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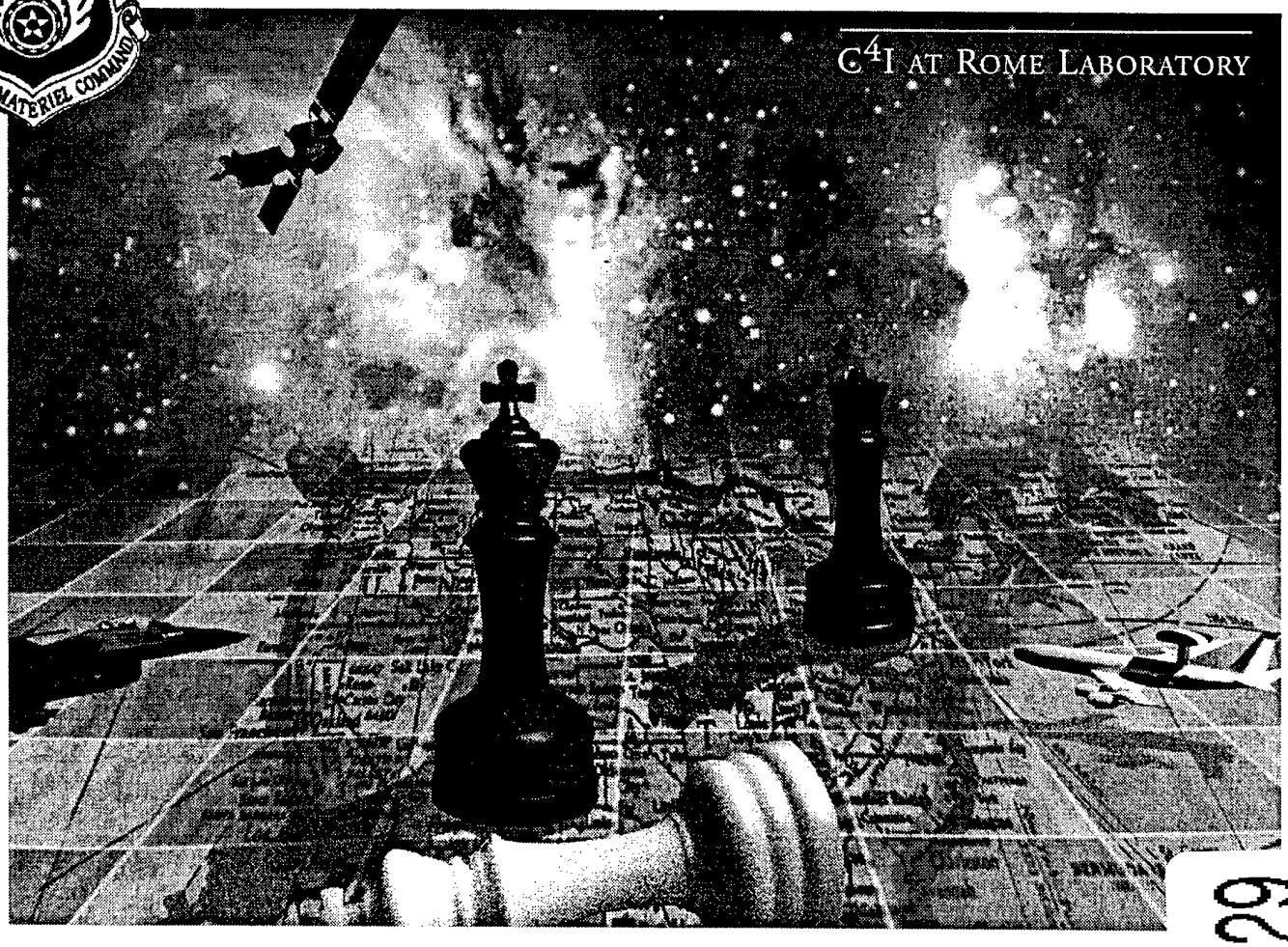
FY97

COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS & INTELLIGENCE

C4I

TECHNOLOGY AREA PLAN

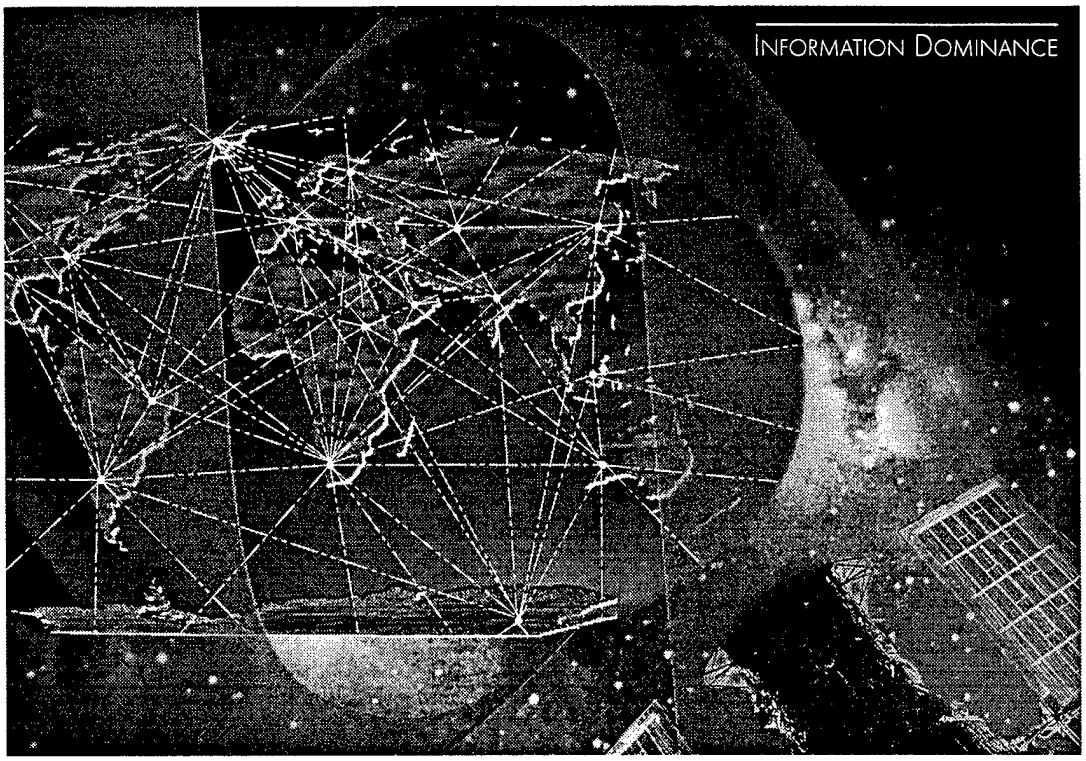


HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE & TECHNOLOGY
WRIGHT-PATTERSON AIR FORCE BASE, OH

NOTE:

This Technology Area Plan (TAP) is a planning document for the FY97-02 S&T program and is based on the President's FY97 Budget Request. It does not reflect the impact of the FY97 Congressional appropriations and FY97-02 budget actions. You should consult RL/XP for specific impacts that the FY97 appropriation may have had with regard to the contents of this particular TAP. This document is current as of 1 May 1996.

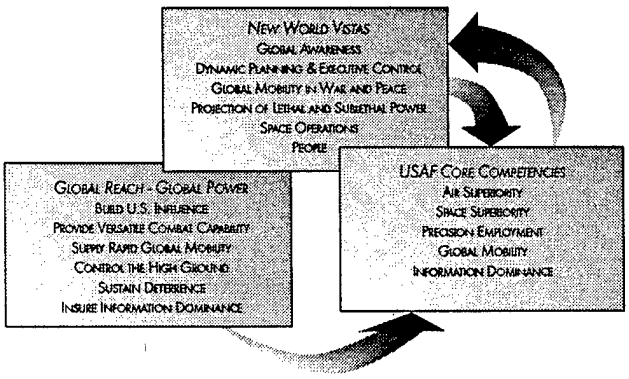
On the Cover: *Rome Laboratory ensures that our warfighters have whatever data they need, whenever they need it, under any circumstances. We do this through the development of the enabling technologies of C^4I. In space, in air, and on the battlefield, we deliver total information dominance.*



C4I

VISIONS & OPPORTUNITIES

In order for the Air Force to continue into the 21st century as the world's best and most respected, it must develop those core competencies that provide properly trained people, superior equipment and the right information - at the right place and at the right time - concerning its own forces and those of any adversary.



For this reason, C4I is more important than ever, and a critical element in ensuring that the Air Force can fulfill its mission. Our military forces, although reduced in size must be highly flexible, globally responsive, and at times deadly precise. They must operate successfully in high threat, high technology environments, and in new missions such as humanitarian assistance. With revolutionary C4I technologies, we can achieve *information dominance*; responding accurately and effectively to the rapidly changing international scene and controlling both the increasing instability of the battlefield, and sophistication of our adversaries.

Our vision is simple. We want to ensure that our warfighters have control and an omniscient view of the battlefield. We will give our warfighters access to whatever data they need and will ensure that it's up to date and accurate. We will:

PROVIDE THE RIGHT INFORMATION ANYTIME, ANYPLACE, FOR INFORMATION DOMINANCE ...

- Interoperable distributed systems
- Secure communication networks
- Offensive/Defensive information warfare
- Improved surveillance systems
- On-time intelligence information
- Up-to-date maps, charts and graphics
- Improved mission planning
- Adaptable communication networks
- Data compression and transmission

... UTILIZING POWERFUL, USER-FRIENDLY INFORMATION PROCESSING SYSTEMS ...

- Advanced signal processing algorithms
- Heterogeneous databases
- All source data fusion and correlation
- Rapidly reprogrammable software
- Multilevel security
- Artificial intelligence

... WHICH ARE AFFORDABLE AND MAINTAINABLE.

- Reliable components
- Built-in diagnostics
- Emphasis on low cost

Our current C^4I systems support our forces world-wide. They are the eyes and ears of Global Reach/Global Power — the notebooks and decision aids, the infrastructure for effective information dominance. The C^4I technologies described in this Technology Area Plan (TAP) support our present systems, but look strategically to the future. These technologies will support a smaller force, but one that still has global responsibilities. These technologies are also in the forefront of the technology revolution with regard to how future wars are fought and won. Technologies in signal processing, data fusion, information warfare, mission planing, communications, artificial intelligence, distributed information systems, intelligence exploitation, new semiconductor materials, multispectral active and passive sensors and cost effective C^4I system support technology will ensure that the appropriate information is available to most effectively use our stealth and smart weapons.

Where applicable, C^4I technologies will leverage commercial R&D in communications, computer systems, artificial intelligence, and other related areas. This allows us to concentrate scarce AF resources on those problems that have no commercial equivalent.

Conversely, C^4I technologies in other areas such as signal processing, photonics, and intelligence are having tremendous dual-use potential in areas such as health and criminal justice — our defense investment reaps commercial dividends as well.

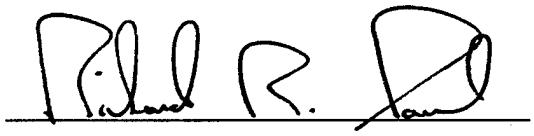
Improved C^4I technologies will allow us to plan more effective joint operations and more effective coalition ventures by increasing interoperability — and will free operational commanders to concentrate on strategy, operations and tactics. These technologies will enhance the commander's view of the battlefield, the timeliness of his decisions, and the expansiveness of his control. These technologies will provide solutions to some of the most vexing problems facing DoD today including:

- Maintaining near perfect real-time knowledge of the enemy and communicating that to all forces in near real time
- Integrating situation assessment, planning, and force execution to ensure the most appropriate force is used to achieve the objective with minimum casualties and collateral damage

In short, as Global Reach/Global Power and the use of smaller, integrated, highly adaptable forces become the dominant themes in Air Force operational thinking, the ability of C^4I systems to manage information and support battle management grows ever more critical. The C^4I technologies under development at Rome Laboratory will allow the warfighter to operate in a seamless environment at all levels of engagement. The program described in this TAP will ensure that we build the technological foundation for both evolutionary improvements in current systems and revolutionary development of new capabilities for Global Reach/Global Power. Our objective remains:

TOTAL CONTROL TO THE WARFIGHTER THROUGH BATTLE SPACE

This plan has been reviewed by all Air Force Laboratory commanders/directors and reflects integrated Air Force technology planning. We request AFAE approval of this plan.



RICHARD R. PAUL
Major General, USAF
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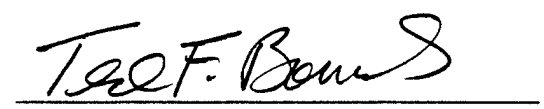


TED F. BOWLDS
Colonel, USAF
Rome Laboratory

INFORMATION DOMINANCE

In implementing the AF Global Reach/Global Power model, we need to address the issues associated with the new operational environment — smaller and different force structures, loss of forward basing, time critical operations and a broad spectrum of contingencies. While we can no longer afford to physically deploy forces in every region of concern, we must continue to assert American presence. Through the concept of Global Presence the Chief of Staff Air Force (CSAF) identifies a mechanism for achieving national security goals without always needing to employ the physical interaction of military forces. This concept expands the definition of presence to include the application of virtual means achieved through interaction with America's information based technologies and capabilities. As we consider the many aspects of modern warfare, information and the requirement for information dominance in the joint battlespace has moved to centerstage. One important element of this is Information Warfare — a powerful capability that will have profound implications in the way American forces influence, deter and, if necessary, fight wars.

The successful execution of this concept then, categorically depends on the ability to exploit information and gain dominance in the information realm. A key component of gaining information dominance is the ability to secure and protect the global information grid while providing the warfighter with correct information in a timely manner. The key technical challenge in the information warfare arena is the development of technology that provides unconstrained use of cyberspace in the face of multiple information threats.

The ability of the grid to serve all warfighters, in joint and coalition operations, will probably be limited, even in the long-term, by information security and access control requirements and restrictions. These technologies are just emerging and can be difficult to integrate and use. Similarly, DoD's desire to use commercial services and Commercial Off-the-Shelf (COTS) systems/equipment will open the door for increased information warfare threats against us.

Since the DoD is more dependent on information technology than its adversaries, technology development to protect DoD grid assets is of paramount importance. Offensive information warfare efforts should follow, not lead, protect technology development.

These views are reflected in Air Force Executive Guidance, draft AF Doctrine Documents 1 and 5, CSAF concept document Cornerstones, and joint staff policy. In response, Rome Laboratory has initiated an Information Warfare technology program as a part of the Information Dominance Area of Emphasis. The Baseline for this Area of Emphasis consists of a subset of the technical areas of DISTRIBUTED INFORMATION SYSTEMS, COMMUNICATIONS, and DEFENSIVE and OFFENSIVE INFORMATION WARFARE. That subset is most closely associated with the emerging "smart" systems and their supporting communications infrastructure.

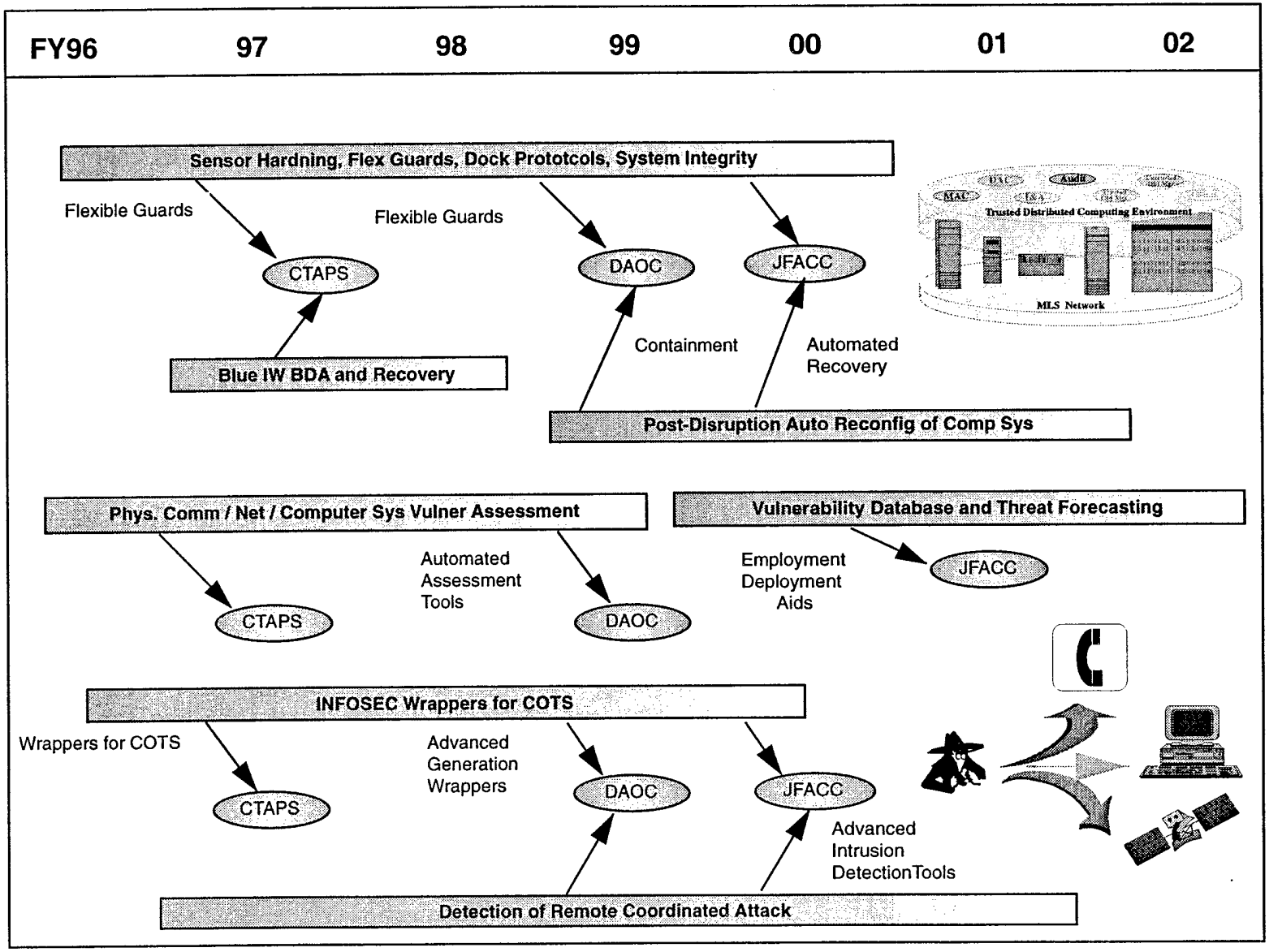
The AF S&T Baseline program in Distributed Information Systems and Communications is responsive to the current technology issues. The AF S&T Baseline for Information Warfare is not. The AF Scientific Advisory Board, New World Vistas report, 15 Dec 95, recommended that any initiative into this area be focused on the Defensive Counter Information aspects of the overall problem. As defined by the CSAF, Defensive Counter Information (DCI) is any action taken to protect our information and its functions from denial, exploitation, corruption, or destruction. Within the Rome Laboratory Information Warfare Initiative, this protective capability is addressed by research and development in five Key Activity areas. These areas are Integrity & Availability, Recovery, Risk Assessment, Wrappers, and Indications & Warning. Operationally, the initiative will focus on air operations within the Joint Staff vision, "C^4I for the Warrior," ensuring warfighter information needs are met in a timely, correct, and accurate fashion.

To form the Baseline of this overall Defensive Counter Information program, the small AF S&T Defensive Information Warfare Baseline is supplemented by, leveraged outside funding. The leveraged outside funding is mainly the ARPA Information Survivability program, Firestarter and NSA efforts — all being conducted at Rome Laboratory. This work forms the majority funding for the Baseline. The focus of these Baseline technologies is to provide **protective** measures to AF C^4I systems during the "Trans-Attack" period of an information attack. The ARPA program focuses on detection of intruders once they are in the "net" as well as wrappers for COTS, while the Firestarter and NSA focus is on various mechanisms to protect during the attack (e.g. secure voice, guards, assurance, etc.). The small AF S&T Baseline funding also focuses on "Trans-Attack" protection mechanisms by addressing additional survivable communications and networking technologies.

As noted above, the Baseline programs in this area focus only on certain pieces of the problem. As a result many technology "holes" remain, which could lead to specific operational vulnerabilities or catastrophic failures. Functionally, these "holes" are centered upon the "Pre-Attack" and "Post-Attack" periods of an information attack. More specifically, there is currently little to no capability to provide defensive measures during these time frames. Therefore, it is on these "holes" that the new work focuses its research, with the work aimed at areas of high investment payoff.

By adding the new work proposed to that of the Baseline, the overall DCI program addresses the "pre-" (prepare), "trans-" (survive), and "post-" (endure) information attack periods and closes the technology loop "holes" per the New World Vistas recommendation.

DEFENSIVE COUNTER INFORMATION



CONTENTS

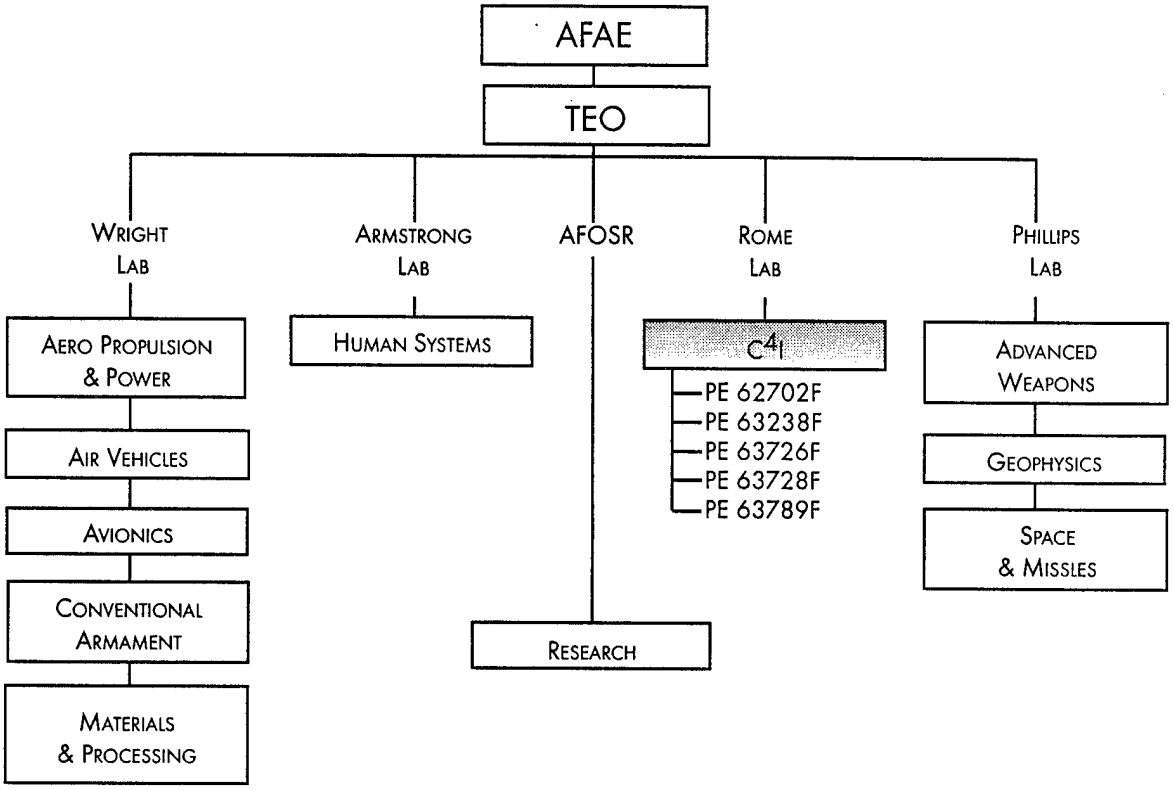


***Figure 1.** Air Force S&T Program Structure*

INTRODUCTION

BACKGROUND

C4I IN PERSPECTIVE

Command, Control, Communications, Computers and Intelligence (C^4I) capabilities provide the vital eyes, ears, and voices for the National Command Authorities and military commanders. The Air Force of the future must be effective, affordable, and capable in seamless joint and multinational operations in which it achieves its purpose "to fight and to win the Nation's wars."[1] Throughout history, the scales of conflict have repeatedly tilted in favor of the commander who could penetrate the "fog and friction" of battle and thus maintain Information Dominance.

In the post-Cold War world, as we enter a period of Warm Peace, the Air Force must respond to a variety of situations requiring effective use of air power anywhere on the globe, while simultaneously drawing down to a significantly smaller force structure. The Air Force needs improved C^4I systems which allow flexible, coordinated use of available forces while enabling lightning-fast response to changing situations. These C^4I systems must be reliable in any environment, robust in the face of hostile actions, highly mobile to accompany deploying forces, and affordable. Further, the C^4I systems must be able to fully integrate both the warfighting functions and capabilities of component forces - the entire Joint Force.

The C^4I technology program plays an integral part in addressing the six capabilities identified in the New World Vistas[2] Scientific Advisory Board (SAB) study results. Rome Laboratory has been designated as lead in two areas, Global Awareness and Dynamic Planning and Execution Control.

The transition from the Cold War to a Warm Peace calls for an awareness of what is going on from a world wide perspective. There is a predominant need to have an awareness of the many global potential and current hostile environments that involve United States forces. Information collection from many sources, rapid transmission of that collection for analysis and correlation, building of data bases to support

[1] General Ronald R. Fogleman, Address to Air Force 2025, Maxwell AFB, AL, 6 September 1995

[2] New World Vistas, SAB Summer Study Report, 15 Dec 95

situational change, cartography information correlation, electromagnetic detection and correlation, moving target detection and track, hostile target identification, global weather situation on demand, etc. are all required for Global Awareness. All type of sensors — space, ground, human, open source, Unmanned Aerial Vehicle (UAV) are essential. Communications, computer processing, data base construction and correlation, analytical algorithms, mass storage, etc. technologies are also involved.

Further, the planning and execution of missions in a dynamic and very unpredictable changing environment requires significant changes to the current models used in conventional campaign planning. With targets that are very mobile, battle areas changing quickly, environments where friend/foe determination is difficult, and there are complex combinations of combat assets ranging from people to information data bases, the battle environment for planning and execution is extremely dynamic, complex and dependent on many sources of information. The concept of Dynamic Planning and Execution Control is to exploit the Global Awareness acquired through the technologies listed above. C^4I technology is the key to success in both of these areas.

Information Dominance, an Air Force Core Competency and AFMC/ST Emphasis Area, for which Rome Laboratory is lead, is a major part of addressing the New World Vistas capabilities. It involves Communications Technology, Distributed Info Systems Technology, Defensive Info Warfare Technology and Offensive Info Warfare Technology in order to create, disseminate, provide access to, plus manipulate and control not only our own but the enemy's information. Rome Laboratory has active ongoing programs addressing all of these areas.

Rome Laboratory's technology program addresses to some level all of the Air Force Core Competencies. Figure 2 identifies the application of the C^4I TAP Thrusts to the Core Competencies.

RL TAP Thrusts	Air Superiority	Space Superiority	Precision Employment	Information Dominance
Command & Control	●	◕	◕	●
Communication	●	◕	◔	●
Intelligence	●	◕	◕	●
Surveillance	●	◕	◔	◕
Signal Processing	●	●	◔	◕
Photonics	◕	◕	◕	◕
Computer Science	◕	◕	◕	◕
Electromagnetics	◕	◔	◔	◔
Reliability	◕	●	◕	◕

Figure 2. *AF Core Competencies/C^4I Matrix*

This Technology Area Plan (TAP) describes a focused program of developments and demonstrations across the spectrum of relevant technologies. This program will provide the improvements to both current and future systems required to match Air Force C^4I capabilities to operational demands both within the Air Force and the Joint Force.

Figure 3 shows the C^4I Technology Area as the responsibility of Rome Laboratory within the Air Force Science and Technology (S&T) program. By its nature, C^4I is pervasive, and much of the work described in this document is coordinated or conducted jointly with other laboratories, services, and a variety of agencies. This technology program provides significant benefits to both the commercial and military industrial base.

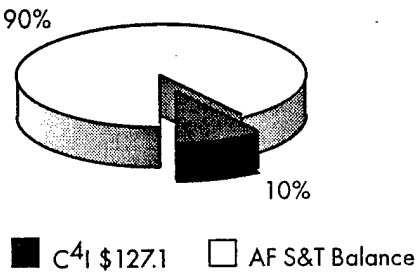


Figure 3. *C^4I S&T vs AF S&T FY97: $1.272B*

As depicted in Figure 3, this Technology Area is projected to receive $127.1 million, or 10% of the FY97 AF S&T program based on the FY97 President's Budget request. Note, the program described in this TAP is subject to change based on possible Congressional action.

Recent Accomplishments

The Rome Laboratory C^4I program has achieved significant progress over its broad spectrum of technology thrusts:

- Efforts under Rome Laboratory's passive sensor technology area have developed techniques which exploit ambient background signals as non-cooperative illumination sources for the detection, tracking and identification of targets. A passive surveillance mode of this technology exploits the coherent nature of any ESM-detected signal, intercepts both the direct path and scattered targets echoes, and coherently processes the collective returns. This coherent processing utilizes the relative time delay, doppler offset and angle-of-arrival measurements information of both the direct background signal and its multiple target echoes to create a target picture against a map background. The application of this technology will give the platform a unique capability to unobtrusively provide situational awareness of the battlefield to commanders.

- The Offboard Augmented Theater Surveillance (OBATS) testbed capabilities were demonstrated for both Theater Missile Defense (TMD) and Suppression of Enemy Air Defense (SEAD) scenarios applicable to Joint STARS mission requirements. The OBATS capability is the first demonstration of the application of advanced distributed fusion and multisensor resource management techniques to locate, identify and prioritize Transporter-Erector-Launchers (TELs) and other strategic/tactical ground targets including "stationary movers." Key features demonstrated include the usage of Joint STARS, AWACS, RIVET JOINT and UAV platform resources, automatic and manual resource allocation across the platforms, display fusion providing a composite surveillance picture, and an advanced Multiple Hypothesis Fusion Tracker providing precise critical target location and identification. OBATS has proven the power of correlated/fused data, real time sensor resource management, and represents the bridge to multidisciplinary full battlefield awareness.

- An optical Wave division Multiplex capability developed under a Rome Laboratory sponsored SBIR effort is being deployed in Army Tactical Command Centers in Europe. These devices increase the capabilities of existing Local Area Networks by a factor of four.

- Rome Laboratory demonstrated the Asynchronous Transfer Mode (ATM) Reachback communications to/from an Air Mobility Command KC-135 aircraft. Demonstrations included transmission of AMC database information to an in-flight aircraft over an AFSATCOM UHF link. This effort is focused on AMC's stated need for worldwide in-transit (transoceanic) visibility to a number of CONUS and forward-based information databases. Rome Laboratory will evolve this program to include wider bandwidth SATCOM systems with low cost conformal phased arrays for higher data rate service into the aircraft.

- Rome Laboratory performed technology demonstrations of the SPEAKeasy Phase-1 Advanced Development Models (ADMs) at the Ft Franklin Technology Enclave during the Joint Warrior Interoperability Demonstration (JWID) 95. The simultaneous operation of two similar and dissimilar waveforms in both ECCM and non-ECCM modes was demonstrated in the same and different bands. Simultaneous operation of and voice bridging between Citizen Band (CB), Air Traffic Control (VHF-FM), Army-SINCGARS (VHF-Frequency Hopping), and Air Force Have Quick (UHF-Frequency Hopping) waveforms was demonstrated. The ability to change a waveform via the download of software on a floppy disk was also highlighted.

- Rome Laboratory completed fielding of the Advanced Planning System to all of the Navy carrier groups; the Marine Corps aviation wings; and selected as a GCCS migration application. The program has now transitioned to ESC as an integral part of the Theater Battle Management Core System.

- The Force Level Execution System has been identified for inclusion in the initial operational release of the Theater Battle Management Core System, and with the enhancements incorporated from the ARPA Local Attack Controller development will provide the Air Force with its initial planing capability for Time Critical Targets.

- A Deployable Optical Jukebox (DOJ) has been delivered and interfaced to AFSOC's mission planner. The system is based on an earlier brassboard. The DOJ supports large capacity storage (120GB), world-wide deployability with fast set-up/tear-down times. AFSOC personnel are trained to operate the system and participate in the evaluation.

- The Rome Laboratory three dimensional optical memory (sugar cube) development has progressed to the point where the chemistry has been finalized for the Write Once Read Many times configuration. Writing architectures have been developed and tested for both orthogonal and pulse collision. Error correction and detection algorithms testing has begun with excellent results. A brassboard reader has been fabricated to demonstrate feasibility.

- The Machine Aided Voice Translation system which translates spoken English into spoken Russian, Arabic, and Spanish and vice versa was successfully demonstrated at the Dubai Air Show and to the Air Force and Army Special Operations Forces. This technology is being developed to meet AF needs in training and interrogation.

- The Correlation System Operation Evaluation program was installed on-site in South Korea and has significantly improved our ally's ability to perform situation assessment. The system sanitizes and correlates multi-source SIGINT to provide operational benefits that include multi-source emitter correlation and correlated air-ground situation display.

- Major Intelligence Data Handling System software releases were developed and installed in over 50 operational sites. These software releases provide enhanced IDHS message handling, situation assessment, database, client server, and imagery management capabilities for the unified and specified commands critical intelligence missions.

- Rome Laboratory successfully participated and demonstrated Image Exploitation 2000 (IE2000) technologies in the multi-service exercise, Global Yankee 95, held at

Fort Drum, NY in Jun 95. Imagery data collected just prior to the exercise and the digital target graphics that were produced from it were put on Photo CD and made available to National Guard personnel for intelligence purposes during the exercise. The IE2000 team also flew numerous helicopter missions during the exercise collecting additional imagery utilizing a digital 35mm camera. This data was subsequently processed in real time using on-site IE2000 computer resources and provided to Air Force and Army personnel to support exercise activities including a B-1 bomber mission, CC&D deployment tactics and a search & rescue operation.

- The Rome Laboratory Distributed Shared Resource Center came on line in July 1995 with a 321 node Intel Paragon High Performance Computer (HPC) for unclassified applications and a 28 node Intel Paragon for classified applications. The 321 node computer ranks among the top 20 largest supercomputers in the world, over 90 billion floating point operations/second (BFLOPS), and possesses the largest input/output capability of any supercomputer. This is a unique resource to address the needs of sensor related processing and the embedded signal and image processing communities, which is available to DOD research facilities across high bandwidth links to the internet (155 megabits/second).

- Rome Laboratory's innovative short stack memory concept which dramatically improves circuit density by stacking thinned memory die has been transitioned to militarized high performance computers. It was recognized by being the first recipient of the General Ronald W. Yates Award for Excellence in Technology Transfer. The Air Force has been awarded a patent for this technology.

- The joint ARPA and Rome Laboratory Knowledge-based Planning and Scheduling Initiative (ARPI) successfully executed its fourth Integrated Feasibility Demonstration focused upon the application of advanced decision support technology to air campaign planning, specifically automation for plan expansion and feasibility estimation. For the first time, air campaign planners can now realistically approximate the details of missions at the activity level or below, enabling them to perform feasibility checks on the evolving air campaign plans and ensure that only executable plans result.

- Rome Laboratory demonstrated an advanced telemedicine capability during the Global Yankee '95 military exercise held at Ft Drum. The demonstration was carried out with members of the 167th AES and SUNY-Health Science Center at Syracuse. The telemedicine scenario demonstrated how advanced ATM-based communication integrating audio, video, and high resolution data images could be used for a seamless reachback capability to conduct remote medical diagnosis and consultation for battlefield casualties. The scenario consisted of four remote sites, a MASF (Mobile Air Staging Facility) located at Belevedere Airstrip, an Air Transportable Hospital (ATH) located at the Forward Operating Location (FOL-Wheeler-Sack Airfield, Ft Drum), a second ATH containing a medical doctor located at the Air Operations Center (AOC-Ft Drum), and a level V CONUS hospital located at SUNY-HSC-Syracuse with a resident neurosurgeon. As part of the demo all three sites had video teleconferencing capability with each other, as well as simultaneous whiteboard access to X-Ray images from each of the patients. The result was a diagnosis of the patients condition and instructions for immediate medical treatment. As a result of this capability correct and prompt medical attention can be given to battlefield casualties.

- Rome Laboratory demonstrated integrated planning, force generation, and execution monitoring systems in a distributed collaborative venue supporting all levels of the command structure from the Unified CINC to Air Operations Center (AOC) at JWID 95.

- The joint ARPA and Rome Laboratory Knowledge-based Planning and Scheduling Initiative (ARPSI) delivered to PACAF and JWID 95 a laptop In-Theater Airlift Scheduling (ITAS) brassboard. ITAS has also been demonstrated with considerable interest to AMC/DOUP, C^2IPS Requirements Panel, and USSPACECOM. The major features of ITAS are 1) it is self contained, portable, deployable, and runs on a laptop computer, 2) allows the user to interactively modify the schedule and honors user modifications in subsequent scheduling iterations, and (3) is designed to interface CTAPS and C^2IPS.

- A demonstration of Distributed Collaborative Planning (DCP) using the Theater-Level Analysis Replanning Graphical Execution Toolkit (TARGET) was given to numerous military and industry groups at Fort Franklin, Hanscom Air Force Base. TARGET provides a multimedia, graphical toolkit for real-time collaborative planning between crisis action planners at geographically different locations. Planners between Ft Franklin and MCTSSA used TARGET to collaboratively develop courses of actions and evaluate the best one to meet national objectives. Multimedia conferencing tools and shared object-oriented databases are the enabling technologies that allow participating units to reduce the time frame necessary to achieve an effective, coordinated plan.

- Rome Laboratory fabricated the first unidirectional, integrated amplifier, extremely low noise Diode Ring Laser device (DRL). This DRL development provides an optical source with a unique combination of properties including high spectral purity low noise, high power and efficiency, low cost, and small size for use in phased array

antennas, rf/mm wave photonics links, and interconnects for C^4I optical signal processors.

- Rome Laboratory identified a potential component, board and system failure mechanism due to moisture in optoelectronic devices and developed a strategy which will yield more reliable and environmentally hardened devices. It was determined that water vapor reacts with the epoxies in the package and results in excessive parameter shifts. Laser welding the package lid and incorporating a different humidity resistant fiber seal greatly extends the survival range in high temperature/humidity environment.
- An X-windows-based tool to automatically generate complete WAVES-VHDL testbenches for complex circuit designs has been developed by Rome Laboratory and transitioned to industry. This tool provides a complete test set for verifying complex digital circuit designs and automatically generates IEEE compliant WAVES and VHDL source code. The test sets generated by this tool can be applied during initial design verification and after fabrication during electrical test. This tool significantly improves digital electronics life-cycle support capabilities by automating and more tightly integrating design and test activities.
- Rome Laboratory developed an F-22 Avionics Test Bed to evaluate the Communication, Navigation, Identification and Electronic Warfare Apertures at its Newport Antenna Research & Test Facility. This was accomplished by converting its YF-22 Brassboard Air Vehicle (PAV #2) into the Engineering and Manufacturing Development (EMD) model. Precision antenna and calibration pattern measurements for installed apertures will evaluate the effects of the airframe and its moveable surfaces on system performance. Actual F-22 installed antenna aperture performance data was made available to the SPO well in advance of any production decisions as the first F-22 EMD flight tests are not scheduled to begin until 1997 with the first avionics flight test in 1998. This is the first time that this quantity of installed antenna performance data will be available to designers so far in advance of a production aircraft. This will reduce program risk by identifying possible antenna performance limitations and allow for less expensive design changes early in the development cycle. Rome Laboratory is a key member of the F-22 avionics testbed Integrated Product Team (IPT) and has regularly hosted key technical interchange meetings.

Technology Thrusts

This TAP is organized into nine thrusts as summarized in Table 1. The first four are mission area thrusts directed primarily to the C^4I systems of Rome Laboratory's parent Product Center, the Electronic Systems Center (ESC). The remaining five represent Rome Laboratory's corporate responsibilities —emphasizing the technologies that enable enhanced performance, affordability, and availability of electronic systems.

Thrust 1: Surveillance
Thrust 2: Communications
Thrust 3: Command and Control
Thrust 4: Intelligence
Thrust 5: Signal Processing
Thrust 6: Computer Science & Technology
Thrust 7: Electromagnetic Technology
Thrust 8: Photonics
Thrust 9: Reliability Sciences

Table 1. *Major Technology Thrusts*

Figure 4 shows the planned allocation of AF S&T funds among these thrusts, including civilian salaries and other operations and maintenance.

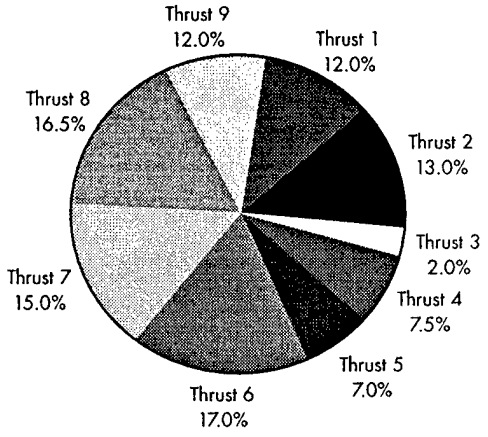


Figure 4. *Major Technology Thrust Funding*

Relationships to Other Technology Programs

Industrial Programs

Independent Research and Development (IR&D)

Rome Laboratory is a strong proponent of joint partnerships with industry in order to forge meaningful dialogue and research to meet C^4I objectives.

The Industry Looks at Rome Laboratory (ILARL) annual

event is a well-established forum designed to update the entire C^4I community on AF plans and requirements and give the community a chance to interact with Rome Laboratory personnel. In addition, Rome Laboratory participates in the Electronic Systems Center's (ESC) Industry Days.

Rome Laboratory implemented in FY 96 the first annual C^4I Reverse Industry Days in order to expand our partnership with industry IR&D in addressing C^4I technology needs. Attendees at the ILARL were encouraged to submit "white papers" showing how their IR&D projects addressed C^4Ineeds. Following Rome Laboratory's technical evaluation, industry IR&D Project Managers were invited to the Lab for further discussions to identify potential areas for joint partnerships. Fifty-five presentations were made with several resulting in ongoing discussions and sharing of information.

An example is work on stress life testing involving Plastic Encapsulated Microcircuits (PEMs). Rome Laboratory and a major aerospace contractor are pursuing a CRDA on this effort whereby Rome Laboratory will receive commercial parts being used on a major aerospace development program for our test and evaluation and we will share test and field information on the use of these parts in various applications.

In addition, Rome Laboratory's Technology Coordinating Committees (TCCs) annually host voluntary and invitational dialogues with industry in their areas of cognizance to exchange current information on IR&D activities. These dialogues include lab presentations of their technology needs and review of industry IR&D projects. MAJCOMs, other DoD, and Federal agencies are included in the IR&D discussions.

Again this year, Rome Laboratory will sponsor the Integrated Diagnostic Technologies Workshop to provide a forum to discuss and exchange ideas on how to solve integration problems. Issues addressed will consist of identifying problems raised by design tool incompatibilities and undefined interfaces, fault detection, and data standards and protocols for diagnostics. Over 100 participants from the Air Force, Army, Navy, industry and academia will attend.

The Rome Laboratory investment strategy considers IR&D to assure that its technology plans take advantage of corporate investments and advances.

A few examples of IR&D Success Stories illustrate the importance of IR&D in meeting AF C^4I needs.

- Rome Laboratory is currently leveraging over $4M of IR&D annually from twenty companies engaged in research in software quality metrics, software engineering for parallel computing, software requirements engineering, and computer security, four areas essential to reducing risks associated with advanced weapons systems development and deployment.
- Rome Laboratory is leveraging a $20M IR&D Investment in a flying testbed with the capability to collect radar clutter data from a moving airborne platform that is crucial to our space-time adaptive processing program. Without leveraging the testbed, we would not have been able to afford to collect this important data. Space-time adaptive processing is required to improve the performance of airborne radars so that smaller targets can be detected in the presence of jamming and clutter.
- Rome Laboratory is leveraging a $25M IR&D investment to advance spacecraft communications technologies with six companies. The IR&D investment is directed at developing advanced processing and design capabilities required to realize space qualified monolithic microwave integrated circuits (MMICs) for 20/44 Ghz applications. Rome Laboratory will be able to populate next generation spacecraft systems with state-of-the-art MMIC components as a result of leveraging this IR&D.
- Rome Laboratory has leveraged a Delphi Natural Language Understanding semantic parser to build the Speech and Language Integration (SPLINT). SPLINT allows independent speaker recognition in a continuous natural speech mode, letting analysts access and retrieve intelligence information from a text and image data base.

Domestic Technology Transfer

The goals of the Rome Laboratory (RL) Technology Transfer Program are:

- improve our communication and interaction with the private sector, state and local governments, and other federal agencies
- leverage Rome Laboratory's S&T budget
- enhance American competitiveness in the world economy.

At Rome Laboratory, technology transfer is accomplished through the laboratory's pursuit of five areas:

- Rome Laboratory uses Cooperative R&D Agreements (CRDAs) as one of its primary tools to accomplish its technology transfer mission. A CRDA is an agreement between Rome Laboratory and one or more industrial organizations, universities, state or local government organizations, or other federal agencies to conduct specified research or development efforts consistent with the laboratory's mission. Rome Laboratory has entered into 62 CRDAs, and currently has 31 active. The technology being pursued includes every facet of the Rome Laboratory technology development mission.
- Another tool is Education Partnerships (EP). An EP is an agreement between the laboratory and an education institution in the United States to encourage and enhance

study in scientific disciplines at all levels of education. Rome Laboratory has entered into 24 EPs to date, and currently has 16 active.

- Grants and Cooperative Agreements are additional methods to effect technology transfer. In 1994 Rome Laboratory received the authority to use these vehicles for research in technical fields related to the laboratory's mission. These new methods quickly became an important way to effectively pursue technology development critical to the laboratory. Their use has consistently increased over the years. In 1995, Rome Laboratory executed 52 of these vehicles.

- Responding to requests for technical assistance from private and public entities is another Rome Laboratory technology transfer area. In 1995 our commitment to a hands-on approach and personal interaction resulted in our answering over 375 requests from industry for both information about our technology and for specific answers to technical problems they were encountering.

- Technology transfer is also being facilitated through the negotiation of patent licensing agreements. The laboratory currently has five license agreements for patents held by its employees and is currently negotiating another three agreements.

The products derived from this cooperative research will provide the private sector and the Air Force with new and improved Information Technology resources. Some examples of Rome Laboratory Technology Transfer successes include:

- Short Stack Memory Chips technology allows an improvement of four to eight times in the number of memory chips packaged into a multi-chip module. Rome Laboratory and Irvine Sensors Corporation developed a method of 3-D silicon processing and packaging which can stack hundreds of chips in a physically compact manner and which is compatible with several multi-chip module (MCM) packaging techniques. This technology is currently being used by IBM to produce chips in their foundry in Burlington, VT. Rome Laboratory personnel were chosen as the winners of the team category of the Gen Ronald W. Yates Award for Excellence in Technology Transfer for 1996 for this technology development.

- A 1995 Federal Laboratory Consortium (FLC) Award winner, the Rome Laboratory Speech Enhancement Technology was shown to improve voice communications for military and commercial uses. This Rome Laboratory developed technology showed a real-time capability that was both cost effective and physically small enough for use in multiple applications. The technology has widespread impact on communications systems by removing noise and interference to improve the speech signal for both human listeners and machines that recognize or code speech in any language.

- Rome Laboratory's Statistical Multiple Object Detection and Locating System, an advanced neural network technique, was designed to be so robust that it could be easily trained on a completely new database and learn to detect and classify new targets. Originally designed for automatic target recognition on the battle field, it was successfully used on digital medical imagery to detect and classify lung tumors as benign or malignant. This technology also won a 1995 FLC Award.

- The completed Sneak Circuit Analysis Tool (SCAT) software is the first automated tool to perform Sneak Circuit Analysis (SCA) on system design schematics. It replaces high cost, labor intensive, manual analysis methods. The low cost of applying the Rome Laboratory/SCAT tool to design schematics has made it cost effective to perform SCA on a wide range of designs where SCA would have been cost prohibitive. The tool has been successfully applied to both military and commercial designs. Commercial applications include the Oregon Public Transit Authority, San Francisco BART system and Ford. Military applications include Army and Air Force systems. A commercial vendor, Phase III Logic, is currently marketing the SCAT tool with great success.

- Under a Cooperative Research and Development Agreement with a local small aerial mapping company, extensive progress was made in the use of Photo Compact Disc technology for the dissemination of imagery and target related information. A BETA capability was obtained from the Eastman Kodak Company to generate and author multimedia Photo Compact Discs on the RL IE 2000 Facility.

- Rome Laboratory is working with NYNEX Telephone Company, Syracuse and Cornell Universities and several other academic and industrial partners in both upstate and downstate New York to address issues related to the implementation of very wide bandwidth fiber optic communications networks and the distributed computing systems that will be built on them.

- A 1996 Federal Laboratory Consortium Award winner, the Rome Laboratory program for developing a method for rapidly synthesizing large amounts of zinc germanium diphosphide (ZGP), a material used for frequency-agile laser applications, has been demonstrated. This method exploits phosphorus injection technology pioneered in-house at Rome Laboratory for indium phosphide. It decreases the time required to synthesize ZGP by more than seven fold.

Dual Use Technology Development

Dual Use Technology Development is an initiative to co-

develop defense related technologies with private industry and universities to benefit both parties and improve the economic infrastructure and competitiveness of America's industrial base. A major program in this area has been the Technology Reinvestment Program (TRP). Rome Laboratory has been a full participant in this program since its inception in 1993. Specifically, Rome Laboratory supplied some of its engineering staff to help evaluate the many proposals that TRP received for each of its three completed competitions and for the current TRP competition. In addition, Rome Laboratory has partnered with industry or has managed winning proposals for the TRP in each of their four competitions. In 1995 Rome Laboratory was also a full participant in the DDR&E Federal Defense Laboratory Diversification Program. This participation resulted in two awards to Rome Laboratory and its technology development partners in the fields of Speech Processing and Infrared Sensors. Lastly, Rome Laboratory is a part of the new ARPA/DDR&E Military Dual Use Applications Initiative. Rome Laboratory has submitted five technology topics for consideration in this program, and will evaluate proposals and manage projects resulting from awards in this program.

Small Business Innovative Research (SBIR)

The Small Business Innovative Research (SBIR) Program stimulates technology innovation while providing the government new, cost effective technical and scientific solutions to challenging problems. The SBIR initiative encourages small businesses to market their SBIR technology in the private sector which in turn helps stimulate the US economy.

Rome Laboratory and ESC work jointly in promoting small business initiatives via the SBIR program. Rome Laboratory manages all SBIR contracts supporting C^4I technology and ESC manages SBIR systems engineering projects. Together Rome Laboratory and ESC will manage contracts valued at approximately $19 million in 1996.

SBIR successes include:

- Rome Laboratory's Multi-wavelength DNA Optical Memory demonstrated the potential of multiwavelength optical storage material using DNA polymers. This will allow optical data storage at very high data density on the order of 100 bits/micron. The advantage of this material is that it operates at near room temperatures whereas most inorganic materials require cryogenics, or at least dry ice temperatures. This effort has significant commercial potential.
- The requirement for highly uniform semiconductor layers for fabrication of advanced optoelectronic devices for high-speed detection and signal processing systems was met by an effort which developed a metal organic chemical vapor deposition (MOCVD) system. The new system has attracted attention from several customers of MOCVD equipment. Commercial sales are expected in the near future.
- Several SBIR programs addressed the development of a high power microwave photodetector. This resulted in a major breakthrough for improvement of the dynamic range of microwave analog fiber optic links. Several other government agencies have purchased the devices from the manufacturer for use in their systems.

Small Business Technology Transfer (STTR)

The STTR Program is designed to provide a strong incentive for small companies and research institutions, i.e. nonprofit research institutions, contractor-operated federally funded research and development centers (FFRDCs), and universities, to work together as a team to move ideas from the laboratory to the marketplace, to foster high-tech economic development, and to address the technological needs of our armed forces. Rome Laboratory began participation in this 3 year pilot program in 1995. Awards valued at $500K included: Unmanned Vehicle C3 Data Link, Helmet Mounted Hands-Free Communication System, A Wavelet Approach to Speech and Background Coding, Compact 3-D optical Data Storage and Retrieval System, and Multisensor Track Fusion for Airborne Surveillance Systems.

International Programs

In addition to being on several international panels, Rome Laboratory is currently active in 22 International Agreements with seven foreign governments. The International Cooperative R&D Program has enhanced Rome Laboratory's technology base by leveraging the technology developments of our allies valued at over $10 million.

Other Government Labs /Agencies

Air Force S&T Programs

The four Air Force superlabs work continuously to clarify and coordinate their programs. Examples include a Memorandum of Understanding between Rome and Wright Labs in the area of airborne communications, and with Armstrong Lab for the intelligent tutor program. Rome Laboratory maintains a continuing dialogue with Wright Lab in electromagnetic technology. Rome Laboratory works together with Phillips Lab to transition C^4I technologies to space applications. A few examples are:

- Rome Laboratory and Wright Laboratory collaborate on all work performed in the non-cooperative target identification/hostile target identification arena. All work is coordinated and deconflicted in joint meetings with the Air Force Combat Identification Integrated Management Team. The Rome Laboratory Hostile Target Identification program addresses positive, timely identification of air targets using surveillance, reconnaissance, and intelligence sensor platforms such as AWACS,

JSTARS, and Rivet Joint. These activities are closely coordinated with Wright Laboratory Non-Cooperative Target ID (NCTI) efforts which address target ID deficiencies for fighter aircraft.

- Rome Laboratory and Phillips Lab are working together to develop an S&T strategy for Air Force space communications programs. Rome Laboratory is assisting Phillips Lab in the submission of their FY 98 POM. This assistance is focused on the proposed space communications technology efforts under PE63401F.
- Rome Laboratory is collaborating with Wright Lab Materials Directorate to provide phosphorous injection expertise and crystal growth expertise in $ZnGeP^2$ for mid-IR Optical Parametric Oscillators needed by WL.
- Rome Laboratory works with Wright Laboratory through an MOA in the area of Bistatic Radar development.
- Rome Laboratory and Phillips Lab are negotiating an MOA to develop an S&T strategy to transition Rome Laboratory photonics technology into PL space programs.
- Rome Laboratory works closely with Wright Laboratory under the S&T Unmanned Aerial Vehicle (UAV) IPT to develop advanced technologies which are applicable to Air Force UAV operational capabilities. The Rome Laboratory High Value Airborne Asset (HVAA) Augmentor Concept was chosen by the IPT as a concept which merited further study. Specific operational needs have been identified, cost estimates provided, and development/technology challenges identified for the IPT.
- Rome Laboratory also works closely with Wright Laboratory in the development of sensor data fusion. Our distributed fusion technology is complimentary to two major programs at Wright Laboratory, and the accuracies required in these programs are a direct product of the Rome Laboratory OBATS program. Conversely, the RIDEX datalink system developed by Wright Laboratory is an absolute requirement for transmitting imagery data required for our all-source fusion algorithms.
- Rome Laboratory, in conjunction with Wright Laboratory, has established a consortium to evaluate the reliability and physical characteristics of microwave power heterojunction bipolar transistors (HBTs) targeted for DoD and commercial applications. Working together, along with five AlGaAs/GaAs HBT manufacturers, critical reliability issues are being addressed for this much needed technology area. Among the recent achievements include successfully modeling the bias and temperature dependencies of base and collector leakage currents, and modeling post-burn-in base current abnormalities.
- Rome Laboratory and Armstrong Laboratory have an MOA in speech processing. Armstrong Laboratory has developed 3D audio technology. Rome Laboratory is testing the application of 3D audio to operator gisting of multiple communications.
- Rome Laboratory is working with the Title III (Defense Production Act) Program Office and Wright Lab to ensure availability from US sources of MMIC qualified gallium arsenide wafers. Development of new characterization techniques and protocols at Rome Laboratory ensures the quality of GaAs substrates delivered for critical military applications.
- Rome Laboratory and WL are working together to develop monolythic millimeter wave components. Rome Laboratory performs component design and test and WL develops GaAs based materials and processing.
- Work under the Rome Laboratory Electromagnetics, Reliability and Photonics Thrusts is planned jointly with the Wright and Phillips Laboratories and reported under the Electron Device Interlaboratory Investment Plan.
- Rome Laboratory works closely with Wright Laboratory in the area of airborne radar. A specific example is our joint work in Space-Time Adaptive Processing.
- All the Labs and AFOSR jointly plan and coordinate their Computer Science and Technology programs through an Interlaboratory Investment Plan and the JDL Technology Panel for Computer Science.

Government Agencies

Rome Laboratory is very proactive in establishing relationships and working with other government agencies and the MAJCOMs, in order to leverage the C^4I technology program. A few examples are:

- Under the SPEAKeasy Program, Rome Laboratory has agreements with several agencies including: an MOA with US Army CECOM and ARPA for the joint funding and management of the SPEAKeasy Phase-1 Program; a User Partnership with National Security Agency in areas including INFOSEC aspects, security requirements identification, INFOSEC data management, and NSA product endorsement; and an MOU with Electronic Systems Center for the establishment of a Shared Management Approach for the SPEAKeasy Program and for the examination of ESC programs for potential SPEAKeasy technology insertion. Other contacts have been made with the Marine Corps Systems Command, the Federal Aviation Administration (FAA), the Federal Law Enforcement Wireless Users Group (FLEWUG), and the Public Safety Wireless Advisory Group (PSWAG) about the potential use of SPEAKeasy technology in on-going programs.
- Rome Laboratory works closely with Air Combat

Command in connection with our Joint STARS Cueing and Correlation Advanced Technology Demonstration (ATD). ACC personnel are providing operational insights necessary to maximize the demonstration's utility. In addition, we have MOA's with both the ESC Joint STARS (JS) SPO and ARPA to increase the performance of this ATD. Rome Laboratory is working closely with the SPO to leverage our technology towards ACC required Joint STARS capabilities. Our ARPA work is focused on the integration of the WARBREAKER Integrated Battlespace Intelligence Server (IBIS) with the JS Exploitation Testbed (JSX) and the development of MTI data exploitation algorithms, and a system integration which allows JS to become a Local Attack Controller platform.

- Rome Laboratory is working with MIT-Lincoln Laboratory in the development of advanced nulling algorithms for spacecraft communications uplink antennas. Rome Laboratory implemented MIT-LL nulling algorithms within the Rome Laboratory Adaptive Nulling Antenna Testbed. The algorithms have future application on EHF spacecraft.

- The Defense Intelligence Agency (DIA) is our prime national customer through the Department of Defense Intelligence Information System (DoDIIS) community, and for Air Force Requirements the 497th Intelligence Group is supported. The Intelligence Data Handling System (IDHS) Product Group uses this advanced technology.

- In an MOA with DISA, ESC, and CECOM, Rome Laboratory has established the control infrastructure for the next generation C, X, and Ku band satellite terminals within the DoD, based on the DISA-developed Fixed Satellite Service (FSS) Demand Assigned Multiple Access (DAMA) standard. This has been financially and technically supported by these other organizations. This MOA established relationships and responsibilities for this effort.

- Through the Defense Cryptological Program (DCP), Rome Laboratory works closely with the National Security Agency, Air Intelligence Agency, Naval Research Laboratory, Naval Command and Control Ocean Surveillance Center R&D, Navy SPAWAR, Army CECOM and Lincoln Labs.

- The IE2000 program has established working relationships with US Navy Space Warfare, the National Photographic Interpretation Center/National Exploitation Lab and the Multispectral Automatic Target Recognition Interactive Exploitation Program Office.

- Rome Laboratory has a joint program with the NAVY (NRL) in the area of cooperative and non-cooperative bistatic radar technology. Joint program planning and cooperation will continue with Rome Laboratory's Adaptive Multimode Bistatic(AMBIS) airborne testbed taking data measurements focused towards quantifying NRL-postulated phenomenology. The detection of this phenomenology could have profound implications towards solving a major NAVY operational requirement. In addition, the AMBIS testbed will also be used to quantify the performance exploitation possible using both littoral and "open ocean" non-cooperative illuminators.

- Rome Laboratory is working with ARPA and Air Combat Command in the formulation and execution of a major new initiative (JFACC 2010) which will develop a revolutionary command and control capability for the Joint Force Air Component Command.

- A 10 million dollar joint program between Rome Laboratory and SPAWAR (Naval Space and Warfare Center) / NRaD entitled COMINT Voice Processor ATD (Advanced Technology Demonstration) is to utilize existing Rome Laboratory audio processing and its existing 3600 MFLOPS processor (tailored and integrated to operate in Naval environments) to demonstrate and test a multi-channel COMINT integrated system for voice processing.

- Rome Laboratory, together with ARPA and Naval Command and Control and Ocean Surveillance Center's R&D Division (NRaD), sponsored a major demonstration of collaborative planning as part of JWID 95. This included interconnected sites at Fort Franklin, the Marine Corp Tactical Systems Support Agency(MCTSSA) and on board the aircraft USS Kitty Hawk, all participating in the joint development of air battle plans.

- Rome Laboratory is ARPA's executive agent for efforts in the Imagery Understanding Program, acts as technical consultant and manages contractual research. This provides for close coordination with Rome Laboratory's related technical efforts in automated imagery exploitation.

- Rome Laboratory is supporting the MILSATCOM Joint Program Office of Space & Missile Center in the development of advanced EHF payload and airborne terminal communications technology for future EHF communications systems.

- Rome Laboratory works closely with scientists at the AF Wright Laboratory, the Naval Research Laboratory and the Army Research Laboratory to plan and advance technology for electromagnetic materials and devices. Rome Laboratory leads in the application of these electron device advances to communication, signal processing and surveillance radars for C^4I applications.

- Rome is jointly developing its AI planning and schedul-

ing technology with ARPA and has an MOA with ARPA for transfer of its software engineering program to ARPAs Software Technology for Adaptable Reliable Systems (STARS) Program. Rome has an MOA to incorporate its software engineering technology into NASA's Computer Aided Software Engineering (CASE) process. As part of the NSA Consolidated Computer Security Program, Rome has specific responsibilities in secure distributed systems, secure database management systems, and the design and verification of secure systems.

- The Naval Air Weapons Center, Naval Surface Warfare Center, Army Strategic Defense Command, Army Research Lab, Army CECOM, et. al., are formally evaluating Rome's software and system engineering technology on systems for tactical air, anti-submarine, ballistic missile defense, tactical communications, etc. Rome is jointly developing knowledge-based engineering (AI) technology with NUWC, TACOM, NRaD, ONR, AFOSR, ARO, and others for application in C^4I Systems for attack submarines, tanks, crisis planning, etc. Finally, with funding from the three services and Assistant Secretary of Defense for C^4I, Rome has joint programs with CECOM and NRaD in distributed computing, database, computer security, and human-computer interface technologies for C^4I.

- Rome Laboratory works closely with Air Combat Command in connection with our Joint STARS Cueing and Correlation Demonstration. ACC personnel are providing operational insights necessary to maximize demonstration utility.

- Rome Laboratory is working with the Air Force Cryptographic Support Center, Kelly AFB to address potential security issues associated with using semiconductor memories (i.e. SRAMs, DRAMs, PLDs and EEPROMs) in Air Force systems. Results will be the development of policy guidelines and recommendations for the use of cited memories for secure use.

- In a MOA with NSWC, ARL, and NASA, Multichip Modules (MCM) technologies with potential high DoD, NASA and commercial usage are being evaluated to determine their performance and reliability in diverse environments. The intent of this effort is discover possible failure mechanisms associated with MCM interconnect structures, design and implement appropriate cost effective reliability and quality assurance procedures and propose corrective actions to the industry.

Project Reliance

Under Project Reliance, the Joint Directors of Laboratories (JDL) continues to improve coordination and reduce duplication among services. Through Project Reliance, the JDL has increased coordination, decreased duplication, and improved joint interoperability.

The following are a few examples of joint programs:

- Rome Laboratory participates in a number of Reliance efforts covered under the Microelectronics Infrastructure JDL panel. Reliability Science R&D efforts in the area of Gallium Arsenide (GaAs) MIMIC and high power HBTs, multichip modules (MCMs), and plastic encapsulated microelectronics are being accomplished jointly with Naval Research Laboratory, Naval Surface Warfare Center, Army Research Laboratory and AF/Wright Laboratory.

- Rome Laboratory works with Naval Research Laboratory (NRL), Naval Command and Control and Ocean Surveillance Center's Research and Development Division (NRaD), and Army CECOM under Project Reliance on speech related identification and transformation technologies.

- Rome Laboratory in conjunction with ASC, five logistic centers, NAWC and Army is supporting ABBET, a set of software interface standards for the test domain to facilitate the transition of test information and implementation of automated tests. These software standards are defined to support software component portability, reusability, exchangeability, and interoperability, and to serve as targets for test-related software development tools. ABBET is to be developed under the auspices of the IEEE through the Standards Coordinating Committee (SCC) 20.

- Rome Laboratory is supporting the Tri-service/ARPA Rapid Prototyping Application Specific Processor (RASSP) program in the area of test and integrated diagnostics, reliability, and design and test methodologies by defining how digital signal processors are specified, designed and maintained. The goal of this program is a 4X improvement in design and life cycle support associated with digital signal processors. Rome Laboratory works closely with AF/WL, ARL, NRL, and ARPA. This support addresses the goal of an order of magnitude increase between maintenance actions, efficient diagnostics methodologies, and design tools and test methodologies to incorporate reliability as soon as possible.

- Under a Project Reliance relationship, the Air Force SPEAKeasy Program Office serves as the DoD Executive Agent of the SPEAKeasy Program, and collaborates with the other Joint Program Partners including: the Advanced Research Projects Agency (ARPA/ISO), US Army CECOM, and US Navy NCCOSE RDT&E Division.

- Rome Laboratory is participating in a Tri-Service, NASA, EPA, Industry, and Academia (GTRI) team evaluating the removal of ozone depleting substances (ODS) solder

fluxes from printed circuit (PC) boards. This effort is serving as a feasibility demonstration of producing reliable military microelectronics without the use of ODS. The results being developed by this effort are being shared with the industry through NTU satellite broadcasts.

- Rome Laboratory supported the MIMIC program through the ARPA/Tri-Service Reliability and Radiation Effects Program where Rome Laboratory worked closely with the Naval Research Lab (NRL) and Army Research Lab (ARL). Several important technologies were developed at Rome Laboratory and transitioned to the MIMIC contractors during 1995 as a result of this support program including: a robust design analysis technique, an accurate finite element models for state-of-the-art heterojunction bipolar transistors (HBT) and a new destructive physical analysis (DPA) technique. These and other technology advances from the ARPA/Tri-Service MIMIC Reliability and Radiation Effects Program are now being leveraged by the ARPA/Tri-Service MAFET Reliability Program, for which Rome Laboratory will provide similar support.

- Rome Laboratory participates in the JDL Electronic Devices Panel in the area of microwave solid state components, microwave photonics, analog opto-electronic integrated circuits, and high speed lasers. Rome Laboratory has joint programs with AF/Wright Laboratory, Naval Research Laboratory, and the Army Research Laboratory. This work is applicable to all communication and radar systems.

- Rome Laboratory's photonics program is very closely coupled with ARPA, particularly in the areas of photonic systems, devices and opto-electronic integrated circuits. One of Rome Laboratory's staff members is assigned to ARPA part time to support their photonics program.

- Rome Laboratory participates as a member of JDL "Science and Technology Reliance Assessment for Modeling and Simulation Technology (STRAMST) tri-Service Ad Hoc working Group." This initiative will establish a service-wide coordinated program in Modeling and Simulation.

- Rome Laboratory is an integral part of the Decision Aids Subpanel of the JDL technology panel on C^4 (TPC^4). Other service participants are the Army CECOM and Navy NRaD Laboratories. Force/component level planning and execution control are the current targeted functionalities for technology cross-feed and interoperability.

- Under the JDL, a Tri-Service advanced networking testbed is being established that will electronically interconnect the Service labs and some limited number of operational users. This testbed will support Tri-Service research in high speed networking as well as the distributed processing and decision aids.

Changes From Last Year

The primary changes in the C^4I S&T program over the past year are:

- Funding and Manpower reductions have caused the transfer of the Advanced Microwave Technology segment of our program to Wright Laboratory. Encouraging results in our Technical Reinvestment Project in commercial Air Traffic Control Radars and emerging commercial microwave components markets indicate that at the present time, the commercial market can support the technical parameters advanced surveillance sensors require. In addition, the ARPA efforts in the Microwave and Analog Front End Technology Program promise to bring costs in line with affordable microwave modules. The transfer allows Rome Laboratory to concentrate effort on high payoff back end processing and algorithm development.

- Rome Laboratory reprioritized its C^4I S&T program to place added emphisis on technology applicable to New World Vistas capabilities, noteably in Global Awareness and Dynamic Planning and Execution Control plus the AFMC/ST emphasis area of Information Dominance.

- The HAVE NOTE Electromagnetic Environmental Effects and the Rome Laboratory Antenna Measurements Facilities were transfered from AFMC/DO EW facility capability funding to Rome Laboratory's 62702F in a zero budget transfer. Rome Laboratory was directed to provide start-up funds for these activities and to become customer reimbursed for these activities in future years.

Summary

The C^4I S&T program is crucial to Global Reach/Global Power. Rome Laboratory C^4I technologies will revolutionize modern combat. The technical foundation of the Rome Laboratory initiative is the ability to sense, analyze, distribute, and use huge amounts of information to support worldwide operations. The technical program will provide these capabilities while controlling costs and achieving major gains in reliability and supportability of complex electronics.

Mission payoff includes both immediate improvements for today's inventory of C^4I systems and the technological basis for future systems. At the same time, this world class technology is significantly impacting the commercial market through technology transfer. The program described in this TAP results from a rigorous investment strategy process which balances the needs of all customers with available resources.

Each of the TAPs thrusts are discussed in the sections that follow. A macro-graphic roadmap of the thrust's technology program is included for each thrust.

THRUST 1

SURVEILLANCE

User Needs

The Air Force needs to improve the performance and reduce the cost of Air Force surveillance systems. Technologies being developed to meet these needs include: advanced cooperative/noncooperative bistatics; space-time processing; sensor/data fusion; advanced array antennas; and Over-The-Horizon Radar.

- The **Surveillance and Reconnaissance Mission Area Plan (MAP)** identifies responsive tasking and the ability to detect and track Critical Mobile Targets as major deficiencies. Other severe C^4I limitations include detection of low altitude, low observable threats and high confidence hostile target identification of wide area threats according to the **Air Combat Command (ACC) Theater Battle Management, Reconnaissance and Surveillance, and Theater Missile Defense MAPs.**
- The **Joint Mission Needs Statement for Theater Missile Defense** states a requirement for "... a robust C^4I and surveillance capability unique to Theater Missile characteristics." The radar cross section and low altitude of cruise missiles makes them very difficult to detect with fielded sensors due to clutter, jamming, and "hot clutter." "Hot clutter" is a terrain scattered interference signal. Developing the ability to reject "hot clutter" is viewed as a major problem by ARPA and the Services.
- USACOM, USSOUTHCOM, and NORAD have identified Over-The-Horizon Radar as a main surveillance asset in the counterdrug mission. This has led to two new Over-The-Horizon Radars being installed in the relatively near future, and has fostered an effective and close working relationship between the operational and technical Over-The-Horizon Radar community. The **ACC Strategic Defense MAP** identified Over-The-Horizon radar as a solution for current C^4I system deficiencies.
- The **Air Force Special Operations Command's** need for real-time situation awareness and threat updates is specified in their **Weapons System Roadmap**. It also emphasizes the need for sensor covertness and cueing using offboard sensors.

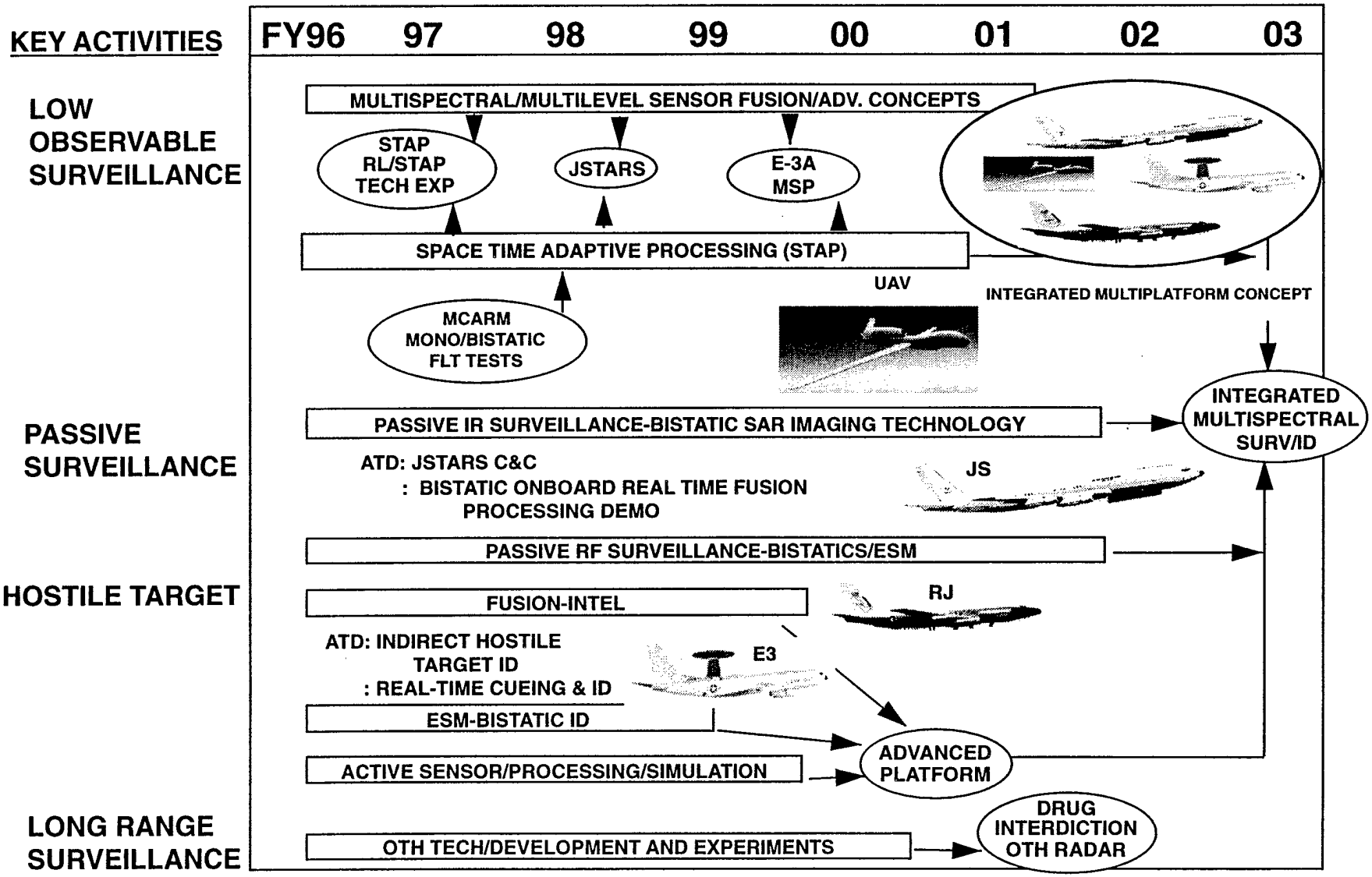
Goals

- Develop Space-Time Adaptive Processing (STAP) techniques for improved detection of low observable targets in presence of serve clutter and jamming.
- Develop bistatic sensor technology and concepts to reduce system cost and to improve sensor survivability and covertness.
- Develop cueing and fusion concepts using offboard sensor data to improve sensor efficiency, hostile target identification, and real-time situation awareness.
- Develop and transition technology in Over-The-Horizon Radar for counterdrug surveillance.
- Develop and transition concealed Weapon Detection and through the wall surveillance advanced sensor fusion techniques in support of the **Penetrating/Identification Radar Defense Technology Objective.**

Major Accomplishments

- Integrated Electronic Support Measures (ESM)/Bistatic Radar technology was transitioned to a major reconnaissance platform for evaluation of operational capabilities. Application of this technology will give the platform a unique capability to unobtrusively provide situational awareness to battlefield commanders.
- The Joint STARS Cueing and Correlation Advanced Technology Demonstration's (ATD's) Offboard Augmented Theater Surveillance (OBATS) testbed capabilities were demonstrated for scenarios applicable to the Joint STARS mission requirements. This capability is the first demonstration of the application of advanced distributed fusion and multisensor resource management techniques to locate, identify and prioritize Transporter-Erector-Launcher's (TEL's) and other strategic/tactical ground targets.
- The Rome Laboratory Space Time Adaptive Processing Algorithm Development Tool (RLSTAP/ADT) has completed Alpha and Beta testing and was released in January 1996. RLSTAP is a comprehensive user friendly toolbox for designers and development of conventional signal processing and STAP algorithms.
- Operational Over-The-Horizon radar continues to play a significant role in counterdrug surveillance and has become the key asset in that capacity. New efforts at Rome Laboratory, such as Noise Excision and Beacon Coordinate Registration, are currently transitioning into the Operational System. This technology will allow the system operator to report target position in azimuth and range to within 5 miles. This is a 4 to 1 improvement over current system capability and will result in more successful and timely interdiction of drug carrying aircraft.
- The Multichannel Airborne Radar Measurements (MCARM) testbed successfully flew 11 data acquisition flights in both monostatic and bistatic radar configurations. The extensive data base will be used to assess the ability of Space/Time Adaptive Processing (STAP) algorithms to suppress ground clutter for detecting small tar-

SURVEILLANCE



gets from a moving platform.

- The Track and ID Fusion effort under the Rome Laboratory Hostile Target Identification program performed a set of critical experiments demonstrating the fusion of data from surveillance, reconnaissance, and intelligence sensors to provide positive and timely identification of air targets, and enhanced situational awareness.

Changes From Last Year

Funding and manpower reductions have caused delay in the execution of this thrust. The manpower reductions will result in the transfer of the Advanced Microwave Technology segment of our program to Wright Laboratory.

Milestones

1997:

- Demonstrate further enhancements to JSTARS performance resulting from cueing and correlation with enhanced radar modes.
- Conduct demonstrations using integrated ESM/bistatic passive surveillance and imaging technology on-board a small aircraft.
- Complete development and testing of active radar target identification algorithms in preparation for demonstration and test on-board an operational surveillance platform.
- Demonstrate special purpose AI machines for both expert and blackboard system.
- Evaluate the performance of STAP algorithms using collected data.

1998:

- Initiate real-time airborne demonstration of all source advanced correlation capability for detection and tracking of time-critical targets.
- Conduct Advanced Airborne Surveillance Program Demonstration.
- Complete development and testing of hardware and software comprising an advanced active radar target ID system for demonstration and test on-board an operational surveillance platform.
- Develop and demonstrate advanced graphical user interface software and platform displays for integrated knowledge-based fusion concepts.
- Complete interface of Computational Electromagnetic (CEM) codes to Rome Laboratory's Space-Time Adaptive Processing Algorithm Development tool.

THRUST 2

COMMUNICATIONS

User Needs

This thrust supports Air Force need for instantaneous wideband information access to provide global communications for the rapid application of air power. Communications systems must provide assured connectivity for timely, reliable, responsive, and affordable transfer of information.

The user needs addressed in this thrust have been derived from the following documented requirements:

- **ACC Theater Battle Management Mission Area Plan (MAP)**
- **Air Mobility Command Airlift MAP**
- **Air Force C4 Agency Communications Squadron 2000**
- **Air Force C4 Agency Superhighway 2000**
- **CAF Mission Need Statement for Counter-Drug Air-to-Air Detection and Monitoring**
- **Defense Planning Guidance (DPG) for MILSATCOM**

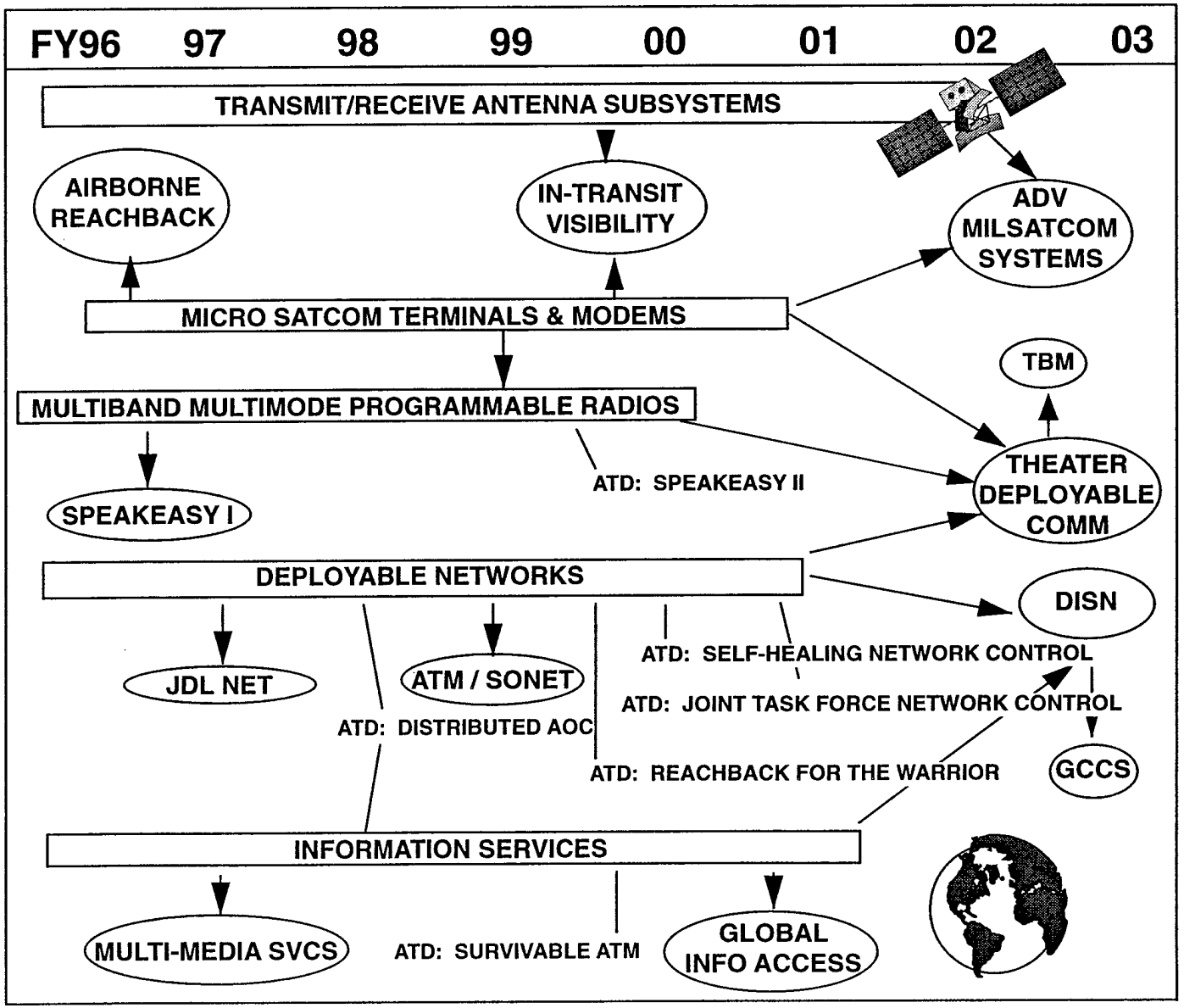
Goals

- Develop and demonstrate advanced communications technologies required to link national command authorities and sources to Air Force components of a Joint Task Force, regardless of location.
- Technology developments include:
  - Modular, programmable radios that are easily maintained, interoperable, robust and multi-level secure.
  - Robust networking systems to provide automatic network restoration and the automatic flow of information at multiple levels of security.
  - Seamless information handling capabilities to achieve an integrated network environment of distributed systems using lighter, deployable communications.
  - Lightweight, miniature, low input power subsystems to reduce the weight of SHF/EHF spacecraft communications payloads by 50% for launch on the Medium Launch Vehicle.
  - Small ground/air transportable communications equipment suite with integrated workstation housed in a ruggedized shelter, configured to provide operators with secure simultaneous multiband, multifunction radio communications.

Major Accomplishments

- Rome Laboratory completed the development of the Secure Survivable Communications Network program which deployed Asynchronous Transfer Mode communications switching capabilities to seven Joint Service/Agency locations. This capability is transitioning to the ARPA/DISA JPO LES network as a virtual enterprise network. The network management capability developed under the SSCN program has transitioned as a major component of the LES operational Network Operations Centers.
- A combined UHF/SHF Satcom radio with DAMA protocol capability was demonstrated.
- The DISA SHF Demand Assigned Multiple Access standard using proof of concept System Control Terminal and Network Control Terminal was validated.
- Completed and demonstrated SPEAKeasy Phase-1 Advanced Development Model (ADM) showing performance comparable to existing legacy radio systems.
- Began development of the SPEAKeasy Phase-2 ADM. This effort will further refine the Multiband, Multimode Radio concept by moving closer to NSA INFOSEC approval, improving the RF performance, increasing the number of waveforms supported and repackaging the technology into a more fieldable form factor.
- Designed and established an in-house high data rate, wideband "Multimedia Wireless Extension" link using commercial-off-the-shelf (COTS) products.
- Flip-Wave (patent pending) was developed in-house as a highly bandwidth efficient, Low Probability of Intercept Spread Spectrum Waveform.
- Demonstrated initial capability of the Traffic Flow Visualization and Control (TFVC) system in a five sensor configuration operating on the Long Island Expressway in New York State.
- The Mini Transportable Communications Central (MTCC) Terminal passed all factory acceptance and field operational tests at the USCG station in Elizabeth City NC. The Transportable Communications Central (TCC), which was the fore-runner to the MTCC, has already been utilized in Search and Rescue efforts in the aftermath of Mississippi Flooding, Florida Hurricanes, and California Earthquakes. It has been deployed to Haiti, Cuba, Guam, Alaska, and to classified sites for drug interdiction operations.

COMMUNICATIONS



Changes From Last Year

The MILSATCOM Joint Program Office (MJPO) of the AF Space & Missiles Center (SMC) is continuing with a technology program for the development of advanced EHF payload and airborne terminal technologies for future EHF Satcom systems. Rome Laboratory and PL are jointly managing technology developments under the MJPO program.

Milestones

1997:

- Demonstrate communications protocols capable of operating in ATM/Synchronous Optical Network (SONET) based systems under theater threat conditions.
- Demonstrate Reach-back for the Warrior and DISN capabilities with two ATDs under the Information For The Warrior Program.
- Demonstrate the SPEAKeasy Phase-2 Man-Machine Interface and a Limited Capability Demonstration model.
- Demonstrate low cost EHF antenna subarrays for airborne platforms.
- Prove out the SPEAKeasy Phase-2 technology in the Tactical Air Control Party (TACP) role at the Task Force XXI Demonstration at Ft Irwin, CA.
- Demonstrate the Traffic Flow Visualization and Control (TFVC) system utilizing multiple types of communications media.
- Demonstrate an ultra-wideband (UWB) communications system, capable of input rates as high as T2 (about 6 MBPS), using an Acoustic Charge Transport neural network as broadband nonlinear filter.

1998:

- Demonstrate 44 GHz Satcom phased array with multiple simultaneous beams.
- Demonstrate the full functionality and utility of the SPEAKeasy radio with both narrowband and wideband waveforms, internetworking capability, an advanced RF subsystem, and smart radio functions in a joint/combined operations scenario.
- Demonstrate a seamless communications design environment from high-level software through to hardware implementation via 'soft-hardware.' System/subsystem evaluation will occur in real-time or near-real-time.
- Demonstrate a Secure ATM switch and integrate into ESC's TDC Program.

1999:

- Demonstrate the total functions of the SPEAKeasy radio and the utility of the radio for joint/combined operations.
- Demonstrate advanced communication signal processing on wafer-scale signal processor. Candidate applications include advanced waveforms and interference mitigation algorithms.
- Demonstrate an advanced communications engine, developed under ARPA TRP, to support multiband multimode radio functions.

2000:

- Demonstrate initial capability of Smart Radio system, including advanced network and link level capabilities.

THRUST 3

COMMAND & CONTROL

User Needs

The changing world picture has dramatic implications for the Command and Control (C^2) capabilities of U.S. forces. In implementing the Air Force Global Reach/Global Power model, we still address the issues associated with the new operational environment — joint operations, new force structures, force draw down, loss of forward basing, and emphasis on time critical fixed and mobile targets. Overcoming the downside of these issues demands continued development of flexible, modular, and interoperable C^2 to support force multiplication, rapid power projection of joint or combined forces with extensive reachback capability, and real time operations.

The context for such C^2 has been articulated by the **Defense Planning Guidance for 1995-1999** and by the Joint Staff through both the **"C4I for the Warrior"** (**C4IFTW**) concept, and its implementation — the Global Command and Control System (GCCS). Further articulation of the technology implications have been developed under the USAF Scientific Advisory Board New World Vistas Study and the Defense Science Board Information Architecture for the Battlefield. All emphasize priority improvements in information technology for the dynamic battlefield environment. The Chief of Staff at the Air Force C^4I Review identified Shortened Decision Cycle as a key requirement. These priorities have been promulgated downward and articulated through the following documented user needs:

- **ACC Theater Battle Management MAP and TBM General Officers Steering Group (TBM/GOSG) Operational Goals** include: Reducing the Planning Cycle, Improving Joint Interoperability, and Establishing a common picture of the battlefield.
- **Contingency Theater Automated Planning System (CTAPS) Operational Requirements Document** states the need for automated planning and decision support tools to plan, direct, control, execute, report and replan the air mission. Interoperability with other TBM, Service and Allied automated systems for joint and combined operations is also a key need.
- **Mission Needs Statement for Air Tasking Order (ATO) Interoperability:** identifies the need to develop, analyze, and execute the ATO in a timely and accurate manner within a constantly changing battlefield.

Goals

- Support "come as you are" warfighting with "anywhere, anytime information — based support." Per TBM/GOSG direction the focus is on the Commander Joint Task Force (CJTF), Joint Force Air Component Commander (JFACC), and the Air Operations Center (AOC) with horizontal, joint service interoperability.

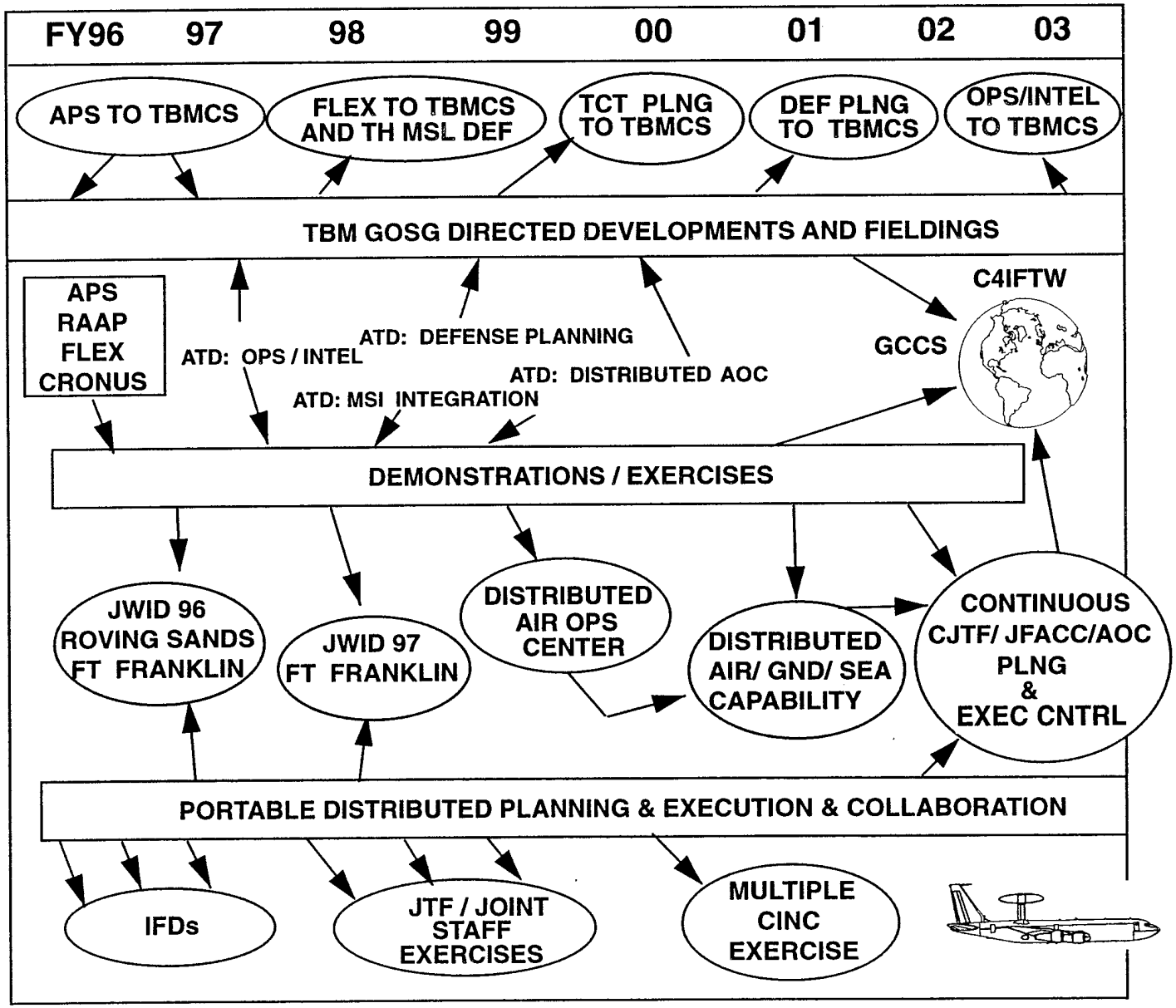
To support this goal, the thrust has been structured with activities of both a near-term focus, as overseen by the TBM GOSG, and a longer term vision which strives to harness new intelligent information technologies for application to the C^4IFTW Mid-Term and Objective phases. Spanning these two activities is an Operation Evaluation Environment, which supports Joint and/or Air Force only tests and demonstrations. The thrust can be effectively separated into the following four measures of effectiveness/payoffs:

- •• Focus near-term investment on information technology that will support Air Operations Center operational requirements for AF/joint automated decision support tools for reduced decision cycles.
- •• Develop next generation intelligent information services which will support a globally dispersed, joint and coalition capability which provides single thread collaborative planning from the CINC to the units, real time execution monitoring and replanning, integration of all information sources, reachback, and traceability from guidance to mission execution.
- •• Demonstrate efficient and effective acquisition concepts (e.g.. rapid prototyping) and technology transition strategies (e.g. user/developer testbeds) for software systems.
- •• Demonstrate operational utility in regular military exercises involving unified commands and their component services, and in Joint Warrior Interoperability Demonstrations where evolving technologies can be seen and evaluated by the user community.

Major Accomplishments

- The Advanced Planning System (APS), has been operationally installed in NATO and USAFE to support Operations Deny Flight and Provide Promise in Bosnia.
- APS has been designated by SECAF as one of the four modules to generate/disseminate the Air Task Order for Joint air operations.
- The Time Critical Target (TCT) Engagement Planner from the ARPA Local Attack Controller brassboard has been merged with the Force Level Execution (FLEX) to provide a TCT replanning capability.
- The FLEX and APS programs have been modified to incorporate the new Joint ATO format.
- A collaborative planning demonstration was executed during Joint Warrior Interoperability Demonstration

COMMAND AND CONTROL



(JWID) 95. It integrated Air Force, Navy and ARPA planning technologies, and showed single thread, CINC to unit, joint planning involving planning cells aboard the USS Kitty Hawk, at Camp Pendleton and at Fort Franklin, Hanscom AFB, MA.

- The Distributed Air Operations Center (DAOC) ATD was initiated and preliminary capability demonstrated as part of the JWID 95.

Changes From Last Year

- Program management responsibility for the APS program has transitioned to ESC/AVB as part of the TBMCS program office.
- A new joint initiative with ARPA, the JFACC Battle Management Initiative, was begun to support the continuous, real time planning and execution process of the "JFACC after next."

Milestones

Strong relationships continue with the Advanced Research Projects Agency (ARPA), and the Air Force TBM programs. These partnerships sponsor work in both the near-term TBM and longer term Distributed C^2 activities.

At the same time, portions of the ARPA Portable C^2 for the CJTF program are being pursued to extend long term distributed information processing activities from the AOC only to joint issues inherent to task force collaborative planning in C^4IFTW and GCCS. The Thrust provides these programs with a transition path into the TBM/GOSG directed operational architecture enhancement process as well as transition to GCCS for C^4IFTW.

Major milestones include:

1997:

- Transition FLEX to CTAPS/TBMCS Version 1.0 to include advanced TCT software from WARBREAKER/LAC to support TMD/TAD tasking/re-tasking battle management.
- Continue development of an Operational Evaluation Environment
  - Continue to support JWID, Fort Franklin, Global Yankee and other similar annual exercises.
  - For JWID 96, expand the shared context, distributed collaborative planning demonstration by inclusion of a mobile processing and communications node.
  - Add OPS/INTEL and DEFENSIVE PLANNING ATD capabilities.
  - Extend connectivity to the Air Warfare Center to support user/developer interaction/demonstration for the JFACC Battle Management Initiative.
- Complete the JTF/ATD Integrated Feasibility Demonstration and initiate transition to an ACTD.

1998:

- Complete OPS/INTEL ATD and initiate transition to TBMCS.
- Demonstrate Distributed Air Ops Center and initiate transition to TBMCS.

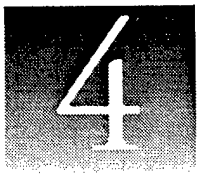
1999:

- Simultaneously develop and demonstrate distributed, collaborative C^2 for "build a little/test a little" transition into TBMCS and GCCS.

2000:

- Demonstrate continuous, real time planning, execution monitoring and replanning capabilities to support distributed CJTF/JFACC as part of JFACC Battle Management Initiative.
- Complete DEFENSIVE PLANNING ATD and transition to TBMCS.

THRUST



INTELLIGENCE

User Needs

The Intelligence community must provide timely and accurate information in order to enhance air and space superiority, precision employment, global mobility and information dominance. Work under the Intelligence Thrust is directed at meeting these needs:

The **Air Combat Command (ACC) Theater Battle Management MAP** and **Reconnaissance and Surveillance MAP** requires timely battle damage assessment with the results being inserted into the Mission Planning /Air Tasking Order.

The **Department of Defense Intelligence Information System (DoDIIS)** needs to monitor threatening situations, pass imagery from Headquarters to Units, and provide Indications and Warning updates on a timely basis to support regional conflicts.

The **Intelligence Functional Area Plan and Air Intelligence Agency (AIA)** require data processing techniques to manage information warfare, extract tactical information from communications and to develop tactical deception plans.

The **National Air Intelligence Center (NAIC)** needs advanced signal processing and simulation techniques to model foreign threats and track the proliferation of weapons of mass destruction.

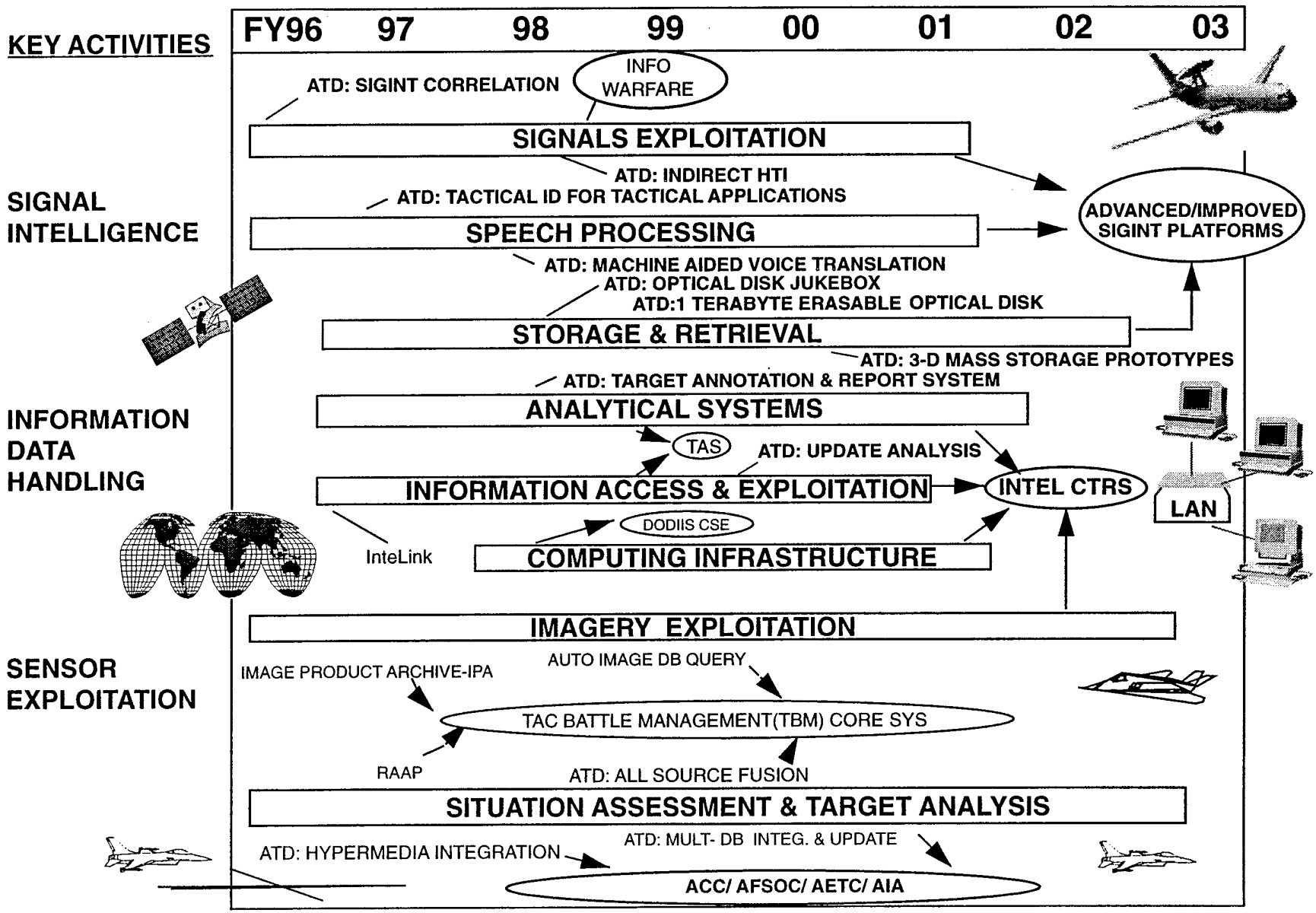
Goals

- All thrust investments will support Global Reach-Global Power, USAF Core Competencies, and New World Vistas.
- Develop technologies for insertion into C^4I architecture and pursue technology transfer to commercial markets.
- Develop enabling information processing technologies responsive to operational deficiencies by improving timeliness, reliability, and accessibility of information to the warfighter.
- Advanced signal exploitation techniques will be developed to respond to operational deficiencies by improving timeliness of intelligence to the warfighter.
- Intelligence Data Handling research will develop technology and techniques to provide rapid access to current and relevant data.
- Sensor Exploitation research will exploit sensor inputs and allow the developed software to operate across different computing platforms.

Major Accomplishments

- A Deployable Optical Jukebox (DOJ) has been delivered and interfaced to AFSOC's mission planner.
- An Optical Redundant Array of Independent Drives (O-RAID) has been delivered to Rome Laboratory for in-house testing in support of the 480 Intelligence Group.
- Completed and installed Hostile Target Identification (HTI) fusion algorithms to process E-3 data.
- Developed the first automatic dialect identification capability which separated Peruvian and Cuban speakers 84% of the time.
- Demonstrated a voice translation system from spoken English to Russian, Arabic and Spanish and vice versa at the Dubai Air Show and for Air Force and Army Special Operations Forces.
- Delivered the Intelligence Analyst Associate (IAA) to the National Air Intelligence Center (NAIC) for information extraction and analysis.
- Joint Integrated Test Facility (JITF) established 1 Jan 95, will support continuing technical transition and certification of the DoDIIS migration systems for compliance with DoDIIS infrastructure.
- In-House Research, the Multi Trainable Time Delay Neural Network (MTTD NN) resulted in a major innovation in the development of an automated capability to generate temporal models that aid intelligence analysts predict inpending military events.
- The Exercise Planning and Management Systems (EPAMS) was transitioned to USSTRATCOM to support the Bullwark Bronze strategic exercise.
- Identifinder Natural Language Understanding (NLU) software was transferred to the US Treasury Department.
- The Imagery Exploitation Support System (IESS), version 1.0 replaced Computer Aided Tactical Information System (CATIS) version 3.2 at six operational sites.
- World Wide Web technology has been exploited in-house to develop an Intelink interface for Image Product Archive (IPA).
- The eXtended Integrated Data Base (XIDB) version 1.2 through 1.2.5 were developed and fielded at STRATCOM, AIA, and FORSCOM.
- A Modeling and Simulation Analysis Tool for Battle Damage Assessment was developed and delivered to the AF and Joint Targeting Schools.

INTELLIGENCE



- The Image Product Archive (IPA) system being developed by Rome Laboratory for CIO was successfully installed at USACOM, USCENTCOM, DIAC, NPIC and 480 IG.
- The Rapid Applications of Air Power Version 2 software was integrated into the Combat Intelligence System (CIS) and fielded.
- Demonstrated under the Hypermedia ATD a hypertext authoring capability which allows efficient linking of multimedia data in an export format widely used on the Internet and which can be integrated with the Sybase commercial data base management system.
- Demonstrated under the All Source Update ATD semi-automated geospatial vector data base update using advanced artificial neural system paradigms. This has application to Tactical Battle Management (TBM) Core Systems and the updating of operational data bases used by the warfighter.

Changes From Last Year

No changes from last year have impacted the Intelligence Thrust.

Milestones

1997:

- A one Terabyte Erasable Optical Disk Jukebox will be delivered and integrated at the 480IG, ACC, for ACCINTNET applications.
- A 3-D Optical Read Only (ROM) Memory device that will verify massively parallel terabit capacity, gigabit throughput rate and nanosecond access time will be integrated for AFINTNET applications.
- Continue to provide technical transition and certification of compliance with DoDIIS infrastructure for DoD migration systems.
- Continue to develop additional tools to efficiently model the temporal, conceptual, and spatial relationships between events in an intelligence scenario.
- Develop and implement additional interfaces between Intelink and other intelligence systems.
- Natural Language Understanding (NLU) software, which reads text and extracts data of importance will be transitioned to operational intelligence data handling systems.
- Virtual Laboratory will provide CIO and Rome Laboratory, with a capability to conduct collaborative image exploitation research and demonstration activities via a secure wideband interconnection.
- The Machine-Aided Voice Translation ATD will translate spoken Arabic, Russian, and Spanish to spoken English and will be demonstrated at AFSOC.
- Rome Laboratory is chairing an Action Group (XAG-7) under The Technical Cooperation Program (TTCP). Rome Laboratory will share US Government developed software for the purpose of collaborative research in the application of Image Understanding (IU).
- A mobile time critical targeting function will be added to the Rapid Application of Airpower (RAAP) system.

1998:

- A 3-D Optical Erasable memory that will verify massively parallel terabit capacity, gigabit throughput rate and nanosecond access time will also be delivered and integrated into the ACC, AFINTNET program.
- The Wideband Recording, Storage & Retrieval area will exploit optical disk and 3-D memory concepts to improve storage capacity, access times and throughput rates.
- Evolve the eXtended Integrated Data Base (XIDB) into the Modernized Integrated Data Base for DIA.

1999:

- The Target ID for Tactical Application will provide the automatic recognition of targets based on audio acoustics.

THRUST 5

SIGNAL PROCESSING

User Needs

Signal processing technology turns raw data into the higher level real-time information that feeds every aspect of the C^4I mission including:

- The Air Combat Command (ACC) Tactical Battle Management Mission Area Plan (MAP) identifies a mission need for E-3 to include programmable adaptive signal processors as key components to significantly improve radar signal processing.
- The Strategic Attack Interdiction MAP requires real-time target location versus small/mobile targets.
- The Space Control MAP includes multiple requirements for high throughput processors and improved surveillance algorithms.
- The ACC Strategic Defense MAP requires improved real time processing capability, real-time displays, and adaptive signal processing for Beyond-Line-of-Sight communications.
- The Intelligence Functional Area Plan and Surveillance and Reconnaissance MAP calls for continued advances in speech and audio signal processing.

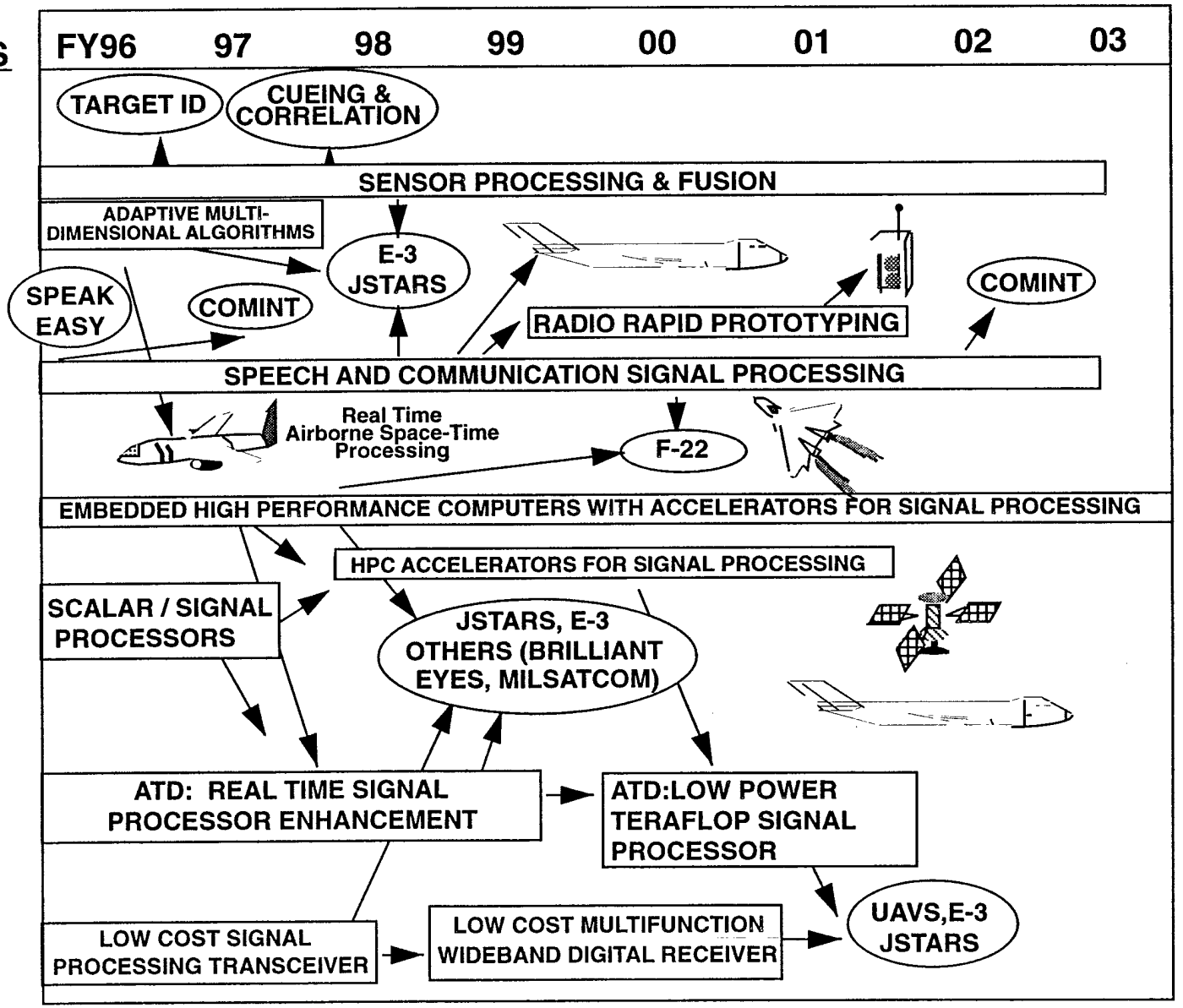
Goals

- Advance signal processing technology, exploiting commercial technology whenever possible and rapid transition of the resultant advanced technology to military and commercial applications.
- Drive down the cost and complexity of C^4I signal processing systems, improving throughput by a factor of 100 every seven years.
- Rapidly field the latest signal processing techniques for surveillance, communications, and intelligence.
- Spin on and spin off technology transfers, maximizing competition and minimizing cost by reusing commercial hardware and software.
- Reduce system hardware complexity by shrinking racks of equipment with hundreds of part types down to single board solutions, simplifying logistics and aiding two level maintenance.
- Provide completely programmable signal processors and enable rapid prototyping of new solutions by replacing the current collections of "hardwired" special purpose boxes with flexible, scaleable systems based on High Performance Computing (HPC) technology.
- Keep C^4I systems current and foster competition by using open systems architectures.

Major Accomplishments

- Established a DoD shared resource center for high performance computing with a 90 billion operations/second Paragon supercomputer with the world's largest real-time input/output capacity (3.3 gigabytes/sec).
- Implemented Space-Time Adaptive Processing (STAP) algorithms on the Paragon supercomputer and then ported these to a smaller, ruggedized Paragon to fly on the MCARM aircraft and process 16 channels from the L-band phased array radar in real time.
- Set a higher standard for efficient radar signal processing on embedded high performance computers by sustaining over 50% of peak throughput on real-time STAP algorithms.
- Developed and tested in real-time hardware high performance temporal filter algorithms which process consecutive frame infrared camera data to suppress moving clouds while detecting and tracking weak slow point targets.
- Received United States patent on Short Stack memory technology.
- Developed novel vertical optical interconnect technologies for three dimensional multichip modules (MCMs) through a CRDA with industry.
- Honeywell RH32 processor demonstrated in brassboard unit.
- TRW RH32 central processing unit (CPU) and memory management unit (MMU) successfully integrated into multichip module.
- Increased tactical speaker identification speed over 16 times through parallelization on a supercomputer NCube.
- Developed and demonstrated a Knowledge-Based approach to small target detection that adaptively determines clutter characteristics to optimize radar detection performance. Demonstrated a 4-5 decibel (dB) improvement in sensitivity using E-3 measurement data.
- Completed a four channel speaker and language identification system for 30% improvement in automatic sorting accuracy by using four 900 MFLOPS tactical signal processing cards with programmable interconnect topology. These cards have also been transitioned into a joint Rome Laboratory/Navy Advanced COMINT Voice Processing ATD.

SIGNAL PROCESSING



- Developed a data fusion methodology for automatic speaker identification resulting in 86% accuracy on 49 speakers using only four seconds of training data.
- Flip-Wave (patent pending) developed in-house as a highly bandwidth efficient, Low Probability of Intercept Spread Spectrum Waveform. This stealthy waveform has been tested and evaluated on Rome Laboratory's Radio Rapid Prototyping Testbed for transition to Speakeasy.
- Demonstrated/evaluated several interference mitigation algorithms for the removal of highly dynamic jamming on alternative architectures, using the Radio Rapid Prototyping Testbed.

Changes From Last Year

The Wafer Scale Signal Processor (WSSP) architecture was changed from a stand-alone architecture to an accelerator within the commercial Paragon high performance computer architecture to leverage the tremendous commercial investments in architecture and software environment. This streamlines the insertion of the WSSP into multiple ongoing applications of embedded high performance computing for signal processing and simplifies its software environment.

Milestones

The signal processing thrust emphasizes the interrelated areas of developing new signal processing algorithms or techniques, and developing high performance signal processors based on commercial off the shelf (COTS) High Performance Computing (HPC) technology.

1997:

- Developing a transceiver module to digitize and calibrate receiver data to provide high channel to channel tracking accuracy.
- Real-Time Signal Processor Enhancement ATD coupled with High Performance Computing technology achieving 100 billion floating point operations per second per $1 million and transitioning to JSTARS for Planned, Programmed Product Improvement (P3I).
- Nonlinear signal processing and neural network technologies applied to communication processors.
- Jam-resistant communications processor using highly compressed speech.
- Rapid prototyping capability for evaluating advanced communications/signal processing concepts.
- Wavelet Transform based spread spectrum interference suppression subsystem.
- Highway monitoring system via video sensor technology for real-time traffic management.
- Demonstrate an ultra-wideband (UWB) communications system, capable of a rate of six megabites/second using an Acoustic Charge Transport neural network as broadband nonlinear filter.

1998:

- Demonstrate a seamless communications design environment from high-level software through to hardware implementation via soft-hardware.
- Automated sorting of signals to improve tactical intelligence processing by 50%.

1999:

- Demonstrate advanced communication signal processing on HPC architectures with the wafer-scale signal processor.
- Demonstrate an advanced communications engine, developed under ARPA TRP, to support multiband/multimode radio functions.
- Demonstrate a low power (3kW) TeraFLOP signal processor enhancement and transition to an unmanned aerial vehicle (UAV) platform.
- Knowledge-based applications to Space-Time Adaptive Processing for improved detection of weak targets in the presence of severe clutter and jamming.
- Advanced speech processing workstation monitoring six to ten channels for AF communications intelligence.

2000:

- Demonstrate initial capability of Smart Radio system, including advanced network and link level capabilities.

THRUST

COMPUTER SCIENCE TECHNOLOGY

USER NEEDS

The key to our sustained military supremacy is enhanced mission productivity and increased command and control agility across the force structure through the use of computer systems and advanced software to perform mission critical functions in a globally dispersed theatre of operations.

Affordability of software development and support, currently running at about $10 billion per year for the Air Force, is affected by the size and complexity of the software for our new systems, and by the expense of maintaining and upgrading hundreds of systems in the inventory. As weapons and C^4I systems become more dependent on computers, the need for an "Infosphere" composed of small, deployable resources which have all of the "illities" of large fixed site systems becomes critical. Thus:

- **AFMC, AETC, ACC and the other MAJCOM's** need better processes and tools for the acquisition, development, and post deployment support of mission critical software systems.
- **ACC, AFSOC, USTRANSCOM, AMC** etc. are concerned with the dependability, adaptability, survivability, security, interoperability with dissimilar systems, "real-time" information access capability, and timely executable plans etc., from their globally dispersed computing assets.

These needs are documented in the AFMC/ESC Technology Needs, the ACC Strategic Defense and Theater Battle management MAPs and the AFSOC Weapon System Roadmap.

Specifically, this thrust addresses:

- Tools, processes and whole "environments" to cut high costs and risks associated with the development and support of military software intensive systems, where productivity is currently growing at 4% and demand at 20%.
- The achievement of secure, dependable, immediate, and uniform access to globally distributed, dissimilar computer systems and databases resulting from distant, and/or joint, and/or multi-national, collateral forces' missions.
- Tools for rapidly generating, evaluating, optimally scheduling, and execution management of combat, transportation, rescue, etc. mission plans and options for the flexible "quick reaction" force structure needed.

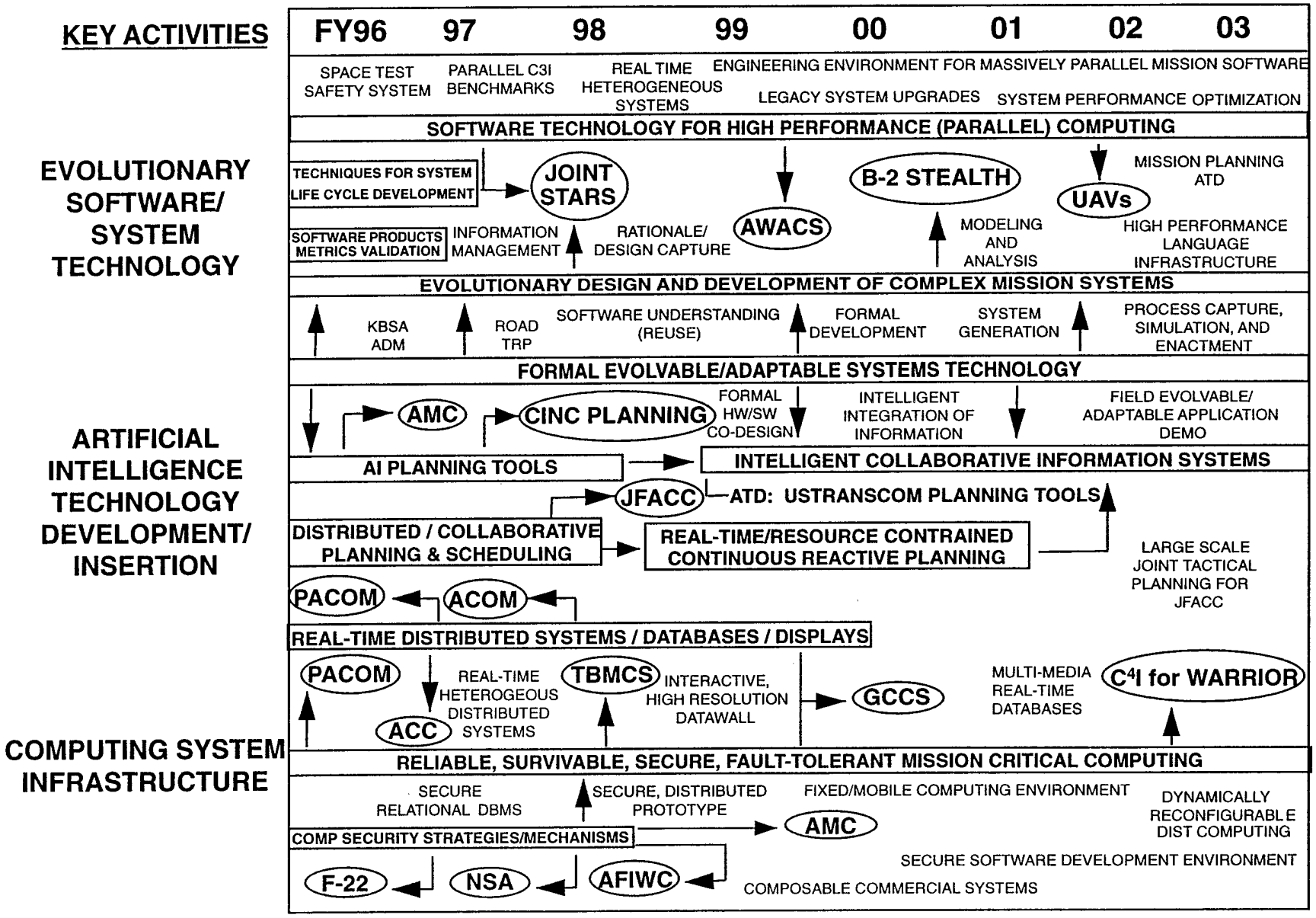
GOALS

- Reduced software costs and enhanced reliability through improvement in software productivity and quality processes within Air Logistics Centers (ALCs) and program offices: Near-term, 2:1 improvement; Long-term, 10:1 minimum.
- 10:1 throughput performance enhancement in distributed computing, achievement of real-time performance in multi-media databases, and achievement of top NSA security standards in distributed computing and databases in support of joint and multi-national collateral missions.
- Factors of 10 to 1000 reduction in times required by the Joint Chiefs on down, for planning and scheduling combat & non-combat missions, and their associated support activities. 80% reduction in the in-theater "footprint" required for C^2 battle staffs.
- Natural human interface to complex C^4I systems by the integration of multi-media, virtual reality, high resolution displays and spoken language.
- Increased military readiness through software systems that are malleable in the context of new or changing operational situations.

MAJOR ACCOMPLISHMENTS

- Demonstrated integrated planning, force generation, and execution monitoring system in a distributed collaborative venue supporting all levels of the command structure from the Unified CINC to Air Operations Center (AOC) at JWID 95.
- Laptop In-Theater Airlift Scheduling (ITAS) brassboard delivered to PACAF.
- Formed a joint program for benchmarking for HPC systems with ARPA to create a benchmarking infrastructure including a common methodology and C^4I based benchmarks, especially for benchmarking real-time HPC systems.
- Successfully transitioned the Process-oriented Software Life Cycle Support Environment (ProSLCSE) to the F-16 Head-Up Display (HUD) software development team at Ogden Air Logistics Center (OO-ALC/TIS), Hill AFB, UT.
- Rome's Cronus Distributed Computing Environment was extended to include new CORBA commercial requirements and used to demonstrate the concept of distributed Air Task Order generation and execution monitoring in JWID 95.

COMPUTER SCIENCE AND TECHNOLOGY



- Established an ATM connected distributed computing testbed called JADEnet with NRaD and US Army CECOM for wide bandwidth application testing.
- Extended the local cluster of the secure distributed computing environment capability to demonstrate heterogeneous hosts and a B3 level of trust.
- Demonstrated automated synthesis of distributed fault tolerant system from KBSA formal specifications.

Changes From Last Year

Following direction from higher headquarters to wind down the technology program in "conventional or classical" software engineering systems by the end of FY 97, considerable attention has shifted to refocusing the remaining personnel and resources on the technical challenges associated with the promising software paradigm called Evolutionary Design of Complex Systems. In partnership with ARPA, a new technology emphasis is emerging on capabilities to allow continuous evolutionary development of families of long-lived military software systems. New technical challenges include:

- Information management technology to support evolutionary development.
- Programming languages that support both incremental development and high performance.
- Technology to support design rationale capture and reuse, including higher conceptual level design representations.
- Technology to enable reuse of past design activities throughout the evolutionary life-cycle, including architectural analysis, system certification and use-case development.

This program transition will take effect over FY 97.

Milestones

1997:

- A brassboard Distributed Air Operations Center built on the CORBA object model and seamlessly coupled with both higher and lower command echelons will be demonstrated to illustrate support for limited deployments and operations.
- Real Time Distributed Computing Environment (RTDCE) executing on a homogeneous, internetted computing cluster will extend to heterogeneous operation.
- A software development environment providing "automated intelligent assistance" to all roles from program manager to programmer will be evaluated on a moderate sized military application and selected aspects demonstrated on commercial applications by the ARPA TRP.
- Demonstrate a feasibility model of a very high resolution, interactive display to support group decision making using a "Data-wall" display with "direct pointing" and "spoken-language" interface.
- Benchmarks will determine suitability of parallel computers to satisfy process and performance requirements for C^4I systems.
- Provide secure data handling capability for the F-22 Operational Flight Program Support Facility based on the Rome developed LOCK Secure Database Management System will be available.

1998:

- A secure RTDCE will be realized.
- Demonstrate separable active data dissemination architecture for integrated access and cooperation among functionally independent intelligent information's systems.
- Demonstrate a hybrid distributed computing environment with both fixed and mobile nodes.

1999:

- Demonstrate performance prediction and effectiveness tools to achieve mission time response needs for the Joint Stars Program.
- Demonstrate timely access, storage, change detection techniques using high performance intelligent information systems integrated with massively large multi source knowledge bases.
- Demonstrate user adaptable/evolvable software allowing automated reconfiguration to accommodate environmental and mission changes.
- Demonstrate performance prediction and effectiveness tools to achieve mission time response needs for the Joint Stars Program.

THRUST

ELECTROMAGNETIC TECHNOLOGY

USER NEEDS

This thrust provides the enabling electromagnetic technology for next generation surveillance and communication systems. This technology supports advanced user needs from **Air Combat Command, Air Mobility Command, Air Force Space Command, and Air Force Special Operations Forces.**

ACC, as lead for all MAJCOMS, is the primary customer for **Theater Battle Management (TBM)** technology. Specific needs, delineated in the **ACC TBM Mission Area Plan (MAP)** are:

- Efficient/effective viewing of air situation and early reporting of data for theater missile defense.
- Early launch detection and assessment.
- Improved detection of low observable targets in clutter.
- Improved communications to all force and C^2 elements with real-time capability.

The **AMC Airlift MAP** identifies needs for improved anti-jam, secure communications providing teleconferencing, patient in-transit visibility, high data rate digital file and image transfer, and robust automatic dependent aircraft surveillance Technologies supporting these needs include the better understanding of propagation conditions and multi-band SATCOM.

The **Air Force Space Command Command and Control MAP** addresses the need for high data rate satellite cross links and efficient communication switches. Technologies supporting these needs are the electromagnetic materials and millimeter wave solid state component research, which also support ACC and AMC mission needs.

The **Air Force Special Operations Forces Weapons Systems Roadmap** identifies the need for secure, interoperable communications with low probability of detection and intercept. Thrust efforts enabling these SOFSOF capabilities are secure, anti-jam, LPI systems for inter-aircraft communications, navigation, high data rate image transfer via satellite, and long endurance, psychological operations with low drag, wideband aircraft antennas.

GOALS

- 1,000-fold improvement in the ability to detect and track low observable (LO) targets.
- 100-fold increase in satellite communication and covert communication terminal sensitivity or 10-fold reduction in terminal size allowing more frequent updates to users.
- 10-fold reduction in the life cycle cost of phased array antennas for these systems.

MAJOR ACCOMPLISHMENTS

Significant progress was made in technology development for advanced, high data rate communications, especially for satellite and covert communications.

- An advanced development phased array for EHF communications applications was link tested in a joint effort with NASA and the other services at JWID 95.
- Superconducting phased array technology for the communications applications was confirmed in FY 95 with a major in-house demonstration of beamwidth, bandwidth, scannability and error control in a sixteen element antenna. All superconductivity technology work has been terminated.
- Monolithic millimeterwave cascadeable amplifiers have been demonstrated for the first time at 52-56 GHz.
- Rome Laboratory developed a unique capability to measure the full set of noise parameters at frequencies up to 60 GHz.

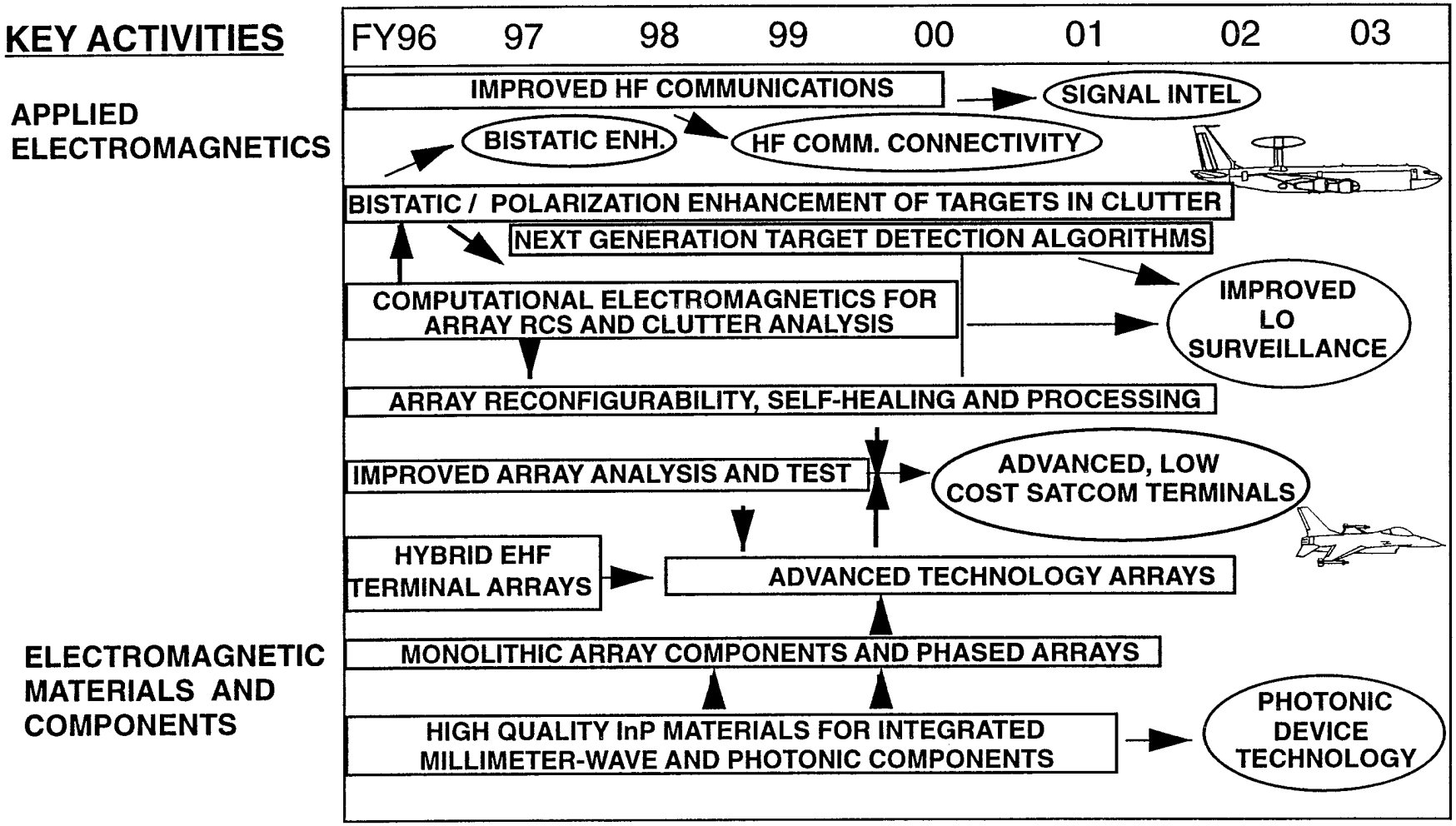
Advanced high performance electronic materials are critical to advances in components, enabling high data rate communications and integrated electronic/optical processing. In particular, Rome Laboratory is an internationally recognized pioneer in InP materials and devices.

- A computer model of phosphorus injection synthesis of InP, employed in Rome Laboratory's in situ InP bulk growth process (patent pending) has been developed.
- A new photoelectrochemical wet etch for p-type InP was invented by a Rome Laboratory scientist which will be an inexpensive competitor for plasma etching.
- Zinc high temperature semiconductor devices were grown hydrothermally at Rome Laboratory. Because the solvent Rome Laboratory employs is much less corrosive than solvents used earlier to grow ZnO, the Rome Laboratory process should decrease production retooling costs, and significantly lower the cost of ZnO substrates. Patent protection will be sought.

The following technology advances make possible high performance, surveillance radar antennas capable of counter LO capability:

- Phased array affordability was advanced this year with the demo of a neural controlled analog beamformed eight-element phased array.

ELECTROMAGNETIC TECHNOLOGY



- Two new CEM simulation tools have been developed that increase the accuracy of prediction of phased arrays mounted on complex platforms.
- A new microstrip to stripline coupler for high density interconnects has been developed and transitioned to private industry through a cooperative agreement.
- An adaptive CFAR algorithm was developed to suppress clutter and interference in radar systems.

Changes From Last Year

Technology for improved HF communications connectivity is de-emphasized in favor of low probability of intercept transmission and signals intelligence for SATCOM.

With the successful in-house demonstration of the 20 GHz superconducting phased array, the effort was terminated in FY 95. All customer money for cryo-electronics will be refused starting in FY 97.

Funding reductions and uncertainties have forced some of the milestones out into the future.

A wide bandgap nitride (III-N) semiconductor effort has begun, spurred by support from an AFOSR New Initiative.

Milestones

1997:

- The upgraded sixteen-element C-band beamformed phased array will be brought back on line with greater bandwidth, higher quantization, and a parallel processor for multiple simultaneous beam demonstrations.
- Confirm 20dB improvement in the detectability of LO targets using bistatic radar polarization diversity.
- Graphical radar cross-section (RCS) code for rapid real-time RCS prediction will be developed.
- A 60 GHz monolithic InP-based transmit chip will be designed and tested.
- HEMTs based on advanced III-V semiconductor materials will demonstrate gain and noise performance exceeding any available today, enabling improvements in signal detection.

1998:

- Demonstrations of simultaneous near-field and far-field nulling are planned to show antenna pattern control of airframe scattering and jammer cancellation.
- Demonstrate second generation compact, low cost, gallium arsenide (GaAs) active phased array antennas for EHF satellite communications from mobile platforms.
- Provide understanding of the physical causes of troposphere to ionosphere energy coupling via lightning and its effects on trans-ionospheric propagation.

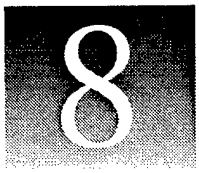
1999:

- An advanced in situ InP synthesis-plus-bulk-crystal-growth process will be developed and transferred into the US defense and commercial industrial bases.
- Demonstrate near-real time models and mitigation techniques for atmospheric and tropospheric weather effects impacting SATCOM links at low elevation angles.

2000:

- Provide near-real time theater radiowave propagation models for rapid performance optimization of deployed military mobile cellular communications.

THRUST



PHOTONICS

User Needs

Current electronic systems are susceptible to electro-magnetic interference. Size constraints, speed and reliability also limit traditional electronic systems. Photonics-based systems, that process information in the form of light (photonics) signals, will provide major improvements in tactical and strategic command, control, communications, and intelligence systems by providing small size, high performance, high capacity, survivable alternatives to electronic-based systems.

- The **Air Combat Command (ACC) Reconnaissance and Surveillance Mission Area Plan (MAP)** identifies timeliness, collection and storage at very high data rates, and multisensor processing as deficiencies in current reconnaissance and surveillance systems.
- The **ACC Strategic Defense MAP** identifies a vast increase in the volume of information to be processed and the inability of current systems to handle this increased workload effectively. The capability to rapidly process sensor and intelligence information is identified as a severe limitation.
- The **ACC Theater Battle Management MAP** requires battle damage assessment in real time; automatic target identification and infrared detection of theater ballistic missiles are identified as planned enhancements to current systems.
- **Air Force Special Operations Command (AFSOC)** has identified the operational requirements for faster utilization of data, greater databases; mission planning and rehearsal; mass data storage (gigabytes) with rapid access.
- The **Air Force Space Command Communications & Space Based Communication MAP** requires low power input, multiple beam, null steering antennas for MILSATCOM, lightweight and power signal processors for critical satellite communications functions.
- **Air Intelligence Agency Functional Area Plan Deficiency** requires remote, low loss, low distortion microwave remoting systems.
- The **Air Force "New World Vistas" Sensors Panel Report** calls for the Air Force to initiate a 6.1 through 6.3 program to significantly improve the state of the art in multifunction RF apertures for radar, and communication from 1 to 160 GHz.

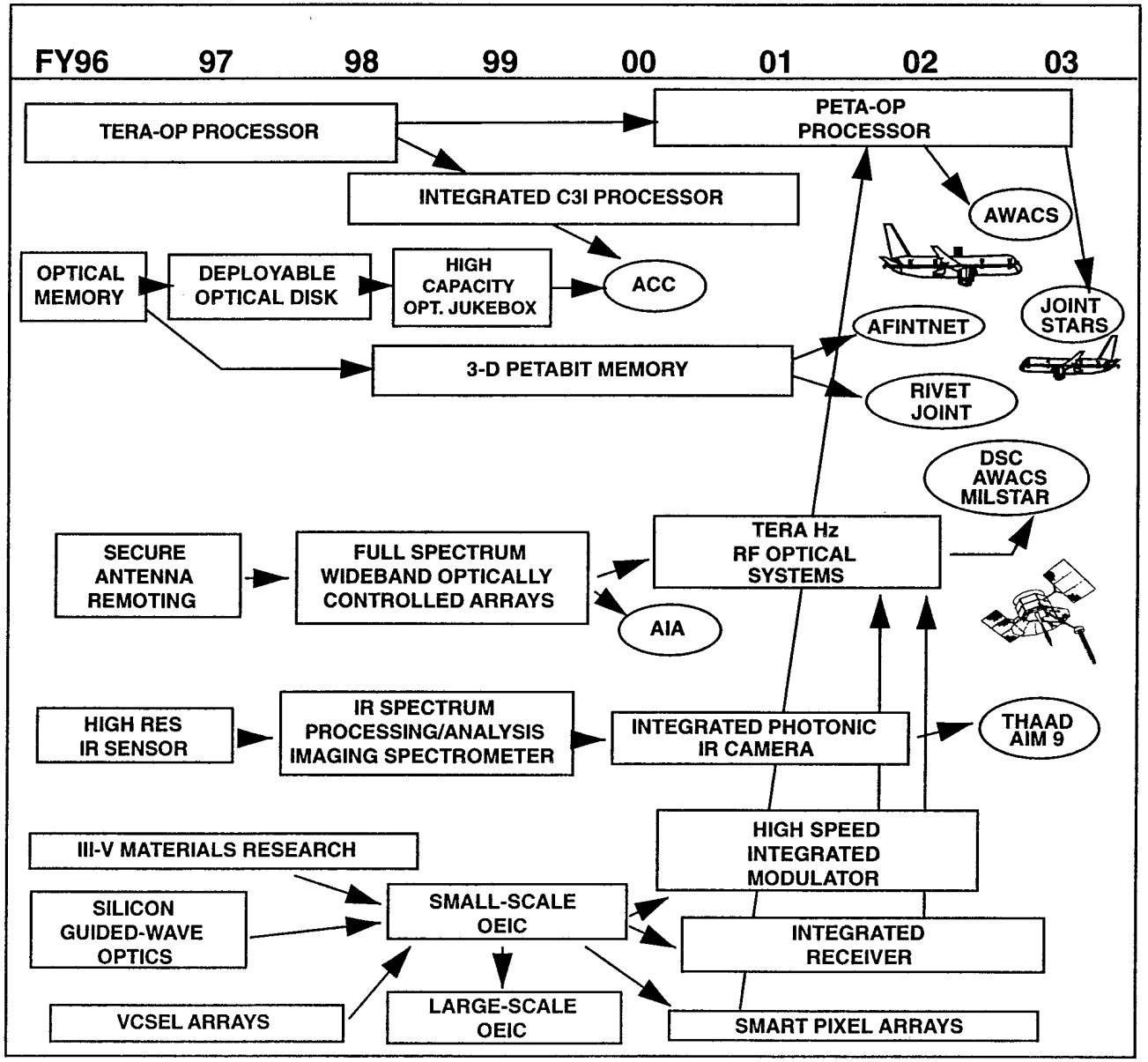
Goals

- High capacity/rapid access memory (one thousand trillion bits with nano second access).
- Full spectrum infrared sensor systems.
- Photonics-based RF systems.
- Wideband/multi-frequency/multi-beam antenna systems.
- High speed/high performance compact signal processors.
- Integratable opto-electronic devices.

Major Accomplishments

- Successful delivery and integration of the 120 Gigabyte Erasable, Deployable Optical Disk Jukebox to HQ AFSOC for mission planner.
- Pre-brassboard 3D memory completed.
- High dynamic range millimeterwave interconnect system demonstrated.
- Monolithic semiconductor ring laser for high quality RF-photonic systems fabricated.
- First room temperature operation of InP Vertical Cavity Surface Emitting Laser (VCSEL) at 1.55 micrometers.
- Demonstrated holographic image demultiplexing with up to 16,000 separate channels.
- Demonstrated a traveling wave photodetector with bandwidth efficiency product of 76 GHz.
- High resolution/low loss true time delay at arbitrary radio frequency carrier was demonstrated.
- Successful field demonstration of an optical 2-18 GHz antenna remoting system.
- Demonstration of a high optical power handling photodetector (20 mW at 20 GHz).
- High resolution/low loss true time delay at arbitrary radio frequency carrier was demonstrated.
- Successful field demonstration of an optical 2-18 GHz antenna remoting system.
- Demonstration of a high optical power handling photodetector (20mW at 20 GHz).
- Demonstrated growth and poling of single-crystal films of barium titanate on strontium titanate and lithium aluminate substrates for optical modulation and switching.
- Developed a secure optical personnel-entry biometric identification system based on phase-only optical correlation.

PHOTONICS


KEY ACTIVITIES
OPTICAL PROCESSING
MEMORY
MW / MMW PHOTONIC PROCESSING
OPTICAL SENSORS
PHOTONIC DEVICES AND MATERIALS
FY96
97
98
99
00
01
02
03
TERA-OP PROCESSOR
PETA-OP PROCESSOR
INTEGRATED C3I PROCESSOR
AWACS
OPTICAL MEMORY
DEPLOYABLE OPTICAL DISK
HIGH CAPACITY OPT. JUKEBOX
ACC
JOINT STARS
AFINTNET
3-D PETABIT MEMORY
RIVET JOINT
DSC
AWACS
MILSTAR
SECURE ANTENNA REMOTING
FULL SPECTRUM WIDEBAND OPTICALLY CONTROLLED ARRAYS
TERA Hz RF OPTICAL SYSTEMS
AIA
HIGH RES IR SENSOR
IR SPECTRUM PROCESSING/ANALYSIS IMAGING SPECTROMETER
INTEGRATED PHOTONIC IR CAMERA
THAAD
AIM 9
III-V MATERIALS RESEARCH
HIGH SPEED INTEGRATED MODULATOR
SILICON GUIDED-WAVE OPTICS
SMALL-SCALE OEIC
INTEGRATED RECEIVER
VCSEL ARRAYS
LARGE-SCALE OEIC
SMART PIXEL ARRAYS

- Demonstrated high-performance metal semiconductor metal photo-detectors on indium gallium arsenide using substrate removal and backside illumination.
- Designed a unipolar silicon/zinc selenide quantum-well intersubband laser for use as an integrated optical source.
- Demonstrated the feasibility of multiplexing up to 40 color bands in an IR multispectral imaging sysytem for spectral feature extraction.
- Developed the first bismuth silicate crystal with controlled photorefractive characteristics for optical processing applications using a unique hydrothermal growth technique.
- Developed the first detailed model of optical two-wave mixing gain in semi-insulating indium phosphide.
- Invented a new method for measuring thickness and composition of thin semiconductor films to within 0.5% across the wafer.

Changes From Last Year

No changes from last year have impacted the Photonics Thrust.

Milestones

1997:

- Begin development for an optically controlled phased array ATD aimed at EHF airborne and spaceborne applications.
- Demonstrate brassboard integrated C^4I optical processor ATD emphasizing the utilization of optical interconnects and rapid access optical memory for near real-time interactive processing of sensor (active/passive), intelligence and imaging systems.
- Initiate a comprehensive RF signal distribution system ATD for secure remoting for all radio frequencies up to 100 GHz.
- Demonstrate a LWIR photoemissive IR sensor.
- Develop a fully-packaged directly-modulated 25 GHz laser for analog fiber optic communications at 1.3 μm wavelength. The lasr diode is a strained multiquantum-well device engineered for high-efficiency and low-cost.
- Complete studies of the optical and physical deficiencies related to wide-bandgap (GaN) emitters and detectors.

1998:

- Complete development of a three-dimensional write once read many times (WORM) optical memory system ATD.
- A high capacity Terabyte Erasable Optical Disk Jukebox ATD will be integrated at the 480IG, ACC for AFINT-NET applications.
- An experiment to demonstrate optically controlled phased arrays for airborne application at SHF for the Defense Satellite Communications System (DSCS) will be demonstrated.
- Integrate with MWIR PtSi sensor for dual-band imaging.
- Demonstrate the application of epitaxial transfer integration (ETI) to development of functional hybrid III-V optoelectronic integrated circuits on ceramic, organic and semiconductor substrates.
- Demonstrate ultra high-fluence and ultra low-fluence optical detectors using bandgap engineered structures with advanced surface passivation technology at 1.3-1.5 μm.
- Develop a high performance silicon/indium gallim arsenide separate absorption and multiplication avalanche photodiode using semiconductor fusion technology.

1999:

- Develop an erasable 3D memory system ATD.
- Demonstrate fully integrated infrared optical processor that can be resolved into color imagery.
- Develop a packaged high-speed vertical cavity surface-emitting laser for room-temperature, continuous-wave operation at 1.3-1.5 μm wavelength.

THRUST

RELIABILITY SCIENCES

USER NEEDS

The basic objective of the Reliability Sciences Thrust is to ensure that Air Force/DoD electronic systems perform their specified mission in diverse military environments. This research includes technology areas that stress development and use of tools and techniques such as: modeling and simulation, materials and process characterization, operational assessments, failure modes and effects assessment, and correction. This technology thrust is utilized by both the commercial and industrial base in the design, development, production and maintenance of cost-effective, reliable systems that meet customer needs. The Reliability Sciences Thrust provides major technical support to the Air Force Core Competencies of emphasis such as: Air/Space Superiority, Information Dominance and Precision Deployment. Reliability and Diagnostics technology is central to the Air Force core competencies in the areas of Readiness, Sustainment and Logistics.

This program contributes to the DoD science and technology strategic thrusts including the Global Surveillance and Communications thrust, the Precision Strike thrust, the Technology for Affordability thrust, and the Air Superiority & Defense thrust. Special emphasis is placed on supporting the following Defense Technology Objectives: Affordable Multichip Modules for Phased Array Antennas, Integrated Design Environment Technology, Electronic Module and Packaging Technology and High Performance Microelectronics for Signal Processing and Computing. All of these topics are covered by the Electronics portion of the Defense Technical Area Plan. The following validated MAJCOM requirements span all mission areas in this thrust:

- Reliable satellite communication (**AFSPACECOM**).
- Simple automatic testing and diagnostics (**AFSPACECOM**).
- Improved test and fault isolation capabilities for increased system availability and efficient maintenance (**ACC**).
- Reduced risk from part obsolescence and diminishing manufacturing sources (**ACC**).
- Improved reliability and deployability (**ACC**).
- Monitor environmental conditions impacting electronic systems (**ACC**).

ESC validated technology needs encompass major Reliability Sciences program outputs such as: integrated diagnostics technology; reliable traveling wave tubes; advanced electronics systems environmental stress sensing technologies; electromagnetic environmental effects (E3) modeling and analysis tools; and tools for translating operational requirements into performance based diagnostics/reliability, maintainability and logistics requirements which meet the goals of current acquisition reform directives. Additional Reliability Sciences thrust user needs are documented in **DoD Advisory Group on Electron Devices (AGED) Special Technology Area Reviews; Electronics Defense Technology Area Plan; and AFMC TPIPT Technology Needs.**

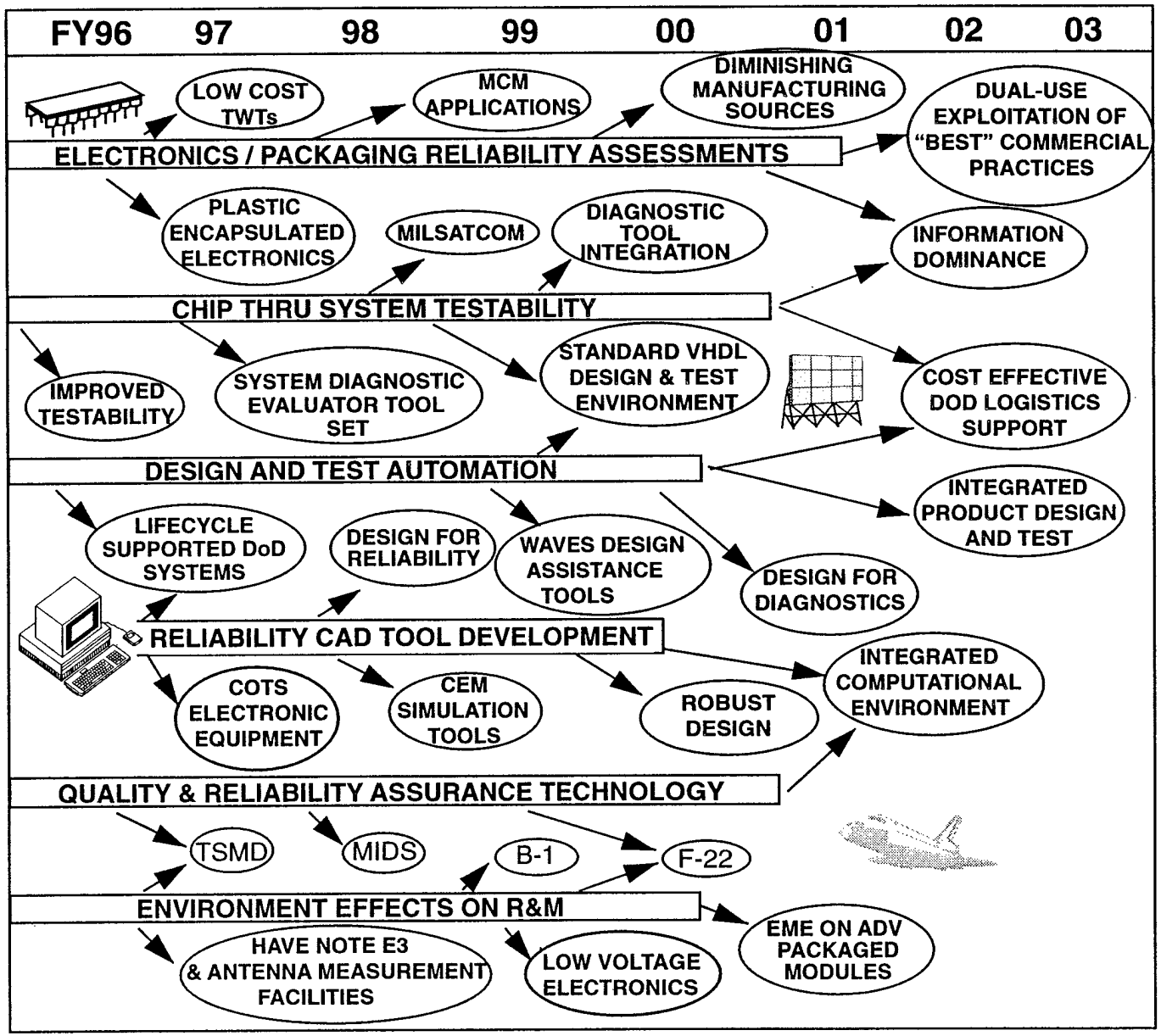
GOALS

- Achieve an order of magnitude increase in mean time between maintenance actions and a factor of four or greater decrease in support costs attributed to external test equipment, personnel, and training.
- Develop design tools and test methodologies to incorporate reliability technologies at the earliest stages of design and development for new and upgraded systems.
- Assess device and system failure modes/mechanisms and operational environmental factors to determine the stresses imposed on devices and systems, and translate this information into affordable robust system and component designs.
- Develop efficient diagnostic methodologies to reduce, by 10 fold, the high levels of unnecessary maintenance actions and to allow for on-equipment fault detection/isolation.
- Achieve increased electronics reliability and performance through identification and reduction of the effects of electromagnetic environment (EME) exposure.
- Develop tools and technologies for the successful integration of Commercial-Off-The-Shelf (COTS) components and equipment into diverse military applications.
- Investigate application of R&M techniques and tools for assessing failure points/weaknesses/vulnerabilities exploitable for information dominance purposes in C^4I designs.

MAJOR ACCOMPLISHMENTS

- Development of an X-windows-based tool to automatically generate complete WAVES-VHDL testbenches for complex component, board and system circuit designs. This tool provides a complete test set for verifying complex digital circuit designs and automatically generates IEEE compliant WAVES and VHDL source code. This tact significantly improves digital electronics life-cycle support capabilities by automating and more tightly integrating design and test activities. It is being utilized by

RELIABILITY SCIENCES



the ARPA sponsored Rapid Prototyping of Application Specific Signal Processors (RASSP) demonstration as an affordable design for test methodology.

- Identified a potential failure mechanism due to moisture in optoelectronic devices and developed a strategy which will yield more reliable and environmentally hardened devices to extend their survival range in high temperature/humidity environments.
- Published the Reliability Engineers Toolkit — Best Commercial Practices edition. It incorporated many significant revisions especially those relating to the use of commercial-off-the-shelf (COTS) parts and designs, as well as non-traditional design practices that are common in the commercial world. This has become a critical aspect for many new acquisitions as a result of the June 1994 SecDef Perry memorandum on this issue.
- Developed an Avionics Test Bed to evaluate the Communication, Navigation, Identification and Electronic Warfare Apertures on the F-22. Precision antenna and calibration pattern measurements were conducted to evaluate the effects of the airframe and its moveable surfaces on system performance. Actual F-22 installed antenna aperture performance data will be made available to the SPO well in advance of any production decisions. This program will take advantage of the newly developed advanced measurement system which increases measurement capabilities by a factor of 100, without sacrificing any data accuracy or quality.
- Nineteen months of B-1B flight data, representing a comprehensive database of environmental and operational stress data were collected from operational aircraft at Dyess AFB, TX and Edwards AFB, CA using the Time Stress Measurement Device (TSMD). The TSMDs monitored and recorded Built-in-Test (BIT) detected events and environmental data before, during and after the event. The date shows incidences of power and voltage transients, denial of proper cooling air and other effects detrimental to the avionics.
- Defined a preliminary approach for automatic redesign of Sequential CMOS Microcircuits to manage the susceptibility to hot electron degradation. This approach was implemented in a brassboard software tool and was used to evaluate Field Programmable Gate Array (FPGA) circuits.

Changes From Last Year

The HAVE NOTE Electromagnetic Environmental Effects and the Rome Laboratory Antenna Measurements Facilities were transferred from AFMC/DO EW facility capability funding to PE62702F in a zero budget transfer. Rome Laboratory was directed to provide start-up funds for these activities and to become customer reimbursed for these activities in future years. Funding reductions in PE62702F have resulted in no new contractual starts in FY 96.

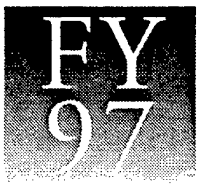
Milestones

1997:

- Develop the requirements and architecture necessary to develop a System Diagnostic Evaluator tool or tool set to support efficient diagnostic design process trade-offs and provide cost-effective means for evaluating the diagnostic performance of electronic systems.
- Develop a software tool set that will provide fault injection, fault simulation, and test generation within an industry standard VHDL design and test environment.
- Develop a cost/performance based tool for use in assessing the suitability of commercial-off-the-shelf electronic equipment for use in diverse military operational environments.
- Develop Advanced Computational Electromagnetics (CEM) simulation tools for analyzing the performance of complex antennas/arrays while mounted on their operational platforms.
- Develop and validate of low cost Traveling Wave Tubes (TWTs) for DoD Applications.
- Complete performance assessment of low voltage electronics in diverse commercial and military environments.

1998:

- Develop an Automated Design Environment for Reliability Trade-off assessments and robust implementations.



GLOSSARY

3D: *Three Dimensional*
ACC: *Air Combat Command*
ACCINTNET: *ACC Intelligence Network*
ADM: *Advanced Development Model*
AF: *Air Force*
AFAE: *AF Acquisition Executive*
AFGIHS: *AF Geographic Information Handling System*
AFMC: *Air Force Material Command*
AFOSR: *Air Force Office of Scientific Research*
AHDL: *Analog Hardware Descriptive Language*
AI: *Artificial Intelligence*
AIA: *Air Intelligence Agency*
AJ: *anti-jam*
ALC: *Air Logistics Center*
AMC: *Air Mobility Command*
AOC: *Air Operations Center*
APS: *Advanced Planning System*
ARO: *Army Research Office*
ARPA: *Advanced Research Project Agency*
ASARS: *Advanced Synthetic Aperature Radar System*
ASIC: *Application Specific Integrated Circuit*
ATAF: *Allied Tactical Air Forces*
ATD: *Advanced Technology Demonstration*
ATM: *Asynchronous Transfer Mode*
ATO: *Air Tasking Order*
ATR: *Automatic Target Recognition*
ATS: *Automatic Test System*
AWACS: *Airborne Warning and Control System*
BEA: *Budget Estimate Agreement*
BM: *Battle Management*
C^2: *Command and Control*
C^3: *Command, Control, and Communications*
C^4I: *Command, Control, Communications, Computers and Intelligence*
CAD: *Computer Aided Design*
CASE: *Computer Aided Software Engineering*
CCD: *Charge Coupled Device*
CECOM: *Communications and Electronic Command*
CINCNORAD: *Commander and Chief NORAD*
CJTF: *Commander Joint Task Force*
CONOPS: *Concept of Operations*
COTS: *Commercial Off The Shelf*
CRDA: *Cooperative Research and Development Agreements*
CTAPS: *Contingency Tactical Air Combat System Automated Planning System*
DAMA: *Demand Assigned Multiple Access*
DARO: *Defense Airborne Reconnaissance Office*
DAWS: *Defense Automated Warning System*
DDR&E: *Department of Defense Research and Engineering*
DEA: *Data Exchange Agreement*
DIA: *Defense Intelligence Agency*
DISA: *Defense Information Systems Agency*
DISN: *Defense Information Services Network*
DMA: *Defense Mapping Agency*
DoD: *Department of Defense*
DoDIIS: *Defense Intelligence Information System*
DSCS: *Defense Satellite Communications System*
ECRS: *East Coast Radar System*
EHF: *Extremely High Frequency*
ELINT: *Electronics Intelligence*
EM: *electromagnetic*
EP: *Education Partnership*
ESC: *Electronic Systems Center*
EW: *Electronic Warfare*
FAA: *Federal Aviation Administration*
FBI: *Federal Bureau of Investigation*
FDDI: *fiber distributed data interface*
FLEX: *Force Level Execution*
FY: *fiscal year*
GaAs: *Gallium Arsenide*
GHz: *GigaHertz*
GOSG: *General Officers Steering Group*
HEMT: *High Electron Mobility Transistor*
HF: *high frequency*
ICTP: *Information Collection, Transfer & Processing*
IDHS: *Intelligence Data Handling Systems*
INFOSEC: *Information Security*
InP: *indium phosphide*
IR: *infrared*
IR&D: *Independent Research and Development*
JDL: *Joint Directors of Laboratories*
JFACC: *Joint Force Air Component Commander*
JPL: *Jet Propulson Labs*
JSTARS: *Joint Surveillance Targeting and Reconnaissance*
JWID94: *Joint Warrior Interoperability Demonstration*
km: *kilometer*
LAN: *local area network*
LO: *low observable*
LPI: *Low Probability of Intercept*
MAJCOM: *Major Commands*
MAP: *Mission Area Plan*
MCM: *Multichip Module*
MILSATCOM: *Military Satellite Communications*
MIMIC: *Monolithic Microwave and Millimeter Wave Integrated Circuits*
MLV: *Medium Launch Vehicle*
MMIC: *Monolithic Microwave Integrated Circuit*
MOA: *Memorandum of Agreement*
MOU: *Memorandum of Understanding*
NAIC: *National Air Intelligence Center*
NASA: *National Aeronautics and Space Administration*
NATO: *North Atlantic Treaty Organization*
NORAD: *Northern Region Air Defense*
NRaD: *Naval Research and Development*
NRL: *Naval Research Lab*
NSA: *National Security Agency*

NTSB: *National Transportation & Safety Board*
NUWC: *Naval Undersurface Weapons Center*
NYNET: *New York Network*
NYNEX: *New York New England Exchange*
ONR: *Office Naval Research*
OSINT: *Open Source Intelligence*
OTH: *Over-The-Horizon*
P^3I: *Pre-Planned Product Improvements*
PACAF: *Pacific Air Force*
PAWS: *Parallel Assessment Window System*
PL: *Phillips Laboratory*
PSIDS: *Prototype Secondary Information Dissemination System*
PtSi: *Platinum Silicide*
QML: *Qualified Manufacturers List*
QPL: *Qualified Products List*
R&D: *Research & Development*
R&M: *Reliability and Maintainability*
RAAP: *Rapid Application of Air Power*
RCS: *Radar Cross-Section*
RL: *Rome Laboratory*
RTOK: *Retest OK*
S&T: *Science and Technology*
SAR: *Synthetic Aperature Radar*
S/TODS: *Strategic/Tactical Optical Disk System*
SATCOM: *Satellite Communications*
SBIR: *Small Business Innovative Research*
SHF: *Super High Frequency*
SIGINT: *Signals Intelligence*
SLCS: *Software Life Cycle Support*
SLCSE: *Software Life Cycle Support Environment*
SOCOM: *Special Operations Command*
SOF: *Special Operations Forces*
SONET: *Synchronous Optical Network*
SPACECOM: *Space Command*
SPAWAR: *Space & Naval Warfare System Command*
STARS: *Software Technology for Adaptable Reliable Systems*
STIG: *Space Technology Interdependency Group*
STRAMST: *S&T Reliance Assessment for Modeling and Simulation Technology*
STRATCOM: *Strategic Command*
TACC: *Tactical Air Control Center*
TACOM: *Tank and Automotive Command*
TAP: *Technology Area Plan*
TAS: *Timeline Analysis System*
TASE: *Thrust Assessment Support Environment*
TBM: *Theater Battle Management*
TCC: *Technology Coordination Committee*
TCT: *Time Critical Targets*
TDC: *Theater Deployable Communications*
TDPA: *Tactical Deception Planning Aid*
TENet: *Theater Extension Network*
TEO: *Technology Executive Officer*
THAAD: *Theater High Attitude Area Defense*
TMD: *Theater Missile Defense*
TPC^3: *Technology Panel on C^3*
TRANSEC: *Transmission Security*
Tri-TAC: *Tri-Service Tactical Communications*
TRP: *Technology Reinvestment Program*
TSMD: *Time Stress Measurement Device*
UAV: *Unmanned Aerial Vehicle*
UHF: *Ultra High Frequency*
ULPI: *Unit Level Prototype Implementation*
USACOM: *US Army Command*
USAF: *United States Air Force*
USAFE: *United States Air Force in Europe*
USSOUTHCOM: *US Southern Command*
VHF: *Very High Frequency*
VHSIC: *Very High Speed Integrated Circuit*
VLF: *Very Low Frequency*
WATCHCONS: *Watch Conditions*
WL: *Wright Laboratory*
XIDB: *eXtended Integrated Data Base*

INDEX

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TECHNOLOGY MASTER PROCESS OVERVIEW

Part of the Air Force Materiel Command's (AFMC) mission deals with maintaining technological superiority for the United States Air Force by:

- Discovering and developing leading edge technologies
- Transitioning mature technologies to system developers and maintainers
- Inserting fully developed technologies into our weapon systems and supporting infrastructure, and
- Transferring dual-use technologies to improve economic competitiveness

To ensure this mission is effectively accomplished in a disciplined, structured manner, AFMC has implemented the **Technology Master Process** (TMP). The TMP is AFMC's vehicle for planning and executing an end-to-end technology program on an annual basis.

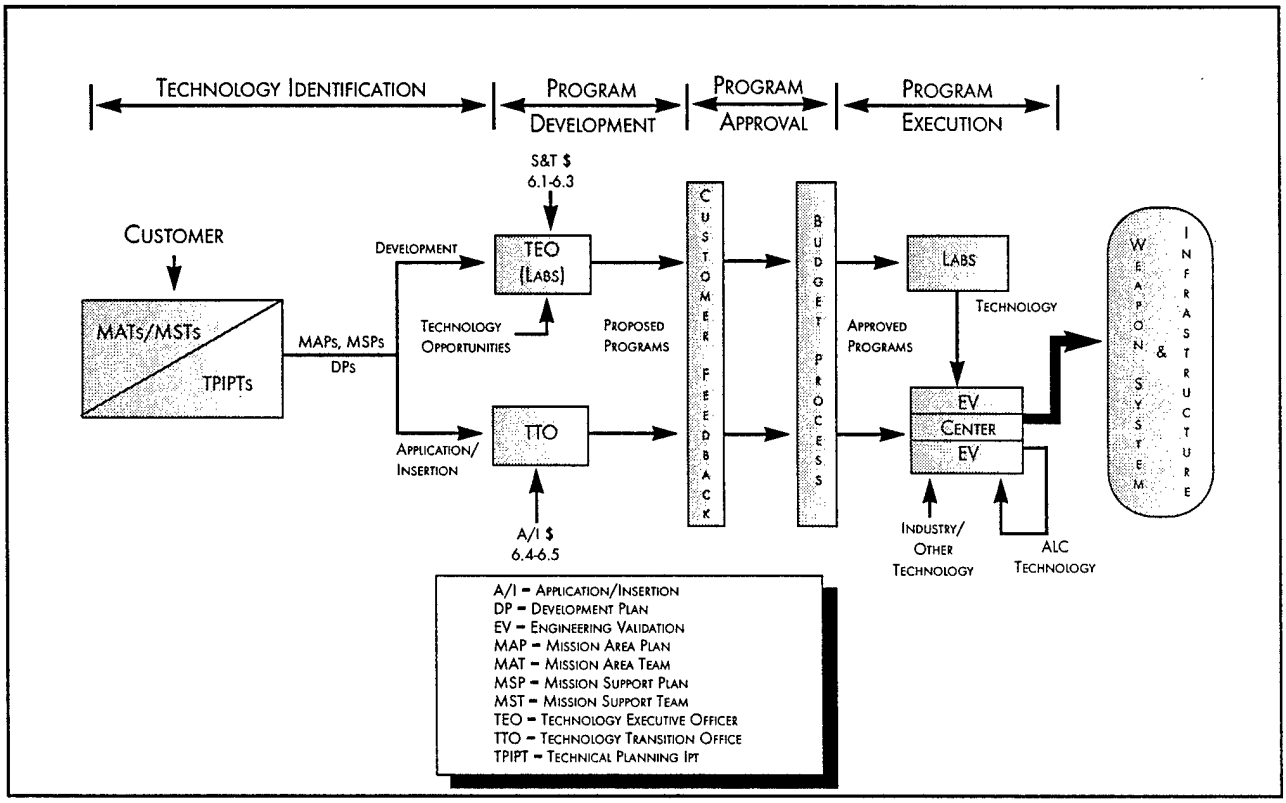

Figure 1. *Technology Master Process*

The TMP has four distinct phases, as shown in Figure 1:

- Phase 1, **Technology Needs Identification** — Collects customer-provided and customer-prioritized technology needs associated with both weapon systems, product groups and supporting infrastructure; then identify them by the need to develop new technology or apply/insert emerging or existing technology. These needs are derived in a strategies-to-task framework via the user-driven Modernization Planning Process.

- Phase 2, **Program Development** — Formulates a portfolio of dollar constrained projects to meet customer-identified needs from Phase 1. The Technology Executive Officer (TEO), with the laboratories, develops a set of projects for those needs requiring development of new technology, while the Technology Transition Office (TTO) orchestrates the development of a project portfolio for those needs which can be met by the application/insertion of emerging or existing technology.

- Phase 3, **Program Approval** — Reviews the proposed project portfolio with the customer and obtains approval for the portfolio through the budgeting process. The output of Phase 3 is the authorizations and appropriations required, by the laboratories and application/insertion programs, to execute their technology projects

- Phase 4, **Program Execution** — Executes the approved S&T program and technology application/insertion program within the constraints of the Congressional budget and budget direction from higher headquarters. The products of Phase 4 are validated technologies that satisfy customer weapon system and infrastructure deficiencies.

Additional Information

Additional information on the Technology Master Process is available from HQ AFMC/STR, DSN 787-6777/8764, (513) 257-6777/8764.