Tm: L. B. Ault: DRA

space benefits

the secondary application of aerospace technology in other sectors of the economy

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SPACE BENEFITS:

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

- Prepared for -

The Technology Transfer Division
(Code ETD-6)
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- Prepared by -

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

PREFACE

Space Benefits is prepared for the NASA Technology Transfer Division 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. Since it was first published in 1975, portions of Space Benefits have been updated and/or expanded in various editions; currently, new editions are prepared annually.

The 1980 edition contains 454 paragraphs that describe over 580 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. It should be noted that many potential transfer cases have not been, and may never be, fully documented. The examples in this publication are only a portion of all such transfer activity and, therefore, do not indicate the magnitude of technological effects from NASA programs.

This document is divided into three sections: (1) Transfer Overview, (2) Benefit Cases and (3) Indexes. The Transfer Overview section presents general observations concerning technology transfer activity. The questions of concern are: what technical contributions are considered; how are they transferred; and what are the beneficial effects from this activity?

The benefits section is subdivided into 20 subject areas. Each subsection presents transfer paragraphs relevant to the subject area, with many of the paragraphs containing more than one benefits example. At the end of each paragraph, pertinent transfer data are presented; these data indicate the communications link with NASA (e.g., Tech Brief/Technical Support Package or TB/TSP, Contractor), the DRI Transfer Example File (TEF) number and individual case numbers associated with the technology and examples used, and the date of latest contact with the user organizations.

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 presented in Section III.

Floyd I. Roberson, Director
Technology Transfer Division

NOTICE: Supporting material for the examples described in this document is available from the TU Communications Branch, NASA Scientific and Technical Information Facility, P.O. Box 8757, Baltimore/Washington International Airport, Maryland 21240. Telephone (301)796-5300, Ext. 213.

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TRANSFER OVERVIEW

Eight common transfer modes have been identified among the hundreds of examples reported herein:

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.

NASA efforts to stimulate technology utilization have involved the deliberate use of Modes V through VIII, as well as Mode III. Most of these have been conducted by the Technology Transfer Division, which operates a range of transfer services in Mode VI. There is little systematic management of transfer activity outside Mode VI except for the private efforts of a few contractors in Modes I through IV. Transfer costs, success rate, and total number of successful transfers for an innovation vary widely, even within Mode VI.

Economic Benefits

Economic benefits from technology transfer activities have been defined in various ways. The definition used here is based on the beneficiary's judgment concerning technical alternatives. That is, benefits are measured as the difference in economic effects from applying a NASA innovation as compared to the technical alternative that would have been used.

TRANSFER OVERVIEW

New technology generated by NASA programs represents a major addition to the nation's total reservoir of technology. This section presents a brief overview of the scope, transfer processes, and benefits surrounding technical innovations included in Space Benefits.

Scope of Technical Innovations Reported

NASA 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 equipment designs, processes, technical expertise and design data. The scope of NASA contributions reported in Space Benefits is indicated below.

Indirect applications. A vast majority of the benefit examples report adaptation and use of technology originally developed to satisfy NASA mission requirements. These indirect, or "secondary," applications found their way to the marketplace as new or improved products, processes or services.

Direct applications. A relatively small number of the benefit examples describe the direct application of NASA technology by the private sector or by public sector organizations. For example, NASA research in aeronautics has directly influenced aircraft design, and satellite technology has directly affected weather forecasting, navigation, etc. In some instances, NASA, in conjunction with private industry and/or other federal agencies, has developed secondary applications to satisfy well-defined public needs.

Off-the-shelf products. NASA purchases off-the-shelf products for use in its primary mission-oriented programs. If this type of procurement activity did not require product improvement or otherwise contribute to innovations in the product line, the product is not included in this document.

Management techniques. Benefit examples involving specific innovations in management practice are included because management is considered a technical field.

Transfer Modes

The availability of NASA technology alone is not sufficient to generate beneficial change in the nation's economic system: it is also necessary that potential users acquire, select, adapt and implement such innovations within the economic system. These activities constitute the technology transfer process. Transfer research has shown that several factors are important in determining the economic effects of this process. The major factors are: type of technological innovation; method of acquisition (i.e., transfer mode); and technological environment of the recipient.

Transfer modes are significant in the process because they can be configured, selected, and managed to a greater extent than any other factor. A single innovation, for example, might generate similar benefits per application for several secondary users, but the transfer cost could vary by orders of magnitude depending on which transfer mode is used.

A

MANUFACTURING CONSUMER PRODUCTS

A. MANUFACTURING CONSUMER PRODUCTS

A-1 + Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed by contractor employees and now being produced and marketed by Inframetrics, Inc. (Massachusetts) . . . . 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, idenfifying 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. (Purchased product line, Customer, TEF 398, Case No. 112249, 8/79)

A-2 Management method for R&D programs: developed for Marshall. . . . used by The Upjohn Co. (Michigan) to develop network management method for its pharmaceutical research programs. . . . saved Upjohn substantial person-hours. . . . provides continuing cost savings. (TB/TSP, TEF 452, Case No. 60860, 11/77)

A-3 + Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing new graphite composite product line. . . . golf club shafts, priced from $12 to $30, sold to pro shops for custom reshafting of woods and irons, and to Wilson Sporting Goods for premium line of woods . . . . unfinished tennis racket frames also produced for Wilson; complete racket retails for $200. . . . company also manufactures composite parts for business machine and computer manufacturers, such as Xerox. (Trade journal/ TSP, TEF 490, Case No. 87986, 3/79)

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. . . . company has sold 30 to 40 systems for use in new textile weaving mills worldwide (particularly, Poland, France and Belgium). . . . 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. 4793, 10/78)

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. . . . continued use as reference document in manufacture of television components. . . . current annual sales about $6.5 million. (TB/TSP, TEF 262, Case Nos. 31286, 39662, 10/78)

Economic data are not available for some transfer examples because the data may not be estimable or they may be proprietary. In some Space Benefits examples, sales data are given to indicate the level of economic activity associated with the transfer example; however, such data do not represent benefits attributable to NASA technology since other technologies, capital expenditures and/or labor costs were also required to produce the goods or services involved.

In general, technological innovation is an investment activity and NASA technical contributions add to the availability of such investment opportunities. In this context, benefits occur when NASA technology provides a better return than alternative opportunities. One of the important objectives for government-operated transfer services is to increase the efficiency of technological evolution within the economic system by reducing the total costs of individual searching in the market place for technology investment opportunities. Technology transfer is the subject of considerable research activity in the U.S. and internationally since it has the potential for reducing costs in technological evolution. In order to achieve this potential, however, the process must be systematically analyzed, developed and managed. Current research is directed toward this goal.

A-12 Computer modeling handbook for thermal analysis: prepared for Johnson by Grumman Aerospace Corp. . . . 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 . . . . a company subsidiary, Grumman Energy Systems, Inc. (New York) 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. . . . product currently being distributed nationally. (Contractor, TEF 616, Case No. 117155, 7/78)

+A-13 Paragraph deleted, 9/79

+A-14 Paragraph deleted, 9/79

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 "Space Mountain," a roller coaster ride at both Disney World (Florida) and Disneyland (California). . . . company accessed the program through a computer service to determine the size and strength of structural components. . . . benefits include substantial cost savings from not overstrengthening the track supports. . . . program now used in design of all new roller coaster-type rides, such as the "Big Thunder Railway" being constructed at both Disney locations. . . . benefits expected to continue. (Personal contact, TEF 410, Case No. 119307, 6/79)

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 four years. . . . elimination of ride breakdowns due to axle failure has saved $150,000 to date in labor and materials costs. (TB/TSP, TEF 634, Case No. 119299, 10/78)

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. . . . units range in price from $1,600-$3,200. . . . Deere is third largest U.S. company marketing snowmobiles. (Professional society, TEF 451, Case No. 101903, 9/79)

+A-18 Paragraph deleted, 9/79

+A-19 Paragraph deleted, 9/79

+A-20 Paragraph deleted, 9/79

A-21 Paragraph deleted, 1/78

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, 10/78)

A-8 Intumescent fire retardant coatings: developed by Ames. . . . used, under
+ NASA license, by AVCO Corp., Specialty Materials Div. (Massachusetts) to develop commercial product line. . . . FLAMAREST intumescent paint and FIRE-FLEX intumescent tape and sheet sold to manufacturers of inboard pleasure boats. . . . used on hulls, fuel hoses and tanks, and other fuel storage containers. . . . improves fire safety for boating. (License, TEF 554, Case No. 108481, 9/79)

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 $2 million. . . . over 700 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., one Israeli company, and one Swedish company licensed to use processes. (Contractor, TEF 575, Case No. 109338, 8/79)

A-10 Microbiological handbook: compiled for Marshall. . . . used by Astra Pharmaceutical Products, Inc. (Massachusetts) to familiarize employees with biological fundamentals of plant cleanliness. . . . company manufactures prescription and over-the-counter drugs. . . . company saved $35,000-$40,000 by not having to compile same information. (Personal contact/TSP, Professional Society/TSP, TEF 402, Case No. 112994, 5/77)

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 solar collector product line. . . . flat collector panels coated for Chamberlain by Olympic/National Plating Co. (Ohio) using process developed by Olympic in conjunction with Lewis. . . . product line sold to Solaron Corp. (Colorado) in 1978; new line doubled size of company. . . . Solaron recently entered licensing agreement with Jacorossi-AGIP, an Italian manufacturer, to sell collectors, under Solaron name, in 11 Western European nations; Olympic/National will also coat panels for Jacorossi. . . . Solaron's annual sales currently $2 million; will receive 4% of Jacorossi's gross sales. (Conference/contact/Lewis, Purchased product line, TEF 600, Case Nos. 114859, A010333, 8/79)

A-28 Electromotive series for metals: developed for Marshall. . . . used by Tech-Etch, Inc. (Massachusetts) since 1969 in manufacture of etched metal parts . . . . components sold to electronic manufacturers such as Sylvania, Raytheon, IBM. . . annual production cost savings are $5,000. (Office of State Technical Services/TSP, TEF 259, Case No. 27828, 7/77)

A-29 Cryogenic data handbook: compiled for Kennedy. . . . used by American Atomics Corp. (Arizona) to improve cryogenic system design and performance prediction . . . . system used in manufacture of self-luminous light sources used as tubes in digital watches. . . . customers include Texas Instruments and National Semiconductor. . . . saved at least 30 hours in research time; continuing use as a reference document. (TB/TSP, TEF 248, Case No. 8784, 6/78)

+A-30 Fabric handle measurement: method and apparatus developed by Langley to improve selection of flexible materials used for balloons, decelerators, and other inflatable devices. . . . provides quantitative measure of the handle, or "feel," of fabric--qualitative property related to flexibility, compressibility, foldability and pliability. . . . applicable to wide range of flexible materials, such as knits, films, composites and laminates. . . . former NASA employee obtained NASA license and formed TEX-CHAR Co. (Virginia) to market fabric evaluation service to U.S. textile manufacturers. . . . customers include DuPont, Johnson and Johnson, Celanese and Burlington Mills. . . . company also plans to market the equipment, called handlemeters. . . . ability to measure fabric handle very important to textile firms; previously done only by subjective methods, such as vision and touch, and limited to a few general properties. (Personnel/Langley, TEF 766, Case No. A009451, 7/79)

+A-31 Electronic component handling practices: compiled for Johnson. . . . review of procedures, materials, and equipment for safe handling of MOS circuit elements and other electrostatic-sensitive devices (EDS's). . . . used by The Upjohn Co. (Michigan) in designing equipment for new pharmaceutical facility . . . . reduced potential for particulate contamination by reducing electrostatic charge build-up on stainless steel pumps used to fill containers with drugs. . . . expected benefits include 10-25% reduction in drug contamination problems when facility becomes operational in January 1980. (TB/TSP, TEF 726, Case No. STIF-83493, 5/79)

+A-32 Thermodynamic and material property estimation methods: developed by JPL . . . . enables estimation of thermodynamic critical constants and viscosity for many substances from their molecular structure and chemical composition; also, molar volume and expansion of polymers can be estimated from glass transition temperature of polymer and available tabulated data. . . . new methods replace expensive, time-consuming laboratory procedures. . . . used by ESB Ray-O-Vac Corp. (Pennsylvania) to develop procedures for selecting suitable organic liquids for "button cell" battery products. . . . batteries used in watches and pacemakers. . . . information saved approximately 450 hours of engineering time. . . . used by Hoffman-La Roche, Inc. (New Jersey) to design equipment for new chemical plant. . . . information on physical constants of chemicals essential in selecting pipe diameters, pumps, and heating or cooling mechanisms. . . . company manufactures pharmaceuticals (largest producer of vitamins in world), hair care products, and animal health products; annual sales of $500 million. (TB/TSP, TEF 767, Case Nos. A009452, A010578, 8/79)

A-22 Data transmission bidirectional system: developed for Johnson. . . . method for transmitting two signals simultaneously in opposite directions on one line. . . . used by Allen Science Research, Inc. (North Carolina) in designing instrumentation, automation and control system products. . . . reduced number of wires between control computers and automation systems. . . . method applied in several custom-designed systems to date; incorporation into a standard product line anticipated. . . . systems used to control production in textile mills. (TB/TSP, TEF 671, Case No. 123104, 10/78)

A-23 Aluminum alloy data handbooks: developed for Marshall. . . . design properties for five aluminum alloys. . . . used by A.M. Castle and Co. (California) to help customers solve fabrication problems. . . . company sells aluminum alloys mainly to manufacturers of lawn care equipment, cookware. . . . over 11 million pounds sold annually. . . . handbooks increased sales and technical capability. (Trade journal/TSP, TEF 685, Case No. 104310, 5/77)

A-24 Compressible fluid flow parameters: developed for Kennedy. . . . used by Tennant Co. (Minnesota) to improve the design of a vacuum floor sweeper product. . . . increased vacuum without increasing engine power. . . . sweeper being marketed for commercial, household uses. (TB/TSP, TEF 684, Case No. 113508, 4/77)

A-25 Inconel Alloy 718 data handbook: compiled for Marshall. . . . used by National Distillers and Chemical Corp., U.S. Industrial Chemicals Co. Div. (Illinois) . . . . data on corrosion properties and high pressure characteristics used for quality assurance analysis of vessels and piping made of the alloy. . . . vessels used in production of perfume quality odorless alcohol for men's cosmetics. . . . over 100,000 gallons produced monthly. (TB/TSP, TEF 537, Case No. 104098, 5/77)

A-26 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by Scott Paper Co., Foam Div. (Pennsylvania) to help design pressure cylinder component of production equipment for reticulated polyurethane foam product. . . . customers use foam as filtering material in home air conditioners and lawn mowers. . . . manual reduced equipment design time several days. (TB/TSP, TEF 384, Case No. 53257, 5/77)

A-27 Materials flammability in oxygen environments: analyzed by Marshall. . . . flame propagation rates and flammability ratings for almost 1,000 commercial materials, including 170 commonly used for electrical harnesses, connectors and potting compounds. . . . results used by AMP, Inc. (Pennsylvania) to increase safety of electrical cable connector products. . . . provided evaluation data for meeting Underwriter Laboratory standards on plastics flammability in home appliances. . . . company sales approximately $1 billion per year. (TB/TSP, TEF 659, Case No. 120866, 10/78)

Other Relevant Examples:

B-9 (lubricant deposition process); B-19 (flammability tests of home furnishings); B-23 (spun metal fibers for web filters); B-28 (sports stadium); B-31 (paint production); B-42 (process equipment seal); C-5 (fabric metallizing process); C-13 (sports and recreational equipment); F-2 (product safety); F-9 and F-19 (food processing); F-13 (anti-fog); H-11 (automobile fuel R&D); I-5 (home safety product); I-12 (performing arts hall); I-27 (sound insulation compound); K-3, K-4, K-5 and K-6 (automobile design and production); K-7 (studless winter tires); K-9 (automotive diagnostic equipment); S-14 and S-15 (outboard motors)

B

MANUFACTURING CAPITAL GOODS

B. MANUFACTURING CAPITAL GOODS

B-6 Surface finishing method for nickel alloys: developed for Marshall. . . . standard process at Westinghouse Electric 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, 4/79)

B-7 Inert-gas welding enclosure: developed by Lewis. . . . used by Communications Satellite Corp. (Maryland) to fabricate microwave components for satellites and ground stations. . . . made it possible to use very lightweight metals for components and reduce production time tenfold. . . . continued use in R&D laboratory. (TB/TSP, TEF 189, Case No. 19795, 10/78)

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. . . . about 200 sold to date; current base price ranges from $50,000 to $70,000, can cost up to $120,000 with additional options. . . . fluidic controls are half the cost of electric controls, also more reliable and maintainable. (TUO conference, TEF 193, Case No. 101902, 10/78)

B-9 Lubricant deposition process: developed for Goddard Orbiting Solar Observatory program by Ball Corp., Ball Aerospace Systems Div. (Colorado). . . . process commercialized in 1969 by BBRC into VacKote line of several hundred lubricant products. . . . company holds several patents on lubricant variations. . . . sales derived from products and lubrication service. . . . over 300 industrial customers. . . . 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, 5/77)

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. . . . also used to test other alloys and nonmetallic materials, such as ceramics and metal-oxides, used in high temperature applications. . . . product quality improved through reduction in structural failures. (Professional society, TEF 451, Case No. 101901, 6/79)

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. . . . regularly used as input to computer analysis for solving hundreds of problems each year. (TB/TSP, TEF 321, Case No. 32416, 12/77)

B. MANUFACTURING CAPITAL GOODS

+B-1 Paragraph deleted, 9/79

B-2 Infrared scanner and television display: operational unit developed for Marshall. . . . contractor employees founded Dynarad, Inc. to market unique product line of IR scanners. . . . units display heat picture on TV screen . . . . over $2 million in total sales, unit price ranged from $6,500 to $25,000. . . . customer applications included 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. . . . company and product line sold to Inframetrics, Inc. (Massachusetts) in 1975. . . . improved version de-
+ veloped and several models now being sold at prices ranging from $27,500 to $51,000. . . . customer applications include detection of building heat loss and inspection of industrial and military instrumentation. . . . annual company sales are proprietary. (Personnel/contractor, Purchased product line, TEF 398, Case Nos. 70001, 112249, 8/79)

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 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. . . . used multiple transducers for significant improvement in speed and accuracy
+ . . . . more than 25 manufacturers purchased between 1 and 100 Manipulators at $800 each before production ceased. . . . larger number of firms fabricated in-house versions. . . . used for quality control inspection of aircraft components and steel pipe manufactured for petrochemical applications. . . . delta technique still used in auxiliary product for company's primary ultrasonic instrument product, a Reflecto Scope. . . . auxiliary unit sells for $3,000; 3-5 sold annually. (Contractor, TEF 387, Case No. 59201, 8/79)

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. . . . benefits expected to continue. (TUO conference, TEF 381, Case No. 57802, 11/78)

B-5 Contamination control handbook: compiled for Marshall. . . . used at Xerox Corp., Microelectronics Center (California) to improve contamination control in production of computer hardware and peripherals, such as disc files, and to develop procedural guidelines for clean room personnel. . . . important applications in microelectronics research. . . . guided development of procedures for high purity water systems and toxic gas delivery systems in Xerox facility. . . . reduces research time 8-10 hours per week, allowing several hundred dollars per week in labor savings. . . . other benefits include reduced clean room costs and significantly reduced quality control failure rate caused by contamination. (TB/TSP, TEF 262, Case No. 33050, 9/78)

B-19 Flammability tests of home furnishings: conducted for TTD by Battelle Columbus Laboratories to compare performance of aerospace materials with conventional furnishing materials in full-scale bedroom fires. . . . report used
+ by Monsanto Co.'s Fire Safety Center (Missouri) from 1975 to 1977 to design flammability tests for fire retardant chemicals and other company products used in the construction industry. . . . Center phased out in 1977 after all full-scale fire tests completed. . . . 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. . . . results recently used in marketing of wall panel and ceiling products. . . . valuable reference; benefits expected to continue. . . . also 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. . . . use expected to continue. (Contact/contractor, NTIS, TEF 539, Case Nos. 107043, 107044, 107046, 7/79)

B-20 Electronic power dividers and switching components: developed for Johnson Apollo communications systems by Transco Products, Inc. (California). . . . applied to commercial products by Transco. . . . enabled design of compact, hermetically sealed, highly reliable electronic components. . . . applications in aerospace and nonaerospace microwave communications equipment. . . . average annual sales of $10 million during past three years. (Subcontractor, TEF 562, Case No. 109336, 7/78)

B-21 Standards for material handling equipment testing: developed for Johnson
+ . . . . used on a continuing basis by Goodyear Atomic Corp. (Ohio), DOE 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. . . . one of three UF_6 diffusion facilities 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, 4/79)

B-22 Apollo Program management techniques: developed for Johnson by Rockwell
+ International Corp., Space Div. . . . used by RI's Mass Transit Div. (formerly Rockwell-Standard) (Michigan), major producer of truck and bus components such as axles and brakes, 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 $1.5 billion. . . . also implemented by Resistoflex Corp. (New Jersey) as part of subcontract requirements with RI. . . . company subsequently applied management identification and traceability techniques in production of tube fittings for military and commercial aircraft. . . . benefits include improved quality control . . . . company also implemented regular formal design reviews on basis of NASA experience. (Personnel/contractor, Subcontractor, TEF 573, Case Nos. 109337, A008595, 6/79)

B-12 Weld strength prediction method: developed for Marshall. . . . used at Eastman Kodak Co. chemical plant (Tennessee) to improve safety at little cost . . . . reduced hazard of rupturing pipes that contain chemicals. . . . also, information has been incorporated into company's maintenance procedures. (TB/TSP, TEF 359, Case No. 41946, 9/78)

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. . . . in mid-1970's, product 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. . . . currently, semiconductor industry is primary customer for flowmeters and flow controllers. . . . over 5,000 units sold each year at an average price of $500 each. . . . since initial NASA market in 1965, growth in annual sales from $300,000 to almost $3,000,000, employment up from 20 to 80. . . . majority of business based on fallout from Apollo Program. (Subcontractor specifications, TEF 563, Case No. 109332, 7/78)

+B-15 Paragraph deleted, 9/79

B-16 Paragraph deleted, 10/78

B-17 Temperature and solvent resistant sealant: developed for Marshall. . . . used by Weed Instrument Co. (Texas) to develop sensing component for new temperature control product. . . . enabled identification of sealant which maintains high purity of platinum wire sensor. . . . product varies in price from $23 to $2,000, depending on complexity; sales led to substantial increase in annual revenue (expected to reach $1.75 million in 1978). . . . purchased by various industries to control temperature of plant process equipment. (TB/TSP, TEF 541, Case No. 90086, 10/78)

B-18 Guidelines for fabrication of hybrid microcircuits: compiled for Marshall
+ . . . . used on regular basis since 1974 by Watkins-Johnson Co. (California), manufacturers of microwave communications systems, to improve processing techniques in assembly of microcircuits. . . . benefits include improved product quality and production yields, increased marketability and sales . . . . 1979 sales up 80% over 1978, and annual increase of 50% expected over next 3 years due to demand for microwave microcircuits. . . . units priced from $50 to $1,000, with average sale at $200; 180,000 units expected to be sold in 1979. . . . used routinely by "R" Engineering (California) for production line start-up and solving production problems for solid-state relay products. . . . use of manual expected to continue. (TB/TSP, TEF 501, Case Nos. 83967, 101726, 6/79)

B-29 Visual simulation system: 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 for approximately $450,000 each. . . . IMAGE 100 no longer marketed as a separate product, but still used by GE in its commercial data processing services for same applications. . . . services, offered through GE's Digital Image Analysis Laboratory, include standardized interactive analysis for $250/hour as well as custom processing. . . . customers include government agencies and private companies engaged in natural resource management. (Contractor, TEF 389, Case No. 109340, 4/79)

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 the shelf life of rubber components and products containing plastics such as floor coatings and polishes. . . . also used to educate customers on the need for replacement schedules for age-sensitive components. . . . customers include food processing plants, steel and aluminum fabricators, warehouses, state and municipal governments, hospitals and airports. . . . benefits to Tennant include cost and time savings; customers benefit from reduced production downtime. . . . company's annual sales currently $80 million. (TB/TSP, TEF 457, Case No. 69356, 4/79)

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. . . . was formerly 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, 5/77)

+B-32 Paragraph deleted, 9/79

B-33 Paragraph deleted, 10/78

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. and supplied to Apollo Program contractors. . . . company now the Hydraulic Research Div. of Textron, Inc. (California). . . . filters commercially available from HR since 1971; currently comprise 80% of annual nonaerospace sales. . . . unit price ranges from $50 to $25,000; average sales at $200 per unit. . . . annual sales have grown from $500,000 in 1975 to $4 million; market size expected to increase 30% annually. . . . 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, 10/78)

+B-24 Paragraph deleted, 9/79

+B-25 Paragraph deleted, 9/79

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 and two modifications for an optical scanning probe product. . . . probes sell for $100,000 to $250,000 . . . . used to align control surfaces of aircraft by U.S. Air Force and commercial manufacturers including Boeing Co., McDonnell Douglas Corp. (TB/TSP, TEF 529, Case No. 99316, 5/77)

B-27 Paragraph deleted, 1/78

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. . . . annual sales of "air film systems" currently $3 to $4 million and expected to double in 1979; cost per system ranges from $1,000 to over $300,000. . . . product applications include: assembly line movement of heavy components, such as Allis-Chalmers crawler tractors, Caterpillar earthmovers and Boeing 747 cargo holds; equipment transport, such as American Bakeries bread racks and transformers in Mexico; 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, 10/78)

B-39 Photodiode design methods: developed by Ames. . . . two methods used by Hewlett-Packard Co., Optoelectronics Div. (California) to improve knowledge of performance characteristics for photodiode product line. . . . one method used to characterize 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 through broader applications for photodiodes, and increased capacity to meet customer requirements. (Personal contact/Ames, TEF 595, 604, Case Nos. 114471, 114472, 10/78)

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 concept to develop new product line of nickel-iron cut cores. . . . cores sell for $6 to $167 each, depending on size and quantity ordered. . . . major customers include Raytheon, General Electric and TRW . . . . sales approximately $100,000 per year. . . . data also used to produce company brochure on transformer materials selection. . . . benefits include wider range of market segments and enhanced reputation in transformer component market. (Personal contact/JPL, TEF 597, Case No. 114474, 10/78)

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. (Pennsylvania) to produce new line of gas chromatograph analyzers for industrial process control. . . . Honeywell also obtained a NASA license to use the basic invention. . . . product line features faster analysis time, greater reliability, simpler operation and reduced maintenance. . . . 3 models currently available at prices ranging from $7,500 to $40,000, depending on complexity. . . . Honeywell controls over 20% of national market for such products. . . . customer benefits include conservation of utilities, improved quality and process controls and reduced product waste. . . . industrial control applications include petrochemicals, steel, pharmaceuticals, food processing, coal gasification and oil shale. (Purchased product line, TEF 144, Case No. 114854, 6/79)

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 and formed Ferrofluidics Corp. (Massachusetts) to develop new product line of ferrofluidic seals, materials and dampers. . . . products include: Ferrometic^{R} rotary vacuum seals, exclusion seals for computer disk storage units, ferrofluids for loudspeaker drivers, and inertia dampers for stepper motor applications. . . . customer applications include production equipment for electronic components, analytic instrumentation, machine tools, medical equipment, computer peripherals and sound systems. . . . company employs 65 people, sales figures are proprietary. (Personnel/contractor, TEF 607, Case No. 114870, 8/79)

B-34 Connector seals for cryogenic fluid lines: developed by Goddard. . . . Cryolab, Inc. (California) acquired a 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 to $3,000 in 1975; in 1978, sales reached $10,000 and are expected to be at same level in 1979. . . . most seals now available by special order at retail prices of $63 for aluminum seals and $74 for stainless steel seals. . . . customers include Rockwell, Rocketdyne, Hughes Aircraft, Union Carbide, UCLA, and goverment laboratories. (TB/TSP, TEF 354, Case No. 49067, 4/79)

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 initially to produce a four-model line of automated tube flaring machines; concept still in use, but product line reduced to 3 models. . . . retail cost ranges from $11,900 to $20,000 each. . . . machines purchased primarily by the government and some 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. . . . major application by the U.S. Navy on aircraft. . . . company spokesman estimates Navy may be saving millions of dollars in time and materials. (License/contractor, TEF 52, Case No. 114858, 8/78)

B-36 Paragraph deleted, 10/78

B-37 Eddy current nondestructive testing training manuals: developed for Marshall. . . . manuals published by contractor (Convair Div. of General Dynamics) 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 . . . . benefits expected to increase. (Professional society, TEF 14, Case No. 114855, 12/77)

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 remove sulfur from waste gases emitted from chemical plants. . . . principal customers are major oil companies. . . . since ~~1974, program~~ used in design of 10-20 plants at engineering design costs ranging from $10,000 to $100,000. (Personal contact, TEF 463, Case No. 104279, 7/79)

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. . . . 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. . . . new bag marketed in 2 basic models: a trash bag selling at average price of $16, and a hotel/motel line selling at average price of $15 per bag. . . . used by most of the major building maintenance firms, such as Bekins, and commercial lodging companies, such as Holiday Inn and Sheraton Lodges. . . . bag for bulk handling of clay-like refuse recently developed for a mining firm; average price per bag $80 . . . . ease in handling material enabled firm to cut cost and reduce product price by $10 per ton over competitors. . . . TRS also developing bag for underwater salvage industry. . . . annual sales figures proprietary. (Subcontractor, TEF 615, Case No. 117156, 10/78)

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 $1,100, and annual sales have been between $20,000 and $25,000. . . . sales expected to continue. . . . applications include fabrication of precision components and preparation of metallurgical specimens for analysis. (Former NASA employee, TEF 11, Case No. 119301, 5/79)

B-51 High-temperature strain measurement system: developed for Dryden 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. . . . 1978 sales totaled $200,000. . . . used in electric power plants and oil refineries to monitor stress in boilers, pipes and valves. (License/contractor, TEF 637, Case No. 119304, 7/79)

+B-43 Paragraph deleted, 9/79

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 pro-
+ posed circuit for a satellite transponder. . . . customers include Lockheed (builds satellites for the USAF) and General Electric Co. . . . saved approximately $500 in research effort. . . . handbook continues to be used as a reference source. (Personal contact/TSP, TEF 623, Case No. 112272, 7/79)

+B-45 Paragraph deleted, 9/79

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 customer inquiries on the safety of using TCE in the degreasing of aluminum parts. . . . chlorinated solvent used for commercial clothing and metal cleaning. . . . use of information improves customer relations. . . . benefits expected to continue. (TB/TSP, TEF 619, Case No. 111778, 10/78)

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. . . . over 100 units sold annually at prices ranging from $385 for a 1/4-in small hydraulic flow meter to $15,000 for a 54-in line size used for water service. . . . 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, 7/79)

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,
+ 13,500 units have been sold. . . . basic model retails for $48.50. . . . cable stripper marketed through direct advertising, sales representatives, and distributors. . . . customers currently include TV stations, manufacturers of citizen band radios and the U.S. Navy. (Personal contact/Ames, TEF 60, Case No. 52691, 4/79)

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 about 6 models of the transmitting element, called Pinger, at prices ranging from $400 to $700 and 2 models of the receiver at prices of $3,000 to $5,000. . . . 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. . . . current annual sales figures are proprietary. (Contractor, TEF 4, Case Nos. 117158, 117159, 10/78)

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. . . . product introduced in January 1976; currently, 200 sold annually at $480 each. . . . generator used by technicians for signal detection when repairing and servicing electronic equipment . . . . benefits include reduced R&D costs by approximately $100 and increased sales. . . . company products used mainly for teaching electronics in schools. (TB/TSP, TEF 629, Case No. 114740, 7/79)

B-58 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 such as 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. . . . units range in price from $30,000-$40,000 each . . . . used primarily by petrochemical and pharmaceutical industries for monitoring numerous production processes, including hydrogen, ethylene, ethyl alcohol, ammonia, vinyl chloride, sulphur hexafluoride and carbonyl sulfide. . . . market expected to expand. (Contractor, TEF 656, Case No. 121462, 8/79)

+B-59 Paragraph deleted, 9/79

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 pro-
+ duced in different sizes and sold for approximately $470, depending on pipe size. . . . new version, called "Split Delta-T," recently introduced; two-part instrument provides greater flexibility. . . . price of new unit depends on configuration, most sell for about $500. . . . annual sales of $40,000 in early 1970's, increased to $100,000 in 1978. . . . transducers 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, university and private laboratories. (Personnel/Ames/License, TEF 222, Case No. 119300, 6/79)

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 recommended to customers who do precision welding. (TB/TSP, TEF 626, Case No. 105576, 10/78)

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 DOE's nuclear reactor program. . . . saved research time and approximately $500 in outside laboratory testing costs. . . . also used by Ball Corp., Ball Aerospace Systems Div. (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. . . . also used by SIMCO, Inc. (South Carolina) to identify alloy scrap. . . . company processes scrap metal. . . . annual company sales over $3.5 million. . . . tests save $3,000-$5,000 per year in reduced time and outside testing expense. (TB/TSP, Personal contact/TSP, TEF 378, Case Nos. 44734, 56616, 114830, 3/77)

+B-55 Paragraph deleted, 9/79

B-67 Wing design concepts and Propeller parametric performance data: developed
+ by Langley. . . . used by Brod & McClung-Pace Co. (Oregon) in design of fan product line for heating and ventilating in commercial and industrial applications. . . . Langley results described as critical in design of airfoil fans which account for 50% of fan sales, or almost $1,000,000 annually. . . . applications include air pollution control, venting and fruit drying. . . . total annual sales of $13 million, 265 employees for various HVAC systems produced by company. (Langley Publications, TEF's 631, 639, Case Nos. 120515 120516, 8/79)

B-68 Bioastronautics data book: prepared for Headquarters by U.S. Navy contractor. . . . design factors for manned systems support equipment. . . . used by Eastman Kodak Co., Tennessee Eastman Co. (Tennessee) to improve working conditions and productivity in unheated plant areas. . . . information on cold, wind velocity, protective clothing led to installation of wind shielding devices on 50 warehouse fork lifts. . . . increased productivity by reducing number of work stoppages for operator warm-up. . . . also, lowered warehouse operating costs. (Personal contact/SP, TEF 665, Case No. 121869, 10/78)

B-69 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 Eastman Kodak Co., Tennessee Eastman Co. Div. (Tennessee) in designing buildings and production equipment for chemicals, plastics, and fibers. . . . program used for analysis of stress in piping systems, wind load on exhaust stacks, and vibration of processing equipment. . . . many engineering hours, thousands of dollars
+ in equipment costs saved. (Personnel/TSP, TEF 410, Case No. 121868, 6/79)

B-70 Numerical method for fluid dynamics: developed by Ames. . . . provides set of approximate solutions for nonlinear fluid flow problems. . . . used by General Electric Co., General Purpose Controls Dept. (Illinois) in analyzing laboratory test results for a new motor starter product. . . . provided better understanding of flame front propagation properties for the hazardous operating environment. . . . calculation time reduced and $5,000 saved in testing costs. . . . starter is a "high volume item" in company product line; sales data proprietary. (Personal contact/TSP, TEF 666, Case No. 115170, 10/78)

B-71 Temperature sensor with direct readout: developed for Langley . . . . used
+ by Logical Technical Services Corp. (New York) to design new product line of digital thermometers and multimeters with LED display. . . . $10,000 saved in product design and testing. . . . approximately 100-150 instruments sold annually at prices ranging from $225 to $325. . . . customers include commercial and government electronics laboratories, universities and hospitals . . . . Federal Aviation Administration purchased 150 units to test airport electronics equipment. (Contractor/TSP, TEF 668, Case No. 122587, 8/79)

B-72 Microelectronic wire bond testing: developed for Marshall . . . . used by Inter-Logic Systems Co., Inc. (California) as reference to provide applications and service information to customers. . . . company sells microcircuit wire bonding equipment to manufacturers of integrated circuit components used mainly in cable TV and radio equipment. . . . helped increase sales. (TB/TSP, TEF 661, Case No. 120756, 1/78)

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. . . . small transformers account for 95% of company's product line; 75,000 to 130,000 produced annually. . . . handbook formulas now run on small calculators; reduces time needed to obtain design data. . . . company has current annual sales of $4.4 million. (TB/TSP, TEF 547, Case No. 99844, 7/79)

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 tele-
+ phone companies. . . . provides parallel modules so that if one fails, second unit takes over; also, reduces downtime due to component failure. . . . technology reduced subsystem development costs substantially. . . . HICOM product line sold to Harris Corp., RF Communications Div. (Colorado) in 1977. . . . to date, 20-25 systems sold at prices ranging from $750,000 to $2.5 million . . . . customers include regional subsidiaries of AT&T such as Mountain Bell and Northwest Bell. (TB/TSP, Purchased product line, TEF 645, Case Nos. 86548, A010794, 9/79)

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 Div. (Indiana)
+ to solve TIG welding problem. . . . modified TIG welder used since 1975 to weld small parts; 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, 6/79)

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. . . . 250 units sold annually at $5,000 each. . . . also used to solve lubrication problem in a washability tester manufactured for Gardner by a subcontractor. . . . about 100 testers sold annually at an average price of $650 each. . . . used by Eastman Kodak Co., Tennessee Eastman Co. (Tennessee) as reference for plant maintenance. . . . contributes to better maintenance, greater equipment reliability. . . . over 10 hours engineering time saved each year since 1974. (TB/TSP, TEF 497, Case Nos. 93222, 97564, 8/78)

+B-64 Paragraph deleted, 9/79

B-65 Paragraph deleted, 10/78

+B-66 Paragraph deleted, 9/79

B-80 Wire soldering technique: developed by Marshall. . . . used by Toefco Engineering, Inc. (Michigan) to install and repair nichrome wire heating elements in electric ovens. . . . company operates high temperature ovens to provide coating service for valve and sprinkler manufacturers. . . . benefits include more than $2,000 annual savings in production costs. (SBA/TSP, TEF 696, Case No. STIF-63895, 12/77)

B-81 Optical alignment training manual: compiled by Marshall. . . . used regularly by Hutchinson Industrial Corp. (Minnesota) to align its production equipment for photo-etching metal components for computers. . . . provided method for achieving required precision, 10 millionths of an inch. . . . savings in production costs estimated at $3,500 per year. (TB/TSP, TEF 208, Case No. 30342, 7/77)

B-82 Electrical connectors handbook: compiled for Marshall. . . . guide for designers in selecting electrical connectors according to "total system" concept; includes information on types of connectors, electrical performance and mechanical requirements, and environmental considerations. . . . used by Hughes Aircraft Co., Missiles Div. (California) in selection of connectors for satellite-controlled missile guidance system being developed for the U.S. Air Force. . . . system required over 500 high reliability connections. . . . saved one week of engineering research time. (TB/TSP, TEF 732, Case No. A007889, 10/78)

B-83 Metal-glass fluoride lubricant coating: developed by Lewis. . . . improved, high-temperature, self-lubricating plasma-sprayed coating. . . . commercialized by Hohman Plating and Manufacturing Co. (Ohio), under nonexclusive license, as Surf-Kote C-800. . . . has service range from -200°F to 1600°F . . . . reduces wear and prevents galling and seizure for loads under 10,000 lbs psi. . . . applications include hot glass processing machinery, mechanical seals and rings for pumps, compressors and turbines. . . . customers include Machlett Laboratories, Picker Corporation and General Electric. . . . simpler and faster process than previous methods. . . . sales expected to increase. (License/TSP, TEF 748, Case No. A008059, 10/78)

B-84 Microcircuit seal failure study: conducted for Marshall to eliminate circuit failures in Saturn hardware. . . . identified electroless chemical reduction of lead in glass seals of microelectronic packages as probable cause of failures. . . . study report used by Harris Corp., Government Information Systems Div. (Florida) to determine cause of electrical shorts in semiconductor products sold to manufacturers of military hardware. . . . saved considerable research effort by eliminating need to perform in-house failure analysis. . . . semiconductors redesigned and repackaged; improved compliance with stringent quality control standards. (Personal contact, TEF 747, Case No. A008058, 10/78)

+B-73 Paragraph deleted, 9/79

B-74 Heat pipe applications: developed for Lewis and Langley by Hughes Aircraft Co. . . . commercialized by Hughes in several sizes to cool electronic parts
+ and recover heat. . . . used by Hughes Thermal Products Dept. (California) to develop heat recovery product, HeatBank™. . . . captures waste heat from high temperature furnaces to preheat air coming into furnaces, increasing the overall efficiency for process heat to about 60%. . . . production rights for HeatBank™ sold to Torin Co., Applied Products Div. (Michigan) in 1978. . . . 3 models currently available, T15, T30 and T40 Series; price ranges from $0.50 to $1.50 for each cubic foot per minute of capacity. . . . applications include paint drying ovens, metal die castings, heat treating or brazing furnaces, chemical reactors, petroleum refining and food drying . . . . specific sales figures not yet available, although Torin currently selling an average of one system per week. (Contractor, Purchased product line, TEF 197, Case Nos. 109343, A010334, 8/79)

B-75 Wire harness manufacturing techniques: four standard reference handbooks prepared for Marshall. . . . data on wire and cable preparation, fabrication, installation and quality control. . . . routinely used by Hewlett-Packard Co., Instrument Group, Colorado Springs Div. (Colorado) to determine appropriate methods for attaching cables to various instrument products. . . . group manufactures oscilloscopes, cathode-ray tube displays and logic analyzers used in research and various industries. (TB/TSP, TEF 536, Case No. 94140, 4/77)

B-76 Paragraph deleted, 10/78

B-77 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. . . . North American Manufacturing Co. (Ohio) obtained a non-exclusive NASA license and used the circuit design information to improve its combustion control products. . . . improvements increase energy efficiency of furnaces used for industrial space heating, copper smelting and iron and aluminum shaping. . . . energy savings estimated at 5% to 10% . . . . approximately 60 control units sold at $1,000 each. . . . market expected to increase. (TB/TSP, TEF 622, Case No. 115974, 6/77)

B-78 Elastic material cutter: developed by JPL. . . . cuts elastic accurately, leaves cut surface flat. . . . used by Stewart-Warner Co., Thor Power Tool Co. Div. (Illinois) to cut noise insulation and protective materials for pneumatic tool products. . . . insulation used to dampen jackhammer noise . . . . protective material used around handle of nut setting tool sold primarily to automotive manufacturers. . . . saves about $500 per year in production costs. (TB/TSP, TEF 681, Case No. 108398, 4/77)

B-79 Electric motor heater: developed for Kennedy. . . . used by Midwestern Electric Co., Inc. (Wisconsin) to design a similar heater. . . . heater rented to customer for drying out and restoring several milling machine motors in reactivated rolling mill. . . . heater now available for rent to other customers. . . . benefits include $5,000 savings in engineering time. (TB/TSP, TEF 691, Case No. STIF-66155, 12/77)

+B-89 Electronic component handling practices: compiled for Johnson. . . . review of procedures, materials, and equipment for safe handling of MOS circuit elements and other electrostatic-sensitive devices (ESD's). . . . used by Compugraphic, Inc. (Massachusetts) to improve in-house handling practices for components used in word processing and photocomposition equipment products. . . . achieved significant reduction (20-30%) in failure rate of microelectronic chips used in integrated circuit components by adopting recommended practices and retraining employees. . . . company employs 3,600 people in 11 plants and has annual sales volume of $260 million. (TB/TSP, TEF 726, Case No. STIF-83390, 5/79)

+B-90 Calculating wire-bundle diameter: developed for Johnson. . . . rapid, accurate calculation method which allows closer sizing of brackets and clamps needed to hold wire harnesses in place. . . . used by TRW Systems (California) in recent update of in-house standards manual for its Cable Design Section . . . . benefits include rapid verification of numbers in designer specifications. . . . manual used routinely by 30 members of Section; also serves as a reference document for another 100 company employees. (TB/TSP, TEF 758, Case No. VANONESPAC, 2/79)

+B-91 Wire selector/calculator: developed for Johnson to facilitate selection of most appropriate gage and type of wire for the Space Shuttle (40,000 separate wires required). . . . used routinely by Martin Marietta Corp., Denver Div. (Colorado) in specifying new wiring systems for plant facilities. . . . allows Facilities Dept. to reduce wire selection time by 50%. . . . increases confidence in selection because NASA requirements more stringent than state or local building codes. (TB/TSP, TEF 754, Case No. GEA5190WLA, 1/79)

+B-92 Thermodynamic and material property estimation methods: developed by JPL . . . . enables estimation of thermodynamic critical constants and viscosity for many substances from their molecular structure and chemical composition; also, molar volume and expansion of polymers can be estimated from glass transition temperature of polymer and available tabulated data. . . . new methods replace expensive, time-consuming laboratory procedures. . . . used by El Paso Products Co. (Texas), a petrochemicals manufacturer, to estimate physical constants required by in-house computer program. . . . program used to design new petrochemical processing equipment. . . . simple, accurate method saves several hours engineering time; use expected to continue. . . . used by Structural Composites, Inc. (California) to assist in determining appropriate mix ratio for resins used to form filaments for filament-wound pressure vessel products. . . . lightweight pressure vessels used in breathing apparatus for firemen, aircraft escape slide systems and helicopter flotation systems. (TB/TSP, TEF 767, Case Nos. A010535, A011265, 8/79)

+B-93 Deflection amplifier for image dissectors: developed by JPL for use in celestial navigation systems. . . . symmetrical deflection amplifier provides precise control of image definition. . . . used by Pako Corp. (Minnesota) to upgrade the circuitry in standard oscilloscopes which are used in-house for production quality control. . . . increased accuracy of oscilloscopes and saved two days of engineering time during redesign effort. . . . oscilloscopes used for quality analysis of computer control system product. . . . control systems are sold to photoprocessors for monitoring and controlling the temperatures of chemicals and for identifying individual rolls of film as they are being processed. (TB/TSP, TEF 771, Case No. A009456, 7/79)

B-85 Solid polymer electrolytes: developed as part of spacecraft (e.g., Gemini) fuel cells for Johnson by Du Pont and General Electric Co. . . . used by GE (Massachusetts) to develop a hydrogen generator product. . . . usual operation for fuel cells is reversed so that water and electricity are consumed to produce oxygen and very pure hydrogen (99.998%). . . . laboratory scale production rates (220 cc/minute) for up to two weeks without maintenance . . . . over 1,000 generators sold at $1,595 each. . . . customers obtain purer hydrogen with fewer hazards than from bottled hydrogen. . . . GE now testing a larger scale unit (236,000 cc/minute) as a potential product; also cooperating with U.S. Department of Energy and a consortium of private and public organizations to develop bulk production units (over 10,000 scf/hour) for chemical and transportation uses of hydrogen. (Contractor, TEF 738, Case No. A007893, 10/78)

+B-86 Rotational vibration analysis methods: developed for Marshall and Lewis by the University of Virginia, Mechanical and Aerospace Engineering Dept. . . . includes new mode and computer models for analyzing aircraft and spacecraft . . . . used by same researchers in the University's Industrially Supported Program for the Dynamic Analysis of Turbo-Machinery. . . . provides client firms with accurate design data for specific machines based on data such as shaft diameter, shaft length, and the natural frequency during operation . . . . provides client firms with accurate design data for specific machines based on data such as shaft diameter, shaft length, and the natural frequency during operation. . . . reduces design errors and improper operation of turbomachinery; end users of machinery save about $250,000 per machine in operating expenses. . . . industrial sponsors who have benefited from the program include: Bryon-Jackson Co., which produces water pumps for nuclear reactors; Ingersoll-Rand Corp., which produces compressors; vibration instrumentation manufacturers such as Bently-Nevada and Spectral Dynamics, Inc.; vibration consulting groups such as Structural Dynamics Research Co.; and turbo-machinery users such as Monsanto Chemical Co. and Union Carbide. (Contractor, TEF 658, Case No. 121463, 8/79)

+B-87 Composite materials data: compiled for Marshall. . . . used by Babcock and Wilcox Co. (Ohio) in designing new graphite composite product lines. . . . one product, called Nil-Cor, is a composite ball valve designed for use in high temperature and severely corrosive environments. . . . valve ranges in size from one to four inches and in price from $300 to $2,000. . . . can replace valves made with exotic alloys, such as nickel or titanium. . . . valves used in chemical processing, pulp and paper, and basic metals industries. (Trade journal/TSP, TEF 490, Case No. 87986, 3/79)

+B-88 Counting digital filter: developed by JPL. . . . includes variations for optimizing speed, precision or cost. . . . new basic concept for digital filters; applies new approach for numerical representation of data. . . . used by RCS Associates, Inc. (California), a small electronics consulting firm, during design of a computerized control system for silicon wafer cutting and grinding machinery. . . . information saved engineering time and considered valuable input to design effort. (TB/TSP, TEF 774, Case No. A010285, 7/79)

+B-94 Integrated circuit design system: developed by Marshall and by RCA Corp. (New Jersey) under contract to Marshall. . . . computer-based design system includes software, interactive display, and a library of previously developed basic circuits which serve as the building blocks in creating new, custom-designed circuits. . . . automated system provides logic simulation, performance analysis, test sequences, and tape output for generating photomasks used to produce circuit. . . . adopted and refined by RCA to develop in-house system for designing large-scale integrated (LSI and VLSI) circuits to customer specifications. . . . provides major cost reduction in custom design work; LSI and VLSI design time reduced from 6-12 months to 1-3 months. . . . over $1 million in cost savings and increased contract revenue due to shorter design time. . . . applications for company's LSI and VLSI circuits include helicopter control systems, auto emission controls and RCA communication systems. (Contractor, TEF 761, Case No. A009019, 4/79)

+B-95 Power factor controller: developed by Marshall. . . . electronic control circuit that can be added to AC induction motors to conserve energy. . . . raises power factor from 0.2 to 0.8 by reducing voltage to motor during partial load operation. . . . achieves 10-20% reduction in electrical energy required for variably loaded motors; potentially significant contribution to energy conservation. . . . at least 10 firms have obtained nonexclusive NASA licenses to manufacture this invention, and at least 2 of those firms have developed products and initiated market development. . . . Electronic Relays, Inc. (Illinois) has developed two controller models for industrial motors: one for 1/16-hp motors that sells for $5 and one for 100-hp motors that sells for $1,000 in large quantity lots. . . . company offers several product lines of solid state relays for a variety of industrial uses; has successfully introduced other important innovations in recent years. . . . W.J. Purcell Co. (Ohio) has developed one model, a single-phase controller for industrial motors, and is developing a three-phase model. . . . widespread publicity for this invention is generating many inquiries from potential customers. (TB/TSP, License/TSP, TEF 760, Case Nos. A008646, A008954, 3/79)

Other Relevant Examples:

A-3 (office equipment); A-9 (production machinery lubrication); A-30 (textile evaluation equipment); A-32 (chemical processing equipment); C-1 (energy conservation equipment); D-3 (dispatch computers, electric power); D-6 (nuclear power plant equipment design); D-7 (steam turbine, steam generator and high temperature gas-cooled reactor design); D-9 (nuclear power plant design); D-29 (industrial gas turbine design); E-12 (manufacturing contamination prevention); E-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); 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); I-18 (heating/cooling equipment); I-29 (industrial power tools); J-5 (flat conductor cable); M-3 (production inspector training); M-14 (ball bearing design); M-17 (fabrication tools); M-22 (aircraft and engine design); M-41 (computerized parts list system); N-5 (decontamination procedure); O-4 (soldering school); O-6 (R&QA training); O-7 (instrument training); Q-3 (electron tubes); Q-18 (medical instrument production); R-11 (metal processing hazards); T-11 (valve production)

C

NEW CONSUMER PRODUCTS AND RETAILING

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. . . . annual sales about $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 . . . 15%-20% business in training, educational films . . . . customers include U.S. Navy, Signode Corp., Children's Television Workshop. (SBA/TSP, TEF 436, Case No. 56028, 5/77)

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. . . . used on 160 yachts that competed in the Newport, R.I.-to-Bermuda race. . . . 30 rafts purchased by the U.S. Coast Guard for Antarctic operations; additional rafts recently purchased for D.C.-based Oceanography Dept. . . . other customers include commercial shipping lines. . . . 3 basic models marketed at retail prices ranging from $375 to $1,086 for 2- or 4-person rafts and from $1,018 to $1,937 for 12-person rafts. . . . annual sales total approximately $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, 10/78)

C-8 Chlorate candle oxygen supply: improved for Johnson. . . . Industrial Applications Center provided information on chlorate candle technology to Pyro-
+ netics Devices, Inc. (California). . . . information used to develop portable welding torch product that incorporates chlorate candle oxygen supply. . . . distributed through hardware stores. . . . currently, 3 models available at retail prices ranging from $30 to $60; approximately 30,000 to 40,000 units sold annually since 1972. . . . product weighs 7 lbs and gives a 5,000°F flame. . . . home and hobby applications. (IAC-WESRAC, TEF 466, Case No. 87123, 12/78)

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 system for department store chains. . . . largest supplier of such systems. . . . has installed about 60 on-line computer systems, with over 50,000 point-of-sale (POS) credit authorization terminals connected to these systems. . . . typical system with 1,000 terminals in 250 stores costs about $2 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, 10/78)

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 an Industrial Applications 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 sales initially directed toward home and commercial markets, now directed toward industrial market. . . . 10,000 of these units sold in 1974 at $100 and 15,000 produced in 1977. . . . Thermo-Coil and Isocycle lines marketed mainly to commercial users. . . . products increase heat efficiency by 8-10%. . . . Isothermics capturing large market share early in trend toward energy conservation equipment. (IAC-TAC, TEF 197, Case No. 83601, 12/77)

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 at $700,000. . . . also marketed by SKICO, Inc. (Colorado). . . . annual sales about $6,000. . . . 95% sold for recreational uses. . . . customers include Diving Co. of America which markets under its own label. (Professional journal/TSP, TB/TSP, Trade journal/TSP, TEF 423, Case Nos. 75288, 81856, 81857, 5/77)

C-3 Paragraph deleted, 10/78

C-4 Battery-powered hand tools: developed for Johnson by Black and Decker Manufacturing Co. (Maryland). . . .development included a computer program for designing the Apollo Lunar Surface Drill. . . . program used by B&D in developing improved product line of cordless power tools. . . . improved design of permanent magnet in battery-powered DC motors and reduced power consumption. . . . line includes 3 grass shear models, 2 shrub and hedge
+ trimmers, spot vacuum, light duty drill for hobbyists, and 2 models of professional duty drills. . . . tools range in price from $15 to $89. . . . sales data not available. (Subcontractor, TEF 300, Case No. 33607, 7/79)

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. . . . line of space blankets now marketed under trade names Astrolon and Astrolar; several million sold annually at retail prices of $2-$8 each . . . . coating sells for $3-$5 per pound, depending on thickness . . . . also used for home and commercial wall covering products; customers include General Tire Co., Stauffer Chemicals and Borden's Columbus Coated Fabrics
+ plant. . . . market for wall covering film over $4 million. . . . coated material purchased by Wind-N-Sun Shield, Inc. (Florida) for development of new, heat insulating drapery liner product, marketed under same name. . . . since liner introduced in December 1978, sales have doubled each month and are expected to reach several million dollars annually by 1982. (Contractor, Customer, TEF 160, Case Nos. 37434, A009445, 7/79)

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. . . . approximately 25,000 sold to date; current retail price is $90. . . . used by homeowners, travelers, craftsmen, truckers, and State Highway Patrols in Minnesota, Oklahoma and Missouri. (Personnel/contractor, TEF 561, Case No. 109327, 10/78)

C-16 Lubricant deposition process: developed for Goddard Orbiting Solar Observatory program by Ball Corp., Ball Aerospace Systems Div. (Colorado). . . . process commercialized in 1969 by BBRC into VacKote line of several hundred lubricant products. . . . new product called "Sound Gard" introduced in mid-1976 for use on phonograph records. . . . available through record stores. (Contractor, TEF 201, Case No. 42849, 5/77)

C-17 Inorganic silicate paint: developed by Goddard. . . . formula information
+ used by Sperex Corp. (California) in 1965 to improve new paint product it was developing. . . . heat-resistant inorganic paint, called VHT, sold primarily to automotive and nuclear power plant industries. . . . used on car and truck exhaust systems, fire walls, brake drums, and engine manifolds . . . . paint sold under company name and other labels. . . . VHT sales represent 50% of company's total volume; sold primarily in 16-oz. aerosol cans for $5 each and available in one gallon cans for about $38 each. (SBA/TSP, TEF 34, Case No. 4535, 1/79)

C-18 Tool carrier: developed for Marshall. . . . NASA waived patent to contractor . . . . licensed and commercialized by Hydrometals, Inc., GC Electronics Div. (Illinois) as "Tool Kaddy". . . . special meshing devices allow easy placement, firm retention of tools. . . . worn on workman's belt. . . . customers mainly TV repairmen and antenna installers. . . . over 2,000 sold for almost $5 each since late 1975. (License/contractor, TEF 678, Case No. 123702, 2/77)

C-19 Density slicing equipment: developed by Johnson for analysis of photographs of lunar surface. . . . customized by Spatial Data Systems Co. for free-lance photographer Howard Sochurek (New York). . . . used to develop new electronic art form; produces vivid illustrations of images using up to 310 different colors . . . . illustrations retail for $1,000 to $2,000 each. . . . credits include Time and Newsweek covers, National Geographic, Fortune, and other books, films and advertisements. . . . $50,000 per year in gross revenue attributed to NASA technology. . . . provides a more direct, flexible and immediate technique than current posterization methods. (Personal contact/Johnson, TEF 735, Case No. A007890, 4/78)

+C-20 Photochemical etching of stainless steel: developed for Johnson. . . . process combines conventional materials and techniques to produce tougher, more adherent photoresist coating that withstands longer exposure to acid without cracking or flaking. . . . maximum etching depth increased from 0.025 cm (0.010 in.) to 0.127 cm (0.050 in.). . . . used by the owner of a one-man jewelry shop, The Studio (New Mexico), to create one-of-a-kind pieces of jewelry. . . . etched designs provide "artistic" effects not otherwise possible. (Personal contact/TSP, TEF 704, Case No. TH03529CON, 6/79)

C-10 Paragraph deleted, 1/78

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 a 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 $60 to $100. . . . popular consumer product. . . . sales figures not available. (Subcontractor, TEF 560, Case No. 109328, 2/79)

C-12 Highly reliable flashlight switch: developed for Langley by ACR Electronics, now the Chromalloy Electronics Div. of Chromalloy American Corp. (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 . . . . sold primarily for emergency or recreational uses through department stores, boating catalogs, other outlets. . . . over 2 million units sold at $6 to $7 each. (Personnel/contractor, TEF 312, Case No. 109333, 4/77)

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 lines for Comfort Products,
+ Inc. (Colorado). . . . heated protective clothing for use by consumers involved in sports and recreational activities. . . . product line initially included electrically heated "Lunar Gloves"; gloves still in stock and sell for $30 per pair but no longer being manufactured. . . . current products include "FOOTWARMER II," a built-in heating system for ski boots that retails for $80, and "PROFOOT" insoles that cushion and insulate any type of footwear and retail for $3. . . . insoles currently included in selected models of Adidas and Converse athletic shoes. . . . total sales doubled since 1976, now exceed $1 million. . . . new product, nonfogging heated ski goggles, recently developed for a company in France; will be marketed in the U.S. in 1979. (Personnel/contractor, TEF 587, Case No. 112248, 5/79)

C-14 LANDSAT imagery: program under supervision of Goddard. . . . 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 publica-
+ tion in March 1974, approximately 50,000 copies sold; current retail price is $9. . . . guide updated several times and now called THE BAJA BOOK II . . . . the Baja Spaceposter is a 24" by 54" black and white mosaic, composed from 38 LANDSAT images, that shows the Baja peninsula, Gulf of California, and west coast mainland of Mexico. . . . approximately 12,000 posters sold at $4 each since May 1975. . . . guidebook and poster sold in bookstores and sporting goods stores. . . . 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. . . . since maps released in fall of 1975, approximately 1,800 sold at $7 each. . . . primary customers are tourists who purchase maps from gift shops in Arizona area. (Popular press/U.S. Geological Survey, TEF 500, Case Nos. 114475, 117160, 8/79)

Other Relevant Examples:

A-3 (golf club shafts); A-29 (digital watch light source); A-32 (watch batteries, vitamin production, hair care products); 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); F-27 (computer programming for food production); H-15 (energy conservation program); I-2 (geodesic domes); I-5 (home safety device); I-14 (solar collector); I-25 (Solar Schematic); I-30 (solar energy meter); J-7 (home alarm system); K-4 (automotive electronic ignition); K-5 (automotive gas turbine engine); P-12 (Paper Money Identifier); T-1 (sports telecast)

D

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., Houston Lighting and Power Co., and Pennsylvania-New Jersey-Maryland power pool control center. . . . product line sold to Rockwell International, Communication Switching Systems Div. (formerly North American Rockwell Information Systems Co.) (California) . . . . installed at Philadelphia Electric Co. (Pennsylvania) as part of dispatch computer system developed by Rockwell. . . . system also installed for several other electric utilities, including Potomac Electric Power Co. and Wisconsin Power and Light Co. . . . DCTV provides operator/dispatch computer interface with greater accuracy, shorter response time, and more versatility, decreasing the chance of another major blackout. . . . Rockwell division now expanding into management information systems, automatic readout systems, and finger print readers as a result of pattern recognition work done for NASA. (Contractor, TEF 465, Case Nos. 86006, 86007, 9/78)

D-5 Paragraph deleted, 10/78

D-6 Fracture toughness tests (and analytic methods): developed by Lewis. . . . included in ASME Boiler and Pressure Vessel Code for nulcear 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) . . . . Westinghouse also using tests in development of pressure vessels for coal gasification. . . . annual capital investment in nuclear power has grown from $3.5 billion in 1972 and 1973 to $8.84 billion in 1977 and an estimated $10.77 billion for 1978. . . . trend toward larger nuclear plant designs (200 MW in 1965, 500 MW in 1969, and over 1100 MW in 1977-78). (Professional society, TEF 451, Case Nos. 85203, 85204, 85206, 85208, 85212, 86001, 10/78)

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 Corp. (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. . . . especially helpful to Westinghouse in determining cause of turbine rotator failure at TVA's Gallatin Station. (Professional society, TEF 450, Case Nos. 85202, 85207, 85213, 86000, 86002, 11/78)

D. ELECTRIC UTILITIES

D-1 Combustion analysis computer programs: developed by Lewis and for Johnson . . . . used 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. (36 boilers modified, emissions reduced 50 - 70%); Los Angeles City Department of Water and Power (14 boilers converted to natural gas and modified); Consolidated Edison Co. of New York, Inc. (also used approach on all oil burning plants and turbines, enabling compliance with pollution control regulations); and Houston Lighting and Power Co. (12 to 15 boilers modified, new flue-gas recirculation boiler based on KVB design installed and proved effective in reducing pollution). . . . 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, 10/78)

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. . . . boiler sales currently $1 million per year. . . . also being used in development work on MHD power generation . . . . unique capability to analyze operating trends for experimental hardware, a guide in design improvements. (Personal contact/Lewis, TEF 463, Case No. 86016, 10/78)

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, multitiered computer systems. . . . installed at General Public Utilities Corp. (Pennsylvania and New Jersey), Arkansas Power and Light, Public Service Co. of Oklahoma, Portland General Electric Co. (Oregon), Swedish State Power Board, and two facilities each in Argentina and Spain . . . . Apollo software also used by TRW Industrial Operations (California) to provide real-time control capability in Bonneville Power Administration (Washington) dispatch computer system ($5.2 million installation). . . . benefits cited by BPA include decreased blackouts and $400,000 annual transmission savings. . . . systems estimated to have useful life of 10-15 years; provide both fuel and labor cost savings. . . . TRW is second largest producer of dispatch computer systems in U.S. (Contractor, TEF 465, Case No. 86005, 6/79)

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 nuclear industry; includes solenoid-operated valves and liquid metal valves. . . . benefits include successful contract proposal and substantial savings in overhead costs. (Subcontractor, TEF 444, Case No. 84979, 12/78)

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, most recently at a synthetic gas plant. (Personal contact/TSP, TEF 378, Case No. 114626, 12/77)

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 Dept. (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. . . . GE estimates multimillion dollar savings for industry due to fewer turbine malfunctions which cost up to $100,000 per day. . . .benefits expected to increase as more utilities use the improved controllers. (Contractor, TEF 444, Case No. 87031, 10/78)

+D-16 Paragraph deleted, 9/79

D-17 Subcritical subsonic airfoils: developed by Langley since 1950's. . . . includes math models and wind tunnel test results. . . . used by Grumman
+ Energy Systems, Inc. (New York) to design rotor blades for a prototype wind energy electric generator, called Windstream 25. . . . new windmill, with 25-ft. rotor blades, generates 15 kilowatts. . . . 14 sold for approximately $23,000 each before production discontinued. . . . customers included U.S. Air Force and Navy, DOE, Georgia Institute of Technology, University of Iowa and dairy farms. . . . second generation prototype, using 33-ft. rotor blades with same airfoil, designed and fabricated for DOE-funded program to develop and test small commercial wind machines. . . . results of DOE comparison tests expected by 1981. (Personnel/contractor, TEF 631, Case No. 120514, 8/79)

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 (now DOE) in comprehensive quality assurance specs for nuclear plant licensing. . . . General Electric Co. (Florida) implemented Apollo specs under NASA contract, now offers Nuclear Support Services to do same service for electric utilities with similar AEC specs. . . . services include: quality assurance programs for plant design, construction and operations; development of departmental procedures; assistance in ASME code compliance; and development of management systems . . . . current customers include Illinois Commonwealth Edison Co., Florida Power Co., Baltimore Gas and Electric Co., Pennsylvania Power and Light Co., Detroit Edison Co., Public Service Co. of Oklahoma and TVA. . . . services also provided to offshore oil facilities, nuclear fuel manufacturers, as well as suppliers and contractors to the energy industry. (Interagency for AEC, Contractor, TEF 444, Case No. 84976, 10/78)

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. . . . used by Turbodyne Corp. (New York) in dynamic modeling and analysis of steam turbine wheels, including blades and blocks. . . . saved $50,000 in development costs; savings expected to continue. . . . also, provided added engineering capabilities and improved products through increased product safety and reliability. . . . company produces combustion and steam turbine systems and electrical equipment for domestic and overseas markets. (Personal contact, Professional journal/COSMIC, TEF 410, Case Nos. 84977, 84981, 86003, 6/77)

+D-10 Paragraph deleted, 9/79

+D-11 Paragraph deleted, 9/79

D-12 Time-temperature techniques for alloy fatigue analysis: developed by Lewis . . . . used by Combustion Engineering, Inc. (Tennessee) for stress-rupture analysis of alloys. . . . important in evaluating alloys for potential use in high-temperature electric power generating equipment such as steam
+ boiler tubing. . . . benefits include annual savings in testing time of new and existing alloys. (Personal contact/Lewis, TEF 449, Case No. 85209, 4/79)

D-24 Magnetic particle nondestructive testing training manuals: developed for Marshall. . . . used by General Electric Co., Large Steam Turbine-Generator Div. (New York) for in-house training program. . . . 36 production inspectors trained and 48 technicians in turbine laboratory re-certified in past three years. . . . manuals used in all nondestructive testing programs. . . . GE is the largest producer of electric generating equipment. (Professional journal/TSP, TEF 261, Case No. 31534, 5/77)

D-25 Gas turbine cooling technology: developed by Lewis. . . . used by United Technologies Corp., Pratt and Whitney Aircraft Co. Div. (Connecticut) in product design procedures. . . . company produces gas turbines for ground power generation. . . . operating temperatures increased from 1,650°F to almost 2,000°F through use of convection cooling methods that incorporate Lewis technology. . . . 10% increase in thermal efficiency. . . . turbines supply supplemental power for peak load requirements, extend life of existing power plants by several years. . . . also make possible less expensive, lower capacity power plants for average requirements. . . . division sells 25-30 units each year to customers such as Hartford Power and Light Co. . . . price is several hundred thousand dollars each. (Personal contact/ Lewis, TEF 469, Case No. 90556, 6/77)

D-26 Electronic and electromechanical component reliability data: compiled for NASA Pasadena Office by JPL. . . . includes failure modes, screening requirements, derating factors and stress analysis. . . . routinely used by General Electric Co., Nuclear Energy Div. (California) to evaluate electronic components in reactor product moderating instrumentation. . . . saved 2 to 4 person-days in evaluation. (TB/TSP, TEF 627, Case No. 111214, 4/77)

D-27 Systems management techniques: compiled by Marshall. . . . used by Boston Edison Co., General Test Div. (Massachusetts) to improve efficiency in testing laboratories. . . . techniques for records management and data analysis are particularly valuable. . . . 80 to 100 person-hours saved each year. (TB/TSP, TEF 494, Case No. 76659, 5/77)

D-28 Transformer design manual: developed by JPL. . . . used regularly by Square D Co., Electromagnetics Industries Div. (Florida) in transformer design training sessions. . . . significantly enhanced design skills of 30-member engineering department. . . . division produces instrument transformers used in utility industry. . . . benefits will continue. . . . also used by Electro-Pacific, Inc. (California) in the design and production of transformers. . . . provided validation of existing procedures, as well as new design concepts. . . . important daily reference document for 3-4 company design engineers. (TB/TSP, TEF 694, Case Nos. STIF-65974, STIF-66804, 1/78)

D-18 Flight test data system: developed for Dryden 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 DOE 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 DOE Facility contractor, Aerojet General Corp., at average base price of $25,000. . . . modified version currently being developed for TVA's three nuclear power plants. . . . applications will include fire detection, security controls and operations recording. . . . sales to TVA expected to be over 200 units at $4,000-$5,000 each. (Contractor, TEF 650, Case No. 121305, 9/78)

D-19 Rotational vibration analysis methods: developed for Marshall and Lewis by the University of Virginia, Mechanical and Aerospace Engineering Dept. . . . 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 a nuclear power equipment manufacturer, the Bryon-Jackson Co. . . . . results used to modify pump bearings and reduce vibrations. . . . also, Ontario Hydro, Canada's major utility, uses rotary machinery designed with these methods. . . . estimated that end users of machinery save over $250,000 per machine in operating expenses. (Contractor, TEF 658, Case No. 121463, 8/79)

D-20 Paragraph deleted, 1/78

D-21 Tungsten alloy metallographic technique: developed by Space Nuclear Systems Office for preparation of test samples. . . . used by Gibson Electric, Inc. (Pennsylvania) to test electrical contact products and improve their reliability. . . . products used by General Electric, Westinghouse, and Federal Pacific Utilities in electric power transmission equipment. (TSP/SP, TEF 675, Case No. 123409, 1/77)

+D-22 Steel data handbooks: compiled for Marshall. . . . used by Lear Siegler, Inc., Energy Products Div. (California) in designing product for nuclear power plants. . . . provides valuable input to materials analysis and stainless steel selection for control rod drive mechanism product. . . . about 100 custom-designed drive mechanisms produced and sold each year at over $250,000 each. (TB/TSP, TEF 538, Case No. 120412, 5/79)

D-23 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by General Motors Corp., Detroit Diesel Allison Div. (Indiana) in design testing programs for gas turbine engines. . . . manual provides best techniques for installing gages on engine components to obtain test data. . . . engines sold to telephone and gas utility companies for standby electric power generators. . . . saves considerable research and instrumentation time annually. (Personal contact/SBA/TSP, TEF 384, Case No. 61738, 5/77)

+D-29 Turbomachinery flow analysis computer programs: developed by Lewis. . . . four programs use application of velocity gradient and finite difference methods to analyze how the flow field in turbomachinery is distributed across blade surfaces, between blades, and radially from hubs to shrouds. . . . used by Westinghouse Electric Corp. (Pennsylvania) in designing large industrial gas turbine and induced draft fan products. . . . cost savings of 2 person-years, worth $120,000, attributed to programs. . . . other benefits include increased sales from improved products. . . . helped in development of new designs which are more efficient and more reliable due to reduced erosion by particulate matter such as ash or dust. . . . new designs used in first controllable-pitch axial fan to be designed and produced in the U.S. . . . unit now operating in electric generating system of Oklahoma Gas and Electric Co. (TB/COSMIC, TEF 780, 6/79)

Other Relevant Examples:

B-6 (gas turbine electric generators); B-23 (nuclear reactor filters); B-51 (strain measurement); B-54 (reactor equipment test); B-86 (turbomachinery design); 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); G-15 (LNG plant safety); I-10 (portable power poles); I-19 (windmill generator study); O-5 (NDT training service); O-23 (safety education)

E

ENVIRONMENTAL QUALITY

E-5 Weather satellite data: program managed by Goddard. . . . Automatic Picture Transmission (APT) ground receiver developed by Goddard and EMR Telemetry (formerly EMR Div. of Weston Instruments [Maryland]). . . . satellite data from APT receivers combined with ground-based sensor information by National Weather Service (Maryland) to prepare facsimile maps forecasting wind conditions. . . . maps used by Air Pollution Control Div., Colorado Health Dept., in conjunction with Pollutant Standard Index (established June 1977) for twice-daily check of pollutant concentrations and dispersal prediction. . . . dispersal prediction crucial for implementing pollution control sequence (advisory, alert, warning, emergency). . . . predictions accurate within four hours. . . . reduces economic loss due to unnecessary industrial shutdowns. . . . growing number of people using weather satellite data. . . . 800 ground stations in operation, 350 by the government. (Interagency, TEF 26, 194, Case Nos. 78001, 96526, 11/77)

E-6 LANDSAT 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 New York state. . . . partial basis for legal action by State of Vermont against paper mill and State of New York. . . . LANDSAT 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, 8/79)

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 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. . . . currently, imagery being used, in conjunction with LANDSAT data, to inventory surface mines in the eastern coal producing states. . . . recent results include an inventory of mining activity for the Southwest Virginia 208 Planning Agency and the identification of surface mine damage and subsidence due to underground mines in Pennsylvania for the Appalachian Regional Commission. (Contractor, TEF 199, Case No. 101912, 9/78)

E-8 Remote sensor for air pollutants: operational prototype developed for Johnson. . . . correlation spectrometer sold by Barringer Research, Ltd.
+ (Canada). . . . approximately 65 units with various accessories sold. . . . current unit price is $25,000; accessories kit available at $2,500 each . . . . unique air pollutant measuring capability. . . . measured NO_2 profiles over Los Angeles and San Francisco, SO_2 profile over Chicago. . . . currently used by customers to provide daily profiles of regional pollution . . . . also used by air pollution agencies in U.S., Canada, Australia, Japan, France, Spain. (Contractor, TEF 482, Case No. 95608, 12/78)

E. ENVIRONMENTAL QUALITY

E-1 Skylab carbon monoxide monitor: developed for Ames. . . . commercialized by Andros, Inc. (California). . . . 30 units sold by Andros before product line sold to Beckman Instruments, Inc. (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 50 Beckman units sold at $8,500 each before commercial version discontinued. . . . units still being used by EPA for pollution profiles and by the U.S. Army for measuring CO levels inside tanks after guns are fired. . . unit modified to U.S. Navy specifications for monitoring air in submarines . . . . approximately 250 of these sold at $15,000 each . . . . also, 7 specially designed units sold to Lewis Research Center. . . . only units currently being produced are those for the Navy. (Contractor, Purchased product line, TEF 481, Case Nos. 93827, 93828, 7/79)

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 at $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 . . . . 3,500 cars tested annually. . . . 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. . . . primary use for automotive tuneups rather than emission testing. . . . to date, over 2,500 portable units sold for approximately $1,600 each. (Contractor, TEF 486, Case No. 93832, 10/78)

E-3 Filter cassette for sampling particulate pollutants: designed and produced for Lewis air pollution program in Cleveland by General Metal Works, Inc. (Ohio). . . . company modified cassette and marketing as "filter paper cartridges". . . . to date, approximately 5,000 cartridges sold; current price is $32. . . . used in governmental pollution monitoring stations . . . . considered by pollution experts to be best cartridge on market . . . . prevents sample contamination during transport to and from monitoring stations. (Contractor, TEF 493, Case No. 99658, 10/78)

E-4 Satellite telemetry systems: developed for Goddard by General Electric Co. for NIMBUS and LANDSAT. . . . used by GE to develop statewide computerized air pollution monitoring network (COPAMS) for the Pennsylvania Department of Environmental Resources. . . . 17 stations currently operating throughout state; measure 14 emission parameters once every minute and transmit data to central office. . . . real-time data on pollution levels enables immediate action for emergency alert situations. . . . data also used to prepare daily air pollution index and to chart long-term trends. . . . enables state to assess effectiveness of air quality laws. (Contractor, TEF 483, Case No. 96532, 11/78)

E-15 Biosatellite telemetry and life support systems: developed for Ames by General Electric Co., (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. . . . prototype land-based unit installed for evaluation in Florida and later certified company also licensed technology to Matsui Corp. (Japan). (Contractor, TEF 584, Case No. 112241, 6/79)

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 conducted a field evaluation of the facility. . . . tests showed plants were effective in meeting all required secondary treatment standards; e.g., reduced suspended solids, phosphorus, nitrogen and oxygen demand. . . . benefits include the ability to meet EPA water quality standards and a cost savings of $500,000 by not having to install expensive chemical and mechanical treatment system. . . . routine use of water hyacinths expected to continue. . . . method also used by the Coral Springs Improvement District (Florida) to construct 100,000-gal./day pilot sewage treatment facility for District's 8,000 residents. . . . water hyacinth facility reached full operation May 1978 and preliminary test results demonstrate it meets all federal sewage treatment standards required by January 1, 1980, except those for phosphorus (this inexpensive process to be done separately). . . . capital costs for facility, exclusive of land, are 40-70% below those of conventional advanced treatment facilities and operating costs, including phosphorus precipitation, are about 25% less. . . . water hyacinths are harvested, dried, and hauled to local nursery for use as fertilizer. . . . Walt Disney Productions, WED Enterprises Div. (California) used the water hyacinth method to construct a prototype sewage treatment facility as part of its "Experimental Prototype Community of Tomorrow" at Disney World (Florida). . . . the purpose of this 50,000-100,000-gal./day pilot plant is to demonstrate the feasibility of this inexpensive method for small, rural communities. . . . if tests prove successful, the plant will become an integral part of Disney World's larger sewage system. (Personal contact/NSTL, Unknown, TEF 617, Case Nos. 117162, A008619, A008620, 2/79)

E-9 + Computer models for Apollo Program: developed for Johnson by TRW Systems . . . . systems engineering expertise developed under contract used by TRW's Environmental Engineering Div. (California) to develop 60 air and water quality models. . . . pollution levels can be projected 2-5 years in future . . . . provided technical basis for implementing pollution laws in Alaska, California, D.C., Ohio, South Carolina, Vermont. . . . most of division's $10 million annual revenue from EPA contracts, some state and regional funding. (Contractor, TEF 487, Case No. 96531, 8/79)

E-10 Lunar Module rocket engine test facility: developed for Johnson. . . . being used by TRW Systems (California) to develop inexpensive coal desulfurization process. . . . since 1974, EPA funding has totaled $5 million for research and pilot plant design. . . . process could eliminate need for expensive stack gas removal equipment for electric utilities. . . . pilot plant at LM engine test facility being used to test process on large-scale basis; other technological innovations being tested at the facility include tertiary recovery of oil, water pollution control and extraction of biomass . . . . full commercialization expected within 5 years. . . . primary customers would be small utilities and older plants that do not fall under new federal requirements for scrubbers on coal-fired power plants. . . . SO_2 pollution control a critical financial problem for coal-fired power plants. (Contractor, TEF 488, Case No. 96530, 9/78)

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 LANDSAT multispectral digitized imagery. . . . joint funding by TTD 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. . . . monitoring of lakes continues. (Contractor/TTD-Applications Project, TEF 520, Case No. 104142, 12/77)

E-12 + Manufacturing contamination prevention handbook: compiled for Marshall . . . . used by Carrier Corp., Carlyle Compressor Co. Div. (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 in 1973 and still in effect. (TB/TSP, TEF 544, Case No. 86150, 1/79)

E-13 Paragraph deleted, 1/78

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. . . . sales continuing. (Subcontractor specifications, TEF 563, Case No. 109332, 7/78)

+E-21 Correlation interferometer for pollution measurement: developed for Langley, as well as other agencies and institutions, by Barringer Research, Inc. (Colorado and Canada). . . . automatic, self-contained remote sensing instrument which minimizes the data needed to measure several atmospheric trace elements, including carbon monoxide, simultaneously. . . . commercialized by Barringer. . . . 8 custom-designed units sold for prices ranging from $70,000 to $100,000. . . . customers are U.S. and Canadian government agencies which mainly use the instruments for monitoring air pollution. (Contractor, TEF 731, Case No. A008596, 1/79)

+E-22 Data contouring computer program: developed by and for Langley. . . . triangulation contouring technique allows randomly spaced input data to be contoured without having to fit data into a rectangular grid. . . . used by Burns and McDonnell Engineering (Missouri), an engineering and architectural consulting firm, to contour air pollution data for environmental impact statements. . . . benefits include savings of $15,000 due to avoidance of in-house development costs and more efficient data processing, as well as increased marketability for services improved with the new capability. (COSMIC, TEF 778, 4/79)

+E-23 Stack plume visualization system: developed by Langley. . . . portable solar radiometer for remote monitoring of particulate density, and nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) concentration and velocity for gaseous suspensions such as smokestack effluents. . . . reduces need for more expensive, in-stack instrumentation. . . . one of Langley innovators obtained exclusive NASA license and formed Research Ventures, Inc. (Virginia) to market commercial version of detector, called Visiplume. . . . microprocessor computer-controlled system uses ultraviolet video techniques to measure SO_2 concentration and gaseous flow velocity in order to determine emission rate. . . . system sells for $32,700 and is intended primarily for monitoring coal- or oil-fired power plants and facilities that manufacture sulfuric acid. . . . first commercially available instrument for this type of remote monitoring. (Personnel/Langley, TEF 781, 7/79)

Other Relevant Examples:

B-67 (air pollution venting); B-78, F-22 and I-27 (noise reduction); D-1 and D-2 (air pollution control for power plants); D-8 (nuclear safety); D-17 (windmill generators); G-1 and G-33 (new sewage treatment method); G-2, G-3 and G-5 (water quality and supply data); G-27 (sewage plant maintenance); 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 and K-16 (auto emission analysis); O-13 (resource management training); Q-23 (carbon monoxide dosimeter)

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
+ . . . . in 1975, Arthur Technology, 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, now marketed as a "Wastewater Respirometer". . . . highly reliable, versatile instrument used to measure and control sewage treatment processes. . . . 50 units sold annually at $1,295 each. . . . customers include manufacturing companies, city governments, federal agencies, universities and research organizations . . . . 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. . . . sales expected to continue. (Personal contact/TSP/License, TEF 622, Case No. 117769, 7/79)

E-18 Boundary layer wind analysis: developed for Headquarters and by Marshall . . . . combined studies were an exhaustive analysis of boundary layer wind
+ . . . . used by Colorado State University, College of Engineering, Fluid Mechanics and Wind Engineering Program 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., Interstate Power Co. of Iowa, and Pacific Gas and Electric Co. to aid pollution reduction efforts, and in physical modeling of toxic gas dispersion, such as methane from LNG spills, to determine safety problems where complex terrains are involved. . . . used by Calspan Corp. (New York) in its Atmospheric Simulation Facility to model pollutant concentrations, including smoke flow visualization, for design engineering firms, government agencies and industrial clients. . . . projects have included the Douglas Point Nuclear Generating Station (Maryland), Karn-Weadock Generating Complex (Michigan), Wright-Patterson Air Force Base Compressor Research Facility (Ohio), an EPA-sponsored examination of stack effluents from steel mills and power plants near the Monongahela River (Pennsylvania), and a room ventilation study for Martin Marietta's aluminum smelting plant. . . . also used in a project for SRI International, sponsored by the Federal Highway Administration, to study the relationship between vehicular traffic and other factors in air pollutant dispersion. (Professional journal, Personal contact, TEF 643, Case Nos. 120222, 120511, 8/79)

E-19 Hazard reduction methods: developed for Marshall. . . . used by Deleuw Cather and Co. (Illinois) in designing a Chicago water treatment facility . . . . enhanced safety of facility which is under construction. (TB/TSP, TEF 701, Case No. STIF-59509, 12/77)

+E-20 Contamination control techniques: developed for Langley to prevent prelaunch contamination of the Viking Lander. . . . assured nontoxicity, sterility, and inertness of the equipment and construction materials. . . . used by the U.S. Environmental Protection Agency (North Carolina) in specifying construction materials for new pollution monitoring equipment. . . . saved $30,000 in materials testing costs. . . . equipment is new, high-volume source assessment monitor for measuring constituents of smoke stack effluents. (Customer/subcontractor, TEF 762, Case No. A009047, 4/79)

F

FOOD PRODUCTION AND PROCESSING

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. (Arizona) 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 TesTender beef with instrument. . . . amount of premium-priced TesTender 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. . . . Armour leases Tenderometers to other meat packing companies; also, cattle growers use the instrument data for selective breeding programs. (Contractor, Customer/contractor, TEF 505, Case Nos. 101898, 103418, 7/79)

F-9 Compressed/freeze-dried food: developed for Johnson by U.S. Army Natick Laboratory. . . . used by Innovative Foods (California) to develop new product line. . . . products sold mainly to food processors who add other ingredients and package mixtures for sale as soups and casserole dishes. . . . principle customers are Lipton Tea Co., Wylers, Nestle's, and other instant food producers. . . . major market with Defense Dept. expected; already contracted to supply food products to Philadelphia installation. . . . annual sales reached $1 million by 1976; steady growth since. . . . with military market, $2.5 million in sales anticipated for 1979-1980. . . . also, company actively pur-
+ suing Asian and Middle East markets. . . . during 1975-1977, Johnson, the Texas Research Institute of Mental Sciences, United Action for the Elderly, the University of Texas, LBJ School of Public Affairs, the Texas Department of Public Welfare and the Ford Foundation sponsored an experimental project, called "Meal System for the Elderly," to demonstrate that freeze-dried foods developed for NASA could provide easy-to-prepare, nutritious and well-balanced meals for senior citizens. . . . Oregon Freeze Dry Foods, Inc. (Oregon) participated in project and subsequently developed food system product for seniors, called EASY MEAL™. . . . system consists of a carton of 12 complete meals, each packaged separately; meals shipped directly to customers. . . . retail price ranges from $20 to $24 per carton (or approximately $2 per meal). . . . meals contain foods which are familiar and attractive, well-balanced, require no refrigeration, and easy to prepare (5 to 10 minutes). . . . publicity on project led to formation of Skylab Foods, Inc. (New York) to market modified version of meal system. . . . production began in January 1978 and approximately 100,000 meals sold by the end of the year. . . . customers primarily homebound handicapped and senior citizens. . . . company currently developing special packaging techniques for new product lines for the blind, camps and schools without normal kitchen facilities and underdeveloped countries. (Personal contact/contractor, Contractor, Popular magazine, TEF 502, Case Nos. 101896, A006754, A008931, 3/79)

F. FOOD PRODUCTION AND PROCESSING

+F-1 Paragraph deleted, 9/79

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. . . . 30% 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). . . . tractor currently one of most popular models on the market . . . . Deere annual sales approximately $4 billion, about 20% of farm machinery market. (Professional society, TEF 451, Case No. 101903, 9/79)

+F-3 Paragraph deleted, 9/79

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. (TB/TSP, TEF 262, Case No. 31762, 2/77)

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 food
+ processing facilities at Pillsbury and all employees receive contamination hazards training. . . . improved product quality; product recalls due to contamination reduced to zero. . . . approximately 100 management manuals (720 pages) are sold annually at $40 each to other food processors. (Contractor, TEF 503, Case No. 101910, 8/79)

F-6 Microbiological handbook: compiled for Marshall. . . . used by Kraftco Corp. (Illinois) as reference for sanitary techniques in food processing plants and in research. . . . especially beneficial in sludge treatment process developed by company. . . . used by USDA scientists (Missouri) in development of improved milk processing procedures and equipment now used in dairy industry . . . . valuable reference in both cases, particularly for familiarizing engineers with biosystems terminology. (TB/TSP, TEF 402, Case Nos. 51578, 51786, 12/77)

F-7 Nondestructive spot test procedure: compiled by Langley. . . . 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. (Trade journal/TSP, TEF 378, Case No. 115014, 6/78)

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 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. . . . soil surveys also conducted for several foreign countries, including Mexico, The Republic of Sudan, Nepal, and Syria. . . . surveys used to project country's resource base and determine most productive crops for particular soil conditions. . . . currently, surveys cost $.20/acre as opposed to $3/acre for conventional surveys. (Personal contact/grantee, TEF 605, 9/79)

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 has resulted in savings of more than $13,000 since 1975. (Professional journal/TSP, TEF 497, Case No. 97966, 5/79)

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 available in grocery stores throughout the U.S. for about $1 per box of 14. . . . also produced by company subsidiaries in Europe and Australia for international markets. . . . sales figures are proprietary. (Contractor, TEF 229, Case No. 33602, 6/79)

F-19 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 $2 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, 8/79)

F-10 Eutectic salts for low temperature batteries: developed for Goddard by Artech Corp. (Virgina). . . . used by Artech to develop Irreversible Warmup Indicator. . . . shows, by color change, whether frozen foods have defrosted
+ during transportation or storage. . . . over 3 million sold before production suspended due to shortage of materials; expected to be resumed in 1979-80. (Contractor, TEF 504, Case No. 101897, 4/79)

+F-11 Paragraph deleted, 9/79

F-12 Computer programs for LANDSAT data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . used by Texas Water Development Board, in joint project with DOI's Bureau of Reclamation and Texas Department of Water Resources, to develop monitoring program for playa lakes (short-lived, caused by rainstorms) in Texas High Plains region . . . . first phase of project (1 or 2 counties) scheduled for completion in December 1978; expanded project to cover about 25 counties anticipated. . . . computer analysis of LANDSAT data will permit production, every 6 months, 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, 10/78)

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 30% of cold storage market. . . . annual sales estimated to be $10,000. . . . applied to eyeglasses and windows to prevent fogging associated with refrigeration equipment operations. . . . increased worker safety. . . . also marketed by SKICO, Inc. (Colorado) to packing plants and other industrial users for safety glasses. . . . company sales about $6,000 annually. (Professional journal/TSP, Purchased product line, TEF 423, Case Nos. 75288, 112244, 6/79)

+F-14 Paragraph deleted, 9/79

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. . . . tested by Ohio farmers to dry thousands of bushels of corn and wheat. . . . production rights for Soloron sold to Kuss Corp. (Ohio) in Febraury 1978 . . . . collector now on market and priced at $1,950. . . . company estimates collector will save 20-25% of fuel costs for farmers in northern states and up to 100% in southern region. . . . other applications include heating of agricultural facilities such as hog farrowing buildings and workshops. . . . sales figures not yet available. . . . recent price increases and curtailed supplies of normal fuels, such as propane, have created significant problems for grain drying. (Personnel/Lewis, Purchased product line, TEF 606, Case Nos. 114869, A010287, 8/79)

F-25 LANDSAT imagery and Weather satellite data: programs under Goddard supervision. . . . Earth Satellite Corp. (District of Columbia), under contract to Goddard, participated in development of analysis and interpretation techniques for satellite data, including techniques for estimating vegetation vigor and stress. . . . satellite data used by EarthSat to develop new agricultural information system, called CROPCAST™. . . . system aggregates data on crop stress and soil moisture conditions, and from biological simulation models, to provide weekly or daily forecasts of local and regional crop yield and productivity. . . . accuracies of better than 5% have been achieved up to 2 months before harvest. . . . CROPCAST available to customers via interactive terminals in Washington, D.C., California, New Jersey and London. (Contractor, TEF 500, Case No. A008056, 10/78)

F-26 Aircraft remote sensing program: conducted by Ames. . . . joint project with U.S. Dept. of Agriculture, Water Conservation Laboratory (Arizona) to develop techniques for predicting crop yield and irrigation scheduling with infrared thermometry. . . . NASA aircraft equipped with thermal scanners conduct biweekly over-flights of USDA experimental sites; thermograms used to produce color-graded temperature maps indicating soil moisture conditions. . . . data compared with USDA surface measurements made with experimental, hand-held infrared thermometer to determine accuracy and techniques for using the new infrared "gun". . . . gun now available as product for use by individual farmers in estimating yield and insect threats and in improved irrigation efficiency and reduced costs from unnecessary watering. . . . also, aircraft thermograms expected to have high use among large corporate farms and farm associations. (Interagency, TEF 199, Case No. A006752, 7/78)

F-27 Assembly language programing methods (STRCMACS): developed by Goddard. . . . system of assembly language macros for grouping statements into various control structures and conceptual units. . . . used by Ralston Purina Co. (Missouri) for program conversions, data entry, and development of new computer systems . . . . savings of over $40,000 through reduced development time and process efficiencies. . . . international food and feed company well known for its breakfast cereals, soy protein products, pet foods and livestock feed. . . . annual sales over $3 billion. (Trade press/COSMIC, TEF 751, 12/77)

+F-28 Finite element thermal stress analysis program: developed for Space Nuclear Systems Office. . . . FEATS program calculates the steady state temperature and stress fields in two-dimensional planes and in axisymmetric volumes, and provides graphical display. . . . used by Deere and Co., John Deere Waterloo Tractor Works (Iowa) in analysis of pistons, connecting rods, and rocker arms for diesel engines. . . . benefits include considerable time and cost savings more accurate test results, and improved product efficiencies and reliability . . . . diesel engines used in extensive line of farm equipment. (COSMIC, TEF 779, 11/78)

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, called Integral Heating Food Service System . . . . 50 systems leased to institutional food services such as hospitals and nursing homes. . . . provides fast, relatively easy, efficient and safe food handling for 44,000 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, 4/79)

F-21 Aluminized plastic film: basic patent by National Research Corp. in 1962 . . . . first applications (ECHO I, spacecraft, space suits) developed for Lewis . . . . NRC acquired by Norton Co. in 1965 and renamed Metallized Products Division. . . . Division sold to King-Seeley Thermos Co. (Massachusetts) in 1971. . . . film commercialized for "flexible" packaging of foods . . . . used by St. Regis Paper Co. for potato chips, by Smuckers Co. for single serving jelly packets, and by several coffee companies for 6-8 cup brewing packets. . . . over 2 million pounds of film sold or under contract for food packaging. . . . market success attributed to reduced use of aluminum which has increased in price as energy costs increased in recent years. (Contract or/Purchased product line, TEF 160, Case No. 37434, 10/78)

F-22 Strain-gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by Deere and Co., John Deere Waterloo Tractor Works (Iowa) to help in reducing noise in products, diesel engines for farm tractors. . . . strain gages used to measure effects of piston slap, other engine actions to aid in identifying design modifications that reduce noise. . . . benefits include reduction of instrumentation time. (TB/TSP, TEF 384, Case No. 55583, 5/77)

F-23 Capacitance multiplier circuit: developed for NASA Pasadena Office. . . . circuit multiplies capacitance without increasing overall gain. . . . used by U.S. Army Natick Laboratories (Massachusetts) to design electronic filter for use in microorganism measurement tests. . . . lab conducts research in food processing, preservation, packaging. . . . saved research time, advanced some food testing programs as much as one month. (TB/TSP, TEF 679, Case No. 108037, 4/77)

F-24 Heat pipe applications: developed for Lewis and Langley by Hughes Aircraft Co. . . . commercialized by Hughes Thermal Products Dept. (California) as heat recovery product, HeatBank™; production rights sold to Torin Co., Applied Products Div. (Michigan) in February 1978. . . . product used by Rudolf Foods Co. (Ohio) to reduce energy consumption of meat cookers. . . . units installed on 12 cookers; enabled 15% reduction of direct fuel costs, or $200,000 annual savings. (Contractor, Purchased product line, Customer, TEF 197, Case Nos. 109343, A005994, A010334, 8/79)

+F-29 Meteorological satellites: developed for Goddard, owned and operated by NOAA . . . . remotely sensed data from GOES, TIROS and NOAA series satellites processed by the National Weather Service to produce weather charts for tropical region of Pacific Ocean. . . . charts are regularly transmitted from U.S. Coast Guard stations in California to ships in Pacific via radio facsimile (FAX). . . . used by U.S. tuna fleet to avoid bad weather. . . . about half of the 140 purse seiners in fleet have FAX equipment. . . . benefits include increased safety and efficiency in tuna fishing. . . . approximately 250,000 tons of tuna are harvested annually by U.S. ships in tropical Pacific area. (Interagency, TEF 775, Case No. A011267, 8/79)

+F-30 Space simulation chamber: developed and maintained for Johnson by McDonnell Douglas Corp. (Missouri) for Mercury and Gemini programs. . . . first commercial applications involved restoration of millions of water-damaged records with heating/freeze-drying process. . . . expertise with water vaporization in vacuum chambers led to DOE contract to develop small demonstration model of a microwave vacuum crop drying system, called MIVAC. . . . prototype system, installed in USDA research facility near Tifton, Georgia, has been used to dry rice, nuts, grain sorghum, corn, hops and lumber; also, pine seeds dried in experiment for Georgia Department of Forestry. . . . advantages of MIVAC over conventional drying systems include on-site conversion of fuels to electricity, more efficient energy usage, and improved preservation of food quality due to low temperature method. . . . tests to date have shown promising results for new method; commercial MIVAC units expected. (Contractor, TEF 511, Case No. 101914, 10/79)

Other Relevant Examples:

A-9 (production equipment lubrication); A-23 (aluminum cookware); B-41 (process control equipment); B-63 (Colorimeter); B-67 (fruit drying); B-74 (process heat conservation); G-32 (crop surveys); G-33 (fertilizer and cattle feed); I-27 (noise reduction in food processing); K-3 (farm tractor design); O-13 (training for remote sensing); O-27 (agricultural machinery design); S-8 (tuna boat insulation)

G

G-3 LANDSAT data collection system: developed by Goddard. . . . used by U.S. Geological Survey (Florida) to telemeter hydrologic data from 30 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. . . . 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, 10/78)

G-4 Computer programs for LANDSAT data analysis: developed for Johnson by Lockheed Corp. at request of Texas Water Rights Commission. . . . used by Texas Water Development Board, under contract to U.S. Army Corps of Engineers, Nashville District (Tennessee), to analyze LANDSAT imagery for verification of dam inventory in Tennessee. . . . water bodies of 5 to 10 acres identified with 70% accuracy; 100% identification for all larger reservoirs. . . . reduced verification cost by factor of 10. . . . using LANDSAT imagery, total estimated cost to inventory all dams in U.S. is $500,000. . . . 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. (Personal contact/Johnson, Interagency, TEF 513, Case Nos. 101895, 101905, 10/78)

G-5 Skylab photography: program under supervision of Johnson. . . . used in NASA-funded EREP 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 showed 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 provided
+ funds to publish the hydrologic and vegetational maps for land use management; used by various government agencies and land developers from 1974 to 1978. . . . maps recently updated with other high altitude photography. (Interagency, TEF 508, Case No. 101929, 5/79)

G-6 Paragraph deleted, 10/78

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 operated by Orange County Sanitation District (California), with NASA and county funds ($200,000), to develop scale-up design data. . . . county developed one million-gal./day prototype plant on cost-sharing basis (county 12.5%, state 12.5%, EPA 75% of $3.4 million); became operational in mid-1978. . . . successful evaluation of prototype may lead to construction of 10 million-gal./day plant. . . . also, 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, 10/78)

G-2 LANDSAT 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, under contract to Goddard, developed computer program to analyze remote sensing data for land use planning; applications include a computerized inventory of state land use and the development of land use projections; program will be incorporated into the state computer system. . . . State of Georgia's Department of Natural Resources has a continuing program to utilize LANDSAT 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 at over $1 million and several person-years); map used for farm pond 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 used by field geologists to define geological structures and identify surface water and land forms; led to publication of both a physiographic and a geologic map of the state (cost savings due to availability of LANDSAT data estimated at 50%). . . . 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, and by the Environmental Protection Division for land use analysis and waste disposal site identification. . . . University of Utah used imagery for map preparation, a hydrologic 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, 10/78)

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 had to 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. . . . also, 1977 flood in Kansas City, Missouri led to restoration contracts totaling $10,000 for bank, medical and insurance records, electrical equipment and retail furs. . . . recent customers include the Kentucky Department of Revenue and referrals from the U.S. Library of Congress. . . . service also includes sterilization process to prevent growth of bacteria on items contaminated with sewage. (Contractor, TEF 511, Case No. 101914, 4/79)

+G-12 Paragraph deleted, 9/79

G-13 Fireman's breathing apparatus: developed by Johnson and Lewis, in cooperation with firefighting community, using extravehicular life support system technology. . . . funded by TTD. . . . Martin Marietta Corp. and Structural Composites, Inc. (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. . . . Scott Aviation holds a NASA license to produce and sell system . . . . units became commercially available in mid-1976; to date, over 10,000 sold at approximately $700 each. . . . customers include fire departments in Boston, New York City, Dallas, and Houston; an oil company in Saudi Arabia; and Taiwan. . . . one customer, the Crystal Volunteer Fire Dept. (Pennsylvania) is using 12 of the breathing systems. . . . in the first 6 months, about 25 volunteers had used the system with beneficial results. . . . considered a valuable piece of firefighting equipment. (TTD-Applications Engineering, License/contractor, Customer/contractor, TEF 519, Case Nos. 107781, 114863, STIF-62969, 10/78)

+G-14 Paragraph deleted, 9/79

G-15 Risk-management system: developed by Kennedy for rocket fuel storage and handling. . . . used by Kennedy in TTD-funded project to provide New York City Fire Department with management system for liquefied natural gas (LNG) storage facilities. . . . project undertaken after 1973 fire at large LNG tank on Staten Island killed 40 people. . . . used to evaluate plans for liquified and natural gas plants constructed by Brooklyn Union Gas Co. and a fuel cell installation being constructed by Consolidated Edison of New York and DOE. . . . public safety increased through better identification, analysis, and control of hazards associated with such facilities. . . . LNG Risk Management System Workshop conducted at Kennedy in September 1975 for over 50 government, public utility, and industry officials. (TTD-Applications Engineering, TEF 549, Case No. 107737, 7/79)

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 $750,000 already installed at post offices in 4 cities (Binghamton, N.Y., Greensboro, N.C., Chicago, Ill. and Indianapolis, Ind.). . . . additional installations for Postal Service anticipated at 2 to 3 systems per year. . . . data acquisition technology used in automated system for real-time collection and processing of hydrometeorological data from Columbia River Basin for Bonneville Power Administration (Oregon) . . . . 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, 10/78)

+G-8 Paragraph deleted, 9/79

G-9 California Four Cities Program: funded by NASA (1971-1974) and NSF (1972-1978) and managed by Jet Propulsion Laboratory (California) to transfer aerospace-generated technology to local governments. . . . initially, four aerospace companies (Northrop Corp., Science Applications, Inc., Aerojet-General Corp., and Lockheed Missiles and Space Co.) were paired with four cities (Anaheim, Fresno, Pasadena, and San Jose). . . . each company provided its paired city with a Science and Technology Advisor and technical support. . . . eleven formal projects undertaken, as well as informal consultation and advising. . . . program 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 achieved considerable cost savings and operational improvements, with quantified savings from only two projects estimated at more than $600,000 . . . . by July 1978, program had evolved into a non-profit corporation, called Southwest Innovation Group (California), supported primarily by local governments. . . . SIG currently serves 13 local governments in California and 2 in Arizona, with plans to include Nevada. . . . general types of assistance from science advisors include information dissemination, technical support, seminars and workshops, and exchange programs with scientific and technical community. . . . many of the advisors are from outside of aerospace companies, but aerospace management techniques still considered important element in program. (Contractor, TEF 512, Case No. 101915, 10/78)

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. . . . airport control center currently being used for special city projects, such as the Fire Protection Improvement Program. . . . initial project so successful, additional control center funded by city as City Council Goals and Progress Center. (Contractor, TEF 510, Case No. 101924, 10/78)

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 in early 1970's. . . . 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. . . . techniques still being used by medical data staff. . . . benefits have included significant time reduction for contract processing, enhanced research team project efforts, and a more useful data system. (Personnel/contractor, TEF 573, Case No. 113675, 6/79)

G-23 Laser electro-optical alignment pole for surveying (LEAPS): developed by Goddard with TTD 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; accurate to within six inches per mile. . . . 4 units now routinely used in surveying operations and 3 more on order; unit cost is $70,000. . . . estimated annual savings are $4 million due to surveying land in 1/3 the previous time at 1/3 the previous cost; also, cost-benefit analysis of unit indicates pay-back period is only 2 years. . . . estimated time for completing survey program substantially reduced, which will help to avoid legal action involving private lands adjacent to national forests . . . . 300,000 total miles of forest boundary to be defined; 35,000 miles have been delineated. (Contact/Goddard, TEF 599, Case No. 114860, 10/78)

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. . . . operational test phase of project began May 1976 in Mendocino County, California. . . . sensor transmitted signals via the GOES satellite. . . . test program so successful that a 20-station network is now in operation and a 60-station network, covering the Sierra foothills, central coast and northeastern region, will be operational by the spring of 1980. . . . benefits include the availability of real-time data, improved planning capability, and reduced costs for fire fighting resources; also, public "goodwill" improved by avoiding unnecessary closures for areas with unknown fire hazard conditions. (Interagency, TEF 526, Case No. 104771, 7/79)

+G-25 Paragraph deleted, 9/79

G-16 Flammability tests of home furnishings: conducted for TTD 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. . . . continued use as a reference. . . . used by Columbus Fire Department (Ohio) since 1975 to obtain data on combustion gases and improve safety for firefighters. . . . Fire Chief states report has provided valuable input to department activities. (TTD conference, Contact/TTD and contractor, TEF 539, Case Nos. 107034, 107040, 5/79)

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 mechanical engineers. . . .
+ dry air systems now installed on almost all Navy ships; system prevents ionization which can damage electronic components such as radar waveguides and coaxial cables. (TB/TSP, TEF 542, Case No. 98756, 5/79)

+G-18 Paragraph deleted, 9/79

G-19 Infrared electro-optical imaging systems: developed for Goddard and JPL by Hughes Aircraft Co., (California) for use on observation satellites and inter-
+ planetary space probes. . . . used by Hughes' Industrial Products Div. (California) to design portable infrared imager for the U.S. Army. . . . lightweight, hand-held, infrared viewer commercialized as PROBEYE. . . . 3 models, priced from about $6,600 to $7,600, currently available; over 1,800 units sold to date. . . . used by fire and police departments, forestry departments and industry. . . . applications include detection of: hotspots; people and objects concealed by smoke or darkness; flammable or hazardous materials leakage; forest fires (from helicopters); overheating in industrial electrical systems. . . . also used for mining equipment inspections (advanced PROBEYE model certified by Mine Safety and Health Administration) and assessment of insulation effectiveness for residential, commercial and industrial facilities. (Contractor, TEF 576, Case No. 109342, 5/79)

+G-20 Paragraph deleted, 9/79

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., Aeronautical Sciences Div. (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 equip-
+ ment. . . . program used on a continuing basis by approximately 20 structural engineers in division. . . . majority of contracts with DOD. (Customer, TEF 410, Case No. 114851, 6/79)

G-30 Combustion analysis computer program: developed by Lewis. . . . used by U.S. Department of the Interior, Bureau of Mines, Pittsburgh Mining and Safety Research Center (Pennsylvania) in computer modeling for coal mine fire and explosion research. . . . enables analyses of flame temperatures, combustion products and flame expansion ratios under various conditions. . . . provides input to other computer programs for evaluating different flame inhibitors, explosion hazards, and venting requirements for vessels which may be subjected to explosion pressures. . . . research results include toxicity of combustion products from flame inhibitors, design information for producers of automatic detectors and quenching systems, and input to a proposed National Fire Prevention Association guideline. . . . program used about once every two weeks, less costly and more accurate than the other alternative of performing experiments. (Contact/Lewis, TEF 463, Case No. 86017, 10/78)

G-31 Lunar Rover navigation system: developed by Marshall to chart vehicle's position on lunar surface. . . . used by Planning Maps, Inc. (New Hampshire) to develop specially equipped vans for collecting data as part of a statewide tax mapping program. . . . Rover system generated 9 pulses per wheel revolution, adapted so that van wheels generate 180 pulses per revolution . . . . 1970 New Hampshire law requires all towns to have tax maps by 1980
+ . . . . maps prepared for 17 New Hampshire towns before business sold to Land Inventory Systems (New Hampshire) in late 1978. . . . van still being utilized to generate tax maps with an accuracy of 1/4-inch in 100 feet. . . . company also provides microfilm containing backup and source material for maps; includes deeds, surveys, subdivisions, and "computer plot" produced by equipment in van. . . . to date, sales from service total $180,000 and are expected to reach $400,000 by the end of 1979. . . . company has current contracts with 15 towns in New England area, 3 more are committed for 1980, and 17 other towns are interested, pending funding. . . . rapid growth of business anticipated. (Purchased product line, TEF 718, Case No. A010286, 8/79)

G-26 Electronic and electromechanical component reliability data: compiled for NASA Pasadena Office by JPL. . . . data includes failure modes, screening requirements, derating factors and stress analysis. . . . used by the U.S. Department of Labor, Mine Safety and Health Administration, Approval and Certification Center (West Virginia) 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. . . . benefits include time savings and improved reliability specifications for mine safety equipment. (Personal contact/TSP, TEF 627, Case No. 111080, 9/79)

G-27 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Metropolitan Sewer Board of the Twin Cities Area, Metropolitan Wastewater Treatment Plant (Minnesota) as a reference for equipment maintenance. . . . plant treats 220 million-gal./day but has 600 million-gal./day capacity for peak periods; serves over 2 million people. . . . handbook used to select less expensive lubricants and reduce inventory from 60 to 16 types; only one new lubricant added to inventory since 1976. . . . $1,000 annual savings. . . . handbook also used by Norfolk Naval Shipyard, Public Works Dept. (Virginia) to identify military specifications for lubricants so they could be ordered through federal supply system. . . . lubricant inventory reduced from 50 types to 7, saving hundreds of dollars in acquisition and handling costs. . . . consultant contractor used handbook to train over 20 maintenance personnel in proper lubrication for 400 weightlifting units of various types; also, standardized lubrication process and presented one-work course on new program. . . . training reduced overlubrication, operating costs and equipment down-time, and increased productivity. (TB/TSP, TEF 497, Case Nos. 93724, 97988, 5/79)

G-28 Solar heating and cooling performance measurement: developed by Marshall . . . . technique for comparison of performance characteristics between solar and conventional energy devices; includes efficiencies, auxiliary energy requirements, solar energy requirements. . . . used by Kentucky Dept. of Natural Resources and Environmental Protection, Office of Planning and Research in design of seminar programs on future environmental control. . . . public seminars held three times a year and primarily addressed to builders, architects and architectural students. . . . provides program speakers with topical information on advancements in solar heating and cooling devices. (TB/TSP, TEF 711, Case No. STIF-55495, 2/78)

G-29 Photovoltaic power system: solar cells developed by Lewis for satellite power. . . . adapted by Lewis to provide power systems for joint USDA program to develop more effective insect control programs. . . . systems used by USDA's Science Education Administration, Cotton Pest Control Unit (Texas) to power insect traps in four remote locations for almost three summers. . . . eliminated constraint of power availability in the field. . . . data used to predict population patterns of harmful insects and develop improved insect control programs leading to reduced cotton crop damage. (Interagency, TEF 722, Case No. A006434, 7/78)

Other Relevant Examples:

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 (DOE licensing regulations); D-18 (TVA data telemetry system); E-3 (pollution monitor filter); E-4, E-5, E-8, E-9 and E-21 (air quality agencies); E-6 (state vs. state case); E-7 (state legislature); E-11 (EPA National Eutrophication Survey); E-16 (community sewage treatment facilities); E-17 (water quality monitor); E-19 (hazard reduction method); F-4, F-6 and F-30 (USDA food processing); F-5 (FDA training manual); F-16 (tax assessment); F-26 (joint project with USDA); H-1 (USGS regulations); H-25 (high temperature thermal insulation); H-26 (Iranian Government); H-29 (MSHA mine safety services); I-6 (New York City sewage system); I-7 (U.S. Army Corps of Engineers dam projects); 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-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); R-10 (hospital radiation safety); S-2 (NSF Polar Program); S-3 (Great Lakes Winter Naviation Program); T-2 (weather information transmission)

+G-32 Laboratory for Applications of Remote Sensing (LARS): developed at Purdue University (Indiana) for Johnson and Office of University Affairs, NASA Headquarters. . . . includes computers, remote terminals, remote sensing data bank, and computer software for data analysis. . . . provides software development, data analyses, and training for government agencies (e.g., U.S. Forest Service, U.S. Department of Agriculture, State of Indiana) and private companies (e.g., St. Regis Paper Co.). . . . over 1,000 people have attended LARS symposia and short courses, or participated in visiting scientist program . . . . approximately $750,000 annually from funding sources other than NASA . . . . government applications include food crop surveys, soil mapping, and stripmine surveys. . . . private company applications include timber inventories. . . . LARS remote terminal at Indiana State University provides similar services. . . . applications include ecological studies for Environmental Protection Agency, land use planning research for State of Indiana, and stripmine rehabilitation monitoring for AMAX, Inc. . . . LARS demonstrates usefulness and efficiency of using remote terminals tied to a large central computer for processing data from satellites such as LANDSAT. . . . client benefits include reduced cost, timeliness and standardization for resource surveys. . . . also, St. Regis Paper Co., Southern Timberlands Div. (Florida) participated with Johnson in jointly funded "Forest Resource Inventory System" to develop methods for using LANDSAT data for timber surveys; computer software for project developed at LARS. . . . benefits from project include better evaluation of acquisition sites, more efficient use of ground crews and aerial photography, and more accurate information for settlement of assessment disputes with county tax officials. (Contractor, Contact/contractor, TEF 513, Case Nos. A008930, A010403, A010405, 4/79)

+G-33 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 the Rio Hondo (Texas) Mayor's Office to develop sewage treatment system for its 2,000 residents. . . . cost of system only $11,000 versus $240,000 for a conventional treatment facility. . . . system, which has been in use since mid-1970's, has proven effective on a year-round basis and keeps water quality level far above legal requirements. . . . other benefits include lower operating costs than conventional facilities and easy disposal of harvested plants as fertilizer for farmland. . . . permit for system issued by Texas Parks and Wildlife Division after tests showed plants would not create clogging problems in nearby rivers after periods of flooding. . . . used by San Diego Water Utilities Dept. (California) as method proposed to California State Water Resource Control Board for a one million-gal./day pilot plant. . . . recent feasibility study by the department concluded that the water hyacinth method was promising and should be tested further. . . . state board is expected to approve proposal; construction expected to begin in early 1980. . . . successful prototype will lead to construction of three larger facilities by 1990 . . . . method offers inexpensive and effective approach for development of effluent-to-drinking water recycling program; other benefits would include reduced costs and increased revenue from sale of harvested hyacinths for fertilizer and cattle feed. . . . department operates one of the larger water and sewage districts in the U.S., with over 1.5 million customers. (Personal contact, TEF 617, Case Nos. A008618, A008621, 8/79)

H

PETROLEUM AND GAS

H-5 Multiplexer circuit for Saturn rocket instrumentation: developed for Marshall by SCI Systems, Inc. . . . used by SCI (Texas) in remote data acquisition and control systems product line. . . . approximately 60 systems installed on oil and gas pipelines and oil field production equipment; cost of these systems ranged from $200,000 to $500,000. . . . also, 4 systems installed at petrochemical plants; cost ranged from $75,000 to $150,000. . . . customer benefits include better centralized monitoring and control, with less manpower, and improved service for pipeline customers through better control and centralized billing. (Contractor, TEF 119, Case No. 4793, 10/78)

H-6 Heat pipe applications: developed for Marshall, Langley, and Ames by McDonnell Douglas Corp. (California) 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. . . . MDC has produced 138,000 Cryo-Anchors. . . . will be installed around pipe supports for 390-mile elevated portion of 800-mile pipeline. . . . other uses by general construction industry for schools, a hospital, a water tank and power pole support 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, 12/77)

H-7 + Infrared scanner and television display: operational unit developed for Marshall. . . . commercial infrared TV scanner developed by contractor employees and now being produced and marketed by Inframetrics, Inc. (Massachusetts). . . . product used for maintenance inspections at petrochemical plants and refineries by 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. (Purchased produce line, Customer, TEF 398, Case No. 112249, 8/79)

H-8 + Hot tapping method for pipes: developed for Johnson. . . . used at American Oil Co.'s Whiting Refinery (Indiana) to repair leaking oil line. . . . normally, pipe or valve leaks require up to 8 people and either partial shutdown or elaborate safety procedures. . . . new method can be done by one or two people in half the time, with no shutdown and little fire hazard . . . . company found outside vendors to fabricate and install tapping apparatus, then sent maintenance letter to 11 other Amoco refineries listing available vendors. (Trade Journal/TSP, TEF 460, Case No. 75018, 4/79)

H-9 Paragraph deleted, 1/78.

H. ENERGY

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. . . . contributed to 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, involving over 2,500 oil leases. . . . new Recommended Practices and Specifications issued by American Petroleum Institute (Texas) for subsurface safety valves and surface safety systems partly based on Marshall recommendations. . . . will be adopted by industry and included in USGS regulations. . . . new program to license equipment manufacturers was initiated in 1978. (Interagency, Contact/USGS, TEF 484, Case No. 93831, 9/79)

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 17 billion std. cu. ft. in 1976 and projected to be 870 billion std. cu. ft. in 1980. (NBS Cryogenic Data Center, TEF 364, Case No. 50868, 9/78)

H-3 Paragraph deleted, 5/76

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. . . . system 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 increas-
+ ed production. . . . Exxon Corp. (Texas) has computer production control (mostly TRW) in 20 major U.S. fields and estimates 1-2% production cost savings. . . . system recently installed for Petrobras (Brazil) and Maui Natural Gas (Australia); to be installed for PEMEX (Mexico) to control pipeline from Mexico to southern Texas. . . . 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, 6/79)

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. . . . to date, more than 50,000 individuals (over 52% of CENGAS' customers) have visited utility sales offices to find out whether they needed insulation in their homes, businesses or schools. . . . in first year of program (1975), insulation sales in Lincoln area increased by more than 20% over previous year; steady increase since. . . . Lincoln School System initiated program to reduce energy losses from schools; one school saved $700 during first two months after reroofing and insulating; successful results led to $250,000 investment to conserve energy in local schools. . . . businesses and homeowner associations in Lincoln area initiated cooperative efforts to conserve energy; total savings in energy costs for only two companies estimated at $550,000 since 1975. . . . CENGAS plans to expand program to 24 more towns in Nebraska and to initiate door-to-door pilot study of energy-use audits (checking insulation, windows, doors) for 5,000 private homes. . . . energy-use audits currently being conducted in most of the Lincoln-area hospitals. (Personal contact/grantee, TEF 605, Case No. 115406, 10/78)

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, in developing an employee safety program, and in all subsequent hydrogen-related projects. . . . improved safety conditions for 40 employees as well as the safety features designed into project prototypes. . . . used, for example, during study of a reactor simulator with hydrogen bubble at 280°F at 1,000 psi pressure; study was part of program to determine cause of 1979 reactor accident at the Three Mile Island nuclear facility in Pennsylvania. . . . used in development of prototype electrolizer product which produces hydrogen and oxygen from water. . . . U.S. National Weather Service interested in electrolizer to inflate weather balloons in remote areas; on-site hydrogen production capability would eliminate transportation costs and storage problems. . . . electrolizer also used in remote Alaskan hospital for production of oxygen and in a Billings project to convert automobiles to run on hydrogen. . . . manual also used to develop "Hydrogen Homestead" in Provo, Utah. . . . project, sponsored by DOE, involved modifying home appliances to run on hydrogen and developing storage tank for 5-day fuel supply; second phase will emphasize development of safety factors for storage facility. (TB/TSP, TEF 258, Case No. 113024, 5/79)

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. . . . to date, 90 units have been sold at prices ranging from $54,000 to over $1 million for large units. . . . rapid market growth expected to continue . . . . primary customers are oil and chemical companies. . . . payback time to customer is 2-3 years. . . . smaller version developed for retail gas stations. . . . will be in $5,000 to $10,000 price range. . . . undergoing market tests; if successful, could lead to significant new market. (Trade journal/TSP, TEF 497, Case No. 97902, 4/78)

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 person-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. . . . program also used in calculations for high temperature steam-reforming of hydrocarbons and coal gasification. . . . enables equilibrium modeling which would not be attempted otherwise. (Lewis conference, TEF 463, Case No. 93825, 10/78)

+H-12 Paragraph deleted, 9/79

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. . . . currently used on a continuing basis to solve routine conversion problems. . . . 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. . . . continued use as a reference for conversion problems. (Personal contact/TSP, Trade journal/TSP, Personnel/TSP, TEF 527, Case Nos. 102812, 103018, 114861, 6/79)

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 avoid buckling problems in design of three industrial boilers for Gulf Oil Corp. . . . boilers used for steam processing in Gulf refineries. (Contact/COSMIC, TEF 410, Case No. 91178, 6/79)

H-21 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by Carrier Corp., Elliott Co. Div. (Pennsylvania) in collecting performance data from turbine and compressor products. . . . customers include petroleum refineries and petrochemical companies. . . . several research days saved each year in determining best methods for attaching gages to turbine blades and compressor impellers. (TB/TSP, TEF 384, Case No. 56996, 5/77)

H-22 Cryogenic data handbook: compiled for Kennedy. . . . used by Exxon Corp., Baytown Petroleum Refinery (Texas) to obtain design data for processing equipment. . . . also used to maintain quality control standards in low temperature refining operations. . . . provided specific piping insulation requirements to assure optimum temperature ranges during polyester fiber production. (TB/TSP, TEF 248, Case No. 72128, 5/77)

H-23 Paragraph deleted, 10/78

H-24 Nondestructive spot test procedures: compiled by Langley. . . . used by General Motors Corp., Harrison Radiator Div. (New York) to help in making field repairs on its products. . . . heat exchanger products used in natural gas transmission. . . . tests applied to identify metals for welding and repair in the field. . . . handbook replaces commercial testing kits costing up to $50 and limited to specific metals. (Personal contact/TSP, TEF 378, Case No. 124096, 6/77)

H-25 High temperature thermal insulation: developed by Goddard. . . . used by Stearns-Roger Corp. (Colorado) to insulate portions of the pipe system in a coal gasification pilot plant. . . . high temperature pipe carries limestone slurry, temperatures up to 1,500°F. . . . design time reduced. . . . pilot plant operations under contract to Department of Energy. (SBA/TSP, TEF 699, Case No. STIF-61506, 12/77)

H-26 Satellite photographs: obtained during Gemini, Apollo, and Skylab missions supervised by Johnson and LANDSAT program supervised by Goddard. . . . photographs marketed by the Technology Application Center (TAC), a NASA Industrial Applications Center located at the University of New Mexico . . . . for over 10 years, Trollinger-Gosney and Associates (Colorado), a geological consulting firm, has used NASA photographs of the earth's surface to support its conventional exploration techniques, which also include aerial observations and photographs. . . . satellite sources provide approximately 10% of input to final composite products (maps and photographs) which are then used in petroleum exploration work by major oil companies. . . . photograph of Iran was instrumental in locating previously unknown salt dome formations in 1970. . . . provided Iranian Government with information about a substantial new source of sulphur. (Personal contact/TAC, TEF 199, Case No. 40315, 9/78)

H-17 Electronic and electromechanical component 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 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, 8/79)

H-18 Neutron shielding material: developed for Space Nuclear Propulsion Office . . . . used by Gearhart-Owen Industries, Inc. (Texas) to develop geophysi-
+ cal exploration tools. . . . one, a well logging tool, emits neutrons to measure presence of hydrogen and porosity of rock in deep petroleum exploration wells and coal mines; the other uses same process to detect natural gas. . . . shield prevents contamination of detector components. . . . both tools priced at $18,000 each; 80 logging tools and 200 gas detectors sold annually. . . . 90% of sales to company subsidiary, GO-International, for commercial exploration services. . . . major petroleum company customers . . . . new product using same technology, a tool to locate oil and gas in old steel-encased wells, currently under development. (Personal contact/ TSP, TEF 532, Case No. 102354, 7/79)

H-19 Rotational vibration analysis methods: developed for Marshall and Lewis by University of Virginia, Mechanical and Aerospace Engineering Dept. . . . 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. . . . also used by several manufacturers of vibration measuring equipment. . . . estimated that end users of machinery save over $250,000 per machine in operating expenses. (Contractor, TEF 658, Case No. 121463, 8/79)

H-20 Titanium alloy data handbook: compiled for Marshall. . . . includes physical and mechanical properties, metallurgy, corrosion, fabrication and joining techniques. . . . used by Sundstrand Corp., Fluid Handling Div. (Colorado) to improve design of centrifugal pump products. . . . impeller component is cast from titanium alloy. . . . several thousand improved pumps sold for about $5,000 each. . . . customers are petrochemical companies such as Standard Oil Co. of California, Amoco Oil Co. (TB/TSP, TEF 683, Case No. 122796, 4/77)

Other Relevant Examples:

B-2, B-74, F-15, F-24, I-28 and K-10 (energy conservation); B-10 (LNG tankers); B-14 (petrochemical production); B-23 (blowout valve system); B-38 (combustion analysis); B-41 and B-58 (process instrument); B-51 (strain measurement); B-56 (underwater equipment locator); D-8 (quality assurance for offshore rigs); E-7 (coal mine inventory); G-15 and I-6 (LNG storage facilities); G-30 (coal mine safety); G-32 (strip mine surveys); I-21 (plant facilities); M-13 (fuel flow control); M-52 (oil rig helicopter); O-34 (alternative energy sources); S-1 (oil tanker communications); S-4 (oil rig paint); S-16 (oil tanker navigation charts); T-7 (gas flow monitor)

H-27 NECAP (NASA Energy-Cost Analysis Program): developed by Langley. . . . thermal load calculations and energy usage predictions to determine and minimize energy consumption for buildings. . . . used at the Georgia Institute of Technology to analyze factors involved in controlling the internal environment of over 100 campus buildings. . . . predictions used to develop computer control program for campus HVAC systems; also, used to adjust building usage (e.g., class schedules) to improve energy efficiency . . . . tested on several buildings and resulted in 20-30% reduction in energy consumption; estimated that substantial savings will be realized when adjustments made for entire campus. . . . also, $8,000 saved to date by having analysis capability in-house. (COSMIC, TEF 752, 8/77)

H-28 Chemical vapor deposition of silicon carbide: data compiled by Lewis; included information on insulation materials, techniques and efficiencies . . . . used by Weed Instrument Co, Inc. (Texas) in development of a new, high temperature (over 3000°F) sensor product. . . . enabled identification of a sealant with high temperature insulation characteristics. . . . unit price ranges from $800 to $1,200; several hundred sold to date. . . . sensors used in coal gasification equipment. . . . new product helped small company almost double in size (from 29 employees in 1977 to 50 by mid-1978) and exceed a million dollars in sales in 1978. (SBA/contact/Lewis, TEF 716, Case No. A006468, 7/78)

+H-29 Coal mine hazards study: conducted for Goddard as one of the early ERTS (now LANDSAT) "Principal Investigator" studies. . . . computer enhancements of LANDSAT images were analyzed for patterns of lines associated with geologic fractures in the rock beneath a region. . . . results indicated a correspondence between observable linear patterns and hazards such as roof falls in underground coal mines. . . . study methods and results used in numerous mine safety studies conducted by private mining companies and government agencies . . . . the U.S. Dept. of Labor, Mine Safety and Health Admin. (MSHA), Denver Technical Support Center (Colorado) frequently advises companies with hazardous mines on how to use LANDSAT data, aerial photographs, and mining data to pinpoint areas where cave-ins are likely to occur. . . . MSHA provides the training and equipment needed to analyze the data. . . . estimated that over 100 mining companies (primarily coal) have used these methods for analyzing hazardous areas in underground mines; results in improved safety records and increased production. . . . Western Slope Carbon, Inc. (Utah) has been using MSHA's LANDSAT data analysis services since an August 1975 roof collapse in its Hawksnest mine killed two people. . . . company has been able to avoid extending operations into potentially dangerous areas, resulting in improved safety and significant increases in coal production (estimated at 20% for 1978). (Professional journal, Contact/MSHA, TEF 500, Case Nos. A011910, A011911, 7/79)

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 Electrical Code amendment. . . . prior to decline of new housing starts in early to mid-1970's, monthly sales of interrupter units totaled 40,000; currently, steady rise in market and monthly sales approximately 13,000 units and expected to reach 20,000 units by late 1979. . . . hotel/motel market for interrupters developing as a result of 1975 Electrical Code amendment. (Contractor, TEF 119, Case No. 4793, 10/78)

I-6 Cryogenic data handbook: compiled 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, 10/78)

I-7 Fusion welding workmanship standards: compiled for AEC (now DOE) and NASA Space Nuclear Propulsion Office. . . . used by Gannett, Fleming, Corddry, 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. . . . have been used to specify procedures for construction of aluminum hand rails and stainless steel gates on the Tioga/Hammond Lakes Dam project. . . . 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, 7/78)

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 railroad tank cars and propane tanks. . . . THERMO-LAG sold primarily in 55-gal. drums at current price of approximately $780 per drum; also available in smaller quantities for about $14 per gallon. (Personnel/contractor, TEF 521, Case No. 104141, 6/79)

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 each and 200 activities printed per hour compared to $3.60 each and 10 per hour for manual production in 1974). . . . sales have increased about 80% since 1975 and continued increases are expected. . . . one construction company customer estimated cost savings of $270,000 from using EZPERT, rather than conventional techniques, on a $43 million construction project. (Personnel/contractor, TEF 517, Case No. 103406, 12/77)

I-2 Geodesic structure design program: developed for Headquarters by R. Buckminster Fuller at Southern Illinois University. . . . computer program used
+ by Space Structures International Corp. (formerly Dome East Corp.) (New York) to design commercial geodesic structures. . . . applications include recretional enclosures, greenhouses, homes, etc. . . . since 1970, sales have totaled $15 million for 261 completed domes. . . . product line includes medical facility dome, Medidome, built in Florida, Nigeria and Saudi Arabia; Medidome represents largest portion of sales. . . . product line continues to expand with recent addition of aluminum "space frame" for building upper floors and roofs, as well as development of 334-ft. diameter stadium dome. (Personnel/grantee, TEF 479, Case No. 91454, 1/79)

+I-3 Paragraph deleted, 9/79

I-4 Fiberglass fabric: Beta fiber yarn invented by Owens-Corning Fiberglas Corp. (Ohio). . . . company developed first application for fiberglass fabric with 1967 contract from Johnson for nonflammable clothing and structures; included development of Teflon coating for fabric. . . . application experience used to develop commercial market. . . . current uses
+ include protective clothing and roofs; yarn priced at $3 per lb., coated fabric price not available. . . . coated fabric used commercially in air structures developed by Birdair Structures, Geiger-Berger & Assoc. (New York) and others. . . . installations include a vinyl-coated fabric covering for the U.S. Pavilion at Expo 70 in Osaka, Japan; Teflon-coated fabric coverings for stadiums, arenas and other recreational facilities, such as the "Silverdome" in Pontiac, Mich., University of Northern Iowa stadium in Waterloo, University of South Dakota stadium in Brookings, the sports arena at Laverne College, Calif., the multipurpose student center at Milligan College, Tenn., and the picnic area at Sea World in San Diego, Calif. . . . recent applications include roofs for office buildings, department stores such as Bullocks in San Jose, Calif., and airport facilities such as the $3 million roof for the Haj Airport Terminal in Saudi Arabia. . . . in past year, over $200 million worth of construction involved this material and Birdair's annual revenue from such projects is over $4 million. (Contractor, Customer/contractor, TEF 324, Case Nos. 103412, 103413, 103414, 9/79)

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. . . . company received patent on collector panel design. . . . now marketed under trade name ROM-AIRE, panels sell for approximately $10 per square foot and come in 4'x8' and 2'x12' sizes. . . . to date, collectors installed in 450 homes and 30 businesses. . . . sales figures not available. (Personnel/ Lewis, TEF 606, Case No. 114869, 7/79)

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, 9/78)

+I-16 Paragraph deleted, 9/79

+I-17 Paragraph deleted, 9/79

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 & McLung-Pace Co. (Oregon) which designs and builds customized central heating and cooling equipment for the construction industry. . . . used to improve computer program for analyzing sound
+ levels in fan designs. . . . modification made program five times faster and reduced computer operating costs. . . . program used in standardizing basic fan wheel and housing designs to satisfy Air Moving and Conditioning Association (AMCA) recommendations. . . . company research director also distributed copies to AMCA's Technical Advisory Committee on Sound Standards for use in revising sound measurement standards for the fan industry. (TB/ TSP, TEF 628, Case No. 114494, 8/79)

I-19 Boundary layer wind analysis: developed for Headquarters and by Marshall . . . . combined studies were an exhaustive analysis of boundary layer
+ wind. . . . used by Colorado State University, College of Engineering, Fluid Mechanics and Wind Engineering Program in wind simulation model for structural design of Yerba Buena Center (California), World Trade Center Towers (New York), Federal Reserve Bank Building (Virginia), Johns-Manville World Headquarters (Colorado), the Anaconda Tower (Colorado), Candlestick Park (California), and the University of Pennsylvania Hospital. . . . provided basis for estimating accuracy of simulation. . . . CSU also has National Science Foundation grant to study windmills for electric power and contracts with Bechtel and Sandia Laboratories to study effects of wind on solar collectors. . . . 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, 8/79)

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 major buildings, to convert over 50 programs for IBM 370 computer system. . . . annual operating cost savings. . . . program applications include slope stability, seepage problems, and analysis of pile driver data. (TB/TSP, TEF 527, Case No. 10334, 5/77)

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. . . . government and commercial sales about $100,000 annually. . . . 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, 9/78)

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. . . . millions of feet sold at prices ranging from $4 to $35 per foot, depending on order quantity . . . . used in demolition industry for controlled removal of obsolete structures. . . . various buildings and over 80 bridges nationwide removed with JetCord. (Contractor, TEF 559, Case No. 109329, 6/79)

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) for the University of Akron's Edwin J. Thomas Performing Arts Hall (Ohio). . . . used to adjust tension in 150-cable suspension system of Hall's 3-section, 40-ton moveable ceiling. . . . benefits from use of tool are: reduces number of load cells required in suspension system; reduces cable inspection time; and saves $1,000 annually in not having to hire outside specialist to conduct inspections. . . . most modern, moveable ceiling facility in country. . . . 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, Customer, TEF 489, Case Nos. 91230, 91480, A009407, 6/79)

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 increase in utility bills of over $400 annually. . . . used by Ener-tech, Inc. (South Carolina) to install residential solar heating systems. . . . company's owner used information to design solar systems, including one for his own home, while employed at a plumbing company; he formed Ener-tech in January 1979 to specialize in installation of solar systems. . . . company currently installing solar water heating system in 14-story apartment building. . . . use of information has saved approximately $2,500 to date. (Popular magazine/TSP, Personal contact/TSP, TEF 496, Case Nos. 106862, A009259, 5/79)

I-26 Thermal analysis computer program (MITAS): developed for Marshall by Martin Marietta Corp. (Colorado) for Saturn rocket program. . . . Martin Marietta later used MITAS to develop hybrid program, SOLCOST, under contract to the Department of Energy. . . . SOLCOST helps determine heat load characteristics, and assess practicality, of different solar heating and cooling systems. . . . Solar Environmental Engineering Co. (Colorado) licensed by Martin Marietta to use SOLCOST program. . . . used in selecting appropriate solar heating system for 2 new branch offices of Crown Realty Co. (Colorado). . . . analysis indicated solar-assisted heat pump would provide economical alternative to conventional heating and cooling equipment. . . . systems installed and undergoing operational evaluation; favorable results may lead to additional installations in future offices . . . . also gives Crown salespeople first-hand knowledge of solar heating systems. . . . licensee stated that SOLCOST is a valuable component of firm's solar analysis package. (License/contractor, TEF 744, Case No. A007922, 10/78)

I-27 Sound insulation compound: developed for Johnson to solve vibration problem with Apollo guidance control system. . . . former NASA employee started new company, SMART Products (Massachusetts), to develop compound into sound insulation products. . . . SMART (for Sound Modification and Regulated Temperature) Compound is currently available as paneling (1/8-inch-thick insulation sheets) or in liquid form (55-gal. drum covers 700 sq. ft. at 1/8-inch thickness and provides a 30-dB sound insulation) . . . . annual sales are $500,000; unit cost in liquid form is $20/gal. . . . . used, for example, in a General Electric Co. light bulb plant to reduce production noise level from 105 dB to 70 dB, and by another company on hundreds of food processing machines sold to Wendy's and Burger King food outlets. . . . currently being evaluated by Hilton Hotels, Detroit Edison (for power plants), the New York Port Authority (for traffic tunnels), Ford Motor Co., an aircraft company and hospitals. . . . compliance with OSHA noise level standards is important buyer stimulus in sound insulation market. (Personnel/Johnson, TEF 750, Case No. A008104, 10/78)

I-28 NECAP (NASA Energy-Cost Analysis Program): developed by Langley. . . . thermal load calculations and energy usage predictions to determine and minimize energy consumption for buildings. . . . used by Stearns-Roger Corp. (Colorado) in designing new buildings. . . . provides analysis of design factors that allow buildings to be heated, ventilated and cooled more efficiently despite seasonal changes. . . . benefits include more efficient design analysis, more accurate results, and additional design capabilities. . . . customers benefit from reduced energy consumption, resulting in lower utility costs. . . . also being used in energy consumption analysis of buildings owned by the State of Colorado. (Personal contact/COSMIC, TEF 752, 10/77)

I-20 + Wind model for structure design: developed for Ames by Colorado State University, College of Engineering, Fluid Mechanics and Wind Engineering Program as part of STOL-Port design studies. . . . included development of new hot-wire anemometer measurement method. . . . method used routinely by CSU for private and government contracts to analyze wind flow around proposed buildings, particularly downwind turbulence. . . . results applied in structural design of buildings. (Contractor, TEF 647, Case No. 120517, 8/79)

I-21 + Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Raymond International, Inc., Engineering Services Div. (Texas) in solving lubrication problem for custom-designed hydraulic pile driving hammer. . . . handbook data saved 3-5 months in manufacturing hammer, avoided delay in contract work. . . . currently, handbook used by over 50 employees as a guide in solving project lubrication problems; considered valuable source of information. . . . company is largest in heavy foundation construction business, with over 1,000 projects completed in last 12 months. . . . projects have included foundation construction for 12 large electric power plants, 3 LNG facilities, tanker terminals on the Mississippi River and in Panama, a 6.5-mile trestle for Amoco operations in the Arabian Gulf, and a concrete products casting yard in Saudi Arabia. (TB/TSP, TEF 497, Case No. 92980, 6/79)

+I-22 Paragraph deleted, 9/79

+I-23 Paragraph deleted, 9/79

I-24 Ultrasonic nondestructive testing training manuals: compiled for Marshall . . . . used by Chemical Industries, Forge and Foundary Supply Co. Div. (California). . . . to develop expertise techniques for commercial testing service. . . . ultrasonic tests used for steel "I" beams when construction requirements are more exacting than usual. . . . reveals discontinuities that may lead to future structure failure. . . . company customers include U.S. Steel, Bethlehem Steel, Consolidated Steel Companies. . . . significant benefits not quantified. (TB/TSP, TEF 375, Case No. 123910, 4/77)

I-25 Residential solar heating system: developed by Langley. . . . low-cost system (approximately $2,000 for materials) designed for installation by individual homeowners. . . . supplements conventional forced-air heating system, resulting in 40% reduction of annual utility costs. . . . used by Home Building Plan Service (Oregon) to develop new product for homeowners and residential contractors, the Solar Schematic. . . . schematic contains illustrated, simplified information on evaluating and constructing a solar energy system for new or existing residential structures. . . . plan retails for $10. . . . information on NASA system saved $2,000 in research costs and was the best available in laymen's terms. (NTIS/TSP, TEF 727, Case No. A007516, 4/78)

+I-32 Flat conductor cable for surface-mounted wiring systems: developed by Marshall with TTD funding after NASA Technology Applications Team identified need for commercial and residential building wiring system that could be installed efficiently. . . . Temporary Interim Amendment to 1978 National Electrical Code (NEC) was passed to allow usage of FCC. . . . Parlex Corp. (Massachusetts) gained production and application experience in FCC as a supplier to Marshall. . . . company developing commercial market in construction industry. . . . currently selling 2,000 ft. of FCC annually to firms that are developing construction applications. . . . sales expected to increase due to NEC Amendment. . . . TATeam activity also stimulated development of a low voltage switching device for FCC. . . . product line, called Surface Switch, introduced by Switchpack Systems, Inc. and then sold to Non-Linear Systems, Inc. (California) in 1974. . . . unit prices range from $10 to $15; about 2,000 sold annually. . . . Marshall contributions used by Western Electric Co., Inc. (New Jersey) in developing new FCC products. . . . one product, a Telephone Under-Carpet Cable (TUCC™) system, is designed for low cost installation in open space offices. . . . complete, ductless wiring system for electric power and telephones estimated to provide as much as 10% reduction in construction costs. . . . complete system prototype installed in Bell System office building in 1974. . . . TUCC is expected to become a major sales item for Western Electric due to passage of NEC Amendment and high potential for cost savings in new construction and rewiring projects . . . . office wiring system products using FCC also developed by AMP, Inc. (North Carolina) and Thomas & Betts Corp. (New Jersey) as a result of NASA's applications activities. . . . both companies anticipate major sales as a result of the NEC Amendment. (Contractor, Purchased product line, Contact/ Marshall, TEF 13, Case Nos. A005996, A009052, A009447, A009448, A009449, 5/79)

Other Relevant Examples:

A-11 and A-12 (solar collector); A-15 (roller coaster support structure design); B-2 (insulation inspection device); B-11 (chemical plant design); B-19, G-16 and N-7 (fire safety); B-37 (NDT training); D-9 (nuclear power plant design); G-10 (airport construction management); G-15 (LNG storage facilities); G-28 (solar energy seminars); H-2 (LNG import facilities); H-27 (energy conservation); R-8 (fire alarm inspection)

+I-29 Battery-powered hand tools: developed for Johnson by Black and Decker Manufacturing Co. (Maryland). . . . development included a computer program for designing the Apollo Lunar Surface Drill. . . . program used by B&D in developing improved product line of cordless power tools for industrial and consumer markets. . . . improved design of permanent magnet in battery-powered DC motors and reduced power consumption. . . . industrial tools sell for about $100 each. . . . used in construction industry for installation of aluminum siding and small areas of dry wall. . . . other markets include the sheet metal and automotive industries. . . . sales data not available. (Subcontractor, TEF 300, Case No. 33607, 7/79)

+I-30 Solar energy meter: developed by Lewis. . . . inexpensive, pocket-sized insolometer measures amount of energy available from ambient sunlight; covers range of 1 to 1,250 watts/meter^2. . . . enables designers of solar energy systems to make on-site measurements of available energy in order to determine size of system needed. . . . Dodge Products, Inc. (Texas) was formed in 1976 to market a compact, commercial version of the solar meter. . . . meter can be used to check the performance of solar collector panels, to measure the transmission loss through transparent materials (e.g., glare reducing films on windows), and to estimate the performance of solar system components, such as concentrators, lenses and mirrors. . . . unit price is $54.50 . . . . customers include solar systems contractors, architects, government agencies, research laboratories, universities and individuals. (TB/TSP/Lewis personnel, TEF 768, Case No. A009446, 7/79)

+I-31 Ultrasonic bolt-tensioning monitor: developed by Langley. . . . measures changes in the resonant frequency of bolts to determine amount of stress exerted in bolts; uses a ROUS (reflection-oscillator ultrasonic spectrometer) system. . . . monitor received Industrial Research IR-100 award in 1976. . . . Panametrics, Inc. (Massachusetts) obtained nonexclusive NASA license in 1977 to produce monitor. . . . over $75,000 invested in development of commercial version; marketing will begin in late 1979. . . . unit price will range from $2,000 to $10,000, depending on configuration. . . . primary customers will be construction contractors for large, steel-framed buildings. (Contact/Langley, TEF 772, Case No. A009455, 7/79)

J

LAW ENFORCEMENT

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 . . . . since mid-1977, system produced on custom-order basis only; at that time, sales totaled $30 to $35 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), Louisville, Kentucky Police Department (1973), and Scotland Yard ($4.5 million, 1977). . . . provides compact, automated fingerprint file system used successfully in all installations and criminal history files (including photographs) in some installations. . . . Canadian system still used; reduced cost of fingerprint searches. (Contractor, TEF 226, Case No. 66201, 10/78)

J-2 Paragraph deleted, 10/78

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 (total cost to install is $42 million; $40 million provided by city, $2 million from LEAA). . . . system expected to be operational in 1981. . . . will serve as a model program for consortium of major cities established to facilitate subsequent technology transfer. (Contractor, Contact/contractor, TEF 514, Case Nos. 103399, 103400, 11/78)

J-4 Paragraph deleted, 10/78

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. . . . currently, company employs over 15,000 people and has annual sales of about $1 billion. . . . 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. . . . 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, 10/78)

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 lighting products. . . . one product, called Streamlite-1 Million, is a portable spotlight that has "true color," is 50 times brighter than automobile headlights, and can operate from automobile cigarette lighter. . . . approximately 1,600 sold at $475 each. . . . used by fire and police departments in security and emergency situations; other customers include the FBI and the Iranian Government. . . . second product, sold to State Highway Patrols, truckers and county governments, is an emergency flashlight; Stream Lite-20. . . . approximately 25,000 sold at $90 each. . . . third product, recently introduced for the law enforcement market, is a heavy duty flashlight that is 7 to 10 times brighter than conventional flashlights. . . . product, called Streamlite-35, retails for $115. . . . approximately 200 sold during first 2 months on market; over 1,000 expected to be sold in 1979. (Contractor, personnel, TEF 561, Case No. 109327, 10/78)

J-7 Silent Communications Alarm Network (SCAN): developed for Headquarters by Jet Propulsion Laboratory. . . . emergency communication system used by
+ jail guards or other staff. . . . consists of a pen-sized ultrasonic transmitter (no batteries or electronics), receiver, and control-display cabinet to locate person requiring assistance. . . . licensed by Sentry Products, Inc. (California) in 1974. . . . company refined original system and now markets a broad line of SCAN systems to juvenile halls, correctional institutions and court facilities. . . . customers include: juvenile facilities in California, Colorado and Arizona; correctional and court facilities in California, Arizona, Georgia, New Mexico, Connecticut and Wisconsin. . . . other applications include schools, hospitals, government and public buildings, apartments for retired and handicapped persons, and personal safety for business executives. . . . specific sales figures are proprietary; however, company experiencing rapid growth rate in U.S. and European markets. (Purchased product line, TEF 586, Case No. 112243, 5/79)

J-8 Thermal-control coating specifications: developed by JPL for large radar antenna structures exposed to solar radiation. . . . used by Harris Corp., Harris Electronic Systems Div. (Florida) in designing communications and telemetry systems. . . . JPL data used to determine coatings for paper rollers of high speed, high resolution facsimile system called Laserfax . . . . system sold to law enforcement agencies for radio or telephone transmission of high quality fingerprint and identification photographs . . . . several hundred units sold at $15,000 to $17,500 each. . . . users include Los Angeles and New York City Police Departments, Los Angeles County Sheriff's Department. (TB/TSP, TEF 200, Case No. 30520, 1/77)

+J-9 Paragraph deleted, 9/79

Other Relevant Examples:

B-72 (police radios); C-15 (high intensity light); 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); G-32 (tax assessment evidence); I-5 (electrical code requirements); O-6 (legal education)

K

HIGHWAY TRANSPORTATION

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 Electronics Div. used to develop new products and production line testing for most Chrysler cars and
+ trucks. . . . 1.2 million new vehicles produced in 1978. . . . 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. . . . Chrysler radios (150,000 in 1979), clocks and ignition systems also sold to other automotive manufacturers; customers include American Motors, International Harvester and European companies. . . . electronic components represent 10 percent of the cost for a 1980 Chrysler Corp. automobile. . . . 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, 9/79)

K-5 Combustion analysis computer program: developed by Lewis. . . . used by Chrysler Corp. (Michigan) in gas combustion analysis projects. . . . current projects include: performance tests on internal, two-cylinder combustion engines; high temperature tests on ceramic materials that would improve efficiency of gas turbine engines. . . . standard analytic tool for engine projects; used several times a month. (Lewis conference, TEF 463, Case No. 103409, 10/78)

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 compo-
+ nents. . . . enables analysis of output from sophisticated test instrument; saves testing time and reduces 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, 12/78)

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, the F-32 all-winter radial. . . . the F-32, introduced in 1974, is now Goodyear's most popular winter radial tire. . . . price ranges from $64 to $107, with 24 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, 8/79)

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 C. W. Hatcher, Inc. (California) which developed and holds patents on grooving and grinding machines which are manufactured by others. . . . does highway grooving worldwide, mostly under subcontract to state's departments of highways contractors. . . . also used by Pavement Specialists, Inc. (Texas) to manufacture (on custom order basis) and rebuild grooving machines. . . . used by General Electric Co., Specialty Materials Dept. (Ohio). . . . G.E. distributes booklet, A Guide to Highway Grooving, and sells synthetic diamonds for grooving machine blades. . . . also used by State of California, Dept. of Transportation. . . . since 1966, State has grooved about 325 freeway miles (averaging about 7.5 lanes/mile) and about 5 conventional highway miles (averaging 2 lanes/mile) for a total cost of nearly $15 million. . . . wet accidents reduced by 50% (or 6 per million-vehicle-miles of wet travel compared to 12 per million miles in 1970) on grooved pavement. . . . over 25 states have contracted to have dangerous highway sections grooved. . . . wet highway accidents on grooved sections reduced by about 60%. . . . about 20% of all accidents occur on wet pavement. (Contact/Langley, TEF 168, Case Nos. 101917, 101919, 101920, 101921, 10/78)

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). . . . SAFER System installed and operating in 9-square mile South Bay area of Los Angeles County (California). . . . project cost about $800,000; funded by U.S. DOT Urban Systems Program (71%), County of Los Angeles (22%) and State of California (7%). . . . evaluation of South Bay System by Los Angeles County Road Dept. showed a 9% reduction in total vehicle hours spent waiting at 112 South Bay traffic lights and a reduction in left-hand turn accidents; also, test data indicate a benefit to cost ratio of 4.6 to 1. . . . TRW also installed traffic control systems in Baltimore, Maryland (1,000 traffic lights), Overland Park, Kansas and Inglewood, California. . . . no further installations planned by company. (Contractor, TEF 465, Case No. 103415, 6/79)

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 100 design engineers trained to use program. . . . influenced design of every major component in these products (no quantitative information on benefits 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, 11/78)

K-11 Paragraph deleted, 10/78

K-12 Steel data handbooks: compiled for Marshall. . . . used by Gulton Industries, Inc., Servonic/Instrumentation Div. (California) in designing transducer products. . . . provides data on corrosion resistance and low temperature
+ strength for stainless steel 301 used in transducer case. . . . currently, over 200,000 sold annually in price range of $50 to $800. . . . products used by automobile manufacturers as components of air conditioning and fuel system regulating systems. . . . since 1976, unit sales have increased by a factor of four due to heavy demand from automotive industry. . . . customers include Ford Motor Co., General Motors Corp. (TB/TSP, TEF 538, Case No. 101020, 5/79)

K-13 Westar satellites: launched by Kennedy for Western Union Telegraph Co. . . . satellites linked to five major Earth stations, 20 designated access cities, five TV operations centers within 9,000 linear-mile microwave network. . . . private circuit leased by Mack Truck, Inc., Parts and Services Div. (New Jersey) to link four parts distribution centers with central warehouse. . . . used to locate and order parts not regularly stocked by 450 distributors, 2,000 parts transactions daily via Westar. . . . compared to previously used land-based service, communications downtime reduced from 35% to less than 10%, lease costs reduced by $1,700 per month. (Customer/contractee, TEF 676, Case No. 123701, 2/77)

K-14 Electroplating for titanium alloy: developed by Marshall. . . . used by General Motors Corp., Guide Div. (Indiana) to improve titanium plating equipment. . . . division fabricates titanium-plated brightwork for headlamps and grilles used on GM passenger cars. . . . thousands of units produced each month. . . . benefits expected to continue from improved electroplating process. (TB/TSP, TEF 552, Case No. 94102, 5/77)

K-15 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, and assisted in developing other applications which now include wheelchair cushions, artificial limb socket lining, and finger splint padding for patients with hand burns. . . . product line sold to Becton, Dickinson and Co., Edmont-Wilson Div. (Ohio). . . . material now being sold in quantity to company which produces cushion pieces for school bus seat backs. . . . Sheller-Globe Corp., Superior Coach Div. (Ohio) has fitted approximately 100,000 seat backs to date . . . . sales efforts also being developed for manufacturers of trucks, office furniture, sporting goods. (Personnel/contractor, BATeam, Purchased product line, TEF 570, Case No. 111711, 6/77)

K-16 Relative humidity equation: developed by Dryden. . . . equation for computing relative humidity from wet and dry bulb temperatures and atmospheric pressure . . . . eliminates tedious use of tables. . . . used by Ford Motor Co., Research and Engineering Div. (Michigan) in EPA-required nitrous oxide emissions testing program. . . . equation programmed into division's computer and used to adjust automotive emissions readings, made in varying humidity, to constant humidity condition required by EPA. . . . improvement in analytical method for adjusting data to comply with EPA standards. (TB/TSP, TEF 719, Case No. A007573, 6/78)

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 onboard truck weighing systems. . . . first application on logging trucks; over 2,000 systems sold at $2,000 each. . . . since 1975, market has expanded to include almost all types of highway transport trucks (e.g., device used on feedlot trucks for proper mixing and dispensing of grains). . . . current sales total 1,000 units per year at about $2,100 each. . . . 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, 10/78)

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. . . . vehicle emission inspection centers using this equipment constructed and operated for the State of Arizona (12 centers) and the State of California (17 centers). . . . contracts with additional states anticipated . . . . company also used the technology to develop "Autosense," computerized diagnostic equipment which isolates motor vehicle malfunctions and helps define repairs. . . . used by both large and small companies and government agencies to improve vehicle repair services; customers include General Motors, Sun Oil, AT&T, Avis, Hertz, National, Commonwealth Edison, the U.S. Army and General Services Administration, and the Canadian Armed Forces. . . . to date, over 1,000 units sold for approximately $17,500 each. . . . benefits to customers include reduced training time for repair personnel, improved diagnosis and repair definition for vehicles that are becoming more complex, and better consumer relations by avoiding unnecessary repairs. . . . benefits to Hamilton include new products and services and increased company revenue. (Contractor, TEF 621, Case No. 117306, 7/79)

K-10 Aerodynamic drag reduction tests: performed by Dryden 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%. . . . new "Bullnose" livestock trailers (8' wide,
+ 43' long, 13' high) introduced in mid-1975, and over 300, at average price of more than $20,000 each, sold annually in first few years; 175 units sold in 1978. . . . new trailers comprise about 90% of company's livestock trailer sales. . . . company also manufactures a similarly modified version of its refrigerated trailer line. . . . modified unit currently accounts for only 10% of sales of this line, but expected to increase in 1979 due to new interior insulation system designed to fit trailer's streamlined shape. . . . shape of new insulation system will allow trailers to be a foot longer than conventional units. . . . benefits to company include increased sales and several thousand dollars saved in aerodynamic testing time. . . . customers save more than $300 annually in fuel costs. (Trade association, TEF 620, Case No. 119273, 1/79)

+K-17 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 a hydrogen-fueled bus for the City of Riverside, California. . . . bus currently undergoing testing and modification program. . . . Billings also testing a Chrysler Omni which it has converted into a dual fuel (hydrogen and gasoline) automobile. . . . a fleet of 10 converted cars, including an electrolyzer for producing hydrogen and oxygen from water, will be marketed to the public by Billings. . . . manual was used in the design of safety features for the electrolyzer. (TB/TSP, TEF 258, Case No. 113024, 5/79)

+K-18 Arc suppression techniques evaluation: conducted for Marshall. . . . used by Vapor Corp. (Illinois) in design of mass 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 suppression relays for door openers and temperature controls on buses. . . . company installs system on 5,000 buses each year. (Professional journal/TSP, TEF 128, Case No. 1520, 7/79)

Other Relevant Examples:

A-1 and B-22 (automobile components); B-9 (lubricant for car air conditioners); B-94 and E-11 (vehicle emission control); C-14 (travel guide); C-17 (heat resistant paint); E-2 (vehicle emissions certification); E-18 (pollution dispersal); I-15 (bridge standards); I-29 (cordless power tools); M-12 (highway planning); O-22 (teaching automotive design)

L

L-5 Arc suppression techniques 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 over 80% of rail car circuitry. . . . company installs system on average of 500 cars per year at cost of approximately $5,000 per car. (Professional journal/TSP, TEF 128, Case No. 1520, 7/79)

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 the Chemical Propulsion Information Agency at Johns Hopkins University (Maryland), under contract to
+ U.S. Department of Transportation (District of Columbia) to develop Emergency Services Guide for Selected Hazardous Materials. . . . procedures for tank car spills of 30 hazardous chemicals are presented. . . . approximately one million copies of the DOT guide have been distributed to emergency services personnel and firms handling hazardous materials, including: fire, police and civil defense departments; ambulance and medical technicians; railroads; and government training facilities. . . . use of guide improves safety conditions for emergency personnel and general public. (Interagency, TEF 550, Case No. A010335, 8/79)

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., Inc., Boeing Vertol Co. Div. (Pennsylvania) to redesign new mass transit rail car product, Standard Light Rail Vehicle (SLRV). . . . eliminated uncomfortable vibrations with new non-linear suspension system, rather than conventional method of increasing vehicle weight. . . . benefits include less track wear and power consumption, and increased passenger comfort. . . . electric-powered SLRV's currently being delivered to Boston (175) and San Francisco (100) mass transit systems . . . . average price of an SLRV is $350,000, depending on options. . . . division also used program to design the 2400-Series car for the Chicago Transit Authority. . . . CTA has ordered 200 cars at a cost of $29 million. (Contact/Langley, Personal contact, TEF 410, Case Nos. 107063, 114867, 10/78)

L. RAIL TRANSPORTATION

+L-1 Paragraph deleted, 9/79

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 on 300 miles of track in 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. . . . system expected to reduce maintenance and fuel costs. . . . 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. . . . Con-Rail and Union Pacific also interested in installing system. (Contractor, TEF 465, Case No. 86005, 6/79)

L-3 + Dynamic and static modeling techniques: developed by Marshall. . . . used by Martin Marietta Corp. (Colorado) since 1975 in development of dynamic model for railroad locomotive derailment tendencies and ride confort. . . . TTD 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 by improving the design of locomotive and car wheel assemblies (called trucks). . . . various truck designs have been empirically tested and compared through computer analysis. . . . comprehensive test and analytic similation results will be available in 1980 for specific design studies by the railroad industry, government agencies and other researchers. (TTD-Applications Engineering, 8/79)

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. . . . Videofile System used by Southern Pacific Co. (California) since 1968 for all documentation related to railroad freight (waybills) . . . . initial cost of system $750,000; system add-ons provided by Ampex during past 4 years total $250,000. . . . also, 7-year maintenance contract recently established with Ampex. . . . 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 through reduced operating costs. (Contractor, TEF 226, Case No. 66201, 10/78)

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., Inc., 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 currently being delivered to Boston (175) and San Fransicso (100) mass transit systems. . . . SLRV's average $350,000 each, depending on options. . . . also used in design of a rail car for the Chicago Transit Authority. . . . CTA has ordered 200 cars at a cost of $29 million. (Professional journal, TEF 610, Case No. 114866, 10/78)

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 modify railroad passenger cars under U.S. Department of Transportation contract. . . . cars used in the high speed (240 km./hr.) Metroliner train system operating between Boston and Washington, D.C. . . . previous suspension system limited speed to 140 km./hr. in order to satisfy DOT ride quality standards. . . . computer programs and assistance from Langley personnel important to successful redesign effort. (Personal contact/Langley, TEF 608, 609, Case Nos. 114871, 114873, 8/79)

L-10 Paragraph deleted, 10/78

+L-11 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. . . . THERMO-LAG sold in 55-gallon drums for approximately $780 per drum. . . . effective, inexpensive coating used by railroad industry on tank cars that carry hazardous materials such as ammonia and propane. . . . recent changes in federal regulations now require railroads to use fire retardant coatings for tank cars with hazardous cargo. (Personnel/contractor, TEF 521, Case No. 104141, 6/79)

M

AIR TRANSPORTATION

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, 11/78)

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 (ALPA). . . . grooving endorsed by FAA, ALPA and airlines. . . . FAA urged grooving of 200 runways in 1977 letter to regional directors. . . . ALPA requested that critical airports be grooved first. . . . pavement grooving is a $2-$2.5 million industry. . . . less than ten firms involved in grooving in the country. . . . C.W. Hatcher, Inc. (California) developed and holds patents on grooving and grinding machines which are manufactured by others. . . . company also grooves runways worldwide. . . . Pavement Specialists, Inc. (Texas) manufactures and rebuilds grooving machines. . . . Cardinal Engineering (Pennsylvania) does 70% of world's runway grooving, including 17 airports in U.S. . . . company work volume has increased 500% in three years. (Contact/Langley, TEF 168, Case Nos. 101916, 101917, 101918, 101919, 101922, 12/77)

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 about 200 localities throughout U.S. (hotels, airline ticket offices, and 50 airports). . . . Validata system can now be accessed through AT&T's "Transaction Telephone"; provides faster verification of credit card purchases. . . . each subscriber inquiry takes less than 5 seconds to process and subscription fee per inquiry ranges from 3 cents (ticket) to 12 cents (personal check) . . . . over 33 million inquiries processed since 1972; responsible for stopping bad credit transactions worth $15 million. . . . caused major reduction in use of stolen tickets. . . . subscribers include: (airlines) Continental, Eastern, Hughes Airwest, Japan, Lufthansa, Mexicana, Northwest, PSA, Qantas, TWA, Western; (car rental agencies) Hertz, National, Budget; and (hotels) Holiday Inn, Mariott. . . . credit data from service also used in American Airlines and United Airlines reservation systems and by Master Charge and American Express. (Contractor, TEF 465, Case No. 104260, 10/78)

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 almost $1.4 billion in 1976 (out of $17.4 billion for private R&D). (Contact/Langley, 9/78)

+M-2 Paragraph deleted, 9/79

M-3 Liquid penetrant nondestructive testing training manuals: compiled for Marshall. . . . used to train and certify production line inspectors at Beech Aircraft Corp. (Kansas). . . . to date, over 200 inspectors certified. . . . saves company outside training costs of $600 per employee for 2-week course . . . . very important in quality control. . . . second largest producer of business and utility aircraft. (TB/TSP, TEF 374, Case No. 40622, 10/78)

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
+ . . . . applications include flight test monitoring, training simulators, in-flight checkout systems and air traffic control. . . . used in $700,000 display portion of $3.5 million computer system for flight testing McDonnell Douglas DC-10 in 1970; automated data analysis reduced total test flight hours from projected 2,000 to actual 1,250. . . . used in training simulators by the U.S. Navy and Canadian Air Force. . . . used in checkout systems for all DC-10's, some DC-9's, and Boeing's advanced 7X7 prototypes. . . . used in air traffic control systems by U.S. Air Force at Vandenberg and by U.S. Navy at the Pax River Air Test Facility. . . . being installed as display portion of Canada's national air traffic control system; will include 140 display units at cost of over $18 million. (Contractor, TEF 99, Case No. 76502, 12/78)

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. . . . 59 airlines now use Carousel IV units in air transports. . . . majority of inertial units in commercial aircraft are Carousel IV; standard equipment on Boeing Co. 747 and installed on the 707, 727 and 737; other installations include the DC-8, DC-10, Airbus, Concorde, and various military aircraft such as the C-141, C5-A and KC-135 . . . . 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, 10/78)

M-14 Advanced ball bearing development program: conducted by and for Lewis. . . . developed 2 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., TRW Bearing Div. (formerly Marlin-Rockwell Div.) (New York), use program results in designing improved bearings for turbine main shaft and other applications. . . . GE and P&W purchase the improved bearings for installation in new and overhauled engines. (Contractor, TEF 349, Case Nos. 44286, 44288, 7/79)

M-15 Composite tank for fireman's breathing apparatus: developed for Johnson by Structural Composites, 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 and 300 more units on order; complete set for a Boeing 747 includes 10 units. . . . also now sold to other airline companies. (Contractor, TEF 519, Case No. 114863, 10/78)

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 (Pennyslvania) participated in a NASA-funded passenger comfort survey. . . . survey results were used by the company to develop a more comfortable seating arrangement in 10 NORD 262 shorthaul aircraft . . . . remodeling costs totaled $500,000. . . . increased revenue expected to exceed this cost. . . . airline operates 130 commuter flights per day from airports in Washington, D.C. area, New York, New Jersey, Connecticut and Pennsylvania. . . . second largest U.S. commuter airline, carries 400,000 passengers per year. (Personal contact/contractor, TEF 608, Case No. 114872, 10/78)

M-17 Electromagnetic tool for metal fabrication: developed by Marshall to remove distortions in Saturn V fuel tanks. . . . contracts from Marshall TUO to manufacturing firms for evaluating other applications of tool. . . . after Boeing Co. evaluation in 1968, used by Boeing Commercial Airplane Co. Div. (Washing-
+ ton) to develop 3 fabrication tools for production line operations: electromagnetic riveter, dent remover, and proof loader. . . . semiportable riveter, invented and patented by company, used on 747 wing panels where automatic riveting machine cannot be used. . . . dent remover and portable proof loader used on all 700 series aircraft to pull dents from damaged components and to inspect bonded structures. . . . dent remover saves company $40,000 annually through inexpensive repair of components that would otherwise be rejected. (Contractor, TEF 105, Case No. 115402, 7/79)

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. . . . program modified as permanent subroutine of Allison Fortran and used daily in research program to reduce air pollution from engines. . . . also used for rocket engine thrust applications . . . . benefits include convenience, speed of calculation, accuracy and low cost. . . . major producer of turbo-prop engines. (Professional journal, TEF 463, Case No. 103408, 8/78)

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 to develop brake systems for commercial aircraft. . . . saved time during the development process. . . . customers include Boeing and Lockheed. . . . 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, 8/78)

+M-11 Paragraph deleted, 9/79

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. . . . used since early 1970's in U.S. Navy and Air Force pilot training programs. . . . first commercial system, called COMPU-SCENE, installed on Boeing Co.'s 700 series aircraft flight simulators in 1975; certified by FAA and now considered key element in Boeing's flight training program. . . . other applications include: training for air traffic controllers, ship captains, and armored vehicle crews; air-to-ground and air-to-air weaponry/targeting; aerial navigation and refueling; and periscope viewing. . . . unit price ranges from $1.5-$3 million, depending on configuration. (Contractor, TEF 389, Case No. 64101, 4/79)

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. . . . current unit price is $13,000. . . . 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, 10/78)

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 UH-60A BLACK HAWK, S-76 SPIRIT, and CH-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. . . . used by Beech Aircraft Corp. (Kansas) in design of new aircraft. . . . enables more exact modeling of designs and consideration of additional design options . . . . primary benefit is reduced cost for eliminating design uncertainties; use will continue. . . . used by Teledyne, Inc. (Ohio) in the design of aircraft gas turbine components (including rotor and combustor components, compressor housings and engine frames) and in studies of gas turbine and compressor blades. . . . several thousand dollars saved annually; other benefits include improved designs from more accurate computations, improved product reliability, and increased marketability. . . . also used by Lockheed Aircraft Corp., Lockheed California Co. Div. (California) to design wing panels and analyze composite floor posts on its L-1011 and S-3A aircraft. . . . annual savings estimated at 2,000 person-hours and $300,000; other benefits include improved product safety and reliability, improved productivity and increased marketability. (Personal contact, Trade press/personal contact, COSMIC, TEF 410, Case Nos. 119302, A008103, 8/79)

M-23 Cowling airflow models: developed by Langley. . . . research on cowling geometry for reciprocating engines included drag measurement and the effect of 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 $345 million. ([Unknown], TEF 633, Case No. 119298, 10/78)

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 $345 million. ([Unknown], TEF 630, Case No. 119295, 10/78)

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 SPIRIT commercial helicopters; design insures helicopter stability if a blade damper fails. . . . division saved time and testing costs by using this method. . . . the S-70 was tested by the U.S. Army and adopted as its new generation utility tactical transport, designated UH-60A BLACK HAWK. . . . division has long-term contract (1978-85) to produce over 1,100 BLACK HAWKS at estimated cost of $2.5 billion; more than 200 currently authorized for delivery. . . . production of the S-76 SPIRIT commercial helicopter began in late 1978 and, to date, over 200 sold; future orders expected to be in the thousands. . . . major markets will be offshore oil support, corporate executive transport and general utility operations. (Personal contact/Langley, TEF 614, Case No. 117151, 8/79)

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 SPIRIT commercial helicopters; this eliminated the need to redesign the helicopters and improved the final design. . . . the S-70 was tested by the U.S. Army and adopted as its new generation utility tactical transport, designated UH-60A BLACK HAWK. . . . division has long-term contract (1978-85) to produce over 1,100 BLACK HAWKS at estimated cost of $2.5 billion; more than 200 currently authorized for delivery. . . . production of the S-76 SPIRIT commercial helicopter began in late 1978 and, to date, over 200 sold; future orders expected to be in the thousands. . . . major markets will be offshore oil support, corporate executive transport and general utility operations. (Contractor, TEF 613, Case No. 117152, 8/79)

M-20 Aircraft icing research: conducted by Lewis in special wind tunnel facility
+ as part of a continuing icing research program. . . . facility used by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut) to evaluate turbine inlet designs on its military and commercial helicopters. . . . shape of inlets redesigned to reduce ice build-up. . . . use of facility saved division several million dollars; also, considered essential for obtaining FAA and military certification of induction systems. . . . Sikorsky helicopters used by all U.S. military services, the U.S. Coast Guard, military services in over 30 countries, and commercial operators throughout the world. (Personal contact/Lewis, TEF 636, Case No. 119305, 8/79)

M-21 Fracture toughness tests: developed by Lewis. . . . used with NASA crack propagation data by United Technologies Corp., Sikorsky Aircraft Div. (Connecti-
+ cut) to redesign the rotors on its S-61 commercial and S-65 military helicopters. . . . also used in the design of components for the S-76 SPIRIT commercial and S-70 military helicopters; S-70 in production for U.S. Army under designation UH-60A BLACK HAWK. . . . use of tests resulted in lighter aircraft without loss of structural reliability. . . . will be used in all future aircraft design. (NASA publications, TEF 451, Case No. 119303, 8/79)

M-30 Flight test data system: developed for Dryden by Teledyne, Inc. Teledyne Control 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. . . . over 48 units sold at average base price of $25,000 each. (Contractor, TEF 650, Case No. 121305, 9/78)

M-31 Lubrication handbook: available data on commercial lubricants compiled for Marshall. . . . used by Varian Associates, Eastern Tube Div. (Massachusetts) in selecting proper lubricants for motors and bearings used in aircraft radar products. . . . products include magnetron tubes and components. . . . used in airborne radar equipment by U.S. Department of Defense, Federal Aviation Administration, commercial and small aircraft producers. . . . handbook saves about $2,500 each year in engineering research costs. (Trade journal/TSP, TEF 497, Case No. 115778, 6/78)

M-32 Nondestructive spot test procedure: compiled by Langley. . . . used by AVCO Corp., Aerostructures Div. (Tennessee) to identify metal alloy stock for aircraft component production. . . . components include large wing structures fabricated for Grumman Gulfstream II and Lockheed L-1011. . . . procedure reduces test time and metal wastage. . . . annual sales of several million dollars for aircraft components. (TB/TSP, TEF 378, Case No. 50566, 12/77)

M-33 Intumescent fire retardant coatings: developed by Ames. . . . used, under
+ NASA license, by AVCO Corp., Specialty Materials Div. (Massachusetts) to develop commercial product line. . . . FLAMAREST intumescent paint used on military and twin engine civil aircraft. . . . single coat (approximately 1 gallon) applied between fuel tank and cell structure. . . . also, sprayable form of paint recently applied to the actuators of aircraft engines. . . . improves fire safety. (License, TEF 554, Case No. 108481, 9/79)

M-34 Methods for using optical instruments: manual compiled by Marshall. . . . used by Textron, Inc., Bell Aerospace Div. (New York) to improve optical measuring techniques used by calibration technicians. . . . procedures assure proper calibration of tool fixtures for fabricating helicopter doors and engine cowlings. . . . helicopter customers include police, rescue units, petroleum companies. . . . manual improvement technical capabilities of laboratory personnel. (Trade journal/TSP, TEF 529, Case No. 122209, 5/77)

M-35 Aluminum alloy data handbooks: compiled for Marshall. . . . physical, mechanical, fabrication, and other characteristics of five aluminum alloys. . . . frequently used by Eastern Airlines, Inc., Engineering Div. (Florida) as reference for aluminum alloy data related to aircraft maintenance. . . . handbooks provide data on corrosion control, cracking resistance, and materials processing. . . . division overhauls several hundred aircraft and engines each year at a cost of over $60 million. . . . also used by A.M. Castle and Company (California) to help customers solve fabrication problems. . . . company sells aluminum alloys to aircraft manufacturers. . . . handbooks increased sales and tehcnical capability. (TB/TSP, Trade Journal/TSP, TEF 685, Case Nos. 100876, 104310, 5/77)

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 $345 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, the Model 77 "Skipper," will be marketed in early 1979. (Personal contact/Langley, TEF's 631, 632, Case Nos. 119296, 119297, 10/78)

+M-26 Paragraph deleted, 9/79

M-27 + Instrument readout window: developed for Goddard by Honeywell, Inc., Avionics 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 2,200 units sold to date. . . . current price range is $3,700-$4,200, with window cost representing about 1 percent of unit price. . . . standard equipment on DC-9's, installed on some Boeing 727's and 737's. (Waiver/contractor, TEF 303, Case No. 42924, 8/79)

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. . . . since 1976, company size has almost doubled and annual sales up to $120 million. . . . Beech Aircraft Corp. (Kansas) uses Hartzell propellers on all Duke and King Air aircraft, and most of its Baron series. . . . continuing benefits include improved aircraft performance. (Personal contact/Langley, Customer, TEF 639, Case Nos. 119306, 119703, 11/78)

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. . . . current price range is $300,000 to $600,000; approximately 35 systems sold to date. . . . customers include 20 major U.S. and foreign airlines. . . . maintenance time to checkout electronic units reduced by over 75 percent. . . . additional test capabilities being developed for the product (e.g., radio frequency tests). (Contractor, TEF 649, Case No. 121303, 8/78)

M-40 Steel data handbooks: compiled for Marshall. . . . used by Gulton Industries, Inc., Servonic/Instrumentation Div. (California) in designing transducer products. . . . provides data on corrosion resistance and low temperature
+ strength for stainless steel 301 used in transducer case. . . . currently, over 200,000 sold annually in price range of $50 to $800. . . . products used by aircraft manufacturers as components of engine monitoring and control instruments. . . . customers include Boeing Co., Lockheed Aircraft Corp. and McDonnell Douglas. (TB/TSP, TEF 538, Case No. 101020, 5/79)

M-41 Computerized parts list system: developed for Space Nuclear Propulsion Office. . . . used by Chandler Evans, Inc., Control Systems Div. (Connecticut) as part of in-house order control system. . . . time and labor saved by locating parts through number and drawing. . . . division builds pre-production and prototype fuel controls and high pressure fuel pumps for the aerospace industry. (Trade publication/TSP, TEF 286, Case No. 5455, 7/77)

M-42 Fiber-modified polyurethane foam: developed by Ames to provide foam material for filling voids around fuel tanks in aircraft. . . . used by Sargent Industries, Kahr Bearing Div. (California) to develop protective, elastomeric seal for bearing products. . . . company manufactures spherical bearings for commercial and military aircraft. . . . product improved with new seal to protect bearings from hydraulic oil contamination. (SBA/TSP, TEF 705, Case No. STIF-62671, 2/78)

M-43 Electronic component handling practices: compiled for Johnson. . . . review of procedures, materials and equipment for safe handling of MOS circuit elements and other electrostatic-sensitive devices (ESD's). . . . used by McDonnell Douglas Corp., McDonnell Aircraft Co. (Missouri) in developing process specifications for vendor-supplied ESD's. . . . reduced the number of damaged ESD's received. . . . vendors supply 25% of electronic components used by company in production of aircraft. (TB/TSP, TEF 726, Case No. STIF-84073, 9/78)

M-44 Aerodynamic flow simulation: computer programs developed by Ames, which cooperates with design engineers to implement simulation models. . . . computer simulation of 3-dimensional flow over wing from inputs such as sketch of proposed wing design. . . . used by Raisbeck Group, Inc. (Washington), under contract to Rockwell International, to redesign the wing for Rockwell's Model 60 Sabreliner, a small jet aircraft. . . . saved over 4 months testing time, or about $200,000, in development of new wing configuration. (Personal contact, TEF 737, Case No. A007892, 10/78)

M-45 Boundary layer calculations program: developed by Lewis. . . . program solves the two-dimensional, compressible laminar and turbulent boundary layer equations in an arbitrary pressure gradient. . . . especially useful for turbomachinery, where boundary layer growth affects blockage and losses. . . . used routinely by Teledyne, Inc. (Ohio) in design of aircraft gas turbine engines . . . . annual savings of about $3,500 attributed to labor savings of 10 person-hours per month by having program available. . . . other benefits include improved designs from more accurate computations, improved product reliability and increased marketability. (COSMIC, TEF 749, 1/77)

M-36 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by General Motors Corp., Detroit Diesel Allison Div. (Indiana) in design testing programs for gas turbine engines. . . . manual provides best techniques for installing gages on engine components to obtain test data. . . . engines sold to Textron, Inc. for Bell helicopter product line, "Ranger". . . . saves considerable research and instrumentation time annually. (Personal contact/SBA/TSP, TEF 384, Case No. 61738, 5/77)

M-37 Inconel alloy materials data handbook: compiled for Marshall. . . . used regularly by ASTECH Co. (California) as reference for producing aircraft panels from Inconel. . . . panels are engine fairing components for DC-10 and other aircraft. . . . total 1975 sales revenue $25 million. . . . handbook saves $1,000 per year in research time. (TB/TSP, TEF 122, Case No. 4920, 3/77)

M-38 Polymide plastic process: developed by Lewis. . . . in situ polymerization of monomer reactants (PMR) produces polyimide resins with excellent thermal stability, lower handling costs and long shelf life. . . . used by Ferro Corp., Composites Div. (California) to synthesize PMR plastics for fiberglass based composite. . . . material used to fabricate high temperature aircraft turbine and wind tunnel compressor blades, as well as structural components. . . . prototype products sold to aerospace companies with government contracts for construction of engine and wind tunnel components requiring long-term heat aging up to 600°F. . . . several hundred yards sold at $6-$8 per yard to United Technologies Corp., General Dynamics Corp., Boeing Co. and other aerospace companies. . . . also used by HITCO, U.S. Polymeric Div. (California) to develop high strength graphite-polymer composite molding fabric suitable for applications up to 600°F. . . . about 300 pounds sold at $80 to $100 per pound to Rockwell International, TRW and other aerospace companies, as well as government agencies, for fabrication of high performance engine components . . . . also used by Fiberite Corp. (Minnesota) in production of graphite-polyimide composite molding material suitable for temperatures to 550°F. . . . several hundred pounds sold at $100 per pound to General Electric and other aerospace companies for government-sponsored engine prototype programs. (Personal contact, TEF 677, Case Nos. 123484, 123485, 123486, 2/77)

M-39 Nondestructive testing training manuals: compiled for Marshall. . . . used by Valley Bolt-Todeco Corp. (California) to train employees for quality control inspection of products. . . . manuals reduce training time, increase confidence. . . . company manufactures metal fasteners, mainly for aircraft industry. . . . magnetic particle inspection required in government specifications. . . . customers include Lockheed Aircraft Corp., Boeing Co. . . . fastener sales reported at several million dollars per year. (Trade journal/TSP, TEF 261, Case No. 27614, 3/77)

+M-51 Lightning safety research: conducted primarily for Lewis, Langley and Dryden . . . . NASA-sponsored research on lightning damage to space vehicles, launch facilities, and aircraft have produced state-of-the-art advances in lightning protection technology for commercial, private and military aircraft. . . . former contractor employee started small consulting firm, Lightning Technologies, Inc. (Massachusetts) to specialize in the study of lightning and related safety measures for aircraft design. . . . designs incorporated in the Piper Cheyenne 3 and Lear Avia's new Learfan jet. . . . LTI also consulting with Lockheed, General Dynamics, Beech Aircraft, Cessna and DOD, as well as performing lightning studies for NASA. . . . formed in 1977, firm now has 4 employees and annual income of $200,000. . . . benefits include cost savings to clients and improved safety in air transportation. (Personnel/contractor, TEF 764, Case No. A009324, 5/79)

+M-52 Graphite/epoxy composites moisture tests: conducted for Johnson to select doors for the Space Shuttle. . . . measured effects of moisture on various, commercially available graphite/epoxy compounds; specifically, absorption tendencies of compounds and effects on shear strength and stiffness at various temperatures. . . . used by Boeing Co., Inc., Boeing Vertol Co. Div. (Pennsylvania) to determine probable effects of humidity on helicopter components constructed from graphite/epoxy composites. . . . company was modifying its CH-47 military helicopter for British Airways to use in servicing oil rigs in the North Sea; data needed because rotor blades and fuselage constructed from composites. . . . substantial savings realized by avoiding expensive materials testing program. (TB/TSP, TEF 776, Case No. A010534, 8/79)

+M-53 Composite airframe structures: concept developed and tested for Langley by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut). . . . feasibility of co-cured, integrally molded skin/stringer/frame concept for low cost airframe structures tested on division's CH-53D military helicopter . . . . allows 30% weight reduction in airframe components. . . . experience with co-curing systems, developed on NASA contracts, utilized in the design of composite structures for the S-76 SPIRIT commercial helicopter. . . . to date, over 200 SPIRIT helicopters have been ordered by 49 commercial operators in 16 different countries; deliveries started in late 1978. . . . customer applications include offshore operations, corporate transportation and medical evacuation. . . . base price for this 12-passenger, twin-turbine helicopter is $1 million. . . . first commercial helicopter with primary composite structures certified by the FAA. (Contractor, TEF 728, Case No. A007571, 8/79)

+M-54 Boron/epoxy reinforced airframe: designed and tested for Langley by United Technologies Corp., Sikorsky Aircraft Div. (Connecticut). . . . CH-54B Skycrane military helicopter redesigned to use boron/epoxy reinforced aluminum strips instead of a thick aluminum skin; performance analysis of prototype proved such stringers are effective in reducing the weight required for airframe stiffening and have above adequate strength for structural integrity . . . . experience enabled division to use boron/epoxy reinforcement stringers in the design of its UH-60A BLACK HAWK military helicopter. . . . division has long-term contract (1978-85) with the U.S. Army to produce over 1,100 BLACK HAWKS at an estimated cost of $2.5 billion. . . . more than 200 currently in production. . . . BLACK HAWK has been adopted as Army's new generation utility tactical transport. (Contractor, TEF 729, Case No. A007572, 8/79)

M-46 Laser Doppler velocimeter: developed by and for Marshall. . . . laser beam reflected off airborne particles, such as dust, permits measurement of air velocity via Doppler shift. . . . Lockheed Aircraft Corp., Lockheed Missiles and Space Co. (Alabama) was Marshall contractor in development of instrument and measurement techniques. . . . company subsequently developed LDV-equipped van which includes computer graphic displays to show air turbulence formation and dissipation. . . . van used, under contract to U.S. Dept. of Transportation, to study turbulence produced near runways by wide-bodied aircraft; turbulence creates hazardous conditions for small aircraft attempting to land . . . . currently monitoring incoming flights at Chicago's O'Hare International Airport; analysis of data will enable airport officials to determine when safe conditions exist for small aircraft landings. . . . van will be used at other major U.S. airports to complete the DOT study. (Contractor, TEF 439, Case No. A006753, 7/78)

M-47 Axial flow compressor design program: developed by Lewis. . . . used by Teledyne Inc. (Ohio) in design of low cost axial compressor for aircraft gas turbine engines. . . . saved 150 person-hours in design effort, or approximately $3,500. . . . also, eliminated need to develop program in-house, provided more efficient design computations and increased product marketability. (COSMIC, TEF 753, 3/77)

+M-48 Transformer design manual: developed by JPL. . . . used regularly by Kollsman Instrument Co. (New Hampshire) in designing flight instrumentation for commercial and military aircraft. . . . specific instruments include a true air speed calculator for South African Airlines and a radio-altimeter for the U.S. Air Force air-launched cruise missile. . . . transformers are primary components of such systems. . . . manual, which consolidates information from many sources, considered major reference tool; used at least once a month since 1976. (TB/TSP, TEF 694, Case No. A010310, 8/79)

+M-49 Interpolation algorithm for sensor arrays: developed by JPL. . . . improves resolution of sensor arrays by a factor of 5 to 20 through a relatively simple wiring algorithm and the geometry of sensor elements. . . . used by Boeing Co., Inc., Boeing Commercial Airplane Co. Div. (Washington), in conjunction with automated tooling dock, to align the body sections of its new 767 airplane . . . . assists in obtaining positioning precision of a few thousandths of an inch; saves 30 minutes of manual manipulation during each alignment. . . . new, 210-passenger plane will go into commercial service in mid-1982. . . . estimated that the 767 will be 30-40% more fuel efficient and substantially quieter than current commercial aircraft. (TB/TSP, TEF 770, Case No. A009454, 7/79)

+M-50 Pressure measurement system: developed by Langley. . . . electronically scanned sensors and associated microcomputer provide pressure data at high scan rates for wind tunnel testing. . . . one of Langley innovators left NASA, obtained a nonexclusive license, and formed Pressure Systems, Inc. (Virginia) in 1977 to manufacture the system. . . . marketing began in 1978. . . . system can accomodate any specified number of scanning valves and includes minicomputer for real-time data assimilation. . . . typical system has 5 scanners and sells for $30,000. . . . customers include users of wind tunnels, such as Boeing, Grumman and McDonnell Douglas. (Personnel/Langley, TEF 773, Case No. A009654, 7/79)

+M-55 Hydrogen embrittlement of nickel: study conducted by Ames. . . . comprehensive analyses of hydrogen embrittlement in high-purity nickel over a range in temperature. . . . report used by Boeing Co., Inc., Boeing Vertol Co. Div. (Pennsylvania) during in-house study to determine cause of cracks in sulfonate nickel coatings on its helicopter blades. . . . enabled company to eliminate hydrogen embrittlement as cause and contributed to avoidance of $150,000 materials testing program. . . . sulfonate nickel coating used on rotor nose cap and blades of Boeing's CH-46 and CH-47 military helicopters and the commercial 107 model used primarily in logging operations. (TB/TSP, TEF 777, Case No. GALPOB1685, 8/79)

+M-56 Ultrasonic nondestructive testing techniques: developed for Marshall and Johnson by Automation Industries, Inc. (Connecticut). . . . commercial applications by Automation included Delta Manipulator product which used multiple transducers to achieve greater speed and accuracy. . . . Delta Manipulator units purchased by General Electric Co., Aircraft Engine Div. (Ohio) and used in quality control inspection for gas turbine engines. . . . enables inspection of otherwise inaccessible weldments, 1-4 per engine. . . . purchase of additional delta jigs and automation of inspection process planned for near future. (Customer/contractor, TEF 387, Case No. A011266, 9/79)

Other Relevant Examples:

B-2 and B-3 (aircraft production quality control); B-10 (fracture toughness tests); B-22 (aircraft component production); B-56 (crash locator); B-71 (avionic test equipment); B-94 (helicopter control circuits); C-7 (life raft); G-10 and I-1 (airport construction management); G-21 (aircraft modification); K-1 (pavement groover); O-5 (NDT training service); O-7 (technical training); O-14 (airport design research)

N

INSURANCE, BANKING, AND REAL ESTATE

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. . . . TRW has 15% share of market for such systems. (Contractor, TEF 465, Case No. 104260, 10/78)

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. . . . since mid-1977, system produced on custom order basis only; at that time, sales totaled $30 to $35 million. . . . American Republic Insurance Co. (Iowa) has been using $1.5 million Videofile system since 1972. . . . contains all of company's insurance records, providing claims and rate analysts with immediate access to records. . . . system is faster and minimizes chance of error. (Contractor, TEF 226, Case No. 66201, 10/78)

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
+ . . . . benefits expected to continue. . . . used by Economics Research Associates (California) to convert in-house economic model program to different, time-shared computer system. . . . company's economic modeling services used for large-scale land development and recreational projects. . . . saved $2,000 through reduced operating costs. (Trade journal/TSP, TEF 527, Case Nos. 102198, 102294, 7/79)

N-4 Safety yoke for construction workers: developed for Kennedy. . . . used by insurance companies to provide customer services and reduce industrial accident claims. . . . Employers Insurance of Wausau (Wisconsin) distributed copies to 12 construction safety specialists, who then redistributed it to about 175 safety consultants. . . . consultants advise construction company policyholders on safety techniques and materials. . . . company writes $600 million worth of insurance annually. (Trade journal/TSP, TEF 103, Case No. 10323, 11/77)

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) has 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 . . . . also assisted university with ventilation problem in bacteriological department. (Professional journal/TSP, TEF 402, Case Nos. 58500, 61395, 87001, 11/77)

+N-6 Paragraph deleted, 9/79

N-7 Flammability tests of home furnishings: conducted for TTD 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) in 1974 to design a full-scale, flame-spread test for residential units; part of applied research program for the Factory Mutual Insurance System. . . . still used as a basic reference document. . . . used by Liberty Mutual Insurance Co. (Illinois) to provide field inspectors in midwest division with information on nonflammable aerospace materials. . . . information used to conduct better analyses of building and room combustibility; improved evaluations have lowered underwriting risks. . . . also used by Marsh McClennan Insurance Brokers (California) to provide selected clients and field inspectors with data on the combustibility of interior furnishings. . . . reduced risk to clients by increasing their understanding of hazards due to furnishings, even in fireproof buildings. (Contact/TTD, Professional society, TEF 539, Case Nos. 107052, 107053, 107054, 7/79)

N-8 Aluminum circuit board design factors: developed for Marshall. . . . used by
+ Burroughs Corp. (Michigan) in designing new line of computerized banking machines. . . . multiple transistors mounted on one aluminum circuit board; reduces production costs. . . . current models, the S 1000 Systems, to be replaced in late 1979 by new generation, the S 3000 Systems; new machines will use 10 heat sinks. . . . company expects to sell 2,000 of the new machines annually at prices ranging from $25,000 to $80,000 each. (Personal contact/ TSP, TEF 180, Case No. 15430, 6/79)

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 $2 billion worth of casualty insurance for commercial and industrial clients annually. (Professional journal/TSP, TEF 524, Case No. 57717, 10/78)

~~+N~~-10 Biosatellite telemetry and life support systems: developed for Ames by General Electric Co. (Pennsylvania) for Biosatellite Program. . . . systems measured physiological and metabolic data with low-level signal conditioning and processing subsystems. . . . used by GE, in cooperation with the Metropolitan Life Insurance Co. (New York), to design new product line called Medical Data Acquisition Unit. . . . self-contained, portable, electromechanical unit for recording blood pressure, height, weight, electrocardiogram, and other physiological data during life insurance examinations. . . . Metropolitan purchased manufacturing rights from GE in 1977 and changed name of unit to Metscan. . . . 200 units currently in use at company field locations. . . . agents can be trained in use of unit in 1-2 hours; can perform complete examination in 7 minutes. . . . use of Metscan reduces cost and time for conducting examinations, insures objectivity, and provides enough data to issue insurance in amounts up to $175,000. (Purchased product line, TEF 584, Case No. A009444, 6/79)

Other Relevant Examples:

B-31 (loss prevention training); G-2 and G-32 (land use planning); G-5 (land use law suit); I-26 (solar heating for realty offices); T-1 (The Wall Street Journal transmission)

O. EDUCATION

O-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. . . . two models currently available, priced at $45 and $68. . . . approximately 1,000 globes sold annually. . . . globes used in junior high schools to illustrate interplanetary motion. (License/contractor, TEF 154, Case No. 106372, 10/78)

O-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 respi-
+ ration procedure. . . . unit used daily for 11 years by USC medical students, interns, and anesthesiology residents; also, upgraded for use in training nurses in respirator techniques. . . . SIM demonstrations provided several times a year for high school and civic groups, Boy Scout Troops, and visitors from foreign medical schools. . . . evaluations of SIM I have shown it to be cost effective, even with high initial costs. . . . USC has submitted proposal to HEW to develop new generation of SIM that could lead to commercialization. (Contractor, TEF 528, Case No. 106373, 1/79)

O-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 used in the University's College of Nursing self-instruction laboratory; over 130 nursing students received childbirth training with this prototype. . . . also, 100 students at Lexington Community College (Kentucky) have 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/Kennedy, TEF 274, Case No. 82701, 8/79)

O-4 Soldering school: held at Ames. . . . center provides facilities, books, and materials to train people in high quality soldering of electronic compo-
+ nents. . . . instructors usually retired Ames employees hired by agencies to instruct their students. . . . two-week course offered 12 times per year, with 10-12 students in each class. . . . over 1,000 people trained since 1963 . . . . total includes NASA, DOD and contractor personnel, as well as high school shop instructors and students, Mountain View High School Adult Education (California) participants, and Neighborhood Youth Corps (California) enrollees. . . . NASA certificate, given upon completion of course, virtually assures employment as electronics solderer. (Contact/Ames, 9/79)

O-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 $800 each, annual revenue to Convair about $115,200. . . . 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. (Contractor, TEF 14, Case No. 53871, 11/77)

O-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; currently contains about 1,800 references. . . . NASA personnel from several field centers assisted professor in developing bibliography. . . . 40 students have completed course, and many now work in industry. . . . in 1977, course was taken by a law student as a special study with emphasis on accident prevention. . . . one of first academic courses offered in nation on prevention and analysis of system failure. (TB/TSP, TEF 474, Case No. 65764, 9/78)

O-7 Optical alignment methods: compiled by Marshall. . . . used at Milwaukee Area Technical College (Wisconsin) as text and reference material in photography, printing, photo-optical and photoinstrumentation courses. . . . fulfills need for text on instrument techniques, providing students with better training . . . . 150 students each year. . . . 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's 208, 529, Case Nos. 91984, 91985, 5/77)

+O-8 Paragraph deleted, 9/79

O-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 have included 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 dist-
+ ribution to Florida county school systems. . . . since 1967, approximately 300 students have taken the undergraduate course which presents R&D methodology through research projects. . . . over 150 secondary school students participated in Industrial Arts Program (recently terminated) where they learned R&D techniques by designing and building things such as fluidic circuits and motorbike heating systems. . . . prototype models of a fuel cell, solar panel, and rocket car were developed by FSU program staff to be used as teaching aids in science classes. . . . program staff, with state funding, also developed descriptions of 156 different occupations, including astronaut, for distribution to 67 county school systems. . . . 25 industrial arts teachers from across the nation attended 1967, 1968, and 1969 summer institutes at FSU, with U.S. Office of Education funding, to explore use of space technology for industrial arts education. (Contact/Kennedy, TEF 311, Case No. 35912, 5/79)

O-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. . . . 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, was published in mid-1976 and currently sells for $6; it contains information on accessing remote sensing projects and obtaining remote sensing imagery . . . . company now offers 75 different packages, including the handbook, at prices ranging from $1 to $266. . . . customers for remote sensing imagery include a local artist, a consulting firm that prepares environmental impact statements, an environmental center, oil companies, government agencies, secondary schools, and colleges and universities. . . . sales data not available. . . . in 1974, TAC also entered joint production with Audio-Visual Institute (New Mexico) to market photograph/audio packages using LANDSAT and Skylab imagery. . . . first package, "Remote Sensing: Tool for Managing Earth Resources," introduced in October 1974 and 170 copies sold at $80 each in first 15 months. . . . in October 1975, "Food Watch by Satellite: Toward Managing Our First Resource" was introduced and 45 packages sold at $90 each in first 2 months. . . . market success led to 3 more packages on prospecting and hydrology by satellite, and forestry and remote sensing; a sixth package, "Orbital Remote Sensing Systems and Capabilities," will be introduced in late 1979. . . . all packages currently priced at $100 each. . . . customers include the Agency for International Development, high schools, and 400-500 colleges and universities; used for teaching how remote sensing can be applied to resource problems. (Personal contact/USGS, Personal contact/TAC, TEF 199, Case No. 115403, 8/79)

O-14 Wind study for airport design: conducted for Marshall by Colorado State University, College of Engineering, Fluid Mechanics and Wind Engineering Program as part of STOL airport research program. . . . wind tunnel used to test effect of structures on air flow. . . . CSU professor used data to develop a physical model for simulating 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. (Contractor, TEF 640, Case No. 119308, 8/79)

O-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 structural design courses. . . . provides demonstration of computerized finite element analysis. . . . also used by professor in consulting activities. (Customer/contractor, TEF 410, Case No. 121304, 6/79)

0-10 + Experimental multiple-use communications satellite (ATS-6): developed for Goddard. . . . launched in May 1974 to demonstrate viability of satellite communications for educational, cultural and civic applications. . . . provided 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 established with inexpensive transmitter and ATS-1 or ATS-3 satellite. . . . hundreds of experiments conducted annually before ATS-6 ceased operations in mid-1979. . . . used by HEW in Health/Education Telecommunications (HET) experiment for the delivery of such services to remote regions. . . . as part of experiment, demonstration projects conducted by Indian Health Service (Alaska), Appalachian Regional Commission (District of Columbia), and numerous other health and education agencies. . . . project applications included medical training, teleconferencing, and diagnosis; career education, continuing education, and in-service teacher training. . . . projects developed TV programs for the different applications. . . . for example, 1,500 junior high school students at 56 remotely located schools in 8 Rocky Mountain states received career education TV programs from Denver; students communicated between schools and with Denver instructor. . . . important educational benefits cited by students, teachers, and citizens in these remote communities. . . . satellite also used to broadcast educational programs to 5,000 rural villages in India as part of that country's effort to reduce illiteracy. . . . success of experiments led to high degree of carryover to permanent applications on commercial satellite systems, including Westar, RCA-A and B, and Comsat. . . . more than 80 representatives from colleges, government agencies, publishing houses, medical organizations, and HET projects formed the Public Service Satellite Consortium (California) to coordinate distribution of educational programs. . . . PSSC buys large blocks of time on commercial systems for allocation to users at reduced rates. . . . distribution system, the National Satellite Network, formed in 1978 for nonprofit users. (Interagency, TEF 530, Case No. 107035, 8/79)

+0-11 Paragraph deleted, 9/79

0-12 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 Technical Design and Production (Connecticut) in graduate seminar, "Theatre Planning, Engineering, and Construction". . . . provides students with reference material on cable rigging systems and procedures for analyzing cable loads. . . . approximately 115 students have completed the course. . . . primary benefit to students is increased safety in theatre rigging. . . . other benefits include: improved course content, contributed to theatre technology literature, and increased appreciation of technology diffusion. (TB/TSP, TEF 489, Case No. 112246, 10/78)

O-22 Nondestructive spot test procedure: compiled by Langley. . . . used by Pennsylvania State University, Mechanical Engineering Dept. (Pennsylvania) in a materials and processes course to demonstrate alloy identification . . . . course offered each year. . . . procedure also incorporated in automotive design course for identifying abraded engine metals in oil pan. . . . automotive course offered every three years. (Professional journal/TSP, TEF 378, Case No. 66874, 1/78)

O-23 Contamination control handbook: compiled for Marshall. . . . used by Sacramento City College, Electromechanical Dept. (California) in mechanical engineering technology course. . . . improved teaching of safety precautions for handling toxic substances and radiation equipment. . . . graduates become stationary engineers or operators for large physical plants in schools, hospitals and nuclear facilities. . . . about 300 students have used handbook since 1970. (TB/TSP, TEF 262, Case No. 23944, 10/78)

O-24 Amateur radio satellites: launched as vehicle ballast with NOAA 2 and 4 meteorological satellites under Goddard direction. . . . built by nonprofit Radio Amateur Satellite Corp. (AMSAT) (District of Columbia) from components donated by AMSAT member groups, including RCA, Yellow Springs Instrument Co., + National Semiconductor Corp., J.W. Miller Corp. . . . eight satellites, called Orbiting Satellite Carring Amateur Radio (OSCAR), launched at no cost to radio amateurs . . . . OSCAR 7 and 8 still in orbit. . . . can receive, store, retransmit morse code, voice, and teletype messages between amateur stations separated by as much as 5,000 miles. . . . American Radio Relay League (Connecticut), national "ham" organization, provides comprehensive curriculum guide to teachers in elementary and high schools. . . . used in space science studies to give students practical experience in satellite communication. . . . approximately 7,500 curriculum packets distributed; currently being updated. . . . League also developed guide for science educators in community colleges. . . . distributed primarily by Smithsonian's National Air and Space Museum. . . . over 300 copies distributed in U.S. (Personal contact, TEF 672, Case No. 123105, 5/79)

O-25 Broadband square-law detectors: developed for NASA Pasadena Office. . . . used by Villanova University, Astronomy Dept. (Pennsylvania) to help in designing a radio telescope. . . . provided basis for building a broadband square-law detector used to measure noise characteristics of radio telescope receiver. . . . saved several weeks in making the radio telescope which is used for research by astronomy graduate students. (TB/TSP, TEF 629, Case No. 122213, 5/77)

O-26 Linear programming manual: compiled for NASA Headquarters. . . . used by University of Nebraska, Engineering Mechanics Dept., in computer methods course for advanced engineering students. . . . also provided faculty with updated information on linear programming techniques. . . . convenient and very useful reference for course taken by over 100 students each year. (TB/TSP, TEF 534, Case No. 94724, 5/77)

O-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, 10/79)

O-17 Mobile Automatic Metabolic Analyzer (MAMA): developed by Marshall in TTD-funded Application Engineering Project with Apollo and Skylab astronaut monitoring technology. . . . measures inhaled/exhaled air volume and heartbeat 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 35 students currently enrolled, many employed in hospitals and medical instrument firms. (TB/TSP, TEF 655, Case No. 121459, 10/78)

O-18 Bone impedence 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 illustrations of instrumentation and data analysis. . . . about 35 students currently enrolled, many employed in hospitals and medical instrument firms. (TB/TSP, TEF 652, Case No. 121457, 10/78)

+O-19 Paragraph deleted, 9/79

O-20 International System of Units handbook: compiled by Marshall. . . . required system for NASA reports. . . . names, symbols, definitions, conversions for SI units included. . . . measurement system has been adopted by 41 of the
+ principal industrial nations. . . . during early 1970's, handbook distributed by the University of Illinois to over 2,400 new engineering students during Fall orientation classes. . . . currently required or highly recommended by most engineering professors. . . . estimated that several hundred students obtain handbook each year; available through University bookstore. . . . provides effective introduction to SI units and encourages thinking in metric terms. (Former NASA employee, TEF 663, Case No. 121870, 5/79)

O-21 Practical solar energy heating and cooling system: developed for Marshall . . . . report used by Central Missouri State University (Missouri) in construction technology courses. . . . also used by 25 graduate engineering students in research methods course. . . . both uses expected to continue . . . . also used by metal shop instructor and students in Litchfield High School (Minnesota) in design and construction of solar-powered heating system . . . . cost of system was less than $2,000; primary heat source for metal shop. . . . heating capacity equivalent to 10 gal. of fuel oil per day. (Professional journal/TSP, Personal contact/TSP, TEF 496, Case Nos. 118635, 120484, 12/77)

O-33 Combustion analysis computer program: developed by Lewis. . . . used at Arizona State University in departmental research programs. . . . professor in the Chemistry Dept. uses program in atomic spectroscopy research. . . . enables estimation of free atom fractions and associated spectra in flame environments. . . . benefits include savings in research time and extension of research into previously unapproachable areas. . . . another professor uses program in NSF-sponsored project to calculate composition of minerals, at equilibrium, subjected to high temperatures and pressures. . . . considered valuable research tool; approximately 5% of research budget allocated to using program. . . . also aided two chemistry Ph.D. students in thesis projects. . . . used by Geology Dept. professor in modeling thermodynamic and chemical equilibria constituents of gaseous nebulae. . . . saves research time and allows more extensive studies. (TB/TSP, Personal contact, TEF 463, Case Nos. 104278, A007917, A007918, 10/78)

O-34 Air/salt/gravity flow solar heating system: developed by Langley. . . . system has vertical solar panels and utilizes: air as the medium (eliminates freezing problems and is renewable resource); molten-salt for energy storage (weighs less than rock, larger heat storage due to fusion); and gravity flow circulation (avoids costly pumping systems). . . . information used by Franklin High School (Massachusetts) science teacher in design of new course on alternative energy sources, "Energy: Year 2000". . . . approved by school committee for introduction in 1979-80 school year; offered to juniors and seniors. . . . course includes plans to construct an actual solar heating system. (TB/TSP, TEF 741, Case No. A007920, 10/78)

+O-35 Laboratory for Applications of Remote Sensing (LARS): developed at Purdue University (Indiana) for Johnson and Office of University Affairs, NASA Headquarters. . . . includes computers, remote terminals, remote sensing data bank, and computer software for data analysis. . . . provides software development, data analyses, and training for government agencies and private companies. . . . applications include food crop surveys, soil mapping, stripmine surveys and timber inventories. . . . LARS remote terminal at Indiana State University provides similar services. . . . used by ISU Geology Dept. in NSF-funded "Student Science Training Program in Remote Sensing". . . . program, started in 1978, offered to 18 high school students each summer. . . . students design and conduct projects in satellite imagery (e.g., LANDSAT) data analysis using remote terminal and LARS data systems. . . . program expected to continue. (Contact/contractor, TEF 513, Case No. A010404, 4/79)

Other Relevant Examples:

A-7 (optical training manual); B-31 (employee training); B-57 (electronic equipment); B-90 (cable design manual); D-24 and M-3 (NDT training manuals); D-28 and M-48 (transformer design manual); F-6 (sanitary techniques training manual); G-27 (lubrication training course); H-15 (energy conservation for schools); I-12 (university performing arts hall); J-7 (school alarm system); K-15 (school bus seats); M-12 (training simulators); N-5 (insurance representative training); P-12 (reading tool for the blind)

O-27 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by Kansas State University (Kansas) in undergraduate course on agricultural machinery design . . . . supplements standard text, provides accurate information on materials testing methods. . . . 20-25 students affected each year. (TB/TSP, TEF 384, Case No. 58506, 5/77)

O-28 Systems management techniques: compiled for Marshall. . . . used by University of Miami, Management Dept. (Florida) in both Health Administration and Management Science courses. . . . provides systems management applications that improve student conception of subject. . . . used in two courses each semester for past four years. (TB/TSP, TEF 494, Case No. 84058, 5/77)

O-29 Telecommunications systems analysis techniques: handbook developed 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 University of Alaska in communications systems theory course . . . . approximately 10 students each quarter. . . . also used by associate professor of electrical engineering to prepare proposal for communications satellite research project. (Trade journal/TSP, TEF 623, Case No. 122108, 4/77)

O-30 Microbiological handbook: compiled for Marshall to provide design information for planetary-landing spacecraft. . . . used by Wayne State University, Occupational and Environmental Health Dept. (Michigan) in a course on control of airborne microorganisms. . . . course taught at least once yearly as part of Industrial Hygiene Program. . . . approximately eight students enrolled each time. (Personal contact/TSP, TEF 402, Case No. 124094, 6/77)

O-31 Control device for spin-rate: developed for Ames. . . . used by University of Nebraska, Engineering Mechanics Dept. to illustrate principles of spinning objects in a graduate course on dynamic motion. . . . particularly helpful in showing gyroscopic applications. (TB/TSP, TEF 693, Case No. STIF-66445, 11/77)

O-32 Remote sensing of vegetation: developed by Goddard. . . . technique for analyzing reflected microwaves to estimate water content and height of vegetation, moisture content of soil. . . . used by University of Miami, College of Engineering (Florida) as source material for remote sensing course and student research projects. . . . significant addition to course content, approximately 50 students per year. (TB/TSP, TEF 695, Case No. STIF-64790, 7/78)

P

HEALTH SERVICES /REHABILITATION

P-5 Nickel-cadmium battery technology: developed for Goddard by Applied Physics Laboratory 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. . . . six-year research effort funded by the University's School of Medicine, Baltimore City Hospital, and Heart Association of Maryland. . . . Pacesetter Systems, Inc. (California) licensed by university to produce units. . . . first human implant for the
+ product was 1973; 7,000 implanted before production discontinued in early 1979 . . . . pacemaker 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. . . . 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. . . . PSI continuing research into electrostimulation applications for nickel-cadmium battery, including treatment of intractable pain, epilepsy, cerebral palsy, spasticity and hypertension. (Personal contact/contractor, TEF 646, Case No. 120519, 9/79)

P-6 Paragraph deleted, 10/78

P-7 Paragraph deleted, 1/77

+P-8 Paragraph deleted, 9/79

+P-9 Paragraph deleted, 9/79

P-10 Electromechanical stimulator modules: developed for Ames by Stanford Research
+ Institute (now SRI International) to obtain sensory feedback from remote manipulators. . . . used by former SRI employee to develop new reader for the blind, Optacon. . . . Telesensory Systems, Inc. (California) was founded in 1970 to market the new reader; company holds patent rights. . . . unit size is about the same as a small tape recorder. . . . in operation, hand-held photodetector 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 initially introduced: the R1B for reading only printed materials, and the R1C which could be adapted to read information from video terminals and electronic displays. . . . over 4,500 units sold before replaced by current model, the R1D, which is priced at $2,995. . . . approximately 6,000 Optacons (all models) currently in use. . . . customers include the U.S. Office of Education and Office of Vocational Rehabilitation, employers of blind people, foundations, school districts and individuals. . . . 100 units are used in Pennsylvania schools and 20 California school districts provide Optacon training. . . . company also has major overseas market. . . . 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, 8/79)

P. HEALTH SERVICES/REHABILITATION

P-1 Paragraph deleted, 10/78

P-2 + Composite materials: developed by Langley for spacecraft, aircraft, and rocket motor applications. . . . used in BATeam project to design lightweight leg braces. . . . heavy, metal brace components replaced by molded composites; brace weight reduced by over 50%. . . . prototypes tested at Coastal Center for Mental Retardation (South Carolina) and Mississippi Methodist Rehabilitation Center. . . . new braces improve mobility and are more attractive. . . . new composite processing methods recently developed, resulting in 10-20% reduction in manufacturing costs and greater flexibility in equipment design . . . . BATeam and Mississippi Methodist, with Langley funding, currently developing other applications for molded composites, including: lightweight footplates for use by arthritics; aneurism clamps and skull plates that would eliminate problems of x-ray interference and biochemical effects caused by metal clamps and plates; and a lightweight wheelchair that could be manufactured at a reasonably low cost. (BATeam, TTD-Applications Engineering, 9/79)

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 . . . . cushion sizes retail from $27, bedsheet sizes from $160, depending on thickness and type of cover, if any. . . . dramatic increase in sales in two years, 1977 projections high. (Personnel/contractor, BATeam, Purchased product line, TEF 570, Case No. 111711, 6/77)

P-4 + Mobile Automated Metabolic Analyzer (MAMA): developed by Marshall in TTD-funded Application Engineering project with Apollo and Skylab astronaut monitoring technology. . . . used since 1974 in experimental program to measure energy expended by prosthetic-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. (TTD-Applications Engineering, TEF 655, 9/79)

P-11 Hand physiotherapy device: developed by Langley in response to BATeam problem statement. . . . Langley prototype, called Finger Joint Flexor, was field tested at North Carolina Memorial Hospital and Jackson Memorial Hospital (Florida). . . . . prototype redesigned on basis of tests. . . . used successfully since January 1974 at North Carolina Memorial Hospital. . . . inflatable mitt operated by portable pumping system controlled by patient. . . . allows patient-administered physiotherapy for flexing and extending finger joints; enables more efficient utilization of therapist skill and training. . . . alleviates contractures which may result from frostbite, burns, arthritis, orthopedic procedures. . . . model further improved at Langley on basis of hospital ex-
+ perience. . . . Langley employee formed Bardon Corp. (Virginia) to market the device. . . . two sizes of pumping unit available: a hospital version which sells for about $550 and a home version which sells for $325. . . . the gloves are sold separately for about $60 each. . . . products introduced at, and offered for sale after, two hand symposiums in late 1976. . . . 3 home units have been sold and several demonstration units have been placed in hospitals and with plastic surgeons. . . . one recent application involved a car accident victim with spinal injury who did not respond to conventional therapy; use of device led to a 10% improvement in patient. (BATeam/Applications project, Personnel/Langley, TEF 571, Case Nos. 109326, 120518, 7/79)

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 400 units sold at $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, 12/77)

+P-13 Paragraph deleted, 9/79

Other Relevant Examples:

F-9 (meal system for the handicapped)

Q

HEALTH SERVICES /DIAGNOSIS AND TREATMENT

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 between 1972 and 1976 at $1,000 each . . . . production stopped in 1976, but most of original instuments are still in use. . . . 2-lb self-contained instrument supplies liquid nitrogen to cryoprobe tip for controlled destruction of tissue. . . . chief surgical application for proctological procedures. . . . 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, fast recovery and lower cost. (Contractor, TEF 197, Case No. 109343, 8/79)

Q-7 Biomedical electrodes: developed by Ames. . . . commercialized by In Vivo Metric Systems (California). . . . product is 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. . . . two product packages available: E-227 contains 12 high quality electrodes, sells for $12; F-228 contains 12 ultra flexible electrodes, sells for $8. . . . approximately 1,000 of each package sold . . . . accessories such as skin cleaner, electrode gel, and adhesive discs are also available. . . . firm has established foreign trade market. . . . main customers are research laboratories and university medical schools. (Conference, TEF 582, Case No. 110592, 7/77)

Q-8 Automatic infrared optometer and visual focus simulator: developed for Ames by Stanford Research Institute (now SRI International). . . . 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; overall quality of patient care and vision services. . . . ophthalmologists enthusiastic because technicians can operate equipment accurately, leaving them free to treat eye disease. . . . approximately 1,000 units sold, current price $27,000 each. . . . 800 in domestic market. (Personnel/contractor, TEF 581, Case No. 110593, 2/77)

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%. . . . several tools now used for routine maintenance and repair of existing equipment. . . . considered standard tool box item. (TB/TSP, TEF 579, Case No. 77130, 5/79)

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. . . . federal funding allocated to local governments for emergency medical training. . . . SCI product line sold to Telecare, Inc., now NARCO, Telecare (Texas). . . . one model, Telecare II, currently available in unit price range of $5,500 to $9,000, depending upon configuration. . . . over 200 cities and counties now using one or more Telecare units, including Houston, Corpus Christi and San Antonio, Texas; Montgomery, Alabama; Altoona, Pennsylvania; Montgomery County, Maryland; Washington, D.C.; Suffolk County, New York; Memphis, Tennessee; and San Francisco, California. (Purchased product line, TEF 557, Case No. 108484, 5/79)

Q-2 Fluorometer instrumentation technology: developed for Headquarters, Marshall, and Electronics Research Center for diagnostic and Apollo instrumentation by Whittaker Corp. . . . used by Whittaker's Space Sciences Div. to develop new blood and urine lead detection device, Micro-Porph. . . . 10 to 15 instruments sold at approximately $3,000 each. . . . Whittaker purchased by Gulf & Western industries Inc. and division now the Applied Science Laboratory (Massachusetts). . . . Micro-Porph still available, although no instruments sold since 1976. . . . annual sales volume for Micro-Porph supplies approximately $2,500. . . . 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 at $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, 7/78)

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 contamina-
+ tion control. . . . results in improved product quality and higher productivity. (TB/TSP, TEF 544, Case No. 86664, 6/79)

+Q-4 Paragraph deleted, 9/79

+Q-5 Paragraph deleted, 9/79

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 such as atmosphere, pilot breath, spacecraft environment, Martian soil. . . . modified by company
+ to develop commerical product line of Medical Gas Analyzers, Model MGA-1100 Series, to measure respiratory, anesthetic and blood gases. . . . units can monitor up to 8 gases simultaneously and signal if any fall below critical levels. . . . current price range is $23,000-$27,000. . . . applications include laboratory analysis of respiratory functions, cardio-pulmonary testing, in-vivo blood gas analysis, and breath-by-breath monitoring of an anesthetized patient before, during and after surgury. . . . units used in approximately 200 hospitals throughout the U.S., Europe and Japan. . . . MGA is also key component in company's new Respiratory Monitoring System, RMS III . . . . system provides real time respiratory and anesthetic data for up to 16 patients; used in operating and recovery rooms and in intensive care units. (Contractor, TEF 656, Case No. 121462, 8/79)

Q-14 Contamination control handbook: compiled for Marshall. . . . used at 375-bed Oak Park Hospital (Illinois) for infection and sanitation control procedures . . . . reduced 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 4,000 person-hours and $500,000 due to NASA handbook, according to Oak Park Hospital expert. (Personal contact/TSP, TEF 262, Case No. 27506, 8/78)

+Q-15 Paragraph deleted, 9/79

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 DOE 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 500 units sold since 1975; current price is $18,000 per unit. . . . customers include Middle Georgia Hospital, Lake County Ohio Hospital, the University of Missouri Medical Center, and hospitals in Hawaii, Massachusetts, New Jersey, Florida, South America and Japan. . . . provides fast, accurate analysis for medical diagnosis. (Personal contact/contractor, TEF 660, Case No. 121465, 7/79)

+Q-17 Paragraph deleted, 9/79

Q-10 Communication equipment evaluation techniques: developed by Lewis. . . . used by American Heart Association, Northeast Ohio Chapter in selecting emergency communications system equipment for pilot, coronary paramedic services project that linked Fairview General Hospital (Ohio) and a fire department rescue unit. . . . system provided remote electrocardiograph monitoring in emergency cases; reduced critical treatment time following initial heart attack. . . . success of project led to formation of the West Shore Area Rescue (WESHARE) Committee, which linked 6 community fire department paramedic squads with FGH and Lakewood Hospital. . . . WESHARE currently serves 196,000 people and has extended paramedic training to include noncardiac emergencies . . . . in 1978, 8,000 calls were answered, of which over 1,200 were cardiac related; system directly responsible for saving the lives of 172 out of 339 patients who had developed life-threatening cardiac rhythms. (Personal contact/Lewis, TEF 602, Case No. 114862, 8/79)

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. . . . customers include neurosurgeons, neurologists, physiologists, psychiatrists, private hospitals, university medical laboratories, and the Veterans' Administration . . . . retail price is $39.50 each, with an increase to $45 planned for late 1978. . . . annual sales have grown from $5,000 in 1975 to $14,000. . . . benefits include establishment of a new business with small capital investment. (TB/TSP, License, TEF 596, Case No. 114852, 7/78)

Q-12 Microbial load monitor: developed for Johnson by McDonnell Douglas Corp. (Missouri). . . . diagnostic instrument that makes multiple microbial identifications simultaneously and 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. . . . MDC established new subsidiary, Vitek Systems, Inc. (Missouri), to manufacture, market and service the system . . . . over 50 units have been sold to community and Veterans' Administration hospital, university medical centers, private clinical laboratories, and U.S. Army and Air Force facilities. . . . unique, automatic, general purpose microbiology processing system for variety of biomedical diagnostic specimens. (Waiver/contractor, TEF 654, Case No. 121460, 4/79)

Q-18 Welder for fine gage wire: developed by Langley. . . . used by Fibra-Sonics Inc. (Illinois) to develop butt welder for producing medical instrument components. . . . thermocouple wires as small as 0.001-inch diameter can be joined without buckling. . . . saved $5,000-$10,000 in development costs for new production equipment. . . . net benefits from timely market introduction of improved products estimated at $50,000 from 1972 to 1977. . . . current annual sales for products containing thermocouples are $57,000. . . . instruments, used in medical surgery such as cataract removal, improved with the introduction of small thermocouples. (TB/TSP, TEF 431, Case No. 59162, 10/78)

+Q-19 Paragraph deleted, 9/79

Q-20 Strain gage installation manual: compiled for Marshall. . . . techniques for bonding strain gages to many materials. . . . used by St. Joseph's Hospital, Barrow Neurological Institute (Arizona) in program for early detection of childbirth labor signals and signs of fetal stress. . . . helped in selecting least obtrusive method for attaching strain gage to expectant mother, diagnosis and treatment may require prolonged instrumentation. . . . increased patient comfort. . . . method provides more reliable diagnostic data. (TB/TSP, TEF 384, Case No. 55420, 5/77)

+Q-21 Paragraph deleted, 9/79

Q-22 Tungsten alloy with improved ductility: developed by Lewis. . . . used by High Voltage Engineering Corp. (Massachusetts) to improve filament life expectancy for electron beam and x-ray tube products. . . . hair pin filaments produced since 1968 from this alloy do not have whiskers. . . . x-ray tube used in cancer diagnosis, treatment and research. . . . company does $4 million annual business. (Trade publication/TSP, TEF 140, Case No. 11411, 7/77)

Q-23 Solid polymer electrolytes: developed as part of spacecraft (e.g., Gemini) fuel cells for Johnson by Du Pont and General Electric Co. . . . used by GE (Massachusetts) to develop a product for monitoring exposure to carbon monoxide, called Pocket Dosimeter. . . . instrument is based on the fact that output voltage from a fuel cell is a function of the concentration of input gases. . . . sales figures unavailable. . . . used in mines, factories and other localities where CO concentration may be high and regulations require monitoring of worker exposure. . . . GE plans to develop additional dosimeter products, using similar technology, for nitrogen oxides and sulfur dioxide. (Contractor, TEF 738, Case No. A007893, 10/78)

Other Relevant Examples:

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

R

HEALTH SERVICES /GENERAL

R-6 Implantable biotelemetry systems: developed for Ames by Konigsberg Instruments, 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 30 single channel units, priced at $225 each, and 5 to 15 multichannel units, priced from $2,700 to $6,500 (depending on options), are sold each year. . . . users include the Universities of Texas and Utah, several major drug companies, and government medical researchers. (Contractor, TEF 644, Case No. 120513, 7/78)

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. . . . about 10 to 12 units sold annually for $3,000 each; handheld unit priced at $395 recently introduced. . . . used primarily for biomedical research. . . . customers include medical research laboratories, universities in Europe and U.S., VA hospitals, NIH. (Personal contact/Ames, TEF 653, Case No. 121458, 7/78)

R-8 + Fire alarm inspection device: developed by Goddard. . . . used by Beechwood Nursing Home (New York) in regular inspection of 100 fire alarms throughout buildings and for weekly testing of building alarm system. . . . provides practical, reliable, fast testing method for heat detector-type alarms. . . . improvement over previous method. (Popular magazine/TSP, TEF 664, Case No. 115064, 4/79)

+R-9 Paragraph deleted, 9/79

R-10 Radiological control manual: prepared by Marshall. . . . safety procedures for radioactive materials. . . . used by Veterans Administration Hospital (New York) in biomedical radiation research program. . . . provided leak detection method that was included in safety plan submitted to obtain license for radioactive materials possession. . . . license granted by Nuclear Regulatory Commission and leak detection method now used as part of routine biomedical radiation research. (Trade journal/TSP, TEF 674, Case No. 112236, 1/77)

R-11 Health hazards of ultrafine metals: developed for Lewis. . . . used by Wright Industries (New York) to verify health and safety procedures for production workers. . . . use of document saved over $2,000. . . . company manufactures magnetic materials, including iron oxide pigments. . . . products used for electrophotographic applications such as copying machine components. (TB/TSP, TEF 323, Case No. 32560, 3/77)

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 University of Miami, Comprehensive Cancer Center of 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. . . . benefits have included an increase in professional cooperation, improvements in delivery of health services, and optional methods of operation. . . . Center, which includes a Dade county hospital, a VA hospital, and private patients, employs a staff of 75 physicians and scientists and 150 technical and support personnel . . . . approximately 3,000 new cancer patients admitted each year. (BATeam, TEF 573, Case No. 112251, 6/79)

+R-2 Paragraph deleted, 9/79

+R-3 Paragraph deleted, 9/79

R-4 Remote health care delivery system: developed by Johnson to satisfy biomedical requirements in manned spacecraft design. . . . used in 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
+ encompassing over 23,500 square miles. . . . cost-benefit analysis, radio communications, human factor analysis, and medical data transmission techniques were used to acquire equipment, train personnel, and schedule projects . . . . initial savings of $50,000 in consultant fees and 3 months of planning effort. . . . federal funds supporting program during first 4 years have totaled almost $1.3 million; local agencies will begin funding program in 1980. . . . provides vital medical services for more than 337,000 people . . . . benefits including savings in salaries, materials and service delivery, as well as improved services, expected to continue. (Contact/Johnson, TEF 588, Case No. 112250, 3/79)

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. . . . about 22 sold to date, usually on a custom order basis; price range of $55,000-$200,000. . . . a third version, helmetmounted, under development. . . . used primarily for vision research in education, aircraft pilot training, highway driving studies, psychological testing. (Waiver/contractor, TEF 82, Case No. 121307, 10/78)

R-12 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 Becton, Dickinson and Co., Edmont-Wilson Div. (Ohio), which developed several markets for the material including application for seat cushions. . . . material purchased by Dentsply International, Inc. (Pennsylvania) to develop new line of dental stools, called CLASSIC™ Dental Stool. . . . 4 models available at $420 each; distributed nationwide through dental equipment suppliers. . . . approximately 1,000 stools sold to date, with target of 3,000 by the end of 1978. . . . seats are pressure sensitive and conform to individual body contours, thereby providing better support and relieving buildup of "numb" pressure points. (Purchased product line, TB/TSP/customer, TEF 570, Case Nos. 111711, STIF-74858, 4/78)

Other Relevant Examples:

A-2 (drug research); A-5, A-32 and B-41 (drug production); E-12 (health conditions improved); E-18 (pollution reduction); F-9 (meal system for the homebound); F-20 (food service); G-22 (FDA data system); H-15 (energy conservation in hospitals); I-2 (medical care facilities); J-7 (safety system for the handicapped); N-5 (contamination control); N-10 (remote health care screening); O-2 and O-3 (medical training simulators); O-10 (remote health care); O-17 and O-18 (bioengineering education); O-23 (safety education); O-30 (industrial hygiene program)

S

WATER TRANSPORTATION

S-4 + Inorganic silicate paint: developed by Goddard. . . . adapted and commercialized by International Paint Co., Inc. (New Jersey) as "Interzinc" product line. . . . uses ethyl or sodium silicate, rather than potassium silicate. . . . sold mainly to large users for application to sand-blasted steel. . . . 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. . . . customer benefits include excellent protective properties and resistance to salt water corrosion. (Trade journal/TSP, TEF 34, Case No. 763, 7/79)

S-5 + Printed circuit fabrication methods evaluation: developed for Marshall to resolve fabrication problems for space-rated circuits. . . . used by Boeing Co., Inc., Marine Systems Div. (Washington) to design automatic control system for a hydrofoil boat product line, Jetfoil. . . . information applied in selecting proper materials for microelectronic components in system. . . . saved 50-60 engineering hours. . . . 15 Jetfoils have been sold to date; 4 to 5 sold annually at current price of approximately $10 million. . . . used as passenger ferries in Hong Kong, Japan, Venezuela and England. (Trade journal/TSP, TEF 256, Case No. 26334, 5/79)

+S-6 Paragraph deleted, 9/79

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 100 FORTRAN programs have been converted. . . . savings in operating costs estimated at $15,000. (Trade journal/TSP, TEF 527, Case No. 102850, 10/78)

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. (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, and takes one-fourth the time to install. . . . before environmental issue over porpoise kills (1975-78), more than 40 tuna boats completed and sold at prices ranging from $1-$4 million each. . . . issue resolved and 4 tuna boats now in production, with market expected to increase. . . . current price range of boats is $2.5-$12 million . . . . customers have included Starkist, Van Camp Seafood Div., and Ralston Purina. (Customer/contractor, TEF 361, Case No. 115405, 7/79)

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. . . .
+ first MARISAT satellites launched for COMSAT General Corp. in 1976 to provide ship communications service. . . . service now used routinely by Exxon for tanker fleet and drilling rigs. . . . benefits and cost savings expected to continue. (Contact/Goddard, TEF 530, Case No. 114857, 7/79)

S-2 LANDSAT 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 Antartica, to support exploration activities. . . . U.S. Navy ice maps, prepared daily from LANDSAT imagery, were used to chart an accurate, reliable course through dense ice by detecting small cracks in ice packs. . . . benefits included savings of 70 hours in aircraft surveillanceflying time, avoidance of ship delay or damage, and demonstration of feasibility for locating a ship resupply base 1,200 miles closer to exploration area. . . . still used on a weekly basis to chart ice positions. . . . provides ships in polar waters with more precise and time-saving navigational information; e.g., data saved one ship 5 to 6 days during 2,000-mile trip between supply stations. (Interagency, TEF 500, Case No. 114853, 10/78)

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 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 1974-75 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 Dept. (Minnesota) participated in test with a large iron ore ship. . . . ice information permitted ship operation in winter months . . . . benefits included reduced transportation and ore storage costs, prevention of ship damage and delay. . . . company has participated in program since initial test; time saving and extended shipping season benefits continue. (Interagency, TEF 603, Case No. 114856, 10/78)

S-14 Rolling element fatigue life: research conducted at Lewis. . . . data on contact pressure and fatigue of metals and alloys used by Brunswick Corp., Mercury Marine Div. (Wisconsin) to solve bearing fatigue problems in its boat motor products. . . . two-cycle outboard motors have frequent bearing problems and causes are difficult to determine (e.g., material fatigue or improper lubrication). . . . specific information on materials and material limitations aided in development of design and lubrication alternatives. . . . availability of data saved extensive research efforts. (Professional journal/contact/Lewis, TEF 723, Case No. A007919, 10/78)

S-15 Relative humidity equation: developed by Dryden. . . . equation for computing relative humidity from wet and dry bulb temperatures by Brunswick Corp., Mercury Marine Div. (Wisconsin) in testing programs to improve its boat engine products. . . . information used in establishing procedures to adjust for weather data variations, such as barometric pressure, temperature and relative humidity, and to eliminate the effect of these variations on engine horsepower readings. . . . benefits include reduced development time. . . . use expected to continue in product testing programs. (TB/TSP, TEF 719, Case No. A004868, 6/78)

+S-16 Meteorological satellites: developed for Goddard, owned and operated by NOAA . . . . remotely sensed data from TIROS and NOAA series satellites processed by the National Environmental Satellite Service (NESS) to estimate ocean temperature and location of Gulf Stream off the U.S. East Coast. . . . results transmitted to the U.S. Coast Guard, Oceanographic Unit (District of Columbia) for comparison and adjustment with data from CG ships. . . . final charts for temperature and Gulf Stream produced weekly and transmitted to CG units and subscribers. . . . used by CG search and rescue units to estimate location for lost boats from their last known positions. . . . used by Exxon Corp., Marine Dept. (Texas) for oil tanker navigation along East Coast. . . . in cooperation with NESS, Exxon experimented with its East Coast fleet in 1975 and obtained average fuel savings of 5% when charts were used. . . . northbound ships were able to stay in Gulf Stream current and southbound ships avoided it. . . . Exxon subsequently directed all of its East Coast fleet to use the charts. . . . estimated annual savings of $360,000 from routine use of data by fleet. (Interagency, Contact/NESS, TEF 775, Case Nos. A010513, A010514, 3/79)

Other Relevant Examples:

A-8 (pleasure boat safety); B-10 (LNG tankers); C-7 (life raft); E-15 (waste treatment system); F-29 (fishing boat safety); H-2 (LNG transfer system)

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., Inc., Marine Systems Div. (Washington) to program an automatic control system for a hydrofoil boat product line, Jetfoil. . . . boat used for high-speed ferry services; ranges in size to accomodate from 200 to 300 passengers. . . . rigid hydrofoils on boats by other companies caused a rough ride that was unacceptable to many passangers. . . . Jetfoil features variable hydrofoil with control system to compensate for waves and provide satisfactory ride quality. . . . 15 Jetfoils have been sold to date; 4 to 5 sold annually at current price of approximately $10 million. . . . customers include commercial ferry services in Hong Kong, Japan, Venezuela and England. (Conference, TEF 608, Case No. 115408, 8/79)

S-10 Nondestructive spot test procedure: compiled by Langley. . . . used by Rockwood Systems, Inc. (Maine) to identify metal alloy stock. . . . company
+ produces ball valves and fire protection equipment for ships. . . . complete shipboard fire suppression system, which includes foam generator nozzles, valves and hoses, sells for $5,000 to $50,000. . . . ball valves used in sea water and air line systems are priced from $5 to $3,000. . . . customers include Todd Shipyards, Avondale Shipyards, oil companies such as Exxon and Gulf, and the U.S. Navy Ship Parts Control Center. . . . estimated savings of $9,500 by using spot test rather than purchasing spectrographic equipment and reference samples. (TB/TSP, TEF 378, Case No. 44636, 5/79)

S-11 Steel data handbooks: compiled for Marshall. . . . used by Lear Siegler,
+ Inc., Energy Products Div. (California) in designing product for nuclear ship propulsion systems. . . . provides valuable input to materials analysis and stainless steel selection for control rod drive mechanism product used on U.S. Navy ships. . . . average price of drive mechanism is $250,000. . . . company is major producer of nuclear ship drive mechanisms. (TB/TSP, TEF 538, Case No. 120412, 5/79)

S-12 Copper-plating solution purity test: developed for Marshall. . . . used by Long Beach Naval Shipyard, Electronic Restoration Shop (California) to improve process control for copper plating of circuit boards. . . . shop repairs or reproduces circuit boards as replacement parts for Naval equipment. . . . new in-house test for acidic plating solutions decreases circuit board rejection rate and reduces work stoppages. . . . saves about five working days per month, worth about $1,000, and avoids previous cost of outside consultant tests. (TB/TSP, TEF 698, Case No. STIF-65475, 12/77)

S-13 Nonflammable materials: developed for Johnson by various contractors; one, Durette, is a fluorinated fabric developed by Monsanto for astronaut clothing. . . . Fire Safe Products (Missouri), one of the firms that manufactured Durette for Monsanto, purchased the production rights in 1973 and now produces Durette fabric commercially. . . . has high resistance to heat, flame and abrasion; also is self-extinguishing. . . . fabric used to custom-fit over 100 diving chambers; orders can include Durette covers for bedding, walls, and furniture. . . . cost to outfit a six-person chamber about $6,000 . . . . fabric also used to manufacture clothing for divers to wear in chamber. . . . customers include private oceanographic research centers and government oceanographers. . . . Durette covers and clothing increase safety in highly flammable oxygen environment of diving chambers. . . . company also actively marketing fabric for use in auto racing. (Subcontractor/purchased production rights, TEF 324, Case No. A006432, 7/78)

T

COMMUNICATIONS

T-3 Amateur radio satellites: launched as vehicle ballast with NOAA 2 and 4 meteorological satellites under Goddard supervision. . . . built by non-profit Radio Amateur Satellite Corp. (AMSAT) (District of Columbia) from components donated by AMSAT member groups, including RCA, Yellow Springs Instrument Co.,
+ National Semiconductor Corp., J.W. Miller Corp. . . . eight satellites, called Orbiting Satellite Carrying Amateur Radio (OSCAR), launched at no cost to radio amateurs. . . . OSCAR 7 and 8 still in orbit. . . . can receive, store, retransmit morse code, voice, and teletype messages between amateur stations separated by as much as 5,000 miles. . . . requires relatively low-powered ground equipment costing as little as $250. . . . over 5,000 radio amateurs in more than 100 countries (2,000 in the U.S.) use the satellites to transmit messages, medical data, weather bulletins, and emergency communications. (Personal contact, TEF 672, Case No. 123105, 5/79)

T-4 Contamination control handbook: compiled for Marshall. . . . used by Amperex Electronic Corp., Electro-Optical Devices Div. (Rhode Island) to train over 300 employees in proper cleanroom techniques. . . . significant cost reduction through prevention of particle contamination in assembly of "Plumbicon" vacuum tubes for television cameras. . . . thousands of tubes sold each year at about $2,500 each. . . . customers are television camera manufacturers, television studios, and outside equipment manufacturers such as RCA and Norelco. (Personal contact/TSP, TEF 262, Case No. 111726, 9/78)

T-5 Wire harness manufacturing techniques: developed by Marshall. . . . used by AEL-EMTECH, Manufacturing Div. (Pennsylvania) to train new engineers in quality control procedures for wire harnesses. . . . company produces components, such as transceivers and antennas, for use in television and radio broadcasting equipment, rail mass transit dispatch systems. . . . two to eight person-weeks saved in developing training materials. (TB/TSP, TEF 536, Case No. 93839, 5/77)

T-6 SATCOM Satellites: launched by Kennedy on reimbursable basis for RCA Corp. . . . . SATCOM I, II link six earth stations serving 10 major access cities . . . . RCA American Communications, Inc. (New Jersey) providescommunications services to manufacturers, financial institutions, television broadcasters, government agencies. . . . includes private line/voice/data/facsimile transmissions. . . . reliable, economical alternative to land-based systems for long haul and multi-point communications. . . . lease rates are 25% less than land-based links. (Customer/contractee, TEF 680, Case No. 123703, 1/77)

T-7 Frequency discriminator/phase detector: developed for NASA Pasadena Office by JPL. . . . used by Telemetry Systems Engineering, Inc. (Massachusetts) to modify design of data telemetry system product for water and gas utilities . . . . system uses telephone lines for monitoring flow at remote locations . . . . modification enabled greater density of signals. (TB/TSP, TEF 686, Case No. 108565, 5/77)

T. COMMUNICATIONS

T-1 Westar Satellites: launched by Kennedy on a reimbursable basis for Western Union Telegraph Co. (New Jersey). . . . built by Hughes Aircraft. . . . first commercial satellite system for U.S. business community. . . . two solar-powered satellites, Westar A and B, linked to 5 major ground stations, 20 cities and 5 television operations centers within 9,000-mile microwave network. . . . provides transmission service for private line voice, data facsimile, mailgram message, and radio, television broadcasts. . . . used since 1974 by Dow Jones and Co., Inc. (New Jersey) which leased transmission service, installed data transmission equipment, built three ground stations to send and receive data, and began transmitting The Wall Street Journal copy from editorial offices in Massachusetts to Southern Edition printing plant in Orlando, Florida. . . . system transmits about 150,000 bits of information per minute, produces one newspaper page every four minutes. . . . data transmission costs reduced from $25,000 to $2,000 per month. . . . company built four more ground stations for transmitting copy to additional printing plants in Denver, Colorado, Riverside and Palo Alto, California and Seattle, Washington. . . . company estimates that a 150% increase in cost has increased coverage by 300%. . . . Westar facilities also used since mid-1975 by Robert Wold Co., Inc. (California) to transmit sports and news events to 10 independent television stations coast-to-coast. . . . first use of commercial satellites for commercial telecast. . . . in mid-1976, company entered $3.8 million contract with Western Union Telegraph Co. to transmit 1,800 broadcast hours per year for seven years. . . . system provides reliable broadcast facilities at one-third cost of previously used leased land lines. . . . the Corporation for Public Broadcasting (District of Columbia) is using Westar services to transmit audio and video signals to 150 terminals serving 165 broadcasting stations. . . . reduces amount of intermediate equipment between stations (common carrier transmission requires relay towers every 25 miles), thereby reducing equipment failure problems and costs. . . . also, system enables new stations to come on-line more easily and may make digital audio transmission and auxiliary audio channels feasible in near future. . . . according to Western Union, cost saving benefits of Westar realized over longer distances because satellites require only one relay tower between earth stations; land-based costs increase with distance because many towers are required. (Customer/contractee, TEF 676, Case Nos. 123410, 123411, A007926, 10/78)

T-2 Thermal-control coating specifications: developed by JPL for larger radar antenna structures exposed to solar radiation. . . . used by Harris Corp., Harris Electronic Systems Div. (Florida) in designing communication system equipment. . . . JPL data used to design heat-operated image development unit in high speed, high resolution facsimile system called Laserfax. . . . system sold to Associated Press (New York) for resale to news bureaus. . . . used for transmission and reproduction of high quality news photos. . . . Harris producing 1,500 of these units at approximately $3,500 each, most already delivered. . . . similar system also sold to National Weather Service (Maryland) for transmission and reproduction of weather satellite images. . . . users include local weather stations, TV stations, newspapers, airlines. . . . several hundred of these systems sold for approximately $13,000 each. (TB/TSP, TEF 200, Case No. 30520, 1/77)

Other Relevant Examples:

A-4, C-9, D-3, D-4, D-18, H-4, H-5, H-17, M-8, N-1 and N-2 (monitoring/control systems); B-7 and B-20 (microwave components); B-18 (electronic components); B-44 (communications satellite transponder); B-48 (cable stripper); B-61 (telephone system); B-72 and J-5 (radio dispatch system); B-94 (communication system circuits); C-6 (animation for advertising); C-14 (Baja guide book); C-16 (phonograph record lubricant); C-18 (TV repairman equipment); E-5 (weather information); G-2, G-3, G-24 and O-13 (resource data communication); G-21 (military communications); I-32 (telephone wiring system); J-1, J-3 and J-8 (law enforcement communication); J-7 (silent alarm system); K-4 (car radio); K-13 (truck parts system); L-4 (railroad billing system); O-10 (educational satellite); O-24 (teaching satellite communication); O-35 (teaching satellite data analysis); Q-1, Q-10 and R-4 (medical systems); S-1 and S-3 (ship communication)

T-8 Management method for R&D programs: developed for Marshall. . . . used by General Dynamics, Electronics Div., National Data Buoy Systems Group (California) to establish management plan for developing electronic control systems under contract to the National Oceanic and Atmospheric Administration. . . . many person-hours saved in the development project. . . . division adopted similar approach to manage multimillion dollar annual business . . . . division develops and manufactures electronic systems, radio communications equipment, and navigation, oceanographic and meteorological buoys. (TB/TSP, TEF 452, Case No. 54821, 7/77)

T-9 Weather satellite ground receivers: developed by Goddard and EMR Telemetry (formerly EMR Div. of Weston Instruments [Maryland]) in conjunction with weather satellite program. . . . commercialized as product by EMR Telemetry (Florida); prices range from $30,000 to $50,000 each. . . . more than 50 APT receivers sold, primarily to foreign governments such as Canada, Greece, Norway, Portugal, India and Libya for use in remote regions. . . . provides important communication link to weather satellite system. . . . EMR also produces complete satellite terminal systems (includes support equipment for APT receiver station). . . . cost of complete system runs several hundred thousand dollars. . . . new markets being developed in South America and the Pacific. (Contractor, TEF 194, Case No. 431, 7/78)

T-10 NIMBUS transmission system: developed and operated by Goddard. . . . Handar, Inc. (California) developed, under Goddard contract, satellite tracking beacon transmitters used to provide a radio signal link through NIMBUS-6 . . . . satellite relays signal from beacon unit on-board remote equipment (e.g., weather balloon) to ground control centers, enabling accurate location of unit. . . . Handar marketed a commercial version of the beacon (Model 420A). . . . unit weighs only 18 pounds and sells for $1,300-$2,000 . . . . product and NIMBUS-6 used in recent attempts to cross the Atlantic with manned balloons. . . . credited with saving the crew of Double Eagle balloon which went down off Iceland with no other radio contact possible. . . . product and NIMBUS-6 also used by Japanese explorer making a solo trip by dog sled to North Pole in 1978. . . . provided accurate location information so supplies could be delivered by aircraft. . . . searching delays avoided in resupply flights such as after polar bear consumed all the dog food. (Contractor, TEF 740, Case No. A007915, 7/78)

+T-11 Explosive and fill/drain valves: developed for Langley Viking Program contractor by Pyronetic Devices, Inc. (California). . . . commercialized by company as new product line of 1430 and 1431 explosive valves and 1831-Series fill and drain valves. . . . primary customers are manufacturers of commercial communication satellites such as INTELSAT and TELESAT (Canadian). . . . benefits include time and money saved in developing specialized commercial product. . . . approximately 25% of company's business is due to these products. (Subcontractor, TEF 763, Case No. A009050, 3/79)

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