U.S. Aviation
Science and Technology
Roadmap
Volume 1 Aviation Vision

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FOREWORD

The JACG Aviation Science and Technology Roadmap is a collaboration tool to be used for focussing and coordinating the nation's aviation science and technology (S&T) efforts. These S&T efforts encompass the total spectrum of aviation technology development, including fixed and rotary wing aircraft; subsystems; airborne weapons; the supporting aviation infrastructure; and operations at subsonic through hypervelocity speeds at all altitudes within the atmosphere continuum. The Roadmap facilitates more coordinated planning across all U. S. agencies having interests in aviation-related activity which will foster transitions of new technology into aviation programs, products, and infrastructure. It is intended to be a resource for use by all levels within the S&T and acquisition communities across the member agencies.

The Roadmap is organized into two parts. The first part (Volume I) begins with an executive summary which addresses rationale for the aviation S&T investment, an assessment by the National Research Council and a brief summary of top level (DoD and DoT) agency guidance to its aviation S&T execution offices. It continues with a compendium of JACG member agency Chapters characterizing each agency's aviation vision, strategic goals and objectives, technology insertion roadmaps, future needs/deficiencies, and common themes. It concludes with a set of common issues and themes cutting across several agencies. The second part (Volume II) is a web-sited relational database constructed from individual project summaries provided by each agency. The database includes projects, objectives, approaches, status, resources, points of contact, and links to military service as well as OSD requirements.

This roadmap was prepared by the S&T Process Board of the JACG and will be updated regularly, nominally on an annual basis. Electronic readers are encouraged to use the hyperlinks to the most recent information released on a topic. Volume I was first published in 1996 and updated in 1997. Volume II is in continuous development and its database is updated whenever significant progress is identified or budgets are reprioritized. The roadmap is available for use by anyone within the participating agencies and can be viewed at the JACG website.

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EXECUTIVE SUMMARY

VISION

Maintain U.S. world leadership in superior air vehicle systems by aggressively pursuing the design, development, and demonstration of timely, cost-effective air vehicle product and process technologies that will provide safe, affordable, rapid delivery of people, supplies, weapons, and information.

JACG TASKING

The Joint Aeronautical Commanders Group (JACG) is chartered by the Joint Logistics Commanders to serve as the focal point for all joint aviation activity within their commands and associate organizations. Working closely with the DoD Defense Technology Area Planning (DTAP) teams, the JACG links all U.S. Government aviation science and technology (S&T) to system development and support. The JACG has directed the S&T Process Board to develop an Aviation S&T Roadmap to encompass all aviation S&T activity within the JACG membership structure.

SCOPE

In response to JACG direction, the JACG S&T Process Board has compiled a two-volume military and civilian Aviation S&T Roadmap. This roadmap encompasses aviation basic research, applied research, and advanced technology development conducted in the United States by the Department of Defense, National Aeronautics and Space Administration, and Department of Transportation. It addresses fixed and rotary wing vehicles, including unmanned air vehicles along with the full integration of associated contributing technologies. These associated technologies are delineated in the Defense Technology Area Plan, and include: Aero Propulsion and Power; Chemical and Biological Defense; Command, Control, and Communications; Computing and Software; Conventional Weapons; Directed Energy Weapons; Electronic Warfare; Electronics; Environmental Quality; Human Systems Interface; Manufacturing Science and Technology; Materials, Processes, and Structures; Modeling and Simulation; and Sensors.

It has become evident that during the coming century, it will be necessary for a major portion of the S&T community to begin the important task of developing a fully integrated safe aerospace operating environment and infrastructure. It is also clear that the S&T community, even with its relatively small percentage of the total aerospace budget, is best positioned and has the most flexibility and innovative genius to lay the technology foundation for this task. Clear lines between aircraft and spacecraft will fade as aerospacecraft emerge to fill various assigned roles across the aerospace continuum. Affordability must be addressed from the beginning to shift away from the current paradigm of un-affordability. Developing an aerospace S&T roadmap will become a near-term action item for the S&T Process Board.

Numerous requests have been received from the private sector for access to the S&T Database. This issue is under S&T Process Board review. [Meanwhile, Volume 1 is available on an unlimited distribution basis to industry and academia at the JACG Web site http://jacg.wpafb.af.mil.]

The volumes comprising the JACG Aviation S&T Roadmap are:

Volume I Aviation Vision
Volume II Aviation Interactive S&T Database

Volume I describes the JACG tasking to the S&T Process Board and the scope of the Aviation S&T Roadmap. It outlines the top level (DoD & DoT) guidance to S&T planning, and rationale for investment. It provides summaries of each agency's Vision, Mission Overview, Strategic Goals and Objectives/ Major Thrust Areas, a Technology Insertion Roadmap, Future Needs/Deficiencies and agency Common Themes. It concludes with a set of cross-agency Common Themes. This volume represents a major update to the original volume published in 1996 and updated in 1997.

Volume II is an interactive programmatic and budgetary database and is a comprehensive compendium of federal aviation S&T projects. It contains necessary information for planning, implementing, tracking, reporting, and assessing S&T efforts. Consequently, Volume II will be a useful tool for determining those S&T areas where reliance and synergism may be increased and duplication decreased through joint planning and execution of programs. Activity is currently underway, utilizing the capabilities of the Defense Technical Information Center, to incorporate various report generation features for the database, including eventually, formal roadmap generation. Such capability would be responsive to user format requirements.

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RATIONALE FOR AVIATION S&T INVESTMENT

From a military perspective, there are four primary reasons for continuing a strong DoD investment in aviation-related technology:

1) **Aviation technologies have strong US military relevance:** Aircraft will continue their vital role in US warfighting capability and DoD spends approximately $100B/year on aircraft related research, development, test and evaluation (RDT&E); system acquisition; and operations and support (O&S).
2) **Our technology goals are aggressive:** As an example, current DoD goals include 70% reduction in unit flyaway cost, a 100% increase in engine thrust/ weight ratio, and a 40% reduction in fuel consumption over currently fielded systems.
3) **Potential systems payoffs to the warfighter are significant**: Weapon system-level benefits from achieving the above goals include an 100+% increase in aircraft range/ payload, a 35% reduction in aircraft ownership cost, increased force mobility, and reduced logistics footprint.
4) **There are numerous windows-of-opportunity for technology transition:** The technologies currently being pursued have transition potential into a wide variety of legacy, developmental, and new aircraft systems.

From an economic perspective, the rationale for S&T investment is equally compelling. In 1998, aerospace ranked first (+$41B) in positive trade balance. As was noted in the 1996 version of this Volume, the United States leads the world in manufacturing aircraft and associated systems.

In spite of the compelling military and economic rationale for S&T investment aside, from 1999 to 2000, while the Federal Science and Technology Budget rose in constant dollars by 2.4% from $48.3 billion in FY 1999 to $49.4 billion in FY 2000, overall DoD aeronautics-related S&T investments (Category 6.1, 6.2 & 6.3) dropped by 20% from $500M/yr to $400M/yr. The current five-year projection shows little change from this reduced level. Several factors have contributed to this reduction including need to supplement Readiness accounts, Information Technology Plus-ups (~$100M in FY 2000) and the need for the Air Force to more adequately fund DoD space-related programs.

Just as military air vehicles are essential to this country's national security, both military and civil air vehicles remain critical to the economic security of the United States. Beginning with a top-level perspective, total U.S. transportation contributes 11 percent of America's Gross Domestic Product (GDP). That translated in 1995 to $777 billion of a $7.25 trillion GDP. According to the Aerospace Industries Association Indicator, http://aia-aerospace.org/ combined military and civilian industry annual aerospace sales in 1999 were approximately $157 billion and, including airlines, this industry provided over 800 thousand high-quality jobs. Civil plus military exports accounted for over $60 billion in positive trade balance, this country's largest for manufactured products. The projected demand for global air travel is anticipated to grow at an average rate of five per cent per year into the new century, creating a potential air transport market in excess of $800 billion over the next 20 years. This potentially lucrative market has attracted very significant competition from around the world. Significant technological advances in key areas will be needed to allow the U.S. aircraft industry to expand or even maintain its position in this highly competitive world market. In spite of the sound rationale presented for the Federal aviation S&T investment, the budget projection is discouraging and has prompted the following assessment by the NRC.

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NRC ASSESSMENT

In 1999, the National Aeronautics and Space Administration (NASA) commissioned the Aeronautics and Space Engineering Board (ASEB) of the National Research Council (NRC) to conduct a four-month evaluation of the U.S. aeronautics program. The assessment included work supported by government agencies and industry. The intent of the study was to provide a timely review of national support of S&T in traditional aeronautics. Traditional aeronautics was defined as including both fixed- and rotary-wing aviation but excluding space operations, space launch and reentry, and some of the new air-breathing hybrid technologies proposed for hypersonic entry into space flight. The recently completed strategic assessment of U.S. aeronautics contains a wealth of information of vital interest to JACG planners. [It is available from Aeronautics and Space Engineering Board, HA 292, 2101 Constitution Avenue, N.W., Washington, DC 20418. (202) 334-2855.] Some exerpts from the assessment are quoted in the following paragraphs.

The assessment found symptoms of a serious national problem - that the aeronautics segment of the economy is becoming less competitive. Data presented in the assessment show that the U.S. share of world aerospace markets fell from nearly 70 per cent in the mid-1980s to 55 per cent in 1997. The absolute level of aeronautical sales has also dropped in the United States during the 1990s. Lowering trends in market share and the absolute level of economic activity, if uncorrected, will naturally lead to the demise of aeronautics as a viable enterprise. Maintaining a competitive industry with a significant market share is clearly important. National security is closely tied to superiority of U.S. aeronautical capabilities. The assessment observed that, although a strong national program of aeronautics S&T may not, by itself, ensure the competitiveness of the U.S. aviation industry, without it, the United States is likely to become less competitive in aeronautics relative to countries with stronger programs. Aviation is an S&T-intensive industry. Maintaining a successful, state-of-the-art aeronautics industry has required that a higher percentage of net sales be invested in S&T than other industries associated with rapid innovation and application of scientific advances.

Although certain aeronautical advances are immediately useable, more often, aeronautics S&T advances are evolutionary, and a substantial number of years can pass before the aviation systems making use of these advances enter service. Modern aircraft are complex "systems of systems," and advances in one discipline, such as aerodynamics, may require an advance in another discipline, such as structures, before they can be applied in a new aircraft design. Years of validation, testing, and certification are, therefore, usually required before a new aeronautics S&T development can be exploited. However, data are presented in the assessment showing that aeronautics R&D funded by U.S. industry dropped by almost 50 percent between 1988 and 1991, followed by reductions in sales and employment. Similar declining S&T funding trends are presented for NASA and DoD. In sharp contrast, government support for aerospace S&T in the European Union has been growing, underpinning Europe's increasingly successful economic challenge to the U.S. in aeronautics.

Militarily, a dominant aeronautics capability projects a U.S. global presence and influence as no other technology does, or will do, for the foreseeable future. No other capability allows for the rapid projection of force over long distances or is as flexible in providing combat air support for ground forces. The United States needs a strong aeronautics capability to meet its international commitments and responsibilities in an uncertain and volatile global political environment. This future capability rests solidly on today's aeronautics S&T investment strategy.

With regard to economic factors, a recent market study summarized in the assessment, projects a worldwide civil aircraft market of $810 billion over the period 1999 to 2008. The study showed that large civil transports account for over one-half of this market. The remainder is comprised of regional/corporate airplanes, military airplanes, and civil and military rotorcraft. In addition, $274 billion in gas turbine engine sales are projected over the same period, more than one-half for aviation uses, and the projected market for aircraft retrofitting and modernization is $20 billion. In total, the world market for aeronautics products is expected to exceed $1 trillion over the next 10 years, and most of it will be captured by companies (and countries) that have made and continue to make sizeable investments in aeronautics S&T.

The market study cited above provides information only on the primary economic benefits from goods and services associated with aeronautics S&T. Secondary benefits are also accrued. For example, investments in air traffic control systems worldwide are expected to range from $41 to $58 billion. Also, the technology to develop efficient gas turbine engines has been used to develop gas turbine engines for other uses, such as ship propulsion and emergency electrical generation in critical buildings. In fact, examples of the general applications of aeronautical technology abound. These secondary benefits not only add to the gross national product, but they also enhance national security, the economy, and the general quality of life.

A considerable portion of the U.S. S&T investment must continue to support critical infrastructure. Yet the assessment finds that Government aeronautical test facilities are another area of concern. The construction, maintenance, upgrading, and use of some of the nation's specialized aeronautical testing facilities, typified by large-scale wind tunnels, are company or university assets, but most have been built and operated by the government—NASA or the U.S. Air Force, for example. Many such facilities have been or are being closed down. The U.S. government has backed away from proposals to construct major new facilities which were earmarked "to assure the competitiveness of future commercial and military aircraft produced in the United States." U.S. aircraft companies are increasingly going overseas to perform wind-tunnel testing of new U.S. designs.

Although knowledgeable observers may differ in their assessments of the degree of the severity of the consequences, the assessment points out that continued reductions in funding for aeronautics S&T may have irreversible consequences. The assessment endorsed the three key goals from the National Science and Technology Council (NSTC) 1995 Goals for a National Partnership in Aeronautics Research and Technology. These may be referenced through the Office of Science and Technology Policy. [Available on-line at www.whitehouse.gov/WH/EOP/OSTP/html/aero/cv-ind.html.] Briefly stated they are:

- Maintain the superiority of U.S. aircraft and engines.
- Improve the safety, efficiency, and cost effectiveness of the global air transportation system.
- Ensure the long-term environmental compatibility of the aviation system

The assessment supported NASA's response to these challenges, in which it defined three pillars, supported by 10 technology enabling goals. The second and third goals of the National Science and Technology Council can be considered as broadening the old "higher, farther, faster" pure performance objectives of the past. The assessment observed that, in the past, the old National Advisory Council for Aeronautics and the military were once the primary federal organizations involved in aeronautics S&T. Now the Department of Defense, NASA, the U.S. Department of Transportation (including the US Coast Guard and Federal Aviation Administration), all have significant S&T programs related to aviation. The focus of each program is determined by each agency's missions, legislative charter, and annual budget appropriation. The coordination among these agencies is increasingly important for at least three reasons:

- The result of the overlapping responsibilities arising naturally from greater density of aviation operations and the growing sophistication of flight systems, which are increasingly dependent on electronics, optics, and computers.
- The burgeoning costs to develop increasingly capable aeronautical systems under the pressure of constrained budgets.
- The widespread acceptance in the military of "dual-use science and technology" (combining civil and military applications) and commercial-off-the-shelf equipment and systems for military applications. As stated by the National Science and Technology Council, "Nationally we have the infrastructure—government, industry and universities—to maintain leadership. We must now renew our focus on partnership to meet national challenges and accomplish national goals."

Once the position of the United States in aeronautics is lost, it will be exceedingly difficult to regain because of the difficulty in reassembling the infrastructure, people, and investment capital.

On a final note, the assessment addressed the perception in some quarters that the aeronautics industry, particularly the civil aeronautics industry is mature, characterized by diminishing technological opportunities and low returns on S&T investment. It challenged that perception by projecting that aeronautics S&T has many areas of great opportunity reflecting its S&T-intensive nature and use of inputs from other S&T-intensive industries. The application of information technology to aircraft controls, guidance and navigation, traffic management, and propulsion is only one example. The use of advanced metallic and composite materials is another. The industry also faces ample opportunities for far-reaching innovations in production management and methods. The top tier of firms in aeronautics is complemented by a very large number of smaller supplier firms, many of which are relatively recent entrants to the industry. In at least some supplier sectors, such as avionics, significant entry by new start-up firms has occurred and is bringing innovative vitality to the industry.

In short, the characterization of aeronautics as a mature industry says little if anything about the level of technological opportunities. The assessment saw little reason to anticipate that these opportunities will diminish in the near future. Indeed, the continued social demands for quieter, safer, and more environmentally friendly air transportation all require innovative responses.

Organizational reaction to these challenges identified in the assessment and outlined above has been swift and dramatic. We have gone, for example, from the five major producers of fixed-wing military aircraft that we reported in the 1996 *Volume 1 Aviation Vision* to three. Government agencies are downsizing and restructuring. A large portion of the aeronautics infrastructure base has been shut down. Aeronautics departments in many universities are dissolving.

Therefore, what is now needed is a national resolve for increased collaboration to meet these challenges and accomplish our national goals. An integrated national vision and strategy for aeronautics investment must be developed to facilitate increased leveraging of resources to meet common objectives.

To understand how the aviation S&T community can respond to these challenges, it is important to summarize here and reflect on the guidance being provided by each member agency's top organizational element. The three organizations guiding the great bulk of federal government aviation investments are the DoD, NASA and the DoT (which directs the FAA and also the Coastguard in peacetime).

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TOP LEVEL ORGANIZATIONAL GUIDANCE

A plan redefining the roles of several U.S. government agencies in the development of aviation goals was released in December 1999 by the White House and the Dept. of Transportation. The document, entitled "National Research and Development Plan for Aviation Safety, Security, Efficiency and Environmental Compatibility," says that while implementation of the goals will continue to rest largely with the FAA and the aviation community, NASA and the Dept. of Defense will "play an essential role." The plan restructures a 1998 agreement between FAA and NASA for closer collaboration with DoD. It contains an explicit mandate to "maintain a close partnership in the pursuit of complementary goals for aviation and future space transportation and to coordinate their planning and tracking of accomplishments toward achievement of those goals."

The plan also restructures the existing coordinating committee into a new "FAA/NASA Executive Committee" and charters it to oversee the partnership. The Executive Committee, in collaboration with DoD, is beginning a review of goals. It will focus on areas of research for civil aviation related to safety, security, national airspace system efficiency, and the effect of aviation on the environment.

Top level (DoD and DoT) guidance provides insight as to where aviation (and future aerospace) S&T development must be directed and how it must be shaped to meet the objectives of the JACG member top-level organizations. This guidance may be found at the agency websites.

The *Defense S&T Strategy* was originally published in 1996. The 2000 version is fully compatible with the newly released Joint Vision 2020, was released in May of this year. [It may be viewed at https://ca.dtic.mil/dstp/2000_docs/ststrategy/strategy.htm.]

The Department of Transportation has responsibility for the Federal Aviation Administration and, in peacetime, the Maritime Administration United States Coast Guard. [The *DoT 1997-2003 Strategic Plan* is provided in detail at http://www.DoT.gov/hot/DoTplan.html.]

The individual agency Chapters that follow will address their responses to this guidance as well as agency-specific guidance. The set of individual agency Chapters, collected in this volume, together with the *Volume 2 U.S. Aviation Interactive S&T Database*, will provide a roadmap not presented elsewhere, for engineers and managers alike, to guide aeronautics S&T planning into the brand new century.

It will be seen that a major shift in emphasis will be required in aeronautics S&T to fully respond to an urgent national need to fully integrate much of our air and space commercial and military activity. It will also be recognized that agency responses are aligning in such a way as to provide the opportunity, as never before, to meet that need.

In developing this Roadmap, extensive use has been made of hyperlinks. Links to key references are provided as well as to several of the roadmaps. Even during the course of preparing this document, significant changes have occurred and by linking to a reference or roadmap, one may be assured of finding the most recent information available.

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DEFICIENCIES AND S&T FUNDING SHORTFALLS

At the April 1999 meeting of the JACG Principals' Lt. Gen Raggio, the USAF Principal, urged the S&T Process Board to "Identify deficiencies in our current and projected national aviation S&T investment strategy. These deficiencies may be used to mitigate the decreasing investment trend." Indentification of specific deficiencies is essential to properly capture the specific need for increased aviation S&T investments. The Subsequent Principals' meetings provided agency responses, captured in the following paragraphs.

Air Force:

Starting with FY00, the AFRL strategy is to enable the aerospace force of the future. This strategy will entail increasing the S&T investment in space unique technologies, maintaining the investment in common, or shared, air and space technologies, and protecting the investment in the most critical air unique technologies.

AFRL budget trend data shows the total S&T budget decreasing from approximately $1340 million in FY96 to approximately $1180 million in FY00 (then year dollars). The slope of the reduction has been fairly constant since the early 1990s, representing a 55% drop over the past decade. In addition, in FY00, the S&T budget is absorbing two former non-S&T space-related programs, Space Based Laser and Discoverer II. These have a combined budget of $94 million in FY00, effectively further decrementing the budget.

As a result of its investment strategy, the AFRL investment in aviation-related S&T has decreased from 87% of its total budget in FY99 to 71% in FY00 and to a planned 68% by FY05. By category, the greatest decrease will be in the enabling technologies, the 6.2 budget category.

Projected impacts on the investment strategy of the AFRL's major aviation technology areas are:

- **Air Vehicles**: The AFRL strategy will protect investments in Unmanned Combat Air Vehicles, Aging Aircraft, and Composites Affordability for JSF. It will transfer, privatize, or close a number of research and test facilities, eliminate research in aircraft subsystems and significantly reduce research in aircraft performance technologies, including conventional structures, stability and control, and flying qualities.

- **Human Effectiveness:** The strategy will protect investments in distributed mission training and simulation, directed energy bio-effects and protection, deployment and sustainment, and crew systems interface. It will eliminate or reduce investments in manpower and training research, aircrew physiology research, and oxygen generation research.

- **Materials and Manufacturing:** The AFRL strategy will protect investments in the following areas: aging aircraft, low observable materials maintainability, survivability and sensor materials, and affordable materials and processes. It plans to reduce investments in environmental remediation.

- **Propulsion and Power:** The strategy will protect AFRL investment in the Integrated High Performance Turbine Engine Technology program (for F-22, JSF, and UCAV applications), high cycle fatigue research, and turbine engine durability research. It will reduce high-speed air-breathing propulsion research and aerospace fuels and lubricants programs.

- **Sensors**: The strategy will protect investments in GPS modernization, threat warning, combat identification, automatic target recognition, and sensor-to-shooter situational awareness. It plans to delay some research in electro-optics and reduce airborne radar technology development.

Coast Guard:

- Engine high pressure turbine reliability improvement,

Army:

The strategy for Army aviation calls for achieving requirements of the Objective Force as identified in the Army Vision. This strategy requires significant resource commitments that will be addressed annually as part of the cycle of planning, programming, and budgeting. There currently exist S&T funding shortfalls and a trend of reductions that contribute to potential deficiencies for the Army. A summary of these deficiencies is provided below.

- **Reconnaissance/security** represents the single greatest deficiency in Army aviation. The Army remains completely committed to the RAH–66 Comanche helicopter (currently in Engineering and Manufacturing Development), a variant of which may be considered as the possible long–term solution for the attack helicopter beyond AH–64D Apache Longbow.
- **AH–64D Apache Longbow** is the logical progression of the world's finest attack helicopter. Current actions modernize this aircraft, but do not recapitalize it. While the remanufacture program helps, it does not solve the problem. The Army must extend the operational life of the aircraft through a recapitalization program.
- **Army aviation digitization programs** are generally under–funded and not aligned with the Army's digitization schedule. The requirement for seamless sensor–to–shooter connectivity across the vast battlespace and the need to capitalize on the emerging information exchange capability of the tactical internet demand a maneuverable airborne command vehicle and tactical internet compatibility for aviation platforms.
- **Utility and MEDEVAC** mission area deficiencies also require attention. The UH–60A to M recapitalization program will address the aging of the UH–60A fleet and provide a more capable aircraft. Modification of MEDEVAC UH–60A aircraft to the UH–60Q configuration, coupled with aircraft life extension, is the objective solution to address MEDEVAC mission requirements. Achieving the Objective Force also requires funding commitment for additional UH–60 procurement.
- **CH–47D** The aging fleet is forcing the Army to address performance, digital compatibility, and rising support costs. The CH–47F initiative will address these shortcomings in the mid– and far–term periods. The CH–47F program is designed to accommodate the FTR, modernizing only the number of CH–47Ds required to bridge the gap until FTR projected fielding in the 2020 time frame.
- **The Army aviation S&T program** should include additional funds for FTR competitive demonstrations to reduce cost and risk for drive train, rotors, and airframe. The FTR engine (15,000+ horsepower) demonstrator program (single contractor) should be fully funded for transition of technology to the Preliminary Design and Risk Reduction effort. The Rotorcraft Open Systems Architecture for FTR and the Objective Force should be funded to provide commercially available electronic components and standards to reduce life cycle avionics costs, component weight, and power consumption.
- A **Common Engine Program** is needed for the AH–64 and UH–60 helicopters systems to meet current range and payload requirements and reduce operating costs based on increasing demands placed on these aircraft during their operational lives.

Navy/USMC

Similar to the other JACG member Services and Agencies, the Navy's investment in aviation S&T has declined substantially over the last decade. In terms of constant year dollars (FY98), the decrease has averaged approximately $10 million (4%) per year since FY85, for a total decrease of approximately $120 million (50%). This substantial decline, combined with the recent major investment shift by both the USAF and NASA from aviation to space S&T efforts, is a cause for grave concern. Perhaps most importantly, the Navy S&T investment reductions have occurred primarily in air vehicle technologies (e.g., aerodynamics, CFD applications, flight dynamics, structures, aerospace materials), the same areas in which the USAF and NASA have significantly reduced their respective investments. The following provide a summary for the technology areas in which the Navy has inadequate aviation S&T investment.

- **<u>Air Vehicles</u>:** Naval aviation systems have unique requirements. These are imposed by the harsh maritime environment (corrosive salt spray, anti-icing), by carrier-based flight deck and hangar deck operations (high impact structural loads, high thermal/cyclic loading, bolter/wave-off thrust response, single engine rate of climb, limited maintenance/storage space) and by the harsh electromagnetic environment in the immediate vicinity of the carrier. Air Vehicles related S&T is required to provide the foundation for designing new, as well as maintaining legacy, aircraft weapon systems which accommodate these requirements. This foundation includes engineering analysis and predictive capability and technologies for maintenance cost reduction. The spiraling O&M costs for aging platforms need to be reversed. High priorities are: (1) Developing more accurate dynamic interface models and simulation capabilities; (2) Determining and modeling failure mechanisms for dynamically loaded fatigue susceptible components to specify longer service lives and maintenance intervals; (3) Quantifying the structural reliabilities corresponding to various maintenance options; (4) Characterizing the degradation mechanisms of the corrosive environment and develop maintenance technologies to maximize operational utilization and affordability; (5) Developing operationally robust high performance structural materials, and affordable environmentally compliant manufacturing and repair processes; and (6) Developing methodologies and test methods for the acceleration of materials and processes innovation, engineering and insertion.

  To shift from our current business practices the Navy needs to invest in (1) altering building block certification methodology to reduce development cost and time; (2) improving analytical capabilities and test methods to introduce radical, cost-saving structural concepts (3D architecture and unitized structure); (3) quantifying the technical and reliability risks inhibiting the use of innovative, lower cost composite materials to replace metals, which are subject to corrosion and fatigue; and (4) accelerating materials synthesis, characterization, process development and engineering transition via advanced combinatorial, computational, empirical and analytical methods. While the above are pertinent to all air vehicle disciplines, they are particularly important to aero and flight dynamics, flight controls, and structural design for fixed wing and rotary wing air vehicles.

- **<u>Propulsion & Power</u>:** Due to their operating environment, Navy aviation platforms have unique propulsion requirements. These include carrier-based operations (high impact structural loads, high thermal/cyclic loading, bolter/wave-off thrust response, single engine rate of climb, limited maintenance/storage space, etc.) and the maritime environment (highly corrosive salt air/spray, high EMI/FOD, anti-icing, etc.). Navy also has unique engine size/cycle requirements to meet multi-mission and V/STOL needs. In this context, the Navy has unmet S&T investment needs in Advanced Research funding for electrical power; thermal management; propulsion materials; fuels and lubes; propulsion component technologies (e.g. emissions, noise, durability, prognostics, high-speed) and in Advanced Technology Development funding for drive systems; rotary-wing propulsion; high-speed turbine-based propulsion; and advanced propulsion systems compatible with V/STOL Unmanned Combat Air Vehicles.

- **Crew Systems:** Advanced Research funding for enhanced resolution and sensor fusion for Helmet Mounted Displays; non-linear materials and optics for eye protection; visualization strategies and data compression techniques for 3D data presentation.
- **Avionics & Sensors:** Magnetic Anomaly Detection technology for ASW sensors; Mine countermeasures technology; Automatic target recognition technology; technologies for mitigating the impact of electromagnetic interference
- **Ship-Board Systems:** Automation of ship-board aviation services (e.g., weapons handling, aircraft launch & recovery). Next generation helo recovery system for air capable ships. Operations of UCAVs onboard ships. Accurate prediction of airflow vector in vicinity of ship landing pads.
- **Air-to-Air Weapons:** Smaller, more maneuverable targets in the cruise missile and unmanned air vehicles area join the larger, faster fighters and ballistic missiles to present a much larger spectrum of targets. Coupled with a neck-down acquisition strategy, improvements in our ordnance lethality are required. Critical S&T investment areas are as follows: (1) Missile Kinematics--The operational objectives associated with this technology development area are to support neck-down to a single AAW weapon (AIM-120C-5 size and weight) that exceeds the range and average velocity performance of the AIM-120C-5 while maintaining the inner boundary performance of AIM-9X. (2) Sensor Performance--In the short-range encounter, the desired capability is 4π steradian multiple target tracking capability, with good terminal accuracy to provide a high P_k and excellent performance in clutter and against countermeasures. One response to these challenges to the weapon sensors is a dual-mode seeker suite that combines the many advantages of the Surface Wave Antenna Guidance concept with a terminal IR seeker (which, itself, may be two-color). These investments need to be coupled with investments in advanced helmet-mounted vision systems. (3) Ordnance Lethality--High lethality is a function of all the weapon's subsystems working together in an integrated fashion, thus minimizing miss distance to maximize warhead effects. Investment in these various technologies is critical to providing the advantage to our warfighters.
- **Aircraft Survivability Technologies:** With threat integrated air defense systems becoming more capable and more widely fielded, the Navy and the DoD need to invest in technology areas which provide increased survivability, that is, in low observables and in countermeasures. In the LO, or stealth, technology area, the focus of investment should be in developing low maintenance, easily repairable materials and techniques. In the countermeasures area, investment should in all aspects, RF, infrared, laser, and optical.
- **Cost of Ownership:** Faced with declining resources, aging aircraft inventory and rapidly escalating operating costs, the NAVAIR TEAM has taken a leading role in reducing the cost

of doing business for the Navy. The challenge is to sustain our superior warfighting capabilities, improve Fleet readiness, and ensure that the Navy can maintain our aviation superiority well into the future. Total Ownership Cost (TOC), as defined for the ASN (RD&A) Strategic Plan, includes all costs associated with the research, development, procurement, operation, logistical support, and disposal of an individual weapon system including the total supporting infrastructure that plans, manages, and executes that weapon system program over its full life. But both ASN (RD&A)'s TOC directive and the DoD thrust have been based upon the NAVAIR's Affordable Readiness program. TOC reduction is the overall umbrella and Affordable Readiness is the process for implementation of Life Cycle Support/In-service programs - while the application of Cost As an Independent Variable (CAIV) is the process for managing cost during R&D / pre-production programs

- **Training:** The development of advanced, state-of-the-art training systems is critical to fleet needs and is a major objective of the Naval Air Systems Command. The Naval Air Warfare Center Training Systems Division (NAWCTSD, Orlando, FL) is a cornerstone of the National Center of Excellence for Simulation and Training .The Training Systems Division specializes in training systems, human performance measurement, learning and simulation technologies in virtual environments, modeling and simulation, electronic environments as well as dual-use technology development. As the principal Navy center for Naval training systems, the TSD is a major national asset in that it provides R&D, Acquisition, fully integrated life-cycle support and critical inter-service coordination for training systems in support of other defense agencies and services (Army, Air Force, Coast Guard, etc).

NASA

At the 25-26 Aug 1999 JACG Principals' Meeting, NASA Headquarters, provided a detailed account of NASA's aviation investment strategy. Since the mid-1990's the aeronautics budget has been reduced by about 33%; to its projected level of about $640 million (FY2000 President's Budget Request). NASA stated that this level should not be viewed as a floor, but as a new ceiling for aeronautics investment. Two NASA programs were reviewed, the Advanced Subsonic Technology Program and the High Speed Research (HSR) Program, which are being phased out or terminated in NASA's shift of long term investment to space related technologies.

As a result of budget cuts and the direction to maintain the in-house work force, NASA is faced with the potential loss of key research facilities; the modernization and rehabilitation of remaining aging facilities will also likely be delayed to the future. The direction to maintain the in-house work force presents NASA with a difficult situation. Currently, over 50% of its aeronautics budget is for personnel related expenses; NASA's aeronautics research with industry has been sharply curtailed.

The budget cuts, coupled with the investment shift to space, have decimated NASA's investment in vehicle technologies. With the termination of the HSR program, the vehicle technology budget was cut by 70% from FY99 to FY00 (from approximately $320 million to approximately $90 million). As an example of the impact, NASA has eliminated investment for research in the following areas:

- **Lightweight composite airframe structures**
- **High temperature combustor materials**
- **Aerodynamic performance technologies.**

On a positive note, NASA anticipates that the administration and the Congress may recognize that the cuts in aeronautics technology have been too deep. The next fiscal year will see a few new NASA program starts. The Ultra Efficient Engine Technology (UEET) program will continue research on reducing nitrous oxide in engine exhaust and will sustain in-house core competencies and retain some facilities. The program, however, does not validate any resulting technologies integrated into a complete system nor does it involve the end user. The Synthetic Vision Project augments the Aviation Safety Program; it sustains basic flight deck research, accelerates technology validation, and adds research support for certification. The Revolutionary Concepts (REVCON) Program revitalizes advanced concept studies within the context of NASA goals. It will serve as a reminder to the public and to Congress that innovations in aeronautics are still necessary and have a high payoff. This program will identify these innovations early, accelerate the development to a flight article, and conduct flight testing to insert the reality that this activity brings.

Return to TOC

FEDERAL AVIATION ADMINISTRATION

VISION

The Federal Aviation Administration's vision is to provide the safest, most efficient and responsive aviation system in the world, continuously improving service to customers.

OVERVIEW OF AGENCY MISSION

FAA provides a safe, secure, and efficient global aviation system that contributes to national security and the promotion of U.S. aviation. As the leading authority in the international aviation community, FAA is responsive to the dynamic nature of customer needs, economic conditions, and environmental concerns.

R,E&D OVERVIEW

The United States President, Congress, and the American public hold the Federal Aviation Administration responsible for providing a safe, secure, and efficient National Airspace System (NAS). Furthermore, they expect FAA actions and regulations to be effective in improving aviation safety and security while still mitigating the impacts of aircraft noise and emissions upon the environment. Better research and the implementation of effective new solutions increasingly hold the key to meeting the rising expectations of the American people and their Government.

The significance of the FAA's research and development (R&D) will grow in proportion with the demands placed upon it. The FAA's R&D program finds and prepares to field technologies, systems, designs, and procedures that directly support the agency's principal operational and regulatory responsibilities: air traffic services, certification of aircraft and aviation personnel, operation and certification of airports, civil aviation security; and environmental standards for civil aviation.

Safety remains the agency's top priority. While the FAA, NASA, and other R&D sources have introduced many new technologies and procedures over the past 20 years—and the accident rate has dropped dramatically as a result—expectations are constantly being raised. The R&D program supports essential agency initiatives to reduce fatal accidents by 80 percent by the year 2007. Without a major infusion of new technologies and procedures, it will be extremely difficult for the FAA and the aviation community to meet this goal.

To support the agency's principal operational and regulatory responsibilities, the FAA's R&D program is functionally divided into seven areas: Air Traffic Services, Airport Safety

Technology, Aircraft Safety, System Security, Human Factors, Environment and Energy, and an overall planning and coordinating function titled R,E&D Program Direction.

- *Air Traffic Services*—R&D focuses on increasing system safety and capacity and enhancing the flexibility and efficiency of air traffic management operations. A key element in achieving these objectives is developing decision support tools that will enable FAA air traffic specialists to manage traffic flows more efficiently while collaborating with the user community in making decisions affecting their operations.

  The R&D program is also working to reduce the risks of runway incursions, midair collisions, and aircraft encounters caused by the effects of wake vortices and hazardous weather. Research is developing new technologies that will improve navigational accuracy and provide improved landing guidance. Communication research develops technologies that improve the reliability of pilot-controller communications and permit the exchange of large data files, such as weather data to pilots.

  The FAA is introducing new technologies to support a Free Flight system, in which aircraft operates could vary their speed and flight path to increase operational efficiency, while air traffic controllers ensure that safety is maintained.

- *Airport Technology*—R&D develops and evaluates technologies and materials designed to ensure and improve safe and efficient operations on the airport surface and in the immediate vicinity of an airport. Research focuses on development and evaluation of advanced, innovative technologies involving pavement design construction, and maintenance; airport visual and navigation aids; rescue and firefighting equipment and procedures; runway friction, and wildlife control techniques. Research results are used to update FAA standards for the design, construction, and operation of airports and airport equipment, and are incorporated into guidance material used by airport operators, consultants, and equipment manufacturers.

- *Aircraft Safety*—RE&D focuses on ensuring the safe operation of in-service aircraft. It addresses the hazards to all aircraft in service, as well as the special hazards endemic to select portions of the civil aircraft fleet. Older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft with digital flight control and avionics systems and associated imbedded software are more susceptible to disruption from external electromagnetic interference. Research focuses on developing technologies and standards for maintenance and modification of in-service aircraft to ensure continued airworthiness. It includes research in structural integrity of airframes and engines, maintenance and repair of composites, atmospheric hazards, crashworthiness, fire safety, and forensics capabilities to support accident investigations.

- *Aviation Security*—R&D develops technologies and standards the threat of terrorism and criminal acts targeted at aviation. Research focuses on developing and evaluating passenger, baggage, mail, and cargo screening devices to detect concealed explosives and weapons; aircraft hardening techniques to increase aircraft survivability in the event of an in-flight explosion; human factors aspect of detection and alarm resolution; and integration of airport security technologies and procedures. An important consideration in this research is to develop effective, reliable technologies and procedures that have minimal impact on airport and airline operations.

- *Human Factors and Aviation Medicine*—R&D directly supports the National Plan for Civil Aviation Human Factors and the validated needs of the FAA's lines of business and NAS users. The program addresses major human factors priority areas related to the flight deck, ATC, flight deck/ATC system integration, airway facilities, aircraft maintenance, and aero medical aircraft cabin environments.

- *Environmental and Energy*—R&D develops technical information, standards, and procedures to mitigate the environmental impact of aircraft operations (in particular, noise and air pollution emissions), and to better understand and manage the impact of FAA operations on the environment.

- *R,E&D Program Management*—includes the management, planning, control, and support activities associated with formulating the FAA R&D program. These efforts ensure that the program is a cohesive and integrated effort, consistent with the FAA strategic goals and objectives, and fully coordinated with stakeholders and customers.

LONG TERM RESEARCH

The Research, Engineering, and Development Management Reform Act of 1996 directed the FAA to identify the allocation of resources among long-term research, near-term research, and development activities.

Long-term research, as defined in the Aviation Safety Research Act of 1988, is a research project that is "unlikely to result in a final rulemaking action within five years, or in the initial installation of operational equipment within 10 years after the date of the commencement of such project."

The FAA's R&D is principally associated with applied research. That is leveraging off new technologies identified by research programs in space, aeronautics, communications, computer science, and other related fields of exploration. Developmental activities beyond this stage are found in the Engineering, Development, Test, and Evaluation activity of the FAA's Facilities and Equipment (F&E) appropriations.

The FAA has a statutory requirement, pursuant to 49 United State Code 4450 (c) to publish yearly a National Aviation Research Plan. Copies of the 2000 Plan are available to JACG Principals and Board members.

Of the $156,495M appropriated for R&D efforts in FY 2000, 28% of these funds are earmarked for long-term research, with the remainder devoted to developmental/near-term efforts. Similarly, the $184.366M FY 2001 Congressional budget submission for R&D designates 23% of the total request for long-term research.

STRATEGIC GOALS, FOCUS AREAS AND ROADMAPS

The FAA strategic goals, focus areas and roadmaps are grouped into four major categories i.e. safety, security, efficiency and environment.

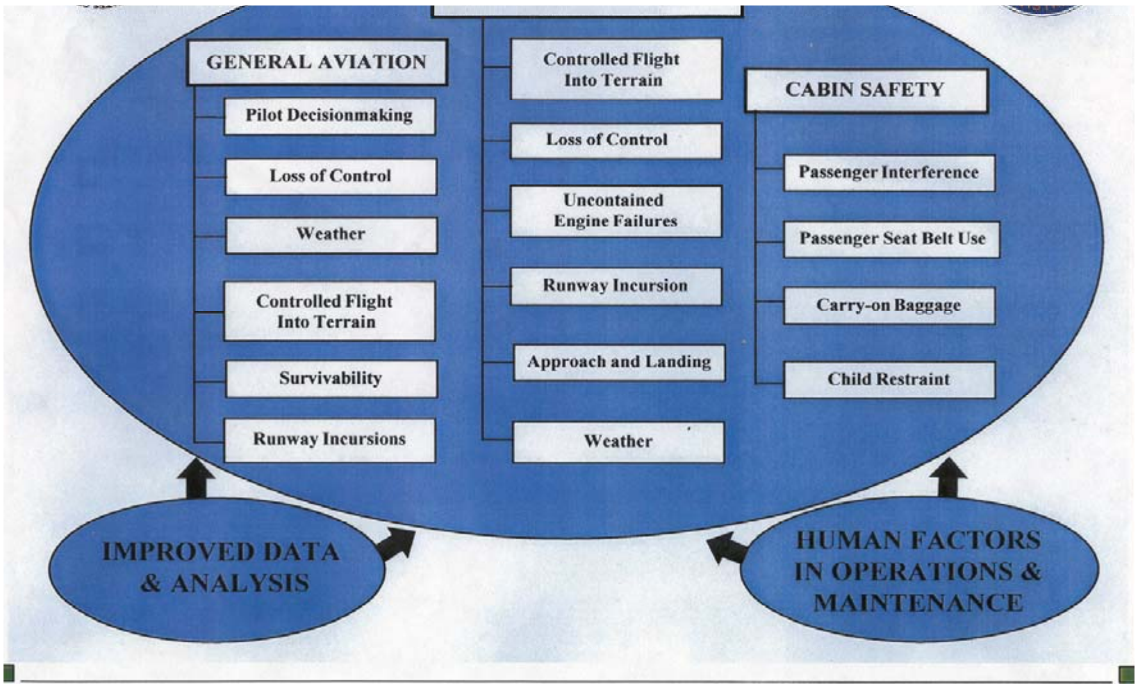
Goal 1: Aviation Safety

By 2007, reduce the U.S. aviation fatal accident rates by 80% from the 1996 levels. The focus areas associated with this goal include:

- Reduce fatal accident rate
- Reduce overall accident rate
- Reduce fatalities and losses by type of accident
- Reduce occupant risk
- Accident Prevention
- Surveillance and Inspection
- Safety Information Sharing and Analysis
- Regulatory Reform

In 1997, the President's Commission recommended the FAA launch a concentrated effort to reduce accidents fivefold over the next decade. The National Civil Aviation Review Commission (NCARC) concurred and further advised that the FAA work with industry on safety data analysis. Later that year, the Administrator committed the agency to developing a five-year plan to focus its resources on the accident prevention steps that hold the greatest potential. "Safer Skies" was the result. The essence of the initiative was to look at available data and to draw lessons from it—a pointed, pragmatic research emphasis.

Safer Skies has focused on these areas: commercial aviation, general aviation, and cabin safety. This focused agenda is depicted in the following chart.


GENERAL AVIATION
Pilot Decisionmaking
Loss of Control
Weather
Controlled Flight Into Terrain
Survivability
Runway Incursions
Controlled Flight Into Terrain
Loss of Control
Uncontained Engine Failures
Runway Incursion
Approach and Landing
Weather
CABIN SAFETY
Passenger Interference
Passenger Seat Belt Use
Carry-on Baggage
Child Restraint
IMPROVED DATA & ANALYSIS
HUMAN FACTORS IN OPERATIONS & MAINTENANCE

Goal 2: Security

Prevent security incidents in the aviation system. The focus areas associated with this goal include:

- Increase explosive device and weapons detection
- Increase compliance with security requirements
- Reduce risk and vulnerability at airports and airway facilities
- New Security Baseline
- Performance and Procedures
- Information Security Architecture

Goal 3: Efficiency

Provide an Aerospace Transportation System that meets the needs of user and is efficient in application of FAA and aerospace resources. The major focus areas associated with this goal include:

- Increase system flexibility
- Increase user access
- Reduce system delays
- NAS Modernization
- Free Flight
- Systems Integration

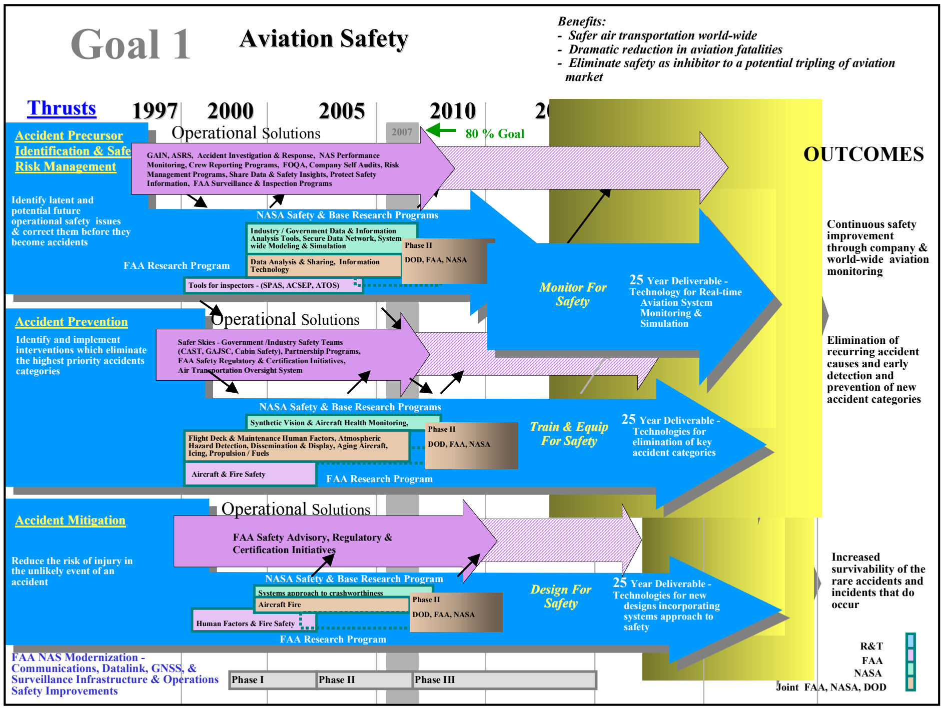
Goal 4: Environment

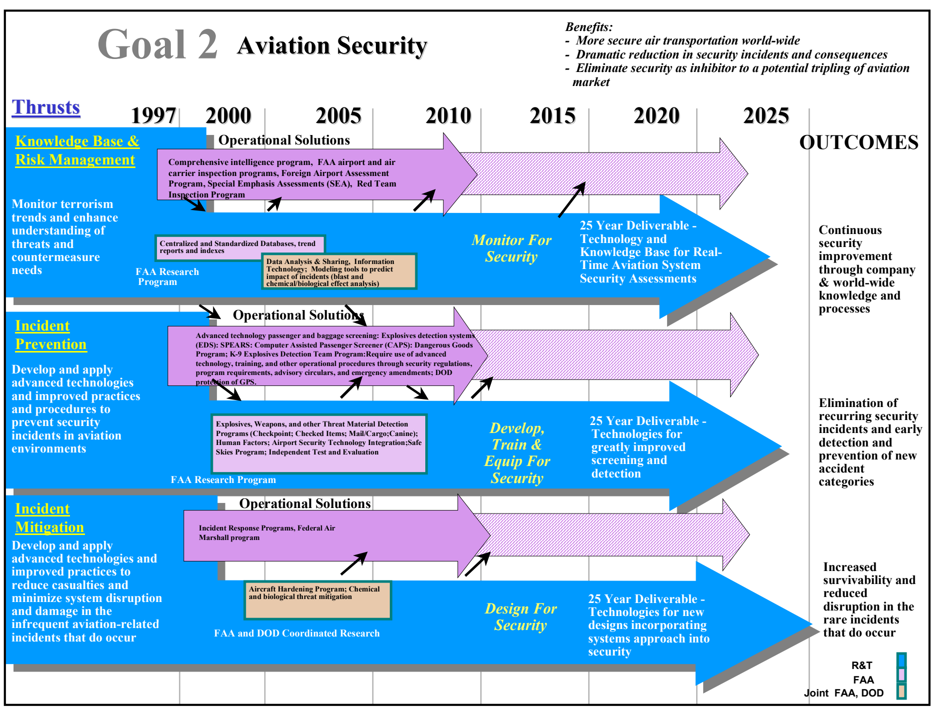
The environmental impact of aerospace must be reduced in ways which do not constrain aviation and commercial space transportation activities. The focus areas associated with this goal include:

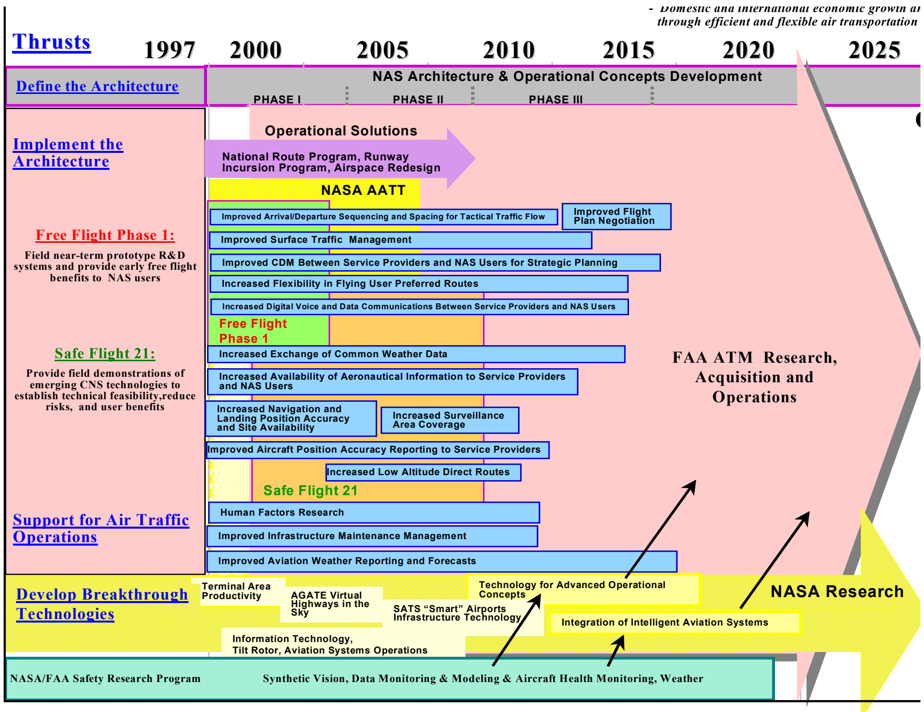
- Reduce environmental and community impact of aircraft noise
- Reduce environmental and community impact of harmful emissions
- Understand environmental impacts

The above noted areas will be addressed by: developing noise and emission standards for certification of new and modified airframe and engine designs (joint FAA/NASA partnership), developing technical guidance on certification procedures and practices and by developing models and impact criteria for civil aviation authorities' use in environmental assessment of proposed NAS changes.

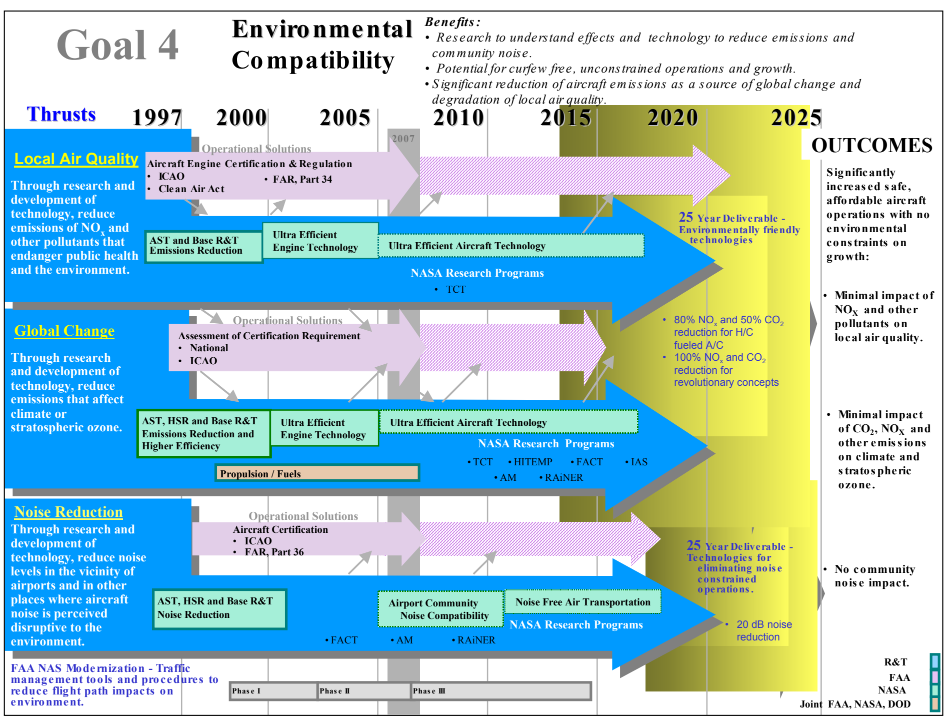
TECHNOLOGY INSERTION ROADMAP







Domestic and international economic growth through efficient and flexible air transportation
Thrusts
1997
2000
2005
2010
2015
2020
2025
Define the Architecture
NAS Architecture & Operational Concepts Development
PHASE I
PHASE II
PHASE III
Implement the Architecture
Operational Solutions
National Route Program, Runway Incursion Program, Airspace Redesign
NASA AATT
Improved Arrival/Departure Sequencing and Spacing for Tactical Traffic Flow
Improved Flight Plan Negotiation
Free Flight Phase 1:
Field near-term prototype R&D systems and provide early free flight benefits to NAS users
Improved Surface Traffic Management
Improved CDM Between Service Providers and NAS Users for Strategic Planning
Increased Flexibility in Flying User Preferred Routes
Increased Digital Voice and Data Communications Between Service Providers and NAS Users
Free Flight Phase 1
Increased Exchange of Common Weather Data
Safe Flight 21:
Provide field demonstrations of emerging CNS technologies to establish technical feasibility,reduce risks, and user benefits
Increased Availability of Aeronautical Information to Service Providers and NAS Users
Increased Navigation and Landing Position Accuracy and Site Availability
Increased Surveillance Area Coverage
Improved Aircraft Position Accuracy Reporting to Service Providers
Increased Low Altitude Direct Routes
Safe Flight 21
FAA ATM Research, Acquisition and Operations
Support for Air Traffic Operations
Human Factors Research
Improved Infrastructure Maintenance Management
Improved Aviation Weather Reporting and Forecasts
Develop Breakthrough Technologies
Terminal Area Productivity
AGATE Virtual Highways in the Sky
SATS "Smart" Airports Infrastructure Technology
Technology for Advanced Operational Concepts
Integration of Intelligent Aviation Systems
NASA Research
Information Technology, Tilt Rotor, Aviation Systems Operations
NASA/FAA Safety Research Program
Synthetic Vision, Data Monitoring & Modeling & Aircraft Health Monitoring, Weather



Goal 4
Environmental Compatibility
Benefits:
• Research to understand effects and technology to reduce emissions and community noise.
• Potential for curfew free, unconstrained operations and growth.
• Significant reduction of aircraft emissions as a source of global change and degradation of local air quality.
Thrusts
1997
2000
2005
2010
2015
2020
2025
OUTCOMES
2007
Local Air Quality
Through research and development of technology, reduce emissions of NO_x and other pollutants that endanger public health and the environment.
Operational Solutions
Aircraft Engine Certification & Regulation
• ICAO
• Clean Air Act
• FAR, Part 34
AST and Base R&T Emissions Reduction
Ultra Efficient Engine Technology
Ultra Efficient Aircraft Technology
NASA Research Programs
• TCT
25 Year Deliverable - Environmentally friendly technologies
Significantly increased safe, affordable aircraft operations with no environmental constraints on growth:
• Minimal impact of NO_X and other pollutants on local air quality.
Global Change
Through research and development of technology, reduce emissions that affect climate or stratospheric ozone.
Operational Solutions
Assessment of Certification Requirement
• National
• ICAO
• 80% NO_x and 50% CO_2 reduction for H/C fueled A/C
• 100% NO_x and CO_2 reduction for revolutionary concepts
AST, HSR and Base R&T Emissions Reduction and Higher Efficiency
Ultra Efficient Engine Technology
Ultra Efficient Aircraft Technology
NASA Research Programs
• TCT • HITEMP • FACT • IAS
• AM • RAiNER
Propulsion / Fuels
• Minimal impact of CO_2, NO_X and other emissions on climate and stratospheric ozone.
Noise Reduction
Through research and development of technology, reduce noise levels in the vicinity of airports and in other places where aircraft noise is perceived disruptive to the environment.
Operational Solutions
Aircraft Certification
• ICAO
• FAR, Part 36
25 Year Deliverable - Technologies for eliminating noise constrained operations.
• No community noise impact.
AST, HSR and Base R&T Noise Reduction
Airport Community Noise Compatibility
Noise Free Air Transportation
NASA Research Programs
• FACT • AM • RAiNER
• 20 dB noise reduction
FAA NAS Modernization - Traffic management tools and procedures to reduce flight path impacts on environment.
Phase I
Phase II
Phase III
R&T
FAA
NASA
Joint FAA, NASA, DOD

COMMON THEMES

- Safety
- Engine Emissions and Noise
- Aging Aircraft/Avionics
- Security
- Modeling and Simulation
- Human Effectiveness
- Material and Manufacturing Technology
- Weather, icing, and winter operations
- Airport and Terminal Airspace Capacity
- Technology Transition

Return to TOC

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

VISION

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

OVERVIEW OF AGENCY MISSION

The mission of NASA's Aero-Space Technology Enterprise is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aeronautics and space transportation technologies. Through its research and technology accomplishments, it promotes economic growth and national security through a safe, efficient national aviation system and affordable, reliable space transportation.

STRATEGIC GOALS AND OBJECTIVES

Research and technology play a vital role in ensuring the safety, environmental compatibility, and productivity of the air transportation system and in enhancing the economic health and national security of the Nation. However, numerous factors including growth in air traffic, increasingly demanding international environmental standards, an aging aircraft fleet, aggressive foreign competition, and launch costs that impede affordable access to and utilization of space represent formidable challenges to the Nation. In 1997, NASA released its 3 Pillars and 10 Goals, establishing a new strategic framework for the Aerospace Technology Enterprise. Since that time, we have made tremendous technical progress, learned a great deal, have adjusted our priorities and have also expanded the scope of the Enterprise to include long-term space technology. Consequently, we are updating our strategic framework to reflect these changes and learning. The new strategic goals and objectives will be published in the NASA Strategic Plan in Fall 2000, and further details will be available through the Aerospace Technology Enterprise Strategic Plan which will be published soon after. The goals represented below are from the existing framework.

Pillar One: Global Civil Aviation

Prior to 1974, large commercial transport manufacturing was the domain of the United States, which held more than 90% of the world market share. Today, that market consists of more than 12,000 airplanes in commercial service, and the U.S. share has dropped significantly. Projections linked to world economic growth suggest that the demand for air travel will triple over the next 20 years, requiring thousands of new aircraft. To preserve our Nation's economic health and the welfare of the traveling public, NASA must provide technology advances for safer, more environmentally compatible, and more affordable air travel.

Goal 1: Aviation Safety

Our society is highly dependent on air transportation. Great strides have been made over the last 40 years to make flying the safest of all the major modes of transportation. If air traffic triples as predicted within the next 20 years, even today's low rate of less than two accidents per million flights will be unacceptable. Dramatic steps, through joint FAA and NASA research, will assure unquestioned safety for the traveling public.

Enabling Technology Objective: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Goal 2: Emissions Reduction

Based on analyses of contributors to worldwide emissions, aviation plays only a small role. To be sure that this does not change, even as air traffic grows, aviation products need to be environmentally friendly. To make sure that the next generation of aircraft is as clean as possible, NASA is working on the necessary technologies. In the global picture, it is in everyone's best interest to ensure a clean environment for future generations.

Currently, NASA is focused on research to reduce nitrogen oxides (NOx), which are emitted from jet engines. The impact of NOx is that at low altitudes it contributes to smog, and at higher altitudes it can affect the ozone layer.

NASA research is attacking this problem from two sides. First, we want to understand atmospheric chemistry and the impact of emissions. The second approach is to reduce the engine combustion byproducts. The scientific analyses are helping us model the atmosphere to understand and assess its long-term health. Combined with the technology to reduce emissions, these studies will help guide rational decision-making for aviation.

Enabling Technology Objective: Reduce emissions of future aircraft by a factor of three within 10 years, and by a factor of five within 25 years.

Goal 3: Noise Reduction

NASA's 10-year goal is to develop technology to reduce the noise impact from aircraft so that the communities surrounding airports hear one half of the noise that they heard in 1997. In technical terms, this means a 10-decibel (dB) reduction in noise. This amount of noise reduction is similar to the difference in traffic noise from a road with heavy traffic and the same road with light traffic. The source of the noise from today's airplanes is primarily from jet engines, but noise from the airplane itself, particularly during approach, is a strong contributor to the overall noise impact.

Enabling Technology Objective: Reduce the perceived noise levels of future aircraft by a factor of two from today's subsonic aircraft within 10 years, and by a factor of four within 25 years.

Goal 4: Aviation System Capacity

Between 1990 and 1993, each of the 23 major U.S. airports experienced more than 20,000 hours of flight delay. Approximately 64 percent of those delays were attributed to poor weather, and 28 percent were attributed to congestion. These delays cost an estimated $6 billion per year. With the projected growth in air traffic, the number of delays will continue to increase. An additional concern is the rising number of reported surface incidents (287 in the United States in 1996).

Enabling Technology Objective: While maintaining safety, triple the aviation system throughput, in all weather conditions, within 10 years.

Goal 5: Affordable Air Travel

For the aircraft manufacturers, a major challenge is to reverse the trend of increasing aircraft ownership and operating costs. Dramatic savings in design time, manufacturing, and the cost of certification are needed.

Enabling Technology Objective: Reduce the cost of air travel by 25 percent within 10 years, and by 50 percent within 25 years.

Pillar Two: Revolutionary Technology Leaps

Aviation has always been an exciting and risk-taking endeavor. With a strong partnership among industry, Government, and academia, there has been an incredible history of innovation and technological breakthroughs.

The pioneering spirit at work in the X-1 and X-15 projects is being recaptured through the renewed emphasis of X-planes. The breakthrough work accomplished by these projects will move our country forward with an improved base of technical knowledge.

In addition to the tools of flight, next-generation design tools will revolutionize the aviation industry. Design was once simply applying lead to paper. Research in information technology will elevate the power of computing tools through fuzzy logic and artificial intelligence. These tools will integrate multidisciplinary product teams, linking design, operations, and training data bases to dramatically cut design-cycle times.

Goal 6: High-Speed Travel

To ensure our Nation's long-term aeronautical leadership, we must look to a future of value-based competition. Simply put, the United States must bring to market products that dramatically benefit the travelling public and do so without harming the environment.

Since the sound barrier was broken 50 years ago, most modern fighter aircraft have the capability to fly faster than the speed of sound. However, today's supersonic engines cannot meet the public's standards for a clean and quiet community. To bring this capability to commercial air travel, a number of technical barriers must be overcome.

Enabling Technology Objective: Reduce the travel time to the Far East and Europe by 50 percent within 25 years, and do so at today's subsonic ticket prices.

Goal 7: General Aviation

The general aviation segment of air travel, which includes privately owned aircraft, has tremendous potential for growth if a number of technical issues are solved. At its peak in 1978, the U.S. general aviation industry delivered 17,811 aircraft. In 1993, the number of aircraft delivered had fallen to 954, an all-time low. Along with a critical tort reform in 1994, the technology innovations anticipated for general aviation will revolutionize and revitalize this industry.

Enabling Technology Objective: Invigorate the general aviation industry, delivering 10,000 aircraft annually within 10 years, and 20,000 aircraft annually within 25 years.

Goal 8: Design Tools and Experimental Planes

NASA is about opening the air and space frontier. Our heritage of experimental aircraft programs has and continues to push the envelope. Experimental aircraft, or "X-planes", are invaluable tools for exploring new concepts and for complementing and strengthening laboratory research. New design tools will cut cost and cycle time while improving safety and the quality of new products.

Enabling Technology Objective: Provide next-generation design tools and experimental aircraft to increase design confidence, and cut the development cycle time for aircraft in half.

Pillar Three: Advanced Space Transportation

Our experience with the vast resource of space has already yielded new treasures of scientific knowledge, life-enhancing applications for use on Earth, and fantastic celestial discoveries. The potential for the future seems almost limitless, but we must begin now if we are to succeed in realizing the benefits that leadership in this endeavor will bring. NASA envisions successive but overlapping efforts to dramatically reduce costs and increase the reliability of space transportation.

Goal 9: Low-Cost Space Access

Without affordable and reliable access to space, the future of the space program is hindered by the high cost, low reliability, and poor operability of payload launch. Government space access needs are only a part of the growing U.S. space enterprise. In the last 25 years, the U.S. has developed one major launch vehicle and rocket engine. To realize the potential for research and commerce in space, America must achieve one imperative overarching goal – affordable access to space.

Enabling Technology Objective: Reduce the payload cost to low-Earth orbit by an order of magnitude, from $10,000 to $1,000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

Goal 10: In-Space Transportation

While enabling low-cost Earth-to-orbit transportation (Goal 9) is a critical first step, over 70 percent of all payloads need transportation beyond low-Earth orbit. In-space transportation systems of the future will feature simpler, lighter weight, low-maintenance vehicles that may use alternative energy sources.

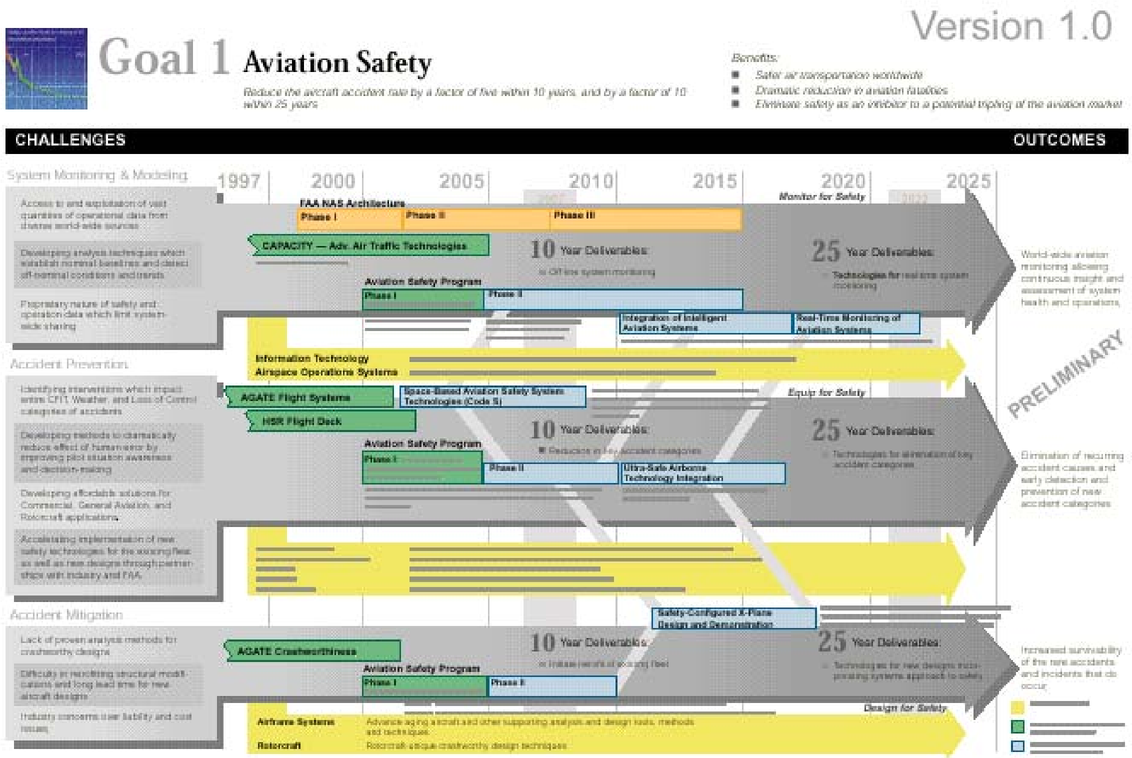
Enabling Technology Objective: Reduce the cost of interorbital transfer by an order of magnitude within 15 years, and reduce travel time for planetary missions by a factor of two within 15 years, and by an order of magnitude within 25 years.

TECHNOLOGY INSERTION ROADMAP

The strategic goal roadmaps articulate the challenges we must meet, the outcomes we seek, and the logical progression of programs that will overcome the challenges and enable the outcomes. Fundamentally, the roadmaps represent what NASA can contribute through advanced technology and new system concepts toward National goals that advance the air and space transportation interests of our Nation and the world.

The central element of the roadmaps is the critical technology programs that are required to meet the goals. However, the goals will only be achieved through the application of the technologies to real operational systems. Therefore, it is fundamental that we perform these programs in partnership with the air and space transportation manufacturing and operational communities. It is essential that we continue to build and evolve the roadmaps over time to ensure the flow of technologies into service.

Below is a sample Aviation Safety Roadmap and links to the internet websites of the ten current Enabling Technology Objective Roadmaps. [These are described at: http://www.hq.nasa.gov/office/aero/ .]



[Aviation Safety Roadmap]
[Emissions Reduction Roadmap]
[Noise Reduction Roadmap]
[Aviation System Capacity Roadmap]
[Affordable Air Travel Roadmap]
[High-Speed Travel Roadmap]
[General Aviation Roadmap]
[Design Tools and Experimental Planes Roadmap]
[Low-Cost Space Access Roadmap]
[In-Space Transportation Roadmap]

FUTURE NEEDS/DEFICIENCIES

In order to determine the requirement for new Programs, an assessment is made of the contents of each Goal Roadmap, and whether existing Programs will allow the goal to be achieved. Where gaps exist, a Goal Needs Statement is developed to address the deficiency. Those statements, when available, can be accessed from the Roadmaps.

COMMON THEMES

Since it is the mission of NASA to develop aeronautical technologies for application by industry, the military, and other government customers, there is little in the NASA Program that is not a common theme with another agency. Some of the specific common aeronautics themes and formalized relationships are listed by NASA Goal:

Goal 1: Safety - FAA and NASA both have formalized Safety Programs.
NASA has MOU with USAF, MOA with FAA, and is on JACG's
IPT on Aging Aircraft.
USAF - NASA Partnership Area: Concurrent airspace operations
of UAVs
FAA & NASA interests in weather, icing, runway friction.
Goal 2: Emissions - USAF - NASA Partnership Area: Propulsion
Goal 3: Noise - FAA & NASA interests in noise reduction.
Goal 4: Throughput - DoD developing runway-independent aircraft (V-22)
Goal 5: Affordability - DoD considers affordability goal of JSF equal priority to
Performance
Goal 6: High Speed - USAF - NASA Partnership Area: Advanced Vehicles
Goal 7: General Aviation - NASA, FAA, and AFRL are partners in AGATE
Goal 8: Design Cycle & X-Planes - USAF - NASA Partnership Area: Advanced
Vehicles
USAF - NASA Partnership Area: Simulation-Based Acquisition / Intelligent Synthesis Environment
Goal 9: Access to Space - AFRL/VA Integrating Concept

Return to TOC

U.S. AIR FORCE

VISION

The Air Force's approach to defending the national security interests has changed tremendously over the last decade. Traditional approaches and organizational structures will no longer be effective in resolving the challenges that continued declining budgets and world situations present to Air Force capabilities. This realization has led to a new vision for America's Air Force Vision 2020– Global Vigilance, Reach and Power.

With Global Vigilance, Reach and Power, the Air Force will provide balanced aerospace capabilities, key to meeting national security objectives and realizing the full spectrum dominance envisioned by DoD Joint Vision 2020. The United States Air Force is a mission-focused, combat-proven, decisive fighting force. This vision will guide America's Air Force in meeting the diverse challenges of the 21st Century as a part of America's Joint Military Team.

**Revolutionary technological developments and dramatically improved operational concepts led to recent successes in Bosnia, Southwest Asia and Kosovo...
and promise even greater potential as we continue to transform the way we approach warfare.**

OVERVIEW OF AGENCY MISSION

The Mission of the Air Force is – "To defend the United States and protect its interests through aerospace power." Teamed with the Army, Navy Marine Corps and Coast Guard, the Air Force is prepared to fight and win any war if deterrence fails. As members of the Joint Team, our commitment is equally firm to live up to the trust of our multinational partners. To meet this challenge, the Air Force brings six core competencies to the fight:

- Aerospace Superiority
- Information Superiority
- Global Attack
- Precision Engagement
- Rapid Global Mobility
- Agile Combat Support

The Air Force bases these core competencies on a shared commitment to three core values -- *integrity first, service before self, and excellence in all we do*.

STRATEGIC GOALS AND OBJECTIVES/MAJOR THRUST AREAS

The Air Force is an innovative, adaptive force. We challenge ourselves after every mission, every day. What worked? What didn't? How do we become better? This kind of continuing innovation leads over time to dramatic improvement—sometimes known as transformation. Real transformation is not the result of a one-time improvement, but a sustained and determined effort. We have been engaged in that effort for more than ten years, and it is paying off in the dramatic improvements in capability that have been on display in places like the Persian Gulf and Kosovo. Impressive as those improvements have been, they are just the beginning. We recognize that aerospace power is America's asymmetric advantage—and we're determined to ensure America keeps that advantage.

We will continue exploring both science and technology and operational concepts, identifying those ideas that offer potential for evolutionary or revolutionary increases in capability. We'll test those ideas rigorously through experimentation to determine which have practical application worthy of development. We will ensure technological innovations continue to be accompanied by innovations in doctrine, organization and training. These intellectual innovations will prepare us to conduct and sustain decisive operations in major theater war and in other forms of conflict.

We will leverage information technology as a way to continue transforming our operational capabilities and command and control. And we'll encourage innovation in our research and battle labs, our product centers, logistics centers and warfare centers and across the force—recognizing that it is in the imagination of our people that new concepts and technologies key to future aerospace operations will be born.

The Air Force Science and Technology Investment Strategy sets the framework for detailed S&T planning. The strategy, first and foremost, calls for migration of the investment from aeronautical to space-related technologies, in order to enable the aerospace force of the future. This will be done by increasing the space investment, maintaining the investment in technologies that support both air and space, and protecting and focusing the most critical air investment. In FY00 an examination of the AF S&T investment showed that just over 70% of the technology portfolio applied to the "Air" or aviation mission set.

To better respond to the needs of the Air Force and DoD, the Air Force Research Laboratory (AFRL) has integrated its portfolio across directorates in the form of Enabling Technology Area (ETA) programs. ETA programs provide technology options for improved warfighting capability and include options for performance, sustainment, and affordability improvements. Some of the enabling technologies are single-discipline technology efforts and may transition directly to Air Force systems. The enabling technologies are managed by the technology directorates. Planning for these enabling technologies is by ETAs identified along with their technical thrusts below.

Space Vehicles ETA Space-Based Surveillance Space Capability Protection	**Directed Energy ETA** Advanced Optics and Imaging Laser Technology High Power Microwave	**Information ETA** Global Awareness Dynamic Planning & Execution Global Information Exchange
Sensors ETA Radio Frequency (RF) Sensors & Countermeasures Electro-Optical (EO) Sensors & Countermeasures Automatic Target Recognition & Sensor Fusion	**Munitions ETA** Hard Target Smart Munition Technology Hard Target Functional Defeat Technology Counterproliferation Munition Technology Air Superiority Missile Technology Small Smart Bomb Technology Anti-Materiel Munition Technology AEF Technology Close Air-Support Weapon Technology	**Propulsion ETA** Air Propulsion Power Technology Aerospace Propulsion Space Propulsion
Air Vehicles ETA Aeronautical Sciences Structures Control Science	**Human Effectiveness ETA** Crew System Interface Warfighter Training Bioeffects and Protection Deployment & Sustainment	**Materials and Manufacturing ETA** Materials and Processes for Structures and Propulsion Material and Processes for Sensors and Survivability Materials and Processes for Sustainment & Deployment

Air Force S&T Technical Thrusts by ETA

Of these 9 ETAs, 7 contain major areas of investment related to "aviation" missions. The rest of this section will be spent discussing these 7 ETAs.

Information

"Information Dominance for Space and Air Superiority"

The Information ETA develops Air Force unique information technologies for aerospace command and control using commercial practices and it transitions them to Air Force space, air, and ground systems for Global Awareness, Dynamic Planning and Execution, and Global Information Exchange. Areas of investigation for this ETA include fusion, communication, collaboration environments, distributed information infrastructures, modeling and simulation, defensive information warfare, and intelligent information systems and databases. Successful outcomes from these areas will provide affordable technology options required for Air Force Information Dominance and Aerospace Superiority. This ETA is committed to Information Dominance supporting Global Awareness by moving the relevant information through the Global Information Exchange environment that is predominantly commercial-based for the dynamic planning and execution of the battle plan.

Investment Strategy for Information ETA

The investment strategies defined by this ETA support *Joint Vision 2020*, the 10 JWCOs of the JWS&TP, and Service/Agency visions and requirements. Information superiority will allow warfighters to dominate and control the battlespace. This control is essential to virtually all joint warfighting capabilities in the 21st Century.

Strategic investment priorities must address warfighters' stated needs. Four generic considerations have high priority in making decisions about which specific technologies are pursued: affordability, dual use, accelerated transition, and a strong technology base. Diminished resources require greater emphasis on affordability throughout the S&T program. Dual use aspects of the program will contribute to building a common industrial base by using commercial practices, processes, and products and by developing, where possible, technology that can be the base for both military and commercial products and applications. However, to maintain our technological superiority, DoD must still field new state-of-the-art systems, at the rapid pace set by Air Force requirements.

The following capabilities are being developed to support the warfighter: acquire, store, distribute and protect information; quickly assimilate raw data for rapid ascension from data to knowledge to effective decisions; collaboration of real-time decisions across the force; assess, choose and rehearse courses of action; monitor execution results; and adjust plans, processes and resources to accommodate the dynamic battlespace environment. Technology efforts within the Information ETA are responsive to Air Force S&T and the unified DoD S&T investment strategy and are reported under the Project Reliance Information Systems Technology Panel.

FYDP Investment Strategy for Information ETA

To provide these capabilities the Information ETA has three thrusts: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange. Descriptions of each thrust are itemized as follows:

Information Technology ETA Thrusts

- Global Awareness
- Dynamic Planning and Execution
- Global Information Exchange

Global Awareness

Global Awareness provides a single, integrated battlespace picture on demand to support operations. The thrust has three subthrusts: Information Exploitation, Information Fusion, and Global Information Base. Information Exploitation is a set of processes that interpret and extract information from a time history of data. It registers the information in both time and geographical reference and stores the results in an easily accessed form in the Global Information Base. Information Fusion will correlate and analyze events, activities and movements, as they occur in time and space, for determining location, identity and status of individual objects (equipment and units). This correlation also determines threats to coalition operations and detects patterns for activities that reveal intent or capability. Global Information Base (GIB) is a distributed, heterogeneous data/information management system which stores awareness information and provides information services to dynamic planning and execution operations. Global Awareness goals include increasing the amount of data exploited,

Global Awareness Subthrusts

- Information Exploitation
- Information Fusion
- Global Information Base

information fusion, with scalable resolution and accuracy, and storage /processing of information on platforms.

Dynamic Planning and Execution

Dynamic Planning and Execution describes the future operational capability to acquire and exploit superior, consistent knowledge of the battlespace. To accommodate the full scale of Air Force missions, dynamic planning and execution capabilities will be scaleable to minimize the deployment footprint. This will be accomplished by a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligence information specialists.

The Dynamic Planning/Execution thrust has three subthrusts: Next Generation C2, Collaboration/ Simulation/Visualization Technologies, and Aerospace Integration. The next Generation C2 program focuses on enabling a two orders of magnitude improvement in the agility, accuracy, timeliness, and efficiency over current command and control processes and structures. The technology will permit unprecedented opportunities for future aerospace battlestaffs to shape and control the pace and phasing of engagements. Collaboration/Simulation/Visualization Technologies will provide planners and decision-makers with the ability to view, understand and analyze the vast amounts of information available from C4ISR systems. Collaborating teams require a common, shared-context data environment, where the visualization of the data is tailored to the application domain and the user preference. Specific M&S capabilities will assist in both proactive and reactive assessment. Aerospace Integration recognizes that the information system environment, in order to support future C4ISR operations, can no longer be limited to ground-based centers for the support of air operations. Aerospace Integration extends the current C4ISR information architecture to include sensor to decision-maker to shooter concepts, the integration of space assets, and the incorporation of airborne-C2 into a seamless aerospace information environment. The Dynamic Planning and Execution thrust's goal is faster, proactive, and timely planning and scheduling which will be coordinated across multiple components.

Global Information Exchange

Global Information Exchange is the ability to interconnect anywhere, at any time, and for any mission all members of the Air Force via a secure, survivable, high capacity, netted communication and information system. Inherent in this capability is the idea of universal information availability across different transmission media with different characteristics. The Air Force's information network must have global reach for its normal day-to-day operations as well as the capability to allow an instant surge of connectivity and capacity into a localized theater for mobile and fixed-site users.

Global Information Exchange Subthrusts

- Global Communications
- Defense Information Warfare
- Information Systems and Networking

The Global Information Exchange thrust has three subthrusts: Global Communications, Defensive Information Warfare, and Information Systems and Networking. Global Communications goals center on wireless information exchange systems and technologies that interconnect remotely separated command and control systems and users, providing high quality, timely, secure and low-probability-of-exploitation communications to air, land, and space. These services include voice, data, and multimedia with linkage to land-based terrestrial networks. The required capabilities provide line-of-sight and beyond-line-of-sight connectivity spanning the frequency ranges. Defensive Information Warfare is concerned with the defense of friendly information systems to ensure the authorized use of the information spectrum. This technology seeks to protect against corruption, exploitation and destruction of friendly information systems; ensure confidentiality, integrity and availability of systems; and integrate actions (offense, defense, and mitigation) to ensure an uninterrupted flow of information for weapons employment and sustainment. Information Systems and Networking will develop and integrate information-related technologies to improve operational C4I capability in a worldwide military/commercial infrastructure environment. Information systems management, network management and communications technologies need to be integrated to provide in-transit visibility of aircraft, airborne situational awareness, and warfighter reachback on diverse airborne platforms.

The Global Information Exchange thrust provides information anywhere, anytime, for any mission through adaptable and scaleable communications.

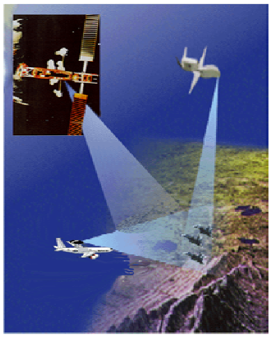
Information ETA FY25 Vision

This information ETA will continue to proactively pursue innovative technologies and strategic partnerships enhancing U.S. information dominance in the 21st Century. Its vision for FY25 is focused in three areas: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange.

Global Awareness will be achieved through a single, integrated battlespace picture to support operations. It will provide a fifty-fold increase in amount of data utilized, and a hundred-fold increase of information fusion with scaleable resolution and accuracy with a thousand-fold increase in storage and processing of information on platforms. Global Information Exchange will provide information anywhere, anytime, for any mission through adaptable and scaleable communications, but missions will have expanded into Space, and may include SpacePlane vehicles and other Space Force information requirements and resources. The scope of the Global Information Exchange Thrust will continue to include widely distributed and mobile C2 (now including "in-space" assets), in-transit visibility (for airborne and spaceborne vehicles), information on demand, information warfare attack detection and recovery, and assured survivable, and self-healing networking technology. Dynamic Planning and Execution will help a commander shape and control the pace and phasing of engagements through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligence information specialists.

Sensors

"Sensors for Information Superiority and Global Awareness"



Sensor systems provide the signals, images, and target/threat information needed to build an interactive common battlespace picture - providing comprehensive, accurate, and timely situational awareness for the warfighter. The platforms of the military force that respond to a hostile situation must rely on their sensor systems for effective target/threat engagement and self-defense. Sensor systems are among the most critical of military assets, needed throughout the timeline of military operations. The vision of the Sensors ETA is to develop a full range of affordable air and space sensors, networked to the warfighter, that assure a complete and timely picture of the battlespace for precision engagement and survivability. The Sensors ETA will develop technologies needed by DoD to produce, field, and maintain advanced sensors for air and space reconnaissance, surveillance, precision engagement, and electronic warfare applications. Key areas include radar, active and passive electro-optical (EO) systems, electronic support measures and countermeasures, navigation aids, Automatic Target Recognition (ATR) and sensor data fusion.

Investment Strategy for Sensors ETA

This ETA has three investment strategies. The first is to exploit new sensor phenomenology and architectures to lead the state-of-the-art and inspire revolutionary system concepts and military capabilities. The second is to provide sensor technologies to support the efficient operation of a full-spectrum, multi-directorate revolutionary technology and system concept development partnership. The third is to support warfighter needs of the MAJCOMs to assure that the United States can field the most affordable and effective fighting force in the world.

FYDP Investment Strategy for Sensors ETA

To achieve these objectives, the Sensors ETA's investment strategy is organized around three technology development thrusts. These thrusts are: Radio Frequency Sensors and Countermeasures (CM), Electro-Optical Sensors and Countermeasures, and Automated Target Recognition and Sensor Fusion. To assure sensor technologies are also relevant, technology investments and weapon system applications are tracked within three application objectives that cross-cut the technology thrusts: ISR; precision engagement (PE); and electronic warfare (EW). An additional crosscutting view is maintained for militarily unique electronic devices and components that have pervasive application within a variety of sensor systems.

Sensors ETA Thrusts

- Radio Frequency Sensors and Countermeasures
- Electro-Optical Sensors and Countermeasures
- Automated Target Recognition and Sensor Fusion

Radio Frequency Sensors and Countermeasures

The RF Sensors and Countermeasures thrust develops technologies for airborne and space-based RF sensors to perform all-weather threat/target acquisition,

Radio Frequency (RF) Sensors and Countermeasures Subthrusts

- Radar
- Electronic Warfare
- RF Assured Reference
- Apertures
- Algorithms and Phenomenology
- Digital Receivers and Exciters

tracking, and identification; platform self defense; and counter enemy command, control, intelligence, surveillance and reconnaissance. Specifically included are airborne and space-based radars for target detection and tracking and EW systems for electronic attack and electronic protection. Supporting technologies include low cost compact antennas, digital and optical beam forming, high dynamic range digital receivers, adaptive processing, RF phenomenology, and high performance/militarily unique electronic components.

The RF Sensors and Countermeasures thrust has six subthrusts: Radar, which includes detection of difficult targets, space-based radar, and tool development, electronic warfare (EW), including electronic attack, electronic protection and C3 countermeasures; Assured Reference, which includes GPS modernization, inertial technology and integration technology; RF apertures, which includes large, lightweight antennas, conformal arrays, multi-function, multi-mode antennas and digital beam forming antennas; Algorithms and Phenomenology, which includes adaptive processing, detection and tracking, waveform diversity and phenomenology; and Digital Receivers and Exciters, which include EW, radar, and GPS.

Electro-Optical Sensors and Countermeasures

This thrust conducts advanced and exploratory development of technologies and systems needed to assure that Air Force aerospace vehicles accomplish the full scale of their future missions. Research will be focused on technologies for space, but could provide any aerospace vehicle the capability to rapidly search, detect, identify, and acquire targets, over large geographic areas. The warfighter will use this information to optimize the use of weapons as well as conduct aerospace vehicle self protection against guided/directed threats that operate in the optical/infrared spectral regions. Hyperspectral sensor technologies and Laser Detection and Ranging (LADAR) technologies will be developed and integrated into systems to detect, identify and negate targets in all weather conditions. Laser technologies will be developed to provide high speed, high bandwidth, and low probability of intercept communication between aerospace vehicles. The thrust will also incorporate into our aerospace vehicles active, laser-based countermeasures as well as new expendables to significantly enhance their survivability against the future, sophisticated EO/IR threats.

Electro-Optical (EO) Sensors and Countermeasures Subthrusts

- Target Detection & Identification
- Threat Warning & Countermeasures
- Receivers
- Transceivers
- Algorithms and Phenomenology

The EO Sensors and Countermeasures thrust has the following subthrusts: Target Detection and Identification, which includes large area search/detection, precision/difficult targeting, NBC detection and ID; Threat Warning and CM, which includes large aircraft IRCM, day/night EO/IR tracker CM, new flares and expendables, all aspect threat warning, threat warning/attack reporting, and laser warning; Receivers, which includes hyperspectral sensor imaging (HSI) receivers for target search, detection and threat warning, multi-dimensional imaging sensors, and receivers for eye-safe LADAR; Transceivers which includes frequency agile laser sources, non-mechanical beam steering, long-range, robust laser radar, multi-discriminant EO sensors, and laser communications; and Algorithms and Phenomenology which include n-dimensional LADAR techniques; HSI phenomenology and techniques, imaging threat investigation, and multi-discriminant EO sensors.

The EO Sensor and Countermeasures thrust has two primary goals: provide affordable, long-range, all weather, day/night detection and identification of non-cooperative and deep-hide targets, and provide affordable protection of the Air Force aerospace vehicles from a lethal and potent EO/IR threat.

Automated Target Recognition and Sensor Fusion

This thrust provides warfighters with enhanced capability to rapidly find, fix, identify, and track targets on the surface, in the air, and in space, from airborne and spaceborne platforms. This ATR capability must be timely and accurate enough to prosecute time critical targets under the variety of conditions encountered in both military conflicts and peacekeeping missions. The ATR Thrust works closely with the RF and EO Sensors Thrusts to process and fuse sensor signals to find, fix, identify, and track all targets of military significance in the battlespace.

Automated Target Recognition and Sensor Fusion Subthrusts

- Space and Air Sensors Automated Target Recognition
- Precision Identification and Location
- Automated Target Recognition Spiral Development
- Innovative Algorithms
- Target and Phenomenology Modeling
- Evaluation Science

The ATR and Sensor subthrusts include Space and Air Sensors ATR, which includes synthetic aperture radar ATR, RF moving target ATR, multi-sensor ATR, and hyperspectral ATR; Precision Identification and Location, which includes combat ID and fire control for air and space superiority, special operations forces, and combat ID for time critical targets and other air-to-surface missions; ATR Spiral Development, which includes modeling, simulation, and integration, ATR environment and data generation; and Innovative Algorithms, which includes physics-based ATR, adaptive ATR and resource management for ATR; Target and Phenomenology Modeling, which includes computational electromagnetics (CEM), computer-aided design (CAD) model development, electromagnetic (EM) phenomenology and validation, modeling and simulation physics and application objective support; and Evaluation Science, which includes performance theory, and evaluation experiments.

Sensors ETA FY25 Vision

The Sensors ETA will continue to proactively pursue innovative technologies and strategic partnerships enhancing U.S. sensor dominance in the 21st Century. Its vision for FY25 is focused in three areas: RF Sensors and Countermeasures, EO Sensors and Countermeasures, and ATR and Sensor Fusion.

RF Sensors and Countermeasures will provide sensors for supporting the warfighter to improve space superiority, flexible strike, and EAF protection. Specifically, RF sensor technologies will be developed to enable multifunction micro-satellite ISR capabilities and very compact, flexible radar. EW sensors will be developed to support multifunction UAVs for global awareness and survivability requirements.

EO Sensors and Countermeasures will seek revolutionary and enabling technologies to support the warfighter kinetic kill countermeasure system; a laser threat warning system for air vehicles and space-borne assets; hyperspectral imaging for detection and identification of hidden/camouflaged targets; threat missile warning; multi-band lasers to countermeasure a wide variety of threat systems; secure laser communications for aerospace vehicles; LADAR technologies for ground and airborne targets; non-mechanical beam steering technologies and multi-functional EO systems which provide offensive and defensive capabilities within one configuration.

ATR and Sensor Fusion will provide advanced ATR and sensor fusion algorithms that will be able to process currently unexploited sensor signals and fuse these with existing sensor information to improve friend or foe target recognition. It will provide advanced ATR and sensor fusion algorithms and tagging techniques that can detect and track potential targets. Advanced ATR and sensor fusion techniques that allow reliable detection, identification, and tracking of NBC weapons of mass destruction, as well as their pre-assembly components, will become a reality. Advanced ATR and sensor fusion techniques will be developed to allow reliable detection, identification, and tracking of deeply hidden targets. Rapid target modeling and insertion for rapid updates into algorithms for multiple sensor phenomenology ATR and cross-sensor fusion will also become available.

Munitions

"Highly Effective, All Weather Conventional Weapons for Global Engagement"

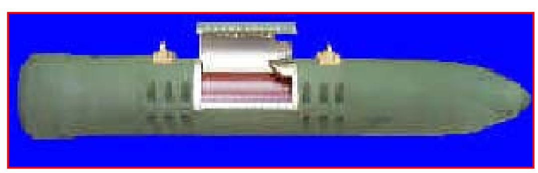
Munitions

- Hard Target Smart Munition Technology
- Hard Target Functional Defeat Technology
- Counterproliferation Munition Technology
- Air Superiority Missile Technology
- Small Smart Bomb Technology
- Anti-Material Munition Technology
- AEF Technology
- Close Air Support Weapon Technology

The vision of Munitions is to develop affordable and highly effective armament technologies to enable warfighters to efficiently accomplish wartime objectives in all weather conditions. The goal is to continuously improve the existing munition fleet through product improvement of existing systems and development of a minimal number of new systems and develop technologies for affordable new weapons that will come online in the new millennium. This vision will be achieved by focusing efforts in eight Integrating Concepts: Hard Target Smart Munition Technology, Hard Target Functional Defeat Technology, Counterproliferation Munition Technology, Air Superiority Missile Technology, Small Smart Bomb Technology, Anti-Materiel Munition Technology, Air Expeditionary Forces (AEF) Technology, and Close Air Support Weapon Technology.

Hard Target Smart Munition Technology

The Hard Target Smart Munition (HTSM) Integrating Concept follows the vision of providing the warfighter with the means to hold many of the enemy's hardened and/or deeply buried structures at risk using conventional, air-delivered munitions. Potential adversaries are increasingly placing their most sensitive installations underground, where they are more difficult to destroy. The nature of these targets and their degree of protection led this team to examine innovative munition case designs that use state-of-the-art materials to aid in penetrating hardened defenses such as reinforced concrete and rock. New fuzing technologies are also under development. The fuzes that are required to detonate a warhead must first survive severe decelerations. The explosives themselves are required to function under similar



loads and still possess enough blast energy to defeat a target. Off the shelf, improved guidance and flight control technologies, that ensure a munition arrives over a target at nearly zero degrees angle-of-attack and at nearly ninety degrees impact angle, can be added to this weapon. There are three main areas of product team emphasis.

1. Support DoD initiatives with regard to hard target defeat using warheads delivered by high velocity missiles or a common aerospace vehicle.
2. Develop and integrate new materials, explosives and fuze designs capable of surviving high velocity impacts into hardened targets. This includes integration with a propulsion system required to attain the appropriate velocity and control systems to attack with pinpoint accuracies.
3. Integrate battle damage assessment (BDA) capability to provide real-time, interoperable, battle management.

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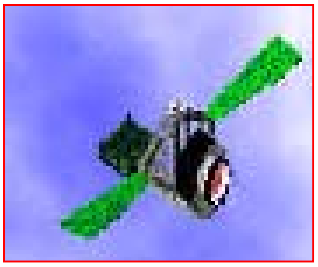
Hard Target Functional Defeat Technology

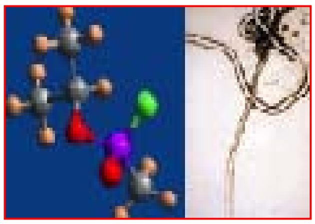
The Hard Target Functional Defeat (HTFD) Integrating Concept is developing technology to provide the warfighter with the means to deny, disrupt, disable, destroy, or gather intelligence on the enemy hard and/or deeply buried targets using non-conventional, air delivered systems. Potential adversaries are placing their most sensitive and highly valued installations underground, where they are more difficult to destroy. These targets require innovative technologies and alternative methods to functionally defeat key components necessary for their operation. To attack these targets several technology areas are being explored. (1) High energy fuels/explosives can be the power source to propel the weapon to the target and subsequently detonate the advanced payload. (2) Micro Electronic and Mechanical Systems (MEMS) can enable target access from numerous target portals. MEMS will reduce the size and weight of fuzing, power sources, guidance and controls, sensors, packaging, communications, logic systems, and propulsion systems. (3) Ground Penetrating Signals to characterize and pinpoint underground facilities and identify their operations. (4) Battle Damage Indicator and Assessments signal can alert the Smart Sensor Web for real-time battle management. (5) Influence Fuze weapons will discriminate between a hostile operation of war and noncombatant activity.



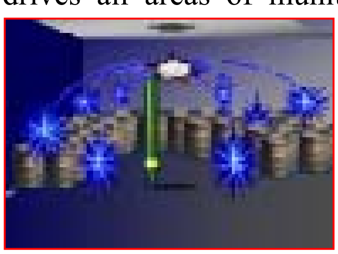
There are three main areas of product team emphasis.

1. Support for Operational Command initiatives with regard to defeating hardened targets using air or space delivered assets.
2. Develop and integrate weapon technologies capable of isolating and negating the enemy's high value facilities.
3. Develop battle damage assessment (BDA) technology for real-time battle management.

Counterproliferation Munition Technology

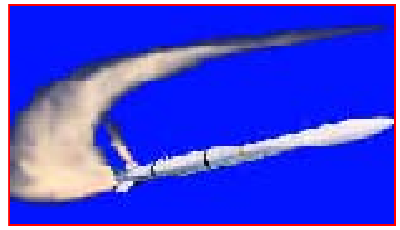


The Counterproliferation (CP) Integrating Concept Team works toward the ultimate goal of providing a weapon that can defeat all targets containing chemical and biological agents without negatively impacting any surrounding civilian populace. This effort is challenging because of the broad target spectrum and the breadth of agents. Counterproliferation targets are not unique to themselves but rather a subset of each type of target class. Chemical and biological agents may be stored and/or manufactured in hardened and/or deeply buried structures referred to as **hard targets**. They may be stored and/or manufactured in **soft targets** such as a sheet metal warehouse. Lastly they may be transported in various containers by a multitude of vehicles or they may already be a part of a mobile ground launched weapon referred to as **mobile targets**. The diversity of this target set demands constant assessment and advancement in a number of key areas ranging from guidance and control, penetrators, advanced payloads, and intelligent fuzes. Each target type is a unique problem with its own demand of weapon requirements. For instance, a hard target may be susceptible to explosive blast pressures while a soft target may be more susceptible to fragmentation. In addition to the type of target, the agents to be defeated add considerably to the overall problem. The basic technologies being explored as possible defeat mechanisms include thermal, photon radiation, and/or chemical neutralization of the agent. Each of these technology areas offers unique capabilities while also presenting significant challenges to the weapon designer. There is currently no one method or technique that is capable of defeating all agents. The differences between a biological and chemical target currently impact the selection of the defeat mechanism. The ultimate goal is to defeat, deny and/or disrupt the enemy's use of chemical and biological agents with a single weapon. The method used to defeat a CP target drives all areas of munition development. For example, as alternative defeat concepts are explored, areas such as new dispenser technologies need to be addressed. Similarly as weapon concepts migrate from explosive to alternative payloads; fuzes, warheads, casings, and penetrator designs will vary. CP targets will require advancements in many key technologies and will require constant interaction and flexibility in the future.

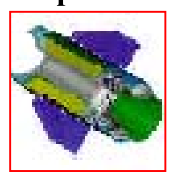


Air Superiority Missile Technology

The Air Superiority Missile (ASM) Integrating Concept is focused on the technical challenges of defeating broad classes of airborne targets as well as a limited set of ground based enemy air defense targets. The Air Superiority technology-planning process consists of four distinct sub-processes designed to provide technology solutions for both current and future postulated air combat operational needs.



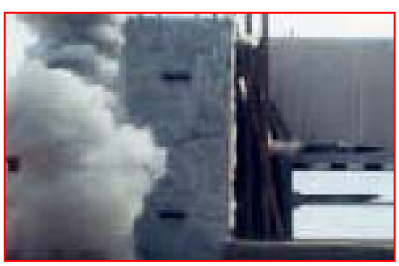
The **first** component of this 4-step process consists of establishing an **operational vision** for the future of air combat and air combat weaponry. The vision for the future of air combat weaponry includes the ability to engage targets at any aspect or geometry relative to the launch platform. This will provide future platforms with a highly lethal ‘offensive sphere’ extending to beyond visual range in all directions. Of particular interest is the development of advanced weapon technologies and weapon concepts to capitalize on the increased capabilities of developmental platforms including the F-22 and the Joint Strike Fighter (JSF), as well as future Uninhabited Combat Air Vehicle (UCAV) concepts. The **second** component consists of establishing a set of time-phased, quantifiable **weapon system performance objectives** to facilitate the realization of the operational vision. These performance objectives include maximizing missile no escape range, maneuverability, target selectivity/discrimination, and others. Achievements over the next 5 years will include ground tests of hybrid aerodynamic/reaction jet controls yielding 90 degree angle-of-attack and 600 degree/second pitch rate maneuverability for AMRAAM class weapons. In addition, ground tests of mass-focused ordnance technologies leading to increased delivered energy and probability of kill and multi-spectral sensor fusion techniques leading to increased missile situational awareness/autonomy will also be developed in this time period. The **third** component consists of identifying and formulating **specific technology programs** to address the time-phased weapon system performance objectives. Several essential technologies have been identified as focus areas for near/far term technology development. These focus areas include hybrid aerodynamic/reaction jet flight controls, multi-aperture sensor fusion, mass-focused ordnance, high angle of attack aerodynamics and integrated guidance/multi-mode ordnance. The **fourth** and final component consists of identifying and pursuing **weaponizable opportunities** for individual/group technologies aimed at a specific system application. This process dictates a ‘technology transition mindset’ in which high payoff technologies are made available to weapon developers in a timely fashion to support weapon upgrade plans. Integral with this weaponizable opportunities process is an assessment of the operational benefits and life cycle production costs of a given technology.



The end-result of AFRL/MN’s Air Superiority initiative is a well coordinated, advanced weapon technology base which, together with industrial partners, produces high payoff technologies to meet both the current and future needs of our warfighting customers.

Small Smart Bomb Technology

The Small Smart Bomb (SSB) Integrating Concept is developing the set of synergistic technologies to allow miniature munitions to defeat 85 percent of the MK-83/BLU-109 target set. This target set consists of fixed soft to moderately hardened targets as well as relocatable targets. There are many benefits to smaller munitions, the greatest of which is an increased loadout capability for fighter and bomber aircraft. Miniature munitions also permit usable payloads to be carried in small delivery platforms such as Uninhabited Combat Air Vehicle (UCAV) and the planned Common Air Vehicle. With each bomb independently targeted and autonomously guided, the number of targets killed for a single aircraft can be tripled or even quadrupled. Besides the capability to increase sortie effectiveness and the number of kills per pass, the smaller volume and weight of miniature munitions versus the more typical 2000 pound munition, means 3-4 times as many munitions can be transported with our current airlift capability. This permits a much more rapid deployment of warfighting capability to the region of conflict. Another benefit is that the bomb's accuracy and lower explosive yield will focus the bomb's lethality on the target while reducing the potential for collateral damage. Technologies to be demonstrated in the next five years include: (1) Low cost range extension technology that can triple the standoff of direct attack munitions and provide more flexible attack options, (2) Low cost LADAR terminal seeker to ensure highly accurate autonomous weapon delivery (less than 3 meters), (3) Miniaturized Anti-jam INS/GPS navigation technology, (4) Smaller, Cheaper fuze technology, (5) Preferential Fragmentation Technology, and (6) Multiple Carriage technology. Transition opportunities include pre-planned product improvements to the planned 500 -pound Joint Direct Attack Munition (JDAM) and future miniature munitions.



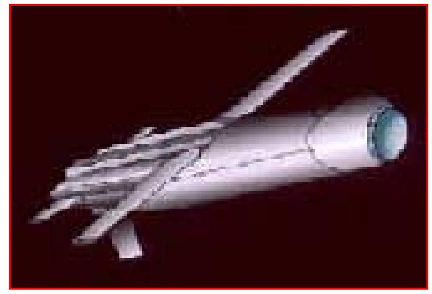
Anti-Materiel Munition Technology

The Anti-Materiel Munition (AMM) Integrating Concept Integrated Product Team is realizing its vision by pulling together four new techniques that will revolutionize air-to-surface warfare against ground mobile targets. Our targets are the enemy vehicles that bring the war to us and include SCUDs, surface to air missiles (SAM), and tanks. The new technologies include a three-dimensional imaging laser radar (LADAR) Seeker and a multi-mode warhead (capable of shooting tank targets with explosively formed slugs and softer SCUD and SAM missile launchers with a shotgun spray of lethal fragments). The Global Positioning System (GPS) will provide the very accurate midcourse guidance that enables the LADAR Seeker to achieve near zero terminal accuracy. The Low Cost Autonomous Attack System (LOCAAS) will also incorporate a miniature turbo jet that will allow the munition to search large areas for targets. Increased range allows the attacking aircraft to stay out of harms way. The 31-inch length and small size of the LOCAAS will allow up to 16 of these killer vehicles to be launched from a single fighter aircraft and nearly 200 LOCAAS from a bomber like the B-1. This gives reality to the new Air Force tactic of "halting" an enemy attack. The small size of LOCAAS will allow cost-effective attacks to be made from futuristic attack platforms like Uninhabited Combat Air Vehicle (UCAV) and Common Aerospace Vehicle (CAV). CAVs will allow the Theater Commander to call down devastating attacks against ground mobile targets from space to any point on the globe. LOCAAS will permit precision strike of all ground mobile targets and will identify the critical military target from a group of support vehicles, allow launch aircraft high survivability through standoff and will allow unprecedented large quantities of munitions to be carried and delivered.

Future concepts for employing LOCAAS will include the Fast Reaction Standoff Weapon, which will strike enemy ground mobile targets in minutes from hundreds of miles away. The LOCAAS effort will culminate in a powered free flight demo in 2002. LOCAAS is a top contender to be developed in the ongoing Miniature Munitions Capability (MCC) acquisition program.

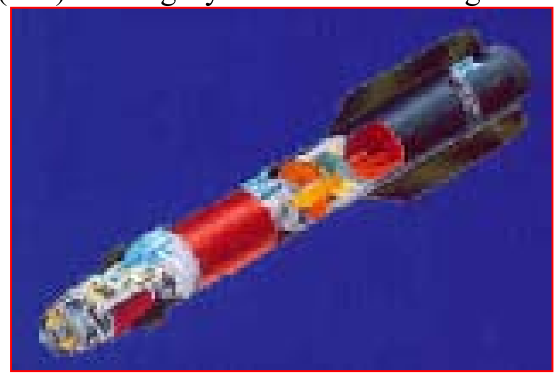
AEF Technology

The Air Expeditionary Forces (AEF) Munition Integrating Concept is developing the set of technologies to rapidly degrade enemy warfighting capability without manned over-flight. By combining long range standoff and low logistics footprints, these concepts will expand the warfighters capability to rapidly respond to any region of conflict. Modular warhead options provide flexibility to defeat an expanded target set. The combination of the accuracy and compatibility with the smart sensor web enables more of the weapons lethality to be focused on the target, minimizing collateral damage. High-energy explosives, mass focus fragmentation and multiple sensor fuzing permits decreased warhead size. These standoff weapon concepts provide the AEF with a flexible response that is lethal against fixed targets and can deny or kill high priority targets. Technologies to be demonstrated in the next eight years include: (1) Advanced payloads options to provide increased penetration, more energetic explosives combined with directional warheads, and low collateral damage ordnance packages, (2) Small low cost propulsion integration to meet the increased standoff goals, (3) Miniature navigation package integrated with advanced low cost FLASH LADAR seeker(s) for precise target engagement, (4) Precision burst point control for optimum effectiveness, and (5) Smart Sensor Web integration for in-flight target updates and Bomb Function Information.



Close Air-Support Weapon Technology

The Close Air-Support (CAS) Integrating Concept Integrated Product Team will pull together new technologies for Joint Strike Fighters (JSF) and legacy aircraft to attack ground mobile targets in close proximity to friendly forces. CAS targets include fixed and mobile, precisely and non-precisely located targets (e.g. tanks, APCs SCUDs, SEADs, pillboxes, snipers etc.) The new technologies include 3-D imaging Flash Ladar Seekers, Identify Friend or Foe (IFF) algorithms and new improved conventional lethal mechanism warheads. Global Position System (GPS) aided Internal Navigation System (INS) for mid course guidance will allow up to 40-mile standoff capability. Ground or aircraft forward air controllers (FAC) may augment the guidance system and provide either pilot or FAC executed post launch man in the loop attack decision control. Real time Battle Damage Assessment (BDA) will be incorporated via the Flash LADAR Seeker and video camera with appropriate data links. The guidance system will provide near zero miss distance accuracy. The CAS weapon will be targeted by the pilot or FAC or other third party targeting systems.



The CAS weapon will be a miniature munition less than 80 inches in length and smaller than 7.5 inches in diameter and will weigh less than 200 pounds. Component packaging and carriage technologies, such as the Small Munitions Dispenser (SMD) will allow up to 16 weapons per fighter aircraft (JSF and legacy aircraft). If Unmanned Combat Vehicles (UCAV) enter the CAS combat arena, the small size of the CAS weapon will allow their employment from UCAVs. The key IFF technology will allow pilots to fire into a group of friendly and enemy combat vehicles in close proximity to friendly forces and strike only the enemy targets. New functional defeat warhead technologies may augment conventional high explosive lethal mechanisms.

The long legs envisioned for the CAS weapon will enhance aircraft survivability by allowing a pilot to standoff from long distances (40 Miles) and high altitudes (up to 21thousand feet) and conduct close air support. Large load-outs will allow the battle field commander to employ devastating fire on only the enemy targets. Single shot probability of kill will exceed 0.8. The CAS weapon will defeat typical counter-measures, e.g., smoke, decoys, camouflage, and jamming devices. The CAS weapon will perform its mission with minimal collateral damage. The BDA capability will allow the battle commander real time updates on the battle field situation. Future derivatives of the CAS weapon may include rotary wing variants that provide a lurk and loiter type weapon that will both fly and attack from battle field locations to provide close air support in extremely complex urban combat situations. The lurk and loiter capability of the urban combat version of a CAS weapon will allow the ground commander to call down deadly "mobile artillery fire" to defend his troops or press an attack in urban combat zones. The close air support weapon and the derivative urban combat weapon will revolutionize modern war fighting.

Propulsion

"Propulsion and Power Dominance for Space and Air Superiority"

The vision of the Propulsion ETA is to provide preeminent global leadership in military propulsion and power technology. This ETA provides research and development on all Air Force propulsion technologies in order to create and transition propulsion and power technology for military dominance of air and space. This ETA leads the development of propulsion technologies for air and space vehicles including turbine and rocket engines, advanced propulsion systems, and the fuels and propellants on which they run. It also provides leadership for most forms of power and energy conversion technology.

The Propulsion ETA benefits all aspects of Air Force operations by providing balanced improvements in affordability, performance, reliability and supportability. As these improvements are deployed, they are routinely adopted by the other services and the civil sector.

Investment Strategy for Propulsion ETA

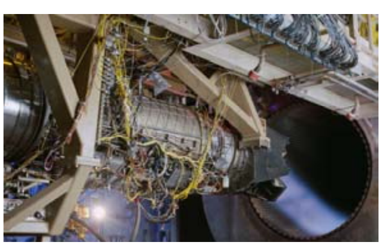
The goal of transitioning from an air and space force to a space and air force will place more emphasis on the Aerospace and Space thrusts with the investment in these thrusts growing steadily over the next several years. The Propulsion ETA's investment principles are consistent with the Secretary of Defense military strategy and the National Science and Technology strategy. Compliance is assured through frequent reviews and guidance from DDR&E, AFMC, SAB panels, and AFOSR.

FYDP Investment Strategy for Propulsion ETA

The Propulsion ETA develops near and far term technologies across a broad spectrum of propulsion and power. Currently, the Propulsion ETA invests 42 percent of its funding in near term activities primarily focused at the sub-system and demonstration level. The remaining 58 percent of the current ETA funding is invested in mid-term exploratory development activities to provide evolutionary technologies at the system level. This percentage of funding allocated for advanced development and exploratory development is not expected to change more than eight percent over the course of the FYDP. The Propulsion ETA is divided into four major technology thrusts: Air Propulsion, Aerospace Propulsion, Space Propulsion and Power Technology. The following sections will cover Air, Aerospace, and Power technology sub-thrusts applicable to the aviation mission set.

Propulsion ETA Thrusts
- Air Propulsion
- Aerospace Propulsion
- Space Propulsion
- Power Technology

Air Propulsion


Turbine Engine Durability Testing

Air Propulsion has the subthrusts of Aircraft Propulsion and Air Launch Missile Propulsion. The Aircraft Propulsion subthrust includes turbine engine technologies, advanced fuels and lubricants. The Air Launch subthrust includes tactical missile rocket propulsion technology efforts.

Air Propulsion Subthrusts
- Aircraft Propulsion
- Air Launch Missile Propulsion

The Integrated High Performance Turbine Engine Technology (IHPTET) program is a major portion of the near term aircraft propulsion subthrust. IHPTET is a coordinated program involving the three services, DARPA, NASA, and industry. There is an overall government plan and each of the six aircraft turbine engine manufacturers has a complementary Advanced Turbo Propulsion Plan (ATPP) that addresses IHPTET. IHPTET develops component technologies to increase propulsion system performance while reducing weight, fuel consumption, production cost, and maintenance cost. IHPTET has been further enhanced to improve engine operational reliability. These component technologies are integrated into an advanced Turbine Engine Gas Generator (ATEGG) where the performance, cost, durability, reparability, and maintainability aspects can be assessed in an integrated component-testing environment. The Aircraft Propulsion subsystem Integration (APSI) program includes demonstrator engines such as the Joint Technology Demonstrator Engine (JTDE) for manned systems and the Joint Expendable Turbine Engine Concept (JETEC) for unmanned air vehicles and cruise missile applications. APSI further matures the core technologies as well as addressing some of the systems integration aspects of inlets, fans, turbines, nozzles, engine/airframe compatibility, and low-observable technologies. Near term application of IHPTET technology will enhance the capabilities of systems such as the JSF, UCAV, and F-18/F, as well as provide for upgrades to existing systems. Advanced fuels and lubricants that are thermally stable, cost-effective, and capable of higher temperatures are being developed for use in aircraft and missile engines. Conventional petroleum and alternate fuels are developed and evaluated for Air Force applications.

Key Air Force guidance in this area is to migrate investment from aeronautics to space, meet customer requirements with the most cost effective technology possible, and pursue fundamental enabling technologies that provide options for tomorrow's Air Force. In the near term, the requirements of JSF and UCAV will dictate a significant investment in turbine engines through IHPTET. In the future, it is anticipated that a further partnering arrangement with the commercial side of government and industry will enable significant advancements in turbine engine versatility and affordability while reducing Air Force investments. This new initiative, termed the Versatile Affordable Advanced Turbo Engine (VAATE), will have as its primary focus a significant enhancement in propulsion affordability through reduced cost of ownership, including development, production, and maintenance cost. Specific goals for VAATE are currently under development, but it is anticipated that an order of magnitude improvement in affordability (i.e., propulsion capability/cost) may be achievable.

The Air Launch Missile Propulsion subthrust focuses on developing technologies that improve both air-to-air and air-to-ground missiles. Programs in this subthrust focus on increasing rocket system impulse, increasing range, decreasing time to target, and reducing cost. The major initiative in this area is developing technologies in both case and propellant improvements to achieve increased velocity and decreased time to target payoffs.

Power Technology


Revolutionary Power Generation

The major focus of this thrust is electrically based secondary power systems for air and space vehicles, both manned and unmanned. Led by the Air Force, the More Electric Initiative (MEI) leverages support from the

Power Technology Subthrusts
- Advanced Aircraft Power
- Advanced Spacecraft Power
- Weaponry Power
- Foundational Power R&D

three services, NASA, and over 50 individual companies. The emphasis is on reducing the cost of force projection by doubling power system reliability and reducing our dependence on aircraft ground support equipment. The "more electric" concept is made possible by successful development and improvement in key power components. These enabling technologies and components are then integrated and demonstrated within the four critical technologies – power generation, power distribution, energy storage, and subsystems interaction. The "more electric" concept will not only reduce support equipment and costs, and improve current aircraft effectiveness but is also seen as the technology direction of opportunity relative to numerous other military and commercial systems.

The MEI will reduce the cost of global force projection by minimizing/eliminating troublesome power subsystems. Existing problem areas include centralized hydraulics, and bleed pneumatic subsystems. This MEI approach mandates a high degree of self-sufficiency, improved reliability, maintainability, and supportability – all yielding a quicker turn-around time. The required maintenance and logistics support for this concept is significantly reduced versus conventional approaches due to the use of line replaceable units and the implementation of a two-level maintenance concept. Improved efficiencies reduce overall heat rejection to the fuel and all aspects of an electric-based system lead to significantly reduced life cycle costs. These combined benefits directly support the user defined needs to reduce deployed logistics/maintenance and increase range, payload, and maneuverability. Additionally, a space power initiative will investigate how to apply the lessons learned from the MEI to space systems.

The Power Technology thrust is divided into four subthrusts: Advanced Aircraft Power, Advanced Spacecraft Power, Weaponry Power and Foundational Power Research and Development, which supports the other three subthrusts.

Aerospace Propulsion

Mach 6 Global Reach Strike Aircraft

Aerospace Propulsion Subthrusts

- Trans-Air Space Propulsion
- Global Reach Propulsion

Aerospace Propulsion is a new thrust which is focusing on identifying and developing propulsion technologies needed for advanced Air Force vehicles capable of operating in both air and space environments. This thrust develops and demonstrates propulsion and power system technologies for future aerospace vehicles and their weapons. The near-term focus is on propulsion and power technologies for the first generation of MAVs, such as the space maneuver vehicle component of the military space plane system. First-generation MAVs are likely to employ space-launch flight operations and rely heavily on the existing technology base. The thrust's contribution to these near-term applications stems from ongoing Propulsion ETA efforts planned and initiated before the thrust was created.

Within the FYDP, the primary challenge will be to initiate the development of technologies for the second generation of MAVs. Such vehicles will begin to bridge the gap between complex space-launch operations and flexible aircraft-type operations. They may well employ Combined-Cycle Engines (CCEs), instead of the all-rocket propulsion systems used by the first generation MAVs. These engines are likely to use cryogenic hydrogen fuel for at least a portion of the operating regime and thus have a strong basis in the recent NASP scramjet and present NASA CCE development efforts. New research activities will look far beyond the current technology base and explore innovative propulsion and power technologies to ultimately provide revolutionary military capabilities.

Integration efforts typically focus on component-level integration, such as the structural integration of a fuel tank into an airframe. True technology-level integration is required if MAVs are to achieve the high levels of reliability and operability associated with aircraft-type operations. Current and planned technology development efforts will facilitate the integration of the power subsystems with the vehicle equipment subsystems. For example, fly-by-wire and power-by-wire may well become synonymous for the second generation of MAVs. Similarly, integrating the technologies for the propulsion and vehicle thermal management systems may be critical to minimizing the structural mass fraction of second generation MAVs.

The Aerospace Propulsion thrust has two subthrusts: Trans-Air Space Propulsion and Global Reach Propulsion. The Hypersonic Technology (HyTech) program is developing a hydrocarbon-fueled scramjet with near-term application to hypersonic cruise missiles and far-term application to the first stage of two-stage-to-orbit reusable launch vehicles. The scramjet will be flight tested under DARPA's Affordable Rapid Response Missile Demonstrator in FY02. This technology base will be extended to develop advanced airbreathing propulsion technology that combines the scramjet with rocket and/or turbine engines for reusable launch vehicles. Such combination cycle propulsion will provide two to five times the payload fraction of all rocket systems, greater operational flexibility, aircraft-like operations, and reduced launch cost.

Propulsion ETA FY25 Vision

The Propulsion ETA is continuously evaluating its ability to revolutionize warfighting via the application of new technology. This ETA recognizes the importance of trans-aerospace propulsion and power issues. The Aerospace Propulsion ITT will ultimately enable development of MAVs capable of true aircraft-type operations. By 2025, the propulsion and power technologies ready for transition to system development will allow for revolutionary military-specific warfighting capabilities supporting Global Engagement: daily sorties, wartime surge capability, assured access to space, and global atmospheric/trans-atmospheric transportation. The propulsion and power technologies matured by FY25 will result in systems that are highly reliable, to enable true aircraft-type operability.

The Air Propulsion thrust is working towards revolutionary changes in turbine engines through IHPTET and VAATE. These engines will be ultra-low fuel consumption, high thrust-to-weight and low cost in all phases of an engine's life. The Aerospace and Space thrusts will be focused on the Air Force move from an air force to a space force. Revolutionary power thrust advances in the areas of very high power and electrical power generation capabilities will enable an entire new class of directed energy weaponry for use on tactical airborne platforms.

Air Vehicles

"Leading the Development of Military Fixed Wing Air Vehicle Technologies"

The vision of the Air Vehicles ETA is to deliver the best air vehicle technologies to achieve aerospace dominance against all threats. To achieve this vision of providing full-spectrum aerospace vehicle alternatives to the warfighter, efforts are being focused in four priority areas. The first three areas are Air Vehicles Integrating Concepts – Aircraft Sustainment, Trans-Atmospheric Vehicles (TAVs), and Unmanned Air Vehicles (UAVs). Supporting these Integrating Concepts is a fourth area: Air Vehicles Core Technologies. For

Aircraft Sustainment, Air Vehicles will develop and transition the critical technologies to enable the Air Force to sustain the current fleet well into the 21st Century. For the future fleet, Air Vehicles will focus on technologies to ensure increased design life and reduced cost of ownership. This is of paramount concern given today's budget realities and the budget-constrained environment anticipated in the future. In the area of TAVs, Air Vehicles will develop and field critical Space Operations Vehicle (SOV) technologies to enable affordable, quick reaction trans-atmospheric and space capability. This enhanced capability will form the cornerstone for realizing aircraft-like spaceplane operations to achieve the Air Force Global Engagement vision. For the UAV area, Air Vehicles will deliver the technologies to build and field future high payoff UAV alternatives to meet the warfighters' full-spectrum aerospace-vehicle requirements. The fourth area, Air Vehicles Core Technologies, is embodied in three Centers of Excellence (COE). These centers will create and nurture innovative research into breakthrough technologies that will enable revolutionary capabilities to satisfy evolving warfighter needs and prevent technological surprise. These four elements of the Air Vehicles vision will serve as the technology linchpins for developing the aerospace vehicle systems to ensure air and space superiority well into the 21st Century.

Investment Strategy for Air Vehicles ETA

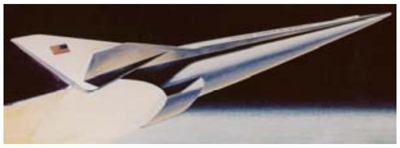
The investment strategy for Air Vehicles is guided by the requirement to provide affordable, revolutionary capabilities to the warfighter that addresses all future threats. The emphasis will be on technology investments that support cost effective, survivable aerospace platforms capable of accurate, quick delivery of a variety of future weapons or cargo anywhere in the world. To achieve this vision, this ETA will invest in three primary areas identified as Integrating Concepts: Aircraft Sustainment, Trans-Atmospheric Vehicles, and Unmanned Air Vehicles. Investments will also be made in three COEs: (1) Computational Simulation, (2) Multivariable and Reconfigurable Control, and (3) Multidisciplinary Technology. These investments provide the technology development needed to fully pursue the respective requirements identified in the Air Force core competencies.

Aircraft Sustainment Integrating Concept

Extend Today's Fleet to Meet Tomorrow's Needs

The goal of the Aircraft Sustainment Integrating Concept is to enable technology insertion to extend today's fleet to meet evolving warfighter needs. Objectives of the concept include increasing the reliability of aircraft systems, reducing depot flow time, reducing operating and support costs and reducing incidents of aircraft loss due to failure. One of the key areas of emphasis within sustainment includes Aging Aircraft Structures. Efforts within the structures area will develop and demonstrate technologies for the design and analysis of bonded composite repairs and lead to a methodology to accurately account for the impact of corrosion and cracking on structural integrity and economic service life. A planned effort in weapons bay noise suppression will develop and demonstrate prediction methods and suppression techniques for high acoustic levels in internal cavities. Other ETA efforts include a program to use active core exhaust mixing with pulsed jets to reduce engine exhaust temperature for increased nozzle service life and decreased maintenance and an effort to develop an optical air data system that is more supportable than existing means.

Trans-Atmospheric Vehicles Integrating Concept



Affordable Quick Reaction Trans-Atmospheric Capability

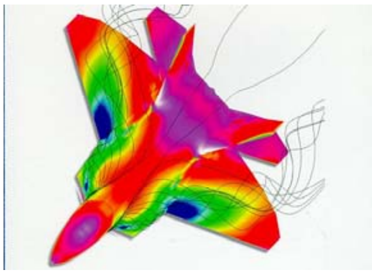
The Trans-Atmospheric Vehicles Integrating Concept supports the need to conduct seamless operations to control the aerospace dimension and enables an affordable, quick reaction, trans-atmospheric and space capability. Emphasis is on Global Engagement in less than three hours, large reduction in reusable launch system life cycle cost, and routine, aircraft-like spaceplane operations. The primary program for this technology area is the SOV. The SOV is a reusable spacelift architecture designed to drastically lower the cost of access to space while offering flexible, responsive military operations to the Air Force. The SOV System architecture contains a matched booster and multiple upper stage options for two-stage-to-orbit operations. The reusable first stage booster is known as the SOV; upper stage options include the Space Maneuver Vehicle and Modular Insertion Stage. SOV technology investments are worked in close concert with NASA's Advanced Reusable Technologies and Advanced Space Transportation Programs, and will carefully leverage advancements accomplished by existing programs such as X-33, Reusable Launch Vehicle (RLV), X-34, X-38, X-40a, Hyper-X, and Future-X. A critical reason for needing reusable military launch vehicles such as the SOV, is the vast improvement in operability (reduced maintenance hours per sortie, reduced turn times, increased reliability) over the current baseline. An on-going effort to develop mechanically attached thermal protection systems has shown significant promise in this area. Planned programs to develop and demonstrate technologies for inspection and repair of thermal protection systems and composite tanks and structures will also contribute to operability improvements. Basic research is being conducted in active hypersonic flow control by using plasma/weakly ionized gases for drag reduction, flight control, and possibly power generation in conjunction with the Propulsion Directorate. Technology efforts are also planned in the areas of integrated vehicle health monitoring and prognostics, adaptive flight controls, actively cooled structures, and advanced electromechanical actuation. Additional programs are currently being formulated to work technologies pervasive to both SOV and hypersonic cruise vehicles.

Unmanned Air Vehicles Integrating Concept

Technologies for Affordable Routine Operations

The Unmanned Air Vehicles Integrating Concept supports the Precision Engagement core competency and develops and transitions technologies that enable current and future UAV systems that satisfy warfighter mission requirements. UAVs provide revolutionary air vehicle potential with the ability to optimize the aircraft for mission effectiveness without consideration of the pilot. At the same time, the air vehicle must be compatible with essential sensor and information fusion technologies, propulsion and weapons technologies, and must be controllable through an operator vehicle interface. Objectives of this technology thrust include increased flexibility, reliability, and survivability with reduced weight and cost of current and future systems. Complimentary with the UCAV technology demonstrator, key technology areas include development of reconfigurable flight control and multi-ship cooperative control. Substantial developmental efforts in multifunctional structures such as load bearing antennas, structurally integrated inlets, and fluidic exhaust nozzles are also key for smaller, more affordable systems.

Centers of Excellence



Virtual Prototyping for Reduced Design Cycle Time

Air Vehicles core technologies are developed in three COEs. The Computation Simulation COE emphasizes the development of new pervasive computational methods. One group focuses on basic research in fluid physics, aeroelasticity and electromagnetics, while another focuses on practical implementation and application of multidisciplinary computational techniques. The Multivariable and Reconfigurable Control COE is committed to the aggressive development and transition to the warfighter of advanced air vehicle control technology to improve weapons system lethality and affordability. The Multidisciplinary Technology COE is dedicated to developing the most efficient techniques and processes for integrating different technologies. One focus is the development of new and innovative optimization algorithms. Another focus is the study of technology interactions, such as aerodynamic and servoelastic control, in order to minimize adverse effects and maximize synergism. The final component is new technology applications, such as energy-based design, with a vision of realizing revolutionary air vehicle concepts. In total, the three Centers of Excellence invent and develop new and improved theories and processes to enable revolutionary aerospace vehicle capabilities for the warfighter.

FYDP Investment Strategy for Air Vehicle ETA

To support the Integrating Concepts and the Centers of Excellence, the Air Vehicles ETA has three technical thrusts: Aeronautical Sciences, Structures, and Control Science. The leaders of these technical thrusts will execute the high-payoff programs identified as important to achieving the technology goals for each integrating concept.

Air Vehicles ETA Thrusts

- Aeronautical Sciences
- Structures
- Control Science

Aeronautical Sciences

The Aeronautical Sciences thrust develops critical technologies that sustain the current fleet and enable the Air Force to build and field future UAVs and space vehicles. This thrust is divided into three subthrusts: Computational Sciences, Aerodynamic Configuration, and Aerospace Vehicle Integration and Demonstration. The Aeronautical Sciences thrust conceives, plans, and conducts basic, exploratory, and advanced development programs to discover, develop, demonstrate, and transition aggressive new technologies for these applications. The SOV will not become a reality without the development of new multidisciplinary design optimization computer codes. These codes are currently under development and will provide affordable computational fluid dynamic solutions for highly

Aeronautical Sciences Subthrusts

- Computational Sciences
- Aerodynamic Configuration
- Aerospace Vehicle Integration and Demonstration

coupled aero-thermal-structural problems. New design codes are also under development to optimize wing-body configurations for innovative UAV applications. Results will yield new vehicles with reduced drag for longer range. New theories and techniques are being conceived and matured to understand highly nonlinear aerodynamics for application to UAVs in future high-threat, highly dynamic battle environments. Technology development is underway to develop, evaluate, and facilitate the separation of small class munitions from weapons bays. This technology is vital to ensuring UAV lethality.

Advanced Aeronautical Science technologies yield a reduction in weight, a reduction in design, development, and sustainment costs, an extension of range, an enhancement of maneuverability and stealth, and an increase in payload.

Structures

Structures Subthrusts

- Extreme Environment Structures
- Structural Sustainment
- Structural Technology Integration

The Structures thrust plans, manages, and conducts research and development programs to solve critical structural problems on fixed-wing aerospace vehicles. These issues are addressed within three sub-thrusts: Extreme Environment Structures, Structural Sustainment, and Structural Technology Integration. These subthrusts advance design, analysis, and integration technology and develop advanced structural concepts and fabrication techniques to improve structural integrity, reduce costs, and reduce weight. They transition developed technology to DoD weapon systems and provide timely solutions to problems arising in DoD and other U.S. aerospace vehicles. Advanced repair techniques and repair design methods developed in the Composite Repair of Aircraft Structures program will provide significant reductions in airframe operations and support cost. The effects of corrosion on the fatigue life of airframe structures will be established in the Corrosion Fatigue program. These life extension and structural integrity methodologies will enable the current fleet of Air Force vehicles to remain viable well past their design life-times. Methods are also being developed to alleviate the effects of buffeting on twin tail aircraft. By reducing the structural vibrations caused by twin tail buffeting, fighter aircraft operations and support cost will be reduced. While working technologies for the current fleet, a robust program has been established to support the future needs of advanced aerospace vehicles such as the UAV and SOV. The Composite Affordability Initiative is providing structures technology for both advanced system types. The Structures thrust will exploit the latest in materials, processes, and manufacturing to produce more durable, lower cost, and survivable structures to meet the needs of the future EAF. Technologies developed by the Structures thrust will lead to a significant reduction in airframe operations and support costs and result in durable, lower cost, and survivable advanced structures.

Control Science

Control Science Subthrusts

- Control Technology
- Simulation-Based R&D

The Control Science thrust has two subthrusts: Control Technology and Simulation-Based R&D. Within this thrust, key technologies are developed that enable the Air Force to build and field future UAVs and space vehicles that meet the warfighter's needs and that also affordable sustain the current and future fleet of military aerospace vehicles. The Control Science thrust conceives, plans, and conducts selected basic, exploratory, and advanced development programs to develop, synthesize, demonstrate, and transition bold, innovative control sciences technology for these applications. Within these competencies or subthrusts, technology is advanced in control theory and systems mechanization to enable control of not only single air vehicles, but also the effective control of multiple aerospace systems. For example, control of swarms of UAVs is envisioned, for power projection and wide area as well as enhanced resolution surveillance. This will include not only the evolving class of UAVs, but also future micro-air vehicles. Precision control of swarms of spacecraft coupled with new sensor technology will deliver a new dimension in warfighter information gathering capability. Research in all electric, photonics-based control systems offers substantial weight and O&S cost savings for future UAVs and Trans-Atmospheric Vehicles. This research also delivers viable technology options to reduce operating costs, increase reliability, and provide a "plug & play" information backbone to support future warfighter requirements of our aging fleet. Pioneering flight management technology development is conducted to enable safe, mixed manned aircraft and UAV combat operations in the future high-threat, highly dynamic battlespace. The aforementioned technology developments highly leverage and integrate with our ongoing research in simulation-based R&D to provide a cost effective and science-based approach to concept evaluation and demonstration, delivering findings in not only engineering terms, but also in warfighter measures of merit. This simulation-based R&D environment covers the full spectrum from single aerospace vehicle evaluation through assessment of multiple technologies on a diverse set of aerospace assets in a complex and highly realistic battle environment. Technology developments by the Control Science thrust will reduce aerospace vehicle life cycle costs, improve combat mission effectiveness, and increase flight safety and reliability.

Air Vehicles ETA FY25 Vision

The Air Vehicles ETA will continue to proactively pursue innovative technologies and strategic partnerships enhancing U.S. air superiority in the 21st Century. This ETA's vision for FY25 is focused in four areas: Sustainment, Global Presence, Precision Strike, and Innovation and Core Technology.

In Sustainment, the vision is technology insertion to extend today's fleet to meet tomorrow's warfighter needs. It foresees increases in system reliability, reductions in depot flow time, reductions in operations and support cost, and reductions in aircraft loss due to failure.

In Global Presence, the vision is affordable, quick-reaction trans-atmospheric capability. It foresees enhanced aerospace vehicles/spacecraft for improved utility, Global Engagement in hours, reductions in life-cycle cost, and aircraft like operation throughout the integrated aerospace environment.

In Precision Strike, the vision is technologies to enable routine operation of high payoff UAV alternatives across the full spectrum of warfare. It foresees reductions in life cycle cost, multi-year shelf life for UAVs, and multi-vehicle cooperative control.

In Innovation and Core Technology, the vision is to create and nurture innovative research into breakthrough technologies, which enable revolutionary warfighter capabilities. It foresees reductions in design cycle time, virtual prototyping, and quantum leaps in warfighter capabilities.

Human Effectiveness

"Human-Technology Integration for Warfighting Superiority"

The Human Effectiveness ETA plans and executes the Air Force human systems S&T program, providing the enabling technologies for high priority warfighter needs. This ETA's mission is to develop, integrate, demonstrate, and transition affordable S&T products for training personnel, protecting and sustaining the crew member, and improving human interface with weapon systems to assure the preeminence of U.S. air and space forces. The ETA's world-renowned professional researchers, with their state-of-the-art facilities, represent a unique, multi-disciplinary national resource for human-centered technology, fully leveraging the S&T investment by collaborating with the other services, industry, academia, and allies.

The impact of human-centered technologies is pervasive across all current and future operational Air Force systems. The Human Effectiveness ETA's S&T portfolio of basic research, applied research, and advanced technology development is structured to improve the warfighter's productivity in high demand, high-threat, information-saturated environments. This is accomplished by discovering better ways to create seamless interfaces between the human operator and weapon system, train forces, sustain and protect forces over time and distance, and improve their protective equipment.

As the SAB noted in its New World Vistas report, people are the heart of the Air Force's military capability and people will continue to be the most important element of the Air Force's success in capitalizing on change.

The Human Effectiveness ETA's vision is to enhance warrior performance for air and space dominance. The goal is to be the premier DoD organization providing world-class, human-centered S&T. By 2020, the ETA will field the technology so all Air Force systems can be human-centered, from design through development and testing, training, operational use and life-cycle management.

Investment Strategy for Human Effectiveness ETA

Within this planning context is the reality of reduced DoD funding, and the emphasis on affordability issues associated with operating the existing, aging fleet, as well as procuring new systems. As the Air Force continues to experience major funding reductions, this ETA's investment strategy is to partner with others. The Human Effectiveness ETA will pursue integrated, multi-disciplinary, cross-ETA teams to address human system deficiencies across all categories of mission areas. Also, the Human Effectiveness ETA will increase the number of CRADAs with academia and industry to share the cost of development and aid the transfer of human-centered technology to the private sector.

The Human Effectiveness ETA works closely with its Air Force customers to ensure that technology solutions not only meet their operational needs but also are affordable solutions. Emphasizing a maximum return on investment, these S&T programs are focused on technologies that are affordable to the user both in terms of lower initial acquisition cost and lower operations and maintenance costs.

In order to meet the Air Force's requirements for human systems technology, this ETA is divided into four thrust areas: Crew System Interface, Warfighter Training, Deployment and Sustainment, and Bioeffects and Protection.

Each thrust area makes a unique contribution to improving warfighter capabilities and enhancing the operational performance of Air Force personnel. This ETA distributes these Air Force S&T resources among the four interrelated thrust areas.

FYDP Investment Strategy for Human Effectiveness ETA

Human Effectiveness ETA Thrusts

- Crew System Interface
- Warfighter Training
- Deployment and Sustainment
- Bioeffects and Protection

The Human Effectiveness ETA investment strategy over the FYDP reflects the pervasive nature of human needs in air, space, directed energy, and command and control operations. In accordance with AFRL's strategy to be responsive to the Air Force migration to space, the ETA investment is being redirected. The focus of the enabling Human Effectiveness technologies will be more on space and command and control issues, and not as much solely on air issues. Over the FYDP, investments will also be increased in agile deployment and sustainment areas as recommended by the SAB study on EAF. Also, based on a thorough business review which included the needs of the warfighter and the status of technologies, several new emphasis areas have emerged: crew performance and effectiveness aiding technology, visual and aural display technology, training the warfighter, non-lethal technologies, and optical radiation countermeasures.

Crew System Interface

Enabling Technology for the Man-Machine Interface

Crew System Interface Subthrusts

- Information Analysis and Exploitation Technology
- Aural Displays and Bioacoustics Technology
- Crew Station Development Technology
- Human Interface Technology
- Visual Display Systems Technology

The Crew System Interface is that vital link between warfighters and their systems and equipment needed to assure effective air and space operations. Examples of typical crew system interfaces include aircraft crew stations, wearable controls and displays, and ground consoles for myriad applications ranging from individual maintenance personnel to teams of operators collaborating in real-time across the gamut of aerospace operations. This thrust area builds the crew system interface technology needed for tomorrow's aerospace force to match the design of systems and equipment with the warfighter's capabilities and limitations in order to maximize performance and affordability. The Crew System Interface thrust area has five subthrusts: Information Analysis and Exploitation Technology, Aural Displays and Bioacoustics Technology, Crew Station Development Technology, Human Interface Technology and Visual Display Systems Technology.

Information Analysis and Exploitation Technology develops new cognitive information-based interface solutions and human speech processing and control solutions for time-critical command and control, to organize battlefield intelligence data, to eliminate decision-making bottlenecks, to gain a common battlespace understanding and to shorten the timeline for intelligence-to-shooter operations. Aural Displays and Bioacoustics Technology provides the vibroacoustics building blocks of 3-D audio, active noise reduction, digital audio, voice warning and integrated audio/visual symbology in order to enhance crew performance under high noise and vibration while mitigating the adverse effects of noise on the Air Force mission. Crew Station Development Technology develops and employs human-centered analysis models with high fidelity, real-time mission simulation to demonstrate tailored crew station design solutions to answer pervasive questions about control/display placement and function, information requirements and flow, and to exploit the new generation cockpit devices. Human Interface Technology encompasses both the development of physical measurement methods to assure the fit of humans to crew stations and equipment, and complex performance assessment techniques to quantify the human performance contribution to system effectiveness. The quantitative measures are used in conjunction with distributed high-fidelity mission simulations to develop and evaluate cutting-edge interface technologies involving bio-centered controls, multi-sensory adaptive displays, and immersive design - extending and leveraging commercial virtual reality technology. Visual Display Systems technology provides the fundamental vision science and advances the state-of-the-art for visual display technology across-the-board. This technology includes helmet-mounted tracker/displays (HMT/D), night vision goggle (NVG) and panel mounted display technologies, large screen, flat-panel, electronic displays, laser eye protection, synthetic vision and vision through visors, windscreens and heads-up displays.

Warfighter Training

Train the Way We Intend to Fight

The Warfighter Training thrust researches, develops, demonstrates, evaluates, and transitions technologies and methods to "train the way we intend to fight." This thrust area develops and demonstrates distributed mission training (DMT) methods and technologies, demonstrates and transitions training methods and physics-based night vision device training technologies, and develops and evaluates measures of warfighter training effectiveness. The Warfighter Training thrust area has four subthrusts: Space Training, Information Operations Training, Aircrew Training, and DMT Engineering.

Warfighter Training Subthrusts

- Space Training
- Information Operations Training
- Aircrew Training
- Distributed Mission Training Engineering

The Space Training, Information Operations Training, and Aircrew Training areas are all aimed at understanding fundamental learning concepts and then using those concepts to develop training methods in these three domains. Key focus areas within those domains are night vision training, force protection training, and maintenance training. The DMT Engineering area is concerned with developing new technologies and taking better advantage of existing technologies to improve the Air Force's capability to train mission skills on a distributed basis using virtual, live and constructed assets.

Deployment and Sustainment


Survivability of Personnel Exposed to Toxic Environments

Deployment and Sustainment Subthrusts

- Readiness Logistics
- Sustainment Logistics

Toxicology

The Deployment and Sustainment thrust develops and demonstrates technologies that improve the performance, affordability, supportability and readiness of current and future weapon systems and technologies that support the deployment and employment of global EAF operations. This thrust area focuses on logistics support capabilities and personnel protection from hazardous materials during deployment in both combat and military operations other than war. The Deployment and Sustainment thrust area has three subthrusts: Readiness Logistics, Sustainment Logistics, and Operational Toxicology.

Readiness Logistics includes wing and theater-level logistics support technologies and methods to improve logistics planning, readiness, deployment and information systems, along with aids and diagnostic processes for wing level aircraft maintenance. Sustainment Logistics develops, demonstrates, and transitions methods, processes, tools, and equipment technologies to enhance weapon system acquisition, affordability, and supportability from design inception through retirement. This subthrust also develops techniques to improve logistics sustainment of global air power operations through better distribution systems and more effective weapon system support. Operational Toxicology develops technologies to prevent mission degradation due to exposure to toxic and hazardous chemicals and materials across a broad spectrum of deployment contingencies. This subthrust also develops methods of detection, identification and assessment of the potential human health risk from operational chemicals and chemical/biological detection (CBD) agents.

Bioeffects and Protection


Predict and Mitigate Mission Degradation

Bioeffects and Protection Subthrusts

- Optical Radiation
- Radio Frequency Radiation
- Biomechanisms and Modeling
- Safe Escape and Impact Protection
- Aircrew Protection
- Sustained Operations
- Spatial Disorientation Countermeasures

The Bioeffects and Protection thrust predicts and mitigates mission degradation due to operational stresses. This thrust area researches the bioeffects of directed energy and provides the database necessary to enable development of effective non-lethal weapons. It defines human response to impact, acceleration, and altitude; provides human systems criteria for emergency escape systems and crash protection; develops and demonstrates life support and oxygen systems; and provides technologies to counter spatial disorientation and improve human performance in sustained operations. There are seven subthrusts: Optical Radiation, RF Radiation, Biomechanisms and Modeling, Safe Escape and Impact Protection, Aircrew Protection, Sustained Operations and Spatial Disorientation Countermeasures.

Optical Radiation includes biological effects of laser radiation that enable RDT&E of non-lethal laser weapons and development of laser eye protection technologies. RF Radiation includes biological effects of RF radiation from acute, chronic, and repeated exposure. Biomechanisms and Modeling includes biological effects of non-lethal DEW applications, development of models for predicting human performance degradation, and the development of warfighter and equipment protection methods. Safe escape and Impact Protection efforts include R&D of human response and tolerance criteria for dynamic environments as well as development and demonstration of advanced crew escape system technologies. Aircrew Protection includes R&D of technologies for aircrew protection from high altitude exposures; research and development of physiological and cognitive response countermeasures to G-induced performance degradation and incapacitation; and development, demonstration, and transition of aircrew life support equipment and advanced oxygen system technologies. Sustained Operations encompasses definition and development of countermeasures for effects of fatigue and circadian disruption due to sustained operations and Global Engagement. Spatial Disorientation Countermeasures investigates the mechanisms of spatial orientation and develops display symbologies and aircrew training procedures to reduce impact of spatial disorientation on flight operations.

Materials and Manufacturing

"Materials and Manufacturing Technologies to Sustain Today's Fleet and Enable Tomorrow's Warfighter"

The Materials and Manufacturing ETA goal is to develop advanced materials, materials processing and manufacturing technologies for today's fleet and tomorrow's warfighters. It also provides systems support to Air Force product centers, air logistics centers (ALCs), and operating commands to solve system-related problems and to enhance the sustainment of operational systems.

The impact of materials technologies is pervasive to all current and future Air Force systems. More importantly, materials and manufacturing capabilities may often represent the limiting factors in system cost, performance, and risk. The challenge is to balance providing better and more affordable material technology support to the current fleet operations and maintenance while developing the material technologies to meet operational challenges for the future Air Force. Whether the challenge is aging Air Force systems or the preparation for next century systems, the vision of this ETA is to provide materials and manufacturing technologies for the entire Air Force, emphasizing technical leadership, technology transition, technology transfer, and systems support.

Investment Strategy for Materials and Manufacturing ETA

In responding to the Air Force Strategic Plan and Integration Plan for a move to aerospace operations, the strategy in this area is to increase the investment in materials and processes for space propulsion. The increase will come at the expense of polymer composite development subthrusts and aircraft sensor technology. The aircraft technology area will slightly reduce by 2005. To support National Materials Research Council recommendations for Aging Aircraft, the investment in Sustainment will be maintained. Non-space sensors and personnel protection continue to be concerns to growing laser threats and technology investment in this area will be maintained. Finally, materials and processes for the area of directed energy are relatively small at the present time. To support Air Force thrusts in this area, the investment will be increased.

FYDP Investment Strategy for Materials and Manufacturing ETA

This ETA maintains expertise in thermal protection materials, metallic and nonmetallic structural materials, nonstructural materials, nondestructive inspection, materials used in aerospace propulsion systems, electromagnetic and electronic materials, and laser-hardened materials. The ETA is also responsible for Air Force technology programs that address affordability and the reduction of Air Force system's materials and processing driven, life cycle costs. Planning is accomplished in these technologies and then integrated across three major S&T thrust areas to provide a balanced program directed at customer needs. The Materials and Manufacturing ETA thrusts include Materials and Processes (M&P) for Structures and Propulsion; (M&P) for Sensors and Survivability, and (M&P) for Sustainment and Deployment.

Materials and Manufacturing ETA Thrusts
- Materials and Processes for Structures & Propulsion
- Materials and Processes for Sensors & Survivability
- Materials and Processes for Sustainment & Deployment.

This ETA has 11 core technology areas (CTAs) that are under the three Materials and Manufacturing ETA Thrusts. These 11 core areas of expertise encompass the development and manufacturing of polymers, organic matrix composites, metallics, ceramics, nonstructural materials, electronic materials, and optical materials. Of these CTAs, three feed all three of the Materials and Manufacturing ETA Thrusts. They are Polymers, Tribology/Coatings, and Manufacturing Technology (Research Program).

Core Technology Areas

1 Polymers
2 Metals
3 Organic Matrix Composites
4 Nondestructive Evaluation
5 Ceramics
6 Tribology and Coatings
7 Materials & Processes for Sensors
8 Laser Hardened Materials
9 Manufacturing Technology
10 Systems Support
11 Air Expeditionary Force Technologies

Materials and Processes for Sensors & Survivability

The overall objectives are to provide new M&P for piloted aircraft, Unmanned Air Vehicles (UAVs), tactical and strategic missiles, launch systems, and satellite structures. Materials under development or transition include metallics, intermetallics, nonmetallics (polymers, ceramics,) and composites thereof. It also includes nonstructural materials such as solid lubricants, coatings and paints. The Metals CTA is being developed to meet the near-term aircraft turbine engine needs and far term spacelift and satellite propulsion systems. The Organic Matrix Composites CTA is being developed to transition affordable materials for aircraft and spacecraft applications including lightweight structures (airframe, control surfaces, trusses, struts, engine components, substructure), space vehicle tankage, space

UAVs

Materials and Processes for Structures & Propulsion
- Metals
- Organic Matrix Composites
- Ceramics

vehicle bus structures, radiators and other structures requiring thermal and/or structural management. The Ceramics CTA is being developed for two primary applications: Low Observable (LO) maintainability and very high temperature air and space structural applications. LO structures require materials, processes and techniques at the field and depot level to restore complete functionality of radar absorbing materials that become damaged while in-service. Very high temperature air and space structural applications include aircraft turbine engines, spacelift rocket engines and aerospace hot structures. The Tribology/Coatings CTA (Nonstructural materials) will develop fluids, lubricants, coatings, aircraft paints, and specialty materials for aircraft and spacecraft. Advanced tribological materials for spacecraft will enable the long life of high-speed ultra-low friction bearing and rotating components (gyroscope). In addition, this CTA will improve corrosion resistant coatings, aircraft topcoats, specialty treatments for low observable systems and spacecraft thermal control coatings.

Materials and Processes for Sensors & Survivability

Materials and Processes for Sensors & Survivability

- Sensor Materials
- Laser Hardened Materials

The objectives of this thrust are to provide new electronic and EM sensor materials and M&P to enhance survivability and sensor detector capability. This thrust is comprised of two CTAs: Sensor Materials and Laser Hardened Materials. For Sensors Materials, the objective is to develop high payoff electronic, optical, ElectroOptical (EO), and magnetic M&P for a wide range of Air Force space, aircraft, missile and ground equipment applications. This includes infrared (IR) detector materials for space; wavelength conversion materials for large aircraft IR countermeasures; semiconductor materials for RF and electronic power applications; IR transparencies for aircraft and missiles; and EO materials for interconnects and satellite communication. The sensor effort is balanced between near-term and mid-term needs. Technologies for current systems will be inserted through upgrades and retrofits. Ultimately, electronics and optical technologies will merge into a single integrated technology for sensing, computing, processing, and communication.


Laser Eye Protection

Laser Hardened Materials will increase survivability of aircrews, sensors, aircraft and space systems from DE threats. This effort will provide validated laser hardening technology options to users, developers, and designers of Air Force systems for the protection of aircrew via day and night protective eyewear; tactical and strategic EO sensor hardening.

Material and Processes for Sustainment & Propulsion

The objective of this thrust is to provide support across all Air Force functional mission areas that will enhance the overall reliability, maintainability and supportability of operational systems. It is comprised of three CTAs: Nondestructive Evaluation (NDE), Systems Support, and Air Expeditionary Force Technologies.

Material and Processes Technology for Sustainment

- Nondestructive Evaluation
- Systems Support
- Air Expeditionary Force Technologies

Mobile Automated Scanner Nondestructive Evaluation System

NDE methods are essential to ensure optimum quality in the design and production of aircraft, spacecraft, and launch systems. Specifically, this area is developing technologies for LO materials and structures and technologies to inspect and maintain integrity of aging aerospace structures and propulsion systems. Systems Support capabilities, information, and processes are needed to resolve problems in the use of materials or in conducting failure analysis of components. This involves materials databases, handbooks and guidelines for materials technology transition and repair. The development of Air Expeditionary Force Technologies is critical to Expeditionary Air Force (EAF) deployment capability. The technologies under development are to provide fire protection and crash rescue, air deployable power generation equipment, environmental controls and shelters; and rapid restoration of operating surfaces.

Materials and Manufacturing ETA FY25 Vision

Long-term planning for this ETA was accomplished through five Strategic Investment Application Areas of Space, Sustainment, Aircraft, Sensors and DE. The long-term vision for each of the areas related to the aviation mission set is explained below.

The Sustainment area will provide critical materials and manufacturing technologies to affordably sustain fielded and emerging systems and enable EAF operations. Envisioned is reduction of EAF footprint and weight, while reducing the EAF personnel requirement and time. There should also be a reduction in the use of toxic materials and reductions in operation and support costs. LO maintenance costs will equal conventional maintenance costs.

In Aircraft, the vision is to ensure continued air superiority with breakthrough materials and manufacturing technologies for propulsion, structures and subsystems. There should be an increase of fighter aircraft thrust/weight ratio and a reduction of metallic and composite materials cost.

In Sensors, the vision is materials and manufacturing technologies to enable global awareness and assure freedom of employment of all personnel and systems. There will be retrofittable laser protection technologies for EO sensor systems, and affordable day/night all-platform threat-diverse laser protective eyewear for military personnel.

In DE, the vision is to enable full exploitation of DE concepts for strike, protection and deterrence with high power, high efficiency laser radiation against seeker threats and laser directed energy effects data and protection technology.

FUTURE NEEDS/DEFICIENCIES

The ETAs mentioned earlier serve as the vehicle to focus S&T investment on the critical needs associated with the aerospace force of the future.

The warfighter will have the need to find, fix and identify visible and hidden targets within a theater/area of interest, with minimal degradation due to adverse weather conditions. This also dictates maintenance of sufficient track quality on all identified mobile targets within a theater/area of interest to acquire and successfully engage adversaries by friendly strike forces. Reduction of strike assets airlift requirements and logistics footprint by an order of magnitude is necessary, as is the conduct of aerospace operations with impunity.

Cellular communication systems, direct broadcast satellite systems, overhead imagery, local and wide area networking and increased computing speeds will allow increased availability and rapid dissemination of information to a large percentage of the world's population. Information technology holds the key to managing the battlefield of the future. Future space and air forces will operate in increasingly information-centric environments rather than platform-centric environments: the critical functions are to maintain situational awareness of who the enemy is, what is happening, and understanding information warfare tactics and strategy. In this future environment, information is the force multiplier. Information systems are the highest leveraging systems in DoD, enabling a smaller and more effective CONUS-based force with worldwide responsibilities. A commander's ability to observe, orient, decide, and act are greatly enhanced by systems that capitalize on information technology-enabled capabilities. A commander must have continuous 24-hour-a-day in-transit visibility of resources and global connectivity to all forces. This information infrastructure will provide on-demand assured universal access to information anywhere in the world with recovery from information attacks detected and fixed in real-time.

The extended use of many military aircraft has resulted in exorbitant maintenance and repair costs due largely to structural cracking and corrosion problems. The USAF alone spends many millions of dollars on direct corrosion maintenance of aircraft systems and equipment. It is critical to more accurately predict and determine the structural life of each aircraft to curb these escalating costs, and the growing number of days lost from operational service. Advanced prediction and detection techniques for locating, quantifying and repairing corrosion and fatigue damage are critical to the assurance of airworthiness and fleet management. To meet this challenge research should focus on developing and transitioning technology solutions for critical sustainment-related areas which include aging aircraft structures, low observables maintainability, high cycle fatigue, and turbine engine durability.

Achieving the capability to train as we fight requires an integrated information environment connecting mission planning, air operations, command and control, and training into a seamless, global network. This requires the integration of technologies such as embedded training in command and control, intelligence, and space control systems and complete mission training and rehearsal via simulations. An effective DMT system is part of the global information network to ensure synthetic representations of the operational theaters within 24 hours. Distribution of assets for planning, rehearsal, execution, debriefs, and analysis will help reduce the deployment footprint by using only those assets necessary in theater.

TECHNOLOGY TRANSITION

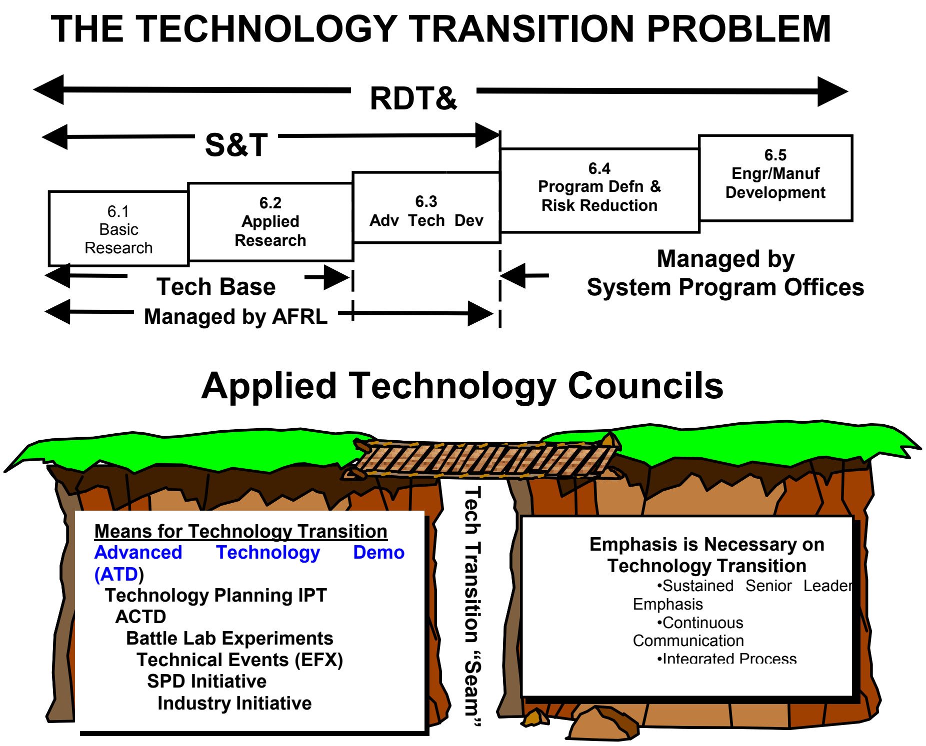
A fundamental objective of the DoD aviation community is to facilitate, in a timely manner, the transition of state-of-the art technologies which will lead to superior operational readiness and war-fighting capabilities of the operating forces. Historical approaches to technology transition have often led to major cost and risk growth as the so-called mature technology was found by the system developer to be anything but mature. Also, system developers have often been reluctant to introduce promising new technology because they were unsure of the war-fighters' understanding and willingness to accept it. Good examples of this issue include the protracted introduction of relaxed static margin (ruled out at that time by mil standard) and digital fly-by-wire flight control systems.

During the early 1999 round of Air Force Chief of Staff (CSAF) Quarterly Acquisition Program Reviews, it was observed that the process for transition of technology from AFRL to the Product Centers was, in general, broken. Key issues included a lack of transition funding at receiving organizations and limited visibility into linkages between Laboratory programs and war-fighter needs. As a result, the CSAF tasked the Air Force acquisition community to develop a new process that focuses available S&T and MAJCOM acquisition funds to assure technology transition to the war-fighting commands. The answer to this tasking, being championed by ASC/CC and endorsed by the CSAF, is the Applied Technology Council (ATC) forum.

ATCs are General Officer management forums that promote timely and affordable technology transition out of the Laboratory. Principal members include the AFRL Commander, Product Center Commanders, and MAJCOM Commanders or Vice Commanders. ATCs in their present form have three specific goals: (a) to link top-priority S&T investments with planned system acquisition investments; (b) to establish organizational accountability for management of technology transition and required funding; and (c) to establish MAJCOM endorsed technology transition plans. From the Laboratory viewpoint, the ATCs identify specific 6.3 technology programs that address operational requirements and commission them as Advanced Technology Demonstrations (ATDs).

Starting with just over 100 AFRL ATD candidate programs during the first round of ATCs which began in November 1999, 58 commissioned ATDs were solidly in place by the end of the second ATC round in September 2000. The number of these ATDs having funded transition paths grew from a total of six in round one to a total of 28 following round two. Many of these 28 ATDs are associated with new acquisition systems such as the Joint Strike Fighter, involve technology in areas having established transition funding lines such as the Aging Aircraft Initiative, or are technology programs that are information and/or software centric. Of these 28 ATDs which possess transition funding, only two picked up their funding in the FY02 POM cycle.

For the near future, ATC cycles will occur every six months with the purpose of reviewing the progress of current ATDs, terminating or redirecting efforts if necessary, and commissioning new ATDs. During this process, Product Center SPOs will be the principle sponsor for all technology transition planning activities and will be responsible for the development and update of Weapon System Capability Plans to be reviewed by future ATCs. This process will give the war-fighter a look at "the art of the possible" for each weapon system he uses. Although the successful transition of technology into war-fighting systems is still extremely difficult in the present fiscally constrained environment, the ATC process has opened many channels of communication in both the acquisition community and the war-fighting commands. Air Force leadership at the highest levels is now aware of the technology transition issue, having discussed this situation in detail at a CSAF S&T Summit on 1 November 2000.



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U. S. ARMY

VISION

Army aviation brings unique capabilities that contribute to the Army's ability to fulfill mission requirements across the full spectrum of operations. The Army is undergoing a major evolution in its doctrine, organizational requirements, and priorities based on the recently established Army Vision: "Soldiers on point for the Nation, transforming the most respected Army in the world into a strategically responsive force that is dominant across the full spectrum of operations. Such a force will exhibit seven characteristics: Responsive, Deployable, Agile, Versatile, Lethal, Survivable, and Sustainable." Army Aviation is a key enabler for the Army Vision and is strategically responsive by either self–deployment or strategic lift. When employed as a part of a Joint Force or as a part of the Army combined arms team, aviation systems are agile, versatile, lethal, and survivable. Aviation systems provide the Joint Force or Land Force commanders a sustainable capability to move rapidly, focus combat power on multiple targets, and enhance near–real time situational awareness.

OVERVIEW OF AGENCY MISSION

The Army is the strategic instrument of national policy that has served our country well in peace and war for over two centuries. It has enabled America to fulfill its world leadership responsibilities of safeguarding our national interests, preventing global calamity, and making the world a safer place, by finding peaceful solutions to the frictions between nation states, addressing the problems of human suffering, and when required, fighting and winning our Nation's wars. The spectrum of likely operations describes a need for land forces in joint, combined, and multinational formations for a variety of missions extending from humanitarian assistance and disaster relief to peacekeeping and peacemaking to major theater wars. Army Aviation will be responsive and dominant at every point on that spectrum, conducting combat development activities and actions developing operational concepts, organization and force design, and materiel system requirements supporting the total force and ensuring Army aviation maintains a modern, effective warfighting capability.

STRATEGIC GOALS AND OBJECTIVES

The strategic goals and objectives for Army aviation modernization are based on the Army Modernization Strategy Tenets: transform in order to meet future warfighting requirements; maintain legacy warfighting capabilities through overmatch, digitization, and recapitalization; focus science and technology to enable timely fielding of the objective force. The three goals and associated objectives for Army aviation modernization are provided below.

Full Spectrum Capable Force:

- Fix reconnaissance and security shortfalls
- Enhance lethality and survivability, while operating as a part of a Joint/Coalition Force, or as a part of the Army combined arms team
- Maintain combat overmatch
- Insert digital technology
- Divest AH–1 by 1 October 2000 and legacy/transitional systems (e.g. UH–1, OH–58A/C) by FY04
- Recapitalize Attack, Utility/MEDEVAC, Cargo, and Fixed Wing Fleets
- Establish and implement new aviation logistical support doctrine
- Establish a common user Aviation Information Management System
- Implement the National Maintenance Policy
- Implement Single Stock Fund Program

Strategic Responsiveness:

- Provide aviation units that are strategically responsive and rapidly deployable
- Shrink the aviation logistics footprint while improving the ability to perform split–based operations.
- Streamline the Theater Aviation support system and management procedures.

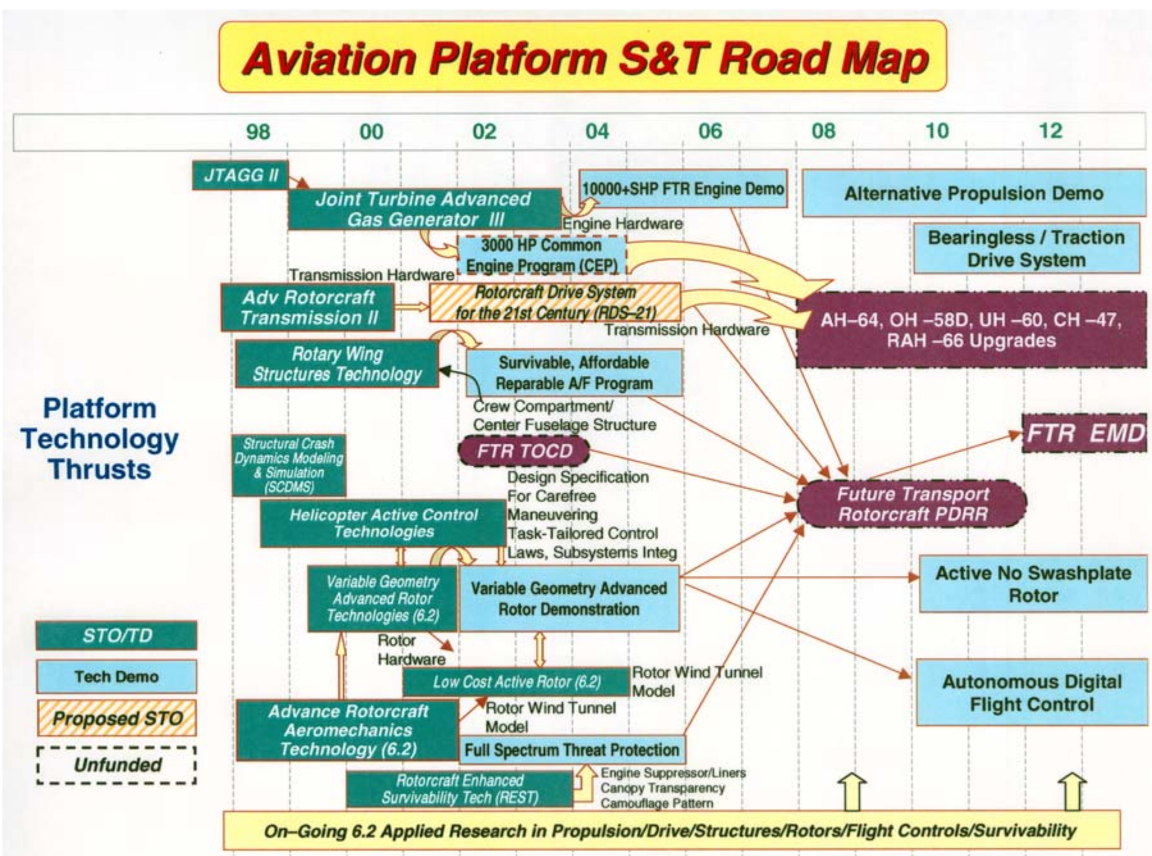
Focused Research, Development, and Acquisition:

- Develop technologies that will maintain aviation overmatch
- Develop technology that will address the Reconnaissance/Security shortfalls
- Reduce operational and support costs
- Leverage Unmanned Aerial Vehicle technology as a complementary system for the reconnaissance mission
- Reduce logistics footprint
- Enhance survivability through lightweight ballistic protection
- Add common user diagnostics systems to all modern fleet aircraft
- Develop unit level soldier equipment productivity management tools
- Leverage training through exportable training devices and embedded training systems on platforms
- Develop and field fully operational integrated electronic technical manuals

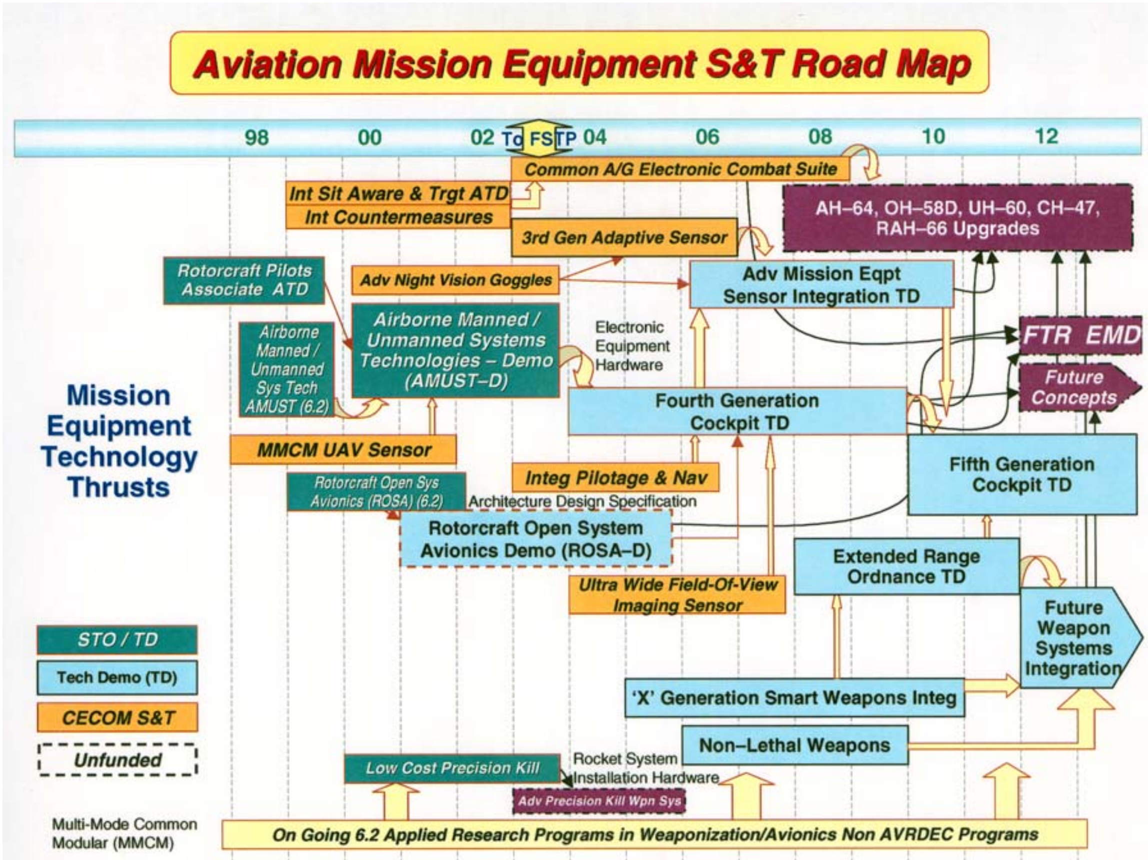
MAJOR THRUST AREAS FOR SCIENCE AND TECHNOLOGY

Science and technology programs support Army aviation by providing the knowledge needed to upgrade existing aircraft or to develop new aircraft to meet the evolving mission requirements imposed by a changing world situation. Future Army missions will require aircraft capable of flying farther, flying for longer mission duration, increasing lift capability, surviving more robust and dispersed threats, defeating a wider spectrum of targets in a more varied environmental and topographical setting, and imposing less logistical demand on supply and maintenance resources. To reach these goals in a timely and cost–efficient manner requires an adequate and well–managed program. The aviation program consists of efforts focused on developing and demonstrating technologies for advanced rotors, drive systems, engines, flight control, structures/airframes, weapon systems integration, survivability, and cockpit design. The aviation program supports a three–pronged strategy: development of a Future Transport Rotorcraft; support of next generation rotorcraft concepts; potential upgrades for Comanche, Apache, Black Hawk, and Chinook helicopters through technology insertions to sustain combat capability and extend operational lives.

The aviation S&T program provides the underpinning for technology insertion and aircraft/mission equipment integration programs. It also develops the foundation for aviation's system upgrades and next generation capabilities to meet changing threats, mission requirements, and to support the modernization strategy. In addition, through the Defense S&T Reliance, the aviation S&T program is the DoD lead focus for rotorcraft technologies. The aviation S&T strategy (Figures 1a–b) shows the interrelationship among the aviation disciplines, Technology Demonstrations (TDs), and Advanced Technology Demonstrations (ATDs). The aviation S&T program addresses technology and advanced concepts for DoD rotorcraft via application of DoD/NASA/academic resources, simulation, virtual prototyping, and Integrated Product and Process Development (IPPD). These approaches reduce risk, minimize costs, and enhance multi–service and dual–use applications derived from the aviation S&T program. Army aviation is preparing to meet tomorrow's challenges by modernizing forces, developing warfighting doctrine, and creating force designs flexible enough to win decisively across the full range of military operations. Aviation's lethality, versatility, and deployability offer the return on investment critical to the Army's investment strategy and future mission successes.



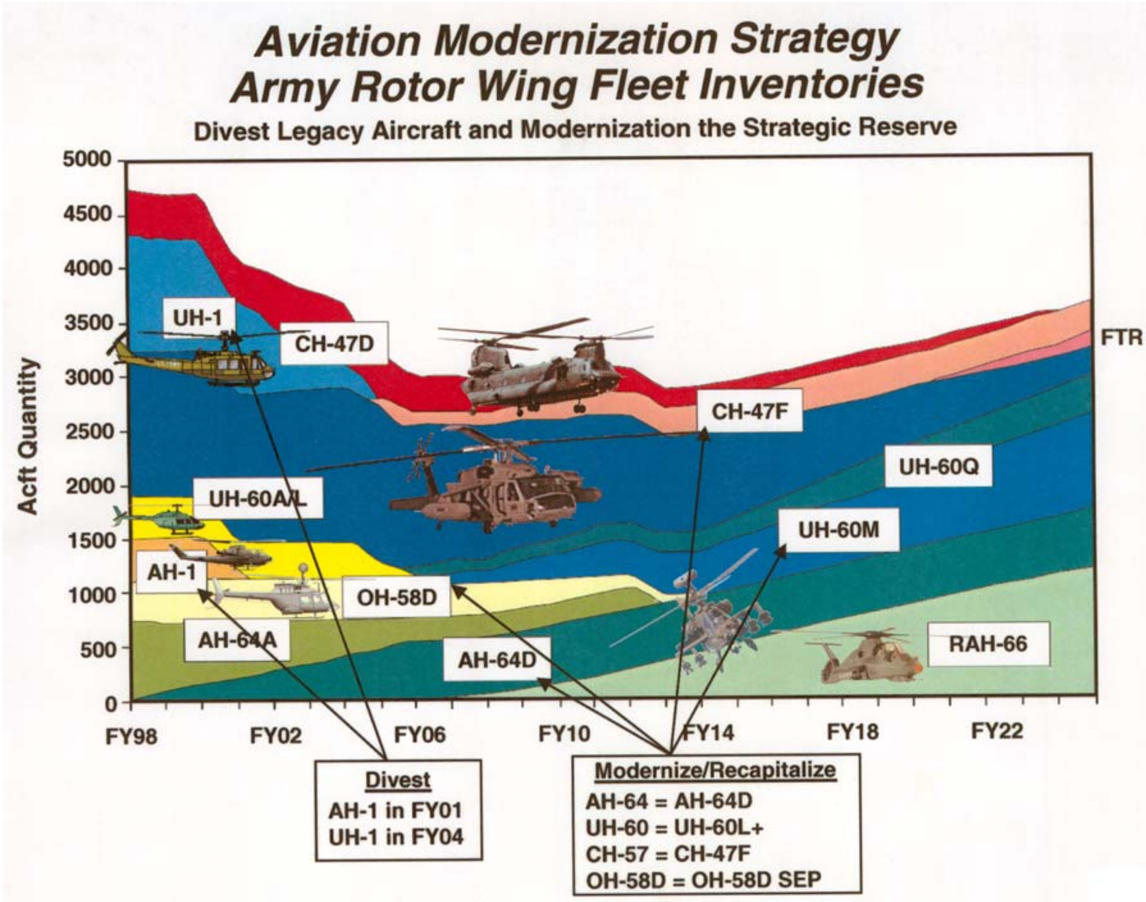
– Figure 1a –



– Figure 1b –

AIRCRAFT MODERNIZATION OVERVIEW

The strategy for Army aviation modernization calls for a transformation of the force to include the acceleration of legacy aircraft retirement and modernization and recapitalization of the aircraft fleet over time. Figure 2 reflects the transformation of the aviation fleet through the year 2025. The primary missions which Army aviation performs and will continue to perform in the future are listed below figure 2. Also included are the platforms which will perform these missions in the future and as well as those aircraft which currently perform the missions.



– Figure 2 –

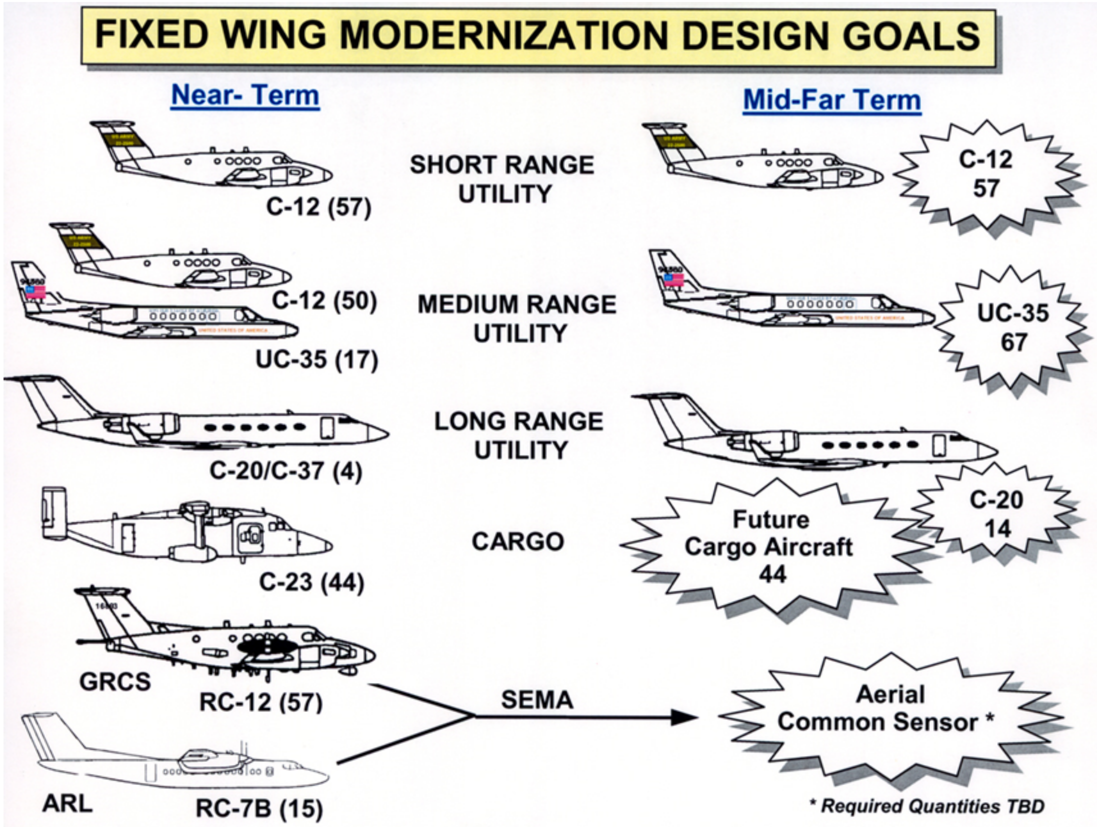
Reconnaissance: The RAH–66 Comanche is the Army's objective reconnaissance aircraft. The current fleet of reconnaissance and attack aircraft consists of the AH–1 Cobra and the OH–58D Kiowa Warrior.

Attack: The AH–64D Apache is a key element of the Army's ability to maintain combat overmatch. The current fleet also includes the AH–64A model Apache and the AH–1 Cobra.

Utility/MEDEVAC: The UH–60 Black Hawk is the foundation of the Army's utility helicopter force. There are currently UH–60A and L models with the UH–60M model planned for long–term utility fleet sustainment. The UH–60Q model will provide first–to–fight units with the world's most advanced battlefield MEDEVAC helicopter.

Cargo: The CH–47F is the improved cargo helicopter program to extend the life and capabilities of the current CH–47D cargo helicopter. The Future Transport Rotorcraft (FTR) is required by the cargo modernization strategy for phase–in during the 2020 timeframe.

Fixed Wing Fleet: The Army's objective for fixed–wing aircraft modernization is to reduce the fleet to five standard platforms for short–range (C–12), medium–range (UC–35), and long–range (C–20) utility aircraft, future cargo aircraft, and Aerial Common Sensor as the objective special electronic mission aircraft (SEMA) platform as depicted graphically in Figure 3.



– Figure 3 –

CONCLUSION

Army aviation has aligned its strategy with the Army Vision. The result is an overall reduction in the number of rotary wing aircraft with a corresponding acceleration in the retirement of legacy aircraft. This action will allow the realignment of aviation funding to help support achievement of aviation objective force requirements. The Army remains completely committed to the Comanche aircraft, which will resolve the single greatest Army aviation deficiency of reconnaissance capability. The Army is committed to a Recapitalization program as part of the transformation. Army aviation will fully address this program and the science and technology efforts will form an essential part of the plan.

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U. S. COAST GUARD

VISION

Coast Guard Aviation will continue to support all of the many varied missions of the Coast Guard, providing the President and the Secretary of Transportation with the capability to respond to any maritime scenario or national emergency in the maritime environment. Applied research, development, test, and evaluation will continually introduce emerging technologies and innovative methods to accomplish this goal. The Coast Guard has released its Vision 2020. [It can be viewed at: http://www.uscg.mil/news/contents.htm.]

OVERVIEW

The Coast Guard has five main roles: maritime safety, maritime security, protection of natural resources, maritime mobility, and national defense. These roles all contribute to our national security—our people, our territory, and our way of life. The Coast Guard has the primary authority to enforce all applicable federal laws and to ensure the safety of persons on, over, and under the high seas and adjacent waters subject to the jurisdiction of the United States. Additionally, the Coast Guard enforces applicable international agreements. To do this, the Coast Guard employs an operating force of multi-mission aircraft, cutters, and boats. The service's multi-mission approach permits a relatively small organization to respond to public needs in a wide variety of maritime activities and to shift emphasis as needs indicate. A CG aircraft may search for and assist distressed vessels, evacuate injured people, conduct pollution detection and surveillance flights, report sightings in conjunction with law enforcement, or carry out the mission of the International Ice Patrol.

Further, the Coast Guard is, under Title 14, U.S. Code, "At all times an armed force of the United States." The Coast Guard is organizationally in the Department of Transportation, but, in time of war, or by presidential decree, reports to the U.S. Navy, providing services to the Department of Defense. Although the Coast Guard is the smallest U.S. Armed Service, it is the twelfth largest navy, in number of vessels, in the world, and operates the world's seventh largest naval air force. The following table shows the breakout of the budget.

BUDGET CATEGORY	FUNDING ($M)	AVIATION SPECIFIC
Total Budget	3,720.0	-----
Operating Expenses	2,577.3	-----
Acquisition, Construction, Improvement (AC&I)	362.3	-----
Traffic Alert and Collision Avoidance System (TCAS) - Phase IV	---------	8.0
Global Positioning System Installation - Phase VI	---------	1.9
HC-130 Side Looking Airborne Radar (SLAR) Upgrade	---------	2.1
Air Station Consolidation	---------	11.0
Research, Development, Test & Evaluation (RDTE)	18.0	-----
Aviation-Related R&D (details in Vol II)	---------	0.8
Environmental Compliance	21.0	-----

AIRCRAFT AND SITING

The Coast Guard presently operates 202 aircraft, which are primarily of four types. The American Eurocopter HH-65A Dauphin serves as a short-range recovery (SRR) asset. The medium-range recovery aircraft is the Sikorsky HH-60J Jayhawk. Dassault's HU-25A/B/C Guardian is utilized for medium-range surveillance (MRS), and Lockheed HC-130H Hercules fill the role of a long-range surveillance (LRS) aircraft. In addition, 2 Schweitzer RG-8A motor-gliders are operated as special-use surveillance aircraft, a Gulfstream VC-4A is used for special-use cargo, and a Gulfstream C-20B is used for long-range command and control. The Coast Guard Auxiliary (a civilian volunteer assistance group) operates 206 various aircraft to assist with Coast Guard missions.

AIRCRAFT	TOTAL*	OPERATIONAL
HH-65A (SRR)	94	80
HH-60J (MRR)	39	35
HU-25A/B/C (MRS)	35	27
HC-130H (LRS)	30	26

* Includes operational and operational spare aircraft, as well as those undergoing Planned Depot Level Maintenance (PDM) and major modification.

The Coast Guard operates its aircraft from 26 Air Stations throughout CONUS, Puerto Rico, Hawaii, and Alaska (Figure 1).

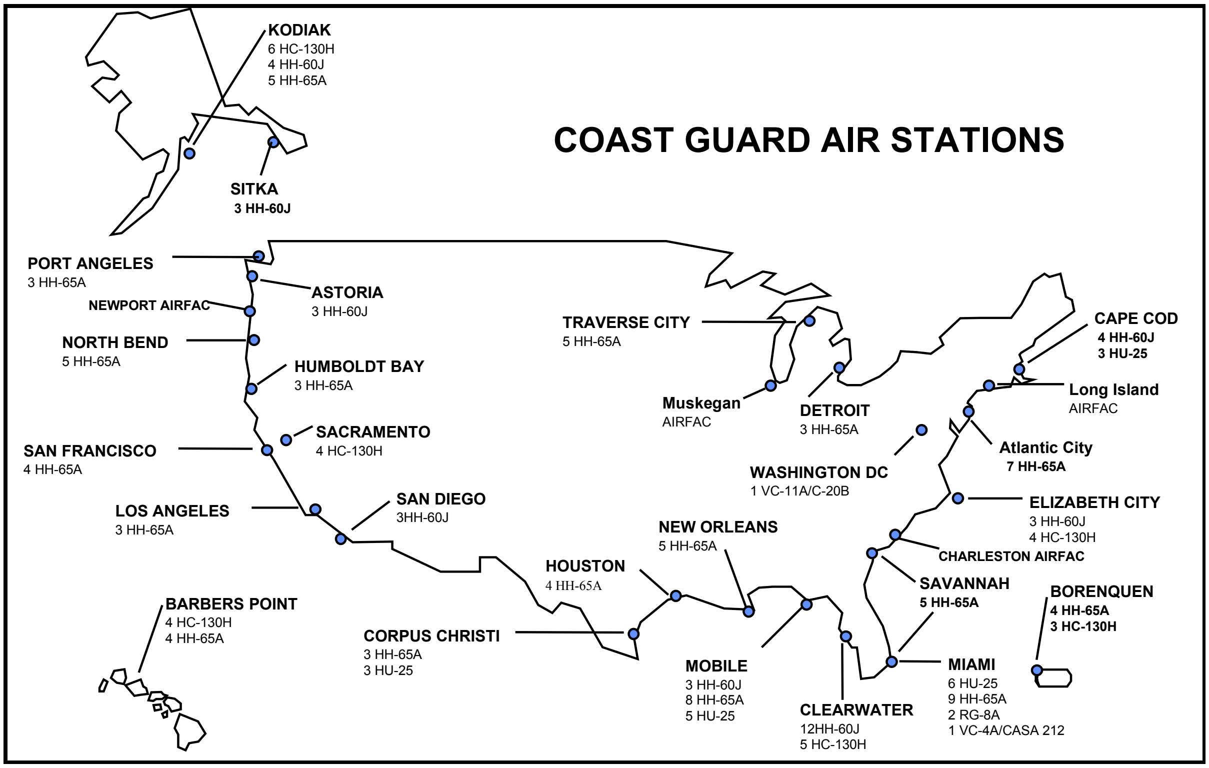

Fig 1 U.S. Coastguard Air Stations

Six part-time Air Detachments are also supported by a nearby Air Station. These are located in Muskegan, MI; Long Island, NY, Charleston, SC; Newport, OR; Cold Bay, AK; and Great Inagua Island, Bahama.

THE FUTURE

Aircraft in the Coast Guard inventory have a planned service life of 20 years. The current projection for each aircraft type's planned service life is shown below (Figure 2). The concept of Planned Service Life (PSL) includes a trigger to initiate a proactive analysis of mission needs prior to the end of asset life. Another element of the PSL concept is to evaluate the capability of the asset to meet designed mission needs. This assessment is currently accomplished through the mission analysis process.

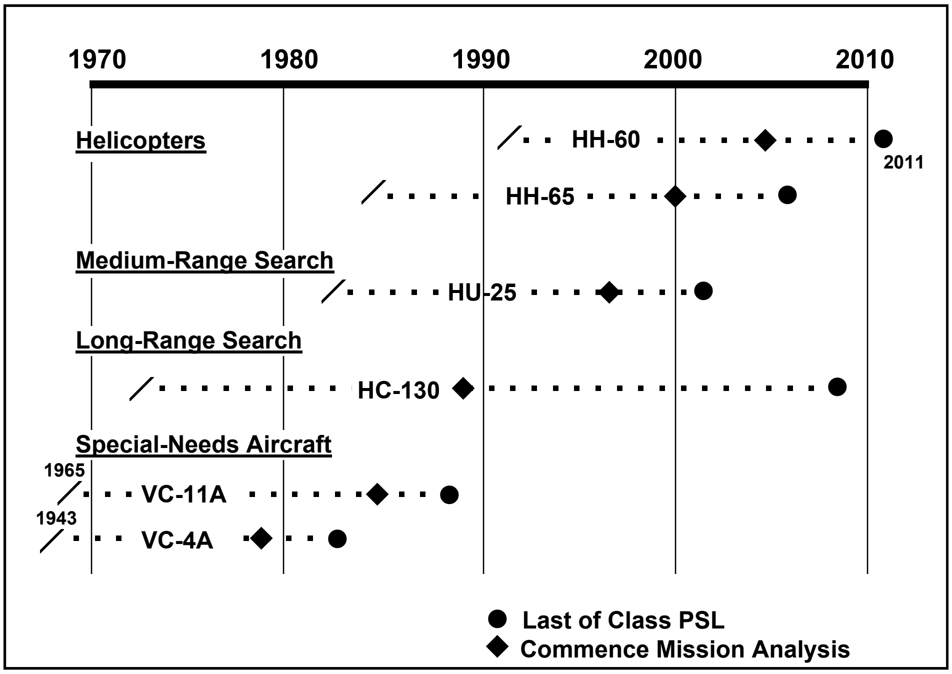

Fig 2-Inventory Planned Service Life

The fleet of 30 HC-130s was built between 1972 and 1987. An LRS mission analysis is scheduled to begin in 1997. This would lead to Initial Operating Capability (IOC) for a replacement aircraft in 2004 and project completion in 2009. A service life assessment program is in the developmental stages, however. The program will assess the fleet condition and develop cost/benefit data to assist in fleet rehabilitation and future acquisition decisions. Fleet improvements including Traffic Alert and Collision Avoidance System (TCAS), Global Positioning System (GPS), and power plant conversions (to a standard engine series) are in progress. An electrical power upgrade, to improve the quality of onboard electrical power, is under consideration.

The original fleet of 41 HU-25s has already been reduced by six, with a further reduction of 12 aircraft planned by 1996. A mission analysis for MRR replacement is scheduled to begin in 1997. IOC would occur in 2001, and the project should be complete in 2005. Ongoing initiatives include engine high pressure turbine reliability improvement, TCAS, GPS, RNAV software upgrades, and an FLIR relocation effort.

The HH-65A planned service life would end in 2006. An SRR mission analysis is scheduled to begin in 2000. IOC would follow in 2004, with the project complete in 2008. A Service Life Extension Program (SLEP), including updated avionics, increased payload, and increased power from the LTS-101 engines, is being evaluated for the HH-65A. If implemented, the SLEP will extend Coast Guard HH-65 operations through 2015. Efforts are already underway to upgrade the HH-65A fleet by adding an NVG compatible cockpit, TCAS, GPS, an upgraded Environmental Control System utilizing R-134, a refrigerant, and an upgraded main gear box to increase payload.

The HH-60J is the Coast Guard's newest aircraft. Deliveries are still in progress with the last of 42 aircraft scheduled for delivery in March 1996. Long range planning for replacement would begin with a mission analysis in 2005, followed by IOC in about 2010. Improvements now in progress include Tactical Data Processor software upgrade, TCAS, Cockpit Voice/Flight

Data Recorder, Mission Data Loader, and engine upgrades. Future aircraft improvements will primarily be driven and coordinated by Joint Services H-60 TEAMHAWK Work Group Initiatives. Cockpit air bag systems, common electronic technical publication systems, vibration absorber systems, and improved communications are under consideration.

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DEPARTMENT OF NAVY
U. S. NAVY/ U. S. MARINE CORPS

VISION

The Navy and Marine Corps Aviation Team is a major component of our nation's overall warfighting capability and provides a flexible forward presence and deterrence to preclude conflicts and preserve the peace. The unique, and demanding, operating environments in which these forces are required to conduct their missions require a robust Science and Technology (S&T) base to continually enhance Naval Aviation effectiveness and operational readiness to defend against advanced technology threats. Our nation's need for a responsive, dynamic, unencumbered, forward-deployed, expeditionary force to provide true flexibility for rapid response will continue to be critical in the 21st century. As a result, our vision is a warfighter who is fast, lean, mobile, affordable, sustainable and prepared for battle with total battlespace situation awareness and information assurance. The common vision of the Navy and Marine Corps espoused in *...From the Sea* and *Forward…From the Sea* focuses on "skillfully handled Naval forces" that "enable the United States to exert its influence in the littoral regions of the world." In concert with this, the Marine Corps' focus, as outlined in "Operational Maneuver from the Sea" (OMFTS), is the "full spectrum of challenges" coupled with "the dangers and opportunities created by new technologies." Together, the Navy and Marine Corps are working to adapt the "tradition of maneuver warfare, not merely to amphibious operations, but to all aspects of warfare in, and around, coastal waters." To do this, we are implementing a re-engineered business strategy-from top to bottom-that complements organizations such as the Naval Warfare Centers, the Naval Warfare Development Command and the Marine Corps Warfighting Laboratory, investigating new technologies and leveraging them into a warfighting edge. We are pursuing research, development, test, and evaluation programs that focus on innovative high-payoff challenges, including some with high technical risk. We are adapting our acquisition processes to take greater advantage of commercial market forces and make better use of private sector information and technology. We are striving to be agile enough to thwart the advanced asymmetric capabilities of potential adversaries.

The Marine Corps and Naval Aviation Communities are committed to developing, integrating and delivering greatly needed technology improvements throughout the fleet for the defense of our nation. Through aggressive partnering with other services, defense agencies, industry and leveraging technology already available, our Sailors and Marines will be provided the tools and services they need to conduct their missions effectively, efficiently and affordably.

OVERVIEW OF AGENCY MISSION

The expeditionary nature of naval forces means that we will continue to be the force of choice for crisis response. Our unique ability to provide combat-capable, self-sustained, unencumbered forces on-scene, almost indefinitely, that can influence and "shape" events ashore, will ensure that we can prevent situations from developing into a crisis or conflict. Our ability to achieve and sustain full battlespace dominance will become ever more important. Naval Aviation will play a critical role in ensuring that we obtain and maintain battlespace dominance in future conflicts. The twin centerpieces of naval expeditionary forces are our aircraft carriers with their embarked air wings and our amphibious assault ships with their embarked Marine Forces. The multi-mission aircraft that are part of these units give us the unique flexibility to respond quickly and precisely.

Our aircraft carrier fleet will comprise eleven active and one reserve carriers. The mix of two conventional powered carriers and ten nuclear powered carriers will be attained in the year 2002. Currently there are ten active and one reserve air-wings to support the carrier fleet. Each air-wing comprises 56 high performance F/A-18 Hornet and F-14 Tomcat multiple-mission-capable strike-fighter aircraft. Additionally, the unique electronic capabilities of the EA-6B Prowler, the multi-sensor capabilities of the E-2C Hawkeye, and the surveillance and reconnaissance capabilities of the S-3B Viking and ES-3A Shadow make the air-wing a lethal and capable power projection team. Maritime Patrol Aircraft at the turn of the century will consist of twelve active and eight reserve squadrons flying P-3C Orion aircraft supporting increasing multi-mission anti-surface warfare requirements.

The Marine Corps will field three active and one reserve wings. The Marine Corps air-wing will consist of high performance F/A-18C/D and AV-8B Harrier aircraft for offensive air support, EA-6B aircraft for electronic warfare and KC-130 Hercules aircraft for aerial refueling as well as CH-46 / 53, AH / UH-1 and the V-22 in 2001 for Assault Support.

STRATEGIC GOALS AND OBJECTIVES

Network Centric Warfare

Network Centric Warfare (NCW) is the vision for future Navy operations. NCW is based on the ability of a widely distributed, self-synchronizing force to mass effects when and where desired. The force, based on timely, accurate, common, shared information, requires high quality, widely distributed and netted sensors; a streamlined command structure; and units capable of autonomous operation and unity of effort. Properly implemented, NCW increases the speed, precision, and effectiveness of Naval forces. It is applicable to all levels of warfare and contributes to the coalescence of strategy, operations, technology, and tactics; it is transparent to mission, force size and composition, and geography.

NCW derives its power from the robust networking of a well informed but geographically dispersed force. It is enabled by the following attributes: highly webbed information services; timely access to all relevant and appropriate information sources; value-added, automated command and control processes; netted, integrated sensors that are closely coupled in time to the shooters and command and control processes; and weapons reach with adequate precision and speed of response.

Affordability ***(Mo rewrite, cob 25 Oct)***

Ownership Costs and System Affordability are Navy and Marine Corps major emphasis areas. This emphasis is reflected in the DoN technology program investments. Several high level initiatives focus on reducing ownership costs and increasing system affordability. Among these are the DoD/NASA/Industry Integrated High Performance Turbine Engine Technology (IHPTET) Program, the USN/USAF/Industry Composites Affordability Initiatives (CAI) Program, the DoD/DoN Manufacturing Technology (MANTECH) Program, and the DoN Reduced Total Ownership Cost (RTOC) Future Naval Capability (FNC). Through IHPTET, in concert with MANTECH, the DoN seeks to develop those technologies that will reduce engine acquisition, operating, and maintenance costs. Efforts include incorporating advanced manufacturing technology techniques into development programs, improving design tools to better predict component life and durability, reducing parts count by utilizing simpler design schemes, increasing stage loading, and increasing system performance. Similarly, the CAI Program, another collaborative undertaking, is investing in both the pervasive technologies and the manufacturing technologies that effect reduced manufacturing costs for composite materials. Through the RTOC FNC, the DoN is investing in technologies that will reduce the operating and maintenance costs for its fleet legacy systems. This FNC process is described at the end of this USN/USMC chapter

Modernization

For both the Navy and Marine Corps, modernization is of utmost importance. The Marines are currently fielding the V-22 tilt-rotor aircraft as the replacement for the CH-46E Combat Assault Helicopter and the Joint Strike Fighter (JSF) is their most important fixed-wing modernization program. The Marine Corps has made the fiscal decision to skip a generation of tactical aircraft by not purchasing the F/A-18E&F, and are reliant upon the JSF being delivered on schedule.

Technology Transitions

A fundamental goal and objective of the Naval Aviation community is to facilitate, in a timely manner, the transition of state-of-the art technologies which will lead to superior operational readiness and warfighting capabilities for the Naval Operating Forces. A number of the Naval Air Systems Command's business processes have been, or are currently being, re-engineered to promote increased partnering, requirements awareness, and goals visibility, as well as to establish performance benchmarks to measure our successes. The Navy's Systems Commands (SYSCOM), in their acquisition roles, will lead the new Future Naval Capabilities (FNC) process to enhance our effectiveness in transitioning technology to our fleet systems.

Joint Efforts

Increasingly, the Navy is moving to more joint research, development, procurement and operations. In the S&T area, there is increased cooperation and interdependency in DoD S&T investment. The Joint Strike Fighter (JSF), IHPTET, X-31 and unmanned aerial vehicles (UAV) are examples of programs where the services have successfully been able to team their S&T efforts for mutual benefit. More recently, the Navy has approved participation in a joint study of a naval concept of operations for a future Unmanned Combat Air Vehicle (UCAV) with DARPA.

The Department of the Navy coordinates its S&T programs through the DoD S&T Reliance process which was started in the early 1990s**.** The Reliance process provides a forum where S&T programs are planned, balanced and reviewed jointly, to ensure that unnecessary duplication is eliminated and to ensure compliance with top-level Defense Strategy and Planning Guidance. Through the Reliance process Technology Area Reviews and Assessments (TARA) are conducted to monitor the state of the art in technology as well as to provide frequent interactions among DoD components. There are presently 14 active technology panels (such as Air Platforms, Weapons, Human Systems, Sensors, Electronics). Reliance is overseen by the Deputy Under Secretary of Defense (Science and Technology) [DUSD(S&T)]. This office is also responsible for preparing the Joint Warfighting S&T Plan, Defense Technology Area Plans (DTAP), Basic Research Plan (BRP) and the Defense Technology Objectives (DTO). [The latest versions of these documents can be found at the web site (URL = https://ca.dtic.mil/dstp/.)]

NAVAL AVIATION TECHNOLOGY MAJOR THRUST AREAS

Air Vehicles

The focus of the Air Vehicle technology thrust area is those technologies that have the greatest impact on the airframe and on the air vehicle aerodynamics and control, especially those that are unique or peculiar to Naval Aviation operations. Current investments include unique aerodynamic concepts; aerodynamics of V/STOL configurations; flight control technologies, especially those related to reconfigurable flight control systems and self-diagnostic systems; aircraft handling qualities for shipboard operations; Uninhabited Combat Air Vehicle concepts; advanced composite structure concepts, and structural life methodologies. Through a variety of vehicles, such as the Air Platforms DTAP, Navy air vehicles S&T investments are generally made in collaboration with one or more partners, e.g., AFRL, NASA, DARPA.

Avionics & Sensors

A major objective of the Navy and Marine Corps is to make avionics and sensor systems lighter and smaller for the functionality required and to have a greater degree of component commonality with other, especially commercial, systems. The Department is moving away from federated avionics systems to distributed systems where common processor modules and shared apertures can be used with great cost and support advantage. A major focus is on dual-use systems that can adapt to emerging communication, navigational, safety and computing concepts, as well as promote safe and efficient flight in the U.S. civil and European airspaces. The Department's interest in advanced avionics and sensor technologies for future generation systems is focused on those technologies that will allow the resulting systems to be fully compatible with its network centric warfare strategy and provide the warfighter with a common tactical battlespace picture. Some specific technology investment areas include the following: advanced radio frequency sensor systems, especially wide band systems and electronically scanned arrays; low probability of intercept sensors; signal processing techniques for synthetic aperture radar sensors; advanced target recognition technologies; advanced imagery compression and transmission technologies; advanced electronic warfare technologies; advanced identification friend or foe technologies; precision identification and targeting technologies; ASW sensors and signal processing techniques for littoral waters; and advanced laser hardware and signal processing techniques.

Crew Systems

The Crew Systems thrust area includes all aircraft flight crew systems technologies, from the human engineering of equipment and displays for aircraft flight crew to the design of hardware and software interfaces for aircraft maintenance personnel. Current technology focus areas are cockpit/crew station integration, emergency egress systems, life support systems, crashworthy systems, personal protection/mission enhancement (especially eye protection), and human systems integration.

Interoperability and C4ISR

A major emphasis area for the Navy and Marine Corps is the development of the technologies that will provide an interoperable and secure C4ISR (command, control, communications, computer, intelligence, surveillance and reconnaissance) infrastructure that encompasses both strategic and tactical needs. This fully interoperable C4ISR infrastructure will provide total battlespace awareness and information assurance with real-time intelligence from sensor to shooter. It will be a major enabler for the Department of the Navy's Network Centric Warfare strategy.

Materials & Structures

The Materials & Structures thrust area provides the Department with a broad range of critical naval technologies for air vehicles, propulsion, avionics, support equipment, and weapons. Inherent in all these is the need for light, durable, corrosion resistant, high performance materials (metallic and composite) and structures and the respective manufacturing and repair/maintenance processes. Research is being conducted to understand the fundamental phenomena associated with material and structural failure, both the initiation of the failure and its subsequent growth or progression. Concerning system support, technology needs include the equipment and techniques for nondestructive inspection and test and corrosion control to provide cost effective, long life operation and support in the maritime environment.

Propulsion & Power

The Navy aircraft propulsion program is highly focused to develop and demonstrate the appropriate propulsion and power system technologies for future Navy and Marine Corps aircraft to significantly improve Naval power projection, conflict deterrence, and fleet defense capability. The primary technology emphasis areas being explored are in STOVL and/or V/STOL capabilities (through improved thrust/ weight ratio), affordable multi-mission aircraft (through reduction in production and maintenance costs), increased aircraft standoff range (through reduced fuel consumption), and increased penetration speed (through increased compressor discharge temperature). Naval operational requirements present unique challenges in each of the main technology component areas of the gas turbine engine (compression, combustion and turbine systems) as well as in the general areas of controls and mechanical systems.

The Navy's power systems program develops technologies that

(1) Produce weight savings for the electrical and thermal management systems in aircraft systems
(2) Improve electrical and thermal efficiencies
(3) Improve secondary power system reliability
(4) Provide large quantities of electrical power for future directed energy weapons

(5) Dramatically reduce maintenance of electrical and thermal management systems.

The goal of this effort is to develop component technologies that can be transitioned to legacy aircraft in need of reliability improvements and weight savings at minimum cost. An example of one major technology area being explored under this effort is the More Electric Aircraft (MEA) concept. The MEA concept uses advanced electric power system components and electric actuators to eliminate present day aircraft hydraulic, pneumatic and mechanical secondary power systems.

Integrated Systems Support

Integrated Systems Support (ISS) is critical to the day-to-day operational effectiveness of the aviation component of the Naval Fleet. ISS includes all the systems, subsystems, equipment, processes, and technologies which collectively provide the operational, servicing, and maintenance support for naval aviation afloat and ashore. Technology emphasis areas are: seabased aircraft operations technology (e.g., for aircraft launch and recovery, landing guidance); support systems technology (e.g., for aviation support equipment, avionics and non-avionics systems, weapons systems, mission systems, and training); environmental protection and compliance technology; and generic logistics (e.g., for manpower reduction, condition based maintenance, affordability). To identify operational requirements, the naval aviation community conducts a wide range of technology studies for the Navy's diverse Aircraft Platform Interface (API) systems. These studies encompass the areas of systems engineering, test evaluation and performance verification, major platform systems integration, limited manufacturing, systems acquisition, integrated logistics support management, and fleet engineering support.

Total Ownership Costs

Faced with declining resources, aging aircraft inventory and rapidly escalating operating costs, the Naval Aviation Systems Team has taken a leading role in reducing the cost of doing business for the Navy. The challenge is to sustain our superior warfighting capabilities, improve Fleet readiness, and ensure that the Navy can maintain our aviation superiority well into the future. Total Ownership Cost (TOC), as defined for the Assistant Secretary of the Navy (Research, Development, &Acquisition) Strategic Plan, includes all costs associated with the research, development, procurement, operation, logistical support, and disposal of an individual weapon system, including the total supporting infrastructure that plans, manages, and executes that weapon system program over its full life. Given this guidance, the Naval Aviation community is focusing a portion of its S&T resources on technologies that can be implemented affordably to reduce the operating and support costs of current inventory systems. Technologies that reduce maintenance time and increase the effectiveness of maintenance personnel are especially important.

Training Systems

The development of advanced, state-of-the-art training systems is critical to fleet needs and is a major objective of the Naval Air Systems Command [see http://www.navair.navy.mil/]. The Naval Air Warfare Center Training Systems Division (NAWCTSD, Orlando, FL) is a cornerstone of the National Center of Excellence for Simulation and Training [see http://www.ntsc.navy.mil/AboutUs/Excellnc.htm]. The Training Systems Division specializes in training systems, human performance measurement, learning and simulation technologies in virtual environments, modeling and simulation, electronic environments as well as dual-use technology development. As the principal Navy center for Naval training systems, the TSD is a major national asset in that it provides R&D, Acquisition, fully integrated life-cycle support and critical inter-service coordination for training systems in support of other defense agencies and services (Army, Air Force, Coast Guard, etc).

Weapons Systems

The Navy and Marine Corps are focusing on a variety of state-of-the-art offensive and defensive weapon technologies that are long-range, high precision, all weather, low-cost, robust and reliable against time-critical, hardened, fixed and moving targets. The weapons program has a highly focused mission area structure which is built on the Office of Naval Research Air & Surface Weapons Technology (ASWT) program goals of developing and demonstrating those technologies which will maintain the Naval warfighter's edge in Land Attack and Air Dominance. The technologies will achieve challenging time-phased mission area performance goals, resulting in significant warfighting payoffs. Technologies being developed and demonstrated include highly advanced automatic target recognition (ATR), real-time retargeting (RTR), Global Positioning System (GPS), jam-resistant GPS, and inertial navigation system (INS) technologies. These technologies will allow for the removal of much of the expensive guidance systems from current precision guided munitions and replace them with simpler, cheaper, more reliable systems that will receive updated guidance information in flight. Current developments in advanced wavelet image compression algorithms and data transmission technologies will allow the feeding of targeting information to and from the weapons and aircraft (sensor-to-shooter) in a more efficient and timely manner.

Tactical propulsion for weapons is largely developed and demonstrated through the Navy's participation in the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. The continued focus on, and developments in, missile kinematics, sensor performance and ordnance lethality will help ensure that weapons which are put into service will provide true precision strike as well as give naval aviators the air superiority performance capabilities they require. These weapon technology development efforts are being performed by the Naval Warfare Centers as well as the U.S. Defense industry.

TECHNOLOGY TRANSITION AND INSERTION ROADMAPS

At the present time, the Department of the Navy is implementing a new technology transition process that is expected to impact numerous technology insertion points and the associated platform technology insertion roadmaps. The technology summaries and roadmaps presented here are therefore not definitive but only representative of the technology insertion points and targeted platforms. Programs which afford transition and joint program opportunities include ongoing programs not yet in production as well as conceptual programs.

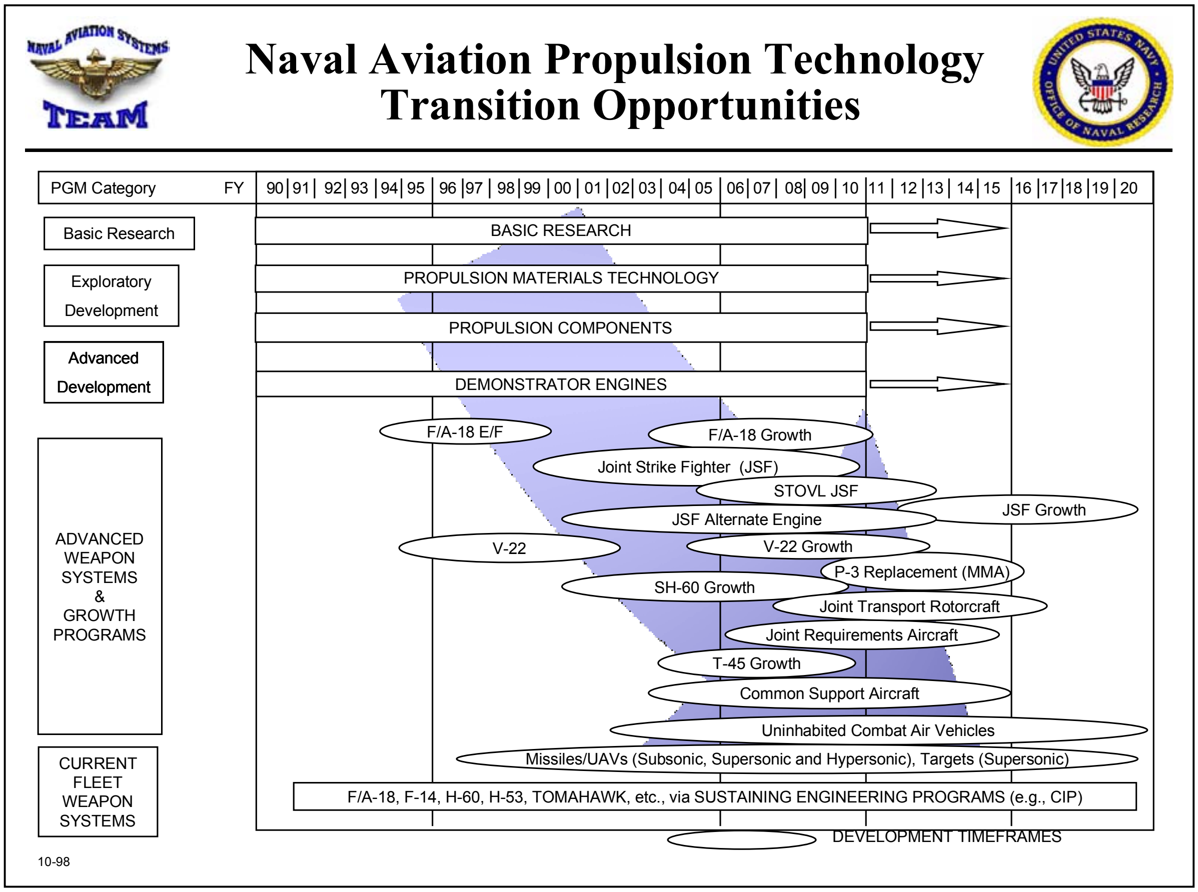

Figure 1 Typical Naval Aviation S&T Transition Roadmap

Figure 1 identifies several Naval Aviation Propulsion and Power technology transition opportunities for Department of the Navy advanced systems. Included are fighter/attack aircraft, patrol/transport/rotorcraft, support aircraft, and missile and UAV systems.

Aircraft Platform Roadmaps

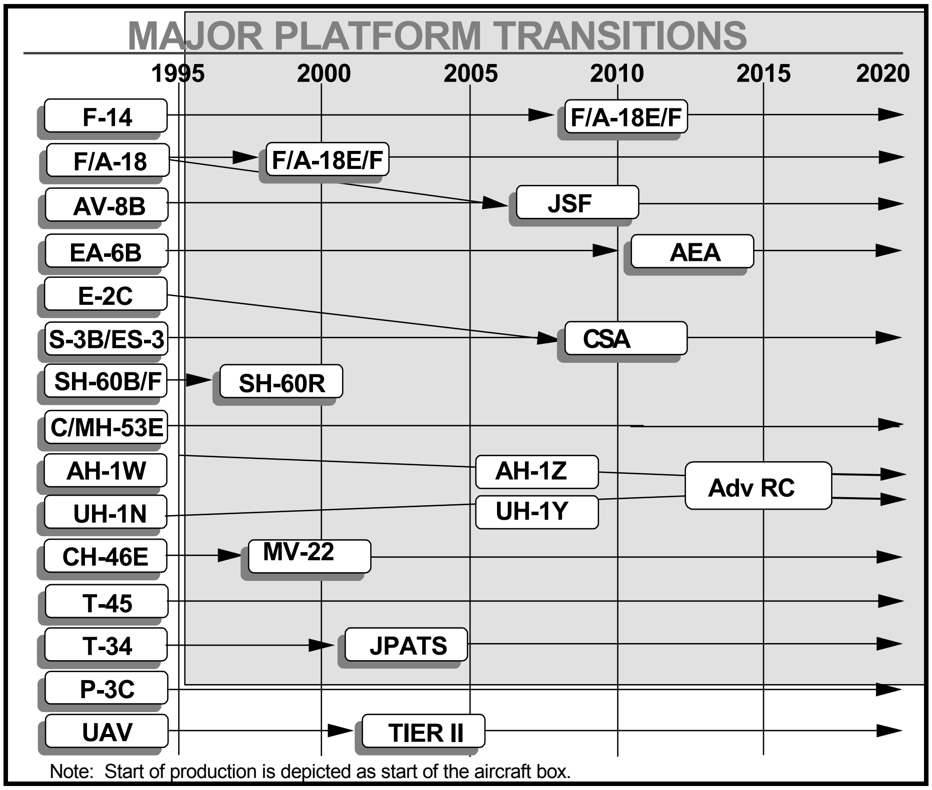

Figure 2: Major DoN Platform Transitions

Figure 2 illustrates platform upgrade and technology transition opportunities for some major Department of the Navy aircraft systems. Included are fighter/attack aircraft, patrol/transport/rotorcraft support aircraft, trainer aircraft and UAV systems. Figure 3 shows primary Marine Corps aircraft platform transitions while figure 4 shows the primary Navy aircraft platform transitions.

The **F/A-18E/F Super Hornet** is the cornerstone of tactical naval aviation for the next two decades. It is currently in production and will replace F-14s as these retire. This modernization development will increase mission radius, endurance, and survivability. It will ensure that throughout the next 20 years the fleet will be capable of countering the evolving threat.

The F/A-18E/F has completed all phases of testing. Operational Evaluation (OPEVAL) began in May 1999 and concluded two weeks ahead of schedule in November 1999. The F/A-18E/F Super Hornet garnered the highest possible rating coming out of OPEVAL when it was declared operationally effective and operationally suitable by the U.S. Navy's Operational Test and Evaluation Force. The OPEVAL report specifically cited the aircraft's key enhancing features (growth, survivability, range and payload) as qualities relative to current fleet operational capabilities. The successful completion of OPEVAL led the Super Hornet to a milestone III decision and approval for full-rate production and multi-year procurement.

F-14 TOMCAT. The Navy has developed a strong, fully funded, executable program through the now short remaining life of the F-14 TOMCAT. The strength of the F-14/LANTIRN program has been ably demonstrated and has provided a firm bridge to F/A-18F. The Navy still intends to retire the F-14A force by 2003, the F-14B force by 2007, and the F-14D by 2008.

The **Common Support Aircraft (CSA)** has been envisioned to be a common airframe replacement for the E-2C, S-3B and ES-3A carrier-based aircraft. The program is currently being reexamined in light of the Navy's modernization goals and various platform upgrade options. If funding is approved, the CSA is expected to provide the fleet with C^3I, early warning, and electronic surveillance capabilities. At the current time the Navy has deferred a formal acquisition plan for the CSA until the critical issues of resources, requirements and program timing have been resolved. Until funding is approved, or the program is cancelled, it may be more appropriate to call the program a Common Support Concept (CSC) which accommodates efforts to tailor carrier-based support missions to the battlespace of the future. The spectrum of solutions for support aircraft modernization does not entail only new aircraft platforms. Current S-3 and C-2 airframe test articles will further define service life limits and alternatives. Support aircraft program initiatives such as the E-2 Multi-Year Procurement, vertically cutting the ES-3A, and shedding S-3B mission areas have succeeded in pushing the requirement for a Common Support Aircraft farther into the future. The conclusions of ongoing analysis will be used to determine future direction of the CSA concept and to move forward with the most cost effective approach for modernizing naval aviation's support aircraft inventories.

Unmanned Air Vehicle (UAV) efforts are being pursued by all of the services as well as the Defense Advanced Research Projects Agency (DARPA). Additionally, several of the Services' battle labs are engaged in experimentation with UAVs. The Navy has just started a Vertical Takeoff and Landing UAV (VTUAV) program to meet its near-term tactical requirements. Initial Operational Capability for the VTUAV is scheduled for FY03. In February 2000 the Navy's Program Executive Office (Cruise Missiles and Unmanned Aerial Vehicles) awarded an Engineering & Manufacturing Development contract for the VTUAV. The platform will provide real-time and near real-time data required to support intelligence, surveillance, and reconnaissance tactical needs. Its vertical launch and recovery capabilities will give the Fleet unique operational assets. The Navy expects this system to perform a variety of roles, including area surveillance and reconnaissance and battle damage assessment. It will also be able to identify targets, relay communications, conduct chemical or nuclear monitoring, and provide naval gunfire support. The Navy is also funding a concepts study for integration of a future Medium Altitude Endurance (MAE) UAV into the naval strike warfare capability.

The DoN, in collaboration with DARPA and through its Future Naval Capabilities process, is investigating Unmanned Combat Air Vehicles (UCAV) for potential future application. The USN/DARPA UCAV Program is examining the technology and operational implications of integrating carrier-based UCAVs into a manned aircraft fleet. In its Autonomous Operations FNC the DoN is investing in technologies that will enable autonomous decision making, as well as in concepts for unmanned air, ground, and underwater vehicles.

The **Marine Corps Warfighting Lab** has on-going projects experimenting with a variety of UAVs. The Dragon Drone project demonstrated the utility of deploying a small UAV with small units and forward deployed forces. The Dragon Warrior project is developing a prototype small VTOL UAV that will be optimized for urban terrain. Finally, the Broad Area Unmanned Responsive Resupply Operations (BURRO) is a project to demonstrate the feasibility of applying unmanned technology to a full sized helicopter for external resupply operations.

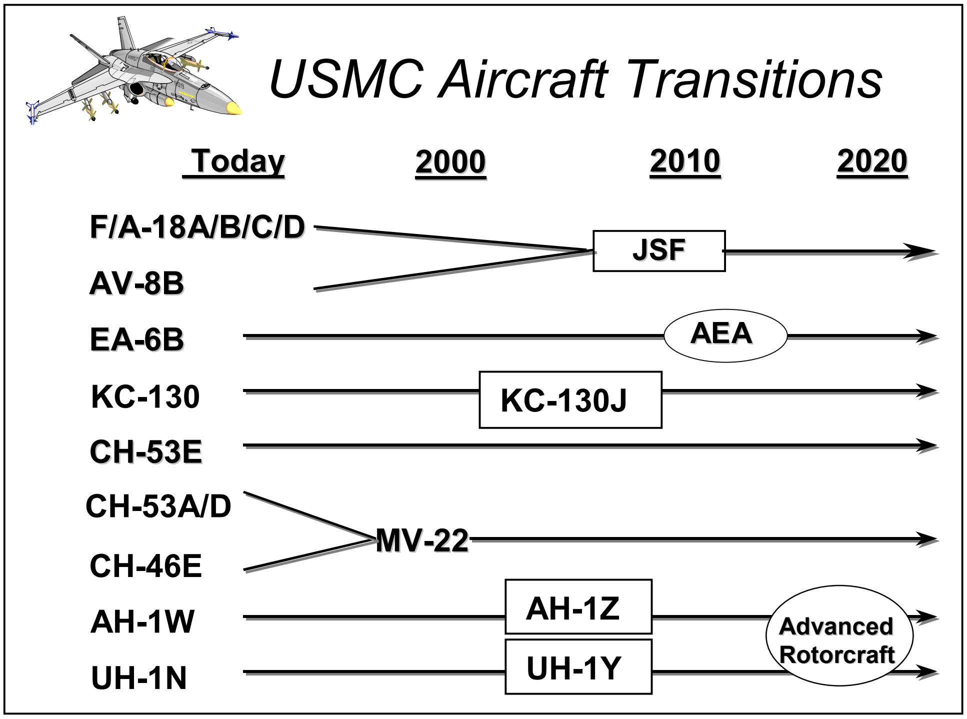

Figure 3: Marine Corps Aircraft Transitions

The **V-22 Osprey** is a multi-mission, medium-lift, Joint Service tiltrotor aircraft, the first ever tiltrotor in production. The program is currently in Low Rate Initial Production (LRIP) with Full Rate Production planned for FY01. The V-22 promises to provide the warfighter with unprecedented flexibility and responsiveness through its speed, payload, range, and survivability capabilities. Currently in OPEVAL, the Osprey is expected to meet or exceed all Service requirements. The tiltrotor technology inherent in the V-22 marks the beginning of the future. This unique and revolutionary technology offers unlimited potential for science and technology growth that may be applied in numerous joint applications.

The **Joint Strike Fighter (JSF)** is a tri-service, multi-role tactical aircraft and is the Marine Corps' number one acquisition priority. JSF is currently in the concept demonstration phase, which will feature flying demonstrator aircraft (Boeing's X-32 and Lockheed Martin's X-35), concept-unique ground and flight demonstrations, and continued refinement of contractor's weapon systems concepts. The Services approved the Joint Operational Requirements Document (JORD) in early 2000. Pratt and Whitney commenced engine testing in the summer of 1998 for Boeing and Lockheed Martin demonstrator aircraft, with tests meeting or exceeding expectations. General Electric/ Allison is also developing an alternate engine for the program. A milestone decision to commence Engineering and Manufacturing Development (E&MD) is planned for the first quarter of 2001. The JSF will IOC in 2010 for the USMC, 2011 for the USAF and 2012 for the USN.

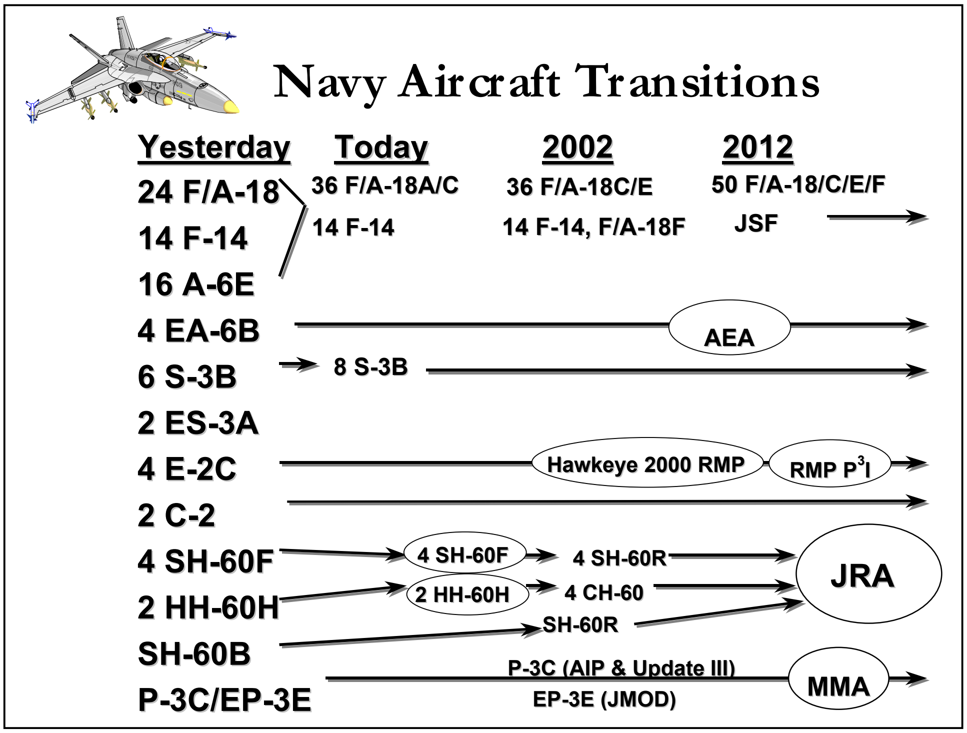

Figure 4: Navy Aircraft Transitions

The **SH-60R** is being developed to effect Navy platform commonality (currently two model types, the SH-60B and SH-60F) and to improve sensor capability, providing the USN with a robust multi-mission capability well into the next century.

The **EA-6B** fleet inventory is improving and increased to 103 of a PAA of 104 jets as of March 2000. Prowler inventory and readiness issues are steadily improving, and the platform's engines will be overhauled at NAS Whidbey Island. Current use of the EA-6B for all DoD Electronic Warfare missions has required close joint service cooperation. Recent lessons learned from Operation Allied Force has highlighted the EA-6B's key role in providing EW support for all strike aircraft. The Prowler will require a replacement in the post 2010 time period. The services are currently working on a joint Analysis of Alternatives (AoA) to determine the best approach.

The **E-2C** began a five-year Multi-Year Procurement in FY99. The procurement plan is for 21 aircraft to be in a Hawkeye 2000 compatible configuration, which consists of cooperative engagement capability (CEC), new mission computer, new workstations, satellite communications, upgraded equipment cooling, upgraded navigation system, and upgraded standard automatic flight control system. The modernized system will center on CEC, which brings significant benefits to all air defense areas, including improvements in track accuracy, continuity, and identification consistency. This capability will provide an identical picture to all CEC capable units, increasing battle space awareness, reducing reaction time, and extending engagement ranges. The Hawkeye 2000 is presently in flight test with all results meeting goals.

Weapon Technology Roadmaps

Naval Aviation possesses numerous types of air-to-air and air-to-ground strike weapons, all of which are designed for different targets, levels of accuracy, and missions.

Close-In Weapons. Weapons such as the Mk-80 series General Purpose (GP) bomb family, Rockeye, Gator, and 2.75" and 5" rockets are close in, direct-attack, unguided munitions. Close-in precision-guided munitions (PGM), such as Laser-Guided Bombs (LGB), AGM-65 Mavericks, and Hellfire II improve weapon lethality via increased accuracy.

The **Joint Direct Attack Munition (JDAM)** currently under development is a multi-service effort to develop a strap-on, GPS-aided Inertial Navigation System (INS) guidance kit that will improve the accuracy of GP bombs in all weather conditions. JDAM also will allow a single aircraft to attack multiple targets from a single release point.

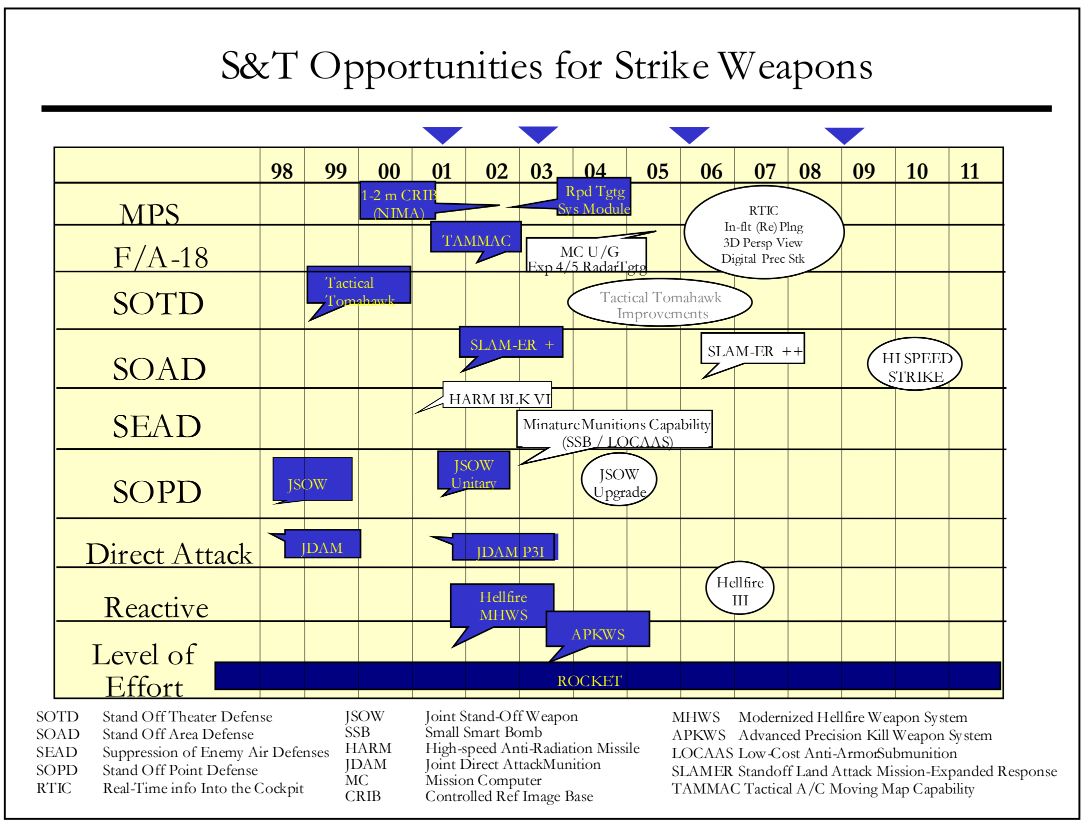

Figure 5: S&T Opportunities for Strike Weapons

Stand-Off Weapons. Point-defense surface-to-air missiles comprise approximately 85 percent of the weapons that make up enemy integrated air defense systems. Naval Aviation's ability to attack targets from beyond the range of these systems is met by the AGM-88 HARM (High-speed Anti-Radiation Missile), SLAM (Stand-off Land Attack Missile), and the AGM-62

Walleye. These weapons acquire and home in on their targets using various techniques, including passive homing on radar and radio emitters (HARM) and electro-optics in the visible (Walleye) and infrared (SLAM) spectra. However, these provide limited adverse weather capability and carry only a unitary warhead for attacks against point targets. HARM has shown great flexibility and continues to be upgraded; the Navy is currently incorporating Block V and VI modifications into the missile, giving it the capability to attack GPS jammers and adding an INS/GPS suite. Walleye, developed in the 1960s, will be phased out of the inventory by 2005.

Joint Stand-Off Weapons. A new family of Stand-off Outside Point Defense (SOPD) weapons was introduced to the fleet in FY 1998, beginning with the Joint Stand-Off Weapon (JSOW). JSOW is another multi-service program that will replace five types of the older air-to-ground weapons currently in the naval inventory. It will provide a family of near precision-guided weapons that will allow naval aircraft to attack area as well as point targets at increased standoff distances, thus greatly increasing aircraft survivability. JSOW will be usable in adverse weather conditions and, like JDAM, will give aircrews the ability to attack multiple targets in a single sortie.

SLAM/SLAM-ER (Expanded Response). SLAM-ER is Naval Aviation's follow-on to the SLAM Stand-off Outside Area Defense weapon. It is a day/night, adverse-weather, precision-strike weapon with over-the-horizon range. SLAM is an anti-ship missile with a GPS-aided INS system for mid-course guidance, an Imaging Infrared sensor and a data link for precise, "man-in-the-loop" terminal guidance. SLAM-ER is an evolutionary upgrade of SLAM, providing the Navy and Marine Corps with a major improvement in precision strike capability. SLAM-ER+ will incorporate Advanced Terminal Guidance (ATG), making it an autonomous weapon, and enhancing the missile's capability against small targets and targets in urban environments. SLAM-ER weapons fitted with ATG will be fielded in the 1999-2000 timeframe.

The **AIM-120 AMRAAM** is the Air Force and Navy's Advanced Medium Range Air-to-Air Missile. A suite of upgrades for the AMRAAM include the rocket motor, warhead, target detector, advanced seeker, ECCM and a new guidance system.

The **AIM-9 Sidewinder** is the Navy and Air Force's short-range infrared-guided air-to-air missile. The latest upgrade to the AIM-9L/M family is the AIM-9X configuration, which is currently undergoing operational testing. Future system upgrades include motorcases, infrared counter-counter-measures improvements, and kinematics and lethality improvements.

FUTURE NEEDS

Possible Air Wing Changes

Naval Aviation leaders are exploring sweeping changes in carrier aviation, changes that would radically alter the makeup of Naval air wings. Deployment changes being explored include reducing the number of strike fighters by 10 percent per wing and forging a more powerful force off the flight deck. Each carrier air wing could shrink by as many as six strike fighters (from 56 to 50) in the coming years. The decrease in airframe numbers would be compensated by mission and operational advances anticipated with the incoming F/A-18E/F Super Hornet (scheduled to join the fleet in two years), as well as upgrades to several current platforms. The cost savings realized from shrinking the air wing could conceivably pave the way for an 11th carrier air wing. Currently, 10 wings rotate to respond to the needs of 12 aircraft carriers. An additional (11^{th}) air wing would greatly mitigate operations tempo on the existing wings as the heavy dependence on air strikes is not expected to change significantly.

Future Naval Capabilities

In June, 1999, the Navy approved a new investment process for the DoN Science and Technology (S&T) Program. This new S&T process focuses on achieving a long-term view not anticipated by currently perceived Naval needs as well as addressing nearer-term Future Naval Capabilities (FNC). Under this new process approximately half of the DoN S&T budget will be focused on carefully selected investment programs; these programs will develop and demonstrate those advanced technologies that address and enable the high priority Future Naval Capabilities. Transition sponsors will be closely coupled to the FNC's to ensure that the capabilities are delivered to the fleet in a more aggressive and timely manner.

At the time of the establishment of this new S&T investment process, a list of twelve FNC emphasis areas was approved by the DoN Corporate S&T Board. An Integrated Product Team (IPT) was formed for each FNC. Led by flag level personnel, each FNC IPT defined specific Enabling Capabilities, prioritized those capabilities, performed a technology assessment and identified technology gaps, and began the development of an appropriate S&T program which will enable those future capabilities to be realized, demonstrated, and transitioned to the fleet. The twelve FNCs are:

- Platform Protection
- Littoral Anti-Submarine Warfare
- Decision Support Systems
- Information Distribution
- Time Critical Strike
- Expeditionary Logistics
- Capable Manpower
- Warfighter Protection
- Autonomous Operations
- Total Ownership Cost
- Missile Defense
- Organic Mine Countermeasures

This new investment process continues to evolve as this brief description goes to print. In November 1999 a final prioritization of the FNC emphasis areas was released, as was a proposed S&T technology investment program. The S&T investment program includes the active coordination with, and leveraging of, appropriate science and technology investments by other Services and Federal Agencies. The Navy's POM-02 budget will provide the first opportunity to implement the S&T program changes which result from this new process.

COMMON THEMES

A review of each JACG member's aviation activities and outlook reveals a number of common themes for potential Navy /Marine Corps S&T focus:

- Life Extension
- Affordability
- Environmental Compatibility/Safety
- Rapid Response/Flexibility
- Modularity/Commonality/Interoperability
- Performance Enhancement
- Total Ownership Costs
- Infrastructure
- Customer Response
- Training, Simulation, and Modeling
- Integrated Support
- Unmanned Air Vehicles (UAV)
- S&T Funding Shortfalls

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