \$900,000. . . . 1973 service income \$2 million. . . . product used to generate computer animation for television advertising for Pontiac, Wards, Amoco, Kellogg, Black Label and Time magazine. (SBA/TSP, TEF 436, Case No. 56028, 8/74)
- C-7 Inflatable/nontippable life raft: developed by Johnson for ocean recovery of astronauts. . . . commercialized by Winslow Co. (Florida) in conjunction with the individual who received exclusive NASA license to practice the invention. . . . 25 rafts sold to commercial shrimp fishermen in Louisiana. . . . 100 units sold to Whittaker Corp. for fishing trawlers purchased by the Mexican government. . . . approved by the U.S. Yachting Association as standard emergency equipment for ocean racing. . . . to be used on 160 yachts competing in the Newport, R.I.-to-Bermuda race. . . . 30 rafts purchased by the U.S. Coast Guard for Antarctic operations. . . . retail cost for a 12-person unit is \$1,645; less for smaller rafts. . . . 300 units sold in 1975 for total sales of \$300,000. . . . company's life raft improves chance of safe rescue by providing radar reflective, thermally-insulated metallized cloth cover. . . . cloth provided by King-Seeley Thermos Co. using other NASA technology. (License, TEF 131, Case Nos. 2440, 115401, 12/75)
- C-8 Chlorate candle oxygen supply: improved for Johnson. . . . Regional Dissemination Center provided information on chlorate candle technology to Pyro-netics, Inc. (California). . . . information used to develop portable welding torch product that incorporates chlorate candle oxygen supply. . . . distributed through hardware stores. . . . over 100,000 units sold since 1972, retail price \$30. . . . product weighs 7 lbs and gives a 5,000°F flame. . . . home and hobby applications. (RDC-WESRAC, TEF 466, Case No. 87123, 7/76)
- *C-9 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized retail sales systems for department store chains. . . . largest supplier of such systems; has installed about 60 on-line computer systems (80% of total installations), with over 50,000 point of sale (POS) terminals connected to these systems. . . . typical system with 1,000 credit authorization terminals in 175 stores costs about \$1.5 million; average improvements over nonautomated methods include 95% reduction in purchases on bad debt accounts, 75% reduction in fraud purchases, 20% cost savings in payroll for authorization employees, and 33% reduction in telephone calls. . . . systems with POS cash register terminals also provide improved inventory control, more accurate and faster sales transactions, more detailed merchandising information, and better sales data for management analysis. . . . TRW customers include Montgomery Wards, May Co., Neiman-Marcus, J.C. Penney, Rich's, Burdine's, Hudson's Bay Co., and many more. (Contractor, TEF 465, Case No. 104260, 10/74)

* Denotes transfer case related to Key Issue

C. NEW CONSUMER PRODUCTS AND RETAILING (CONT.)

- C-10 Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . produced commercially as TEMPER FOAM by former contractor employee. . . . product line sold to a division of Becton, Dickinson and Co. . . . used by another Becton, Dickinson and Co. division, Protective Products (Texas) as padding in football helmet products. . . . compared to conventional helmet padding, reduces shock from impact by 340%. . . . since market introduction in October 1974, approximately 2,000 helmets sold @ about \$20 each. . . . sales mostly to school teams; also purchased by Dallas Cowboys. (Customer, TEF 570, Case No. 109334, 4/74)
- C-11 Quartz crystal oscillator for Apollo Central Timing Equipment: developed for Johnson contractor by General Time Corp. (Illinois). . . . provided stable primary time base and related integrated circuits for all Apollo mission timing functions. . . . GT used the revolutionary new timekeeping base, now called Quartzmatic, and integrated circuits to develop line of consumer clocks and watches. . . . maintain accuracy to within 1 minute per year. . . . produced by GT Westclox and Seth Thomas Divisions in retail price range of under \$30 to over \$250. . . . popular new consumer product. (Subcontractor, TEF 560, Case No. 109328, 5/75)
- C-12 Highly reliable flashlight switch: developed for Langley by ACR Electronics; now Chromalloy American Corp., Chromalloy Electronics Div. (Florida). . . . used in all manned spacecraft. . . . repackaged and introduced by Chromalloy as consumer flashlight, "5 Year Light". . . . long shelf-life guarantee possible because switch will not corrode and cause battery drain. . . . typically stored for emergency use. . . . over 2 million units sold @ \$6 to \$7 each. (Personnel/contractor, TEF 312, Case No. 109333, 5/75)
- C-13 Heated space suit technology: developed for Johnson. . . . included electric heating element designs, thermal and electrical insulation materials, specialized fabrics, flexible joint designs, and production processes. . . . used by former contractor employee to develop new product line for Comfort Products, Inc. (Colorado). . . . heated protective clothing for use by construction workers and consumers; includes boots, gloves, and caps. . . . electrically heated "Lunar Gloves," which sell for \$30 per pair, perform better than others on the market priced up to \$1,200 per pair. . . . total sales for product line are about \$500,000. . . . major consumer markets are skiers and hunters. (Personnel/contractor, TEF 587, Case No. 112248, 7/76)

C. NEW CONSUMER PRODUCTS AND RETAILING (CONT.)

- C-14 ERTS-1 imagery: program under supervision of Goddard. . . . imagery used by Baja Trail publications, Inc. (California) to create visual components of a travel guide and poster for the Baja California peninsula in Mexico. . . . 45 images were combined with highway and other data to create THE BAJA BOOK, a guide that provides the first complete maps for Baja. . . . since first publication in March 1974, approximately 30,000 copies sold @ \$8 each. . . . the Baja Spaceposter is a 24" by 54" black and white mosaic, composed from 38 ERTS images, that shows the Baja peninsula, Gulf of California, and west coast mainland of Mexico. . . . approximately 4,000 posters sold @ \$4 each since May 1975. . . . guidebook and poster marketed through company newsletter and press releases. . . . false color satellite imagery used by Kistler Graphics, Inc. (Colorado) to assist in the production of a 3-D plastic map of Grand Canyon National Park. . . . company is currently experimenting with the imagery, anticipating that it will provide a more realistic view of an area than currently possible with relief and topographic maps. . . . problems using imagery for 3-D mapping include: false color images show certain geographical features in the same color; light characteristics of season of year and time of day when the photograph is taken change emphasis of landscape features. . . . company released Grand Canyon Map in the fall of 1975 and plans to distribute it nationally. (Popular press/U.S. Geological Survey, TEF 500, Case Nos. 114475, 117160, 4/76)
- C-15 High intensity arc radiation source: developed for Johnson Apollo environmental test chamber. . . . contractor personnel formed Streamlight, Inc., (Pennsylvania) to develop arc source into commercial, high intensity lighting products. . . . one product, called Stream Lite-20, is a handheld, rechargeable flashlight uses 10-watt tungsten halogen bulb and is 4 to 5 times brighter than conventional flashlights. . . . several hundred sold @ \$75 each. . . . used by homeowners, travelers, craftsmen and truckers. (Contractor personnel, TEF 561, Case No. 109327, 5/76)
- + C-16 Lubricant deposition process: developed for Goddard by Ball Brothers Research Corp. (Colorado). . . . process commercialized by BBRC into Vackote line of several hundred lubricant products. . . . consumer product, developed from process, introduced in mid-1976 for use on phonograph records. . . . available through record stores. (Contractor, TEF 201, Case No. 42849, 7/76)

Other Relevant Examples:

A-3 (golf club shafts); B-67 (household fans); F-4 (high protein flour); F-5 and F-7 (packaged food quality); F-8 (beef merchandising innovation); F-9 (freeze-dried food); F-10 (frozen food quality); F-13 (anti-fog); F-18 (space food sticks); H-15 (energy conservation program); I-2 (geodesic domes); I-5 (home safety device); I-13 (solar water heater); I-14 (solar collector); J-7 (home alarm system); K-4 (automotive electronic ignition); K-5 (automotive gas turbine engine); P-12 (Paper Money Identifier)

ELECTRIC UTILITIES

D. ELECTRIC UTILITIES

Key Issues

- a. Pollution control: "The environmental crusade was the costliest phenomenon ever to batter the nation's electric utility industry" (Electrical World, 1974). Capital and operating costs for air pollution control were \$1.7 billion in 1971 and \$2.5 billion in 1973. (D-1)
- b. Dispatch computers: Electric utility market for computers growing at 20% annually; major trend is installation of real-time digital computers for dispatch and control of bulk power supply systems (interconnected generating stations). Digital dispatch provides economic, reliable operation of these power pools and prevents recurrence of 1965 Northeast Black-out. Approximately 20 dispatch computer systems installed or under contract. (D-3)
- c. Nuclear power plants: Nuclear generating capacity growing rapidly (from 6,000 Megawatts, or 2% of total, in 1970, to 475,000 Mw, or 40% of total, in 1990). Improved design methods being used to sustain trend toward larger nuclear plants (typically 200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). Annual capital investment in nuclear power was \$3.5 billion in 1972 and 1973. (D-6)

D. ELECTRIC UTILITIES

- *D-1 Combustion analysis computer programs: developed by Lewis and for Johnson used since 1970 by former space program combustion experts, KVB Engineering, Inc. (California), to design firing modifications for power plant fossil-fueled boilers. . . . reduced nitrogen oxide emissions by 40-70% in compliance with legal standards. . . . KVB has analyzed emissions from 160 large boilers, 100 small boilers and 30 ground power gas turbines over 100 large boilers modified for utilities nationwide, e.g., Southern California Edison Co., Los Angeles City Department of Water and Power, Consolidated Edison (New York), and Houston Lighting and Power Co. pollution reductions by KVB method considerably less expensive than by any known alternative; little or no added operating costs. (Contractor, TEF 463, Case Nos. 86009, 86010, 86011, 86012, 86018, 9/74)
- D-2 Combustion analysis computer program: developed by Lewis. . . . used by Babcock and Wilcox Co. (Ohio) to modify utility boiler product designs for reduced nitrogen oxide emissions and to develop new sulfur dioxide removal system for power plant stack gases. . . . unique capability to analyze operating trends for experimental hardware, a guide in design improvements. (Personal contact/Lewis, TEF 463, Case No. 86016, 1/73)
- *D-3 Apollo Guidance Computer software: developed for Johnson. . . . used by TRW Controls (Texas) to develop TRW Executive Program and other software for electric power dispatch computers. . . . provides real-time control capability in large, multi-tiered computer systems installed at General Public Utilities Corp. (Pennsylvania and New Jersey) and Arkansas Power and Light (\$500,000 installation). . . . also being installed at Public Service Co. of Oklahoma and Swedish State Power Board. . . . Apollo software also used by TRW Industrial Operations (California) to provide real-time control capability in new Bonneville Power Administration (Washington) dispatch computer system (\$5.2 million installation). . . . benefits cited by BPA include decreased blackouts and \$400,000 annual transmission savings TRW is second largest producer of dispatch computer systems in U.S. (Contractor, TEF 465, Case No. 86005, 8/74)
- D-4 Digital color television display: developed for Johnson Mission Control Center by Philco-Ford (Texas). . . . P-F developed commercial product for electric utility dispatch computer control center. . . . DCTV display installed at Cleveland Electric Illuminating Co. (Ohio), Houston Lighting and Power Co. (Texas) and Pennsylvania-New Jersey-Maryland power pool control centers. . . . product line sold to North American Rockwell Information Systems Co., NARISCO, (California). . . . installed at Philadelphia Electric Co. (Pennsylvania) as part of dispatch computer system developed by NARISCO DCTV provides operator/dispatch computer interface with greater accuracy, shorter response time, and more versatility, decreasing the chance of another major blackout. (Contractor, TEF 465, Case No. 86006, 2/73)

* Denotes transfer case related to Key Issue.

D. ELECTRIC UTILITIES (CONT.)

- D-5 Atlas-Centaur rocket control system (mathematical model): developed for Lewis same group of experts used method to design control system for high temperature gas-cooled reactor (HTGR) at General Atomic Co. (California). . . . first commercial HTGR is 330-Mw Fort St. Vrain Plant for Public Service Company of Colorado, in operation late 1974. . . . significant advance in nuclear plant efficiency (40% versus 33% for water reactors) due to higher performance; HTGR required more sophisticated control system. (Personnel/contractor, TEF 446, Case No. 84984, 11/72)
- *D-6 Fracture toughness tests (and analytic methods): developed by Lewis. . . . included in ASME Boiler and Pressure Vessel Code for nuclear power plant components. . . . used by major manufacturers to design nuclear plant equipment and steam turbines. . . . users include Westinghouse (Pennsylvania), General Electric (New York), Babcock and Wilcox (Ohio), Atomics International (California), General Atomic (California) and Combustion Engineering (Tennessee) annual capital investment in nuclear power was \$3.5 billion in 1972 and 1973. . . . trend toward larger nuclear plant designs (200 Mw in 1965, 500 Mw in 1969, and 1,000 Mw in 1974). (Professional society, TEF 451, Case Nos. 85203, 85204, 85206, 85208, 85212, 86001, 1/73)
- D-7 Fatigue analysis methods: developed by Lewis. . . . included in ASME Elevated Temperature Design Code. . . . used by General Electric Co. (New York) for steam turbine design, Westinghouse (Pennsylvania) for steam turbine maintenance, General Atomic Co. (California) for high temperature gas-cooled reactor design, Combustion Engineering, Inc. (Tennessee) and Babcock and Wilcox Co. (Ohio) for electric power steam generator design. . . . provides better prediction of fatigue life from high temperature test data. (Professional society, TEF 450, Case Nos. 85202, 85207, 85213, 86000, 86002, 1/73)
- D-8 Apollo Program quality assurance specifications: (NPC 200-2) developed by Headquarters. . . . modified by DOD for military specs (MILQ 9858A) which in turn were largely incorporated by AEC (District of Columbia) in comprehensive quality assurance specs for nuclear plant licensing. . . . General Electric Co. (Florida) implemented Apollo specs under NASA contract, now offers Nuclear Quality Assurance Consulting Service to do same service for electric utilities with similar AEC specs. . . . four utilities and five nuclear plant contractors have used GE service on 12 nuclear plants, including Commonwealth Edison Co. (Illinois), Florida Power Co., and TVA (Tennessee) Ontario Hydro (Canada), third largest electric utility in North America, 15,000-Mw capacity, is using NASA specs to develop own QA specs for contractors. (Interagency for AEC, Contractor for GE, Professional society for OH, TEF 444, Case Nos. 84976, 87032, 2/73)

* Denotes transfer case related to Key Issue.

D. ELECTRIC UTILITIES (CONT.)

+ D-9 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by General Atomic Co. (California) for dynamic modeling of high temperature gas-cooled reactors. . . . use saved 4 man-months in program development and is expected to be used 2-3 times per year. . . . used by Westinghouse (Pennsylvania) for designing nuclear power plants that will float offshore, and Westinghouse Hanford Co., Hanford Engineering Development Laboratory (Washington) for fast breeder reactor design analysis. . . . provides unique capability for using computer in design analysis of large, complex structures. (Personal contact, Professional journal/COSMIC, TEF 410, Case Nos. 84977, 84981, 86003, 12/75)

D-10 Fuel cell technology: developed for Lewis and later supplied to Johnson by United Technologies Corp., Pratt & Whitney Aircraft Div. (Connecticut). . . . used by P&W in joint R&D ventures with two utility groups to develop commercial fuel cells. . . . Team to Advance Research for Gas Energy Transformation (TARGET), including 28 major gas and gas/electric utilities, has spent over \$70 million since 1967. . . . 12.5-kw cells successfully pilot tested at 20 U.S. sites. . . . second venture started in 1972; includes 9 electric utilities and the Edison Electric Institute. . . . goal is 26-mw generating units. . . . field tests for basic 4.5-mw cells expected to start by 1979. . . . both ventures developing cells which convert natural gas or liquid fossil fuels to electricity with greater efficiency and less pollutants than conventional generating methods. (Contractor, TEF 448, Case No. 84992, 5/75)

D-11 Nuclear shielding analysis technique: developed for Marshall. . . . determines statistically the shield thickness necessary to prevent nuclear radiation excursions. . . . used by Burns and Roe, Inc. (New York) in the design of four nuclear power plants: the Oyster Creek, New Jersey and Cooper, Nebraska plants, which are now operational, and the Three Mile Island, Pennsylvania and Forked River, New Jersey plants, which are near completion. . . . saved \$75,000 in engineering time. . . . technique is tailored to power plant shielding applications. (TB/TSP, TEF 252, Case No. 14155, 9/75)

D-12 Time-temperature techniques for alloy fatigue analysis: developed by Lewis. . . . used by Combustion Engineering, Inc. (Tennessee) for stress-rupture analysis of new alloys. . . . important in evaluating alloys for potential use in high-temperature electric power generating equipment such as steam boiler tubing. . . . benefits include savings of one month testing time annually for new alloys and superior estimate of alloy fatigue. (Personal contact/Lewis, TEF 449, Case No. 85209, 12/75)

D-13 Quality assurance for liquid metal valves: developed by subcontractor, Valcor Engineering Corp. (New Jersey), in order to supply valves to Lewis for the Systems for Nuclear Auxiliary Power Program. . . . includes capabilities in quality assurance and control management, nondestructive testing and materials traceability. . . . used by Valcor in production of valves for the fast breeder reactor program. . . . benefits include successful contract proposal and substantial savings in overhead costs. (Subcontractor, TEF 444, Case No. 84979, 12/75)

D. ELECTRIC UTILITIES (CONT.)

- D-14 Nondestructive spot test procedure: compiled by Langley. . . . used by Public Service Electric and Gas Co. (New Jersey) to speed up repair and replacement of faulty parts in gas plants and electrical generating equipment stations. . . . use of procedure enables identification of alloy content in failed parts at the failure site, rather than shipping them to laboratory for analysis. . . . benefits include time savings in fabricating replacement parts and laboratory testing. . . . information used several times each year. (Personal contact/TSP, TEF 378, Case No. 114626, 5/76)
- + D-15 Failure analysis methods: developed for Johnson by General Electric Apollo and Ground Systems Group. . . . applied in Apollo and Space Shuttle reliability programs. . . . used by General Electric's Large Steam Turbine-Generator Department (New York) to improve reliability of electrohydraulic controller products for steam turbines. . . . controllers used in both fossil-fueled and nuclear power plants. . . . failures reduced measurably \$10 million savings to date based on estimate of generator-days lost due to electrohydraulic controller failures and value of electricity generated by average generator per day. . . . benefits expected to increase as more utilities use the improved controllers. (Contractor, TEF 444, Case No. 87031, 12/75)
- + D-16 Photovoltaic solar cells: developed for JPL by M7, International (Illinois) for satellite electric power. . . . resulting expertise used by M7 in designing commercial solar cell arrays to specific needs of various customers value of design expertise estimated to be \$10,000. . . . solar cell market expected to increase rapidly. (Contractor, TEF 648, Case No. 121302, 7/76)
- + D-17 Subcritical subsonic airfoils: developed by Langley since 1950's. . . . includes math models and wind tunnel test results. . . . used by Gruman Corp., Energy Systems Div. (New York) to design rotor blades for commercial wind energy electric generator. . . . new windmill product can generate 15 kilowatts. . . . three sold, more sales expected. (Personnel/contractor, TEF 631, Case No. 120514, 7/76)
- + D-18 Flight test data system: developed for Flight Research Center by Teledyne, Inc., Teledyne Controls Div. (California). . . . included versatile data acquisition component, remote multiplexer/demultiplexer unit (RMDU). . . . RMDU adapted by Teledyne for use with nuclear reactor data. . . . used at ERDA Power Burst Facility (Idaho) for coolant level, heat transfer and reactor core simulation data. . . . part of program to update safety codes for nuclear power plant licensing. . . . 15 units sold to ERDA Facility contractor, Aerojet-General Corp. . . . average base price \$25,000. (Contractor, TEF 650, Case No. 121305, 9/76)
- + D-19 Rotational vibration analysis methods: developed for Marshall and Lewis by the University of Virginia, Mechanical Engineering Dept. (Virginia). . . . includes new mode and computer models for analyzing aircraft and spacecraft used by university professor under private contracts to manufacturers for analyzing vibration problems. . . . reactor core fluid pump vibrations analyzed for nuclear power generator manufacturer. . . . results used to modify pump bearings and reduce vibrations. . . . combined industrial applications of the technology have resulted in total estimated cost savings of \$100 million. (Contractor, TEF 658, Case No. 121463, 9/76)

D. ELECTRIC UTILITIES (CONT.)

Other Relevant Examples:

B-6 (gas turbine electric generators); B-23 (nuclear reactor filters); B-51 (strain measurement); B-54 (reactor equipment test); B-64 (high-energy batteries); E-7 (coal mine reclamation); E-10 (coal desulfurization); E-18 (pollution dispersal); G-2 (power plant siting maps); G-3 and G-7 (hydroelectric plant scheduling and planning); I-10 (portable power poles); I-16 (nuclear safety product); I-19 (windmill generator study); O-5 (NDT training service)

ENVIRONMENTAL QUALITY

E. ENVIRONMENTAL QUALITY

Key Issues

- a. Carbon monoxide pollution in urban areas: a study recently published by the Medical College of Wisconsin showed that three-fourths of those persons examined in Denver, Los Angeles, and Chicago had blood concentrations of carbon monoxide above 1.5%, the level set as harmful by federal standards. A National Academy of Sciences report estimated that in urban areas 4,000 deaths and 4 million illness-related days from work were due to auto air pollution. (E-1)
- b. Vehicle emission standards and certification: New car emission standards have increased average cost of pollution control devices from \$17 in 1968 to \$115 in 1974 to estimated \$246 for 1975 models. New vehicle certification requires vehicle emissions of hydrocarbons, carbon monoxide, and nitrogen oxides to meet EPA standards using EPA-approved testing procedures. States are developing programs for annual emission inspection of all vehicles. (E-2)

E. ENVIRONMENTAL QUALITY

- + *E-1 Skylab carbon monoxide monitor: developed for Ames. . . . commercialized by Andros, Inc. (California). . . . product line sold by Beckman Instruments (California). . . . sold to government agencies, including EPA, and companies used to measure carbon monoxide pollution in urban areas, such as the CO profile over Los Angeles. . . . approximately 80 units sold @ \$8,500 unit modified for Navy specifications to monitor air in submarines approximately 125 of these sold @ \$15,000 each. . . . seven specially designed units also sold to Lewis. (Contactor, Purchased product line, TEF 481, Case Nos. 93827, 93828, 9/76)
- *E-2 Hazardous gas analyzer for Saturn rocket: developed for Marshall. . . . adapted by Chrysler Corp. (Alabama) to develop product line of vehicle exhaust analyzers. . . . over 70 large units sold @ \$15,000-\$50,000. . . . provides simultaneous measure of CO, CO and hydrocarbons. . . . allows automated testing. . . . analyzer accepted as legal alternative standard by EPA and California for vehicle emission certification testing. . . . used by Chrysler (Michigan) for new vehicle certification (heavy duty engines) and quality control during production. . . . used by Chrysler (California) for 2% Quality Audit of new cars, a California requirement (3,000 cars/year, \$600,000 test facilities). . . . also used to trouble-shoot defective vehicles, reducing labor costs at least 50%. . . . Chrysler's portable exhaust analyzer product used for state inspection by garages and car dealers. . . . over 1,000 small units sold @ \$1,600. (Contractor, TEF 486, Case No. 93832, 9/74)
- E-3 Filter cassette for sampling particulate pollutants: designed and produced for Lewis air pollution program in Cleveland by General Metal Works, Inc. (Ohio). . . . commercialized by contractor. . . . \$25 cassette widely sold for pollution monitoring stations. . . . considered by pollution experts to be best cassette on market. . . . prevents sample contamination during transport to and from monitoring stations. (Contractor, TEF 493, Case No. 99658, 6/74)
- E-4 Satellite telemetry systems: developed for Goddard by General Electric Co. (Pennsylvania) for Nimbus and ERTS-1. . . . used by GE to develop state-wide computerized air pollution monitoring network (COPAMS) for Pennsylvania 32 stations to implement air quality laws. (Contractor, TEF 483, Case No. 96532, 2/74)
- E-5 Weather satellite data: program managed by Goddard. . . . used by National Weather Service (Maryland) to forecast wind conditions. . . . forecasting used by state air pollution agencies (Colorado and others) for air stagnation maps and air pollution dispersal conditions. . . . dispersal predication crucial for implementing pollution control sequence (advisory, alert, warning, emergency). (Interagency, TEF 26, 194, Case Nos. 78001, 96526, 10/73)
- E-6 ERTS-1 imagery: program under Goddard supervision. . . . imagery used by scientists at University of Vermont to identify and map major pollution plume in Lake Champlain caused by paper mill in state of New York. . . . partial basis for legal action by State of Vermont against paper mill and State of New York. . . . ERTS imagery and interpretation of imagery accepted as legal evidence in case after review by Supreme Court-appointed master. . . . case was then settled out of court. . . . one of first pollution cases involving state vs. state accepted by Supreme Court. (Contractor, TEF 500, Case No. 101911, 3/76)

* Denotes transfer case related to Key Issue.

E. ENVIRONMENTAL QUALITY (CONT.)

- E-7 Aircraft remote sensing program and imagery: program by Johnson. . . . infrared photographic imagery of Midwest used in 1971 by Purdue University (Indiana) and U.S. Department of Agriculture to analyze spread of corn blight. . . . Indiana portion of imagery used by Earth Satellite Corp. (District of Columbia) to map and measure coal mine refuse piles. . . . maps now used by Indiana legislature in preparing legislation on reclamation of mine refuse sites. . . . 200 sites larger than 2 acres each were identified and reclamation cost estimate exceeded \$14 million. (Contractor, TEF 199, Case No. 101912, 9/74)
- + E-8 Remote sensor for air pollutants: operational prototype developed for Johnson. . . . correlation spectrometer sold by Barringer Research, Ltd. (Canada). . . . approximately 60 units with various accessories sold. . . . total sales of instrument to date \$1,500,000. . . . unique air pollutant measuring capability. . . measured NO₂ profiles over Los Angeles and San Francisco, SO₂ profile over Chicago. . . . also used by air pollution agencies in U.S., Canada, Australia, Japan, France, Spain. (Contractor, TEF 482, Case No. 95608, 12/75)
- E-9 Computer models for Apollo Program: developed for Johnson. . . . used by TRW Systems (California) to develop more than 30 air and water quality models provided technical basis for implementing pollution laws in Alaska, California, D.C., Ohio, South Carolina, Vermont. (Contractor, TEF 487, Case No. 96531, 1/74)
- E-10 Lunar Module rocket engine test facility: developed for Johnson. . . . used by TRW Systems (California) to develop inexpensive coal desulfurization process. . . . EPA funding at \$1.5 million for research and pilot plant design process could eliminate need for expensive stack gas removal equipment for electric utilities. . . . SO₂ pollution control a critical financial problem for coal-fired power plants. ²(Contractor, TEF 488, Case No. 96530, 9/74)
- E-11 Computerized image enhancement: developed by Jet Propulsion Laboratory (California) to process digitized image transmissions from unmanned spacecraft (e.g., Ranger and Mariner). . . . used by JPL in current program to develop computer processing of water quality data from ERTS-1 multispectral digitized imagery. . . . joint funding by TUO and EPA (Oregon) to obtain cheaper, more efficient method for classifying quality of inland lakes in National Eutrophication Survey (NES). . . . good correlation between JPL results and EPA's water sampling data. . . . EPA initiated NES in 1972 to determine lake deterioration caused by phosphorus materials in sewage plant effluent. (Contractor/TUO-Applications Project, TEF 520, Case No. 104142, 10/74)
- E-12 Manufacturing contamination prevention handbook: compiled for Marshall used by Carrier, Carlyle Compressor Co. (New York), to develop in-house pollution control system for process machinery coolants. . . . system reduced pollution emitted into city sewer system, improving employee/citizen health conditions. . . . system approved by OSHA. (TB/TSP, TEF 544, Case No. 86150, 3/75)

E. ENVIRONMENTAL QUALITY (CONT.)

- E-13 Quartz crystal microbalance contamination monitor: developed for Marshall Skylab contractor by Celesco Industries, Inc. (California). . . . led to development of real-time pollution monitor product. . . . highly reliable, operates under wide range of conditions, reveals variety of contaminant sources. . . . numerous units sold @ \$5,000-\$20,000 each. . . . State of New Mexico environmental control agencies use product for particulate measurement. (Subcontractor, TEF 567, Case No. 109335, 5/75)
- E-14 Mass Flowmeters for low gas flow: developed to meet specifications of Johnson Apollo subcontractor by Tylan Corp. (California). . . . used by Tylan to develop product for calibrating air pollution monitoring instruments. . . . provides the extremely accurate measure of gas sample volume necessary for analysis of pollutant concentration. (Subcontractor specifications, TEF 563, Case No. 109332, 5/75)
- E-15 Biosatellite telemetry and life support systems: developed for Ames by General Electric Co., Re-entry and Environmental Systems Div. (Pennsylvania) for Biosatellite Program. . . . provided physical, biological, and chemical management subsystems for spacecraft environmental control during onboard primate experiment. . . . used by GE to design a new product line of packaged waste treatment systems that convert human wastes to water, nonpolluting gases and inert ash. . . . first commercialized as Shipboard Waste Treatment Systems. . . . 5 units installed on ships: a Naval destroyer, an Army Corps of Engineers dredge, and commercial iron ore carriers 2 prototype land-based units installed for evaluation in New Jersey and Florida. . . . Florida certified the unit. . . . system incinerator portion is being evaluated to convert residual sludge from conventional shipboard waste collection systems into ash. . . . company has licensed technology to Matsui Corp. (Japan). (Contractor, TEF 584, Case No. 112241, 6/75)
- E-16 Water pollution abatement with aquatic plants: NASA's National Space Technology Laboratories developed the use of water hyacinth plants for removing pollutants, particularly heavy metals, from wastewater. . . . method used by Orange Grove Utilities, Inc. (Mississippi) in the company's sewage treatment lagoon. . . . company spent \$15,000 to install its water hyacinth lagoon and NSTL is conducting a field evaluation of the facility. . . . preliminary results indicate plants are effective in reducing suspended solids, phosphorus, and oxygen demand. . . . benefits include the ability to meet U.S. Environmental Protection Agency water quality standards and a substantial cost savings since the construction of a \$500,000 chemical and mechanical sewage treatment system has been deferred. . . . use of the water hyacinth treatment method is expected to continue. (Personal contact/NSTL, TEF 617, Case No. 117162, 4/76)

E. ENVIRONMENTAL QUALITY (CONT.)

- E-17 Diode-quad bridge circuit design: developed by Ames for use with solid-state sensing components. . . . minimizes signal distortion, performs well with various transducers, and permits the transducer to be conveniently grounded Arthur Brothers Co., Inc. (Wisconsin) obtained a nonexclusive NASA license and used the circuit design information to produce a transducer component for a new, biochemical oxygen demand (B.O.D.) analyzer. . . . highly reliable, versatile instrument used to measure and control sewage treatment processes. . . . to date, 200 units have been sold @ \$1,200 each. . . . customers include General Mills, Proctor & Gamble, and three cities: Detroit, Michigan; Fremont, Ohio; and Little Rock, Arkansas. . . . benefit to customers is improved water pollution analysis. . . . benefits to company include avoidance of 9-12 month component supplier delay and the ability to market the analyzer at an earlier date. . . . future sales estimated at 40-50 units per year. (Personal contact/TSP/License, TEF 622, Case No. 117769, 4/76)
- + E-18 Boundary layer wind analysis: developed for Headquarters and by Marshall combined studies were an exhaustive analysis of boundary layer wind used by atmospheric simulation group at Colorado State University (Colorado) in wind simulation model that helped reduce intake of car exhaust into Children's Hospital, National Medical Center in Washington, D.C. . . . also used in wind model for Hawaiian Electric Power Co. and Interstate Power Co. of Iowa plants to aid pollution reduction efforts. . . . similarly used by Calspan Corp. (New York) in wind simulation to minimize pollutant concentrations in design of Douglas Point Nuclear Generating Station in Maryland, and Karn-Weadock Generating Complex in Michigan. . . . currently being used by Stanford Research Institute (California) in study for Federal Highway Administration of relationship between vehicular traffic and other factors in air pollutant dispersion. (Professional Journal, Personal contact, TEF 643, Case Nos. 120222, 120511, 7/76)

Other Relevant Examples:

B-67 (air pollution venting); D-1 and D-2 (air pollution control for power plants); D-8 (nuclear safety); D-16 (solar cells); D-17 (windmill generators); G-1 (new sewage treatment method); G-2, G-3, G-5 and G-6 (water quality and supply data); H-1 (reduced offshore oil pollution); H-7, H-10 and H-11 (reduced air pollution for refinery, gasoline bulk stations and engine fuels); K-2, K-4 and K-5 (reduced automobile emissions); K-9 (auto emission analysis); O-13 (resource management training)

FOOD PRODUCTION AND PROCESSING

F. FOOD PRODUCTION AND PROCESSING

Key Issues

- a. Productivity: over the last century, mechanization made possible a ten-fold decrease in farm workers needed to feed U.S. (47% of work force in 1870, 4% in 1970). Farm crop output per man-hour increasing at annual 10% (versus 3% national average); a major factor is improved equipment. In 1960, 40% of tractors were 60 hp. or less; in 1972, two major producers (Deere and Allis-Chalmers) introduced new models over 150 hp. which increase productivity 10-20% by pulling standard implements faster or pulling larger implements. (F-2)
- b. Food products merchandising: continuing developments in merchandising--rigorous quality assurance, improved inspection programs, and open-dating of packaged, perishable food goods--have permitted the \$119 billion U.S. food industry (meat packing \$26 billion) to provide quality food for consumers. Average U.S. family spent 15.9% of its after-tax income on food in 1973. (F-8)

F. FOOD PRODUCTION AND PROCESSING

F-1 Weather satellite imagery and ground receiver: developed for Goddard. . . . used by National Weather Service (Maryland) as a major input to preparing daily fishery advisory charts for eastern Pacific. . . . charts transmitted by National Marine Fisheries Service (California) to radio facsimile receivers on 70 U.S. tuna boats in Pacific; represents 50% of U.S. tropical tuna fleet information reduces time and fuel costs for locating tuna, helps in avoiding adverse weather. . . . annual Pacific tuna catch worth over \$75 million; provides 90% of tuna canned in U.S. (20% of U.S. fish consumption is canned tuna). (Interagency, TEF 194, Case No. 78002, 3/75)

+ *F-2 Fracture toughness tests: developed by Lewis. . . . used at Deere and Co. (Illinois) to improve safety and service life of products (farm tractors and implements). . . . reduced fracture failure of tractor roll-over protection systems (ROPS). . . . ROPS required by OSHA, Deere selected steel on basis of fracture tests. . . . 20% of research department effort on these applications. . . . Deere introduced new 150 hp. tractor in 1972, increased productivity 10% by pulling larger implements or same implements faster. . . . implement service life not decreased, partly due to improved fracture toughness matching higher performance (e.g., plow striking rock could have caused brittle fracture). . . . Deere annual sales over \$1 billion, about 25% of farm machinery market. (Professional society, TEF 451, Case No. 101903, 8/76)

+ F-3 Precipitation-hardened steel alloy: developed for Johnson (Apollo Command Module) by Armco Steel. . . . Armco alloy used by Hopper, Inc. (California) in fabricating Ram-Jet, wind machine for frost protection in noncitrus orchards (apples, almonds, etc.). . . . no longer manufactured, but several hundred still operating in Washington, Oregon and California. . . . company services and supplies parts for existing machines. (Contractor, TEF 223, Case No. 42553, 8/76)

F-4 Contamination control handbook: compiled for Marshall. . . . used at USDA Research Center (Louisiana) for training employees and research. . . . recommended by USDA to food processing firms with contamination problems. . . . one research application was developing a process for converting cottonseed pulp to high protein (67%) flour for human consumption. . . . due to contamination problem, pulp from cottonseed oil production mainly used for cheap animal feed. . . . new process solves problem and one cottonseed mill already producing the more profitable flour. (TB/TSP, TEF 262, Case No. 31762, 8/74)

+ F-5 Clean room technology: developed for Johnson by Pillsbury Co. (Minnesota) Pillsbury originally installed clean rooms, conducted employee training programs, and compiled a contamination control management practices manual for astronaut food production facility. . . . technology applied in all new food processing facilities at Pillsbury, clean rooms are installed in some older facilities, and all employees receive contamination hazards training improved product quality; product recalls due to contamination reduced almost to zero. . . . approximately 200 management manuals (720 pages) are sold annually at \$40 each and used by other food processors and FDA (District of Columbia) to train federal food inspectors. (Contractor, TEF 503, Case No. 101910, 7/76)

* Denotes transfer case related to Key Issue.

F. FOOD PRODUCTION AND PROCESSING (CONT.)

- F-6 Microbiological handbook: compiled for Marshall. . . . used by Kraftco Corp. (Illinois) as training manual for sanitary techniques in food processing plants and in research. . . . used by USDA scientists (Missouri) in development of improved milk processing procedures and equipment now used in dairy industry. . . . valuable reference in both cases. (TB/TSP, TEF 402, Case Nos. 51578, 51786, 9/74)
- F-7 Nondestructive spot test procedure: compiled by Langley. . . . used by Kraftco Corp. (Illinois) for alloy identification when analyzing chemical reactions for food, atmosphere, and stainless steel processing equipment combinations. . . . time and money saved when reaction problem occurs and must be eliminated to avoid food contamination. . . . also used by William Wrigley, Jr. Co. (Georgia) to identify metal particles in batches of gum. . . . rapid identification of particles achieved within two hours of detection, enables company to locate source of particles and repair failing equipment which produced them. . . . benefits include a reduction in the number of production stoppages and prevention of serious equipment failures. . . . benefits will continue. (TB/TSP, Trade Journal/TSP, TEF 378, Case Nos. 47744, 115014, 5/76)
- + *F-8 Electronic strain gage: invented by founder of BLH Electronics, Inc. (Massachusetts). . . . improved and standardized by BLH for space program which was the first major market. . . . used by field centers (Goddard, Lewis and Marshall) and contractors in most rocket engine R&D projects and space vehicles such as the Surveyor lunar lander. . . . commercial markets developed by BLH for standardized products. . . . product used by Armour and Co. (Illinois) in Armour Tenderometer since 1969. . . . company holds patents on the instrument. . . . unique capability to test hanging carcass and accurately predict meat tenderness after cooking, not possible previously. . . . Armour selects and guarantees all TestTender beef with instrument. . . . amount of premium-priced TestTender beef sold annually is tens of millions of pounds. . . . Armour was awarded 1973 Food Technology Industrial Achievement Award for Tenderometer, a major innovation in beef merchandising. . . . cattle growers using the instrument data for selective breeding programs. (Contractor, Customer/contractor, TEF 505, Case Nos. 101898, 103418, 7/76)
- F-9 Compressed/freeze-dried food: developed for Johnson. . . . marketed by Innovative Foods (California) as compact emergency food rations. . . . used by hunters, backpackers, etc. . . . sales expected to reach approximately \$1 million within a year. (Personal contact/contractor, TEF 502, Case No. 101896, 8/74)
- F-10 Eutectic salts for low temperature batteries: developed for Goddard by Artech Corp. (Virginia). . . . used by Artech to develop Irreversible Warmup Indicator shows, by color change, whether frozen foods have defrosted during transportation or storage. . . . 3 million sold, total sales \$100,000. (Contractor, TEF 504, Case No. 101897, 8/74)
- + F-11 Cooling system for Gemini space suits: developed for Johnson by Garrett Corp. (California). . . . adapted by Garrett to develop galley refrigeration system for commercial aircraft. . . . used by Western Airlines. . . . 60 units installed to date at approximately \$12,000 each. (Contractor, TEF 228, Case No. 430, 8/76)

*Denotes transfer case related to Key Issue.

F. FOOD PRODUCTION AND PROCESSING (CONT.)

- F-12 Computer programs for ERTS-1 data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . used by Texas Water Development Board to develop monitoring program for playa lakes (short-lived, caused by rainstorms) in Texas High Plains region. . . . computer analysis of LANDSAT data will permit production, every 30 to 45 days, of maps which show size and location of lakes. . . . data from repetitive monitoring very important for planned effort to utilize playa lakes for farm irrigation and recharge of rapidly depleting Ogallala Aquifer which is vital to High Plains agriculture. . . . preliminary results indicate computer analyzed satellite data much more cost effective than other monitoring methods. (Personal contact/Johnson, TEF 513, Case No. 101895, 5/75)
- F-13 Anti-fog compound: developed for Johnson. . . . prevents condensation fogging on transparent surfaces. . . . more than 60 NASA licenses issued. . . . Nelson-Cross, Inc. (Florida) purchased sales rights for the anti-fog solution, designated C-24, from Analysis Research Associates. . . . solution purchased by 15% of food processing market and 40% of cold storage market. . . . annual sales of \$5,000. . . . applied to eyeglasses and windows to prevent fogging associated with refrigeration equipment operations. . . . increased worker safety. (Purchased product line, TEF 423, Case No. 112244, 9/75)
- F-14 Motivation techniques: developed for Johnson to outline motivation techniques for reducing employee error. . . . used by Kraftco Corp., Kraft Foods Div. (Illinois) to prepare an instructional package on productivity motivation techniques for supervisors. . . . over 10,000 employees trained and productivity increased. . . . also used as a reference guide for manpower planning and placements. (TB/TSP, TEF 583, Case No. 105058, 9/75)
- F-15 Solar energy collector testing program: conducted by Lewis. . . . former Lewis branch chief founded Solar Energy Products Co. (Ohio) in 1972. . . . developed solar energy collector system, called Soloron, for agricultural use. . . . system generates hot air for drying grains such as wheat, soybeans, corn and rice. . . . reduces dependence on conventional fuels for drying and provides user cost savings of over \$500 per growing season. . . . used by Ohio farmers to dry thousands of bushels of corn and wheat. . . . modern grain processing and storage requires low moisture content; grain drying widely practiced to reduce high moisture due to early picking. . . . recent price increase and curtailed supplies of normal fuels, such as propane, have created significant problems for grain drying. (Personnel/Lewis, Purchased product line, TEF 606, Case No. 114869, 7/76)

F. FOOD PRODUCTION AND PROCESSING (CONT.)

- F-16 Soil unit mapping technique: developed for the Office of University Affairs, NASA Headquarters. . . . South Dakota State University Remote Sensing Institute, under a NASA grant, combined LANDSAT (ERTS) and NASA aircraft photographs with other data sources to create soil unit classification maps for 3 counties in the state--Pennington (1973), Meade (1975), and Potter (1976) four LANDSAT images costing \$20 were used for the Pennington County map; conventional methods would have required 1,400 aerial photographs costing \$14,000. . . . map production time also significantly reduced. . . . map data used as major input to university computer program that prints out "conceptual dollar value" of production for each 160-acre area of agricultural land. . . . printouts used by Pennington and Meade County Directors of Equalization (tax assessors) to determine agricultural property taxes. . . . 1970 South Dakota law requires that agricultural land be assessed according to potential production value, rather than land sale value. . . . similar application expected in Potter County; other counties in state also interested in obtaining the information. (Personal contact/grantee, TEF 605, 1/76)
- + F-17 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Lake to Lake Dairy Cooperative (Wisconsin) to reduce number of lubricants used in ancillary dairy equipment (e.g., homogenizers) and select less expensive lubricants for new machinery. . . . Cooperative operates four plants owned by approximately 2,000 farmer-members distributes milk, cottage cheese, dips locally; cheese, butter, dry milk powder nationally. . . . use of handbook estimated to save \$3,500 to \$4,000 annually. (Professional journal/TSP, TEF 497, Case No. 97966, 8/76)
- + F-18 Space food sticks: developed for Johnson by Pillsbury Co. (Minnesota). . . . complete meal in stick form required advances in food technology. . . . commercialized by Pillsbury as "Food Sticks". . . . five flavors sold nationally at many grocery stores for about 69¢ per box of 14. (Contractor, TEF 229, Case No. 33602, 8/76)
- + F-19 Lubricant coating bonding processes for metals: research need identified in quality control study conducted for Headquarters by General Magnaplate Corp. (New Jersey). . . . company developed and patented 4 processes to bond dry lubricants, such as Du Pont's Teflon, on metal surfaces for space applications. . . . many components for Apollo, Viking, Skylab and Shuttle coated by General Magnaplate. . . . commercial coating services introduced; annual sales are \$1.8 million. . . . machinery, coated by company, being used by a variety of food processors. . . . Sealright Co. for dairy carton forming and filling. . . . H.J. Heinz Co. for packaging single servings of condiments. . . . Buitoni Food Corp. used coating when rebuilding 18 year-old ravioli production machinery; saved two-thirds the cost of new equipment. (Contractor, TEF 575, Case No. 109338, 9/76).

F. FOOD PRODUCTION AND PROCESSING (CONT.)

- + F-20 Food heating system: commercial prototype improved for Johnson by 3M Company (Minnesota). . . . control circuits miniaturized and energy conservation features added to meet Apollo Program requirements. . . . improvements used by 3M to develop commercial version, Integral Heating Food Service System. . . . 40 systems leased to institutional food services such as hospitals and nursing homes. . . . provides fast, relatively easy, efficient and safe food handling for 35,000 meals daily. . . . saves up to 60 percent of electricity used in conventional systems. . . . food retains more nutrients, looks and tastes better due to resistance heating elements in the dishes, rather than conventional oven-like heating units. (Subcontractor, TEF 651, Case No. 121306, 9/76).

Other Relevant Examples:

A-9 (production equipment lubrication); B-45 (grain company); B-63 (Colorimeter); B-67 (fruit drying); G-6 (flood forecasting); K-3 (farm tractor design); O-13 (training for remote sensing); S-8 (tuna boat insulation)

GOVERNMENT

G. GOVERNMENT

Key Issues

- a. Sewage treatment facilities: EPA's Needs Survey for 1973 set the costs for new water treatment equipment between 1973 and 1990 at \$61.7 billion to satisfy the water quality requirements in the Water Pollution Control Act of 1972. This represents a threefold increase over the 1971 cost estimate (\$18.1 billion) which was based on previous, less stringent water quality standards. Two major cost factors in the new projection are secondary treatment facilities (\$17.1 billion) and new sewer systems (\$24.5 billion). Costs to be shared by federal (75%) and local governments (25%). (G-1)
- b. Natural resource management: Revenues from natural resources managed by all levels of government were \$3.67 billion in 1971 (\$3.33 billion from federal resource leases, water projects, etc.). All government expenditures for natural resources and the environment were \$11 billion in 1965 (includes \$1.73 billion by state/local) and \$13.7 billion in 1971 (includes \$3.67 billion by state/local), with about 6% for capital outlays. These expenditures covered such areas as land, watershed, and wildlife management, as well as pollution and flood control. Federal aid to state and local governments for resource management increased rapidly from \$300 million in 1965 to \$1.33 billion in 1973. There is a critical need at all government levels for better resource information at lower cost to support the government management efforts required by recent environmental legislation. (G-2)

G. GOVERNMENT

- *G-1 Pyrolytic synthesis of activated carbon: developed for Headquarters by Jet Propulsion Laboratory (California) to prepare rocket insulation. . . . used by JPL, under NASA contract, to develop novel sewage secondary treatment pilot plant. . . . 10,000-gal./day plant converts sewage to activated carbon by pyrolysis. . . . carbon then used to remove organics from primary treatment water, to increase raw sewage settling rates by 100-fold, and to fuel pyrolysis process. . . . minimizes solid waste disposal, eliminates odors, and removes most heavy metal pollutants from waste. . . . effluent will satisfy 1983 water quality requirement set by Water Pollution Control Act of 1972 at a lower total cost than less satisfactory secondary treatments currently used. . . . pilot plant now operated by Orange County Sanitation District (California), with NASA and county funds (\$200,000), to develop scale-up design data. . . . county is developing one million-gal./day prototype plant on cost-sharing basis (county 12.5%, state 12.5%, EPA 75% of \$3.4 million). . . . will determine feasibility and design criteria for combining new process with primary treatment plants nationwide. . . . EPA estimates that \$17.1 billion will be spent on new secondary treatment plants by 1990. (Contractor, Client/contractor, TEF 516, Case Nos. 103403, 103404, 10/74)
- *G-2 ERTS-1 imagery: program under Goddard supervision. . . . used by State of Ohio to construct maps for power plant siting, forest inventory, and pollution and resources management of Lake Erie shoreline. . . . Ohio Department of Economic & Community Development currently under contract to Goddard to develop computer program that analyzes remote sensing data for land use planning; applications include a computerized inventory of state land use, the development of land use projections, and possible new applications of remote sensing for land use planning; program will be incorporated into the state computer system. . . . State of Georgia's Department of Natural Resources has a continuing program to utilize ERTS-1 imagery for land use planning, and geological, hydrological, and geomorphic data collection; applications include a state map (effort took one person-week to prepare; comparable map using ground survey estimated @ over \$1 million and several person-years); map used for farm pond inventories, and earthfill dam inventories (subsequently used by the U.S. Army Corps of Engineers to help in fulfilling dam inspection safety mandate; use of the map saved 25% of total inspection cost). . . . data also being used to map Georgia's coastal marshlands for a comprehensive marshland protection program; also by field geologists to define geological structures and identify surface water and land forms; by July 1976, the department will publish a physiographic map and a geologic map of the state. . . . other state government applications include use by the Attorney General's office in a case that involved pollution in the Savannah River and to make a legal demarcation of the Georgia Coast. . . . University of Utah used imagery for map preparation, a hydro-logic survey, and wild life assessment to develop state management policies for the Great Salt Lake area. . . . the University is also evaluating the potential of LANDSAT and remote sensing imagery in a demonstration project for the government of South Korea; two forest inventory maps have been produced, one of the Seoul area and the other of South Korea's southern tip. . . . State of Utah's Department of Development Services used the imagery to prepare a map of Tooele County for land use planning, zoning, grazing and recreational applications; map is still being used. (Contact/federal agency, Contractor, TEF 500, Case Nos. 101904, 101913, 101925, 101928, 3/76)

* Denotes transfer case related to Key Issue.

GOVERNMENT (CONT.)

- G-3 ERTS-1 data collection system: developed by Goddard. . . . used by U.S. Geological Survey (Florida) to telemeter hydrologic data from 20 key remote Data Collection Platforms in southern Florida. . . . only feasible way to obtain data consistently on a near real-time (less than 1 hr.) basis. . . . data used in water management for 1,500 miles of canals and hundreds of control facilities to supply the water needs of southern urban areas, Everglades, wildlife preserves. . . . rapid monitoring critical for flood control (hurricanes) and maintaining water quality during storm water runoff. . . . USGS ordered 35 more DCP's for southern Florida network. . . . used by Department of the Environment (Canada) to telemeter river discharge data from remote areas subject to intense cold. . . . high quality data obtained at low annual maintenance and operating costs (less than \$100/station, cheaper than radio by a factor greater than 10). . . . data used for flow and flood forecasting, design of future hydroelectric power plants, pollution control. . . . Department of Environment quadrupling (9 to 40) number of DCP's. (Interagency, TEF 509, Case No. 101930, 9/74)
- G-4 Computer programs for ERTS-1 data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . being used by Texas Water Development Board under contract to U.S. Army Corps of Engineers, Nashville District (Tennessee), to analyze ERTS-1 imagery for verification of dam inventory in Tennessee. . . . accurately identifies water bodies over 10 acres reduces verification cost by factor of 10. . . . may be used to verify inventories in other states after Tennessee trial. . . . dam inventory is part of federally funded Program of Inspection of Dams authorized by Congress in response to dam failures at Buffalo Creek, West Virginia and Rapid City, South Dakota. . . . hundreds died in these disasters. (Interagency, TEF 513, Case No. 101905, 9/74)
- G-5 Skylab photography: program under supervision of Johnson. . . . used in NASA-funded EREF experiment by U.S. Geological Survey (Florida) with computer processing to construct detailed hydrologic map of Florida's Green Swamp area. . . . swamp is headwaters for 5 rivers which are critical for water needs of central Florida. . . . map shows well-, moderately and poorly drained land in entire swamp (8,000 sq. miles). . . . key factor in facilitating amicable out-of-court settlement of multimillion dollar suit between State of Florida and land developers by showing which areas could be developed without damaging water supplies Florida Dept. of Natural Resources providing funds to publish the map for land use management. (Interagency, TEF 508, Case No. 101929, 9/74)
- G-6 Slidell computer complex: established by Marshall for production management and checkout of Saturn rocket. . . . a major computer facility in south central U.S. . . . since 1971, also used by National Weather Service to forecast flow and stages of all major rivers in five state area (Mo., Ark., Tenn., La., Miss.) large, third generation computer essential for digital simulation model forecasting (first use of this technique by NWS) which provides 72-hour forecasts accurate within 0.3 ft. . . . forecasts important for flood control; also used by farmers and shippers. . . . other agencies using computer facility include Corps of Engineers (Red River sedimentation analysis), U.S. Geological Survey (environmental studies), National Park Service (user study of Great Smoky Mountains National Park). (Interagency, TEF 506, Case No. 101926, 9/74)

G. GOVERNMENT (CONT.)

- G-7 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . process control technology used to design memory system for new post office automated parcel sorting equipment reduced cost of parcel sorting, high speed and reliability. . . . Chrysler units worth about \$500,000 already installed at 3 post offices (Binghamton, N.Y., Greensboro, N.C. and Chicago, Ill.). . . . 2 more on order for California and Postal Service planning additional installations. . . . data acquisition technology used in automated system for real-time collection and processing of hydrometeorological data from Columbia River Basin for Bonneville Power Administration. . . . 43 data gathering stations linked by microwave and VHF radio to master station in Portland. . . . system used for flood control, management of water and forest resources, and providing data from computing hydroelectric plant generating schedules. (Contractor, Customer/contractor, TEF 507, Case Nos. 101923, 103405, 9/74)
- G-8 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL, under contract to TUO and Los Angeles Comprehensive Health Planning Council, to develop local health care planning computer model. . . . integrates demographic, health, health services and other data. . . . provides better projection of hospital bed requirements than HEW planning model which is now used nationwide by states and local councils to allocate hospital construction funds from HEW successful application by JPL of model within LA council area. . . . California evaluating model for statewide use in place of HEW model. (Contractor, TEF 514, Case No. 103401, 9/74)
- G-9 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . four aerospace companies (Northrop Corp., Science Applications, Inc., Aerojet-General Corp., and Lockheed Missiles and Space Co.) are paired with four cities (Anaheim, Fresno, Pasadena, and San Jose). . . . each company provides its paired city with a Science and Technology Advisor and technical support. . . . eleven formal projects undertaken, as well as informal consultation and advising. . . . program has caused city management consideration or use of new devices and methods, including public safety hardware, planning software, system management and integration approaches, and variety of management technique improvements. . . . ongoing or completed management applications include cable television franchise negotiations, municipal waste, vehicle replacement scheduling, and computerized Municipal Information System. . . . cities achieving considerable cost savings and operational improvements, with quantified savings from only two projects estimated at more than \$600,000. . . . program currently being extended to additional cities, with coordination through the League of California Cities. (Contractor, TEF 512, Case No. 101915, 9/74)
- G-10 Apollo Management Control Room: designed for Kennedy by Midwest Research Institute (Missouri). . . . used by MRI as a model to design a management control room for Kansas City officials overseeing construction of the \$200 million city airport. . . . project so successful, design of 3 additional control centers funded by city and other local government agencies: Jackson County (Missouri) Courthouse, Alcohol Safety Action Project, and City Council Goals and Progress Center. (Contractor, TEF 510, Case No. 101924, 9/74)

G. GOVERNMENT (CONT.)

- G-11 Space simulation chamber: developed and maintained for Johnson by McDonnell Douglas Corp. (Missouri) for Mercury and Gemini programs. . . . used by MDC to restore water damaged records with heating/freeze-drying process. . . . restored more than 20% of 20 million records destroyed or damaged by 1973 fire at Military Personnel Records Center (Missouri). . . . large cost savings by reducing the number of records that must be reconstructed from other sources restoration was not possible without chamber. . . . Center normally uses records to process 9,000 requests daily concerning retirement benefits, entitlements, etc. . . . MDC received \$400,000 for military records restoration and \$200,000 from 10 subsequent restoration contracts. (Contractor, TEF 511, Case No. 101914, 9/74)
- G-12 Nondestructive spot test procedure: compiled by Langley. . . . frequently used by Occupational Health Dept., State of New York Labor Dept., to perform screening tests on samples from companies during investigations of health or safety hazards. . . . provides rapid, inexpensive pretest before more detailed test procedures. . . . investigation results are basis for recommending changes to companies and possible legal action to force elimination of hazards. (TB/TSP, TEF 378, Case No. 44538, 8/74)
- G-13 Fireman's breathing apparatus: developed by Johnson, in cooperation with firefighting community, using extravehicular life support system technology funded by TUO. . . . Martin Marietta Corp. (Colorado) and Structural Composites Industries (California) contracted to build lightweight pressure vessels. . . . A-T-O, Inc., Scott Aviation Div. (New York), contracted to build other system components. . . . resulting unit includes: reduced weight/increased duration, simplified harness, improved helmet, mask, and air depletion warning device. . . . field evaluation of system in Los Angeles, Houston, and New York City. . . . Scott Aviation holds a NASA license to produce and sell system. . . . units commercially available in mid-1976. . . . annual sales expected to exceed 10,000 units. . . . current customers include fire departments and industrial firms. (TUO-Applications Engineering, License/contractor, TEF 519, Case Nos. 107781, 107783, 7/76)
- G-14 Systems management techniques: compiled by Marshall. . . . used by E-Systems, Inc. (Texas) in management of large systems project for Defense Department application of documentation control and computerized task scheduling techniques allowed completion of project on time. . . . company estimated benefits to be worth \$800,000. (TB/TSP, TEF 494, Case No. 99834, 3/75)
- G-15 Risk-management system: developed by Kennedy for rocket fuel storage and handling. . . . used by Kennedy in TUO-funded project to provide New York City Fire Department with management system for liquefied natural gas (LNG) storage facilities. . . . public safety increased through better identification, analysis, and control of hazards associated with LNG facilities in the city. . . . project undertaken after 1973 fire at large LNG tank on Staten Island killed 40 people. . . . LNG Risk Management System Workshop conducted at Kennedy in September 1975 for over 50 government, public utility, and industry officials. (TUO-Applications Engineering, TEF 549, Case No. 107737, 1/76)

G. GOVERNMENT (CONT.)

- G-16 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . test results from report used in government programs to improve fire safety used by U.S. Department of Agriculture's Forest Products Laboratory (Wisconsin) to design better fire tests for wood structure test program. . . . used by National Bureau of Standards (Maryland) to develop simplified model for estimating quantities of combustion gases produced during a fire and to educate fire technology researchers on fire behavior used by Columbus Fire Department (Ohio) to obtain data on combustion gases and improve safety for firefighters. . . . also used by New York City Fire Department to help implement city ordinance on fire safety of commercial high-rise buildings; provides input to department recommendations for interior furnishings. (TUO conference, Contact/TUO and contractor, TEF 539, Case Nos. 107034, 107040, 107041, 107047, 107048, 1/75)
- G-17 Properties of air in microwave components: developed for Marshall. . . . used by U.S. Navy's Puget Sound Naval Shipyard (Washington) to improve dry air systems for shipboard electronics and to educate new electronic engineers to date, dry air systems installed on about 10 ships; reduce ionization in radar waveguides, coaxial cables and other electronic components. (TB/TSP, TEF 542, Case No. 98756, 2/75)
- G-18 Linear shaped explosive charge: developed for Johnson, and improved for Marshall, by Explosive Technology (California) to separate stages of launch vehicles. . . . commercialized by ET as Jet-Axe. . . . used by firefighters to blast holes in burning buildings for forcible entry or ventilation. . . . annual sales 500 units @ \$85-\$150. (Contractor, TEF 559, Case No. 109329, 5/75)
- G-19 Infrared electro-optical imaging systems: developed for Goddard and JPL by Hughes Aircraft Co., Santa Barbara Research Center (California) for use on observation satellites and interplanetary space probes. . . . used by Hughes to design portable infrared imager for the U.S. Army. . . . light-weight, hand-held, infrared viewer commercialized as PROBEYE. . . . used by fire and police departments and industry. . . . applications include detection of: hotspots; people and objects concealed by smoke or darkness; flammable or hazardous materials leakage; and overheating in industrial electrical systems. . . . also, potential use in mine safety. . . . retail cost approximately \$3,500. . . . units purchased by 11 municipalities and 2 industrial firms. (Contractor, TEF 576, Case No. 109342, 5/75)
- G-20 Audio signal processor: developed by Johnson to provide automatic volume control for voice communication systems. . . . used by Los Angeles County Flood Control District (California) in designing communications console key element in District's two-way dispatch system for 300 vehicles and walking patrols. (Personal contact/TSP, TEF 435, Case No. 47886, 8/75)

G. GOVERNMENT (CONT.)

- G-21 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by E-Systems, Inc. (Texas) for installation of airborne command post communications equipment on 6 Boeing aircraft provided analysis of structural effects of removing 12 feet of aircraft fuselage for installation of electronics equipment. . . . enabled company to modify aircraft with greater confidence in the structural tolerances and to select optimum positioning for the equipment. (Customer, TEF 410, Case No. 114851, 12/75)
- G-22 Apollo Program management techniques: developed and refined by Marshall. . . . techniques included incentive contracting, computerized information systems, and project management within matrix organizational structure. . . . used by former Marshall contractor employee, now with the Food and Drug Administration, Public Health Service (Maryland), to organize newly formed medical data staff facilitated staff coordination with the agency's planning and evaluation mission. . . . techniques used to create a computerized medical data system, improve contracting procedures, and develop a more flexible organizational structure. . . . benefits include significant time reduction for contract processing, enhanced research team project efforts, and a more useful data system. (Personnel/contractor, TEF 573, Case No. 113675, 11/75)
- G-23 Laser electro-optical alignment pole for surveying (LEAPS): developed by Goddard with TUO funding. . . . used by National Forest Service (District of Columbia) to expedite surveying thousands of acres of national forest lands. . . . long-range laser sighting capability enables measurement of azimuth bearings between two points over a mile apart. . . . 3 units now routinely used in surveying operations. . . . estimated annual savings are \$4 million due to surveying land in 1/3 the previous time at 1/3 the previous cost. . . . estimated time for completing survey program substantially reduced, which will help to avoid legal action involving private lands adjacent to national forests. (Personal contact/Goddard, TEF 599, Case No. 114860, 12/75)
- G-24 Automatic fire index sensor and transmitter: developed by Ames in cooperation with the California Conservation Department, Division of Forestry, as part of a joint fire index demonstration project. . . . initial phase of project in 1974 used LANDSAT and division's automatic sensing unit to collect data on forest fire hazard potential near Sunol, California. . . . sensors gathered critical data including wind velocity and direction, air temperature, humidity and fuel moisture content. . . . data transmitted via satellites but can also be sent via phone lines or microwave links. . . . operational test phase of project began May 1976 in Mendocino County, California. . . . sensor now transmits signals via the GOES satellite. . . . an operational 24 station network is planned for northern California in 1977. . . . benefits include the availability of real-time data, and improved planning capability for fire-fighting resources. (Interagency, TEF 526, Case No. 104771, 6/76)

G. GOVERNMENT (CONT.)

- G-25 Generalized safety equation: developed for Marshall to define the relationship between safety and reliability, as well as evaluating personnel and equipment safety. . . . used by U.S. Army Materiel Development and Readiness Command, Safety Office (Virginia) in the preparation of a system safety manual. . . . manual has also been distributed as a pamphlet, "Nuclear Weapons Systems". . . . both documents distributed to military safety officials; pamphlet also sent to civilian and government agencies concerned with nuclear safety. . . . pamphlet to be republished under sponsorship of Army Nuclear Weapons Safety Committee. . . . improved safety. (Personal contact/NASA HQ, TEF 525, Case No. 79040, 6/76)
- G-26 Electronic and electromechanical reliability data: compiled for NASA Pasadena Office by JPL. . . . data includes failure modes, screening requirements, derating factors and stress analysis. . . . used by U.S. Department of the Interior, Mining Enforcement and Safety Administration, Pittsburgh Technical Support Center (Pennsylvania) to upgrade quality assurance and reliability testing capabilities to improve safety standards in mines. . . . the center tests and certifies mine safety equipment under the federal "Metal and Nonmetallic Mine Safety Act". . . . specific information on resistor and microcircuit failure modes was used in testing electronic components of gas analyzer instruments for mines. . . . continuing benefits include time savings and improved reliability specifications for mine safety equipment. . . . data will form the basis for an expanded equipment reliability testing program. (Personal contact/TSP, TEF 627, Case No. 111080, 5/76)

Other Relevant Examples:

B-15 (military receivers); B-29 (management information system); C-2 (fire fighting equipment); C-7 (U.S. Coast Guard life raft); C-14 (National Park map); D-3 (Bonneville Power Administration control system); D-8 (AEC licensing regulations); E-4, E-5, E-8 and E-9 (air quality agencies); E-6 (state vs. state case); E-7 (state legislature); E-11 (EPA National Eutrophication Survey); E-17 (water quality monitor); F-1 (National Marine Fisheries Service); F-4 and F-6 (USDA food processing); F-5 (FDA training manual); F-16 (tax assessment); H-1 (USGS regulations); I-3 (HUD Operation Break-through Program); I-6 (New York City sewage system); I-7 (U.S. Army Corps of Engineers dam projects); I-10 (FAA radar beacon siting); J-1, J-3 and J-4 (police departments); J-2 (LEAA information system); K-1 (state highway departments); K-2 (DOT Urban Systems Program/local traffic departments); L-6 (police and fire departments); L-7 (High-Speed Ground Test Center); M-2 (military aircraft); M-6 (FAA fire safety standards); M-7 (airport runway grooving); M-12 (aircraft simulator); M-18 and M-19 (military helicopters); R-1 (cancer program); S-2 (NSF Polar Program); S-3 (Great Lakes Winter Navigation Program)

PETROLEUM AND GAS

H. PETROLEUM AND GAS

Key Issues

- a. Offshore oil production: 176 billion bbl. of oil and 248 trillion cu. ft. of gas have been discovered on worldwide continental shelves, with vast areas still unexplored. Offshore oil production in 1970 was 1.6 million bbl./day for U.S. and 7 million bbl./day worldwide; U.S. production remained the same in 1973, and world production increased to 10 million bbl./day. Pollution from offshore production became major environmental issue in 1969 with Exxon Co. well blow-out in Santa Barbara Channel off California. U.S. offshore industry and regulatory agency, U.S. Geological Survey, improving safety and antipollution regulations in response to public pressure. U.S. leasing was accelerated in 1973. (H-1)
- b. New gas supplies: In 1970, U.S. consumed 23.4 trillion cu. ft. of gas; approximately 95% of this was natural gas produced in U.S. Gas is the premium fossil fuel since it is easy to transport, clean burning and almost pollution free. If supplies were available, 1980 consumption would be 35.8 trillion cu. ft. Estimated that only 24 trillion cu. ft. of natural gas will be produced in 1980, shortfall of 11.8 trillion cu. ft. Synthetic gas production facilities and LNG import terminals are being developed rapidly to improve gas supplies in U.S. Additional 1980 gas supplies projected at 2.1 trillion cu. ft. syngas and 1 trillion cu. ft. LNG imports. U.S. has 2 operating LNG import terminals, 5 under construction and 6 more planned. (H-2)

H. PETROLEUM AND GAS

- *H-1 Reliability and quality assurance methods: developed by Marshall. . . . used by Marshall, under contract to U.S. Geological Survey (District of Columbia and Louisiana), for 1971 study of functional reliability for safety and anti-pollution equipment on offshore oil/gas production and drilling platforms basis for improved assurance by federal government and industry that offshore oil and gas will be produced safely and with minimal pollution. over 4,000 copies of report distributed to offshore industry worldwide by USGS USGS regulates all offshore operators on U.S. Outer Continental Shelf, including 1,800 drilling and production platforms in Gulf of Mexico. . . . new Recommended Practices issued by American Petroleum Institute (Texas) for subsurface safety valves and surface safety systems based on Marshall recommendations. . . . will be adopted by industry and included in USGS regulations will require licensing of equipment manufacturers in 1975. . . . additional API RP's based on Marshall study being prepared. . . . Offshore Operators Committee (Louisiana) designed computerized, industry-wide failure reporting system based on Marshall recommendation, and USGS is reviewing system before actual development and implementation. . . . Exxon Corp. (Texas) and other offshore companies made equipment and operating changes to improve safety and reduce pollution hazards based on the study. (Interagency for USGS, Contact/USGS for API, Offshore Operators Committee and Exxon, TEF 484, Case Nos. 93829, 93830, 93831, 8/74)
- *H-2 Cryogenic transfer system cooldown: data and analytic methods developed for Space Nuclear Propulsion Office and Lewis (NERVA Engine Program). . . . used by Chicago Bridge and Iron Co. (Illinois) to design piping systems at most large LNG import terminals in U.S. cooldown rate of warm pipes at start of flow is a critical design parameter. . . . provided major input to CBI design of \$7 million ship-to-shore LNG transfer system at Distrigas Corp. (Massachusetts) import terminal. . . . first (1971) major LNG import facility in U.S. (over 3 billion cu. ft. storage capacity). . . . also used by CBI to design ship-to-shore piping for Algonquin LNG, Inc. (Rhode Island, 6 billion cu. ft. storage in 1973), Columbia LNG Corp. and Consolidated System LNG Co. (Maryland, 5 billion cu. ft. storage in 1976). . . . U.S. annual LNG imports were 2 billion cu. ft. in 1971 and projected to be 2 trillion cu. ft. in 1980. (NBS Cryogenic Data Center, TEF 364, Case No. 50868, 8/74)

H-3 Paragraph deleted, 5/76

* Denotes transfer case related to Key Issue.

H. PETROLEUM AND GAS (CONT.)

- H-4 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and interface equipment for computerized control systems for oil field production, oil and gas pipelines. . . . major international supplier of such systems, over 3 dozen major oil and gas company customers. . . . provides "real-time" monitoring and control from central station. . . . high-speed data transmission over voice grade circuits between central station and remote terminals is innovation in supervisory control systems. . . . computer systems replacing intermediate-level automation. . . . field production benefits through reduced operating cost and increased production. . . . Exxon Corp. (Texas) has computer production control (mostly TRW) in 20 major U.S. fields (200,000 barrels oil and 850 million cu. ft. gas, daily) and estimates 1-2% production benefit. . . . other customers include Continental Oil Co. (Louisiana and California), Getty Oil Co. (Texas), Imperial Oil, Ltd. (Canada), Mobil Oil Corp. (Oklahoma, California, Louisiana, Pennsylvania), National Iranian Oil Co. (Iran), Shell Oil Co. (Louisiana, Venezuela), and MAPCO, Inc. (Oklahoma). (Contractor, TEF 465, Case No. 86005, 8/74)
- H-5 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. (Texas). . . . used by SCI in remote data acquisition and control systems product line. . . . systems installed on oil and gas pipelines and oil field production equipment. . . . provides better centralized monitoring and control, with less manpower. . . . 50 installations worldwide, 30 in U.S. (Contractor, TEF 119, Case No. 4793, 9/74)
- H-6 Heat pipe applications: developed for Marshall, Langley, and Ames by McDonnell Douglas Corp. (Washington) for Skylab, Shuttle and unmanned satellites. . . . commercial heat pipe products developed by MDC include Cryo-Anchor soil stabilizers to prevent thawing of permafrost under structures in far north. . . . eliminates serious foundation stability problem. . . . MDC received \$13 million contract from Alyeska Pipeline Service Co. (Alaska) to supply over 100,000 Cryo-Anchors for \$5 billion Alaskan pipeline. . . . will be installed around pipe supports for 390-mile elevated portion of 800-mile pipeline. . . . also used by general construction industry in permafrost areas of Canada and Alaska. . . . Cryo-Anchors are 2" or 3" in diameter, range in length from 30 to 60 ft., and sell for \$3 to \$20 per ft. (Contractor, TEF 197, Case No. 86008, 7/76)
- H-7 Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed. . . . product used for maintenance inspections at petrochemical plants and refineries by Allied Chemical Corp. and American Oil Co. (Texas). . . . Amoco remotely detects weak links, leaks, and off-specification equipment temperatures to determine maintenance problems. . . . improved plant efficiency and reduced pollution. . . . widespread interest in scanner by oil refineries caused by Amoco success. (Customer/contractor, TEF 398, Case No. 70001, 8/74)
- H-8 Hot tapping method for pipes: developed for Johnson. . . . included in maintenance manuals used at all American Oil Co. (Indiana) refineries. . . . Amoco fabricated related equipment. . . . previously, pipe or valve leaks required up to 8 people and either partial shutdown or elaborate safety procedures. . . . new method done by one or two people in half the time, with no shutdown and little fire hazard. . . . refinery may have about six serious leaks annually. (Trade journal/TSP, TEF 460, Case No. 75018, 9/74)

H. PETROLEUM AND GAS (CONT.)

- H-9 Nondestructive testing training manuals: developed for Marshall. . . . manuals published by contractor and distributed by American Society for Nondestructive Testing. . . . used by Mobil Oil Corp. (New Jersey) to train new employees in maintenance inspection procedures for refineries. . . . improved training and saved time in preparing instructional materials. . . . Mobil has 10 refineries in U.S. (Professional society/contractor, TEF 14, Case No. 53789, 9/74)
- H-10 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Edwards Engineering Corp. (New Jersey) to select special refrigeration oil and vendor. . . . solved major lubrication problem in using off-shelf compressor for very low temperature condenser component in new Edwards product and reduced product cost. . . . unique product automatically recovers gasoline vapor at bulk distribution stations, in compliance with air pollution standards, and conserves gasoline. . . . @ \$125,000, three installed and 40 on order. . . . very rapid market growth expected to continue. . . . all major oil companies have ordered at least one. . . . pay-back time to customer is 2-3 years. (Trade journal/TSP, TEF 497, Case No. 97902, 9/74)
- H-11 Combustion analysis computer program: developed by Lewis. . . . used by Phillips Petroleum Co. (Oklahoma) to generate chemical equilibrium composition tables for all combustion research projects. . . . saved 3 professional man-years for program development and additional time for each application. . . . applied to reduce air pollution from fuel products during car engine combustion, from in-house incinerators, and from in-house burning of waste gases. (Lewis conference, TEF 463, Case No. 93825, 12/72)
- H-12 Systems safety technology (and other technology related to pipeline safety): developed by several NASA field centers. . . . Regional Dissemination Center provided information to Mechanics Research, Inc. (California). . . . used to prepare proposal for the U.S. Department of the Interior (District of Columbia) for Alaskan pipeline safety project. . . . \$18 million contract awarded in 1974. . . . information extremely important to Mechanics Research, estimated value over \$100,000. (RDC-WESRAC, TUO case, 9/74)
- H-13 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Shell Oil Co. (Texas) in converting approximately 500 programs for new computer. . . . reduced conversion time and saved \$200 in operating costs. . . . used by Mobil Oil Corp. (Texas) in converting 4 programs for new computer. . . . saved \$2,000 in operating costs. . . . used by Bonner & Moore (Texas) to prepare computer models for petrochemical companies. . . . enabled design of programs compatible with various computer systems used by client firms. . . . average time savings of one person-day per month. (Personal contact/TSP, Trade journal/TSP, Personnel/TSP, TEF 527, Case Nos. 102812, 103018, 114861, 9/75)
- H-14 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Babcock and Wilcox Co., Power Generation Div. (Ohio) to design large steam boiler for Gulf Oil Corp. refinery. (Contact/COSMIC, TEF 410, Case No. 91178, 8/75)

H. PETROLEUM AND GAS (CONT.)

H-15 Aerial thermal scanner survey technique: developed for the Office of University Affairs, NASA Headquarters. . . . new technique to display building heat loss and analyze insulation needs demonstrated by South Dakota State University Remote Sensing Institute (RSI) under a NASA grant. . . . used by RSI in 1975 to survey five towns in South Dakota and Nebraska for Central Telephone and Utilities Corp., CENGAS Div. (Nebraska), a natural gas utility. . . . survey results, pictured as thermograms, and interpretation methods used by CENGAS in successful energy conservation program. . . . more than 20,000 individuals visited utility sales offices to find out whether they needed insulation in their homes, businesses or schools. . . . 1975 insulation sales in Lincoln area increased by more than 20% over previous year. . . . Lincoln School System initiated program to reduce energy losses from schools; one school saved \$700 during first two months after reroofing and insulation. . . . businesses and homeowner associations in Lincoln area initiated cooperative efforts to conserve energy. (Personal contact/grantee, TEF 605, Case No. 115406, 1/76)

H-16 Hydrogen safety manual: prepared by Lewis. . . . includes characteristics of hydrogen, system design principles, safety requirements and emergency procedures. . . . used by Billings Energy Research Corp. (Utah) as a reference source in designing its laboratory and hydrogen storage area. . . . also used in the development of an employee safety program. . . . improved safety conditions for 40 employees. (TB/TSP, TEF 258, Case No. 113024, 5/76)

H-17 Electronic and electromechanical reliability data: compiled for NASA Pasadena Office by JPL. . . . data includes failure modes, screening requirements, derating factors and stress analysis. . . . used by Tenneco Corp., Tennessee Gas Pipeline Co. (Texas) in solving maintenance problems for pipeline instruments. . . . provided information for field tests to eliminate high temperature failure of capacitors in pipeline monitoring units; over 350 units along pipeline from Texas to Maine. . . . units being modified for cooler operation in southern portion of pipeline. . . . continuing benefits are reduced repair costs and time, as well as power supply downtime. (TB/TSP, TEF 627, Case No. 110978, 5/76)

+ H-18 Neutron shielding material: developed for Space Nuclear Propulsion Office used by Gearhart-Owen Industries, Inc. (Texas) to develop geophysical well logging tool. . . . tool emits neutrons to measure presence of hydrogen and porosity of rock in deep petroleum exploration wells. . . . shield prevents contamination of detector component. . . . 35 units leased to subsidiary company, GO-International, for use in well logging commercial service major petroleum company customers. . . . new product, gas detector, using same technology to be marketed in October 1977. (Personal contact/TSP, TEF 532, Case No. 102354, 7/76)

H. PETROLEUM AND GAS (CONT.)

- + H-19 Rotational vibration analysis methods: developed for Marshall and Lewis by University of Virginia, Mechanical Engineering Dept. (Virginia). . . . includes new mode and computer models for analyzing aircraft and spacecraft used by university professor under private contracts to manufacturers for analyzing vibration problems. . . . natural gas compressor on offshore oil and gas rig analyzed for major oil company. . . . natural gas was burned off since compressor was out of service due to severe vibrations. . . . analytic results used to modify compressor with squeeze dampers originally developed for aircraft engines through Lewis. . . . compressor returned to service and natural gas conserved. . . . combined industrial applications of the technology have resulted in total estimated cost savings of \$100 million. (Contractor, TEF 658, Case No. 121463, 9/76)

Other Relevant Examples:

B-10 (LNG tankers); B-14 (petrochemical production); B-23 (blowout valve system); B-38 (combustion analysis); B-41 (process instrument); B-51 (strain measurement); B-56 (underwater equipment locator); B-58 (process instrument); D-10 (fuel cells); F-15 and K-10 (energy conservation); G-15 and I-6 (LNG storage facilities); M-13 (fuel flow control); S-4 (oil rig paint)

CONSTRUCTION

I. CONSTRUCTION

Key Issue

Construction project management: total new construction in 1973 was \$130 billion, including \$53 billion for residential buildings, \$26 billion for nonresidential buildings, and \$14.9 billion for public utilities. Material and equipment supply bottlenecks are increasing, which adds to the normal scheduling problems and costly delays. 1965 survey of construction industry indicated a widespread opinion that the Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) would soon become necessary for success in construction contracting. 1972 construction industry survey revealed that only 14% of respondents were successful in applying these advanced management techniques in spite of the widespread interest. Two major obstacles were psychological factors and the cost, in time and money, for generating the necessary network graphics. Computerized methods to use PERT conveniently and cheaply eliminate these obstacles, and applications have been increasing since 1972. (I-1)

I. CONSTRUCTION

- *I-1 NASA Pert computer program (Program Evaluation and Review Technique): developed by Marshall. . . . used by Systonetics, Inc. (California) as principal part of computer service for project scheduling in construction and other industries. . . . program widely used by customers; also available from other service companies and used in-house by some construction firms. . . . since there is no charge for NASA PERT, each user saves about \$500/month compared to alternative software available commercially. . . . Systonetics combined NASA program with in-house program, EZPERT, that automatically generates graphic output. . . . significant additional savings from combined programs due to automated output of network activity graphics (\$.32 @ and 200 activities printed/hour compared to \$3.60 @ and 10/hour for manual production). . . . combined programs from Systonetics used routinely since 1972 by Associates Corp. (Indiana), a Gulf and Western subsidiary in consumer finance field, for many management functions. . . . applications include scheduling modifications or new construction in nationwide branch office system (over 900 offices), corporate planning, modeling accounts receivable and minority affairs programs. . . . very important part of multimillion dollar management system that enables company to come within 10% of time and cost estimates for projects. . . . Associates also using programs to assist South Bend (Indiana) in airport expansion project. (Personnel/contractor, Customer, TEF 517, Case Nos. 103406, 103407, 9/74)
- I-2 Geodesic structure design program: developed for Headquarters by R. Buckminster Fuller at Southern Illinois University. . . . computer program used by Dome East Corp. (New York) to design commercial geodesic structures. . . . applications include recreational enclosures, greenhouses, homes, etc. . . . 1975 sales \$800,000. . . . \$1 million sales expected for 1976, \$5-\$10 million by 1979. . . . 207 domes sold to date. . . . product line includes medical facility dome, Medidome, built in Florida and Nigeria; soon in Saudi Arabia. . . . company entered joint venture with Pittsburgh-Des Moines Steel Co. to build sewage treatment and water reservoir domes. . . . expected to be maintenance free and have a 100 year service life because of aluminum construction. (Personnel/grantee, TEF 479, Case No. 91454, 7/76)
- + I-3 Reinforced plastic structures: initial work under DOD contracts. . . . development continued for Headquarters, Langley, and Lewis for high performance rocket motor cases, stabilizers, and liquid hydrogen pressure containers. . . . new fiber reinforced plastics materials used commercially by Material Systems Corp. (California) to manufacture wall panels for prefabricated housing and warehouses. . . . plastic made from petroleum refinery wastes. . . . company held contract with HUD-Operation Breakthrough Program for 500 units in California and 200 in St. Louis. . . . 800 conventionally-financed units built in U.S., 1974-1975, more in France, Senegal. . . . company plants in France and Senegal each produce about 1,000 panels annually. . . . production to begin in November 1976 in Iranian plant. . . . sales to date total about \$120 million. (Personnel/contractor, TEF 518, Case No. 103411, 7/76)
- + I-4 Fiberglass fabric: invented by Owens-Corning Fiberglas Corp. (Rhode Island) company developed first application for fiberglass fabric with 1967 contract from Johnson for nonflammable clothing and structures; included development of Teflon coating for fabric. . . . coated fabric used commercially in air structures developed by Birdair Structures, Geiger-Berger & Assoc. (New York) and others. . . . installations include a vinyl-coated fiberglass fabric covering for the U.S. Pavilion at Expo 70 in Osaka, Japan and the more commonly used Teflon-coated fabric coverings for stadiums and arenas. . . . \$10 million/year industry. (Contractor, Customer/contractor, TEF 324, Case Nos. 103412, 103413, 103414, 9/74)

* Denotes transfer case related to Key Issue.

I. CONSTRUCTION (CONT.)

- I-5 Instrumentation electronics for Saturn rocket: developed for Marshall by SCI Systems, Inc. (Alabama). . . . design techniques and production methods used by SCI to design a ground fault interrupter that will fit inside a standard home circuit breaker. . . . interrupter prevents electrical accidents in home by tripping circuit breaker when ground fault current occurs. . . . required for all new homes in U.S. by 1971 Electric Code amendment. . . . normal annual rate of two million housing starts. . . . SCI sold 40,000 interrupter units/month before recent housing slump, market expected to improve. (Contractor, TEF 119, Case No. 4793, 9/74)
- I-6 Cryogenic data handbook: developed for Kennedy. . . . used by Mason & Hanger-Silas Mason Co. (Kentucky), a major civil engineering firm, to design low temperature construction projects. . . . applications include at least 4 LNG storage facilities and a refrigeration system for freezing wet, loose ground during excavation in major New York City sewage system project. . . . provided 50% of input to solving serious problem in refrigeration system. . . . also used to identify substitutes for scarce materials used for corrosion control in acid plants and pollution abatement equipment. (TB/TSP, TEF 248, Case No. 9562, 8/74)
- I-7 Fusion welding workmanship standards: compiled for AEC and NASA Space Nuclear Propulsion Office. . . . used by Gannett, Fleming, Corrdry, Carpenter (Pennsylvania), a major civil engineering firm, to develop acceptable weld methods and to qualify welders for dam contractors. . . . saved about \$250,000 on \$50 million Foster Joseph Sayers Dam project (Pennsylvania) for Army Corps of Engineers. . . . current applications for Tioga/Hammond Lakes Dams, also part of Corps program in Susquehanna River basin. . . . flood control and dilution of acid drainage from coal mines. (Contact/DOD, TEF 86, Case No. 28474, 9/74)
- I-8 Heat shield coating for reentry vehicles: coating composition patented by Emerson Electric Co. (Missouri). . . . first market was space program applications; coating properties determined by qualification tests conducted for NASA field centers, including Johnson and Langley. . . . coating sublimates when heated and protects substrate from high temperature. . . . Emerson employees who developed coating formed Thermo Systems, Inc. in 1967. . . . company, now called TSI, Inc. (Missouri), acquired patent rights on coating line THERMO-LAG. . . . significant advance in commercially available fire retardant coatings. . . . reliable, effective, inexpensive coatings used by construction industry to protect high-rise building components, such as structural steel and electrical cables, during fires. . . . structural steel coating .2-inches thick will give two-hour fire protection comparable to four inches of concrete coating. . . . applications include high-rise motels (Florida), a pharmaceutical building (Missouri), and chemical plants (California, Texas, Colorado, Connecticut) other applications include propane tanks and plastics. . . . THERMO-LAG sold in 1, 5 and 55 gal. quantities at \$16.95 per gal. (Personnel/contractor, TEF 521, Case No. 104141, 8/76)

I. CONSTRUCTION (CONT.)

- I-9 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Soil Testing Services, Inc. (Illinois), a consulting engineering firm that designs foundations for buildings such as Sears Building in Chicago, to convert over 50 programs for new computer annual operating cost savings. . . . program applications include slope stability, seepage problems, and analysis of pile driver data. (TB/TSP, TEF 527, Case No. 103034, 1/75)
- I-10 Deployable lattice column: designed for Headquarters study of radio telescope antenna by Astro Research Corp. (California). . . . Astro received waiver and developed commercial product, Astromast. . . . annual government and commercial sales over \$600,000. . . . applications include stage light supports for traveling music show, radar beacon siting studies for FAA air traffic control system, portable power poles and communication towers. (Contractor, TEF 167, Case No. 43251, 4/75)
- I-11 Linear shaped explosive charge: developed for Johnson, and improved for Marshall, by Explosive Technology (California) to separate stages of launch vehicles. . . . commercialized by ET as JetCord. . . . several million feet sold @ \$3.48 to \$45 per ft. . . . used in demolition industry for controlled removal of obsolete structures. . . . more than 50 bridges and various buildings nationwide removed with JetCord. (Contractor, TEF 559, Case No. 109329, 5/75)
- I-12 Cable tension tool: developed for Kennedy. . . . a simple, inexpensive tool for measuring relative tension in a set of load-bearing cables. . . . multi-cable version built by George C. Izenour Associates, Inc. (Connecticut). . . . used in adjusting suspension systems of moving ceiling on orchestra shells in performing arts halls; accommodates up to 150 cables of different sizes used to adjust tension in cable suspension system in the University of Akron's Edwin J. Thomas Performing Arts Hall (Ohio). . . . tool benefits are: reduces number of cable mounted devices, costing \$200 each, required for suspension systems; extends life of cables; and reduces cable inspection time. . . . also used by Dover Corp., Elevator Div. (Tennessee) to fabricate 25 cable tension tools for company service crews to use during elevator installation and inspection. . . . provides more equal cable tension, reducing expensive, premature replacement of drive shaft pulleys and cables. . . . also, reduces inspection time by 20%. (TB/TSP, Trade journal/TSP, TEF 489, Case Nos. 91230, 91480, 9/75)
- I-13 Practical solar energy heating and cooling system: developed for Marshall used by [Clarence and Elizabeth Bonitz] owners of all electric home (New Jersey) to design swimming pool solar heater. . . . avoided increasing electricity cost by \$400 annually. . . . used by CSI Corp. (Wisconsin) to design prototype solar heating and cooling system now installed in new headquarters building. . . . \$3,000 annual savings in utility costs. . . . also being evaluated for new products, such as heat reflective coatings for solar energy systems. . . . used by Walker Plumbing and Heating Co. (South Carolina) in developing prototype residential solar water heater. . . . saved \$20,000 in design of potential new product line. (Popular magazine/TSP, TB/TSP, Personal contact/TSP, TEF 496, Case Nos. 93211, 95004, 106862, 7/75)

I. CONSTRUCTION (CONT.)

I-14 Solar energy collector testing program: conducted by Lewis. . . . former Lewis branch chief founded Solar Energy Products Co. (Ohio) in 1972. . . . developed solar energy collector for commercial and residential space heating systems. . . . collector is the key component in solar heating systems which also include heat storage, conduit and control components. . . . currently installed in four homes and being installed in four more. . . . sales for collectors alone, not including installation or other system components, are approximately \$20,000. (Personnel/Lewis, TEF 606, Case No. 114869, 1/76)

I-15 Fracture toughness tests: developed by Lewis. . . . used by U.S. Steel Corp. (Pennsylvania) to analyze structural steels. . . . developed correlation between results from fracture test specimen and conventional Charpy test specimen. . . . company performed the basic tests and analyses to develop new fracture toughness requirements for bridges. . . . requirements adopted by Federal Highway Administration and American Association of State Highway and Transportation Officials. . . . now required for all federal aid highway programs in U.S. . . . development of new bridge standards initiated after brittle fracture failure caused the Point Pleasant Bridge in West Virginia to collapse in 1967. (Professional society, TEF 451, Case No. 115404, 1/76)

I-16 Method to attach insulation tiles: developed by Johnson for the Space Shuttle Program. . . . felt pads serve as strain absorbing buffers between high temperature insulation tiles and metal surfaces, attached with commercial silicone adhesive. . . . adhesive and bonding technique used by O.Z. Gedney Co. (Connecticut) to attach intumescent material to a metal component in its new fire safety product, a fire stop fitting for electrical conduits where they pass through a fire barrier. . . . product designed for use in nuclear power plants and is required by the NRC. . . . reduced product development costs and benefits expected from product sales. (TB/TSP, TEF 638, Case No. 114356, 5/76)

I-17 ERTS-1 imagery: program under supervision of Goddard. . . . imagery used by Dresser Industries, Inc., Petroleum and Mineral Operations Div. (Texas) to improve construction and mineral exploration activities in Alaska, Australia, and Ireland. . . . provided significant contribution to the location of mineral deposits, selection of construction sites, survey of roads, and identification of geological structures in poorly mapped areas. . . . also used to map uncharted areas. . . . use of imagery resulted in time and cost savings by reducing the need for expensive aerial surveys and mapping. . . . benefits are expected to continue. (Personal contact, TEF 500, Case No. 117157, 4/76)

I-18 Acoustic analysis and testing techniques: compiled for NASA Pasadena Office by JPL. . . . techniques and computer programs to analyze acoustic test data used by Brod & McClung-Pace Co. (Oregon) which designs and builds customized central heating and cooling equipment for the construction industry used to improve computer programs for analyzing sound levels in fan designs. . . . modification makes computer program five times faster and saves approximately \$700 annually in computer operating costs. . . . benefits expected to continue. . . . company research director also distributed copies to the Technical Advisory Committee on Sound Standards of the Air Moving and Conditioning Association (AMCA) for use in revising sound measurement standards for the fan industry. (TB/TSP, TEF 628, Case No. 114494, 5/76)

I. CONSTRUCTION (CONT.)

- + I-19 Boundary layer wind analysis: developed for Headquarters and by Marshall combined studies were an exhaustive analysis of boundary layer wind. . . . used by atmosphere simulation group at Colorado State University (Colorado) in wind simulation model for structural design of Yerba Buena Center (California), World Trade Center Towers (New York) Federal Reserve Bank Building (Virginia). . . . provided basis for estimating accuracy of simulation. . . . group now has National Science Foundation grant to study wind mills for electric power. . . . similarly used by Calspan Corp. (New York) in wind simulation for structural design of Commerce House (Washington). (Professional journal, Personal contact, TEF 643, Case Nos. 120222, 120511, 7/76)
- + I-20 Wind model for structure design: developed for Ames by Colorado State University (Colorado) as part of STOL-Port design studies. . . . included development of new hot-wire anemometer measurement method. . . . method used by CSU for private and government contracts to analyze wind flow around buildings, particularly downwind turbulence. . . . results applied in structural design of buildings. (Contractor, TEF 647, Case No. 120517, 3/76)

Other Relevant Examples:

A-11 and A-12 (solar collector); B-11 (chemical plant design); B-19 (fire safety); B-37 (NDT training); D-9 (nuclear power plant design); G-10 (airport construction management); G-15 (LNG storage facilities); G-16 (fire safety); H-2 (LNG import facilities); N-7 (fire safety)

LAW ENFORCEMENT

J. LAW ENFORCEMENT

Key Issue

Computerized police information systems: The first real-time police computer system was installed in 1964 for the St. Louis department. In a 1971 survey of almost 500 police departments, 38.8% of the responding departments were using computers and 62.5% would be using computers by 1974. Applications include police patrol inquiries on wanted status of individuals or property ownership, automated traffic violation records, patrolman dispatching, automated files for criminal investigations, allocation and distribution of regular patrol units, and crime statistics. The Law Enforcement Assistance Administration (LEAA) has provided federal funds to police departments for computer acquisition. Police efficiency has been improved in some, but not all, instances. In addition, a controversy exists over cost effectiveness of computer use. (J-1)

J. LAW ENFORCEMENT

- *J-1 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets, video output is of professional quality total sales \$23 million. . . . most sales to law enforcement agencies, including Royal Canadian Mounted Police (\$1.1 million system in 1971), Illinois Bureau of Criminal Investigations (\$1.2 million, 1972), and Louisville Police Department (Kentucky, 1973). . . . provides compact, automated fingerprint file system used successfully in all installations and criminal history files (including photographs) in some installations. . . . Canadian system will pay for itself in 3 years by reducing cost of fingerprint searches. (Contractor, TEF 226, Case No. 66201, 9/74)
- J-2 Scientific and Technical Information Management System (STIMS): developed for the Scientific and Technical Information Office, NASA Headquarters, as a computer software package for storing and retrieving bibliographic materials obtained from STIF by the Law Enforcement Assistance Administration, Dept. of Justice (District of Columbia). . . . became the primary operating software for the National Criminal Justice Reference Service, a central computerized information system serving the nation's law enforcement and criminal justice agencies. . . . NCJRS (became operational in September 1972) has 30,000 registered users and performed over 300,000 searches in 1973. (Personal contact, TEF 515, Case No. 103402, 9/74)
- J-3 Systems analysis and computer modeling: developed for Headquarters by Jet Propulsion Laboratory (California). . . . used by JPL Public Safety Program, under contract to Los Angeles Police Department, for requirement definition and design of proposed city-wide emergency command and control communications system. . . . includes master radio network plan, systems design for computer-assisted dispatching, automated vehicle monitoring, automated mobile command center, automated precinct command center, out-of-car communications network, and detailed specifications for mobile digital communication system. . . . will be first totally integrated system in country (cost to install over \$50 million). . . . being established under LEAA funding as model program. . . . consortium of major cities established to facilitate subsequent technology transfer. (Contractor, Contact/contractor, TEF 514, Case Nos. 103399, 103400, 9/74)
- J-4 California Four Cities Program: funded by NASA and NSF (since 1971) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . Aerojet-General Corp. providing Pasadena with a Science and Technology Advisor and technical support. . . . Advisor used systems analysis to help Pasadena Police Department in selecting site for city heliport used by police helicopter, in compiling operations manual for effective helicopter patrol, and in developing program that reduced false alarms from burglary/robbery detection systems by 40%. (Contractor, TEF 512, Case No. 101915, 9/74)

* Denotes transfer case related to Key Issue.

J. LAW ENFORCEMENT (CONT.)

- J-5 Flat conductor cable connector survey: compiled for Marshall. . . . used by AMP, Inc. (Pennsylvania), manufacturer of flat cable interconnection/termination components, to increase product design knowledge. . . . components used to manufacture voice communications systems such as mobile systems used by police departments. . . . used by Spectra Associates, Inc. (Iowa) to locate flat cable hardware suppliers and to develop control heads for public safety vehicle communication system manufactured by customer (systems sold to Iowa Department of Public Safety). . . . 350 control heads produced for customer to date. . . . custom fabrication for other users on special order. . . . saved \$200 in research time; also, reduced number of parts, saved wiring space and provided easy maintenance design. . . . client now in full-scale production of system for police departments and state highway patrols. (TB/TSP, TEF 535, Case Nos. 92532, 93278, 8/76)
- J-6 High intensity arc radiation source: developed for Johnson Apollo environmental test chamber. . . . contractor personnel formed Streamlight, Inc. (Pennsylvania) to develop arc source into commercial, high intensity spotlight, called Streamlite-1 Million. . . . product has "true color," is portable, 50 times brighter than automobile headlights, and can operate from automobile cigarette lighter. . . . several hundred sold @ \$400-\$475; sales are continuing at a steady rate. . . . used by fire and police departments in security and emergency situations. (Contractor personnel, TEF 561, Case No. 109327, 5/76)
- J-7 Silent Communications Alarm Network (SCAN): developed for Headquarters by Jet Propulsion Laboratory. . . . a personal alarm system used by secondary education teachers. . . . system is based on space telemetry systems and consists of personal, pen-sized ultrasonic transmitters and strategically located receivers. . . . former JPL employee received license from NASA to commercialize SCAN, and formed Mentor Co. . . . product line, including license, sold to Sentry Products, Inc. (California) in October 1974. . . . company refined the SCAN system and sold five systems to schools in New York and California. . . . also providing service for fifteen systems previously sold by Mentor Co. . . . total sales and revenue for new product are \$100,000. . . . further product development for home use is currently in progress. (Purchased product line, TEF 586, Case No. 112243, 8/75)

Other Relevant Examples:

D-1 (air pollution standards); E-2 (vehicle emission certification); E-4, E-9 and H-10 (implementing air quality laws); E-6 (legal evidence); E-7 (preparing environmental legislation); F-2 (OSHA safety regulations); G-5 (environmental lawsuit); G-19 (infrared imager); I-5 (electrical code requirements)

HIGHWAY TRANSPORTATION

K. HIGHWAY TRANSPORTATION

Key Issue

Highway safety: Total economic loss due to highway accidents in 1972 was almost \$19 billion. 1972 accidents caused 56,000 deaths and 4,850,000 injuries. California has largest number of fatalities, almost 10% of total. Accident rate per 100 million vehicle miles decreased from 5.5 in 1965 to 4.5 in 1972, an 18% reduction. (K-1)

K. HIGHWAY TRANSPORTATION

- *K-1 Highway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . Langley results were basis for new highway/airport grooving industry with about \$2 million annual business. . . . firms include Pavement Specialists, Inc. (Texas), Cardinal Engineering (Pennsylvania), Transportation Safety Systems, Inc. (Ohio), Super Cut, Inc. (Illinois), Charles R. Watts Co. (Washington), and C. W. Hatcher, Inc. (California). . . . over 25 states have contracted to have dangerous highway sections grooved wet highway accidents on grooved sections reduced by about 60%. . . . about 20% of accidents occur on wet pavement. . . . California Department of Transportation is leading user, with \$8 million total outlay; applications include 400 miles of freeway grooved in Los Angeles area. . . . General Electric Co. (Ohio) produces artificial diamonds used in manufacture of groover cutting blades. . . . GE actively promoting grooving. (Contact/Langley, TEF 168, Case Nos. 101917, 101919, 101920, 101921, 101922, 9/74)
- K-2 Apollo Guidance Computer software: developed for Johnson by TRW Systems (Texas). . . . used by TRW Systems (California) to develop first, real-time computerized traffic control system in U.S., SAFER (Systematic Aid to Flow on Existing Roadways). . . . prototype TRW SAFER installed and operating in 9-mile square South Bay area of Los Angeles County (California). . . . project cost about \$800,000; funded by U.S. Department of Transportation Urban Systems Program (71%), County of Los Angeles (22%) and State of California (7%). . . . more than 15% reduction in millions of vehicle hours spent waiting at 112 South Bay traffic lights. . . . estimated total annual savings to motorists using South Bay streets is \$1 million. . . . TRW also under contract to install SAFER in Baltimore, Maryland (1,000 traffic lights), Overland, Park, Kansas, Boulder, Colorado and Inglewood, California. . . . total revenue \$8 million. . . . no further installations planned by company. (Contractor, TEF 465, Case No. 103415, 8/76)
- + K-3 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Ford Motor Co. (Michigan) for design analysis of car, truck, and farm tractor components since 1971. . . . more than 40 design engineers trained to use program. . . . influenced design of every major component in these products. . . . saved two-thirds of calculating time in achieving 60% improvement for component behavior predictions reduced R&D time and cost, as well as development testing costs (no valid cost savings figure available at this time). . . . General Motors Corp. (Michigan) recently completed development of design application methods to facilitate NASTRAN use by design engineers. . . . program calibrated with data from older vehicles. . . . corporate effort aimed at widespread use of NASTRAN in product design. . . . NASTRAN versatility and continued program maintenance service from Langley are very important to Ford and GM. (Contact/COSMIC, TEF 410, Case Nos. 103416, 103417, 9/74)

* Denotes transfer case related to Key Issue.

K. HIGHWAY TRANSPORTATION (CONT.)

- K-4 Saturn I/IB Systems Development Breadboard Facility: installed and operated for Marshall by Chrysler Corp. (Alabama). . . . electronics design, computer systems, and quality production experience at Huntsville Div. used to develop new products and production line testing for most Chrysler cars and trucks annual production 2 million units. . . . product applications include hybrid circuitry in new solid-state radios for Plymouth and Dodge lines, accurate digital clock for Chrysler line, and ignition retarder to reduce emissions when idling. . . . more durable radio uses 20% of electricity previously required. . . . production applications include methods to produce reliable electronic ignition systems used in all cars and light trucks, automated electrical wiring test system for some car assembly plants, computerized system for automated testing of car distributors and windshield wiper motors, and semiautomated test system for brake cylinders. . . . electronic ignition system is a major improvement in car equipment, better car performance reduces emissions and lowers maintenance cost. . . . 60-second test of car wiring identifies whether rework is needed. . . . 8,000 distributors tested daily at 60 secs. each, with 10 times previous accuracy. . . . brake cylinders tested in 7 secs. (Contractor, TEF 507, Case No. 101927, 9/74)
- K-5 Combustion analysis computer program: developed by Lewis. . . . routinely used by General Motors Corp. (Michigan) since 1970 in combustion research for automotive engines. . . . by modeling the engine combustion process, program improved analysis of how pollutants are formed. . . . research results used in various GM design and development projects. . . . used extensively by Chrysler Corp. (Michigan) in combustion analysis for gas turbine engine development. . . . gas turbines will be introduced in 1975 automobiles. . . . lower emissions and fewer moving parts than standard piston engines. (Lewis conference, TEF 463, Case Nos. 103409, 103410, 9/74)
- K-6 Statistical procedures to analyze time-dependent data: developed for Marshall used by General Motors Corp., Saginaw Steering Gear Div. (Michigan) to analyze noise test data from automobile steering systems and other components. . . . enabled analysis of output from sophisticated new test instrument; saved testing time and reduced costs on a continuing basis. . . . test results used to reduce noise caused by Saginaw components in GMC passenger cars. (TB/TSP, TEF 545, Case No. 87348, 3/75)
- K-7 Rubber tire with low temperature pliability: developed for Johnson Apollo 14 Mobile Equipment Transporter by Goodyear Tire and Rubber Co. (Ohio). . . . used by Goodyear to develop new, studless winter automobile tire. . . . market testing started in 1974 with 4 cities; received good response. . . . price range from \$71.25 to \$79.45, with 4 sizes available. . . . provides traction equal to or better than studded tires on slick surfaces; also good traction on dry surfaces. . . . several states are banning studded tires due to poor traction on dry surfaces and destruction of road surface. (Contractor, TEF 565, Case No. 109331, 5/75)

K. HIGHWAY TRANSPORTATION (CONT.)

- K-8 Production processes and designs for electronic systems: developed for Johnson, Marshall and JPL contractors by ELDEC Corp. (Washington). . . . included advanced designs for systems that condition signals from onboard instrumentation. . . . used by ELDEC to develop new product line of on-board truck weighing systems. . . . \$2,000 system installed on over 2,000 logging trucks. . . . weight readout in cab permits driver to maximize payload while staying under legal highway weight limits. . . . increased efficiency in use of truck capacity provides revenue increase that recovers unit cost in about one year. (Subcontractor, TEF 585, Case No. 112242, 5/75)
- K-9 Automated data management system: developed for Johnson by Hamilton Test Systems (Connecticut). . . . designed for the life support system environmental control unit in a proposed space station prototype; data system would monitor performance, detect malfunctioning units, and activate standby equipment. . . . technology used by company to develop motor vehicle pollution emission test equipment for the State of Arizona. . . . company also constructed 12 vehicle emission inspection centers, housing the equipment, which it operates for the state. . . . company also used the technology to develop "Autosense," computerized diagnostic equipment which isolates motor vehicle malfunctions. . . . this diagnostic equipment sold to General Motors, Sun Oil, and other large companies to improve vehicle repair services. . . . benefits to Hamilton include new products and services and increased company revenues. (Contractor, TEF 621, Case No. 117306, 4/76)
- K-10 Aerodynamic drag reduction tests: performed by Dryden Flight Research Center with funding from DOT. . . . a tractor-trailer unit was used to test several add-on devices for reducing drag. . . . information used by American Trailers, Inc. (Oklahoma) in redesigning large semi-trailers. . . . company incorporated slant front design and shortened air gap between the tractor and trailer. . . . wind resistance reduced by 10%. . . . 350 "Bullnose" livestock trailers (8' wide, 43' long, 13' high) sold at \$12,000 each since mid-1975. . . . comprises 95% of company livestock trailer sales. . . . recently, company began manufacturing a similarly modified version of its refrigerated trailer. . . . benefits to company include increased sales and several thousand dollars saved in aerodynamic testing time. . . . customers save up to \$300 annually in fuel costs. (Trade association, TEF 620, Case No. 119273, 7/76)

Other Relevant Examples:

A-1 (automobile products); B-9 (lubricant for car air conditioners); B-22 (automobile components); C-14 (travel guide); E-2 (vehicle emission certification); E-18 (pollution dispersal); H-11 (vehicle emission control); I-15 (bridge standards); M-12 (highway planning)

RAIL TRANSPORTATION

L. RAIL TRANSPORTATION

Key Issues

- a. Railroad safety: Train accidents caused by improper maintenance increased 300% between 1961 and 1972, and all train accidents increased 25% between 1972 and 1973. Increased use and deferred maintenance of track are major factors in these rises. Over 90% of railroad revenue is from freight service which, growing at 3% annually, totaled 877 billion ton-miles in 1974. The average freight car capacity was 53 tons in 1950 and 68 tons in 1971, but the average capacity of new cars built in 1973 was 85 tons. The average use factor for freight cars is also increasing: in 1973 this was 1,621 ton-miles per car-day, an increase of 9.5% over 1972. Greater use of unit trains, particularly for hauling coal which makes up 26% of rail freight tonnage, is a major cause for the use factor increase since unit train cars annually travel 3-16 times further than ordinary cars. In 1960 the railroads spent \$1.2 billion to maintain structures and 219,400 miles of road; in 1972 these figures were \$1.9 billion and 208,000 miles. Expenditures for maintenance and the importance of inspection equipment will continue to grow. (L-1)
- b. Railroad computer systems: For some time, many railroads have used computers for data analysis and planning at central offices. Some railroads started using computerized information systems in the late 1960's to handle enormous amounts of paper such as waybills (railroad freight documentation). Since 1970 there has been a rising interest in computerized process control applications such as terminal operations and train dispatching. These real-time applications require much more sophisticated computer and communication systems and man-machine interfaces. To date, only one or two prototype systems of this sort have been installed for pilot testing. Computers are currently used in a few rail yards for monitoring and assisting in terminal operations. Between 1975 and 1980, the railroads will install a national freight car information system, TRAIN II, that was pilot tested in 1974. This computerized information system is expected to improve car utilization and to help forecast future needs by updating information such as car location and status on an hourly basis, as compared to the present daily basis. (L-2 and L-4)

L. RAIL TRANSPORTATION

- *L-1 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . company had over \$2 million in contracts to produce innovative equipment for Apollo Program in past few years and has "had commercial spin-offs of several times that amount". . . . for example, Marshall funded the development of company's laboratory prototype into operational ultrasonic Delta Manipulator which Automation then marketed. . . . uses multiple transducers for significant improvement in testing rate and accuracy. . . . delta technique and ultrasonic test equipment now used by Automation in unique rail inspection service. . . . company has operated self-propelled railroad cars since 1928 to detect rail flaws with electric induction technique. . . . currently, 28 cars in operation on U.S. rails, 1 in Mexico, 2 in Australia, and others in Europe. . . . all cars now include ultrasonic test equipment, many use delta technique, and new cars use ultrasonics entirely. . . . one of the all ultrasonic cars used exclusively on New York City Transit Authority subway rails. . . . ultrasonics used to detect rail-end flaws (e.g., bolt hole cracks) and to complement induction method along rail. . . . over 500 million rail joints tested ultrasonically. . . . company does majority of NDT for U.S. rails; only one other NDT car exists, developed by a railroad. . . . since 1928 over 6 million miles of track tested; over 3 million flaws detected and track replaced. . . . over 160,000 miles of track now tested annually for 100 different railroads. . . . average testing speed for test cars is about 7 mph. (Contractor, TEF 387, Case No. 59201, 8/74)
- *L-2 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (Texas). . . . used by TRW Controls (Texas) to develop software and telemetry interface equipment in prototype computerized dispatching system for railroads. . . . prototype installed and being tested in part of Southern Pacific Co. (California) railroad system. . . . one of most sophisticated train control systems in world. . . . TV displays provide central dispatcher with continually updated status of rail switches and trains; system provides for control of rail switches and train movement via light pen input on TV display. . . . test results favorable to date. . . . if prototype successful, Southern Pacific and TRW will develop computerized dispatching system for company's entire railroad system. . . . Southern Pacific is one of 3 largest railroads in nation; 4,000 miles of track, \$1 billion annual freight billings. (Contractor, TEF 465, Case No. 86005, 8/74)
- L-3 Dynamic and static modeling techniques: developed by Marshall. . . . used by Martin Marietta Corp. (Colorado) in current development of dynamic model for railroad hopper cars. . . . TUO applications engineering project funded by Federal Railroad Administration and under technical direction of Marshall. . . . part of a major test program being conducted by Association of American Railroads to reduce number of derailments which are frequently caused by erratic behavior of hopper cars. . . . hopper car testing and model development underway at Martin to identify design modifications that will reduce erratic behavior. (TUO-Applications Engineering, 1/75)

* Denotes transfer case related to Key Issue.

L. RAIL TRANSPORTATION (CONT.)

- *L-4 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key-tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets. . . . important advantages over microfilm and closed circuit systems include reduced processing for storage and improved resolution. . . . \$750,000 Videofile System used by Southern Pacific Co. (California) since 1968 for all documentation related to railroad freight (waybills). . . . Southern Pacific among the 3 largest railroads in nation, \$1 billion annual freight billings. . . . revenue settlement between railroads can take 3 years due to massive paper problem. . . . ICC requires 4-year storage of waybills. . . . Southern Pacific's Videofile in use 24 hours per day, 5 days per week; 500,000 waybills entered per month and 100,000 retrieved. . . . system cost recovered in about 4 years through reduced operating costs. (Contractor, TEF 226, Case No. 66201, 9/74)
- L-5 Arc suppression technique evaluation: conducted for Marshall. . . . used by Vapor Corp. (Illinois) in design of rapid transit control products. . . . electronic noise, created when electricity arcs through switch during switching of inductively loaded circuits, interferes with other control equipment. . . . document used to select diodes, rather than more expensive, less reliable capacitors, for arc suppression. . . . diodes used in 80% of circuitry. . . . company installs system on average of 500 cars per year at \$2,000 to \$5,000 each. (Professional Journal/TSP, TEF 128, Case No. 1520, 8/76)
- L-6 Model for hazardous materials plume dispersal (to determine evacuation area): developed by Lewis for the Joint Army-Navy-NASA-Air Force (JANNAF) Safety and Environmental Protection Working Group. . . . used by Chemical Propulsion Information Agency at Johns Hopkins University (Maryland), under contract to U.S. Department of Transportation, to develop "Emergency Services Guide for Selected Hazardous Materials". . . . procedures for tank car spills of 30 hazardous chemicals are presented. . . . almost 100,000 copies of guide have been distributed, primarily to police and fire departments throughout the country. (Interagency, TEF 550, 1/75)
- L-7 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Langley to select rail installation procedures for DOT's High-Speed Ground Test Center (Colorado). . . . procedures used to prevent buckling of linear induction motor reaction rails. . . . successful operations at test center since 1972 rail installation. . . . used by Pullman, Inc., Pullman-Standard Div. (Illinois) in 3-year project to develop new family of open-top railroad cars. . . . significant design improvements provide more efficient, rugged car for bulk commodity transport. . . . company built new production facilities to manufacture the 7 new gondola and hopper car designs. . . . major industrial and railroad firms have ordered fleets of the new cars. . . . Pullman is world's largest producer of railroad cars. . . . used by Boeing Co., Boeing Vertol Co. Div. (Pennsylvania) to redesign new mass transit rail car product, Standard Light Rail Vehicle (SLRV). . . . eliminated uncomfortable vibrations with new nonlinear suspension system, rather than conventional method of increasing vehicle weight. . . . benefits will include less track wear and power consumption, and increased passenger comfort. . . . electric powered SLRV's being built for delivery to Boston and San Francisco mass transit systems in 1976. (Contact/Langley, Personal contact, TEF 410, Case Nos. 107063, 114867, 1/76)

* Denotes transfer case related to Key Issue.

L. RAIL TRANSPORTATION (CONT.)

- L-8 Biodynamic response data for the human body: developed for Marshall by Air Force Aerospace Medical Research Laboratory to provide design data for launch vehicles. . . . used by Air Force researcher in formulating mechanical vibration and shock standards for International Standards Organization. . . . ISO standards used by Boeing Co., Boeing Vertol Co. Div. (Pennsylvania) to design new mass transit rail car product, Standard Light Rail Vehicle (SLRV). . . . enabled development of an analytic procedure for designing cars with satisfactory passenger ride dynamics at speeds up to 96 km./hr. . . . provides better ride quality than competing products. . . . overhead electric lines power each car to operate on rails laid in streets or subways. . . . SLRV's being built for 1976 delivery to Boston and San Francisco mass transit systems. (Professional journal, TEF 610, Case No. 114866, 1/76)
- L-9 Computer programs to analyze ride quality data and rail vehicle dynamics: developed by Langley. . . . ride quality initially analyzed for STOL aircraft, other transportation modes also studied. . . . used by Budd Co., Railway Div. (Pennsylvania) to redesign railroad passenger cars under U.S. Department of Transportation contract. . . . cars to be used in the high speed (240 km./hr.) Metroliner train system planned for operations between Boston and Washington, D.C. . . . previous suspension system design would have limited speed to 140 km./hr. in order to satisfy DOT ride quality standards. . . . Metroliner cars being built with new nonlinear suspension system design. . . . computer programs and assistance from Langley personnel important to successful redesign effort. (Personal contact/Langley, TEF 608, 609, Case Nos. 114871, 114873, 1/76)
- L-10 Welding high-strength aluminum alloys: handbook compiled for Marshall. . . . integrates results from 19 research programs, including work done for Saturn V describes welding fabrication, aluminum alloy characteristics, weld defects and porosity, role of contaminants, weld thermal effects and residual stresses. . . . used by General Electric Co., Transportation Systems Div. (Pennsylvania) to develop a process for welding high-strength aluminum alloy castings used in locomotive diesel turbochargers. . . . saved over \$5,000 in development costs for new process after previous attempts to weld cast aluminum had failed. . . . 150 castings produced and most still being used in locomotive engines. (Trade journal/TSP, TEF 626, Case No. 107444, 4/76)

AIR TRANSPORTATION

M. AIR TRANSPORTATION

Key Issue

Aircraft research and development: Company-funded R&D in the aerospace industry cost \$1.01 billion in 1971 and is projected to cost \$1.15 billion in 1975; total company-funded R&D for all industries was \$10.64 billion in 1971 and is projected to reach \$13.95 billion in 1975. In 1971, the total R&D activity by scientists and engineers was 359,700 man-years, 21% (or 75,100 man-years) was aerospace and 5% (or 18,400 man-years) was company-funded aerospace. The civilian aircraft industry has relied heavily on government-funded projects to develop and "prove out" new concepts in aircraft design. New designs from NASA and DOD research facilities are typically used first in military aircraft and then in civilian aircraft in order to sustain the continued growth in performance for both types of aircraft. Manufacturer shipments of complete civilian aircraft were: 14,660 units worth \$3.5 billion in 1967; 7,644 units worth \$3 billion in 1971; and (projected) 15,500 units worth \$5.7 billion in 1975. About 80% of the shipment value is due to a relatively small number of large commercial transports (480 in 1967, 223 in 1971, and 304 in 1975). Performance advances have maintained U.S. aircraft domination of world markets. The total aerospace export value hit an all-time high of \$7 billion in 1974 (\$2.8 billion for 230 large transports) and is projected to be \$7.9 billion in 1975 (\$3 billion for 240 large transports). (M-1 and M-2)

M. AIR TRANSPORTATION

- *M-1 Aircraft design concepts: developed by Langley since early 1950's to improve military and civilian aircraft. . . . conducted design development from conceptual stage, through wind tunnel testing, to flight demonstrations for aircraft industry. . . . contributions significantly advanced body/wing designs for supersonic military aircraft, large subsonic air transports, and light planes. . . . area rule of selecting body/wing cross section design for minimum drag is exemplified by "coke bottle" shaped body. . . . used worldwide to design supersonic military aircraft. . . . air transport applications include the humped cab on Boeing Co. (Washington) 747. . . . company-funded R&D for aircraft industry was \$1 billion in 1971 (out of \$10.6 billion total for private R&D) and projected at \$1.1 billion for 1975 (out of \$13.9 billion total for private R&D). . . . only the electrical equipment industry spends more to develop new products. (Contract/Langley, 1/75)
- *M-2 Aircraft design data: obtained by Langley wind tunnel and flight testing programs. . . . tests in late 1940's and 1950's reduced swept back wing concept (a German invention) to engineering practice. . . . design now used for all air transports. . . . tests of engine/wing aerodynamics for Air Force C-5 transport resolved aircraft contractor's (Lockheed) design problems in mounting new generation of large fan turbines on wings. . . . this major contribution to design capability used to mount same generation turbines on commercial air transports; McDonnell Douglas Corp. (California) DC-10 and Lockheed Aircraft Corp. (California) L-1011. . . . DC-10 development cost McDonnell Douglas \$1 billion. . . . test facility provides basic data which reduces development costs for civilian and military aircraft designers. (Contact/Langley, 1/75)
- M-3 Liquid penetrant nondestructive testing training manuals: compiled for Marshall. . . . used to train and certify production line inspectors at Beech Aircraft Corp. (Kansas). . . . 80 inspectors at 4 plants. . . . very important in quality control. . . . second largest producer of business and utility aircraft. . . . 1973 sales about \$160 million. (TB/TSP, TEF 374, Case No. 40622, 8/74)
- M-4 Computer display system for Saturn prelaunch checkout: developed for Marshall and Kennedy by Sanders Associates, Inc. (New Hampshire). . . . significant advances in digital television hardware and software for computer interface systems. . . . used by Sanders to develop commercial product line in 1968. . . . price range \$70,000 to \$125,000; 30 units sold by 1972, with additional sales (unknown) since then. . . . applications include pilot training simulators, flight test monitoring, and air traffic control. . . . used in \$700,000 display portion of \$3.5 million computer system for 1970 flight testing of McDonnell Douglas Corp. (California) DC-10. . . . automated data analysis reduced total test flight hours from projected 2,000 to actual 1,250. . . . used in new Canada-wide air traffic control system; multimillion dollar display portion is 75% installed. (Contractor, TEF 99, Case No. 76502, 1/75)

*Denotes transfer case related to Key Issue.

M. AIR TRANSPORTATION (CONT.)

- M-5 Inertial navigation equipment for Apollo and Lunar Module: developed for Johnson by General Motors Corp., Delco Electronics Div. (Wisconsin). . . . hardware designs and expertise used by Delco to develop aircraft inertial navigation equipment, Carousel IV product line. . . . 39 airlines use Carousel IV units in air transports. . . . majority of inertial units in commercial aircraft are Carousel IV; standard equipment on Boeing Co. (Washington) 747, other installations on DC-8's, DC-10's and 707's. . . . provides self-contained navigation system; independent of magnetic, radio, or radar aids and of weather or man-made interference. . . . pilot provides start and destination points; unit calculates shortest course and can automatically steer via autopilot equipment. . . . saves time and fuel. . . . tests by a major airline proved Carousel IV to be 5 times more accurate than standard navigation method. (Contractor, TEF 170, Case No. 44787, 1/75)
- M-6 Aircraft Materials Development and Evaluation Program: conducted by Johnson, in cooperation with FAA and aircraft industry, to develop better fire protection for passengers and aircraft. . . . testing new, improved nonflammable materials for furnishings under realistic conditions in Boeing 737 fuselage donated by United Airlines. . . . test results providing baseline data for industry to evaluate new materials and for FAA (District of Columbia) to set practical fire safety standards on cabin furnishings. (Interagency, TEF 548, Case No. 107736, 12/74)
- M-7 Airport runway grooving: extensive research and testing at Langley (concept originated in England) to reduce airplane skidding on wet runways. . . . pavement grooves facilitate water runoff, improve contact between tire and surface, and reduce hydroplaning. . . . 40-50 runways have been grooved in cities such as Miami, Atlanta, Denver, Chicago, Detroit, Kansas City, Mo., New York, Dallas-Ft. Worth, Boston and St. Louis. . . . Washington's National was first in U.S. (1967). . . . some have been grooved during construction, others after being cited as dangerous by the Air Line Pilots Association. . . . grooving endorsed by FAA, ALPA and airlines. . . . pavement grooving is a \$2-2.5 million industry less than ten firms involved in grooving in the country, e.g., Pavement Specialists, Inc. (Texas); Cardinal Engineering (Pennsylvania); Transportation Safety Systems, Inc. (Ohio); Super Cut, Inc. (Illinois); Charles R. Watts Co. (Washington); C. W. Hatcher, Inc. (California). (Contact/Langley, TEF 168, Case Nos. 101916, 101917, 101918, 101919, 101922, 9/74)
- M-8 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop Validata service. . . . largest private computer system used by nationwide travel industry in checking credit cards, personal checks, airline tickets and other non-cash payments. . . . system has 10 million credit records in central computer. . . . over 1,000 subscriber terminals in 141 localities throughout U.S. (hotels, airline ticket offices, and 35 airports) each subscriber inquiry takes less than 3 seconds to process and subscription fee per inquiry ranges from 2 cents (ticket) to 8 cents (personal check). . . . over 11 million inquiries processed since 1972; responsible for stopping bad credit transactions worth \$8 million. . . . caused major reduction in use of stolen tickets. . . . subscribers include: (airlines) Continental, Eastern, Hughes Air West, Japan, Lufthansa, Mexicana, Northwest, PSA, Qantas, TWA, Western; (car rental agencies) Hertz, National, Budget; and (hotels) Holiday Inn, Marriott. . . . credit data from service also used in American Airlines and United Airlines reservation systems. (Contractor, TEF 465, Case No. 104260, 1/75)

M. AIR TRANSPORTATION (CONT.)

- M-9 Combustion analysis computer program: developed by Lewis. . . . used by General Motors Corp., Detroit Diesel Allison Div. (Indiana) to analyze turbo-prop aircraft engine product designs. . . . daily application in research program to reduce air pollution from engines. . . . benefits include convenience, speed of calculation, accuracy and low cost. . . . major producer of turbo-prop engines. (Professional journal, TEF 463, Case No. 103408, 9/74)
- M-10 Friction characteristics of graphite and graphite-metal: developed for Space Nuclear Propulsion Office. . . . used by B.F. Goodrich Co. (Ohio) in successful R&D project related to brake products for commercial aircraft. . . . used by Dover Corp., Cook Airtomic Div. (Connecticut) to develop prototype product for aircraft gas turbines. . . . prototype graphite-nickel valve rings successful in flight and ground tests on Pratt & Whitney JT9 turbines. (TB/TSP, TEF 555, Case Nos. 51732, 73982, 4/75)
- M-11 Lightweight hose fittings: redesigned for Johnson by Resistoflex Corp. (New Jersey) for Apollo, Gemini, Lunar Orbiter, and Space Shuttle programs. . . . lightweight, high temperature, fireproof hose fittings used in NASA propellant and other fluid systems. . . . commercial product, Dynatube, marketed by Resistoflex. . . . used on Lockheed L-1011 airliner, hydrofoil boats, and in electrical generator cooling systems. . . . projected 1975 sales of \$30 million. (Supplier/subcontractor, TEF 574, Case No. 109339, 5/75)
- M-12 Visual simulation systems: developed for Johnson by General Electric Co. (Florida). . . . a computer-generated color TV display to simulate spacecraft docking, space shuttle landing and other space-related applications. . . . commercialized by GE in modular design for various applications. . . . currently used in Navy's pilot training program and being installed for Boeing Co. to train pilots for aircraft such as the 727 and 747. . . . other potential applications are: air traffic control training, highway and city planning, ship captain training, and animation for TV advertising. . . . unit's fast storage equipment can accommodate multiple users. . . . system cost is \$250,000 to \$1.5 million, depending on configuration. (Contractor, TEF 389, Case No. 64101, 2/75)
- M-13 Production processes and designs for electronic systems: developed for Johnson, Marshall and JPL contractors by ELDEC Corp. (Washington). . . . included advanced designs for systems that condition signals from onboard instrumentation. . . . used by ELDEC to develop new product lines, including onboard weight and balance systems for large aircraft. . . . used on Air Force C-5A and Lockheed L-1011. . . . 60 systems installed on L-1011's for about \$12,000 each. . . . system allows pilot to optimize aircraft trim settings and minimize fuel consumption. . . . also used by ELDEC to develop another product line of aircraft fuel flow control systems. . . . used on Boeing 747, McDonnell Douglas DC-10 and some military aircraft. (Subcontractor, TEF 585, Case No. 112242, 5/75)

M. AIR TRANSPORTATION (CONT.)

- M-14 Advanced ball bearing development program: conducted by and for Lewis. . . . developed 3 Million DN bearing (DN = bearing bore diameter x shaft rpm) for use on main shaft of aircraft turbine. . . . received 1975 I-R 100 award from Industrial Research. . . . design advances include specifications for alloy hardness, alloy processing, and component surface finishing. . . . extended bearing wear life by a factor of 20 during almost 70,000 hours of testing. . . . results used by General Electric Co., Aircraft Engine Group (Ohio) and United Technologies Corp., Pratt & Whitney Aircraft Div. (Connecticut) to develop ball bearing specifications issued in 1973. . . . bearing manufacturers, including Industrial Tectonics, Inc. (California) and TRW, Inc., Marlin-Rockwell Div. (New York), use program results in designing bearings for turbine main shaft and other applications. . . . bearings installed on new GE (CF-6 for DC-10) and Pratt & Whitney (JT-9D for 747 and JT-8D for other Boeing 700 series aircraft) engines and during overhaul of older engines. (Contractor, TEF 349, Case Nos. 44286, 44288, 1/76)
- M-15 Composite tank for fireman's breathing apparatus: developed for Johnson by Structural Composites Industries, Inc. (California) as part of the fireman's breathing apparatus development program. . . . used to develop new product line of lightweight, filament-wound pressure vessels for commercial aircraft escape slide systems. . . . vessel reduces aircraft weight by 200 lbs. . . . 840 units sold to Boeing Co. for \$300,000. . . . also now sold to other airline companies. (Contractor, TEF 519, Case No. 114863, 7/76)
- M-16 Ride Quality Program: conducted by Langley to analyze ride quality for STOL aircraft. . . . program later expanded to include other transportation modes Ransome Airlines (Pennsylvania) participated in a NASA-funded passenger comfort survey. . . . survey results were used by the company to develop a more comfortable seating arrangement in 8 NORDB 262 shorthaul aircraft. . . . remodeling costs totaled \$100,000. . . . increased revenue expected to exceed this cost airline operates 100 commuter flights per day from airports in Washington, D.C. area, New York, and Connecticut. . . . second largest U.S. commuter airline, carries 300,000 passengers per year. (Personal contact/contractor, TEF 608, Case No. 114872, 1/76)
- M-17 Electromagnetic tool for metal fabrication: developed by Marshall to remove distortions in Saturn V fuel tanks. . . . contracts from Marshall TU to manufacturing firms for evaluating other applications of tool. . . . after Boeing Co. evaluation in 1968, used by Boeing Commercial Airplane Co. Div. (Washington) to develop 2 fabrication tools for 747 production line; electromagnetic riveting system and metal forming tool. . . . semiportable riveting system, invented by company, used on wing panels where automatic riveting machine cannot be used. . . . magnetic forming tool used to pull dents from 747 component surfaces. . . . \$40,000 saved annually by repairing components that would otherwise be rejected. (Contractor, TEF 105, Case No. 115402, 7/76)

M. AIR TRANSPORTATION (CONT.)

- M-18 Mathematical model for stability analysis: developed by Langley to analyze helicopter rotor assemblies. . . . method used by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) in developing the design of hub and rotor assemblies for the division's S-70 military and S-76 commercial helicopters; design insures helicopter stability if a blade damper fails. . . . division saved time and testing costs by using this method. . . . the U.S. Army is currently testing three S-70 helicopters; a decision whether to adopt the new model will be made in late 1976. . . . the S-76 commercial helicopter is expected to be marketed in early 1977. (Personal contact/Langley, TEF 614, Case No. 117151, 3/76)
- M-19 High twist rotor aeroelastic analysis: developed for Ames by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) for the vertical take-off and landing (VTOL) aircraft research program. . . . an existing Sikorsky computer program for analyzing structural behavior of normal rotors was modified to analyze VTOL high twist rotors. . . . division used the modified computer program to design high twist rotor blades for its S-70 military and S-76 commercial helicopters; this eliminated the need to redesign the helicopters and improved the final design. . . . the U.S. Army is currently testing three S-70 helicopters; a decision whether to adopt the new model will be made in late 1976. . . . the commercial S-76 version is expected to be marketed in early 1977. (Contractor/Ames, TEF 613, Case No. 117152, 3/76)
- + M-20 Aircraft icing research: conducted by Lewis as part of a continuing icing research program. . . . used in conjunction with Lewis inlet potential flow research by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) to modify its S-61 helicopter for use where icing rains occur. . . . information was used to redesign the shape of turbine inlets to reduce ice build-up. . . . company currently producing two modified commercial versions of the S-61: S-61L and S-61N. . . . used by regularly scheduled helicopter airlines worldwide; S-61N also used by offshore oil industry. . . . division also using the technology in development of a V/STOL aircraft. (Personal contact/Lewis, TEF's 636, 642, Case Nos. 119305, 120221, 4/76)
- M-21 Fracture toughness tests: developed by Lewis. . . . used with NASA crack propagation data by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) to redesign the rotors on its S-61 and S-65 commercial helicopters. . . . also used in the design of components for the S-70 and S-76 helicopters. . . . use of tests resulted in lighter aircraft and better performance. . . . will be used in all future aircraft design. (NASA publications, TEF 451, Case No. 119303, 3/76)
- M-22 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) to model fuselages of its S-70, S-76, and YCH-53E helicopters to determine natural frequencies so that mechanical vibrational frequencies do not coincide and cause resonance. . . . also used to determine amount of bend and twist in the fuselage when helicopters undergo various maneuvers. . . . benefits include improved helicopter design and a cost-to-profit ratio of 1:3 for using the program. . . . will be used in the design of all future aircraft. (Personal contact, TEF 410, Case No. 119302, 3/76)

M. AIR TRANSPORTATION (CONT.)

- M-23 Cowling airflow models: developed by Langley. . . . research on cowling geometry for reciprocating engines included drag measurement and the effect on engine inlets and cooling vanes. . . . used by Beech Aircraft Corp. (Kansas) in the design of cowlings and cooling vanes for 12 light aircraft product lines. . . . use of cowling models expected to continue. . . . company annual sales are over \$240 million. ([Unknown], TEF 633, Case No. 119298, 5/76)
- M-24 Aircraft duct design: developed by Langley. . . . used by Beech Aircraft Corp. (Kansas) in the design of ducts for engine inlets, as well as heating and air conditioning systems for 12 light aircraft product lines. . . . continuing benefits include reduced costs and improved products. . . . company annual sales are over \$240 million. ([Unknown], TEF 630, Case No. 119295, 5/76)
- *M-25 Wing design concepts: developed by Langley since early 1950's to improve military and civilian aircraft. . . . conducted design development from conceptual stage, through wind tunnel testing, to flight demonstrations for aircraft industry. . . . contributions significantly advanced wing designs for supersonic military aircraft, large subsonic air transports, and light planes. . . . includes subcritical designs and new supercritical wing design that can increase subsonic cruise speed by 15%, or decrease fuel consumption by 15%, or a combination of the two. . . . also, General Aviation Wing-1 (GAW-1), version of supercritical wing. . . . used by nearly all major aircraft manufacturers in current development of most new air transports and light planes. . . . subcritical design routinely used by Beech Aircraft Corp. (Kansas) for wings on all aircraft in production. . . . company reports that Langley contributions are crucial to its wing designs. . . . annual sales over \$240 million. . . . also, developed prototype version of PD-285, a two-place trainer, using GAW-1. . . . resulted in a smaller, lighter plane with greater lift at same drag. . . . modified version may be marketed within the year. (Personal contact/Langley, TEF's 631, 632, Case Nos. 119296, 119297, 5/76)
- M-26 Nondestructive evaluation techniques: guidebook compiled by Lewis. . . . seventy techniques for evaluating materials and structures are described. . . . used by Dyna-Empire, Inc. (New York) to select a nondestructive testing method for product quality control. . . . specifically, eddy current tests and results were used to select the proper testing procedure and to make materials selection decisions. . . . saved several hundred dollars in production costs. . . . guidebook also used periodically in the design of other electronic instruments. . . . company products used in aircraft engines. (TB/TSP, TEF 635, Case No. 113116, 5/76)
- + M-27 Instrument readout window: developed for Goddard by Honeywell, Inc., Aerospace Div. (Minnesota). . . . requires less space and power for easy visibility. . . . company received NASA patent waiver and used invention in an aircraft instrument product line (Model JG 908 Ram Air Temperature/Engine Pressure Ratio Limit Indicator). . . . approximately 2,000 units sold to date at \$2,500 each; window cost represents about 1 percent of unit price. . . . standard equipment on DC-9, optional on Boeing 737 and DC-8. (Waiver/contractor, TEF 303, Case No. 42924, 9/76)

* Denotes transfer case related to Key Issue.

M. AIR TRANSPORTATION (CONT.)

- + M-28 Propeller parametric performance data: developed by Langley. . . . used by Hartzell Propellers, Inc. (Ohio) in design of all aircraft propeller products. . . . best available design data, company unable to achieve its design improvements otherwise. . . . propellers widely used on multi-engine general aviation aircraft. . . . Beech Aircraft Corp. (Kansas) uses Hartzell propellers on all Duke, Baron and Air King aircraft. . . . improves aircraft performance. (Personal contact/Langley, Customer, TEF 639, Case Nos. 119306, 119703, 6/76)
- + M-29 Automatic checkout systems: developed for Marshall, Johnson and U.S. Air Force by Martin Marietta Corp., Denver Div. (Colorado). . . . included computer-controlled test systems for Titan III launch vehicle and Advanced Apollo provided system and man/machine interface design advances that allow use by operational, rather than specialist, personnel. . . . used by company to develop commercial product line, MARTRON system series. . . . automatic test systems for aircraft electronic units. . . . price range \$250-\$550,000; estimated total sales over \$8 million. . . . customers include 20 major U.S. and foreign airlines. . . . maintenance time to checkout electronic units reduced by over 75 percent. (Contractor, TEF 649, Case No. 121303, 9/76)
- + M-30 Flight test data system: developed for Flight Research Center by Teledyne, Inc. Teledyne Controls Div. (California). . . . included versatile data acquisition component, remote multiplexer/demultiplexer unit (RMDU). . . . RMDU adapted by Teledyne to commercial product line for airline and government customers. . . . used in flight certification tests, including Boeing 747 SP, McDonnell-Douglas DC-10. . . . 48 units sold at average base price of \$25,000 each. (Contractor, TEF 650, Case No. 121305, 9/76)

Other Relevant Examples:

B-2 and B-3 (aircraft production quality control); B-10 (fracture toughness tests); B-56 (crash locator); C-3 (Rogallo wing); C-7 (life raft); F-11 (aircraft galley refrigerator); G-10 and I-1 (airport construction management); G-21 (aircraft modification); K-1 (pavement groover); O-5 (NDT training service); O-7 (technician training); O-14 (airport design research)

INSURANCE, BANKING, AND REAL ESTATE

N. INSURANCE, BANKING, AND REAL ESTATE

Key Issue

Electronic funds transfer: The number of commercial banks has remained at about 14,000 since 1946; the number of bank branches, however, increased from 14,000 in 1960 to almost 27,000 in 1973. The total demand deposits have increased from \$248 billion in 1970 to \$322 billion in 1974 and are projected to be \$383 billion in 1980. An estimated 40 billion checks will be written in 1980 on one kind of demand deposit--the checking account. A 1968 survey of almost 1,000 banks indicated that computer automated funds transfer was being used by 71% for demand deposit accounts and by 52% for time deposit accounts. A 1969 survey of 40 banks found that the use of a computer for demand deposit operations reduced personnel requirements by 10-67%. The use of automated, tellerless bank facilities is increasing rapidly due to the competition between banks in providing greater customer convenience and to the availability of satisfactory commercial systems. A national automated clearinghouse for inter-bank exchange of paperless entries is under active consideration by the American Bankers Association. (N-1)

N. INSURANCE, BANKING, AND REAL ESTATE

- *N-1 Apollo Guidance Computer software and Data communication methods: developed for Johnson by TRW Systems (California). . . . used by TRW Data Systems (California) to develop computerized financial communications systems for banks, savings and loan associations, and the Federal Reserve System. . . . major producer for new generation of on-line equipment for account information, automatic funds transfer, and tellerless banking. . . . advantages include 30% faster transactions, rapid installation and servicing, quick teller training, and elimination of almost all normal teller entry errors. . . . market for such systems growing exponentially, and TRW has 20% share. (Contractor, TEF 465, Case No. 104260, 10/74)
- N-2 Videotape storage and retrieval system: computerized system developed for Marshall by Ampex Corp. (California). . . . NASA waived patent rights on key tape transport mechanism to Ampex in 1963. . . . improved and commercialized by Ampex as Videofile System. . . . a single tape reel stores records from 10 four-drawer file cabinets. . . . total sales \$23 million. . . . American Republic Insurance Co. (Iowa) installed Videofile in 1972 for all insurance records. . . . provides claims and rate analysts with immediate access to records. . . . system is faster and minimizes chance of error. (Contractor, TEF 226, Case No. 66201, 8/74)
- N-3 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Computer Directions Advisors, Inc. (Maryland) to convert in-house programs for use by clients using different types of computers. . . . programs part of investment research services for institutional investors. . . . guide increased service capability and reduced operating costs. . . . used by Price Waterhouse & Co. (New York) to convert an in-house statistical analysis program for use by its 300 worldwide field offices when conducting on-site audits for clients. . . . use of program increases reliability of auditing services, providing company clients with more thorough audit. . . . used by Economics Research Associates (California) as reference for running in-house economic model programs on three different, time-shared computer systems. . . . company's economic modeling services used for large-scale land development and recreational projects. . . . anticipated \$2,000 savings in future when programs are fully converted. (Trade journal/TSP, TEF 527, Case Nos. 102198, 102294, 102924, 1/75)
- N-4 Safety yoke for construction workers: developed for Kennedy. . . . used by insurance companies to provide customer services and reduce industrial accident claims. . . . Industrial Indemnity Co. (California) distributed copies to clients in construction industry. . . . at least two clients are using yoke. . . . company writes \$300 million worth of insurance annually. . . . Employers Insurance of Wausau (Wisconsin) distributed copies to its construction safety specialists. . . . specialists now advising industrial clients to use the yoke. . . . company writes \$400 million worth of insurance annually. (Trade journal/TSP, TEF 103, Case Nos. 10323, 18072, 12/74)

* Denotes transfer case related to Key Issue.

N. INSURANCE, BANKING, AND REAL ESTATE (CONT.)

- N-5 Microbiological Handbook: compiled for Marshall. . . . used by insurance companies for industrial customer services and accident claims reduction Commercial Union Assurance Co. (Massachusetts) used handbook to prepare manuals and training programs for regional office field engineers who inspect policyholders for safety regulation compliance. . . . Employers Insurance of Wausau branch office (New Jersey) used handbook to solve problems for two policyholders. . . . eliminated dermatitis claims with new decontamination procedure for industrial plant and implemented new sterilization procedure for hospital. . . . important industrial hygiene reference Liberty Mutual Insurance Co. branch office (Georgia) also used handbook as industrial hygiene reference. . . . provided industrial policyholder with new decontamination procedure. (Professional Journal/TSP, TEF 402, Case Nos. 58500, 61395, 87001, 12/74)
- N-6 Hazardous materials safety handbook: compiled at Lewis. . . . used regularly by Shelby Mutual Insurance Co. (Ohio) in loss prevention service for industrial policyholders. . . . handbook and numerous TSP's received by company over last 7 years have been very useful in program for cross-training service representatives and adjusters. . . . program goal is to reduce number of employees needed to write \$1 million worth of insurance from 19 down to 10 management TSP's used by company president. . . . appropriate process TSP's forwarded to industrial clients. . . . company writes \$71 million worth of property and casualty insurance annually. (Contact/Lewis, TB/TSP, TEF 258, Case No. 119309, 8/74)
- N-7 Flammability tests of home furnishings: conducted for TUO by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . report used by Factory Mutual Research Corp. (Massachusetts) to design a full-scale, flame-spread test for residential units; part of applied research program for the Factory Mutual Insurance System. . . . used by Liberty Mutual Life Insurance Co. (Illinois) to provide field inspectors in midwest division with information on new, nonflammable aerospace materials; information intended for use in conducting better analyses of building and room combustibility. . . . also used by Marsh & McClellan Insurance Brokers (New York) to provide selected clients and field inspectors with data on the new materials. (Contact/TUO, Professional society, TEF 539, Case Nos. 107052, 107053, 107054, 1/75)
- + N-8 Aluminum circuit board design factors: developed for Marshall. . . . used by Burroughs Corp. (Michigan) in designing computerized banking machines, Models S-100 and S-1000. . . . multiple transistors mounted on one aluminum circuit board. . . . reduces production costs and provides a single heat sink. . . . approximately 15,000 banking machines produced annually at \$10,000 or more each. (TB/TSP, TEF 180, Case No. 15430, 9/76)
- + N-9 Low noise air duct valve: developed by Johnson. . . . plans and specifications for valve assembly distributed by Liberty Mutual Insurance Co., Loss Prevention Dept. (Georgia) to policy holders having air systems. . . . part of effort to reduce hearing loss workman's compensation claims from policy holders. . . . company writes about \$1 billion worth of casualty insurance for commercial and industrial clients annually. (Professional Journal/TSP, TEF 524, Case No. 57717, 9/76)

EDUCATION

O. EDUCATION

Overview of benefits to education taken from The Impact of the Space Age on Education in the United States, Staff Report prepared for the use of the Committee on Astronautics and Space Sciences, United States Senate, November 2, 1972.

[Introduction]". . . perhaps the most important and lasting impact of the entire space effort in the United States is and will continue to be in the field of education, the field from which the space age was born. . . . Many educators agree that the space endeavor has steadily upgraded the educational system in America. Initially, this upgrading was centered in the sciences, but gradually it spread over much broader areas in order to balance the emphasis in all fields of learning. In all, it is hard to imagine a school system that has not been affected by the space effort. In these days of orbiting satellites and manned missions into space, teachers must be ready to explain what causes a satellite not to fall and how a man can walk in space so easily. Teachers of many different subjects must be able to work with students who inquire about the practical applications of such subjects to space activities. . . . Sputnik assuredly solidified the recognition of the weaknesses in American education and served as a catalyst in generating the resources for improvement. During the course of the dramatic events that followed, a thorough analysis of the educational system took place as a necessary step toward producing the highly competent scientists needed for the United States to regain its position of world leadership in the new era.

[Elementary and Secondary Education]". . . Before Sputnik, the need for curriculum revision in the elementary and secondary schools was recognized by only a few people, and, as a result, the resources available to make significant changes were sparse. . . . the traditional methods of mathematics education were not meeting the new demands of a technological society; and this fact became a grave matter for thought and subsequent action. After mathematics, educators were concerned with upgrading foreign language instruction and science education, particularly the physical and biological sciences. The social sciences lagged miserably behind and had to be improved, but by 1966, they were only at the level the natural sciences had been nearly a decade earlier. During 1965, attention began to be concentrated on the humanities in order to have a completely well-rounded educational curriculum in the United States.

. . . "The curriculum reform effort was generally marked by a substantial revision of content, a reorganization of subject matter, and the adoption of many fresh approaches to methodology in traditionally taught school courses. In general, the overall trend was toward the introduction of special courses, the use of new subject matter materials, increased use of students' interest in space-age ideas and information, and provision for improved coordination of class instruction from the kindergarten up to the twelfth grade. Since the various curricular materials were planned by top-flight physicists, mathematicians and historians, students were therefore encouraged to think as did the scholars. . . . As early as 1960, a new topic was introduced into several school systems--aerospace and all of its ramifications. . . . The subject of aerospace was often taught as part of an astronomy unit or course, or

O. EDUCATION (CONT.)

integrated in other fields; but sometimes the subject stood alone as a field to be studied. . . . [NASA] played a key role in developing source materials for teachers of all grades in space-oriented mathematics. . . . to assist teachers in bringing to their students a comprehension of space and the problems of its exploration by using the mathematical skills the students already possessed or were in the process of learning. Such topics taught included data treatment, a new numeration system, a scale drawing, and space time. . . . The Educational Programs Division of [NASA]. . . undertook to prepare and make available space-related curriculum supplements for secondary school teachers of different science subjects. The supplement on biology is the only science resource unit published through 1969. But the pattern is expected to be similar in all sciences. The other curriculum supplements are in mathematics, physics, chemistry, space science, and physical science. . . . tryout and evaluation of the NASA supplement on space biology for high school students, was conducted during the summer of 1967. This experiment was deemed a success and the course went into various school systems.

" . . . Many basic general science textbooks devoted whole units or chapters on space study. Examples include a 73-page unit entitled "Instruments and Techniques for Space Study" from the sixth grade text Science and Life used in parochial schools. . . . A 95-page resource unit entitled Exploring Space was provided for in a physical science course in the secondary school curriculum for the New York State Education Department. Such topics as the earth's atmosphere, exploring space from the earth, and exploring outer space were included. . . . [in 1957] there were 177 inexpensive paperback books on science in print; 5 years later, there were in excess of 900. The educational journals published in the United States contained an average of 340 articles on science education in each year between 1948 and 1954; but then, for the 4 years after 1957, the yearly average rose to 535. In the nonprofessional magazines prior to 1958, there appeared approximately 20 articles every year on science education. For the next 4 years, however, the same magazines averaged 151 articles annually on science education. . . . [a 1961 survey of the State Supervisors of Science in 50 states and the District of Columbia] revealed optimistic trends in space education throughout the United States. Sixty percent of the replies indicated that States had introduced courses of study in the area of earth and space science into their school curriculum. . . . 75 percent reported that courses in earth and space science would encourage more capable students to enter these study areas in college.

" . . . By 1968, such polished course materials as the "Lincoln Plan, Introducing Children to Space" was produced by the Lincoln, Nebr., Public Schools for grades kindergarten through six. Another example of space instruction was developed in the Pennsylvania Earth and Space Science Improvement Program by the State's Department of Public Instruction for elementary and secondary levels. . . . basic trends have taken place in social studies curricula to introduce space age topics. . . . increased use of newspapers, news magazines, and current events weeklies in the classroom. Through these materials teachers taught the most important topics of the space age which included scientific change, political and economic developments, and social problems. . . . addition of new study topics on the space age in social studies programs, especially at the junior high school level.

O. EDUCATION (CONT.)

For example, a seventh grade geography course would offer such topics as: The World--Its Place in the Universe, Our Earth in Space, Space-Age Geography, Local Industries Related to the Space Age, the Space Age of Tomorrow, or Space Progress in Foreign Affairs. . . . Much of the widespread attention given to scientific activities and topics was evidenced by the growth of memberships in young people's scientific associations and programs. The Young Engineers and Scientists of America was chartered in 1959. As of 1965, it had 250 chapters in 36 States and 7,500 students as members. The Junior Engineering and Technical Society, chartered in 1958, had as of 1965 a total of 100 chapters in 46 States and a membership of 35,000. The Junior Science and Humanities Symposia program, initiated in 1958, as of 1965 had a total of 6,000 students participating in 20 States. The Science Clubs of America program included more than 25,000 clubs enrolling close to 650,000 students in every State. . . . an important and continuing resource in space age education are the lectures in various areas of aeronautics and space. These include lecturers supplied by the National Aeronautics and Space Administration. In addition, there are other private and public specialized resources and free direct assistance such as NASA publications, films, video tapes, exhibits, field trip opportunities, and aid in planning, organizing, and conducting institutes and courses. These services and aids have been invaluable to educators and their students.

[Higher Education]. . . Changes in college curricula have been widespread in colleges and universities at both the undergraduate and graduate levels. Much has been done in curricula revision to relate the liberal or general education of students to the space age. For example, many traditional first and second year courses were found to be below the level that newly admitted high school students needed because of their previous upgraded education. Because of this situation, colleges found it necessary to step up their courses and make them more relevant to the world of the space age. Most major colleges and universities have programs or courses in space sciences and related fields. As of 1968, a total of 80 institutions offered courses leading to degrees in some kind of space-related field. Some professional schools such as those granting degrees in law and medicine, offer courses or materials relating to space in connection with traditional courses. Perhaps more important, however, is the impact of the expansion of research activities related to space problems in the universities with substantial governmental support. This expansion is also reflected in new buildings and equipment, school and departmental reorganizations, and changes in administration and services.

". . . In 1959, NASA provided a total of only \$3 million to support research in colleges and universities. By 1966, the amount had jumped to \$128 million. The major spurt took place in 1962, when NASA initiated its Sustaining University Program. The funds from this program were allocated for supporting graduate traineeships, campus research, and new facilities. In the first decade of the space age, NASA made direct contributions of nearly \$700 million to over 200 universities and colleges across the United States. Nearly \$500 million of this total was for work in direct support of specific space projects. The other \$200 million went into student grants and into new or improved laboratories and other research and teaching facilities. Another striking swing is evidenced by NASA's

O. EDUCATION (CONT.)

allocation of \$2 million to support predoctoral training. By 1964, this agency was spending \$20 million annually to produce highly skilled specialists demanded by the space age.

[Educational Television Satellites]". . . The idea of using satellites as a tool in education was first put forward at the 1960 General Conference of UNESCO by the French philosopher, the late Gaston Berger. . . . The scientific advances and developments being made possible by the use of satellites and other features of the United States space effort have induced changes in this country's patterns for doing and for living. The rapid rate in which these changes are coming about is the dominant fact of the era of the space age. . . . What has been and is being accomplished. . . gives education new frontiers and new dimensions. . . . space communications properly employed can enhance the possibility for education to win the race with time, especially in the developing countries. Traditional school systems recently have been expanding at a remarkable rate, but the addition of space communications in the countries not yet served would permit a wide geographical extension of improved education. Continuing education all over the world and mass education in the developing countries emerge as systems in which the teacher and the pupil are necessarily separated from one another because of distance, the deficiency of schools, or the dispersion of classes. . . . Eventually, satellite television could give every classroom a window to the world.

[Conclusion]". . . in the words of Vice President H. Humphrey in 1966: 'The space age has placed a premium on knowledge and education. It has also forced us to adopt higher standards throughout our society.' . . . The space age has uncovered a wealth of knowledge by creating an atmosphere where education is sought after and highly respected. And with this came a recognition of the need for better teacher-training to meet the requirements stemming from the expanding role in our society of such subjects as mathematics, science, and technology with a growing emphasis on subject matter as well as on educational techniques. . . . Every level of organized education has directly or indirectly requested NASA to help satisfy an amazing thirst for information about space science and technology.

. . . [Children of the space age] "feel all the educational pressures placed on them in this era. These range from pressures experienced as the result of a tougher elementary curriculum to those of getting into college and going on for graduate degrees. However, they may experience an inner conflict. On the one hand, they expect and want much more from the advanced and sophisticated technological space age society to improve our global social structure and well-being. On the other hand, they despise the mechanical, dehumanizing rapid pace of society which appears to them to overlook world problems such as poverty and to provide the wherewithall to over-meddle in the world political problems. . . . Newsweek's July 7, 1969, issue. . . featured an article entitled 'The Moon Age'. . . [which] said in part: . . . Children find space exploration about as miraculous as the television sets they watch it on. Why does man go to the moon? Because it is there. Where? Right there, on Channel 2, and can I please stay up a half hour late tonight to see if the astronauts find anything good on the moon when they get there? . . . No American child worth his salt, pepper or Pabulum has any doubts that they'll get there (the moon). How far, after all, is the moon from the earth? Precisely the same distance as Vietnam---across the living room."

O. EDUCATION

- 0-1 Flight path simulator: developed at JPL to show interplanetary satellite flight paths. . . . patent rights waived to California Institute of Technology. . . . licensed by Cal Tech to Hubbard Scientific Co. (Illinois) in 1968. . . . company commercialized the invention as a Planetary Celestial Globe product. . . . approximately 1,000 globes sold annually at \$60 each. . . . globes used in junior high schools to illustrate interplanetary motion. (License/contractor, TEF 154, Case No. 106372, 7/76)
- + 0-2 Hybrid computer: purchased by Aerojet-General Corp. (California), while under contract to Lewis and Space Nuclear Propulsion Office, to simulate space nuclear power sources. . . . used by Aerojet in 1967 to design computerized anesthesiology simulator, SIM I, for the University of Southern California. . . . USC held contract from HEW to develop the simulator. . . . SIM I provides medical students with "hands on" experience in performing endotracheal intubation, a vital respiration procedure involved in 75% of all operations. . . . computer used to simulate interrelationships between life signs, enabling SIM I to exhibit variety of life-like reactions to the respiration procedure. . . . original unit used daily for 8 years by USC medical students. . . . Sierra Engineering Co. (California) licensed by USC to manufacture commercial version of the simulator. . . . Aerojet and Sierra working with USC to develop SIM II, a portable model designed for use in emergency medical training programs. (Contractor, TEF 528, Case No. 106373, 1/75)
- 0-3 Phonocardiogram simulator module: developed at Kennedy to calibrate astronaut monitoring instruments. . . . module supplied by Kennedy to University of Kentucky. . . . used in prototype mother/child birth simulator developed and patented by the University; NASA module imitates baby heartbeat which can be varied to simulate different childbirth conditions. . . . simulator an important component of the University's College of Nursing self-instruction laboratory. . . . 200 nursing students received childbirth training with this prototype. . . . also, students at Lexington Community College (Kentucky) gained similar experience with portable version of simulator. . . . use of birth simulator eliminates tension caused by live birth training. . . . need for medical training simulators is increasing because national medical programs, such as Medicare, are reducing number of patients who are willing to be treated by supervised students in order to receive free medical services. (TB/contact with Kennedy, TEF 274, Case No. 82701, 7/76)
- + 0-4 Soldering school: held at Ames. . . . center provides facilities, books, materials, and some instructors to train people in high quality soldering of electronic components. . . . 4-week course for experienced personnel, 6-week course for beginners. . . . 635 people trained since 1963. . . . total includes NASA, DOD and contractor personnel, as well as high school shop instructors and students (32), Mountain View High School Adult Education (California) participants (16), and Neighborhood Youth Corps (California) enrollees (22). . . . NASA certificate, given on completion of course, virtually assures employment as electronics solderer. (Contact/Ames, 1/75)

O. EDUCATION (CONT.)

- 0-5 Nondestructive testing training manuals: developed for Marshall by General Dynamics Corp., Convair Div. (California). . . . used by Convair since 1967 as basis for commercial NDT training service. . . . 3-week course for 12 enrollees offered once a month; covers five major NDT areas. . . . tuition is \$725 each, annual revenue to Convair about \$105,000. . . . most students are management personnel from industries such as electric power, aircraft and NDT equipment. . . . students have come from 25 countries. . . . company also provides audiovisual presentations covering radiography, ultrasonics, and liquid penetrants. . . . presentation on eddy current testing expected to be available by year end 1976. (Contractor, TEF 14, Case No. 53871, 7/76)
- 0-6 Component degradation analysis techniques: developed by Marshall. . . . used in graduate course at University of Illinois. . . . NASA documents on failure modes and effects, as well as related R&QA topics, form major part of course bibliography. . . . NASA personnel from several field centers assisted professor in developing extensive bibliography. . . . 35 students have completed course and many now work in industry. . . . one of first academic courses offered in nation on prevention and analysis of system failure. (TB/TSP, TEF 474, Case No. 65764, 12/74)
- 0-7 Methods for using optical instruments: compiled by Marshall. . . . used at Milwaukee Area Technical College (Wisconsin) as text material in two photo-optical courses. . . . fulfills need for text on instrument techniques, providing students with better training. . . . two-year associate degree program graduates take technician jobs using high speed photography or holography with such companies as General Motors Corp. and United Aircraft Corp. (TB/TSP, TEF 529, Case No. 91985, 1/75)
- 0-8 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by Central Washington State College Computing Center (Washington) to convert programs for new computer. . . . reduced conversion time and saved \$1,000. . . . Center provides academic computing services. (Trade journal/TSP, TEF 527, Case No. 102158, 1/75)
- 0-9 NASA scientific and technical information: made available by Education Office at Kennedy. . . . used by Florida State University in several innovative education programs, as well as special libraries for student projects. . . . applications include an undergraduate course, an Industrial Arts Program in university's primary/secondary school laboratory, development of working models for use as teaching aids, and development of occupation descriptions for distribution to Florida county school systems. . . . since 1967, 200 students have taken the undergraduate course which presents R&D methodology by means of research projects. . . . 150 secondary school students currently involved in Industrial Arts Program where they learn R&D techniques by designing and building things such as fluidic circuits and motorbike heating systems. . . . teaching aid models for fuel cell, solar panel, and rocket car are being developed by program staff and Scott Engineering Sciences (Florida). . . . Scott will market the models as educational products. . . . descriptions of 150 different occupations, including astronaut, developed by university, with state funds, for distribution to 67 county school systems. . . . 25 industrial arts teachers from across the nation attended 1967, 1968, and 1969 summer institutes at Florida State University, with U.S. Office of Education funding, to explore use of space technology for industrial arts education. (Contact/Kennedy, TEF 311, Case No. 35912, 1/75)

O. EDUCATION (CONT.)

- O-10 Experimental multiple-use communications satellite (ATS-6): developed for Goddard. . . . launched May 30, 1974 into geosynchronous orbit. . . . provides high power density communication link from central ground transmitting stations to low-cost receivers in selected rural areas. . . . voice communication from receivers back to control center is established with inexpensive transmitter and ATS-1 or ATS-3 satellite. . . . used by HEW in Health/Education Telecommunications (HET) experiment for the delivery of such services to remote regions. . . . acting for HEW, the Federation of Rocky Mountain States (Colorado) coordinates experiments in Rocky Mountain region, Alaska, and Appalachian region. . . . as part of experiment, demonstration projects conducted by Federation, Indian Health Service (Alaska), Appalachian Regional Commission (District of Columbia), University of Washington's WAMI Program (Washington, Alaska, Montana and Idaho), and more than 15 other health and education agencies. . . . project applications include medical training, teleconferencing, and diagnosis; career education, continuing education, and in-service teacher training. . . . projects developed TV programs for the different applications. . . . for example, in the WAMI Program, satellite provides communication for medical education and conferencing between University of Washington medical faculty in Seattle and their medical students at universities in the four states, as well as doctors at rural Community Clinical Units scattered over 700,000-square mile area. . . . another example, 1,500 junior high school students at 56 remotely located schools in 8 Rocky Mountain states receive career education TV programs from Denver; students communicate between schools and with Denver instructor. . . . important educational benefits cited by students, teachers, and citizens in these remote communities. . . . satellite will be moved in 1975 to broadcast educational programs to 5,000 rural villages in India as part of that country's effort to reduce illiteracy. . . . U.S. groups now promoting development of educational satellite network. . . . more than 80 representatives from colleges, government agencies, publishing houses, and HET projects formed the Public Service Satellite Consortium to coordinate distribution of educational programs and to compile list of potential users for satellite network. (Interagency, TEF 530, Case No. 107035, 1/75)
- O-11 Motivation techniques: developed for Johnson to outline motivation techniques for reducing employee error. . . . used by Owen O. Sabin Skills Center (Oregon) to motivate students to maintain quality workmanship standards in vocational courses. . . . affects 600 students and 10 instructors per year. . . . reduced instructional materials and labor cost by \$5,000. (TB/TSP, TEF 583, Case No. 106408, 8/75)
- O-12 Cable tension tool: developed for Kennedy. . . . a simple, inexpensive tool for measuring relative tension in a set of load-bearing cables. . . . information used by Yale University School of Drama, Dept. of Theatre Design and Technology (Connecticut) in two graduate seminars on theatre building and planning. . . . information also used in undergraduate classes to illustrate practical applications of space technology to theatre design problems. . . . improved course content, contributed to theatre technology literature, and increased appreciation of technology diffusion. (TB/TSP, TEF 489, Case No. 112246, 9/75)

O. EDUCATION (CONT.)

- 0-13 Satellite and aircraft photographs: obtained during Gemini, Apollo and Skylab missions supervised by Johnson, LANDSAT program supervised by Goddard, and aircraft remote sensing program conducted by Ames. . . . used by Pilot Rock, Inc. (California) to develop and market educational packages containing discipline-related aerial infrared photos and text. . . . more than \$75,000 in sales to colleges and universities since 1974 and sales increasing rapidly adds important perspective to normal curriculum for geography, geology and urban planning. . . . the NASA Industrial Applications Center located at the University of New Mexico, TAC, developed and marketed educational packages based on satellite imagery. . . . in 1975, production rights for photograph/text packages sold to Pilot Rock. . . . a resource handbook, Everyone's Space Handbook, will be published in mid-1976; it will contain information on accessing remote sensing projects and obtaining remote sensing imagery. . . . company will now offer a total of 76 different packages, including the handbook. . . . customers for remote sensing imagery include a local artist, a consulting firm that prepares environmental impact statements, an environmental center and a college. . . . in 1974, TAC also entered joint production with Audio-Visual Institute (New Mexico) to market photograph/audio packages using LANDSAT and Skylab imagery. . . . 170 copies of "Remote Sensing: Tool for Managing Earth Resources" sold at \$80 per copy, and 45 copies of "Food Watch by Satellite: Toward Managing Our First Resource" sold at \$90 per copy; total sales over \$17,500. . . . new packages being developed and sales increasing customers include high schools and colleges for use in teaching how remote sensing can be applied to resource problems. (Personal contact/USGS, Personal contact/TAC, TEF 199, Case No. 115403, 4/76)
- 0-14 Wind study for airport design: conducted for Marshall by Colorado State University as part of STOL airport research program. . . . wind tunnel used to test effect of structures on air flow. . . . professor at the University used data to develop a mathematical model for wind flowing around rectangular structures. . . . in 1975, professor authored a textbook incorporating the model, Applications of Fluid Mechanics in Wind Engineering. . . . textbook currently used in several courses offered at the University. (Personnel/Contractor, TEF 640, Case No. 119308, 3/76)
- + 0-15 NASTRAN (NASA Structural Analysis Program): developed by Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by California State Polytechnic Institute, Aerospace Engineering Dept. (California) in several structural design courses. . . . provides demonstration of computerized finite element analysis for two courses held at least twice yearly. . . . program rated by professor as best available for illustrating finite element analysis methods. (Customer/contractor, TEF 410, Case No. 121304, 9/76)
- + 0-16 Solar energy collector dehumidifier: developed by Marshall. . . . self-regenerating desiccant system to prevent moisture degradation of collector coating. . . . technical report used by Syracuse University, Dept. of Mechanical and Aerospace Engineering (New York) in regularly offered solar energy applications course. . . . provides practical illustration of solar energy collector design factors. (TB/TSP, TEF 624, Case No. 118378, 9/76)

O. EDUCATION (CONT.)

- + O-17 Mobile Automatic Metabolic Analyzer (MAMA): developed by Marshall from Apollo technology in TUO-funded Application Engineering Project. . . . measures inhaled/exhaled air volume and heart-beat rate to calculate energy consumption during exercise by patients wearing above-the-knee prosthetic devices. . . . technical report used by University of Detroit, Electrical Engineering Dept. (Michigan) in bioengineering graduate course on medical instrumentation. . . . provides illustration of analysis for a complicated system design. . . . about 20 students from hospitals and medical instrument firms. (TB/TSP, TEF 655, Case No. 121459, 9/76)
- + O-18 Bone impedance measurement method: developed by and for Ames. . . . inplace measurement provides data on loss of bone strength for life science studies report used by University of Detroit, Electrical Engineering Dept. (Michigan) in bioengineering graduate course on medical instrumentation. . . . provides illustration of instrumentation and data analysis. . . . approximately 20 students from hospitals and medical instrument firms. (TB/TSP, TEF 652, Case No. 121457, 9/76)

Other Relevant Examples:

A-7 (optical training manual); B-31 and F-14 (employee training); B-57 (electronic equipment); B-66 (radiotelescope); F-6 (sanitary techniques training manual); H-9 and M-3 (NDT training manuals); H-15 (energy conservation for schools); J-7 (school alarm system); N-5 and N-6 (insurance representative training); P-12 (reading tool for the blind)

HEALTH SERVICES/REHABILITATION

P. HEALTH SERVICES/REHABILITATION

Key Issue

Heart pacemakers: More than 50% of all deaths in the U.S. are due to cardiovascular diseases, which claimed over 1 million lives in 1974. By the early 1970's, heart problems had forced 3.6 million Americans to limit their activities. Heart pacemakers were introduced in the 1950's to rehabilitate patients with one type of heart problem: complete heart block. This is a malfunction of the neuroelectrical control system for heart muscles and is one of the major causes of fatal heart attacks. A pacemaker generates an electrical pulse that rhythmically stimulates the heart muscles to contract regularly. The three pacemaker components are: a battery-powered pulse generator, a stimulating electrode, and electrical wiring leads. In 1952, the first pacemaker was attached to the outside of the patient's chest. In 1958, a pacemaker electrode was placed, for the first time, directly inside the right ventricle of the patient's heart, and the electrical leads passed through the skin to an external pulse generator. Since 1960, the pulse generators have been implanted under the skin, outside the rib cage. Between 1960-1972, 120,000 pacemakers were implanted in Americans; 90,000 of these patients were still living in 1972. Some patients have such severe heart deterioration that 10-15% die within a year after the pacemaker is implanted. Those who survive the first year usually live at least 5 years. Pacemakers cost between \$1,200 and \$1,800 each. For most pacemakers, the battery pack or the entire pulse generator must be surgically replaced every 2-3 years. The replacement pack costs \$200 and the operation costs \$1,500. Recent advances in the batteries and circuitry for newer models have increased the replacement period to 3-6 years. Two new models increased this period even more: a radioisotope-powered unit (5-8 years) and a rechargeable unit (10 years or more). Two additional problems with most pacemaker designs are size, which has been too large for use in children, and malfunction due to microwave radiation. (P-5 and P-6)

P. HEALTH SERVICES/REHABILITATION

+ P-1 Paragraph deleted, 9/76

P-2 Composite materials: developed by Langley for spacecraft, aircraft, and rocket motor applications. . . . used in two BATEams projects to design lightweight leg braces. . . . heavy, metal brace components replaced by molded composites. . . . prototypes tested at Coastal Center for Mental Retardation (South Carolina) and Mississippi Methodist Rehabilitation Center (Mississippi). . . . brace weight reduced by over 50%. . . . new braces improve mobility and are more attractive. . . . easier composite processing methods and cost reductions being developed to facilitate widespread availability of improved braces. (BATEam, TUO-Applications Engineering, 1/75)

P-3 Polyurethane-silicone plastic foam: developed for Ames Integral Passenger Aircraft Seat Program. . . . contractor employee formed Dynamic Systems, Inc. (North Carolina) to market the material under trade name, TEMPER FOAM. . . . BATEam identified initial medical application, bed pads for long-term patients. . . . caused sharp reduction in bed sores. . . . each bed sore increases hospitalization costs by over \$5,000; medical insurance typically allows 25% of expected expense for spinal injury cases to be for bed sores. . . . BATEams assisted in developing other applications which now include wheelchair cushions, artificial limb socket lining, and finger splint padding for patients with hand burns. . . . treatment of burns thus improved. . . . product line sold to Becton, Dickinson and Co., Edmont-Wilson Div. (Ohio). . . . vigorous sales campaign to develop markets identified by BATEam. . . . new line expected to be profitable in a few years. (Personnel/contractor, BATEam, Purchased product line, TEF 570, Case No. 111711, 3/75)

P. HEALTH SERVICES/REHABILITATION (CONT.)

- P-4 Mobile Automatic Metabolic Analyzer (MAMA): developed at Marshall as TUO project using Skylab astronaut monitoring instruments. . . . now used in experimental program to measure energy expended by orthotic-equipped patients at Spain Rehabilitation Center, University of Alabama School of Medicine, an HEW Social and Rehabilitation Services research and training facility. . . . patient walks beside instrument cart rather than on the standard treadmill which disabled patients cannot easily use. . . . provides real-time data, under realistic conditions, for respiratory gases, EKG and velocity. . . . previous monitors measured only cumulative data for gases. . . . new data valuable in evaluation of treatment procedures and patient-assist device designs. . . . also includes Lunar Rover technology in design of battery-powered cart. (TUO-Applications Engineering, TEF 655, 1/75)
- + *P-5 Nickel-cadmium battery technology: developed for Goddard by Applied Physics Laboratory (APL) of Johns Hopkins University (Maryland) for rechargeable spacecraft batteries (e.g., Small Astronomy Satellite). . . . used by Johns Hopkins to develop its patented rechargeable cardiac pacemaker. . . . first total implant of non-rechargeable cardiac pacemaker was in 1960; 120,000 pacemakers implanted in American patients as of 1972. . . . six-year research effort funded by the University's School of Medicine, Baltimore City Hospital (Maryland), and Heart Association of Maryland. . . . Pacemaker Systems, Inc. (PSI) (California) licensed by university to produce units. . . . first human implant for the product was 1973; 3,100 implanted to date. . . . 2 models, constant pulse and demand. . . . price, including briefcase-sized recharger, \$1,550 to \$1,900. . . . provides rhythmic electrical stimuli to contract heart muscles and rehabilitate patients with intermittent complete heart block, one of major causes of fatal heart attacks. . . . rechargeable feature allows 30-60 years (at documented reliability rate of 99.32%), compared to 2-5 years for other units, before replacement surgery is required at a cost of over \$1,500 per replacement. . . . weekly recharging takes 60 minutes, may be accumulated up to 4 weeks. . . . patient anxiety about pacemakers reduced because recharger indicates whether unit is working properly. . . . smaller size, half conventional units, desirable for children, elderly. . . . pacemakers not affected by outside electromagnetic interference such as microwaves. . . . current TUO-funded project at Goddard and Johns Hopkins to incorporate hybrid circuits in unit will further reduce unit's size and improve other features. . . . PSI extending research into other electro-stimulation areas, including treatment of intractable pain, epilepsy, cerebral palsy, spasticity, hypertension, etc. (Contractor, TUO-Applications Engineering, TEF 646, Case No. 120519, 7/76)
- *P-6 Thick-film hybrid circuits and Mercury/zinc battery technology: developed for Goddard and Johnson by General Electric Co. (New York and Pennsylvania) used by GE's Medical Systems Div. (Wisconsin) to develop heart pacemaker product line. . . . over 4,000 units implanted since 1972. . . . current models provide 4-6 years of reliable electrical stimulation to rehabilitate people with certain types of coronary heart disease. . . . unit size reduced by 25% because hybrid circuits improve electrical efficiency by 45% and reduce interconnections by 50%. . . . recently improved batteries have 50% greater capacity than conventional mercury/zinc batteries. (Contractor, TEF 531, Case No. 106952, 1/75)

*Denotes transfer case related to Key Issue.

P. HEALTH SERVICES/REHABILITATION (CONT.)

- P-7 Artificial hand: developed for Marshall by Rancho Los Amigos Hospital (California). . . . includes unique finger control capability which enables amputee to pick up and operate standard power tools. . . . available commercially from General Teleoperators, Inc. (California). . . . important contribution to vocational rehabilitation for hand amputees. (Contractor, 1/75)
- P-8 Control switch: developed for Marshall so immobilized astronauts could operate controls by eye motion. . . . BATeam developed digital controller (linked to eye switch) for rehabilitation environment. . . . Rancho Los Amigos Hospital (California) and Veterans Administration Prosthetics Center (New York) developed breath-actuator so that switch could be used with rehabilitation controller design. . . . allows paralyzed patient to control television set, book page turner, bed position, lights and other objects. . . . prototype breath-actuated system developed with TUO funding at Huntsville Hospital (Alabama). . . . hospital project leader joined Scientific Systems International (Alabama) where he developed new product based on prototype unit. . . . product, called Nu-Life, sells for \$900 to \$4,000 per unit, depending on accessories. . . . higher price includes a miniature computer with capacity for 99 control functions. . . . 17 sold since March 1974. . . . product also generating interest by foreign rehabilitation centers and hospitals. (BATeam, Personnel/TUO-Applications Engineering, TEF 159, Case No. 108483, 3/75)
- P-9 Horizontal shower: developed by Ames for use in long-term bedrest studies related to lengthy space missions. . . . unit consists of horizontal watertight compartment with multiple shower heads. . . . current TUO project to evaluate 2 design variations for bathing bedridden patients underway at Palo Alto Veterans Administration Hospital and Stanford University Hospital (both California) commercial version developed by Sevier Manufacturing Co. (California) portable, side-loading, self-contained, electrically operated unit moves over length of body while patient lies in horizontal position. (TUO-Applications Engineering, Personal contact/Ames, TEF 598, Case No. 120512, 7/76)
- P-10 Electromechanical stimulator modules: developed for Ames by Stanford Research Institute to obtain sensory feedback from remote manipulators. . . . used by former SRI employee to develop new reader for the blind. . . . Telesensory Systems, Inc. (California), founded in 1970, marketed the new reader, Optacon, in 1971. . . . company holds patent rights. . . . unit size is about the same as a small tape recorder. . . . in operation, hand held photo-detector probe is passed over printed material and each letter shape can be felt through a matrix of mechanical vibrators on the 1/2" x 1" stimulator module surface 2 models available; the R1B for reading only printed materials and the R1C which can also be adapted to read printed information from video terminals and electronic displays. . . . R1B retail price is \$2,895, and the R1C price is \$2,995. . . . approximately 2,800 units sold to date, 1/4 to 1/3 outside U.S. . . . 1976 sales to date total approximately \$2 million. . . . 100 units were tested by the National Center for the Deaf-Blind (New York) with favorable results. . . . 100 units are used in Pennsylvania schools 20 California school districts provide Optacon training. . . . user benefits include shorter learning time than Braille and ability to read most standard material. . . . reader is having a dramatic impact on the educational, vocational, and leisure activities of blind and deaf-blind persons. (Personnel/contractor, TEF 594, Case No. 113671, 7/76)

P. HEALTH SERVICES/REHABILITATION (CONT.)

- P-11 Hand physiotherapy device: developed by Langley in response to BATEam problem statement. . . . Langley prototype was field tested at North Carolina Memorial Hospital and Jackson Memorial Hospital (Florida). . . . redesigned prototype used successfully since January 1974 at North Carolina Memorial Hospital. . . . allows patient-administered physiotherapy for flexion and extension of finger joints; enables more efficient utilization of therapist skill and training. . . . alleviates contractures which may result from frostbite, burns, arthritis, orthopedic procedures. . . . manufacturing firms are interested in producing the device. . . . improved model developed at Langley introduced in occupational therapy course at hospital and at San Francisco conference in 1976. (BATEam/Applications project, TEF 571, Case No. 109326, 8/76)
- + P-12 Semiautomatic inspection of microfilm records: developed for Marshall. . . . adapted by BATEam to develop prototype Paper Money Identifier (PMI) to help nonsighted people determine bill denominations. . . . design concepts used by EMR, LTD. (California) to develop combination PMI and light detector product unit powered by 2 rechargeable Ni-Cd cells. . . . approximately 100 units sold @ \$139; 10-20 units given to schools and foundations for the blind increases autonomy for the blind; also, expands career opportunities and reduces fraud. (BATEam/TSP, TEF 558, Case No. 109341, 7/76)
- + P-13 Biopotential monitoring: biotelemetry circuitry developed by Ames and adapted for Marshall by BATEam. . . . standard cassette recorders converted into electrocardiogram (EKG) recording instruments for the University of Texas Medical School (Texas) and the VA Hospital (Florida). . . . provided economical, portable biomedical cassette recorders. . . . commercialized by Modern Medical Methods, Inc. (Texas). . . . permits EKG recording of cardiac outpatients in any environment on standard cassettes. . . . recorded EKG signals can be played back into an EKG machine, oscilloscope or strip chart recorder. . . . retail cost is \$650. . . . has applications in rehabilitation research due to recorder's ability to acquire, store and analyze real-time data. . . . company is currently establishing a foreign trade market for the recorder. (Personal contact/BATEam, TEF 580, Case No. 110591, 6/75)

HEALTH SERVICES/DIAGNOSIS AND TREATMENT

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT

Key Issue

Emergency Medical Services (EMS) systems: The Emergency Medical Services Systems Act of 1973 provides assistance and encouragement for the development of comprehensive emergency medical services throughout the U.S. The goal of this act is to improve patient care significantly and to reduce morbidity and mortality. Current EMS systems include approximately 20,000 ambulances and 200,000 ambulance attendants. About 10 million emergency patients receive EMS treatment each year with 25%, or 2.5 million, being critically ill or injured. In contrast to a few years ago, critical patients can frequently be saved today if initial definitive and rehabilitative care is given in time and the patient is moved through the system to obtain essential services. For example, approximately 50% of all heart attack deaths occur within the first hour following the initial attack. When the heart attack is a cardiac rhythm disturbance, defibrillation within three minutes can lead to recovery for 72% of the patients. As a result of the 1973 act, local EMS systems are being improved through such actions as paramedical training for ambulance attendants and the use of more sophisticated ambulance equipment. (Q-1)

Q. . HEALTH SERVICES/DIAGNOSIS AND TREATMENT

- *Q-1 Emergency care system for ambulance use: developed for Johnson as part of STARPAHC, a cooperative program with HEW to provide health care in remote areas. . . . SCI Systems, Inc. (Texas) partially funded by Johnson to develop portable emergency treatment module, Telecare, to meet STARPAHC remote use requirement. . . . Telecare incorporates Skylab telemetry and medical equipment designs. . . . SCI produced commercial units for ambulance use; allow trained ambulance personnel to communicate with physician, transmit EKG data and provide emergency resuscitation. . . . unit used in several Texas cities, including Houston, San Antonio and Corpus Christi; also Montgomery County, Maryland and Altoona, Pennsylvania. . . . federal funding allocated to local government for emergency medical training. . . . SCI product line recently sold to Telecare, Inc. (Texas). . . . two models now available, Telecare I and Telecare II; unit price range \$3,700 to \$9,000, depending upon configuration. . . . Telecare, Inc. currently establishing international sales force. (Purchased product line, TEF 557, Case No. 108484, 4/75)
- Q-2 Fluorometer instrumentation technology: developed for Headquarters, Marshall, and Electronics Research Center for diagnostic and Apollo instrumentation by Whittaker Corp. (Massachusetts). . . . used by Whittaker to develop new blood and urine lead detection device, Micro-Porph. . . . 10 to 15 instruments sold, current unit price approximately \$3,000. . . . used by public health agencies, such as New York University Medical Center, Baltimore City Hospital, and St. Louis City Health Department, for mass screening of incipient lead poisoning. . . . permits low cost screening by unskilled personnel; 2-minute test costs approximately \$1.00 compared to longer conventional lab test @ \$5.00 to \$8.00. . . . applications include people who live in areas with high lead pollution levels in the air and children who ingest lead-base paint. . . . estimated 400,000 children in U.S. affected by lead poisoning, with 200 deaths reported annually early detection can avoid permanent damage and death. . . . extent of lead poisoning a major factor in restrictions on lead-based paint and shift to unleaded gasoline. (Contractor, TEF 568, Case No. 109324, 4/75)
- Q-3 Manufacturing contamination prevention handbook: compiled for Marshall used by Machlett Laboratories, Inc. (Connecticut), producers of diagnostic X-ray tubes for hospitals, as state-of-the-art reference source on contamination control. . . . resulted in improved product quality and higher productivity. (TB/TSP, TEF 544, Case No. 86664, 3/75)
- Q-4 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Hollister, Inc. (Illinois) to solve major lubrication problem during design of new, automated equipment for colostomy bag production. . . . enabled company to identify a lubricant that would not contaminate product. . . . reduced labor costs. . . . 25 machines affected, with 1-2 million colostomy bags produced per year for hospitals and patients. . . . used by Richardson-Merrell, Inc., Merrell-National Laboratories (Pennsylvania) to solve major lubrication problem on Harvester process equipment that extracts chicken egg fluid for vaccine production. . . . identified lubricant that reduced grease spills and satisfied stringent, sanitary quality control need. . . . reduced labor costs and machine downtime; increased production of vaccines. (TB/TSP, Trade Journal, TEF 497, Case Nos. 91690, 92994, 4/75)

*Denotes transfer case related to Key Issue.

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT (CONT.)

- Q-5 Portable laminar airflow surgical clean room: developed for Headquarters by Martin Marietta Corp. (Colorado) for experiment in control of surgically induced infections. . . . installed for evaluation at St. Luke's Hospital (Colorado). . . . included state-of-the-art aerospace clean room technology, helmet and gown isolator system, and communication system used during 550 orthopedic surgical cases over 2-year period. . . . JPL evaluation of system effectiveness indicated personnel isolator system reduced contamination levels below those achieved with only laminar flow room and much lower than conventional surgical room. . . . major need exists to reduce postoperative infection associated with prosthetic implantation. (Contractor, TEF 577, Case No. 109323, 4/75)
- + Q-6 Heat pipe applications: developed for Lewis and Langley by Hughes Aircraft Co. (California). . . . used, together with aluminized superinsulation by Hughes to develop portable cryosurgical instrument product, Lewis Kryostik approximately 800 units sold since 1972 @ \$1,000. . . . 2-lb. self-contained instrument supplies liquid nitrogen to cryoprobe tip for controlled destruction of tissue. . . . surgical applications include proctological procedures such as hemorrhoidectomies, destruction of malignant tumors and treatment of cervicitis. . . . allows 65% reduction of application time compared to other cryosurgical instruments. . . . compared to conventional surgical methods, advantages in Kryostik hemorrhoid removal are: no hospitalization, no anesthetic, less pain, faster recovery and lower cost. . . . experiments on lab animals indicate Kryostik stimulates auto-immunity to cancerous cells; positive results in 75% of cases studies. (Contractor, TEF 197, Case No. 109343, 5/75)
- Q-7 Biomedical electrodes: developed by Ames. . . . commercialized by In Vivo Metric Systems (California) as FSE-20, a low-cost, flexible skin electrode that is easily applied, conforms to body surface during motion and improves patient comfort. . . . applications include prosthesis control, physical therapy, muscle control and stimulation, nerve stimulation, and pediatric biosensing. . . . retail cost is \$4.50 for pack of three; approximately 100 packs sold to date. . . . accessories such as skin cleaner, electrode gel, and adhesive discs are also available. . . . firm has established foreign trade market. (Conference, TEF 582, Case No. 110592, 6/75)
- Q-8 Automatic infrared optometer and visual focus simulator: developed for Ames by Stanford Research Institute (SRI). . . . former SRI employee hired by Acuity Systems, Inc. (Virginia) to help in designing an electro-optical product for vision testing. . . . commercialized as 6600 Auto-Refractor, the instrument automatically measures optical refractive error and prints out computerized corrective prescription. . . . advantages are: permits objective optical testing; easy to operate; reduces examination time; maximizes physician efficiency; permits accurate testing of persons with communication difficulties; permits acuity maximization; improves patient cooperation; and improves overall quality of patient care and vision services. . . . approximately 400 units sold @ \$22,800 each. . . . firm established foreign trade market and 75 units have been sold outside the U.S. (Personnel/contractor, TEF 581, Case No. 110593, 6/75)

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT (CONT.)

- Q-9 Installation tool for BNC connectors: developed by Ames. . . . used at the University of California Medical Center to fabricate tool for installing connectors on medical equipment at the San Francisco General Hospital. . . . reduced connector installation time by 16%. (TB/TSP, TEF 579, Case No. 77130, 6/75)
- *Q-10 Communication equipment evaluation techniques: developed by Lewis. . . . used by American Heart Association, Northeast Ohio Chapter (Ohio) in selecting emergency communications system equipment for use between Fairview General Hospital (Ohio) and a fire department rescue unit. . . . system provides remote electrocardiograph monitoring in emergency cases. . . . reduces critical treatment time following initial heart attack. . . . system used 12 times in 1975 and estimated to be directly responsible for saving four lives. (Personal contract/Lewis TUO, TEF 602, Case No. 114862, 1/76)
- Q-11 Aesthesiometer: developed for Johnson. . . . an improved biomedical instrument for quantitatively measuring the sense of touch. . . . individual obtained an exclusive license in 1973 to produce the instrument and founded Rowan Products Co. (California) in 1975 to market commercial version. . . . principal customers are neurosurgeons, neurologists and university medical laboratories. . . . retail price is \$39.50 each. . . . first year sales total \$5,000; 1976 sales are \$4,000 to date. . . . benefits include establishment of a new business with small capital investment. (TB/TSP, License, TEF 596, Case No. 114852, 6/76)
- + Q-12 Microbial load monitor: developed for Johnson by McDonnell Douglas Corp. (Missouri). . . . diagnostic instrument that makes multiple microbial identifications simultaneously, tests antibiotic susceptibility. . . . reduces time required for conventional methods by 50-80%. . . . company received NASA patent waivers and introduced two commercial models of Automicrobial System. . . . Model 120 processes 120 specimens at once, costs \$49,500; Model 240 processes 240 specimens, costs \$69,500. . . . unique automatic general purposes microbiology processing system for variety of biomedical diagnostic specimens. . . . Fisher Scientific Co., Automicrobial System Div. (Pennsylvania) awarded sales, service contract. . . . sales expected to begin October 1976. (Waiver/contractor, TEF 654, Case Nos. 121460, 121461, 9/76)
- + Q-13 Mass spectrometer: developed for Goddard, Johnson, Langley, Lewis, Marshall, JPL, by Perkin-Elmer Corp. (California). . . . design features included preset collectors and high reliability for various analyses; including atmosphere, pilot breath, spacecraft environment, Martian soil. . . . modified by company to develop commercial product line. . . . hospital version, Model 1100 Medical Gas Analyzer, measures 8 components of patient's breath, signals if any fall below critical level. . . . can monitor 16 patients simultaneously with greater reliability than competing products. . . . used in intensive care wards by approximately 150-200 hospitals around the world. . . . typically equipped analyzers sell for \$25,000 to \$30,000. . . . market expected to expand. (Contractor, TEF 656, Case No. 121462, 9/76)

* Denotes transfer case related to Key Issues.

Q. HEALTH SERVICES/DIAGNOSIS AND TREATMENT (CONT.)

- + Q-14 Contamination control handbook: compiled for Marshall. . . . used at 375-bed Oak Park Hospital (Illinois) for infection and sanitation control procedures. . . . reduced in incidence of patient infection, shorter hospitalization. . . . also, abstracts from handbook appear in American Hospital Association Handbook (priced at \$7.50) used by many U.S. hospitals in infection control efforts. . . . NASA handbook information on gas sterilization of equipment particularly important since conventional steam sterilization cannot be used on many plastic components. . . . estimated national savings to hospitals in past year are 2,000 person-hours and \$250,000 due to NASA handbook according to Oak Park Hospital expert. (TSP, TEF 262, Case No. 27506, 9/76)
- + Q-15 Automated patient monitoring system and NIMBUS telemetry system: developed for Marshall by Boeing Co. and for Goddard, respectively. . . . Marshall Applications Engineering Project to demonstrate feasibility of using Saturn rocket telemetry system in medical context. . . . former NASA employee formed Care Electronics in 1969 to market new product--modified version of Marshall design. . . . NIMBUS telemetry estimated to have saved \$500,000 in developing commercial system. . . . digital system collects several channels of data, such as blood pressure, EKG, and temperature, from 4 patients simultaneously and transmits to central control station. . . . includes automatic alarm feature. . . . total sales exceeded \$4 million before the product line was terminated in 1974. . . . approximately 200 systems still being used at medical facilities in Tennessee, Connecticut, Ohio and other states. (Personnel/ Marshall, TEF 116, Case No. 62401, 8/76)
- + Q-16 Miniature Centrifugal Fast Analyzer (CFA): developed for Johnson by Oak Ridge National Laboratory (ORNL). . . . adaptation from prior CFA design, developed by ORNL with ERDA and National Institutes of Health funding, included miniaturization, use of whole blood samples, disposable components, and self-contained microprocessor data system for inflight (e.g., Space Shuttle) analysis of astronauts. . . . commercialized by Electro-Nucleonics, Inc. (New Jersey) as Gemeni. . . . approximately 60 units sold @ \$14,875 each customers include Middle Georgia Hospital, Lake County Hospital (Ohio), University of Missouri Medical Center; hospitals in Hawaii, Massachusetts, New Jersey and Florida; as well as other medical facilities. . . . provides fast, accurate analysis for medical diagnosis. (Personal contact/contractor, TEF 660, Case No. 121465, 9/76)

Other Relevant Examples:

B-2 (medical diagnoses); B-14 (medical instrumentation); N-5 (hospital sterilization procedure); O-2 (anesthesiology simulator); O-3 (birth simulator); O-10 (medical training and diagnosis by satellite); P-3 (bed sore treatment)

HEALTH SERVICES/GENERAL

R. HEALTH SERVICES/GENERAL

Key Issue

Cancer center management: Cancer is the second leading cause of death in the U.S. Over 340,000 cancer deaths were reported in 1972. The economic costs for cancer treatment are in the tens of billions of dollars. Nationally, there are 1.3 million cancer patients hospitalized each year at a cost of \$2 billion for cancer treatment alone. Other economic costs include doctor bills, outpatient therapy, lost work time, and other disease-related costs. Early national efforts to control cancer began in 1937 with the National Cancer Institute Act. The Act provided an initial \$700,000 to coordinate cancer research. In 1971, the National Cancer Act was passed. An additional \$100 million was appropriated to initiate a National Cancer Program to be administered by the National Cancer Institute (NCI). The National Cancer Program instituted cooperative programs with state and other agencies to collect, analyze, and disseminate data pertinent to the diagnosis, prevention and treatment of cancer. NCI 1974 funding totaled \$892 million from federal, state, local, private and voluntary sources. A large portion of NCI funding is used to support its Cancer Centers Program. The program supports two types of centers: comprehensive centers and specialized. There are 17 Comprehensive Cancer Centers in the U.S. with NCI-contributed funds totaling \$152 million in 1974. An additional 19 centers will be established by 1980. Comprehensive centers conduct long-term, interdisciplinary research, as well as programs to treat and control cancer. There are approximately 66 specialized centers, partially funded by NCI research grants. These centers offer selective cancer treatment services. (R-1)

R. HEALTH SERVICES/GENERAL

- *R-1 Apollo Program management techniques: developed and refined by Marshall . . . techniques provide a framework for managing complex programs utilizing multi-disciplinary skills. . . . used by the Comprehensive Cancer Center, University of Miami (Florida) to develop organizational guidelines, define goals and objectives, secure staff cooperation, and set priorities for facility acquisition. . . . reduced planning time by several weeks and validated early organizational efforts. . . . future benefits expected include increased professional cooperation and improved delivery of health service. (BATeam, TEF 573, Case No. 112251, 9/75)
- R-2 Computer display system for Saturn prelaunch checkout: developed for Marshall and Kennedy by Sanders Associates, Inc. (New Hampshire). . . . embodied significant advances in digital television hardware and software for computer interface systems. . . . used by Sanders to design and install medical data management computer systems at the Mayo Clinic (Minnesota), Kaiser Memorial Hospital (California) and Walter Reed Hospital (District of Columbia). . . . total value about \$300,000. . . . each system allows data input-output at several remote terminals in hospital. . . . enabled seven-year backlog of admissions and accounting data at Mayo to be brought up-to-date in 30 days. . . . improved capability for managing increasing amounts of medical data from more admissions, shorter stay times per patient, more laboratory test results, and more data inputs to diagnoses. (Contractor, TEF 99, Case No. 76502, 1/75)
- R-3 Biosatellite telemetry and life support systems: developed for Ames by General Electric Co., Re-entry and Environmental Systems Div. (Pennsylvania) for Biosatellite Program. . . . systems measured physiological and metabolic data with low-level signal conditioning and processing subsystems used by GE in designing a new product line commercialized as Medical Data Acquisition Unit (MDAU). . . . self-contained, portable, electromechanical unit for recording blood pressure, height, weight, electrocardiogram and other physiological data during life insurance examinations. . . . reduces cost and time for conducting examination. . . . agents can be trained in operation of unit in one hour. . . . 200 units installed for operational use at Metropolitan Life Insurance Co. field locations. . . . MDAU will be used by company for life insurance amounts up to \$150,000 product is currently being evaluated by three other insurance companies. . . . potential applications include: screening job applicants; providing company physicals; facilitating health care center patient processing; screening in-office insurance applicants; area-wide or remote health care screening with or without medical personnel; and screening personnel in hazardous occupations. (Contractor, TEF 584, Case No. 112241, 6/75)

*Denotes transfer case related to Key Issue.

R. HEALTH SERVICES/GENERAL (CONT.)

- R-4 Remote health care delivery system: developed by Johnson to satisfy biomedical requirements in manned spacecraft design. . . . used in current NASA, HEW/Indian Health Service-funded project to provide remote health services on Papago Indian Reservation (Arizona). . . . Permian Basin Regional Planning Commission (Texas) used the management systems engineering techniques to prepare a comprehensive emergency medical services plan for a 17-county area. . . . cost-benefit analysis, radio communications, human factor analysis, and medical data transmission techniques were used to acquire equipment, train personnel, and schedule projects. . . . savings of \$50,000 in consultant fees and 3 months of planning effort. . . . also, commission assured of \$350,000 federal grant. . . . future benefits expected to include savings in salaries, materials and service delivery. (Contact/Johnson, TEF 588, Case No. 112250, 9/75)
- + R-5 Oculometer for tracking eye movement: developed for Headquarters, Electronics Research Center, FAA and USAF by Honeywell, Inc. (Massachusetts). . . . designed for remote measurement of eye direction and pupil diameter in aircraft pilot human factor studies. . . . company received NASA patent waiver and introduced 2 commercial models. . . . 12 sold to date, price range of \$40,000-\$100,000. . . . used primarily for vision research in education, aircraft pilot training, highway driving studies, psychological testing. (Waiver/contractor, TEF 82, Case No. 121307, 8/76)
- + R-6 Implantable biotelemetry systems: developed for Ames by Konigsberg Instrument, Inc. (California). . . . designed to study effects of space environment on animal, human physiology. . . . commercialized by Konigsberg in complete line of custom-designed implantable single and multichannel biotelemetry instruments. . . . products used by researchers to study physiological responses of animals in controlled or natural environments, minimizes effect of instrumentation on experiments. . . . approximately 70 single channel units, at \$300-\$1,000, and 40 multichannel units, at \$4,000-\$6,000, have been sold to date. . . . users include the Universities of Texas and Utah, several major drug companies. (Contractor, TEF 644, Case No. 120513, 7/76)
- + R-7 Ultrasonic blood flowmeter: designed to Ames specifications by L&M Electronics (California), evaluated by Ames contractor. . . . non-invasive, directional flowmeter using Doppler Principle and ultrasonics to measure effects of high acceleration on distribution of blood in circulatory system. . . . space applications include passenger selection criteria for Space Shuttle. . . . company prototype, modified in response to evaluation, found to be the optimum instrument for this measurement method. . . . L&M commercialized the modified design under the name Directional Ultrasonic Flowmeter. . . . approximately 100 sold @ \$29,095 each to medical research laboratories, universities in Europe and U.S., and Veterans Administration hospitals. . . . used primarily for biomedical research, potential industrial uses. (Personal contact/Ames, TEF 653, Case No. 121458, 9/76)

R. HEALTH SERVICES/GENERAL (CONT.)

Other Relevant Examples:

A-2 (drug research); A-5 (drug production); B-60 (medical research equipment); E-12 (health conditions improved); E-18 (pollution reduction); F-20 (food service); G-8 (health care planning); G-12 (occupational health); G-22 (FDA data system); N-5 (contamination control); O-2 and O-3 (medical training simulators); O-10 (remote health care); O-17 and O-18 (bioengineering education)

WATER TRANSPORTATION

S. WATER TRANSPORTATION

Key Issue

Improved communications for commercial ship operations: U.S. commercial shipping fleets are losing business to foreign flag carriers due, in part, to higher costs for ship operations. 572 oceangoing U.S. flag carriers are currently in service. Super oil tankers cost up to \$2,000 per hour to operate, and general cargo ships have hourly operating costs of \$500-\$600. Freight-On-Board prices for some commodities can fluctuate rapidly; therefore, ship scheduling can become a critical factor in how much is paid for the cargo. In 1975, for example, a one dollar/barrel price increase for Persian Gulf crude oil was announced shortly before the new price was posted. Due to communication delays, a major U.S. oil company was unable to reroute a large tanker in time to buy 1.8 million barrels at the old price. Major U.S. shipping companies and the Maritime Administration are exploring ways to improve ship communications techniques by using the instant communications capabilities of satellites. These efforts are a part of the Maritime Administration's satellite program, called Maritime Satellite Communications/Navigation Program (MarScan), begun in 1970. Operational tests during the program have demonstrated that significant reductions in fleet operating costs can be achieved through the use of satellite communications. As a result of these tests, the COMSAT General Corporation will market test two prototype ship communications satellites in 1976. (S-1)

S. WATER TRANSPORTATION

- *S-1 Satellite communication for ships: ATS series developed for Goddard for various technological and scientific experiments. . . . ATS-1 and ATS-3 satellites were used by Exxon Corp. (New York) in a joint 9-month experiment with General Electric Co. (New York) to evaluate the compatibility of several satellite communications modes with ship operations. . . . experiment linked Exxon oil tanker with company headquarters via a GE ground station. . . . Goddard coordinated use of daily one-hour segments of satellite transmission time to send messages and signals in voice, teletype, and facsimile modes. . . . each mode evaluated as to transmission time and quality, ease of operations, interconnection factors and operating efficiency modes integrated into existing ship operations. . . . benefits obtained during experiment include increased operating efficiency, reduced ship diversion time, improved ship maintenance scheduling, and more rapid emergency communications capability. . . . saved \$15,000 in ship diversion time and \$20,000 in repair costs. . . . experiment demonstrated superiority of satellite communications over previous systems for ship operations. . . . ATS-6 satellite used by United States Lines, Inc. (New York) in a 12-month experiment sponsored by the Maritime Administration (District of Columbia) to evaluate ship communications equipment, services and benefits. . . . technical direction provided by Goddard. . . . satellite used as a 2-way link between ship operations center and a U.S. Lines' containerized cargo ship. . . . teletype, facsimile, and voice signals transmitted to and from the ship during 12 regular commercial trips across the Atlantic. . . . benefits during experiment included faster ship repairs and solution of breakdown and routing problems, fuel savings, and reduced ship turnaround time which permitted timely delivery of supplies. . . . ship operating costs are \$13,500 per day. . . . major benefits expected from operational satellites for ship communications. . . . COMSAT General Corp. plans to have 2 MARISAT satellites launched in 1976 to test the market for a ship communications service. . . . Exxon and U.S. Lines plan to use MARISAT for ship operations. (Contact/Goddard, Interagency, TEF 530, Case Nos. 114857, 115407, 12/75)
- S-2 ERTS-1 imagery: program under Goddard supervision. . . . used by National Science Foundation's Office of Polar Programs (District of Columbia) to establish a ship resupply base at Pine Island Bay, a remote region of Antarctica, to support exploration activities. . . . U.S. Navy ice maps, prepared daily from ERTS imagery, were used to chart an accurate, reliable course through dense ice by detecting small cracks in ice packs. . . . benefits currently include savings of 70 hours in aircraft surveillance flying time, avoidance of ship delay or damage, and demonstration of feasibility for locating a ship resupply base 1,200 miles closer to exploration area. (Interagency, TEF 500, Case No. 114853, 12/75)

* Denotes transfer case related to Key Issue.

S. WATER TRANSPORTATION (CONT.)

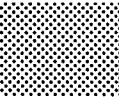
- S-3 Great Lakes all-weather ice information system: developed by Lewis as part of joint federal agency-sponsored Great Lakes Winter Navigation Program's "Project Ice-Warn". . . . program initiated in 1969 by U.S. Army Corps of Engineers (Michigan) to extend shipping season from 8 months to 12 months airborne radar imagery converted to charts showing ice location, distribution, type and thickness. . . . new imagery and charts transmitted to ships via radio facsimile approximately every 2 days by the U.S. Coast Guard Ice Center (Ohio). . . . operational test of system conducted during 1974-1975 winter using 25 ships owned by 5 companies. . . . 15 million tons shipped during test, approximately 6% of total annual tonnage. . . . first year-round season (for test ships) in history of Great Lakes shipping, which accounts for 17% of U.S. waterborne commerce, including 70% of iron ore and 20% of coal shipped by water. . . . economic studies indicate multimillion dollar benefits from operational program. . . . United States Steel Corp.'s Lakes Shipping Department (Minnesota) participated in test with a large iron ore ship. . . . ice information permitted ship operation in winter months benefits include reduced transportation and ore storage costs, prevention of ship damage and delay. . . . company plans to use operational system for ore carriers as soon as it is available. (Interagency, TEF 603, Case No. 114856, 12/75)
- + S-4 Inorganic silicate paint: developed by Goddard. . . . adapted and commercialized by International Paint Co., Inc. (New York) as "Interzinc". . . . uses a sodium silicate, rather than potassium silicate. . . . sold mainly to large users for application to sand-blasted steel in the marine industry. . . . used as a primer paint for ships and on ship freeboard and surface areas subject to excessive wear. . . . principal customers are the marine industry and offshore oil rig market. . . . sold in 5 gallon pails @ \$24 per gallon customer benefits include excellent protective properties and resistance to salt water corrosion. (Trade Journal/TSP, TEF 34, Case No. 4535, 9/76)
- S-5 Printed circuit fabrication methods evaluation: developed for Marshall to resolve fabrication problems for space-rated circuits. . . . used by Boeing Co., Marine Div. (Washington) to design automatic control system for hydrofoil boats. . . . information applied in selecting proper materials for microelectronic components in system. . . . saved 50-60 engineering hours five hydrofoil boats sold @ \$3.5 million each and five more currently under construction. . . . used as passenger ferries in Hong Kong and Hawaii total sales through 1979 expected to exceed \$40 million. (Trade Journal/TSP, TEF 256, Case No. 26334, 11/75)
- S-6 NASTRAN (NASA Structural Analysis Program): developed for Goddard for computer analysis of aircraft and space vehicles. . . . continuing program maintenance services provided by Langley. . . . used by Babcock and Wilcox Co., Power Generation Div. (Ohio) to design bottom-supported, small- to medium-sized steam boilers for ships. . . . provided very important data analysis capability for solving engineering problems related to these steam boiler products. . . . installations include commercial tankers and U.S. Navy ship heating systems. (COSMIC, TEF 410, Case No. 91178, 8/75)

S. WATER TRANSPORTATION (CONT.)

- S-7 Computer program translating guide for FORTRAN (on different computers): developed for Langley. . . . used by National Steel and Shipbuilding Co. (California) to convert computer programs from an outside system to an in-house system. . . . programs used daily by engineers for ship design. . . . approximately 50 FORTRAN programs are being converted. . . . savings of \$5,000 in operating costs. (Trade Journal/TSP, TEF 527, Case No. 102850, 12/75)
- S-8 Insulation technology for Saturn rocket: developed for Marshall by Rockwell International Corp. . . . used by Rockwell to develop polyurethane foam application procedures for tuna boat insulation under contract to boat manufacturer, Campbell Industries, Inc., Campbell Machine Div. (California). . . . used by Campbell since 1970 as standard method for insulating fish storage compartments on boats. . . . polyurethane replaced cork and fiberglass, provides better, cheaper and more reliable insulation. . . . more than 40 tuna boats completed and sold for prices ranging from \$1 to \$4 million each. . . . principal customers are Ralston Purina Co., Van Camp Seafood Div. and Star-Kist Foods, Inc. (Customer/contractor, TEF 361, Case No. 115405, 2/76)
- S-9 Ride Quality Program: conducted by Langley to analyze ride quality for STOL aircraft. . . . program later expanded to include other transportation modes ride quality models used by Boeing Co., Marine Div. (Washington) to program an automatic control system for a hydrofoil boat product line, Jetfoil 200-passenger boat for high speed ferry services. . . . rigid hydrofoils on boats by other companies caused a rough ride that was unacceptable to many passengers. . . . Jetfoil features variable hydrofoil with control system to compensate for waves and provide satisfactory ride quality. . . . 2 units sold to Far East Hydrofoil (Hong Kong) and 3 units sold to Pacific Sea Transport (Hawaii). . . . Jetfoil also being considered for mass transit use in San Francisco Bay area. . . . market expected to increase. (Conference, TEF 608, Case No. 115408, 1/76)

Other Relevant Examples:

A-8 (pleasure boat safety); B-10 and H-3 (LNG tankers); C-7 (life raft); E-15 (waste treatment system); F-1 (tuna fishing charts); G-6 (river flow forecasting); H-2 (LNG transfer system)



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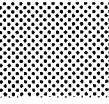
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