Air Force Programs at APL

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The Applied Physics Laboratory is engaged in several diverse projects for the U.S. Air Force. These programs, which are distributed among various Laboratory departments, include Flare Genesis, an Antarctic balloon mission to study the solar magnetic field, and Defense Suppression, a program to test, evaluate, and recommend improvements to the High-Speed Antiradiation Missile. Given the Laboratory's long-standing and fruitful contributions to Air Force technology, such efforts are likely to continue.

INTRODUCTION

As expressed in its Mission Statement, the Applied Physics Laboratory is dedicated "to the development and application of science and technology for the enhancement of the security of the United States of America." In seeking to attain this objective, the Laboratory, during its 53-year history, has become recognized for providing unique solutions to complex and wide-ranging problems. This reputation has attracted various DoD and civilian sponsors. Because of our institutional affiliation with the Navy, APL is often viewed by many as an exclusively Navy facility, but it is regularly engaged in numerous tasks that support other government agencies and branches of the uniformed services. As such, the Air Force has had an extensive history of working with the Laboratory to address topics ranging from research into the interactions of the Earth's magnetic field with the solar wind to the interception of ballistic missiles in space. This article reviews some ongoing programs of particular interest that are partly or fully sponsored by the Air Force and illustrate the wide spectrum of Air Force programs being conducted at APL.

SPACE WEATHER

By one name or another, space weather, and its influence on spacecraft systems, military communications, and high-altitude piloted vehicles, has been of great interest to the Air Force since the dawn of the space age. The discovery in the late 1950s of energetic electrons and ions magnetically trapped in the region of near-Earth space known as the Van Allen radiation belts and the subsequent detection of the solar wind of charged particles emanating radially from the Sun served to highlight the need for further investigation into the space environment. These findings sparked the formation of entire disciplines known today collectively as space science. The search for tools with which to forecast space weather prompted the development of operational instruments to monitor the Sun and near-Earth space. In situ measurements of charged particles, magnetic fields, and ion drift are now made by devices flown on the Air Force's Defense Meteorological Support Program (DMSP) weather satellites. To monitor the response of geospace to solar fluctuations, the Air Force materially participates in the operation of the National Solar Observatory in Sunspot, New Mexico.

The APL Space Department is conducting several programs intended to explore the geospace environment. Two of them, DMSP and Flare Genesis, are directly supported by the Air Force Office of Scientific Research (AFOSR), and a third, the Special Sensor Ultraviolet Spectrographic Imager (SSUSI), an operational ultraviolet instrument for the DMSP satellites, is overseen by the Air Force Space and Missile Systems Center's DMSP program office.

Space Weather from DMSP Charged-Particle Detectors

The Air Force DMSP satellites include sophisticated charged-particle detectors as operational instruments for in situ monitoring of near-Earth space conditions.[1] These detectors measure the energy and flux of ions and electrons in the range from a few electron volts to tens of kilo-electron-volts. Such particles are most often observed in circumpolar regions and are usually associated with auroral optical emissions. The flux, energy, and latitudinal extent of these particles depend on their source in the Earth's distant magnetosphere and on solar-induced geomagnetic conditions. Thus, the DMSP energetic particle detectors provide one of the best and certainly the longest-lasting means of monitoring and predicting space weather and its effect on military systems.

For almost a decade, Patrick Newell of the Space Department's Space Physics Group has pursued work funded by AFOSR. His research has progressed through a logical sequence of steps in an effort to unravel the convoluted data received from the energetic particle detectors aboard the DMSP satellites. The initial focus of his study was to identify the magnetospheric source regions of the charged-particle precipitation detected in the Earth's upper atmosphere. Three principal results of this undertaking have been (1) the publication of a series of scientific papers in the *Journal of Geophysical Research* and *Geophysical Research Letters* that now constitute a standard classification scheme, (2) the development of a sophisticated automated system that identifies these regions by artificial intelligence techniques, and (3) the use of these techniques to produce ionospheric maps reflecting the type of precipitation experienced from space.[2] Figure 1 presents representative products of this space environment research. The figure shows an energy/flux/time spectrogram of ions and electrons detected by a DMSP satellite. The characteristic low-energy signature of the electrons and the dispersion of the ions indicate that these particles originated in the regions of the magnetosphere known as the cusp and the mantle. A map of these regions as they project onto the Earth is shown in Fig. 1b.

SSUSI

In addition to in situ measurements, the DMSP program has an operational need for remote sensing of ionospheric conditions. Scientists from the Space Department, led by Ching-I. Meng and Larry J. Paxton, have demonstrated that remotely sensed spectrographic measurements in the vacuum and far ultraviolet can be

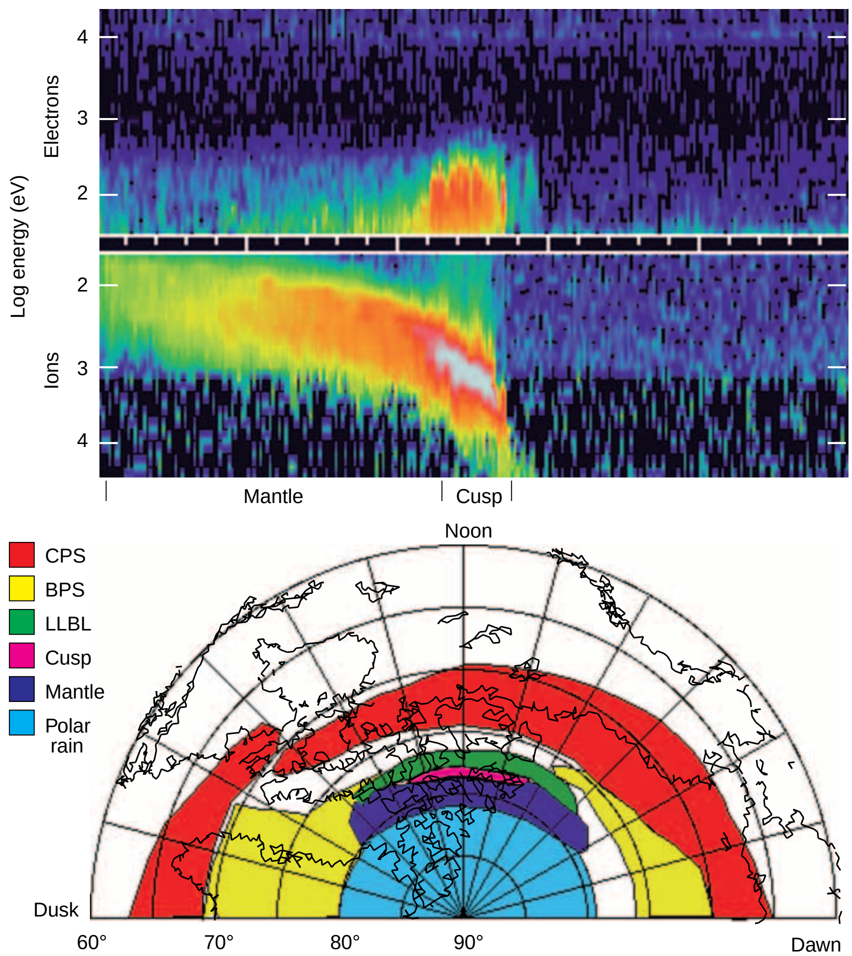

Figure 1. Typical products of AFOSR-sponsored space environment research at APL. (a) An energy/flux/time spectrogram of electrons (top) and ions (bottom) detected by a DMSP satellite. The data show the ionospheric projection of the magnetospheric regions known as the cusp and mantle. (b) The projection of the magnetospheric regions of the central plasma sheet (CPS), boundary plasma sheet (BPS), low-latitude boundary layer (LLBL), cusp, mantle, and polar rain onto a map of the northern polar regions.

used to determine electron and neutral density profiles as well as other atmospheric parameters critical to the understanding of the geospace environment.[3] Consequently, the Space Department has been engaged by the Air Force's DMSP program office to design and develop a new DMSP mission sensor, the SSUSI, which collects an image by scanning a scene while conducting highly resolved spectrographic analyses of each scan line in that scene. This program is under the direction of Glen Fountain, the Space Electronics Systems Branch chief. The SSUSI instrument, shown in Fig. 2, derives from the UVISI (Ultraviolet and Visible Imagers and Spectrographic Imagers) designed for the Ballistic Missile Defense Organization's (BMDO's) MSX spacecraft.[4]

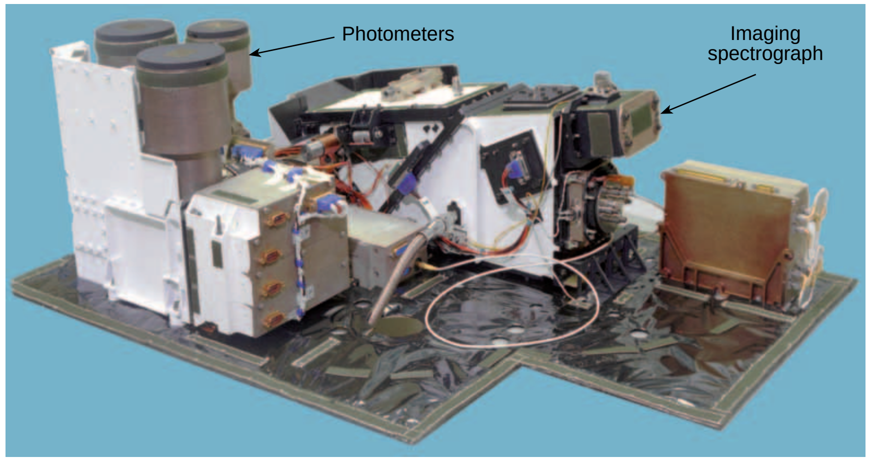

Figure 2. SSUSI protoflight model showing the imaging spectrograph and visible wavelength photometers.

The SSUSI instrument will enhance the Air Weather Service's capability to provide ionospheric forecasts for the Air Force as well as other military and civilian agencies. When functional, SUSSI will generate global ultraviolet line scan images at five wavelength selections in the far ultraviolet from a range of 110 to 180 nm. The instrument hardware consists of a cross-track line scan mirror, an imaging spectrograph with redundant detector packages, visible (blue and red) wavelength photometers, and a support electronics module. This design will allow images to be produced simultaneously at multiple wavelengths. The protoflight model has been completed and was delivered to the spacecraft contractor for the Air Force's DMSP program in the first half of calendar year 1994. Assembly of four flight-mission sensors for follow-on spacecraft is now being completed by APL.

Since the Space Department prides itself on an end-to-end capability, its contribution to SSUSI is not limited to hardware alone. Therefore, in addition to the hardware, the Laboratory is developing, and will update as needed, the algorithms and operational software required by the Air Weather Service to transform the SSUSI data records into meaningful environmental data. The SSUSI program is expected to continue at APL into the next century.

THE FLARE GENESIS PROJECT

Space Department scientists led by David Rust of the Space Physics Group in cooperation with the Air Force's Phillips Laboratory are building a powerful instrument to measure magnetic fields on the Sun. This solar magnetograph is being constructed around a telescope provided by the former Strategic Defense Initiative Organization (SDIO), which is now known as the Ballistic Missile Defense Organization (BMDO). The magnetograph will be operated in the Antarctic stratosphere each December, starting in 1995. It is likely that yearly flights with annual refurbishment and improvements in the experiment will continue until the next peak of the solar cycle in 2000. The goal of the Flare Genesis Project is to learn how to predict flares on the Sun and thereby provide earlier and better space weather forecasts of the environment in which DoD and civilian space assets must operate.[5]

The Flare Genesis telescope has a lightweight 32-in. (80-cm) primary mirror housed in a graphite–epoxy composite for high structural integrity with the lowest weight. Although the entire telescope weighs only 300 lb, it will be the largest ever flown for solar research on a balloon or satellite. A 28-million-ft^3 balloon, lofted to an altitude of 125,000 ft, will provide a platform for the experiment with an unprecedented pointing stability of better than 1 μrad at the focal plane of the telescope. Figure 3 presents an artist's conception of the Flare Genesis balloon and telescope in flight.

This project has proceeded under grants from AFOSR, the National Science Foundation, and NASA. The Laboratory has modified the telescope, tested its electronic camera (a 1535 × 1024 pixel charge-coupled device), and built an onboard computer, pointing mechanisms, and special sensors, including a silicon retina that senses motion at the microradian level. An auxiliary telescope will record the image of the whole Sun and enable the experiment to operate autonomously while it is out of radio contact during its 2–3-week-long flights circumnavigating Antarctica.

David Rust is responsible for the overall management of the project and for setting the scientific goals. Air Force personnel from Phillips Laboratory at the National Solar Observatory and at Kirtland Air Force

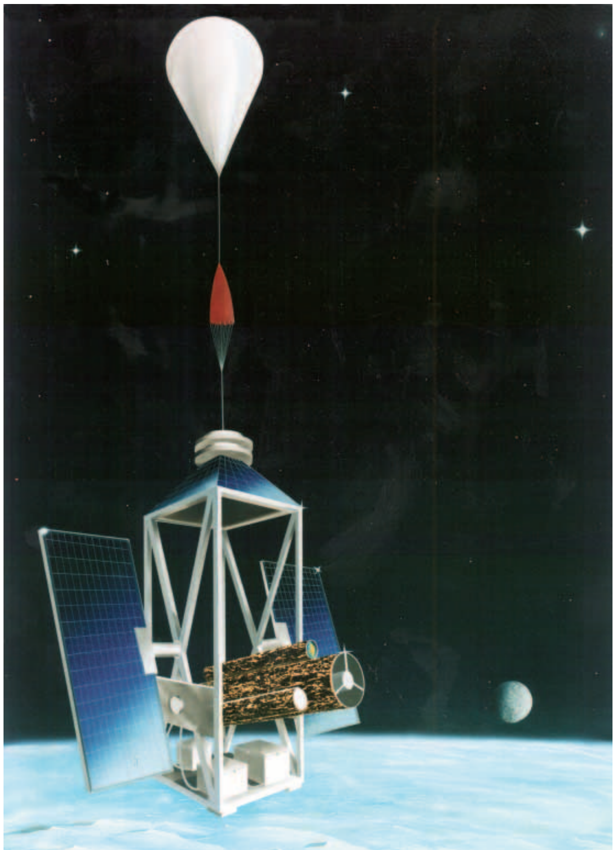

Figure 3. An artist's conception of the Flare Genesis balloon in flight over Antarctica.

Base will continue to assist with flight operations and will participate in the scientific analyses. Teams from APL and Phillips Laboratory organized a test flight in January 1994 at Ft. Sumner, New Mexico. The payload operated within expectations except for the pointing control. Analysis of the flight records showed that an unanticipated wind shear between the balloon and the gondola overpowered the pointing controller. For the flights in Antarctica, a new controller has been designed, and all flights will take place at a much higher altitude than the test flight. The effect of wind shear at 125,000 ft will be one-tenth that experienced in the test flight.

In addition to its high return as a solar monitor for the space environment, the Flare Genesis Project is the beneficiary of technology developed for the Strategic Defense Initiative, and in turn, the engineering experience gathered in the project can benefit future DoD programs requiring high-precision acquisition, tracking, and pointing, such as the Airborne Laser.

MISSILE DEFENSE

Since the early 1980s, APL has conducted research and development and provided technical oversight for the former SDIO and its successor, BMDO. As a result of this effort, the Laboratory has been directly responsible for a variety of unique tasks, from the development of prototype space interceptors (Delta 180) and sensors (Delta 181, 183, and MSX) to the test and evaluation of Theater Missile Defense (TMD) interceptors and architectures. Most recently, the Space Department, building on the work done for the Air Force and BMDO on the Brilliant Pebbles space-based interceptor program, has accepted a task from the Air Force Space and Missile Systems Center (SMC) to support the creation of an air-launched kinetic energy boost-phase interceptor.

Kinetic Energy Boost-Phase Interceptor

The primary mission of the air-launched kinetic energy boost-phase interceptor (BPI) is the neutralization of theater ballistic missiles while they are still thrusting and have yet to deploy submunitions or decoys. Development of BPI, a joint Air Force and Navy program, is under the direction of the SMC. A demonstration of the BPI system will be conducted near the end of the decade. This joint-service (Air Force, Navy, Army, BMDO) effort, sponsored and implemented by the operational user and material development communities, is intended to demonstrate the technology and integrated systems necessary to support the deployment of an air-launched, hit-to-kill missile system by the end of fiscal year 1999. The Air Force is the lead service and has the acquisition responsibility.

Figure 4 illustrates the essential elements planned for the first BPI test, which will demonstrate all of the key technologies of the interceptor missile and the element interfaces required to destroy a thrusting theater ballistic missile and will be of a scale sufficient to establish operational utility. One goal of the demonstration is that the resulting BPI system will retain a military capability and will be producible and deployable to a limited extent.

The Laboratory has a significant role in support of the SMC for Test and Evaluation. James Mueller of the Space Department is program manager for APL and oversees the management and technical direction of this activity. The task is a multidepartmental effort led by the Space Department with assistance from the Aeronautics, Strategic Systems, and Submarine Technology departments and entails functions such as technical advice, technical assistance, target coordination, Global Positioning System (GPS) applications, and post-test analysis. The Laboratory is an adviser to the government for all aspects of the test program, including test planning, instrumentation, test execution, programmatics, and schedule issues. Technical assistance is also provided for aspects of test planning and design such as engagement scenarios, debris analysis, timelines, communications, telemetry, field operations,

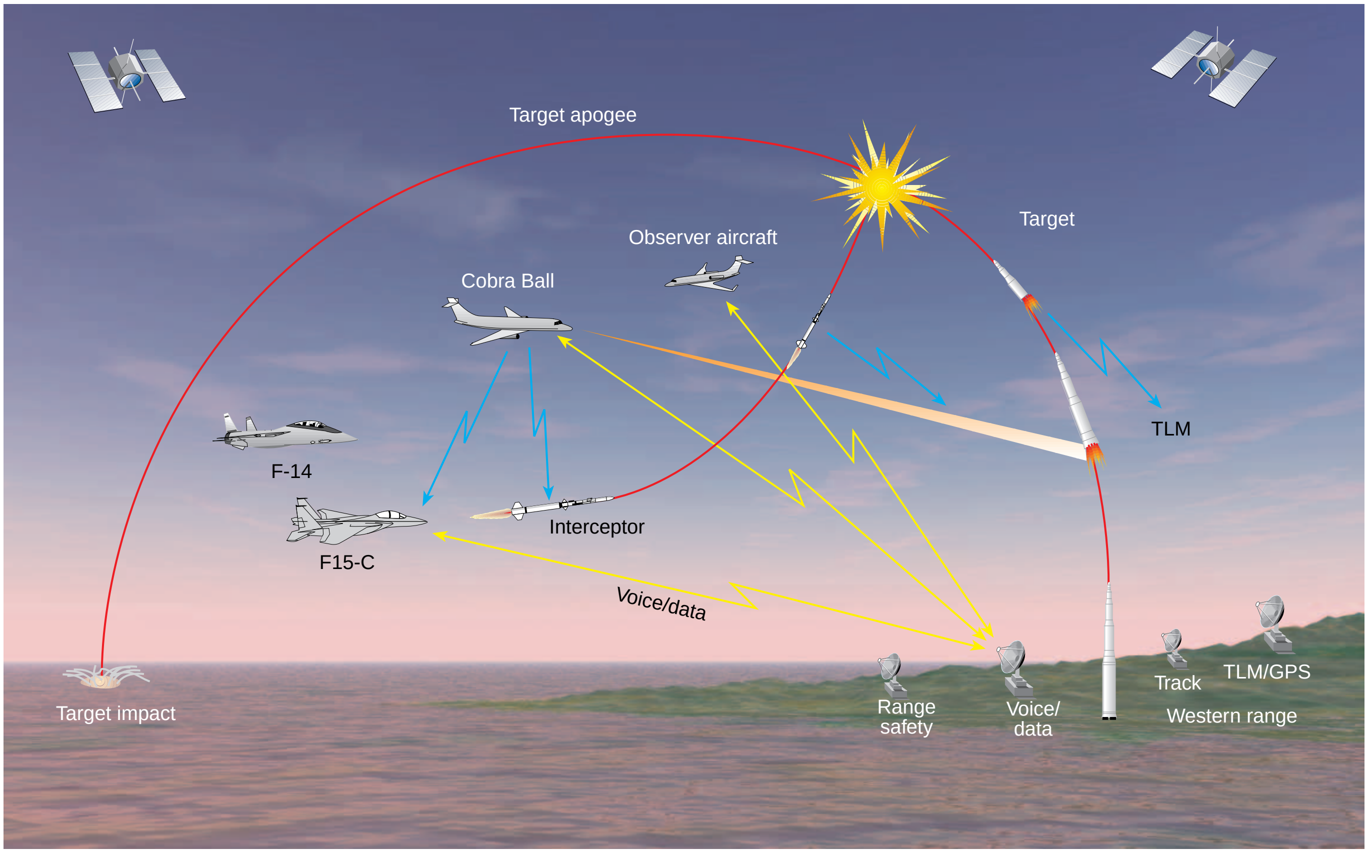

Figure 4. Boost-Phase Interceptor Strawman Test scenario. The interceptor missile is to be launched from an F-15C. The intercept is observed by the Cobra Ball, a second observer aircraft, and an F-14 aircraft. Command, control, communications, computers, and intelligence (C^4I) will be conducted by the Cobra Ball, and in-flight target updates will be supplied to the interceptor every 3 s during flight. (TLM = telemetry, GPS = Global Positioning System.)

instrumentation, technical requirements documentation, kinetic kill vehicle intercept assessment, range resources, and test integration.

The Global Positioning System will be used throughout the test and will provide the common ordinate system reference and position data for test control and evaluation. The Laboratory will define the use of GPS for the evaluation and will participate in post-test analyses. These analyses will be used to provide miss distance information and best estimates of trajectory on the test elements.

Several members of the APL team are procurement officials for the selection of the integration contractor. In addition, the Laboratory is responsible for defining target requirements, conducting target and threat comparisons, developing the Target System Requirements Document, and interfacing with the Targets Group in Huntsville, Alabama. This effort is supported under contract with the Air Force SMC Integration and Systems Test Directorate.

AIR DEFENSE

In modern warfare, suppressing an enemy's air defenses is a most critical concern at the onset of hostilities. The success of any airborne assault, amphibious landing, land operation, air interdiction, or close air support action depends on unrestricted airborne mobility (air superiority), and nothing so guarantees air superiority as the neutralization of an enemy's air defense capabilities. Since most air defense systems rely on electromagnetic radiation, the most effective defense suppression weapon is one that senses and attacks the source of that emission. For U.S. air and naval air forces, that weapon is the AGM-88 High-Speed Antiradiation Missile (HARM).

Air Force Defense Suppression Program

The HARM program was begun in the early 1970s as a Navy effort to provide improved capabilities over then-current antiradiation missiles (AGM-45 Shrike and AGM-78 Standard ARM). The HARM is shown in Fig. 5. In 1975, the Navy and the Air Force signed a memorandum of agreement for the joint development of HARM that designated the Navy as the lead agency for the program. Today, the Navy continues to administer HARM development and acquisition through the Program Executive Officer, Tactical Aircraft Programs [PEO(T)] Defense Suppression Programs Office

Figure 5. The HARM (High-Speed Antiradiation Missile).

(PMA-242), and Air Force participation is managed (through PMA-242) by the Air Force Materiel Command's Aeronautical Systems Center and Warner Robins Air Logistics Center, and the Air Combat Command's Deputy for Requirements.

Early in the program, the Fleet Systems Department at APL participated as a charter member of NAVAIR's Blue Ribbon Review Team, which was tasked to compare the cost and performance of the HARM with other development options. The panel selected HARM as the most promising option, and full-scale development was authorized in 1978. In 1983, NAVAIR called upon the Laboratory to serve as a core member of the Defense Suppression Technical Working Group (DSTWG), an independent evaluation panel for HARM development. One of APL's first challenges as a DSTWG member was to investigate the cause of several recent Navy and Air Force missile live-fire test failures and to conduct extensive modeling predictions for planned test firings. Soon afterward, the joint Navy–Air Force development community invited APL to chair the HARM Queued Six-Degree-of-Freedom (digital simulation fly-out model) Configuration Control Board. Since 1984, APL has served continuously in that capacity and as a key participant in the overall HARM program.

Because of the joint nature of the HARM program, the Laboratory's contributions have been applicable to both the Navy and Air Force. Several of the most significant contributions to the overall program are given in the boxed insert listing APL HARM project accomplishments.

Other APL efforts also conducted under the auspices of the joint program but more pertinent to the Air Force HARM are listed in the boxed insert detailing APL HARM project accomplishments beneficial to the Air Force.

These and other ongoing activities by APL have increased the dependability of the HARM system, effectively reducing the cost of maintaining operational readiness.

CHRONOLOGY OF APL HARM PROJECT CONTRIBUTIONS BENEFICIAL TO THE NAVY AND AIR FORCE

1985 Delivered the first HARM operations document, a technical overview of missile hardware and software design, for use by DoD program participants.

1987 Served as a member of the source selection team for the HARM Low-Cost Seeker, a government-designed, industry-produced alternative to the Texas Instruments' HARM seeker.

1989–1994 Delivered technical evaluations assessing the maturity and feasibility of the following:

1. Dual-mode seeker technology and automatic target recognition algorithms
2. Receiver RF sensitivity enhancements
3. Direction-finding measurement enhancements
4. RF frequency extension
5. Performance improvements resulting from adding an inertial measurement unit to the missile

1992 Developed and delivered two specific complex-waveform target models for inclusion in the Q6-DOF (degree-of-freedom) fly-out model to predict HARM performance against advanced current and projected radar threats; measured power levels of selected radar systems as a predictor of HARM performance. The reported results serve as a baseline for future improvement programs.

CHRONOLOGY OF APL HARM PROJECT CONTRIBUTIONS BENEFICIAL TO THE AIR FORCE

1985 Provided an alternate design for the integration of the HARM weapon system onto F-4E, F-15, and F-16 fighter aircraft. The solution, initially known as the Antiradiation Missile Pack (ARMPAK), was successfully tested on the F-4E and F-16. The ARMPAK, modified and renamed the Avionics–Launcher Interface Computer, is now operationally deployed on F-16C/D Block 30 and F-16C/D Block 50/52 aircraft.

1988 Conducted on-site anechoic chamber tests of actual missile hardware to predict HARM Block II performance against radar targets employing varied individual and collective electronic counter-countermeasures (ECCM) and anti-ARM techniques.

1991 Expanded the Block II ECCM performance prediction effort to include Block III capabilities.

1992 Established the feasibility of a reduced level of periodic inventory testing for Air Force HARM availability. Implementation by the Air Force resulted in manpower and cost savings.

1993 Included a Block IV in the ECCM performance prediction effort. Air Force organizations have used the results as test-planning design tools, important references for test reports, and HARM employment instructional aids.

This work was managed by the Fleet Systems Department's Strike and Air Weapons Program Office and is supported under a task assignment with the Air Force Materiel Command.

Manned Destructive Suppression of Enemy Air Defenses

The F-4G Wild Weasel, equipped with the APR-47 system to detect and locate radars used by enemy air defense units, is the primary Air Force user of the HARM. HARM is employed for the lethal suppression of enemy air defenses. The Gulf War Air Power Survey states that “no single weapon was as significant as the high-speed antiradiation missile (HARM)” in the suppression and destruction of air defenses. The F-4G is now reaching the end of its useful life and is soon to be retired from operational use. The Air Force plans to employ the F-16C/D to retain the capability to target HARMs. The program designated to conduct the transition from the F-4G to the F-16C is the Manned Destructive Suppression of Enemy Air Defenses (MDS).

Under a task assignment with the Air Force Air Combat Command, the Fleet Systems Department conducted the MDS Milestone (MS) I Cost and Operational Effectiveness Analysis (COEA) using cost data from the Aeronautical Systems Command (ASC) and effectiveness data from the Air Force Studies and Analysis Agency (AFSAA). The COEA report was published in January 1992 and distributed to Headquarters/Air Combat Command/Force Enhancement Requirements (HQ/ACC/DRF).

At the conclusion of the Milestone I COEA, the Laboratory began work on an MS II COEA. The Laboratory developed the Offboard alternative for the COEA for MS II. In the midst of this work, Congress directed the Naval Air Systems Command (NAVAIR) to perform a Joint Navy and Air Force COEA on the Joint Emitter Targeting System (JETS). Rather than performing two closely related COEAs, the work on the MDS COEA was merged with the JETS COEA. The Laboratory is leading this COEA, building on the expertise and information developed for the MDS COEA.

In addition to providing targeting for HARM, JETS may potentially provide targeting for other weapons such as the Joint Standoff Weapon (JSOW) and the Advanced Medium Range Air-to-Air Missile (AMRAAM). Platforms to be evaluated in the JETS COEA include the Navy’s F/A-18E/F and EA-6B, as well as the Air Force’s F-15E and F-16C/D. The F-16 is shown in Fig. 6.

AFSAA HARM Simulation Study Project

AFSAA, located in the Pentagon, is responsible for a wide range of studies to support the development and employment of weapon systems, including a series of simulations to analyze the effectiveness of these systems. APL’s two roles in conjunction with AFSAA are (1) to develop and deliver upgrades to defense suppression simulations and (2) to use these simulations to deliver analyses of various technical equipment modifications. Two of the simulations used for defense suppression analyses are the Tactical Antiradiation Missile (TACARM), a one-on-many engagement simulation, and Tactical Electronic Combat (TACEC), a many-on-many mission simulation for estimating own-force attrition.

For several years, APL’s Fleet Systems Department has supported AFSAA in the design and use of these simulations. Most of the work has focused on TACARM, a simulation of a tactical antiradiation missile engagement. Figure 7 shows a TACARM simulation display of threats that lie within a HARM’s field of view.

During a careful scrutiny of this simulation, many problem areas were identified, corrected, and docu-

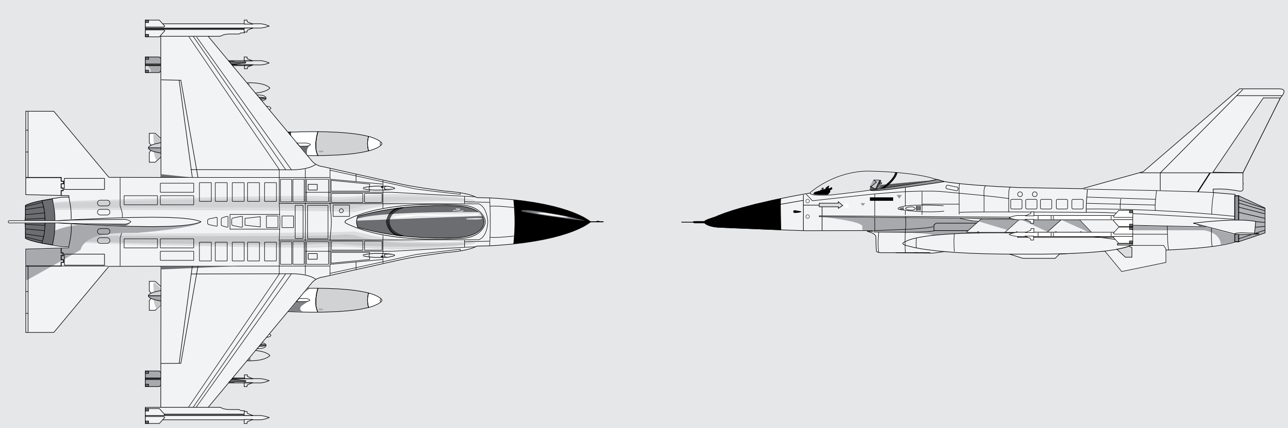

Figure 6. The F-16.

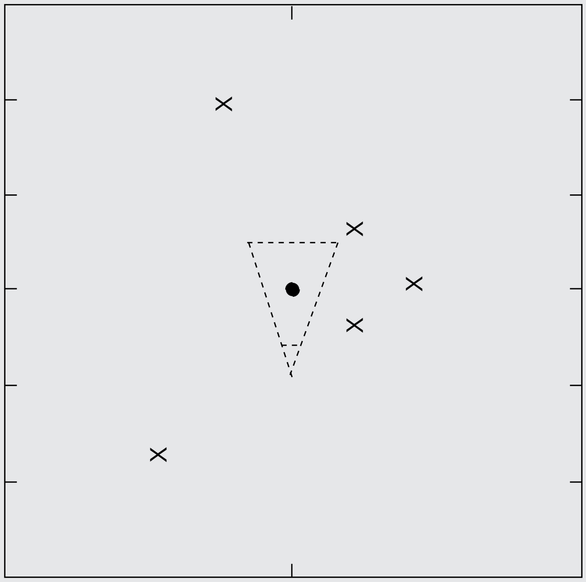

Figure 7. An example of the Tactical Antiradiation Missile (TACARM) simulation graphic display.

mented. As part of this effort, several graphical tools were developed and used to verify the correct processing of candidate targets and to help explain any anomalous behavior observed during simulation runs.

The Laboratory has introduced and coded several major modifications to the TACARM simulation. A launch–aircraft ranging algorithm was added as well as the ability to model multiple radar search and track beams operating in a coordinated manner from the same air defense unit.

Finally, more sophisticated models of time-to-range and ranging accuracy were evolved and implemented into the original TACARM simulation to support the MDS COEA.

Besides modifying and verifying AFSAA simulations, APL conducts analytical studies for the Air Force on the basis of the simulations. For example, we used the TACARM simulation to evaluate the utility of increasing the HARM seeker's performance. Through TACEC, we examined the merits of modifying the aircraft to carry four versus two HARM missiles to determine whether the improved attrition warranted the cost of the modification.

TECHNOLOGY DEVELOPMENT

The Advanced Propulsion Technology Program

More than 50 years of APL experience in the development of ramjet and scramjet engines and advanced missile systems technology is being applied to several Air Force–sponsored programs. The Laboratory role is as technical advisor and technology developer for Air Force programs to advance the state of the art for hypersonic vehicles powered by air-breathing engines. One version of an advanced aerospace vehicle, the National Aerospace Plane (NASP), is shown in Fig. 8. The Advanced Propulsion Technology Program is being conducted under the sponsorship of the Aeropropulsion and Power Directorate at the Air Force Wright Laboratory. Current efforts under the direction of Michael White of the Aeronautics Department's Propulsion Group focus on three principal areas: (1) evaluation of ducted rocket engines for low-speed (Mach 0–3) acceleration of single-stage-to-orbit (SSTO) vehicles, (2) joint efforts with the Russian Central Institute of Aviation Motors (CIAM) to incorporate Russian technology into APL's Supersonic Combustion Ramjet Missile (SCRAM) and test the existing SCRAM freejet engine model in CIAM test facilities, and (3) performance of a feasibility study and formulation of a program plan to develop Mach 6–8 flight-test vehicles for advancing hypersonic flight technology.

The Laboratory has been deeply involved in the NASP Program and its successor, the Hypersonic Systems Technology Program (HySTP). Creating an SSTO vehicle powered by air-breathing engines and capable of aircraft-like operations from a conventional runway was the NASP Program's objective. Under the sponsorship of the DoD/NASA Joint Program Office located at Wright Patterson Air Force Base, APL has made major contributions to the development of the NASP propulsion system.[6] Some of the notable accomplishments include the following:

1. The high-speed inlet experimental test program that evaluated the performance and operability of NASP inlet configurations at Mach numbers between 10 and 18
2. The Mach 12 Direct Connect Arcjet Facility, the world's only large-scale, long-duration scramjet combustor rig capable of operating above Mach 8, in a cooperative program with the NASA Ames Research Center
3. Metric strip technology to enable the first measurement of scramjet thrust in short-duration hypersonic test facilities
4. Confirmation of the viability of external burning for reducing transonic drag in a flight-test program conducted using an F/A-18 at the Naval Air Warfare Command/Aircraft Division, Patuxent River

The Hypersonic Systems Technology Program will focus on a flight demonstration of a rocket-boosted, scramjet-powered vehicle at Mach 15 conditions in a flight-test experiment and will continue development of SSTO technologies on a reduced scale. The Laboratory's participation in HySTP involves working with

Figure 8. The X-30 National Aerospace Plane, a conceptualized view of a hypersonic transatmospheric vehicle.

the National Contractor Team to develop the scramjet test hardware for the flight-test experiment and conducting high-speed inlet tests to advance SSTO technologies.

The Wright Laboratory Flight Dynamics Directorate (WL/FI) sponsors the Aeromechanics Technology Program, in which APL's expertise in the aeronautical sciences is applied to developing advanced Air Force flight vehicles. Currently, the Laboratory is testing advanced nozzle designs for supersonic air-breathing missiles at the Avery Propulsion Research Laboratory. The 1/4-scale experimental program will provide a measure of static thrust and nozzle pressure distribution to allow WL/FI to validate its design methodology before introducing large-scale test configurations. Technology areas for potential future program activity include aerothermodynamic test and analysis, vehicle dynamics, engine and airframe integration, fundamental fluid dynamic phenomena, and applied computational fluid dynamics.

OTHER EFFORTS

Many additional Air Force programs are being conducted within the Laboratory. The Space Department has three technology development programs with the Air Force's Rome Laboratory and one program for the Space Warfare Center in Colorado Springs, which is a joint undertaking with the Fleet Systems Guidance and Control Group. This effort, conducted by Alan Pue, is directed at simulating wide-area, precision GPS. Another project for the Space Warfare Center is managed by David Cowles of the Naval Warfare Analysis Department.

CONTRACTING ARRANGEMENTS

Until the beginning of fiscal year 1995, APL's contract with the Navy encompassed many diverse tasks involving various government sponsors. Since then, the Navy contract has become more exclusive and addresses only tasks directly related to specific Navy efforts. The result of this new way of government doing business with APL has been the establishment of separate contracts with each new DoD and government sponsor agency. Currently, APL has acquired a separate contract for efforts being conducted for the Air Force Rome Laboratories. A single contract with the Air Force that encompasses all Air Force tasks at APL has been proposed to Darleen Druyan, Assistant Secretary of the Air Force for Acquisition.

SUMMARY

The Applied Physics Laboratory is engaged in a continuing effort to meet the technical needs of the Air Force. Throughout the Laboratory, Air Force programs are under way that span vastly different areas of expertise. These endeavors include studies to determine the better use of existing weapons systems and the creation of new simulation tools with which to evaluate and improve these weapons more effectively, projects to develop the next generation of transatmospheric vehicles, and scientific investigations that examine the environment in which Air Force spacecraft must operate today and where tomorrow's pilots will fly. We are also aiding the Air Force in the design of the next generation of theater missile defense by formulating a test and evaluation program for the boost-phase interceptor advanced concept technology demonstration.

As this article has shown, the Air Force has a long history of working with APL. We may therefore expect that the Laboratory will continue to apply its unique and essential expertise to future technical problems faced by the Air Force.

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