1999

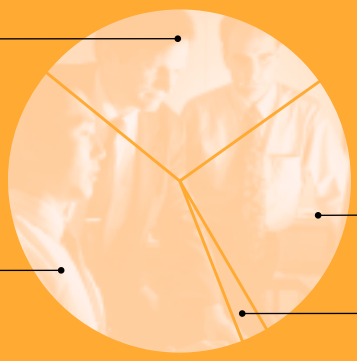
Annual Report

THE AEROSPACE CORPORATION

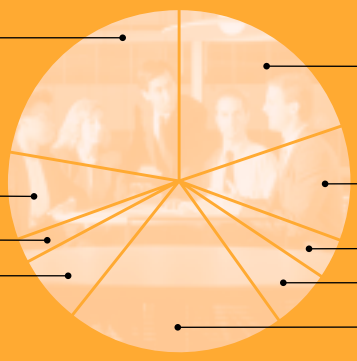
Intellectual Capital

Talent and Experience

Highest Technical Degree



Degree Disciplines



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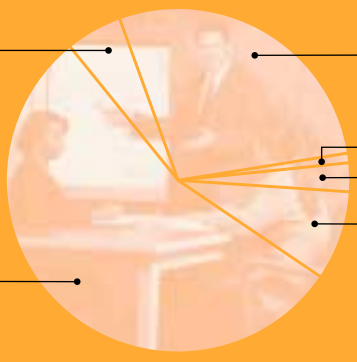

Approximately 66 percent of our 3,000 employees are members of the technical staff; 70 percent hold advanced degrees in a wide range of disciplines; nearly one in three has a doctorate.

THE AEROSPACE CORPORATION

*Our **vision** is to be the world's leader in the application of space technology. Our **mission** is to apply our technical knowledge and expertise to enable our customers to successfully exploit the full potential of space and space technology. Our **values** are simple: integrity, technical excellence, objectivity, dedication to mission success, and commitment to our people.*

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Corporate Letter

Profound and Positive Change

The Aerospace Corporation holds a unique position of trust. As systems engineer for the Air Force Space and Missile Systems Center and the National Reconnaissance Office, Aerospace is responsible for the architecture, development and orbital operation of national-security space systems and missions. Through our operation of a federally funded research and development center, we respond to a broad mandate from military, intelligence, and civil government agencies. Our role as a trusted partner of government and industry gives us unique access to the full range of technology, planning, operations, and proprietary data needed to provide leadership in the specification, development and interoperation of space systems.

In recent years we have expanded our scope to include an array of civil and commercial space activities, both domestic and international. This expansion will enable us to knowledgeably support our primary customers in incorporating the best technical and cost-effective contributions from the entire space community, resulting in a lower cost to all.

Today we are experiencing a profound and positive change in environment, affecting our current operation and future direction. After a six-year decline in our workforce caused by budget reductions and congressional direction, we are undergoing a period of moderate budget growth and increased demand for technical support from a variety of government agencies. This change in environment is a result of several factors:

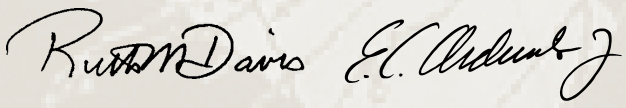
- a growing appreciation of our crucial role in ensuring quality space launch and satellite systems for government and commercial users
- the changing role of space, which has become an essential element in satisfying national security objectives in a highly volatile world
- the critical need for space expertise across more agencies involved with national security
- rapid growth in the commercial space market, highlighting the need for technical excellence and disciplined process knowledge to ensure quality and competitive space products; the equal need for the government to gain a better understanding of commercial practices
- the introduction of new national-security space systems at a time when existing systems are reaching the end of their useful lifetimes, requiring expanded Aerospace involvement to support new and ongoing systems

This environment is placing significant challenges on Aerospace and its management. First, we are faced with recruiting high-quality technical personnel in a competitive employment market. We are fortunate that we do not have to recruit large numbers in this setting, and we are bolstered by low voluntary attrition rates thanks to our favorable environment and the exciting work we perform. Second, we must continue to stay ahead of the rapidly changing technology base for space systems by hiring the best talent, conducting independent research to develop future skills, and fostering initiatives that will put us in a leadership position for the application of revolutionary technologies in space. We are doing all we can to meet these challenges.

Finally, the integration of space into joint military operations requires better cross-program coordination and planning, sharing of "lessons learned," and integration of space systems with air and terrestrial sensors and systems. We have programs in place to address these needs now and in the future.

It is our good fortune—and difficult responsibility—to be near the center of one of the most important issues of our times, national security. National security problems are much more complex than in the past, and we look forward to working with the government and with industry to prepare for the future.

As we enter the year 2000 and prepare to celebrate 40 years of service to the U.S. space program, we look back with pride and look forward with anticipation. There is a great deal of challenging work to be done, and The Aerospace Corporation is well positioned to contribute in the exciting times ahead.



Dr. Ruth M. Davis
Chair, Board of Trustees

Edward C. Aldridge, Jr.
President and CEO

The Nature of Aerospace

Trusted Partner, National Resource

The Aerospace Corporation is an independent, nonprofit company that provides objective technical analyses and assessments for space programs that serve the national interest. We operate a federally funded research and development center (FFRDC) sponsored by the Department of Defense, providing the specific skills, specialized facilities, and continuity of effort required for programs that often take decades to complete. This end-to-end involvement minimizes development risks, reduces costs, and assures a high probability of mission success.

Although we provide technical support to a variety of space-related programs, our primary customers are the Space and Missile Systems Center (SMC) of Air Force Materiel Command and the National Reconnaissance Office (NRO).

Our staff, renowned for its technical knowledge and expertise, helps our customers exploit the full potential of space and space technology. We possess an extensive array of scientific and engineering resources to support the successful application of this technical excellence in the areas of concept definition, engineering design, component development, systems engineering, architecture planning, deployment and operations.

The Defense Department has identified five core competencies for The Aerospace Corporation's FFRDC:

- launch certification
- system-of-systems engineering
- systems development and acquisition
- process implementation
- technology application

Since our formation in 1960 at the initiative of the Secretary of the Air Force, we have been meeting special long-term research and development needs essential to developing a national military space program. After nearly four decades of operation, The Aerospace Corporation is recognized as a national resource and a center of technical excellence.

ARCHITECT-ENGINEER

Members of our technical staff have critical responsibilities in accomplishing complex engineering tasks, from initial space and launch system concept and design through deployment and operation. The staff evaluates and contributes to the progress of many space-related programs, analyzes design alternatives and tests, and resolves problems in collaboration with industrial contractors and government laboratories. Independent laboratory research is directed toward system advancements, feasibility studies of new system concepts, anomaly resolution, and analyses and forecasts of domestic and foreign technologies.

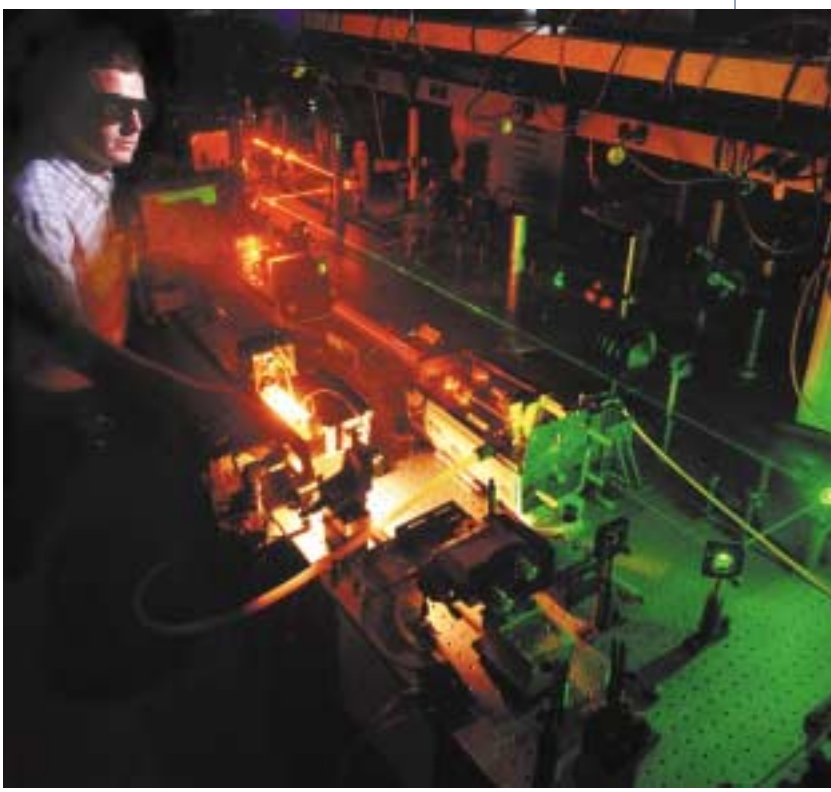
In fulfilling our role of architect-engineer, we minimize system development and operational risks, which helps to maintain time-critical acquisition schedules and contain costs. We estimate our efforts during fiscal year 1999 saved the government approximately $740 million, more than double the funding received from the Department of Defense.

CORPORATE STRUCTURE

Aerospace employs a matrix organizational structure with systems engineering directorates corresponding to specific customer programs. The operational groups draw technical support from a central engineering organization, ensuring efficient use of specialized staff members, effective sharing of technical experience, and the application of corporate memory and "horizontal engineering" across programs.

The Space Systems Group works closely with SMC and is responsible for the systems engineering of military space programs through all phases of system development, deployment, and operation. The group's support encompasses concept creation, technical and engineering analysis, source selection and design validation, through full-scale development, manufacturing and testing, launch, orbital testing, and on-orbit operations. Verifying performance readiness of launch vehicles, satellites, special payloads, and ground systems is a major responsibility.

A technician aligns an Nd:YAG laser in The Aerospace Corporation's picosecond laser facility, which is used to simulate single-event effects in microelectronic devices.



The National Systems Group is responsible for the systems engineering of NRO programs. It participates in planning, developing and deploying space systems essential to national security. This support consists of technical and engineering analyses, concept design studies, source-selection evaluations, long-range planning and architecture studies, and on-site support. The group also analyzes requirements and capabilities in the development of system architectures that will continue to advance the nation's space mission.

The Engineering and Technology Group provides engineering and scientific expertise to the other organizations, performs independent assessments of the technical status of acquisition programs, and assists in the introduction of new technology. The technical staff conducts applied research and aids space programs by developing and applying advanced models, simulations and analytic tools. The group's databases serve as the repository for "lessons learned" during the development, launch and operation of U.S. military, intelligence and civil space programs.

The Systems Planning and Engineering organization focuses our ability to perform cross-program engineering and horizontal planning in support of the national-security space program. It works closely with SMC, the NRO, Air Force Space Command and a variety of other government agencies. It also supports the Assistant Secretary of Defense for Command, Control, Communications and Intelligence on space protection policy, as well as the National Security Space Architect. Primary activities include requirements analysis, cross-mission planning and architecture development; strategic awareness planning; cross-program engineering; systems acquisition development; and operation of the Center for Orbital and Reentry Debris Studies and the Space Operations Support Office.

The National Law Enforcement and Corrections Technology Center–Western Region is operated by Aerospace for the National Institute of Justice, a branch of the U.S. Department of Justice. Its staff acts as a technical resource for public safety agencies, providing technology and system design assistance to local and state agencies. The center has demonstrated promising systems, provided training on emerging technologies, aided in the procurement of complex systems, and supplied day-to-day assistance to more than 1,500 agencies nationwide. During the last six years the center has handled more than 900 forensic support cases in which audio, video or photographic enhancement was critical to law enforcement agencies throughout the United States.

The Aerospace Institute creates a learning environment through an extensive curriculum of education and training programs. Courses focus on critical technical competencies in systems engineering and architecture, as well as in leadership, management, and business skills. The Institute provides extensive

information resources and archival services in the Charles C. Lauritsen Library. It also sponsors conferences and symposia and publishes books and monographs by Aerospace authors.

CORPORATE OFFICES

The corporate headquarters with its engineering and laboratory complex are located in El Segundo, California, adjacent to Los Angeles Air Force Base. Scientific and engineering centers house facilities for research and problem-solving in electronics and sensors, mechanics and materials, propulsion, computer science, and space and environmental sciences. Aerospace maintains offices at Air Force launch sites on the East and West coasts; at Johnson Space Center in Texas; at satellite operations and technology centers in California, Colorado, and New Mexico; and in the Washington, D.C., area. These offices provide cost-effective, on-site customer support.

EMPLOYEES

The Aerospace Corporation comprises more than 3,000 talented men and women dedicated to advancing space technology. We encourage professional development, recognize individual and team achievements, and support the principle of equal opportunity. A comprehensive benefits program supports both personal and family needs, offering a choice of medical and dental plans, insurance, a retirement plan and a voluntary annuity plan. The Aerospace Employees' Association offers special-interest activities through more than 40 organizations.

Aerospace has a strong sense of community. We are particularly dedicated to improving the quality of educational programs in the cities where our people live and work. Our employees participate in teacher-aid programs and science projects, prepare materials for the classroom, act as student mentors, provide drug abuse counseling, and conduct student tours of our technical facilities.

THE AEROSPACE CORPORATION IS HELPING TO SHAPE TOMORROW'S SCIENTISTS AND ENGINEERS THROUGH A VARIETY OF EDUCATIONAL OUTREACH ACTIVITIES SUCH AS THE ANNUAL ROBERT HERNDON ENGINEERING AND SCIENCE SEMINAR.

LOCKHEED MARTIN MISSILES & SPACE

The Year at Aerospace

Objective Analysis, Innovative Solutions

Support to the Air Force Space and Missile Systems Center and to the National Reconnaissance Office in all phases of space systems acquisition remained the major thrust of our efforts during the past year. An increased demand for our expertise beyond these Department of Defense customers resulted in a broad range of significant program activities in the civil and commercial arena as well. The quality of work performed and the exceptional value we provided each customer confirmed our role as a national resource and world leader in the application of space technology.

LAUNCH VEHICLES

Titan and Titan Upper Stages Aerospace participated in the launch of four Titan vehicles by providing technical oversight and performing independent assessments of performance, guidance software, loads, flight environments, and day-of-launch winds aloft. Prior to the launches we played a key role in the investigation of a Titan IVA that failed in August 1998, working with the contractor and the Air Force to establish corrective actions and to verify implementation before the vehicle's return to flight.

The first two launches unfortunately ended in failure from causes unrelated to those of August 1998. In April a Titan IVB with an Inertial Upper Stage launched from Cape Canaveral Air Station, Florida, failed to place a Defense Support Program (DSP) satellite into the proper orbit. The cause was traced to an inter-stage connector problem that resulted in an anomalous separation of the first and second stages. A Titan IVB launched from the Cape later that month failed to deliver its Milstar payload to the proper orbit. The cause was traced to a software error in the Centaur Upper Stage guidance system, which ultimately left the space vehicle in a useless orbit. Aerospace provided key personnel on the accident and safety investigation boards and on the joint engineering analysis boards for both incidents.

Mission success was achieved in May when a Titan IVB carried a National Reconnaissance Office (NRO) satellite to orbit. That success was repeated in June with the launch of a Titan II that delivered NASA's QuikScat weather satellite to orbit. Both launches occurred from Vandenberg Air Force Base, California. Within two hours after each launch, our Space Launch Operations Telemetry Acquisition and Reporting System (STARS) confirmed satisfactory performance.

Atlas Preparations for Department of Defense launches during the year were delayed because of two significant problems with the RL-10 engine used in the Atlas/Centaur, Titan/Centaur, and Delta III second stage.

We joined with Air Force and contractor representatives to investigate failures of the turbopump bearings during production test firings. Although the root cause was never conclusively determined, the investigation revealed that the bearing cage material was below the qualified strength of the previous lot of bearings. Aerospace succeeded in developing criteria for engine acceptance that satisfied Defense Department user concerns.

The second problem was an RL-10 engine failure on a commercial Delta III/Orion launch that resulted in the stand-down of all launch vehicles using RL-10 engines. The investigation revealed that brazing process changes to the thrust chamber's structural jacket resulted in weakened structural integrity. We have been a major participant in the investigation team and have developed a structural model to determine chamber acceptability for engines designated for Defense Department and NASA missions.

Delta A Delta II rocket carried the Air Force P91-1 Advanced Research and Global Observation Satellite (ARGOS) into orbit from Vandenberg Air Force Base along with two secondary payloads. Aerospace evaluated all major systems testing, design changes, dispositions of significant discrepancies, and interface requirements of the Delta II launch vehicle. We also evaluated all component pedigree data and major systems testing and verified the interface requirements from the ARGOS space vehicle to the launch vehicle, space vehicle to launch facility, and launch facility to space vehicle support equipment.

Aerospace provided mission assurance services for the Global Positioning System (GPS) IIR-3 mission slated for launch from Cape Canaveral in early fiscal 2000. This mission was designated the first to insert a GPS satellite via the ascending node.

AEROSPACE ENGINEERS EXAMINE PLANS FOR SPACE LAUNCH COMPLEX 3–EAST AT VANDENBERG AIR FORCE BASE. THE PAD, IN THE BACKGROUND, WAS DESIGNED AND BUILT WITH AEROSPACE INVOLVEMENT. THE FIRST LAUNCH FROM THE NEW SITE WAS SCHEDULED FOR DECEMBER.

Aerospace also provided mission assurance efforts on NASA's Far Ultraviolet Spectroscopy Explorer (FUSE) mission and on Boeing's commercial Globalstar -3, -4, -5 and -6 launches, which were all a success. We monitored all Delta launches in real time using our STARS facility.

EELV We participated in the development of the Evolved Expendable Launch Vehicle (EELV) operational launch-site ground support system by reviewing each contractor's submitted designs for technical sufficiency and viability. We supported the Site Activation Working Group, making significant contributions in integrating range standardization and automation requirements and in developing the basis for reduced explosive safety siting criteria.

THE BOEING COMPANY

We also provided comprehensive technical requirements to initiate a supplemental environmental impact statement, a prerequisite for supplemental launch service contracts that could include EELV vehicles augmented by solid rocket motors. Aerospace provided computational analyses of EELV vehicle emissions, debris corridors, orbital debris, and failure probabilities for proposed new EELV variants in support of the Ultra-High Frequency, UHF-11, source selection.

Space Maneuvering Vehicle The Air Force Space Maneuvering Vehicle (SMV) concept is similar to NASA's Advanced Technology Vehicle (ATV), for which a construction and flight-test contract was recently awarded. NASA and the Air Force are cooperating on SMV and ATV development activities. Aerospace supported the planning for both vehicles. Our SMV efforts included military worth analysis, a technology evaluation plan, and identification of required tasks and staffing to support development by the Air Force Space and Missile Systems Center (SMC). We also provided a roadmap for SMV system development and identified the roles and benefits of SMC leading the ATV flight-test activity.

Aerospace technical experts supported the launch of the U.S. Geological Survey's Landsat 7 Earth remote-sensing spacecraft and assisted in developing orbit shift recommendations.

Environmental Engineering Aerospace investigated the model used to predict the casualties that could result from broken glass caused by exploding solid propellant hitting the ground during a Titan IV failure. Our investigation showed that the model is technically sound, despite many unverified assumptions, but sensitive to several input parameters. We provided updates to the launch failure probability values, explosive yield curves and segment impact orientations. All changes improved the launch availability predictions.

MEMBERS OF THE AEROSPACE TECHNICAL STAFF INSPECT THE FAIRING OF A TITAN II LAUNCHER TO ENSURE PROPER CLEARANCES FOR A DMSP PAYLOAD.

SATELLITE SYSTEMS

DSP The Defense Support Program continues to provide early warning of land- and sea-based ballistic missile launches. This year a DSP satellite was launched into an improper orbit with an anomalous tumble. Our extensive DSP experience and vehicle dynamics expertise were key to the satellite's safe recovery, thus preserving a valuable space asset for the U.S. government's surveillance and technical intelligence missions. Aerospace was an active participant in the satellite on-orbit anomaly-resolution teams, contributing valuable data analysis throughout the recovery effort.

Aerospace continues to support advanced ground applications of DSP data through support to the evolutionary improvement of the Attack and Launch Early Reporting to Theater (ALERT) system, which provides real-time support to warfighters worldwide. Aerospace was instrumental in promoting the development of ALERT's multisource sensor-level fusion capability and its integrated displays of environmental and intelligence information. These new system capabilities were demonstrated during Operation Desert Fox and were later employed during the conflict in Kosovo to aid in battle-damage assessments and combat search-and-rescue missions.

SBIRS The Space Based Infrared System (SBIRS) is a planned constellation of high- and low-altitude satellites with a consolidated, common ground system built to meet U.S. surveillance needs through

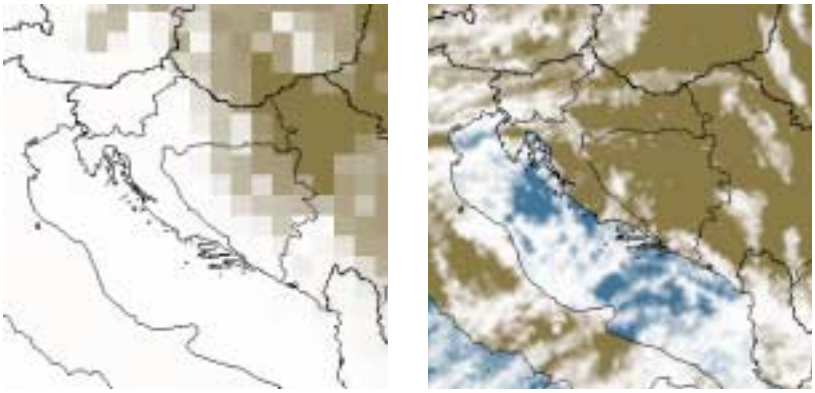
the next two to three decades. SBIRS, which will replace the 29-year-old DSP system, is designed to support multiple missions, including missile warning and detection, missile defense, technical intelligence and battlespace characterization. Aerospace is supporting the acquisition of the two major program elements, SBIRS High and Low.

SBIRS High, scheduled for initial deployment in 2004, will employ satellites in geosynchronous orbit as well as hosted payloads in highly elliptical orbits. The SBIRS consolidated ground system will be developed in three increments, phased to support DSP continental U.S. processing consolidation and the SBIRS High and SBIRS Low constellation deployments. The SBIRS Mission Control Station is a new facility located at Buckley Air National Guard Base in Colorado. Aerospace is providing the Air Force with independent assessments of program execution while supporting the contractor's leadership role in the new acquisition environment.

The SBIRS Low constellation of low-altitude satellites, which will perform midcourse tracking, is planned for initial deployment in 2006. Aerospace has been heavily involved in supporting the development of the government's acquisition strategy, preparation of a request for proposal, the conduct of source selection, and the kickoff of the two contracts for the program-definition and risk-reduction phase.

GPS The GPS constellation is fully operational. The system provides precise navigation and timing services with accuracies two- to three-times better than the current requirements. Aerospace continually monitors the health of each satellite and identifies the most beneficial position in the constellation for each new launch based on the projected next failure, using a launch strategy referred to as "launch on anticipated need."

AN AEROSPACE ENGINEER WORKS WITH A MANUFACTURER TO INSPECT THE AFT SECTION OF A TITAN II ROCKET'S FIRST STAGE. AEROSPACE PROVIDES OBJECTIVE TECHNICAL ANALYSES AND ASSESSMENTS FOR NATIONAL-SECURITY SPACE PROGRAMS AND OTHER SPACE PROGRAMS IN THE NATIONAL INTEREST.



CONTRIBUTIONS BY AEROSPACE ENGINEERS AND ATMOSPHERIC SCIENTISTS WERE CENTRAL TO ACHIEVING GREATLY IMPROVED WEATHER FORECASTING CAPABILITIES TO SUPPORT MILITARY AIR OPERATIONS OVER YUGOSLAVIA. BEFORE-AND-AFTER IMAGES BASED ON DATA FROM DMSP SATELLITES REFLECT THE IMPROVEMENT.

GPS modernization decisions are pending, which will define a major upgrade to navigation and timing services for both military and civil GPS users. The technical and programmatic issues leading to these decisions are extremely complex and costly. New GPS services will bring the current three signals on two frequencies to as many as ten signals on three frequencies. Aerospace activities were dominated this year by participation in the many teams defining the technical approach and evaluating the options and risks.

DMSP The Defense Meteorological Satellite Program (DMSP) continues to provide timely worldwide meteorological and ionospheric data to military users and the civilian community. The current constellation consists of two primary operational and three partially operational satellites.

Aerospace provided critical support to U.S. air operations during the Balkans conflict, in which thousands of tactical missions were conducted in support of U.S. policy. Because of poor weather conditions in the Balkans, the military relied heavily on DMSP satellite data and Air Force Weather Agency small-area forecasts. Aerospace developed algorithms analyzing DMSP satellite imagery to produce cloud analysis and forecasts at a resolution of 5 kilometers, or 3.1 miles—a vast improvement over the previously available resolution of 50 kilometers, or 31 miles. A prototype system was developed and made available in 60 days for use in the Balkans. The system proved to be robust, timely and extremely valuable for theater operations.

NPOESS The National Polar-Orbiting Operational Environmental Satellite System (NPOESS) combines the civil and military polar weather satellite programs POES and DMSP into a single program. The initial phase of the NPOESS program is focused on critical sensor development. We provided technical support for nine complex sensor contracts during the year, participating in all major program milestones. We were also heavily involved in the planning and implementation of the NPOESS Preparatory Program, a joint program between NASA and the integrated program office that will fly some of the NPOESS instruments and provide a follow-on science capability to NASA's Earth Observing System program.

We also supported activities for the early convergence of many ground operations of DMSP and POES to active control by the National Oceanic and Atmospheric Administration (NOAA), particularly with regard to new ground stations and frequency allocation for the NPOESS satellites.

Milstar Milstar satellites F-1 and F-2 continue to function on orbit in a multisatellite mode of operation connected by a communications crosslink. Satellite F-3, launched in April 1999, was lost due to a launch vehicle failure. We supported government studies to evaluate alternative concepts for replacing the F-3 medium-data-rate payload capability and also supported the integration and test of satellites F-4 and F-5. Aerospace resources have been applied to the Milstar program's high-risk areas, such as a crosslink and nuller jitter problem, root-cause determination of numerous electronic parts problems, operational risk-management planning for potential relay transfer during launch, and system performance. We also performed a comprehensive life-cycle cost analysis for the Program Executive Officer for Space of the Automated Communication Management System and an alternative prototype system.

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DSCS The Defense Satellite Communications System (DSCS) has five primary satellites and five reserve satellites on orbit. Aerospace has a major role in the mission assurance of the DSCS nickel cadmium flight batteries, which were transferred from the original supplier to a new

THE AEROSPACE CORPORATION CONTINUED ITS INVOLVEMENT IN THE MILSTAR PROGRAM THIS YEAR WITH EMPHASIS ON THE PROGRAM'S HIGH-RISK AREAS. AEROSPACE SUPPORTED GOVERNMENT STUDIES TO EVALUATE ALTERNATIVE CONCEPTS FOR REPLACING THE MEDIUM-DATA-RATE PAYLOAD CAPABILITY FOR SATELLITE F-3.

contractor for activation. Our support was critical to understanding the initial activation results on new test equipment. This testing, which could not be performed by the contractor and was carried out at Aerospace facilities, supported a decision to switch batteries for the upcoming launch of satellite B8. We also tested segments of the new flight software code for B8 and developed, delivered and integrated an engineering telemetry analysis workstation to support the new Space Command Launch and Early Orbit Control facility at Schriever Air Force Base in Colorado.

Aerospace failure-analysis laboratories also played a central role in the systems-level environmental and functional testing for satellite B8. Our Fein Focus X-ray facility confirmed several suspect harness connectors as the root cause of intermittent operation of critical cryptographic equipment during thermal vacuum testing.

MILSATCOM Advanced Programs We continue to be heavily involved in implementing the transition architecture for the Military Satellite Communications system (MILSATCOM). This includes the Advanced Extremely High Frequency program (AEHF), which will succeed Milstar, and the Wideband Gapfiller program to augment the DSCS and GBS (Global Broadcast System) programs until the future Wideband system becomes defined. We provided the system program office with technical assistance in source selection for the system-definition phase of AEHF as well as the planning and approval process to initiate the Wideband Gapfiller program.

AFSATCOM Air Force Satellite Communications (AFSATCOM) payloads are hosted by other communications satellites, a national system for polar coverage, and the DSCS III satellites for midlatitude coverage. Package D and the older Satellite Data Systems ultrahigh frequency (UHF) payloads provide 24-hour coverage of the polar regions. These payloads augment FLTSATCOM coverage at equatorial latitudes and provide polar UHF coverage to support the Single Integrated Operational Plan. Aerospace supported preparations for transition of operations on polar packages from UHF to EHF.

UHFFO and Advanced Narrowband System Aerospace assists the Navy in its acquisition of UHF Follow-on (UHFFO) communications satellites and in planning for the next-generation Advanced Narrowband System. These systems provide communications to mobile military users worldwide. This past year UHFFO Flight 10 was delivered to the Cape in preparation for launch. Flight 10 carries UHF and EHF payloads as well as the third GBS payload. We assisted the Navy in developing the request for proposal and also in the proposal review for UHFFO Flight 11. In support of planning efforts for the Advanced Narrowband System, we assisted in preparing the concept exploration request-for-proposal materials and were assigned the role of study director for the Advanced Narrowband Analysis of Alternatives plan. Aerospace was responsible for developing and coordinating the plan's approval.

GBS The Global Broadcast System had made significant progress toward achieving an initial operating capability by the end of fiscal year 1999. The second of three GBS transponder platforms was successfully carried into orbit aboard UHFFO Flight 9. Aerospace played a key role in the conduct of site surveys, construction, and activation of the ground injection sites at Wahiawa, Hawaii, and Norfolk, Virginia. We were also on site in the Pacific theater and aboard two Navy vessels for the installation and checkout of receive suites. We were instrumental in coordinating and monitoring the acceptance testing of preproduction units, utilizing an Aerospace-developed procedure for the establishment of clear entry and exit criteria for each test event. Preparations for construction of the third and final ground injection site at Sigonella, Italy, were completed with our support, and development of the receive-suite upgrades to full threshold compliance was initiated.

Defense Information Systems Agency Aerospace continued to support the Defense Information Systems Agency (DISA) in MILSATCOM systems architecture and in the integration of satellite communications with the terrestrial elements of the Defense Information Systems Network. We acted as the deputy program manager for DISA's Nuclear Communications, Command and Control (C3) Enhancement Program, engineering the transition of high-priority nuclear C3 networks from DSCS III to Milstar. We also provided critical technical analysis in support of the Elective Star activity to determine the operational effect of the loss of Milstar satellite F-3.

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Joint Chiefs of Staff Aerospace supported the Joint Chiefs of Staff Satellite Requirements Division in preparation for two meetings of the Global Information

AEROSPACE CONTINUALLY MONITORS THE HEALTH OF EACH SATELLITE IN THE FULLY OPERATIONAL GPS CONSTELLATION AND DEVELOPS RECOMMENDATIONS FOR THE BEST POSITION IN THE CONSTELLATION FOR EACH NEW SATELLITE LAUNCHED.

Aerospace engineers discuss procedures with a contractor in the Solid Rocket Motor Processing Facility at Vandenberg Air Force Base. Behind them is the aft segment of a solid rocket motor upgrade planned for flight on a Titan IVB in 2000.

Grid Senior Steering Group, a three-star-level forum that provides oversight of all current and planned Defense Department communications activities. Aerospace worked with the Satellite Requirements Division and with DISA on several cooperative international activities, including the U.S. response to NATO's solicitation for post-2000 satellite communications services; a presentation on the results of an analytical comparison of SHF and EHF satellite communications jamming performance for the NATO C3 Agency; and the U.S. position on EHF communications for bilateral meetings with France.

Space Test and Experimentation Aerospace has played a critical role in the design, test and integration of the Advanced Research and Global Observation Satellite since program inception. ARGOS was successfully launched February 23 aboard a Delta II rocket. Our ARGOS team provided on-console support during the two-week checkout of the satellite on orbit and assisted when several minor anomalies occurred. We also supported the Research, Development, Test, and Evaluation Support Center at Kirtland Air Force Base, which provides telemetry, tracking and commanding operations for the ARGOS mission.

MightySat Small Satellite Program Aerospace provided broad systems-engineering support to the MightySat program, an Air Force Research Laboratory initiative for emerging space system technologies. For the MightySat I mission we supported final prelaunch testing, launch integration onto the space shuttle Endeavour, and satellite operations during the first months of the mission. Aerospace participation was also critical to ground station anomaly resolution and the interpretation of experiment data from MightySat I.

Members of the Communication Systems Subdivision conduct applied research in the area of high-data-rate communications.

SATELLITE AND LAUNCH CONTROL SYSTEMS

Air Force Satellite Control Network The Air Force Satellite Control Network (AFSCN) system of remote ground stations provides satellite control for most U.S. national security satellites. Faced with numerous studies and sometimes-conflicting guidance about the system's future direction, the Air Force tasked Aerospace to develop a revised evolution strategy addressing current goals and constraints. Our study defined a target architecture for 2007 that could provide interoperable, assured, and cost-effective command and data connectivity between mission controllers and their space vehicles. A comprehensive transition strategy was developed, and protocols, standards, and new security schemes to improve interoperability between AFSCN and other satellite control networks were addressed.

MILSATCOM Integrated Satellite Control System Aerospace played a key role in defining the MILSATCOM Integrated Satellite Control System, which will replace the Satellite Command and Control System and provide an integrated control system for all MILSATCOM legacy and advanced satellites. Aerospace has been the focal point for identifying the urgent need for the system and for identifying an innovative acquisition approach.

Range Safety The Air Force Space and Missile Systems Center has been tasked to modernize range-safety metric tracking by migrating from ground-based radars to GPS receivers aboard launch vehicles by fiscal 2003. This modernization is expected to result in life-cycle cost savings of $150 million to $300 million. Aerospace conducted a comprehensive systems analysis of the use of GPS for metric tracking and firmly established the GPS performance baseline. Our analysis also compared current capabilities of the metric tracking radars to the potential capability of several GPS metric-tracking implementation options. Our study results indicated that although neither the most precise GPS implementation nor existing radars would achieve the accuracy requirements stated in the current range Operational Requirements Document, the performance of the GPS system would be a major improvement over that obtained by the existing radar systems. Furthermore, that performance would more than adequately satisfy overall range-safety needs. As a result of our work, the Operational Requirements Document and the system specification for the spacelift ranges were modified to reflect achievable requirements.

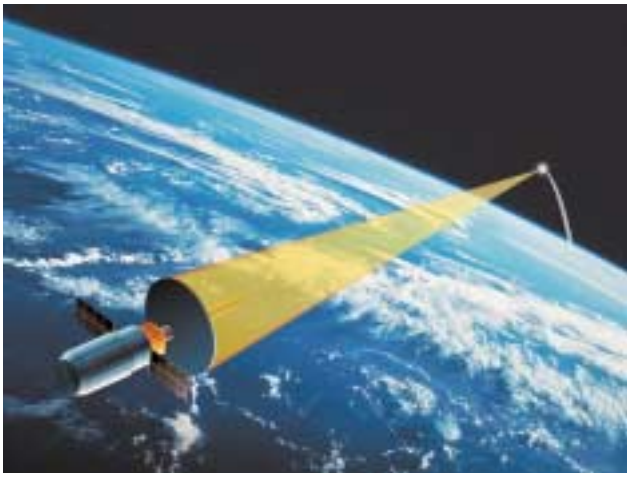
SYSTEMS ARCHITECTURE AND ENGINEERING

System Safety Range safety and the role of EWR 127-1, "Eastern and Western Standard on Range Safety," was a topic of inquiry for a committee chartered by the National Academy of Sciences. In response to the formation of the committee and other safety-related activities, an independent Aerospace team performed a fundamental requirements assessment of the standard. The status and findings were presented at all three of the academy's public meetings on range safety. A final product and recommendations on future concept of operations were delivered to SMC, Air Force Space Command, and the National Academy of Sciences.

Operational Safety, Suitability and Effectiveness Air Force Materiel Command, in response to system failures within the airplane and space segments, has initiated accountability directives for operational safety, suitability and effectiveness (OSS&E) with the appropriate center commander. The accountability, responsibility and authority for operation of Air Force space systems now reside with the SMC commander. SMC is the space product lead for the implementation of Air Force policy directives and Air Force instructions addressing OSS&E. Aerospace assisted in the definition and development of the SMC instruction for OSS&E implementation. An Air Force policy directive for spaceflight worthiness certification supplements the core OSS&E instruction. A formal flight readiness review process will be chaired by the SMC commander's office to ensure that all systems and equipment meet the required performance and safety requirements, are certified as having met those requirements, and that the certification is preserved throughout the system or product life cycle.

Center for Orbital and Reentry Debris Studies Aerospace, through its Center for Orbital and Reentry Debris Studies, provided critical support to NASA's analysis of the reentry breakup of the Ariane 503 core stage, using sophisticated tools to combine data from multiple sensors to reconstruct the reentry breakup trajectory. We also completed analysis of recovered debris from a Delta second-stage reentry. Analysis of the 550-pound fuel tank recovered in Texas showed that aluminum from the stage's structure alloyed with stainless steel during reentry, establishing the maximum temperature reached by the tank. We presented these results at the International Astronautical Federation congress in October. Our efforts may change the way reentry breakup is modeled.

Aerospace hosted the 1999 Leonid Meteoroid Storm and Satellite Threat Conference with the American Institute of Aeronautics and Astronautics in May. The event drew more than 100 representatives of the satellite operations community. Highlights included the prediction of 1999 Leonid storm levels as well as a discussion by satellite operators of precautions being planned to minimize damage to spacecraft. We also sponsored a near-real-time Web site to post worldwide observational data on the peak times and duration of the storm.



TEAM SBL IFX

AEROSPACE PLAYED A KEY ROLE IN HELPING THE AIR FORCE PLAN THE DEVELOPMENT OF THE SPACE-BASED LASER INTEGRATED FLIGHT EXPERIMENT TO DEMONSTRATE THE CAPABILITY TO DESTROY A THRUSTING BALLISTIC-MISSILE TARGET.

Our Space Operations Support Office in Colorado Springs focuses Aerospace support to government, commercial, and international spacecraft operators. We provided assistance on recording and resolving spacecraft anomalies, effects of space weather on satellite systems, and satellite situational awareness, or close-approach warnings. We also provided collision-avoidance services to commercial satellite operators responsible for nearly 100 satellites. This service is considered a pilot for the type of service that will be required in the future.

Space-Based Laser The Space and Missile Systems Center is executing SBL, the Space-Based Laser program, for the Ballistic Missile Defense Organization and the Air Force. Aerospace supported SMC and played a key role in helping the Air Force plan the development of the SBL Integrated Flight Experiment. The goals of the program are to put a high-energy laser in space and to demonstrate the capability to destroy a thrusting ballistic-missile target. At the request of the Air Force we established a senior review panel to review contractor concept-definition studies for the experiment and recommended a course of action consistent with successful space system acquisition experiences. The review included an assessment of each contractor's risks and risk-mitigation plans associated with the designing, building, integrating and testing of the experiment. The results of our review were briefed to an independent review team chaired by retired Gen. Larry Welch, former Air Force Chief of Staff. The independent review team's recommendations helped bring about government consensus on content of the SBL Integrated Flight Experiment program and the establishment of a joint-venture contractor team consisting of Boeing, Lockheed Martin and TRW.

Project West Wing Aerospace Project West Wing continued to provide national-security space customers with technical intelligence counsel on a broad range of topics associated with international space systems, international space technology, and foreign ballistic missiles. We provided key technical support to the intelligence community's assessments of foreign missile systems and applied our insights into the development of the SBIRS High and Low programs. For advanced planning and policy customers, we made projections of future commercial and international space communications systems as well as markets and space remote-sensing systems. The latter efforts were used extensively by the government to assess and modify national space-based remote-sensing licensing policies.

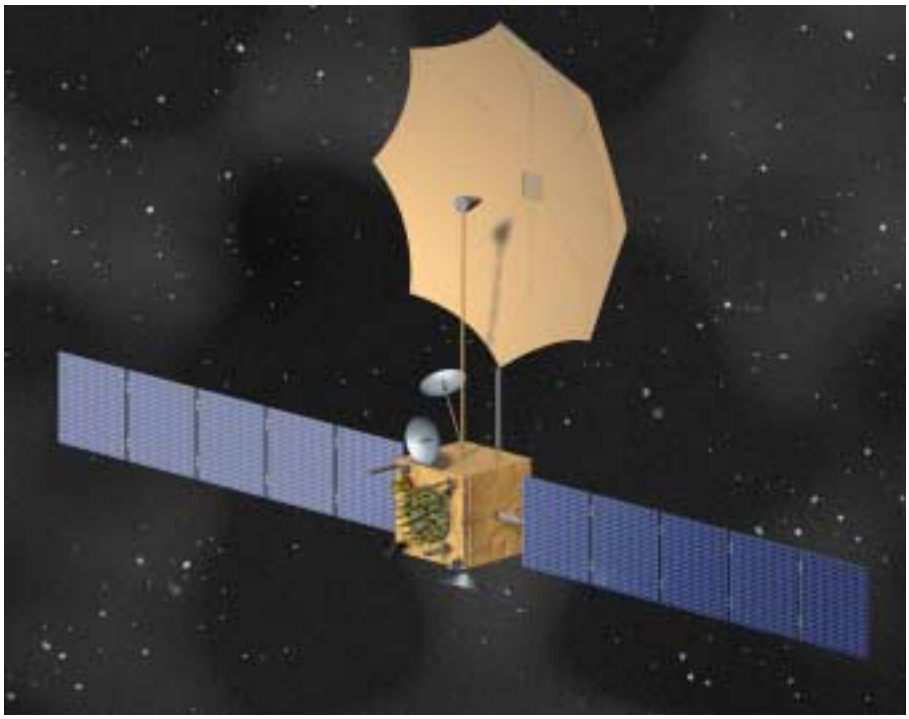
Developmental Planning We continued to refine our concept for maximizing opportunities in the area of multimission space platforms in conjunction with the upcoming modernization of the GPS

program. The Global Multi-Mission Service Platform (GMSP) would fly synergistic payloads that benefit from GPS medium Earth orbit and common bus attributes. We used our Concept Design Center extensively to develop the GMSP concept and to evaluate candidate payloads.

In pursuit of potential concepts for the reduction of certain space operations, we were extensively involved in the Air Force Commercial Space Opportunities Study, which examined opportunities for offloading routine space operations tasks to the commercial sector, thereby freeing-up scarce Air Force resources. We also provided the central technical assistance for the Air Force Joint Expeditionary Force Experiment in the summer of 1999, highlighted by the flight of an Aerospace airborne hyperspectral imager, and for the assessment of the military utility of the SMV reusable spacecraft bus.

National Security Space Architect The office of the National Security Space Architect (NSSA) is responsible for developing, coordinating and integrating the Defense Department's and the intelligence community's mid- and long-term space system architectures to address validated requirements and to account for technology opportunities. We supported NSSA in the transition planning of the Weather and Satellite Operations architectures, in developing the terms of reference for Department of Defense commercial satellite communications strategy, and in the planning for a national-security integrated roadmap for space.

We also provided critical systems-engineering support to NSSA's first architecture effort, a comprehensive examination of national-security mission information management. Aerospace assessed key activities ongoing within the Department of Defense and the intelligence community, identified critical issues and deficiencies, and provided technical oversight of NSSA's 1999 Mission Information Management Report. As part of the mission information management effort, we provided communications expertise for the development of a plan for the National Imagery and Mapping Agency, delivered to Congress June 1.



AEROSPACE DEVELOPED THE CONCEPT FOR THE GLOBAL MULTI-MISSION SERVICE PLATFORM AND EVALUATED CANDIDATE PAYLOADS.

Protection Special-Interest Group Aerospace chairs the Protection Special-Interest Group, an element of an architectural council established by the Air Force Space and Missile Systems Center and Electronic Systems Center, Aerospace, and The MITRE Corporation. The goals of the group are to foster a broader community understanding of the defensive aspects of the space-control mission and to facilitate a common vocabulary for protection of space operations. The group has conducted cooperative reviews of protection requirements and shared findings of vulnerability and threat assessments for ground sites and links. The group addressed concerns of interest within the community and provided comments to the Space Policy Directorate within the office of the Deputy Assistant Secretary of Defense.

Office of the Assistant Secretary of Defense Aerospace supported the Office of the Assistant Secretary of Defense for Command, Control, Communications and Intelligence in its oversight role for national security space programs. Our efforts included plans for the use of commercial communication satellites to support Defense Department missions; analysis of acquisition options for SBIRS High and SBIRS Low; evaluation of space control technology and programs; and assistance in preparing the Intelligence, Surveillance, Reconnaissance Integrated Capstone Strategic Plan. We also assisted in the formation of policy regarding protection, remote sensing, and international defense space cooperation.

Air and Space Integration Our efforts were critical in helping Air Force Space Command demonstrate the benefits of integrating air and space systems in an operational environment. Three efforts are particularly noteworthy.

An interstage skirt, which joins the first and second stages of a Titan II booster, undergoes inspection. Aerospace works closely with contractors throughout the launch process to provide independent assessments for the U.S. Air Force, the National Reconnaissance Office, and other customers.

An Aerospace engineering team designs a space system in real time using networked computers in the Concept Design Center.

We provided technical leadership for the Nordic Thrust Moving Target Indicator enhancement demonstration, which involved live flights of air-breathing aircraft and the orchestrated movement of high-fidelity ground targets. The demonstration validated the military utility of using event correlation and fusion techniques of sensor data in an airborne command-and-control environment to achieve improved discrimination for moving-target indicators. Aerospace provided the systems engineering that successfully integrated a variety of ground- and space-based sensors into a "network-centric" environment and also contributed to the development of the demonstration scenario, which involved air, space and ground assets.

We conducted an end-to-end system-level analysis of a Ku-band video-broadcast link to special-operations aircraft using a commercially available phased-array antenna. We also developed the system-level analytical methods for modeling and assessing the capability of the communications architecture to support other Air Force Special Operations Command mission requirements. The analysis addressed fundamental questions of overall viability and anticipated performance in operational environments. Our effort supports the development of a concept of operations that responds to the Special Operations Command's Joint Operational Requirements Document and Joint Mission Need Statement.

Aerospace supported Operation Noble Anvil and Operation Allied Force during a recent combat aircraft deployment to the British Royal Air Force Station in Fairford, England. For the first time, real-time situational awareness systems were installed aboard two bomber platforms, B-52s and B-1Bs, for use in combat. The systems provided the aircraft crew with threat intelligence data, secure e-mail, image transmission and preflight rehearsal tools. It was notably the first demonstration of real-time target execution of bomber aircraft after deployment. We provided on-site systems engineering and integration oversight, aircrew training support and technical troubleshooting. In support of overall operations, we employed a solution that restored a previously unusable AFSATCOM channel, rendering it operational for the allied bombing effort. This effort provided a force multiplier for the UHF AFSATCOM channels in theater.

NATIONAL RECONNAISSANCE OFFICE

Planning and Communications Aerospace was vital not only to the development of new communications systems concepts but also to the development, test and launch preparation of current NRO communication programs. As consumer demands for high-data-rate intelligence products increase, the NRO has launched new initiatives in terrestrial and spaceborne communications to meet those demands. We played key roles in the development of architectures and technologies to facilitate these new capabilities.

Chief Systems Engineer The NRO director recently appointed the first chief systems engineer responsible for developing a consistent set of engineering practices across the organization's fleet of satellite systems. Aerospace has been intimately involved with this new functional area, coordinating this activity with the architecture development efforts of the Office of Assessments, Acquisition, and Architectures.

International and Commercial Programs Aerospace led the NRO's exploration and development of international and commercial partnerships. We played a key role in negotiating a formal agreement between the United States and an important ally on a major new reconnaissance system. We also supported remote-sensing cooperation between the U.S. government and foreign nations by assisting in negotiations, assessing foreign technology, evaluating architectural options, and assessing the policy implications of the transfer of sensitive technologies. We also helped keep U.S. commercial remote-sensing providers and their vendors informed of sensitivities associated with international cooperation and commercial ventures.

President Pete Aldridge, right, welcomes Lt. Gen. Eugene Tattini, Space and Missile Systems Center commander, and Dr. Lawrence Delaney, assistant secretary of the Air Force for acquisition, during a visit to Aerospace for discussions on the nation's defense space programs.

Advanced Systems and Technology Aerospace helps develop and field low-cost satellites used to demonstrate and evaluate key overhead intelligence system performance technologies in a "faster, better, cheaper" acquisition environment. We provided technical and programmatic assistance on a number of technology developments to enable significant new mission capabilities in future NRO programs.

Future Imagery Architecture Aerospace played a leading role in activities supporting the source selection for the Future Imagery Architecture program. This program will completely restructure U.S. satellite imagery capabilities by including new design imaging satellites as well as new processing, exploitation and dissemination capabilities.

SIGINT Space and Ground Systems Aerospace supports the design, fabrication, integration, test, launch and operation of signals intelligence (SIGINT) systems. In 1999 we helped develop phase 2 of the Integrated Overhead SIGINT Architecture, which will determine the future of signals intelligence, and provided significant efforts in the integration and test activities of a major new spacecraft program. We also assisted the National Security Agency in developing new capabilities for the processing and exploitation of mission data.

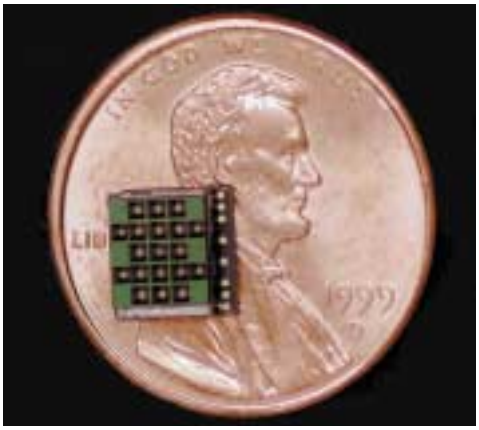
ENGINEERING AND TECHNOLOGY DEVELOPMENT

Concept Design Center Our Concept Design Center offers a collaborative engineering approach for the conceptual design of space systems. Six teams, focused in the areas of payloads, spacecraft, ground systems, and architectures, assisted SMC, NRO and NASA programs through a variety of activities: developing requirements, conducting cost and performance trades, performing source selections, establishing the feasibility of advanced concepts, and examining the effect of new technologies. We transferred the Concept Design Center's technology to other institutions this year, including the Jet Propulsion Laboratory (JPL) and various commercial firms.

Spacecraft Replenishment Planning Software For nearly 30 years our Generalized Availability Program (GAP) has been the industry standard simulation tool for planning satellite launch schedules and replenishment budgets. We invested in redesigning the mainframe GAP code for Windows PC platforms (WinGAP) to provide an integral database of satellite reliabilities, a graphical user interface and Excel output plots. The new WinGAP program provides a single, easy-to-use tool capable of supporting SMC and Space Command constellation availability studies as well as NRO individual-payload availability studies.

Integrated Multimission Analysis Aerospace developed a new analytical tool to assess the ability of the launch and payload-processing infrastructure to meet future government requirements. The tool incorporates a simulation of launch processing, payload processing, and on-orbit satellite availability. We analyzed Department of Defense, NRO, civil, and commercial mission manifests over the next 11 years using simulations that included Atlas, Delta, Titan, and EELV medium- and heavy-lift vehicles. Results of our preliminary analysis show that significant delays of up to three years in the mission manifest can occur due to stand-down time, resource limitations, and variability in EELV processing timelines. The analysis demonstrated the value of long-range mission planning, replanning and prioritization once EELV begins operations.

Microtechnology Research and Development Our Center for Microtechnology achieved two major milestones this year. In April we launched the center's 2,000-square-foot, Class 10,000 clean-room facility for laser micromachining. The centerpiece of this laboratory is a one-of-a-kind direct-write laser machining facility for microstructure fabrication in silicon, ceramics, metals, polymers, diamond, and even specially engineered materials. Our unique laser-processing capabilities advance and complement traditional semiconductor fabrication techniques for microdevices, enabling development and rapid



This tiny chip, included in a shuttle experiment and shown against a penny, contains 19 microthrusters, each of which acts like a rocket engine. Designed and built in an Aerospace lab, the thrusters could be used to orient a nanosatellite.

prototyping of new devices for space system application. In July our Microtechnology Testbed flew successfully aboard the shuttle Columbia, carrying three experiments in the first systematic testing of MEMS (microelectromechanical systems) devices during launch and spaceflight.

Microthruster Test and Evaluation Propulsion is an enabling technology for the deployment and operation of constellations of nanosatellites. Micropropulsion development requires new capabilities for thruster test and evaluation. A "microthruststand" requires the accurate measurement of impulses about one-thousandth of even the smallest conventional satellite thrusters. Aerospace scientists constructed a system that advanced the state of the art by more than a factor of 100 in thrust sensitivity. Our absolute calibration system has enabled us to test thruster design and propellant chemistry with great accuracy and to characterize the performance of solid-propellant microthruster arrays for planned rocket tests.

Picosatellites In an effort sponsored by the Defense Advanced Research Projects Agency, Aerospace scientists and engineers have collaborated with Rockwell Science Center and Stanford University to develop miniature low-cost space platforms to validate microsystems for space applications and advance the development of mass-producible, fully functional nanosatellites. Aerospace supported preflight activities for an experiment involving two tiny satellites—each 1-by-3-by-4 inches and weighing less than half a pound—to be deployed from Stanford University's OPAL satellite after launch by the new Air Force Orbital Suborbital Program Space Launch Vehicle. The picosats are tethered to emulate formation-flying within the range of low-power radios. A picosat mounted on a 50-meter ground antenna forms the third element of a rudimentary constellation. MEMS radio-frequency switch arrays are also to be tested on this mission. The tether has built-in radar targets to aid in acquisition and tracking.

We also provided broad systems engineering support for tracking and communications with the picosats from the large 50-meter dish operated by SRI International in Palo Alto, California. We led the development of spiral search algorithms, which model potential dispersions, to enable tracking at the SRI dish. The spiral search algorithms help facilitate acquisition and track maintenance even if radar tracking by the Space Surveillance Network is unable to acquire the vehicle.

Space Assets for Environmental Monitoring Aerospace scientists and engineers have developed and are using a multisatellite ground station at our El Segundo facilities, the A8 Research Center, to study the use of Defense Department surveillance satellites for environmental monitoring, such as the

detection of volcanic eruptions and explosions of meteors in the atmosphere. We are helping to build and test the Hazard Support System, a U.S. Geological Survey project implementing the use of military satellites for worldwide fire and volcano detection. The December 1998 eruption of the Mexican volcano Popocatapétl provided an opportunity to study multiple, moderate-sized eruptions. Satellite data show that even small-to-moderate volcanic eruptions can be unambiguously detected within a minute of occurrence. Operational use of military satellite data by the Hazard Support System will produce significant improvement over current global volcano monitoring, with application for scientific, civil defense, and aviation safety purposes.

Hyperspectral Imaging SEBASS, our Spatially Enhanced Broadband Array Spectrograph System, was deployed in the Joint Expeditionary Force Experiment this summer to demonstrate the utility of hyperspectral imaging systems in the complex environment of simulated battle conditions involving weapons of mass destruction. SEBASS and other hyperspectral imaging instruments were applied to the detection of concealed, camouflaged, or deceptive targets; warning of chemical weapons attack; friend-or-foe identification; and detection of land mines. Another Aerospace-developed instrument, the Overhead Remote Chemical Analyzer, or ORCA sensor, collected hyperspectral images of the cloud released in the Defense Threat Reduction Agency's Dipole Jewel exercise, in which a laser-guided weapon destroyed a storage facility containing a chemical-warfare-agent simulant. Post-test data analysis yielded the quantity of simulant in the cloud and the cloud's extent and location.

Remote Sensing Laboratory The Remote Sensing Laboratory supports activities in polarimetric and spectral-imaging remote sensing. Projects in 1999 involved the characterization of polarimetric signatures of the environment and various military assets, the design of new polarimetric imaging instruments, and the development of exploitation software. Results support the development of applications for camouflage detection, a novel polarimetric tagging method, and battlefield preparation, identification, and targeting.

A MEMBER OF THE TECHNICAL STAFF TESTS MEMS DEVICES, MICROELECTROMECHANICAL SYSTEMS, AT A COMPUTER-CONTROLLED PROBING STATION. THE AEROSPACE CORPORATION IS A LEADER IN MEMS TECHNOLOGY.

PICASSO A team of Aerospace engineers has developed a new software tool that models design factors significantly affecting image quality. Our Parameterized Image Chain Analysis and Simulation Software (PICASSO) provides image analysts with simulated images whose quality they can visually assess. PICASSO can be used to analyze national, military, civilian, and commercial imaging systems, providing customers with the means to make informed, "fly-before-you-buy" decisions regarding the performance of their systems.

CIVIL AND COMMERCIAL ACTIVITIES

NASA We consolidated much of our NASA work this year by establishing the NASA Programs Office at Johnson Space Center. Aerospace supports the National Aeronautics and Space Administration across a broad range of space science and technology areas.

We were commended by NASA this past year for our contributions to the International Space Station and X-38 Crew Return Vehicle, the Space Transportation Architecture Study, and NASA's Office of Space Science. Our assessment of the X-38 Crew Return Vehicle expanded NASA's systems engineering approach to rapid prototyping. Contributions to the Space Transportation Architecture Study support NASA's long-term launch vehicle investment program, while endeavors for the Office of Space Science provide technical selection criteria for technical risk reduction.

Data from the first flight of our Microtechnology Testbed aboard the shuttle Columbia in July contributed significantly to the advancement of essential new technologies in MEMS. These sensors operate with less power, volume and mass at lower cost and provide critical insight into spacecraft performance not possible with larger systems.

Aerospace evaluated contractor solutions in support of NASA's independent assessment efforts for the Space Transportation Architecture Study. Our evaluations included identification of vehicle system and subsystem technology readiness; commercial viability in light of Aerospace cost estimates; government policy options and commercial price-per-flight projections; and potential savings, considering NASA technology and development costs plus possible NASA contributions to making the commercial business cases viable. We supported a presentation of the study's results to the NASA Advisory Council in August.

We supported JPL in a variety of interplanetary mission design and analysis efforts. We performed technical assessments for the NASA Discovery program office; concurrent engineering for JPL's Project Design Center; Mars communications and navigation constellation planning; applications to mission visualization, requirements and systems analysis for the Mars Sample Return mission; and launch planning for missions to outer planets.

NASA

Aerospace is performing independent assessment of the International Space Station for the National Aeronautics and Space Administration. We are also contributing to NASA's X-38 Crew Return Vehicle, Space Transportation Architecture Study, and Office of Space Science.

NOAA Aerospace technical support to the National Oceanic and Atmospheric Administration's Advanced Weather Interactive Processing System (AWIPS) program this past year included the conduct of operational testing and evaluation, systems security, and antenna de-icing. We shared in the celebration July 1 as AWIPS successfully completed operational testing and evaluation within the schedule and budget mandated by Congress.

We performed an independent assessment of the Safe Hold Mode design for the Geostationary Operational Environment Satellite (GOES) N-Q spacecraft. The major objective was to provide a technical basis for selection between the baseline design and an alternative design. We determined that the baseline design met all operational requirements, while the alternative design offered only marginal overall performance advantages and introduced additional technical and programmatic risks. Our recommendation to retain the baseline design was accepted by NOAA.

United States Geological Survey Aerospace supports the U.S. Geological Survey in its responsibilities for the Landsat 7 Earth remote-sensing spacecraft program. Our recommendation this year to shift the orbit of Landsat 7 will allow a constant sampling period between two key missions. We also supported payload-processing ground-system test and evaluation.

Law Enforcement The National Law Enforcement and Corrections Technology Center–Western Region, sponsored by the U.S. Department of Justice and operated by Aerospace, supported investigations in more than 200 felony cases this year, many of which were successfully prosecuted. The center also led in the design and procurement of a data delivery system for patrol vehicles and supported other advanced communication system designs for several agencies. We received a special commendation from the Los Angeles Police Department for our efforts on a major investigation this year.

Hughes Space and Communications Company Aerospace performs a broad range of engineering consulting services for Hughes Space and Communications Company's commercial space programs. This past year we performed critical infrared thermography analysis of solar cells and solar panels, allowing identification and correction of solar-cell bonding problems to be made before solar panels were installed on a satellite. The results of our efforts were lauded by Hughes for their significant contribution to the company's commercial satellite programs.

Motorola This year we provided systems engineering expertise for the Teledesic satellite telecommunications program as well as operational support for the Iridium satellite constellation. We assisted in the areas of optical intersatellite link specification, constellation analysis, attitude determination and control simulation, power technology assessment, and electric propulsion performance. We also performed independent cost and risk reviews of system designs and ground user equipment. With the cooperation of our U.S. government customers, we supported Iridium with biweekly forecasts of collision risk. This service provides a basis for orbital operations to avoid potential collisions with other space objects, establishes statistical projections of collision risk over the next 20 years, and helps determine critical thresholds for probabilistic collision avoidance within normal satellite station-keeping maneuvers.

XM Satellite Radio Aerospace performed general systems engineering services for XM Satellite Radio, which is developing a new band of radio targeted to launch in early 2001. XM will deliver up to 100 channels of digital-quality music, news, sports, talk and children's programming, which will be uplinked to satellites and broadcast directly to vehicles, homes and portable radios. As an initial task we completed a computer analysis comparing the performance of the firm's signals. We developed several visualization aids to represent the XM Satellite Radio system architecture.

Thuraya Satellite Communications Company We provide space-segment consulting services to the Thuraya Satellite Communications Company for its turnkey Mobile Satellite System. During the past year we provided technical support for the program's critical design phase, development and conduct of the systems test program, unit and subsystem acceptance, and verification to close out the program's integration and test phase.

Korea Aerospace Research Institute Aerospace supported the Korea Aerospace Research Institute (KARI) on KOMPSAT, the Korea Multipurpose Satellite program, focusing on payload test and evaluation, spacecraft and launch vehicle integration, launch readiness preparation and launch operations. We worked closely with KARI's U.S. contractors and with NASA, whose AcrimSat satellite is a secondary payload to be launched along with KOMPSAT.

National Space Development Agency of Japan We investigated methods for developing highly reliable software for Japan's National Space Development Agency, NASDA. Our efforts included evaluating software contractors, measuring software quality characteristics, performing independent software reviews, and identifying existing evaluation criteria for software quality and high reliability. We also performed a variety of studies, including a study of flexible space structures, a cost and risk analysis, and a space experiment to measure low-frequency electromagnetic waves radiating from earthquake regions.

Space Communications Corporation, Japan We assisted Japan's Space Communications Corporation by performing a study of the reaction wheel on satellite N-SAT-110, providing failure mode analysis and ground control procedures. We also evaluated N-SAT-110 orbital operations strategies for collision avoidance.

Information-Technology Promotion Agency, Japan To promote indigenously developed trusted systems, the Japanese government plans to provide Japanese industry with methods of evaluation and certification based on internationally accepted common criteria. Aerospace has been supporting the Japanese Information-Technology Promotion Agency on a project to evaluate trusted system products and to develop evaluation methodologies that reduce cost and schedule. We evaluated a certificate-authority server, a digital signature capability, and a production server for the agency's project.

A scientist examines the cross-section of a failed part in the Focused Ion Beam and High Resolution System Microscopy Laboratory. Aerospace conducts such analyses across a broad range of programs for the Department of Defense and other customers.

Recognizing Excellence

Extraordinary Achievements

The Corporate Achievement Awards Program honors employees who demonstrate extraordinary levels of professional excellence. The Trustees' Distinguished Achievement Award is presented in recognition of performance far beyond normal expectations. The President's Achievement Awards recognize outstanding achievements in such fields as science, technology, engineering, analysis, systems engineering, program and business management, and administration. Awardees are selected from nominations submitted by fellow Aerospace employees.

1999 TRUSTEES' DISTINGUISHED ACHIEVEMENT AWARD

Hiroshi Shibata, widely recognized within the imaging satellite community for his knowledge of control-loop design, development, verification and operation, received the company's highest accolades in 1999 for his leadership in returning a failed national imaging satellite to full mission capability. Shibata proposed a complex, corrective workaround and helped convince the government program office that his strategy was attainable, was cost efficient, and would return the satellite to full mission operations. His idea was investigated and validated by a team comprising personnel from Aerospace, the National Reconnaissance Office, the prime contractor and support contractors. The satellite was successfully restored to full operational status. It played a vital role in support of Operation Desert Fox and continues to collect imagery data to satisfy high-priority intelligence requirements.

1999 PRESIDENT'S ACHIEVEMENT AWARDS

Dr. Todd Beltracchi and **Steven Hammes** were recognized for advancing the state of the art in the use of nonimaging, space-based infrared sensor systems for real-time, special event monitoring. They developed a detection and observation capability called the best in the world by U.S. Space Command. Software tools developed by Beltracchi and Hammes have been applied to significant infrared events critical to national security.

Dr. Kasemsan Siri and **Brian Lenertz** were honored for demonstrating technical excellence and leadership in identifying and ensuring the correction of a critical design flaw in the power system of the first Milstar Block 2 satellite. The design error, had it gone undetected, would have resulted in the loss of the $800 million satellite. The solution has now been applied to all four Milstar Block 2 satellites.

David Kim, Yolanda Jacobs and **Dr. Masahiro Sayano** were responsible for the development and application of a revolutionary, special communications technology. The team of engineers developed COBRA, the Collection of Broadcasts from Remote Assets, which has been proven in more than two dozen high-profile, life-and-death operations. The system is the first and only global capability of its kind.

Michael Muha, Dr. Andrew Moulthrop, Dr. Christopher Silva and **Christopher Clark** were instrumental in advancing communications technology for the National Reconnaissance Office. The team designed and developed a sophisticated and flexible laboratory system that is used collaboratively with contractors to evaluate the principal electronic components and subsystems that limit the performance of high-data-rate communications channels. Their efforts have advanced the state of the art in communication systems analysis, measurement and design for a number of programs critical to national security.

Board of Trustees

Knowledge, Experience

The Aerospace board of trustees consists of eminent individuals from the business, scientific, academic, and public-service communities. The board normally meets four times each year: twice at the corporate headquarters and twice at other locations.

The standing committees are Audit and Finance; Compensation and Personnel; Executive; Governance and Nominating; and Technical. An awards subcommittee annually reviews employee nominations and makes recommendations to the board regarding the Trustees' Distinguished Achievement Award. The Technical Committee meets several times each year to review programs and projects that support the technical mission of the corporation and its customers.

The board elects corporate officers and sets policy while supervising and directing the general management of the corporation. All corporate powers are exercised under its authority, as outlined in the Articles of Incorporation and Bylaws. From its inception, the board has established and maintained strict conflict-of-interest standards for its members and for the corporation's officers and employees.

Board members are elected to three-year terms. Reelection is possible, but no member (other than the president of the corporation, who is elected annually by the board and is an ex officio member) may serve more than three consecutive terms.

Dr. Ruth M. Davis
Chair

President, Pymatuning Group, Inc.; former Deputy Under Secretary of Defense and Assistant Secretary of the Department of Energy

Dr. Bradford W. Parkinson
Vice Chair

Professor of Aeronautics and Astronautics, Stanford University; Chair, NASA Advisory Council; former Vice President, Rockwell International

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Dr. Guion S. Bluford, Jr.

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Consultant; former Director, Air National Guard; former Commander, 102nd Flight Wing, Otis Air National Guard Base [Elected 12-99]

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From left, John Parsons, Marlene Dennis, Jon Bryson, Michael Daugherty, Pete Aldridge, Gordon Louttit, Margaret Anderson, Rodney Gibson and Joe Straus

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