RADC-TR-86-245

DECEMBER 1986

TOD 86-11

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ROME AIR DEVELOPMENT CENTER
AIR FORCE
TECHNICAL OBJECTIVE DOCUMENT

FY – 88

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AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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PUBLISHED BY: John A. Betz

Rome Air Development Center/XP
Griffiss Air Force Base, New York 13441-5700

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS N/A
2a. SECURITY CLASSIFICATION AUTHORITY N/A 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE N/A	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited
4. PERFORMING ORGANIZATION REPORT NUMBER(S) RADC-TR-86-245	5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A
6a. NAME OF PERFORMING ORGANIZATION Rome Air Development Center 6b. OFFICE SYMBOL (If applicable) XP	7a. NAME OF MONITORING ORGANIZATION N/A
6c. ADDRESS (City, State, and ZIP Code) Griffiss AFB NY 13441-5700	7b. ADDRESS (City, State, and ZIP Code) N/A
8a. NAME OF FUNDING / SPONSORING ORGANIZATION Rome Air Development Center 8b. OFFICE SYMBOL (If applicable) XP	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A
8c. ADDRESS (City, State, and ZIP Code) Griffiss AFB NY 13441-5700	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 62702F PROJECT NO. 06RA TASK NO. PL WORK UNIT ACCESSION NO. AN

11. TITLE (Include Security Classification)
ROME AIR DEVELOPMENT CENTER AIR FORCE TECHNICAL OBJECTIVE DOCUMENT FY88 TOD 86-11

12. PERSONAL AUTHOR(S)
Dr. Carlo P. Crocetti (Ed) et al

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
In-House	FROM FY88 TO FY92	December 1986	72

16. SUPPLEMENTARY NOTATION
N/A

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Command and Control; Intelligence
09			Communications; Information Sciences (Cont'd on reverse)
15			

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This TOD describes the technical programs of the Rome Air Development Center in support of the Air Force Command, Control, Communications, and Intelligence (C^3I) mission. The technical objectives have been aligned with the VANGUARD mission areas of Command, Control, and Communications (C^3), Reconnaissance and Intelligence, Strategic Systems (Defense) and Technology as a means of focusing the RADC support of VANGUARD. This document is prepared to provide industry and universities with the midterm technical objectives in these areas.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. Carlo P. Crocetti (Ed)	22b. TELEPHONE (Include Area Code) (315) 330-7052 22c. OFFICE SYMBOL RADC (XP)

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

Block 17. COSATE CODES (Continued)

Field
17
20

Block 18. SUBJECT TERMS (Continued)

Surveillance	Communications Security
Solid State Sciences	Reliability
Electromagnetics	Compatibility

This report has been reviewed by the RADC Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

RADC-TR-86-245 has been reviewed and is approved for publication.

APPROVED:

FOR THE COMMANDER

CARLO P. CROCETTI
Director of Plans & Programs

Accesion For		
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Availability Codes		
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INTRODUCTION

The Air Force Technical Objective Document (TOD) program is an integral part of the process by which the Air Force plans and formulates a detailed technology program to support the development and acquisition of Air Force weapon systems. Each Air Force laboratory annually prepares a Research and Technology (R&T) Plan in response to available guidance based on USAF requirements, the identification of scientific and technological opportunities, and the needs of present and projected systems. These plans include proposed efforts to achieve desired capabilities, to resolve known technical problems, and to capitalize on new technical opportunities. The proposed efforts undergo a lengthy program formulation and review process. Generally, the criteria applied during the formulation and review are responsiveness to stated objectives and known requirements, scientific content and merit, program balance, developmental and life cycle costs, and consideration of payoff versus risk.

It is fully recognized that the development and accomplishment of the Air Force technical program is a product of the teamwork on the part of the Air Force laboratories, the industrial and academic research and development community. The TOD program is designed to provide to the industry and academic community, necessary information on the Air Force laboratories' planned technology programs. Each laboratory's TOD is extracted from its R&T Plan.

Specific objectives are:

a. To provide planning information for independent research and development programs.

b. To improve the quality of the unsolicited proposals and R&D procurements.

c. To encourage face-to-face discussions between non-Government scientists and engineers and their Air Force counterparts.

One or more TODs have been prepared by each Air Force laboratory that has responsibility for a portion of the Air Force Technical Programs. Classified TODs are available from the Defense Technical Information Center (DTIC) and unclassified/unlimited TODs are available from the National Technical Information Service (NTIS).

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the scientist or engineer identified with that objective. Further, you may have completely new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the United States Air Force, you are invited to study the objectives listed in this document and to discuss them with the responsible Air Force personnel. Your ideas and proposals, whether in response to the TODs or not, are most welcome.

HOW TO USE THIS DOCUMENT

Unsolicited proposals to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After your discussion or correspondence with the laboratory personnel, you will be better prepared to write your proposal.

As stated in the "AFSC Guide for Unsolicited Proposals" (copies of this informative guide on unsolicited proposals are available by writing to Air Force Systems Command/PMPR, Andrews Air Force Base, Washington, DC 20334), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your letter be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.

2. Type of Organization (Profit, Nonprofit).

3. Concise title and abstract of the proposed research and the statement indicating that the submission is an unsolicited proposal.

4. An outline and discussion of the purpose of the research, the method of attack upon the problem, and the nature of the expected results.

5. Name and research experience of the principal investigator.

6. A suggestion as to the proposed starting and completion dates.

7. An outline of the proposed budget, including information on equipment, facility, and personnel requirements.

8. Names of any other Federal agencies receiving the proposal (this is extremely important).

9. Brief description of your facilities, particularly those which would be used in your proposed research effort.

10. Brief outline of your previous work and experience in the field.

11. If available, you should include a description brochure and a financial statement.

CENTER MISSION

RADC plans and executes research, exploratory, and advanced development and selected acquisition programs in support of Air Force Command, Control, Communications and Intelligence (C3I). Technical support is provided to technology intensive C3I programs at the AFSC Product Divisions and other Air Force and DOD agencies. The principal technical areas are communications, intelligence and reconnaissance, surveillance, command and control, electromagnetic sciences, solid state sciences, and electronic reliability, maintainability, and compatibility.

RADC is the AF laboratory responsible for the development of a strong technology base in support of AF C3I. RADC has facilities and resources to accomplish its mission at Griffiss AFB New York and at Hanscom AFB Massachusetts. An establishment directly subordinate to the Electronic Systems Division (ESD), RADC reports directly through its Commander, RADC/CC to the Commander, ESD/CC for mission accomplishment.

The major responsibilities are to plan and manage comprehensive research, exploratory development, and advanced development programs in C3I technical areas consistent with the overall C3I technology needs of the AF and to promote the transition and application of technology in conjunction with AFSC system acquisition divisions and other using commands/agencies.

The former responsibility is accomplished through the establishment and maintenance of competent and comprehensive in-house capabilities and through contractual support. The latter is accomplished by providing technical expertise, consultation services and management support to AFSC system acquisition divisions, primarily ESD, test centers and ranges and other AF and DOD agencies as appropriate in regard to studies, analyses, development planning activities, acquisition, test, evaluation, modification, and operation of C3I systems and related equipment.

INVESTMENT STRATEGY

The Laboratory is engaged in providing technical solutions to the Air Force needs for improved Command, Control, Communications and Intelligence. The work has traditionally been organized to conform, where possible, with the AF mission areas of Strategic Offense, Strategic Defense, C3, Recce/Intel and Technology. Within these categories there are some 67 technical areas as shown on the Technical Planning Objectives listing (Table 1). The investment strategy is developed using these 67 areas.

The resources that the Center controls (and have long term effect) are the placement of manpower, the Exploratory Development (6.2) and to a more limited extent, Advanced Technology Development (6.3) dollars. The Center has developed an Investment Strategy for these resources.

In evolving this strategy, a process was developed to:

1. Re-examine the requirements - from all sources with VANGUARD being a major one.

2. List other special interest areas - there are some areas that are directed upon the Center

3. Through a "delphi" process with the Center senior managers, develop a "puts and takes" list for manpower and 6.2 dollars.

4. Examine the effects of the "puts and takes" on the Center as a whole.

It is in this way, that the Center has developed the list of programs for emphasis and de-emphasis.

The sum of the gains when viewed together, show that new areas of emphasis include Project Forecast II, Air Defense Initiative (ADI) and Strategic Defense Initiative (SDI).

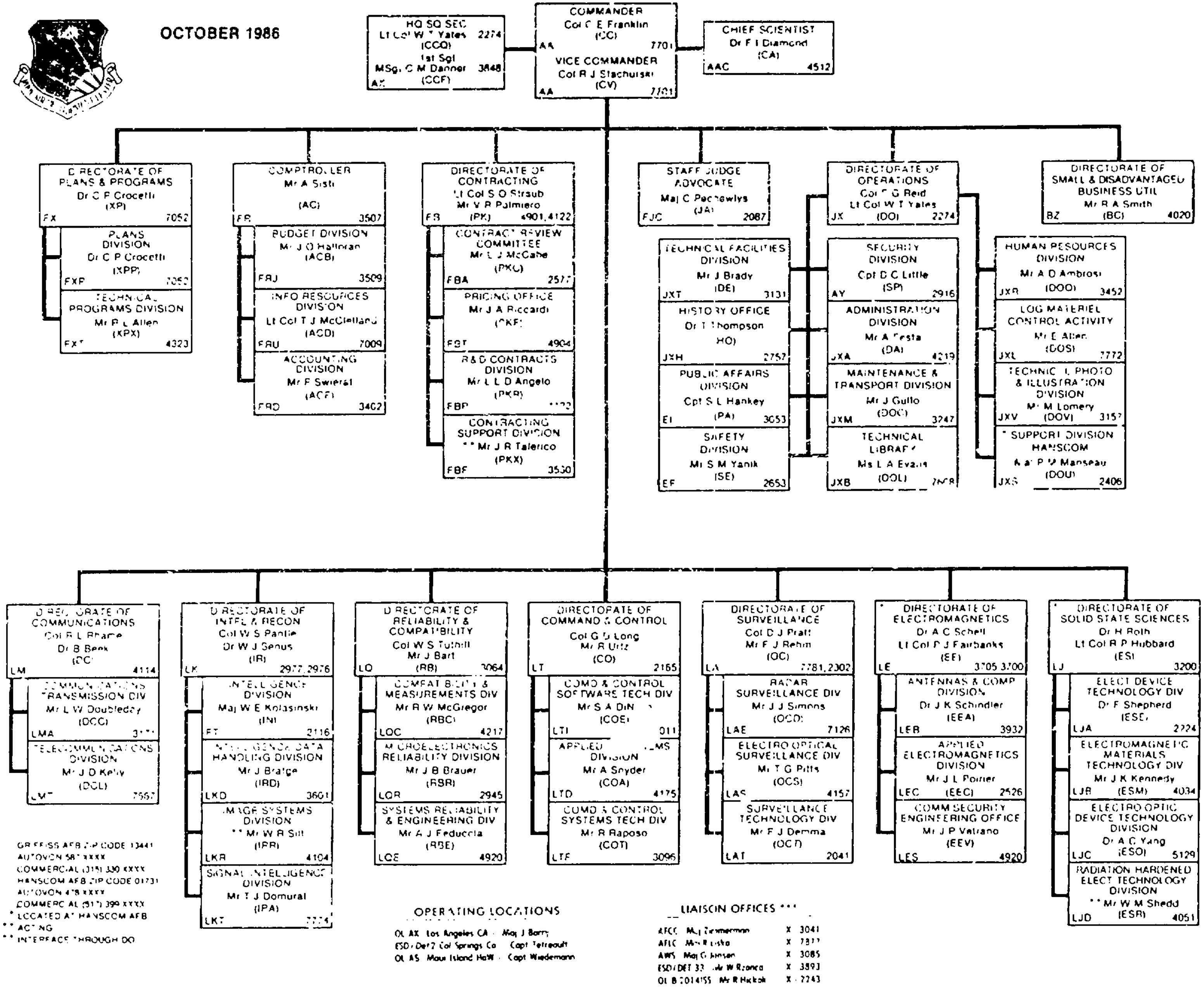
Project Forecast II, an AFSC effort to identify the most promising military technologies for the next twenty years, has yielded ideas that are expected to revolutionize C3I technology. Project Forecast II technologies for which RADC is OPR include areas such as Photonics, Acoustic Charge Transport Devices, Knowledged-Based Systems, Survivable Communications, Smart Built-In-Test, Distributed Information Processing Software, and Smart Skins for C3I Applications. These capabilities manifest themselves in RADC OPR Project Forecast II System Concepts such as Airborne Surveillance System, Theatre Air Warfare C3I and Battle Management Processing and Display System. RADC has directed approximately 69 percent of the RADC managed FY87 budget to kick off development of various Project Forecast II System Concepts and Technologies. This percentage is expected to grow even larger in the future.

A continuing important area of emphasis at RADC is (SDI). RADC is one of the lead AF organizations supporting SDI. RADC is involved in various technologies under the program elements of Surveillance, Acquisition, Tracking, and Kill Assessment (SATKA), Directed Energy Weapons (DEW) and Battle Management (BM/C3). Technology areas being addressed include space based large array radars, signal processing, large optics, adapative optics, IR focal planes, monolithic microwave integrated circuits, radiation hardening, software, artifical intelligence, distributed processing, communications, computer security and I&W. The SDI funds being expended in these areas will also have a definite impact in extending the state-of-the-art of technology for applications to C3I in general. RADC will continue to support this national initiative within the C3I mission areas throughout its program development.

Another important area of emphasis, which is complimentary to SDI, is ADI. The objective of this program is to develop the enabling technologies to support detection/track identification/engagement of air breathing threats to the Continental US. These enabling technologies are required to arrive at informed Full Scale Development and P3I decisions in the early-to-mid 1990s for air defense hardware acquisition programs. RADC is the lead Air Force laboratory in the areas of surveillance and Battle Management/C3. The technology areas being addressed by RADC include airborne radar, multistatics, space based radar, signal processing, multi-media communications networks, intel-radar data fusion, decision support processing, distributed information processing, and deception and countermeasures.

ROME AIR DEVELOPMENT CENTER

OCTOBER 1986



RESEARCH PROGRAMS

The research program of the Rome Air Development Center is designed to provide a sound scientific basis for exploratory and advanced development programs in support of the Air Force's C3I mission. Further, the research programs are selected in order to match the Center's long range needs and to spark innovative exploratory development to provide the basis for future military systems.

Generally, the laboratory's research requirements, reflected in the AFSC Research Planning Guide, are an outgrowth of deficiencies in the laboratory's technology base. The research program which addresses these deficiencies integrates into the total laboratory program through association with the Center's Technology TPO (TPO-4) where the research program is depicted as an integral part of the technology roadmaps of TPO-4. By this technique, the identity of research supporting technology is clearly established.

The major thrusts of the research program, directed toward supporting the C3I technology base of the Center, are concentrated in electromagnetic and solid state sciences but also directly address the areas of signal processing, computer processing, device reliability, and thermionics. Specifically, the major thrusts of the research program follow:

Artificial Intelligence (AI) (University Consortium) Research Program (2304J5) - Artificial Intelligence technology is rapidly being recognized as having the potential to provide more responsive and flexible C3I systems. The availability of high quality AI capabilities is presently manpower limited and localized in primarily three geographic areas of the country, Palo Alto, Cambridge, and Pittsburgh. This effort was initiated as a cooperative, integrated program among the Command & Control Directorate, Intelligence & Reconaissance Directorate, Reliability & Compatibility Directorate and the Communications Directorate to strengthen the artificial intelligence technology base at RADC and accelerate application of the technology in C3I systems.

This effort has established a consortium of universities that are developing artificial intelligence technology applicable to C3I systems. Seven specific C3I applications have been identified which drive the technical requirements for this program. These are: Knowledge Based Mission Planner, Intelligent Analyst System, Knowledge Based Software Assistant, Expert Systems for Maintainability/Testability, Photo Interpretation, Communications Network Management, and Speech Applications. These applications are considered to be technically interrelated and the goal is for the principal investigators of the individual tasks to work jointly and cooperatively to achieve the broader objective.

The conduct of a quality research program that addresses C3I problems is the primary objective of this program. However, to insure that the research is brought out of the laboratory and to provide necessary AI resources to RADC a number of ancilliary objectives must be attained. Therefore, the universities who are conducting this research have developed plans for expanding their own capabilities and developed a program to support RADC in-house research, education and training needs. As a by-product, it is envisioned that this effort will increase the availability of sources and personnel capable of conducting research and development of AI technology and in the application of that technology to C3I and other military systems. Thus the objectives of this program are two fold - a cooperative technical program among universities to advance AI technology and a non-technical goal which helps meet the long term, broader needs for AI in the DOD as well as the RADC community.

Electronic Device and Circuit Research (2305J1) - This program explores semiconductor device phenomena, device fabrication techniques and circuit architectures with the goal of meeting future Air Force requirements for signal sensing and processing. Advances in this area are supported through the development of both new device designs and the application of new device processing techniques. This effort provides the United States a lead in silicide photodiode research.

Electromagnetic Wave Propagation Studies (2305J2) - A major objective of the research in electromagnetic wave propagation is to develop and expand mathematical techniques to predict signal strengths of waves propagating over the surface of the earth, through the atmosphere, in the earth-ionosphere wave guide, and through the ionosphere.

Areas of interest include longwave propagation (ELF/VLF/LF/MF), and high frequency-ionospheric propagation (HF). The non-conventional generation of long waves by the interactions of particle beams in the ionosphere is being investigated. Waves excited by modulating high current electron beams in the ionosphere are being identified and quantified in a theoretical research program, and plans are being developed for an experiment in space to investigate the feasibility of using modulated particle beams to generate ELF/VLF radio waves.

An experimental program is being conducted to measure the propagation of HF radio signals from a ground-based transmitter to a low-altitude orbiting satellite, using ionospherically ducted modes. These signals can propagate to great distances with relatively low losses, and offer the possibility of being exploited for surveillance and communication purposes. Research efforts are addressing a number of critical areas involving such HF ducted modes, including the time/space availability of the modes, propagation losses, duct bandwidths, and signal coherence within the ducts.

Electromagnetic Radiators (2305J3) - RADC research on electromagnetic radiators emphasizes the establishment of those basic physical and engineering principles governing antenna performance in ground-based, airborne or spaceborne environments for diverse Air Force applications.

Environmental effects on antenna performance are often of sufficient strength to impact successful attainment of operational goals, or, when anticipated, can influence the design of the antenna system itself. These interactions can involve remote sources of electromagnetic interference, such as atmospheric irregularities, terrain inhomogeneities, or hostile jamming signals. The interactions can also involve nearby sources of electromagnetic incompatibility, such as other antennas, conducting portions of the antenna's own support structure or vehicle, or the earth. The goal of this work is to discover those principles that permit antenna designs that are better able to cope with those environmental threats expected to be encountered in any particular application.

This goal is accomplished in this research task by concentrating on the following two sub-areas - printed circuit antennas and antenna pattern control.

The printed circuit work concentrates on microstrip structures. By virtue of its low silhouette conformal construction, the microstrip geometry contributes to highly cost-effective antennas for high performance aircraft and missiles, resulting in minimal aerodynamic drag, low weight and small size for given antenna gain and resulting lower susceptibility to jamming. Major emphasis is placed on new architectures for feeding the radiating elements, consistent with broader bandwidth for frequency hopping and monolithic microwave integrated circuit compatibility. Use of substrates that are generally anisotropic represents a new degree of freedom in the analysis of such antennas.

The antenna pattern control work focuses on determining the pro r shape of the antenna radiation pattern, so that a particular Air Force military objective can be met. This includes radar antenna systems with rapid wide-angle scanning coverage and precise broadband null steering with the ability to adapt pattern requirements rapidly to changing mission objectives, for enhanced anti-jam capability. A major emphasis here is the analysis of very large arrays. Digital beamforming techniques are considered as a means for making maximum use of the set of physical signals associated with the ar ay radiators, in contrast with the simple summing of these signals as conventionally done. The adaptive techniques concentrate on simplifyi g the adaptive process and increasing its rate of convergence for large arrays, with special interest directed at main beam jammer cancellation capability for radar systems threatened by jamming from enemy self-screening and escort jammers, as well as from a high angular density for stand-off jammers. The pattern control work also establishes more cost-effective and less complicated antenna analysis techniques, and provides antenna pattern synthesis capability for such new propagation modes as focused waves, for secure satellite-to-satellite communications links, dispersionless pulsed energy transfer, single-pulse target identification and enhanced clutter penetration.

Electromagnetic Signatures (2305J4) - Airborne and ground radars have played important roles in both strategic and tactical warfare over three decades. New radar concepts are needed to deal effectively with the ever increasing complexity and sophistication of hostile threats and to exploit recent technological advances.

The primary goal of the electromagnetic sensor research at RADC is to obtain increased fundamental knowledge of the scattering phenomena on which electromagnetic sensor systems are based so that new electromagnetic techniques can be developed to improve the sensors used in surveillance, reconnaissance, and intelligence. Recent increased use of radar absorbing materials and shaping techniques for target radar cross sections (RCS) reduction has made target detection much more difficult. Since there is little theoretical knowledge or experimental data from radar absorbing materials, a major effort is to expand both the theory and measured data base of scattering from these materials. In the past the theoretical analysis and measurement program have concentrated on monostatic geometries. Owing to the necessity of finding new radar concepts we are emphasizing investigation of bistatic scattering phenomena. In order to facilitate measurements of complex objects we are also devoting significant resources to near field measurement techniques from which the scattered far field can be inferred.

A second major need is an understanding of scattering of radiation from antennas. There has been little study of the scattering phenomena associated with antennas. As the cross sections of aircraft decrease, those of the plane's antennas become increasingly significant. If the antenna cross-section cannot be controlled effectively, the low observable aircraft cannot be realized. We are therefore studying scattering phenomena from antennas and the concept and realization of the minimum scattering antenna.

A third major need is a prediction capability and measured data for bistatic terrain clutter and multipath. Predictive models and data are necessary to improve our ability to detect and tract low flying low observable aircraft. There is very little knowledge about bistatic clutter behavior. We are therefore emphasizing this gap in our research. We are also concerned with the polarization sensitivity of clutter. These studies will lead to new techniques to reduce clutter effects on radar systems and validate the performance of the AASR and SBR radar systems being developed.

Microwave Acoustics and Magnetics (2305J5) - Microwave acoustics, magnetics, and circuits research is focused on deepening our fundamental understanding of acoustic, magnetic, and microwave/mm-wave circuits to meet needs in command, control, communications, and intelligence. Research on integrating passive acoustic and magnetic devices with circuits is required to meet the requirements of Project Forecast II, "Wafer Level Union of Microwave, Digital, Electro-Optical, and Microsensor Functions." A new concept for electronically variable time delay and transversal equalization using a segmented-drain field effect transistor will be experimentally investigated. The backscattering of 94 GHz waves from magnetostatic waves will be investigated for ultimate beam-steering applications. Brillouin scattering will be used for characterizing microwave magnetic phenomena and magnetostic wave excitation and propagation in thin magnetic films. Continue research on theoretical modeling of new microwave magnetic components and investigate coupling of field effect transducers fabricated directly onto the GaAs substrate for generating and detecting magnetostatic waves. Investigate optimum wafer for monolithic integration of magnetostatic and active circuits at microwave frequencies. Perform research on phenomena and techniques for new non-reciprocal mm-wave components compatible with monolithic integrated circuits on GaAs. Experimentally confirm theoretical predictions of millimeter-wave transmission line discontinuities for accurate computer-aided design of monolithic integrated circuits.

Optical Signal Processing (2305J7) - The processing of information using optical devices is an extremely rapid growing area with major implications and impact on a large number of fields both civilian and military where large amounts of data need to be rapidly processed.

Optical processors typically use information impressed on a light beam (often a coherent laser beam) and perform complex operations on the entire beam thereby processing all the information in parallel. The processing may be for such diverse operations as correlation for target identification and pattern recognition, image processing for feature enhancement or deblurring, weight and phase determination for the rapid control of phase array radar, etc. The information encoded on the light beam and being processed may be from a variety of sources such as actual optical imagery, radar data, acoustical data etc. This technology will fulfill many important roles in the C3 mission requirements. These include rapid phase-array radar null determination jams proof radar to 50 db; rapid target identification based on optical and radar image correlation and matched filtering; spread spectrum acquisition based on optical 2-dimensional correlation.

Experimental devices such as spatial light modulators and phase only filters will be explored, fabricated and evaluated, and appropriate processor algorithms and architectures will be developed and studied in view of their applications to the C3 technology.

Thermionics Research (2305J9) - To meet projected Air Force system needs for electromagnetic transmissions, RADC is emphasizing the basic technology required to improve the performance of microwave and millimeter wave high power thermionic devices. Major emphasis is placed on achieving wide bandwidth, enhanced efficiency, higher powers with stable operation at millimeter wave frequencies, etc. and on techniques compatible with long life. Part of the research is conducted under the Air Force Thermionics Engineering and Research Program with the microwave tube industry and the University of Utah.

Other research includes development of techniques to analyze the internals of tubes on a nonperturbing basis. Both of these thrusts help maintain a strong technology base in this vital area. The results of the research are applied to specific microwave and millimeter wave tube developments.

Advanced Electromagnetic Materials (2306J1) - Many electronic and electro-optical device activities are currently materials limited. Effective Air Force C3 capability depends on the availability of key electromagnetic materials. The objective of the advanced electromagnetic materials research program is to prepare and evaluate such materials.

The approach involves the synthesis, growth and characterization of electronic and optical materials in bulk, thin film and fiber form, and the identification and construction of structures that exhibit new or improved semiconductor, electro-optical and other exploitable phenomena. Primary emphasis is on militarily-distinctive, C3-oriented materials generally unavailable from the private sector.

The direct materials activities underway is an important aspect of and supportive to the time and frequency standards, fiber optic communications, integrated optics, optical data storage, monolithic integrated circuits and radiation hardening programs.

Optical Circuit Components Research (2306J2) - Recent advances in the field of optics show promise of having a similar dramatic effect on military technology to that resulting from the development of the integrated circuit technology.

The optical circuit component research at RADC is designed to provide the basis to develop electro-optical components and establish techniques for military fiber optic communications. Optical communications systems, providing jam-proof, secure, broadband capabilities, will fulfill important roles in C3 mission requirements. Advanced communications devices providing intrusion resistant, jam-proof, and highly secure broadband capabilities will be investigated as well as sophisticated switching and signal manipulation devices. High bandwidth operational capabilities of lasers and detectors will be developed. Necessary research will be supported to establish a technology base for optical implementation of digital electronic systems in selected military applictions.

Experimental devices will be explored and evaluated in light of their application to control and communication requirements and their practicality.

Physics of the Interaction of Radiation with Matter (2306J3) - Our strategic policy of maintaining an assured nuclear retaliatory capability imposes a requirement for assessing the vulnerability of command, control and communications systems to the natural radiations encountered in satellite orbits and the severe environments generated by nuclear and laser weapons. Where vulnerability levels are unacceptable, radiation hardening measures must be applied.

The objective of this work is to insure the availability of fundamental information required for identifying, characterizing, and modeling radiation damage mechanisms in electronic, electro-optical and optical devices, components, and systems so that accurate vulnerability assessments can be made and the desired level of hardening achieved. This knowledge is then applied to the design of devices and the evaluation of device characteristics during and after radiation. The program provides the basis for an extensive activity in developing a hardening technology and hardened electronics for a wide variety of Air Force systems.

Device Reliability Research (2306J4) - The evolution of solid state device technology in terms of complexity and speed will result in significant advances in the performance capabilities of future electronic systems. The device reliability research program seeks to develop the fundamental physical information required to assure the reliability of advanced solid state components and the resultant availability of Air Force systems.

The research studies are divided into two areas. First, programs are pursued which provide fundamental physical information on the mechanisms which cause failure of Very Large Scale Integrated Circuits and their associated materials. The current program is concentrating on electromigration in thin film conductors, metal-semiconductor contact degradation and the effects of moisture on interface layers found in complex very large scale integrated circuits.

The second area involves developing analytical techniques required to assess the surface microchemical properties of submicrometer geometry devices and to determine the electrical operation of nodes located within the complex monolithic circuit structures. These studies involve both electron and laser beam analytical techniques.

Future efforts will also be directed toward evaluating the local thermal properties affecting microcircuit reliability. These physical and electrical assessment techniques are essential for understanding the limitations on reliability and performance of emerging solid state device technologies. Finally, the device reliability research studies form the basis for future exploratory development programs pursued under Project 2338, "Assurance Technology for Electronics."

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TITLE OF TPO: COMMAND, CONTROL AND COMMUNICATIONS (C3)

This TPO articulates the goals and approaches that the laboratory is pursuing to make improvements in the Air Force's capabilities to perform its command, control and communication mission.

Within this TPO there are four major areas of concern; namely, Common C3, Strategic C3, Tactical C3 and Electronic Combat C3. The major objectives within each of the missions are to provide the technologies that will enhance the systems survivability, capacity, connectivity and availability.

COMMON C3 is defined to include those areas that are not specifically tactical or strategic in nature and provides the technologies that will improve the survivability, connectivity and security of the long haul common user communications. Although much of this work is in direct support of the DCS, the technologies developed are frequently applicable to the tactical and strategic missions.

In the switching and control of a node, the application of advanced routing architectures and multi-net gateways are being pursued to enhance the interoperability of communication systems. The use of endurable communication links is vital to the DCS and a program to improve link availability through the application of adaptive antennas, signal processing and spread spectrum modulation technologies is being conducted. In addition to link survivability, the network must be capable of withstanding both physical and electronic assault. Improvements in both hardware and software for the control of a complete network are needed. Such issues as fault isolation, distributed technical control, rapid net restoral/reconfiguration and the detection and identification of ECM are being addressed.

Space communications is a much used and critical portion of the support communications mission, but it currently suffers from the lack of AJ, mobility, flexibility and availability. These deficiencies are being addressed by providing the capabilities to operate in the SHF/EHF bands with new conformal beam forming antennas, RF generators, robust signal formats and reducing the potential for self interference at these critical frequencies. Both ground and airborne applications are being considered.

Communication security is an activity that is mandated by national policy. Programs in TEMPEST automation, vocoders and voice intelligibility will add to the Air Force capabilities to meet this mandate.

The STRATEGIC C3 goals are to develop the technologies which will lead to a survivable and enduring C2 structure capable of positive control of the strategic forces on a global basis even in the hostile environment of physical and electronic attack, disturbed propagation and enemy SIGINT activities. The endurance of the command authority throughout a full spectrum conflict will also require the graceful adoption of new technology, along with new procedures. The resulting improvement in Strategic C3 is both mandated by the evolving threat and advances in strategic weaponry.

The development of Signal Processing to support beam and null steering and rapid retune capabilities, along with a variety of signal processing techniques for both narrow and wide bandwidths, are the keystones to future systems. The VLF antenna for ground and air locations remains a major technological issue, a does the need for low probability exploitation transmissions across the band. Those technologies which permit communications to be adaptive, wideband, and mobile will afford low probability exploitation transmissions across the band.

The Strategic C3 experiment is to investigate the technological issues surrounding this endurance issue considering the use and loss of distributed/data bases and the communications interconnecting the data bases. Understanding reconfiguration and reconstitution of the assets to provide command continuity is critical to the system architecture and doctrine.

TACTICAL C3 contains all of the elements of Command, Control, Communications and Intelligence. The major technical deficiencies within today's tactical C3I systems are survivability, capability, timeliness and mobility. It is these system characteristics that are being addressed in the RADC program for tactical C3. Four fundamental functional areas of communications, surveillance and identification, command and control and intelligence will be discussed in order.

COMMUNICATIONS: The approach to meeting the goals of the tactical communications mission is to solve some of the near term problems such as getting fiber optic cables into the field at the earliest possible time while taking a longer term look at systems vulnerabilities to determine future needs. In the near term, for fiber optics there is the generation of standards for connectors, sources and detectors. A little further in the future is a family of transceivers, optical multiplexing, RF transmission, transmission over single mode fiber and intrusion resistance. The goal of advanced survivable communication technology is to develop an enduring communications base that will enable the future TACS to survive the hostile ECM threat. Consideration will not only be given to the growing jammer threat, but also to the need to reduce vulnerability to intercept.

For the longer term solutions, the Communications Vulnerability Assessment (CVA) effort with the associated evaluation of network facilities will provide electronically hardened communications system developments in the future. From this, the design and development of robust distributed and adaptive networks can be effectively done. Within this overall framework is the need for specific advancements in survivable multi-media channels. Low cost data links and associated phased array antennas are key technical issues for near real time information flow and weapon control while being subjected to intensive jamming and SIGINT activity. Voice communications is an important part of the tactical mission, but it must be secure and jam proof. Digital techniques in the EHF band are being exploited to develop a low probability of intercept and highly jam resistant voice channel for air to air use.

SURVEILLANCE: The number, speed and turning capability of airbreathing vehicles within a theater continues to grow while the potential or radar cross section reductions become more real. These target characteristics along with an ever expanding and sophisticated EW threat plus an increasing threat from a variety of weapons designed to destroy ground and airborne surveillance/C3 assets presents a very challenging task for the surveillance and ID systems. Since no single surveillance platform or sensor type can deal with this threat, the Surveillance program includes the development and demonstration of the technology for: a highly mobile advanced ground based phased array radar; a multi-mode ground based passive surveillance system; an advanced airborne conformal phased array system with both active and passive modes; and the netted surveillance technology required to integrate the outputs of these new sensors to generate a single unambiguous air situation picture.

COMMAND AND CONTROL: The current methods of doing force management is largely a manual process and is far too slow for the dynamics of modern tactical warfare. The near term introduction of automated aids and the longer term systems design comprise the RADC program. The three main technical areas being pursued are modeling and simulation, functional automation and man-machine interface. Key features of this approach are that it is evolutionary, relies heavily on user participation and will possess the qualities of interoperability with the current and other evolving force management equipments and concepts. This program will lead to a capability to perform Command & Control functions in a modular and distributed manner. The solution to distributed and interacting data bases is vital to implement the future survivable command and control concepts derived in the recent Air Force 21st century Tactical C2 study.

A communication structure of fiber optic and coax cables that form the backbone of the Command and Control Laboratory has been installed at RADC. This will create the environment for testing/evaluating many of the concepts of heterogenous distributed systems that one would expect to find in the real world. These tools and concepts provide powerful new approaches to tactical warfare management.

A program for the development of a Ground Attack Control Center (GACC) will provide those technologies and strategies to bring together the total system control of sensors, data processors, weapon selection and control for the air interdiction mission. Both of these programs are being conducted in close coordination with the ESD acquisition directories.

INTELLIGENCE: The intelligence TPO covers development of Comint and Elint exploitation technologies and techniques and Combat Sensor. Management and Correlation. Command, Control, Communications and Counter

Measures (C3CM) Deception is covered under the C3CM TPO. In modern tactical warfare, intelligence must be an integral part of the command and control structure and automated to the point that it is compatible with that structure. The approach being pursued is one of both near term and long term developments which will result in a highly automated multi-sensor system capable of meeting the force management needs in a highly dynamic air and ground war.

In the sensor area, work is ongoing to develop a multi spectrum capability. An effort in the automation of SIGINT exploitation and reporting will significantly contribute to the intelligence data process. The Multi-Imagery Exploitation System will provide a near real time capability for detection, identification and precise location of high priority tactical targets. Technical areas applicable to Sigint includes automatic signal detection, automatic signal recognition and near real time information extraction.

The Penetration Analysis Support System is to aid in the process of penetration analysis and decision through automating the mostly manual process. Within the tactical theater there are many diverse sensors and support subsystems that have a wealth of capability and information. They must be brought together in a cohesive and organized manner to produce the most effective results. The Combat Sensor Management and Correlation program is intended to do this and make available to the force manager the best possible picture of the battlefield.

INFORMATION PROCESSING: As cited above, the current methods of doing force management is largely manual and is far too slow and simplistic for the dynamics of modern tactical air and ground warfare. The near term introduction of automated aids and the longer term systems design comprise the RADC program.

The three main technical areas being pursued are modeling and simulation, functional automation and the man-machine interface. Key features of this approach are that it is evolutionary, relies heavily on user participation and must possess the qualities of interoperability with the current and other evolving force management equipments and concepts. This program will lead to a capability to perform Command & Control functions in a modular and distributed manner. The solution to distributed and interacting data bases is vital to tactical and strategic activities if they are to survive in the future scenarios.

A communication structure of fiber optic and coax cables that form the backbone of the Systems Design Development Environment has been installed at RADC. This will create the environment for testing/evaluating many of the concepts of hetrogenous distributed systems that one would expect to find in the real world. These tools and concepts provide powerful approaches to tactical warfare management.

ELECTRONIC COMBAT: Encompasses Command, Control Communications Countermeasures (C3CM), Electronic Warfare (EW), and Suppression of Enemy Air Defenses (SEAD). This TPO subthrust presently addresses C3CM as defined by DOD Direction 4600.4 as the integrated use of OPSEC, deception, jamming and destruction, supported by intelligence in order to deny information to, influence, degrade or destroy adversary C3 capabilities. The countermeasure strategy addressed in the C3CM concent has as its objective the countering of the enemy command and control (C2) function, with the countering of the communication (C) function only as a means to the end.

As defined by JCS MOP 185, the goal of the C3CM is to deny enemy commanders effective command and control of their own forces while maintaining effective command and control of friendly forces. The RADC Electronic Combat subthrust supports the ESD C3CM program designed to develop and field capabilities so that the TAF can employ C3CM warfare strategy effectively. The specific objectives are to: develop a target recognition capability for C3CM battle information management and execution; develop and evaluate decision aids for use in the existing C3 structure to support C3CM and control friendly emitters; develop deception techniques; and to provide an integrated C3CM capability for tactical use.

Integration of intelligence and C3CM will: improve real-time intelligence support to C3CM, provide rapid assessment of enemy intentions, provide intelligence target/EC/deception options to the 21st century TAC's battle staff in near real-time, provide fused, correlated, analyzed and assessed intelligence information regarding enemy courses of action and suggested friendly responsive courses of action, and develop techniques and tools for imitative, manipulative, and operational deception of enemy C3.

These developments will provide the Air Force with the technologies required for force enhancement through an integrated C3 system which orchestrates the use of lethal and non-lethal weapons in a timely manner for Electronic Combat (EC).

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TITLE OF TPO: RECCE/INTEL

The objective of this Technology Planning Objective (TPO) is to accomplish Explanatory, Advanced and Engineering Development and Acquisition in the areas of: Correlation/Fusion, Intelligence Data, Imagery Exploitation Aids, Automatic Target Recognition and Precise Location, Scientific and Technical Intelligence, Analytical Capabilities and Enhanced capabilities for operational Intelligence Centers. Their objectives are addressed under The Reconnaissance and Intelligence (RECCE/INTEL) TPO 2- Correlation and Fusion which includes Data handling, Imagery Exploitation, Precision Guidance and Study Products and Special Intelligence. TPO 4E, RECCE/INTEL, covers the work in Wideband Recording, Speech Processing, Knowledge Based Intelligence Systems and C3I Data Base techniques. The Signal Intelligence, Sensor management and Correlation and Intelligence C3CM Integration work has been previously covered under TPO 1C4 Intelligence and 1D1 C3CM respectively.

The SURVEILLANCE program will provide the technology for detection, tracking, identification and weapon control against slow moving and fixed ground targets from standoff ranges under all weather conditions. The PAVE MOVER radar is a key element to meeting these capabilities and is a maturing ADM currently in acquisition.

CORRELATION and FUSION Intelligence Technology- The objective is to provide the technology required to improve and automate the Air Force and Agency capability to provide useful and timely intelligence information from all sources. Emphasis is in the development of advanced data recording, speech processing, image processing and intelligence information processing techniques to satisfy tactical and strategic intelligence needs.

Near real time digital target classification and multisensor correlation techniques are developed to increase the quality and timelines of military intelligence. New and improved cartographic and photogrammetric methods and equipment are developed for utilizing reconnaissance/mapping imagery in the timely production of digital data bases to support future weapon system and Defense Mapping Agency (DMA) product centers. New initiatives here include Artificial Intelligence application to Cartographic assessment, High Resolution Stereo Shape discrimination and Data Extraction, Multi-Source Feature Analysis and Intelligent Interactive, Mapping Charting and Geodsey, and Camouflage, Concealment and Deception (C2D) intelligence analysis Techniques.

The Scientific and Technical (S&T) Data Base efforts develop analytical and correlation capabilities for analysis of foreign weapon systems. Specific computer programs are prepared that address those unique requirements of the Technical Intelligence analyst.

The Analysis and Correlation work is directed at augmenting conventional S&T intelligence, long range launch detection and vehicle Identification. The technologies are directed at analysis and exploitation of RF externals and unintentional electromagnetic emissions.

DOD Indications and Warning (I&W) efforts are concerned with the modernization and improvement of our ability to monitor, manage and exploit I&W intelligence information. Work in this area includes efforts to demonstrate how a knowledge base system can aid an I&W analyst responsible for determining the threat potential of launches before, during, and after the launch occurs. The Space Foreign Launch Assessment Knowledge Architecture/Demonstration has been developed on a Symbolic 3600 LISP machine using a Metalevel Representation System. Future plans call for expanding architecture and the knowledge base to allow prediction of ASAT foreign launches. 62702F RADC funding has been programmed to begin in FY87 to support development of new technology for I&W applications.

Intelligence Data Handling Systems (IDHS) pull upon all of the above new technology development areas for upgrade of IDHS capabilities to increase the efficiency of Intelligence Production. IDHS Systems have been developed and installed at Air Force and DOD commands such as ADCOM, CENTCOM, SAC, REDCOM, MAC, TAC, USAFE, PACAF and DIA.

A new Program Element has been established called the "Intelligence Advanced Development". Objectives will be to reduce the technical, cost and schedule risk associated with development of Intelligence Data Handling Systems. This will be accomplished by applying advanced technology concepts to prototype developments of IDHS capabilities for evaluation of acceptability/usefulness to operational personnel and operational system intregration issues. Future Plans include Prototypes for Situation assessment, Long Range Air, as well as continuation of Space Foreign Launch Assessment, Mobile Launcher Location and Tracking and Collection Requirements Management.

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TITLE OF TPO: STRATEGIC SYSTEMS.

The objective of this TPO is to pursue the technology related to providing viable surveillance and warning sensors in support of the Vanguard submissions of atmospheric Surveillance and Warning and of Ballistic Missile Surveillance and Warning within the Strategic Defense Vanguard mission.

Although all of the national needs are not considered here, the issues of placing radar and large optical systems in space, the detection and tracking of Cruise Missiles, Intel/Special Radars, Electro-Optical sensors for tracking objects in space, and Ducted Ionospheric Propagation technology for strategic detection are of primary concern.

These subjects are treated under two thrust areas of Atmospheric Surveillance and Warning, and Space Surveillance and Warning. Generally, the feasibility of a concept is proven through actual demonstration. This calls for large amounts of funding and resource commitment. In FY86 a new thrust was added to this TPO to accommodate the technology being developed under the Strategic Defense Initiative (SDI).

ATMOSPHERIC SURVEILLANCE AND WARNING addresses the difficult technology issues of radar surveillance of atmospheric targets from a space platform, Cruise Missile Surveillance, and unique sensors for specific strategic or intelligence missions. The purpose of these efforts is to explore the basic technology needed to demonstrate capabilities in these areas.

The Space Based Radar (SBR) subthrust, driven primarily by the CONUS air defense mission, provides technology for a multimission, all weather, global surveillance capability. Major technology emphasis is on large phased array space deployable antennas, monolithic transmit/receive modules, and advanced on-board signal processing.

In the area of large phased array space deployable antennas, analysis/simulation of a large aperture space-based array lens comprising hundreds of thousands of elements is a formidable problem. A first approximation of element currents from an infinite array analysis of the piecewise sections is being performed with higher approximations providing corrections to the currents on elements in the vicinity of discontinuities. This detailed simulation of the lens has been combined with simulations of other aspects of the SBR antenna (feed, scattering) into an analytical capability for the total antenna. This simulation capability is resident on RADC computers. A generic SBR space-fed lens array membrane was designed and test articles have been built and tested.

The Phased Array Lens Demonstration (PALDEM) test article has demonstrated the capability to integrate monolithic transmit/receive modules into a space-fed lens array membrane. The PALDEM test article will be placed in three feed configurations, horn, corporate array and transform. Each configuration will be evaluated for side lobe cancellation performance. The results will be used in establishing criteria for a full-sized SBR phased array lens.

In the area of advanced on board signal processing (AOSP), a general purpose signal processor capable of supporting space missions of the late 1980s and the 1990s is being developed. The AOSP design is a hard-wired array of mutually synchronous processing elements called Array Computing Elements (ACE), which are interconnected through a system of high speed data busses and controlled through a two-level distributed operating system.

A 9 ACE brassboard has been developed to demonstrate the AOSP distributed architecture, operating system and software. This technology has transitioned to the SDI program and a full capability for a space-based E-O sensor will be built in FY86.

In the Low Observable (Cruise Missile) Surveillance subthrust, high confidence warning and defense against low observable penetration is being pursued through the exploitation of the whole penetration threat scenario and observable multispectral properties to augment current capabilities.

Threat measurement provides the data base for system/sensor design analysis as well as for constructing test and evaluation programs. The multispectral approach is supported by passive/active test programs to evaluate system payoff and detailed design requirements. This activity is supported by multistatic surveillance programs being developed under DARPA funding and coordination activities of AFSC Low Observable Interface Management Group. These 6.2 efforts are direct inputs to the 6.3 demonstration program PE63716, Atmospheric Surveillance Technology (AST) which will lead to advanced Development Models for sensor products by FY87. System products and integrated surveillance/engagement technology products shall be provided in FY88/89.

Unique sensors for the surveillance of satellites, missiles and aircraft have been and continue to be developed and improved to meet requirements for space track, attack warning, intelligence and air defense. There are no 6.2 funds expended in this Intel/Special Radars subthrust since all of the work performed is in support of external agencies who reimburse RADC for the technical effort expended to effect technology transfer to the North Warning Program, BMEWS upgrade, CONUS OTH-B, the E-3A Enhancement Program and COBRA SHOE.

<u>SPACE SURVEILLANCE AND WARNING</u> provides methods to conduct Mission Payload Assessment (MPR) of space objects, and tracking, targeting and kill assessment for ASAT and attack warning by electro-optical concepts. High frequency ducted ionospheric concepts are investigated to provide advanced HF communications and surveillance techniques.

Major areas in the Electro-Optical Surveillance subthrust are Spaceborne Optical Surveillance Technology and Space Defense Surveillance Technology for strategic surveillance applications.

Major breakthroughs have been achieved in large adaptive optics for space, ultra lightweight passive mirrors, active control of space structures and adaptive compensation for atmospheric degradation of optical signals for imaging and laser communications. Substantial progress has been achieved in the design and analysis of groundbased and airborne sensors for near real-time E-O satellite tracking and targeting and in the design and development of adaptive optics for spaceborne laser weapons. The breakthroughs in atmospheric compensation, LWIR imaging and multi spectral data fusion have resulted in the ability to achieve real-time threat assessment and targeting.

Efforts in space optics are aimed at the Space Surveillance and Tracking System requirements and other far term advanced strategic surveillance system requirements where major advances have been made in both active and passive telescope optics in the areas of Adaptive, Ultra-lightweight mirrors, advanced lightweight passive mirrors, sensors, and actuators. However, at the integrated systems level, the control of these components is beyond the current state-of-the-art. In order to achieve the performance required for an integrated telescope for space applications, FY86 6.2 funds will be used to design a complex laboratory experiment to evaluate the integrated control technology optics.

The enhancement of our Space Surveillance goals through real-time optical satellite assessment has been realized with the installation of the Compensated Imaging System and infrared cameras on a 1.6 meter diameter telescope at the Air Force Maui Optical Station (AMOS). 62702F funds have been used to develop and analyze an analytical model of an infrared airborne tracking system for satellite targeting in near real-time.

The Ducted Ionospheric Propagation subthrust is aimed at increased understanding of ducted modes and their usefulness in surveillance and communications application. Recent theoretical research has indicated the possibility of achieving reliable long-range (10,000 km) HF (3-39MHz) radiowave propagation by exploiting ducted modes in the ionosphere at altitudes in the 150-250 km range. Natural as well as artificial modification of the ionosphere by means of intense radio frequency heating near the duct injection point have been investigated as a promising means of achieving coupling.

A satellite experiment is planned to place a unique wideband HF (6-30 MHz) receiver system at altitudes within the expected ducting regions. Several ground transmitters will be used to inject radio signals into the ionospheric ducts utilizing both natural and man-made ionospheric irregularities. These ducted transmissions will be received at the satellite at distances greater than 10,000 km. Several signal parameters will be measured to establish the characteristics of the ducted modes. The satellite receiver system is completed and has successfully passed the required environmental tests and is now fully space qualified.

The SDI is a comprehensive research and technology program to develop and demonstrate the technologies necessary for effective ballistic missile defense.

RADC is a Lead Technology Center within the SDI Organization and has overall responsibility for executing assigned SDI technical efforts in Surveillance, Acquisition, Tracking, Kill Assessment (SATKA), Directed Energy Weapons (DEW) and Battle Management/C3 (BM/C3).

Technology in the support of SATKA includes the development of large lightweight radar/optical operatives and advanced on-board signal processors. DEW requirements support technology development programs for large lightweight adaptive optics and rapid optical fabrication techniques. In the area of Battle Management for SDI, RADC is developing new computer architectures, software engineering techniques, communications, networks and algorithms.

The Air Defense Initiative (ADI) was added to the TPO-3 subthrust (3D). The initiative addresses the "atmospheric threat" created by the introduction of low observable (Cruise Missile and Stealth) technology and compliments the layered defense strategy started under the Space Defense Initiative.

The system concept emphasizes an evolutionary process that first addresses near-term improvements to the present surveillance systems while initiating programs to develop technologies required to support long-term objectives. New sensors, as well as added uses of fused data, are driving the Surveillance and Command and Control functions. Programs related to the ADI Surveillance will be found under TPO sub-subthrst 3D1 while the ADI Command and Control programs will be found under 3D2.

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TITLE OF TPO: TECHNOLOGY

The objective of this TPO is to form the foundation for future solutions to technological problems within the Air Force C3I mission. Though the "ilities" may have direct system application, they are reported in this TPO because of the breadth of their usage. There is concerted effort on the part of management to insure that there is continual cross fertilization between these thrusts and the other TPOs and that as technologies reported here mature, they will transition into the operationally oriented TPOs. In this way there is minimum duplication and clear direction given to the efforts.

There are seven thrusts within this TPO, representative of the technical fields of the Center mission directorates. The majority of the funds identified in this TPO are 6.2 funds used to perform studies, experiments and demonstrations to further the body of technical knowledge.

SURVEILLANCE thrust contains two basic technology subthrusts; Thermionics and Signal Processing. These technology subthrusts form the foundation for future capabilities.

The Thermionic subthrust is aimed at developing technologies for microwave tube/transmitters and solid state transmit/receive modules with improved levels of performance in signal fidelity, bandwith, and efficiency. They must also be lightweight, low cost and easily manufactured to meet the requirements of next generation C3I systems.

For applications requiring very wide bandwidth and/or very high average powers, tubes will be used for at least ten years in the microwave frequency bands and fifteen years in the millimeter wave frequency bands. High Average Power Tube/Transmitter Development provides for tube and transmitter techniques capable of operating at multi-kilowatt average powers and peak powers between 100 KW and 3 megawatts. FY87 emphasis is on the development of 100 to 200 kilowatt peak power coupled cavity traveling wave tubes with efficiencies over 50%. Transition efforts include improved klystron for BMEWS and the AN/TPS-43 Radar and High Efficiency Wideband Klystron for Tropo Comm Tube/Transmitter developments and E3A. Underlying the thermionics area is the Air Force Thermionics Engineering Research program which is a cooperative program among the Air Force, the tube industry and the University of Utah in which new tube concepts and circuits are researched and students are educated to become competent tube technologists.

Adaptive Solid State T/R Module Circuit Technology is being developed including improved concepts, control techniques and validation test procedures to meet ground and airborne surveillance systems. Emphasis in FY86 was on development of efficient variable output amplifiers and MMIC module circuit concepts whose system performance is not sensitive to variations in the manufacturing process. Transmitter efforts include development of the Conformal Array Module and the C-Band Module for tactical environments.

A second subthrust contained in this thrust is Signal Processing which has the primary objective of providing the highest probability of detection in a time varying environment containing natural and man made interference while simultaneously minimizing false alarms. Signal processing techniques are made adaptive so that they are self optimizing in this type environment. With the recent advances in device technology and real time processing algorithms, the signal processing program is oriented heavily toward the actual reduction to practice and experimental evaluation in an actual RF environment. Polarization Algorithm/Experiments will provide an extensive evaluation of several potential discrimination algorithms and will also provide much needed experimental data on the polarization signature on a variety of target types as well as ground clutter, weather clutter and chaff. The optimum modulation/filter will be determined from an assessment of polarimetric processing for the optimum transmit/receive response for target detection and estimation over a two channel radar system.

Performance Limitation Studies have been initiated to update the diagnostic tools to determine the figure of merit for advanced radar systems as affected by the errors and limitations of a system's operating parameters. A wide range of system factors such as synchronization, time and frequency instability, A/D conversion, dynamic range and netting are some of the more immediate issues.

The recent developments in distributed processing, device technology (VHSIC) and high order languages have been used in the design of the Signal Processor for E3A/AASR to achieve high throughput, increased reliability, reduced maintenance and life cycle costs. Brassboard fabrication was initiated in FY-85.

The extremely successful Advanced Onboard Signal Processor (AOSP) development program continued with a contractual effort in FY-85 to develop a 20 ACE Brassboard Processor. The AOSP architecture is currently being designed to accept VHSIC devices with follow-on programs to insert and test VHSIC in the architecture. Joint surveillance and communications Systolic Array Applications Studies will lead to the development of algorithms and architectures for radar/communications signal processing that exploit highly parallel computing such as Systolic Arrays and VLSI/VHSIC technologies suitable for implementation projected for the 1985-1990 period. The fabrication and testing of a systolic array processor has been initiated with testing planned based on these studies.

COMMUNICATIONS technology ensures effective execution of C2 functions through adequate responsive communications in the presence of current and projected C3I ECM threats. Communications techniques that provide high jam resistance, exploitation resistance and improved performance in perturbed channels are being developed. Performance, cost, reliability and physical parameters of communications processing systems will be improved through the application of advances in digital VLSI/VHSIC, optical, GaAs and MMIC circuit technologies in conjunction with new advanced signal processing algorithms and architectures. The developed technology base will fulfill present and future Air Force needs in Satellite Communications, HF Communications, Tropospheric Scatter Communications, Tactical Voice/Data Links, and Air-to-Air Communications Systems.

The Communications Signal Processing Sub-Thrust contains developments in spatial, temporal, and integrated multi-domain signal processing. Specific objectives are to advance the developments of new and improved signal processing techniques to counter a dynamic escalating threat; high performance signal processors exploiting new processing algorithms, architectures and high payoff analog/digital/optical technologies for cost, size, power and performance improvements; antenna and waveform techniques for improved LPE Comm; and improved methodologies and facilities for real-time experimentation and validation.

The exploratory development program in communications is supported by basic research programs investigating advanced algorithms for signal processing, algorithms compatible with VLSI/VHSIC implementations and optimal multi-domain spatial/temporal processing structures. Exploratory development emphasizes advanced communications ECCM processors and advanced communications signal processing techniques.

The development of Advanced Adaptive Communications ECCM processors exploiting newly emerging analog/digital/optical technologies and advanced signal processing algorithms and architectures are being pursued for applications in spatial signal processing, channel equalization, matched filtering and spread spectrum.

Advanced Adaptive processors are being developed for extreme jammer environments where very deep wideband nulls are required. The development of an extremely wideband high dynamic range processor based on Acoustic Charge Transport (ACT) technology is on-going for application to spread spectrum/ LPE Communications.

Devices have been designed, fabricated and tested to show that efficient devices with great bandwidth and large dynamic ranges can be built using the acoustic charge transfer principle. The effort developed the initial device concepts from theory into operating integrated circuit chips.

Improved Communication Signal Processing techniques for advanced SATCOM adaptive arrays are being developed for application to large thinned spaceborne adaptive arrays for Satellite Communications.

An Adaptive Spatial Processing Laboratory Testbed is being developed which will provide the Air Force with a unique state-of-the-art real-time experimental facility to support in-house investigation and comparative evaluation of existing and newly proposed adaptive spatial processing concepts using actual adaptive hardware and interference signals. A key element of the testbed was the development and integration in FY84 of a high performance Flexible Adaptive Spatial Signal Processor (FASSP) which can implement a wide variety of adaptive processing algorithms and architectures. Experimental capabilities to support evaluation of advanced digital and optical adaptive processors were developed in FY86-87.

Studies of sub-micron VHSIC and GaAs MMIC technologies into Communications system applications were initiated in FY86 and FY87.

ELECTROMAGNETICS improve the performance of AF C3I systems by advancing and improving electromagnetic technology for antennas, RF components, the electromagnetics of targets and environments, and propagation.

The Antenna subthrust is divided into two major areas: Antenna Pattern Control, and Conformal and Hemispherical Coverage Antennas.

The program in Antenna Pattern Control addresses primarily ground and airborne radars and communications antennas. Support to ground-based surveillance Radar programs and the Advanced Airborne Surveillance Radar program forms the core of the antenna pattern control effort and includes efforts that address a wide range of technical issues pertinent to future radar syste . Continuing studies address the limits of achievable antenna pattern control, in terms of sidelobes and wideband null depth, and the potential of digital beamforming systems for tactical radar.

The program in Conformal and Hemispherical Coverage Antennas has the goal of developing antenna technology for airborne SATCOM terminals. Present emphasis is on EHF and the MILSTAR system. The program includes monolithic receive-array development at 20 GHz and monolithic transmit-array development at 44 GHz. These programs represent, perhaps, the most advanced antenna development work anywhere in the government. As a result, the work has attracted Navy, Air Force and ESD/MILSTAR interest and support. Also included in the task, is the preliminary study and partial development of a 44 GHz hybrid component antenna array. This work serves as a backup, lower risk technology in the event of delays in the fully monolithic development program. Other antenna technology includes the development of an SHF 16-element, ultra low loss, lightweight demonstration array for aircraft SATCOM.

The RF Components subthrust furthers technology development in the areas of Monolithic Microwave Integrated Circuits (MMIC) and RF, magneto static, and acoustic devices to provide miniature components critical to a wide variety of C3I systems. Areas of emphasis include phase shifters for phased array antenna beam steering applications, frequency synthesizers, stable oscillator development, miniature variable delay lines, and low loss RF switches.

MMIC phase shifters are required for reliable, affordable phased array antennas in both surveillance and communication systems. These phase shifters offer small size and zero insertion loss independent of phase setting. Frequency synthesizers capable of rapidly hopping over a wide range of microwave frequencies are being developed using advances in low loss bulk overtone acoustic resonator technology. A compact, high technology EHF synthesizer is being developed. A rapidly tunable or agile SAW filter can provide anti-jam for ICNIA. A stablized MMIC local oscillator was developed at EHF using a dielectric resonator to eliminate the oscillator oven presently required in MM WAVE radios.

Electrically variable time delay units are required for steering phased arrays with the wide instantaneous bandwidths required for ECCM and tactical target identification. A continuously variable time delay unit with a volume less than one cubic inch is being developed using magnetostatic wave technology. A stepwise variable microwave acoustic delay line is being developed for both phased array beam steering and wideband direction finding. Low loss diode switches with a power handling capacity of one KW are being developed to enable phased array surveillance radars to achieve ECCM with long coded waveforms. SAW oscillators at UHF are needed as multiple use frequency standards to reduce the present cost of acquiring and maintaining a separate clock on each system.

The Electromagnetic of Targets and Environment subthrust, which is in the field of electromagnetic scattering, is divided into Electromagnetics of Targets and Electromagnetics of the Sensor Environment.

Targets are defined primarily as aircraft and missiles and the sensor environment is defined as the physical terrain in which a ground radar is located and in which a target is to be detected. The main emphasis is on scattering phenomena from shaped targets made of lossy absorbers designated as low observables on scattering from both airborne and ground based antennas, on problems of the physical environment, and on the implications of these phenomena for radar detection.

In the electromagnetics of scattering from lossy dielectric materials, analytic and numerical calculations, plus experimental measurements are applied to the problem of detection of low observables. A data base of monostatic and biostatic scattering properties is urgently needed for radar system detection and tracking of low observable missiles. An analytical effort to develop models of scattering from rough surfaces for a variety of terrain types, to make measurements to provide calibrated clutter data for a data base to use in detection, and to verify model predictions addresses the degradation of radar performance in detecting and tracking low observable, low altitude targets due to both clutter and multipath. A program to reduce antenna cross sections while preserving antenna performance is continuing. The characterization of physical terrain permits the calculation of multipath reflections and their effects on radar performance and allows scattering models and prediction of multipath and clutter in real time to be achieved. Earlier work to predict the optimum site for best ULSA performance is now being applied to siting of the AN/TRC-170.

The Spatially Adaptive Propagation Program is exploring limitations imposed by the ionospheric propagation medium of HF adaptive beam control. Research is continuing to study techniques for altering the ionospheric structure over a limited area, using powerful RF transmitters, for improved control of communication and surveillance systems.

The Propagation subthrust is divided into two areas of propagation technology relating to communications and to surveillance. Efforts in communications exploit characteristics of wave propagation for new communication techniques and to improve the performance of existing systems from VLF through EHF with major emphasis on survivable propagation, HF technology, and SHF/EHF communications.

The survivable Communication Programs address the LF, HF and VHF frequency bands. Low Frequency efforts assess propagation during disturbed ionospheric conditions and include an investigation of the survivability and jamming vulnerability of LF signals radiated from aircraft. Previously specified high-altitude propagation parameters are being applied to propagation models for the evaluation of communication reliability and survivability. HF Survivable Communications is receiving increased emphasis with efforts addressing high-altitude survivability and wideband availability. In the VHF spectrum, the survivability and availability of meteor burst propagation is being investigated. SHF/EHF Propagation Programs are being conducted to determine the limitations imposed by the troposphere on microwave and millimeter wave C3 systems. Theoretical and experimental work is proceeding to improve troposcatter models and to investigate frequency dependency troposcatter.

Propagation for Surveillance involves the detection of targets by means of EM radiation in the radio portion of the spectrum from VLF through microwave frequencies with emphasis in HF. Characterization of ionospheric clutter and its suppression for increased effectiveness of OTH radar systems are being pursued. Spatial and temporal statistical properties of auroral radar scatter are being measured with the aim of developing adaptive clutter rejection techniques.

SOLID STATE DEVICES provide for the development of advanced devices for present and future electronic C3I systems by improving knowledge and techniques necessary to develop system timing components, signal processing devices, electro-optical devices, electromagnetic device materials, and electromagnetic radiation hardening of devices.

The Systems Timing Components subthrust addresses precision frequency standards and clocks to ensure precise time interval and accurate time keeping are available for AF systems. Technical emphasis is placed on quartz oscillators and atomic frequency standards.

The Quartz Oscillator Program is directed toward providing quality quartz materials, resonators and oscillators. Improved over all performance is sought by minimizing aging and temperature effects on stability while reducing cost and increasing reliability. Atomic Frequency Standards research and development embodies development of improved rubidium and cesium standards. A comprehensive Time and Frequency Test Facility is operated and maintained for measurements under ambient and simulated operating conditions.

The Signal Processing Devices subthrust is directed towards the development of advanced infrared imaging sensors for C3I systems. Emphasis is given to devices which are based upon silicon VLSI circuit technology and devices which are used for signal sensing and signal processing. Device concepts that originate in a companion 6.1 task are carried through design to fabrication and test at breadboard/brassboard levels under this effort. Earlier, charge coupled device processing devices with throughput equivalent to 10 to the 9th power 8-bit operation per second were demonstrated. At present, a CCD for two-dimensional image processing is under development in a joint RADC/AFATL program. Phototype VLSI-scale infrared focal plane arrays based upon silicide photodiode technology have recently been completed. These devices are now being characterized. At the same time, they are being incorporated into specialized tactical and strategic sensors under cooperative efforts with RADC/OC, other Air Force organizations, the Army Missile Command and the Naval Weapons Center. RADC Sensor designs have now been adopted by several DoD vendors and the Army directed energy program. These efforts are expected to provide major support to RADC, Air Force and SDI surveillance programs.

The Electro-Optical Devices subthrust provides for the development of electro-optic devices and techniques involving fiber optics as a new approach to data transmission and optical processing to achieve higher speeds and decreased component cost and size, while achieving better reliability to adverse environments. Multimode components, long wavelength sources and detectors, planar couplers, wavelength multiplexers and demultiplexers, and E-O switches will provide a modular approach for high performance, low cost fiber optics military transmission systems.

Optical fibers and cables are being characterized to assure performance of general, as well as intrusion resistant fiber optic links. Optical time domain reflectometry, refractive index profiling, exhaustive measurements and analysis, and optical fiber cable connectors are additional device areas being addressed.

Electrical characteristics to correlate electro-optical performance of photorefractive materials for spatial light modulators are also being pursued for optical signal processing.

The Electromagnetic Device Materials subthrust involves the identification, synthesis, characterization, and growth of materials for effective C3I capability. The synthesis and single crystal growth of InP and the epitaxial growth of InP and its ternary and quaternary alloys are being investigated for the fabrication of source and detector devices for fiber optic systems operating in the 1.2-1.6 micrometer wavelength range. The development of improved techniques for the hydrothermal growth of high purity, low defect quartz for time and frequency devices is continuing. A new family of vitreous materials, the heavy metal flouride glasses (HMFG), are being investigated as potential radiation hard, low loss optical wave guides. In bulk form, the HMFG have potential as multispectral, low loss, optical components such as lenses, windows, prisms, etc.

The Electromagnetic Radiation Hardening subthrust supports the development of a radiation-hardened electronic technology base and provides technology assessments to AF system offices.

The program in this subthrust is centered around LSI memories and digital logic circuits. Radiation induced failure modes are identified to support the hardening program and to provide data on advanced technology to SPOs. MESFET and POSFET technologies offer great potential for hardened VLSI. Demonstration circuits hardened to satellite radiation specification levels will be fabricated and tested to show progress and prove the compatibility of hardening techniques used with standard circuit fabrication methods.

RECCE/INTEL provides technology for improved automatic, real-time techniques and equipment to record, process and analyze intelligence information by pursuing developments in wideband recording, speech processing, expert system intelligence analytical methodology, and C3I data base techniques.

Improved recording and data handling techniques are required for the timely processing, storage and dissemination of extremely high rate data, large volume digital information.

In the Wideband Recording subthrust, the successful integration of the first optical disk "Jukeboxes", "10 terrabit" memories have stimulated an even greater desire to now place this versatile concept into operational scenarios and finally into the Space Station. During FY86-87, exploratory development will reduce the risk factors in placing optical disk technology into operational shelters, vans and eventually reconnaissance airborne environments. The 6.3 Tactical Optical Disk (TODS) program will be initiated in FY87 to develop and deliver a family of optical disk capabilities for these applications During FY 86-87, this concept will also be exploited to develop an "Erasable Disk Buffer System" for Fifth Generation, Strategic Computing Applications. Goals include 10/12 storage capacity, extremely high performance buffer systems for super computers at 1.6 Gigabit per second throughput rate. FY 87-90 will extend this technology for Space Station applications. All Programs will include the capability of read/write and erase and include investigation into radiation hardening and electromagnetic Pulse Protection of mass storage devices.

For SIGINT applications, Bragg Cell Optical Recording technology will be evaluated in an airborne environment. A 200 MHz analog recorder has been delivered in the second quarter of FY86. FY 86-90 critical component technology will be exploited to extend recording information bandwidths to 1000 MHz.

Magnetic Perpendicular Recording will also be exploited to demonstrate extended data rate and packing density capabilities for this discipline.

Research in Acoustic Phonetics investigating connected speech work segmentation, intra/inter speaker variability, and coarticulation effects and exploratory development in Narrowband Speech Transmission, Speaker-Independent Connected-Speech Recognition, Voice Data Entry, and Interference-Reduction techniques for cockpit voice control constitute the technology base in the Speech Processing area. Additionally, speech processing technology in the SIGINT area supporting COMINT exploitation develops on-line, real-time, multiple-channel and miniaturized speech processing technology as automated capabilities for analysts exploiting voice traffic.

In the knowledge-based intelligence systems subthrust, developments will study, demonstrate, and prove application feasibility of knowledge-based systems to aid the intelligence analytical process. In the area of artificial intelligence, techniques such as knowledge acquisition, knowledge representation, and knowledge engineering will be applied to specific intelligence domains. Knowledge-based systems are being applied to operational functions such as space missile foreign launch assessment, collection requirements management, and mobile targets. The Intelligent Analyst System concept/technology development will continue through FY90. The Anti-Satellite (ASAT) knowledge base will have expanded to allow predicting of ASAT for all space foreign launches. Work will continue in the development of modeling aids for Indications and Warning (I&W), Key new starts include; Knowledge Engineering for Mobile Targets, Collection Planning Aids and Knowledge Engineering for Space Situation Assessment.

The C3I Data Base Techniques provides technology to increase utility and responsiveness of data base management systems to C3I problems. Concepts and techniques for survivable data bases, data base machines, active data bases, automatic data base generation and distributed data bases are being expanded. New activities include: Source Data Acquisition and Validation, Automatic Data Base Update for Message Handling, Knowledge Representation for Intelligence, and Data Architecture Concepts for Data Base Utilities.

RELIABILITY, MAINTAINABILITY AND COMPATIBILITY encompasses the technology base development of solid state device reliability, equipment/system reliability and maintainability, and electromagnetic compatibility to improve the operational readiness of AF electronic systems. In addition, the DOD VHSIC program support is associated with this thrust, as well as the electrical test and on chip testability technology with emphasis on test structures essential for characterizing and evaluating complex devices.

Research foundations in the Solid State Device Reliability subthrust are being established in advanced physical analysis techniques and in the fundamental mechanisms of device failure. Reliability physics technology and failure mechanism analysis which build on the research foundation, are being continued under exploratory development. Studies concentrate in reliability assessments of technologies, analysis of mechanisms, and assessment of methods required to understand and reduce the frequency of failures in submicron and VHSIC devices. Independent studies will concentrate on reliability assessment of the failure mechanisms found in Very Large Scale Integration (VLSI) devices, such as electromigration, contact resistance, time dependent dielectrics failures, hot carrier effects and package related problems of solderability, die attachment and lead bonding.

The ability to control interface chemistry will lead to packaging and passivation technology for satisfactory life-times for VLSI and ULSI devices to the late 1980s and 1990s. The Quality & Reliability Assurance (QRA) techniques work will concentrate on methods for assessing and controlling the quality, electrical performance and reliability of custom devices, Gallium Arsenide Logic and the application of reliability test elements for accomplishing complex device qualification. Electrical characterization will include VLSI, RAMs, EEPROMS and Advanced Signal Processing Devices to fill the needs of C3I systems now being developed. The Electrical Test Techniques and Testability effort utilizes an in-house computer simulation capability to develop techniques that will reduce the time and cost associated with microcircuit test development and improve the overall fault detection coverage.

The technology base for assuring the reliability of VHSIC devices is covered under Advanced Testing Software, Test Technology, Qualification Procedures, Interim and Advanced Test Capability. The object of this thrust is to provide the methods, procedures and test equipments that will assure the reliable performance of VHSIC Phase I microcircuits in DOD systems.

Finally, a test program for the monolithic microwave integrated circuit (MMIC) Conformal Array Module (CAM) will be initiated to assess mechanisms that contribute to reducing operational performance and development of specifications, quality control procedures and test technology for the effective insertion of MMICs into military systems.

The EM Compatibility subthrust addresses the technology base necessary to provide a high assurance of EMC for AF electronic equipment, subsystems and systems in addition to provide EMC support to RADC, ESD and other AF agencies. Programs are pursued in EMC analysis, prediction, and measurements and in EMC interference control with the overall philosophy of developing techniques and methodologies to assess and control EM interference within AF electronic systems.

Major emphasis over the next several years in the EMC analysis, prediction, and measurements sub-thrust will be the development of analytical and experimental techniques to assess the susceptibility of high-speed, high-density integrated circuits to EM noise.

The upper bound of potential EMI problems has increased with th introduction of super high and extremely high frequency (SHF/EHF equipment on C3I platforms. In the EHF Coupling Models area we wil develop the analysis tools to model C3 systems and accurately predic complex propagation losses due to electromagnetic effects and geometric constrains in the 8 GHz to 45 GHz range.

The Equipment/Systems Reliability and Maintainability subthrust addresses techniques for predicting, demonstrating and improving reliability and maintainability for increased operational readiness and low life cycle costs of AF systems.

Nonoperating failure data was collected and models were developed for all environmental conditions under which the nonoperating periods may occur. In addition, a technique was developed for modeling the reliability of a system taking into account all periods of operation and nonoperation during its life. Techniques were developed for allocating diagnostic resources among automated types, support equipment, and manual types. Diagnostic errors are able to be reduced improving operational readiness. Development of practical design concepts for improving system diagnostics by using Smart Built-in-Test (BIT) was investigated. Artificial Intelligence (AI) programming methods applicable to the BIT problem were designed which identified and reduced the incidence of BIT false alarms and intermittents. New thrusts being initiated address the impact of fault tolerance on system Reliability/Maintainability/Testability, using Computer Aided Design for BIT in developing BIT software modules, and developing AI techniques to reduce false alarms.

Emphasis will continue on the reliability assessment of advanced technologies and cost effective methods of designing in reliability and maintainability. Application of Artificial Intelligence techniques will enhance testability design. VHSIC impacts on system reliability and maintainability will be determined. A concentrated effort to computerize the generation of test specifications will be continued.

COMMAND AND CONTROL TECHNOLOGY - is responsive to the data processing needs of Air Force command and control (C2). Inadequate software technology advancement is the main deterrent to realizing the full potential of automation in C2. Further, the decentralization of computer resources for survivability and increased effectiveness, trusted systems for classified information, and computer assistance in human decision making have all been hampered by inadequate software technology. To combat these problems, software, system architecture, and decision aids/artificial intelligence are being explored.

The software subthrust addresses Software Engineering, High Order Languages and Computer Security. In the Software Engineering area, improved C3I and system performance, quality, and reliability are achieved by addressing the C3I Environment, System Definition Technology, and Software and System Quality. Automated software tools and methodologies are under development in the C3I software environment area.

A C3I Support Environment will provide integrated development, support, and management tools for the entire life cycle. In addition, test and verification techniques for the Ada language is being developed. The Ada oriented products will be available to Ada based environments and the C3I Support Environment. An approach to Ada software test and verification was completed in FY85 and is being followed by an implementation effort. One key attribute of the C3I Environment will be to establisn life cycle traceability and management. Life Cycle Impact Analysis Techniques will enable software developers to determine the impact of changing requirements and other life cycle phase modifications on software. Out-year activities will further refine and enhance the C3I environment by providing user support documentation, new tools and techniques for software development, and management visibility and control for the software development process. A C3I Support Environment User's Guide will enable software developers and acquisition personnel to effectively utilize the environment. Enhancements to the baseline configuration are being developed, as required, to support C3I mission-critical software and is being systematically integrated with the baseline. It is anticipated that an instance or subset of the environment will be transitioned to the ESD Software Center of Excellence or Software Technology Transfer Center for use by ESD program offices and/or their contractors. Thus, the environment will meet Air Force objectives for both software technology transfer and insertion.

System Definition Technology is being developed to address critical issues in the early phases of the life cycle. Two technology thrusts in this area are directed at establishing user requirements and assuring users that all mission-critical needs will be met by full scale development programs. Automated tools are currently available for requirements analysis. In FY85 an effort was completed which will provide guidance to developers in the proper selection of tools and techniques that represent state-of-art solutions. An effort begun in FY84 will enhance the Software Requirements Engineering Methodology (SREM) user interface to provide a graphics oriented view of software requirements and to produce SREM outputs which are more compatible with Air Force Standards for specifying software requirements. The second thrust in this area will provide a rapid prototyping capability to enable the user to more clearly define software requirements prior to full scale development and will complement automated requirements techniques. A C3I Rapid Prototyping Investigation is being continued in FY87 which will specify a baseline capability for prototyping C3I software and will lead to the reusability of C3I specifications and designs. A Very High Level Language prototyping tool was initiated to more closely match mission oriented problem and requirements analyses with automated techniques. Demonstrations will be conducted to validate the prototyping approach and interactions between software developers and users. The out-year program in this area will further improve problem and requirements statement languages by addressing Natural Language Requirements Translation to improve overall response time and coverage. This work will also mesh with artificial software assistance and Automated C3I Software Synthesis.

In the Software and System Quality area, emphasis is being placed on the specification, prediction, and assessment of software quality. Software Quality Measurements are being developed to facilitate this process. Guidance for software acquisition personnel to obtain required/desired software quality attributes and the development of software quality baselines for use in comparing existing and planned developments are being pursued. These assessments will enhance the Air Force's capability to more accurately determine the degree of confidence in delivered software and to what extent system requirements are being met. Work initiated in FY84 to improve Methodology for Software Reliability Prediction will continue. The products from this task are being merged with those from cooperative programs in system reliability combining hardware and software contributions to system reliability, maintainability, and supportability. In FY86 work was completed on the Specification of Software Quality Attributes. The guidance produced under this effort is being disseminated to all Air Force software acquisition project offices and agencies. An effort initiated in FY85 will assist in metric data collection and analysis by developing an Automated Measurement System to reduce the manual and error prone techniques applied in the past. Another effort will augment the C3I Support Environment described above by instrumenting software quality measurements over the life cycle and thus contribute to management visibility in the process. Experiments and demonstrations are continuing in FY87 to validate the current metric set and to promote the development of system software baselines. The out-year program in this area will focus on refining baselines, further automation of data collection and analysis, Ada specific quality metrics, and testbed capabilities for improved software quality assessment. The Data and Analysis Center for Software (DACS), now an official DOD Information Analysis Center, will expand its role in this area to serve the software engineering research community as well as a wide range of customers with application specific needs.

In the High Order Language area, the Ada Integrated Environment (AIE) is the focus for development of Ada compilers and programming support environment that will provide initial capability for Ada software development in the AF.

In FY85, functional designs for a comprehensive Ada test and verification tool were initiated for incorporating state-of-art techniques for testing Ada software. Actual development of the tool were initiated in FY86 under the Ada Test Tool Development and Demonstration Program.

In the Computer Security area, the emphasis is on technology demonstration and on verification technology. The Trusted System Development and Demonstration task is demonstrating maturing technology in trusted system development via a security interface between multi-national intelligence processing systems within the KAIS for PACAF, and a trusted multi-level information management within the KAIS for PACAF, and a trusted multi-level information management system for MAC. Tools and procedures for the formal specification and verification of trusted hardware and software for AF multi-level security applications and requirements will be developed and documented in guidebooks.

Generic computer security research and development will emphasize the areas of secure distributed processing, secure database management and formal verification technology in support of survivable, strategic C3I technology.

A new generation of security models, methods, and formal languages will lead to the implementation of a Second Generation Formal Security Specification/Verification Methodology for C3I. In addition, several technological developments are being pursued which address secure data base management systems, secure relational database management systems, and secure distributed systems with multi-level security.

Finally, the AF is cooperating with the Army in the development of a Multi-level Secure Operating System for Nebula (MIL-STD-1862) computers.

The System Architecture subthrust addresses one of the prime attributes of future C3I systems; namely, dispersion of physical resources to enhance survivability, in particular, decentralization of computer resources and data. Since within a C3I system, the primary objective is to accept, process and present data to a decision maker, both system attributes as well as data dependent attributes must be considered.

The efforts within this subthrust encompass all data processing components within the C2 system as well as the linkages between components.

The Distributed System Control Structures area represents a group of efforts addressing basic issues of resource control in a distributed system and will provide basic guidelines for the design of various classes of distributed system control structures. Successful development of basic control strategies will lead to more advanced and adaptive control structures in FY86 and beyond.

A Distributed Operating System (DOS) prototype effort is providing for definition, design, implementation and evaluation of a prototype DOS and is also providing a demonstration facility. Technical issues related to Distributed System Interoperability are being addressed, in particular, the issue of communication gateways between the local area nets as well as the interoperability of the high levels of protocol. The goal is to support distributed applications spread among several nodes of internetted systems. The result should be a set of Intra-System Protocol Modules. Development of survivable C2 System Elements must provide for a minimum level of performance, that is, graceful degradation and reconfiguration of processing resources to accommodate losses in data processing nodes and/or communication links. During FY85 a Distributed Operating System Testbed was implemented at RADC to support the integration and evaluation of several technology products.

The Intelligence Information Systems Concepts work seeks to adapt the distributed system technology to intelligence application to support concepts such as inferential processing, deductive reasoning and knowledge based processing. Using this analysis and System Architecture Evaluation, an Intelligence Network Architecture will be implemented and evaluated. Distributed Systems Modeling/Simulation, critical to development of distributed processing, provides Performance Models and Survivability/Reliability Models which simulate partial outage modes and communication links within the system and determines the effect on system performance. To provide a vehicle to integrate the various technologies applicable to C2, the implementation of a C3I System Evaluation Facility has been undertaken. The nucleus for the system is a C2 Facility which has been constructed and was populated with necessary hardware and software for IOC during FY85.

Allied with the computer security sub-subthrust is the computer architecture technical area consisting of investigation of advanced highly fault-tolerant computer architectures and investigation of 32-bit computer environments suitable for AF systems. The standard environments for 32-bit computer effort are to define and qualify sets of environments that will satisfy Air Force needs; then develop benchmark programs and procedures which would test various manufacturers' computer systems to determine how well they support the specific environments. The benchmark programs will first be checked out on the MIL-STD-1862 brassboard which was delivered in the first quarter of FY85.

Finally, Advanced Computer Architecture Technology for C2 addresses post-1990 AF requirements and matches these to the technology that can be expected to be in place in that timeframe. The activity tends to look for revolutionary rather than evolutionary approaches to implement computer systems, such that orders of magnitude improvements can be realized in both performance and fault tolerance. The longer term activities anticipate the increased use of VHSIC technology in embedded computers and the increased use of artificial intelligence and decision aids to manage the computing resource itself.

The Decision Aids/Artificial Intelligence subthrust addresses the development of functionally flexible, responsive and user adaptable decision aids using advanced computer information processing and display technology and Artificial Intelligence (AI) technology to assist the C3I decision maker.

The C2 Decision Aids Development Program emphasizes tactical decision aiding, critical strategic functions, and transition of decision aid technology into operational C2. The Tactical Decision Aiding Program is developing a complement of Decision Aids to improve information utilization to achieve more timely and effective command and control. The Integrated TACC will provide more effective horizontal information flow within a TACC, and establish the basis for an advanced concept for the future TACS.

At higher command level, Senior Battlestaff Decision Aids will assist battle commanders to assess apportionment of resources and the impact of action and counteraction of various battlefield options. The initiation of a parallel development program in Strategic Targeting/Reconstitution

Decision Aids is being pursued. Basic analysis and technology-problem domain matching techniques are being applied to defining, designing and complementing Strategic C2 Decision Aids.

Option Generation Aids will produce the tools and environment to aid military decision makers in formulating and evaluating options for courses of action and then selecting the best action. Means of transitioning decision aids technology to a diverse set of end computer support C2 systems and a diverse set of users is being addressed through development of a Decision Aid Development Tools Environment, which when integrated with standard C2 development environments allow developers to build decision aids under competitive procurement constraints; through evaluation techniques for decision aids which provides for pre-operational test and evaluation of decision aids; and through user integrated aids which will provide for greater user acceptability of decision aids in addition to greater ease of learning and effectiveness.

An advanced development effort, Tactical Expert Mission Planner, using knowledge based mission planning concepts from the exploratory development KNOB program will expand the mission areas from Offensive Counter Air to include Defense Counter Air, Battlefield Air Interdiction, Combat Air Patrol and Close Air Support and develop an advanced technology aid compatible with field application. Additional advanced development work has been continuing to extend programs dealing with the identification of Command and Control to support a C3CM planner.

The multiple objectives of the Artificial Intelligence (AI) program are directed toward the solution of Air Force problems found in command, control, and intelligence. Expert Systems are one AI technique for providing intelligent and automated support. The research and development program in this area of AI is attempting to make this particular technique more readily available to systems developers by providing a development guide, a standard framework, and an engineering environment, as well as demonstrating the applicability of this technology in several space related applications. These products will facilitate the development of expert systems by individuals who are not experts in AI. Intelligent man/machine interfaces which place a greater burden on the computer for communicating ideas and commands will reduce specialized training commonly required to use and maintain complex Air Force computerized systems. The benefits of this type of interface have been shown as part of the demonstration of knowledge-based mission planning. Research in natural language/intelligent interfaces will provide an advanced capability for generating such intelligent system interfaces. These may then economically become a part of any system development. Research in planning technology will eventually provide automation to the presently labor intensive problem of missions. Dynamic planning (replanning) and distributed planning will also be investigated using the tactical mission application. This technology may be directly applied to other mission applications as has been shown by both NASA and the US Navy. A major thrust of the AI program is directed toward the ultimate automation of the software life cycle. This technology may be directly applied to all software system developments with a resultant dramatic improvement in cost effectiveness. Initial products will be individual knowledge-based assistants for particular programming languages such as Ada, and will be used in conjunction with standard programming environments. The development of an integrated Knowledge-Based Software Assistant will eventually revolutionize the software paradigm by providing an intelligent environment supporting the total software life cycle. Underlying these major thrusts in applying AI technology to Air Force problems is the need to advance the state-of-the-art of AI. Efforts in logic programming, knowledge base management, and logic programming seek to provide improvements in both usability and performance of the tools used in AI developments.

The approach taken in pursuing expert systems technology is to develop guidelines for matching problems to techniques, to develop a framework which is sufficiently common to support problems with varying characteristics, and to develop an environment (tools) for engineering expert systems. In addition, efforts will be funded by DARPA which will focus on achieving advances in the following areas: explanation and presentation capability; ability to handle uncertain and missing knowledge and data; fusion of information from several sources; flexible control mechanisms; knowledge acquisition and representation; expansion of knowledge capacity and extent, enhanced inference capability; exploitation of expert systems on multiprocessors architectures; and development of cooperative, distributed expert systems.

Current research assessing the present state-of-the-art will serve as the basis for development of tools for the generation of intelligent systems interfaces and the ability to provide natural language explanations from facts and inferences. These generic tools will then be available to builders of AI systems.

The Knowledge-Based Software Assistant program consists of a number of individual efforts directed at developing automated intelligent assistance for particular facets of the software life cycle by formalizing the processes of each facet. These components will then be integrated to create a totally integrated environment supportive of the total software life cycle.

Efforts focused on advancing AI technology will include basic research to develop techniques for acquisition of knowledge from multiple distributed sources and efficient virtual storage and knowledge base management, and development of high performance logic programming systems.

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TITLE OF TPO: SPECIAL PROJECTS

As the name implies, the projects reported in this TPO are special in nature in that logic does not permit their inclusion in the other TPOs. The projects reported are every bit as important to the Air Force as any other but are of a general test and evaluation or support nature.

SYSTEMS/EQUIPMENT EVALUATION provides for highly instrumented, unique and cost-effective facilities for systems/equipment evaluation. These facilities, which include the Electromagnetic Compatibility test annexes, provide for test and evaluation in support of the improvement of weapon system performance and for the reduction of test, evaluation and modification costs.

The HAVE NOTE subthrust is the Air Force continuation of the DOD Special Electromagnetic Interference Program and provides the Air Force with the capability to determine the electromagnetic susceptibility/vulnerability (EMS/V) of air-launched weapon systems to ensure deployment without mission failure from system degradation caused by radiated electromagnetic energy. It provides the Air Force with an improved test and evaluation (T&E) capability to perform EMS/V assessments on selected weapon systems by integrating an environmental threat analysis, high power radiation measurements, and analysis of special electromagnetic interference, utilizing telemetry, instrumentation and computer simulation.

Ultimately it will provide the Air Force with improved EMR methodology, analytical tools and modeling techniques to insure that the latest lessons learned during HAVE NOTE and other appropriate EMR related T&E are transitioned to weapon systems.

The C3 and Protective Systems subthrust provides for highly instrumented antenna evaluation facilities capable of providing extremely accurate cost effective fine grain data for use in the design and development of C3 and electronic warfare antenna systems.

RADC's highly instrumented antenna facilities include dynamic measurement capabilities on the Precision Antenna Measurement System (PAMS) located at the Verona test Annex and static measurement capabilities at the Newport and Stockbridge Test Facilities.

The PAMS Facility accommodates all aircraft types since dynamic antenna measurements are performed through flight testing. The F-4C, D, and E; EF-111A; A-10; F-15; and F-16 airframes are currently available at Newport for antenna evaluation programs. In addition, C3 antennas and aircraft sections are accommodated. A B-52G airframe is mounted at the Stockbridge Facility and a KC-135 airframe is also available for measurements.

The Techniques and Systems Evaluation subthrust provides for expertise for development and implementation of facilities, techniques, instrumentation and procedures for test and evaluation through all phases of system definition, development, acquisition and deployment.

RADC possesses specific test expertise and highly instrumented off-base test facilities to support AFSC directed Center managed programs. These capabilities are integrated into matrix management of Center programs which require test and evaluation.

PHYSICAL SECURITY SYSTEMS (PSS) has the basic mission of detection, identification, and location of unauthorized or potentially hostile personnel and vehicle intrusions into controlled, secure, or protected areas.

Three subsystems visualized to accomplish this mission are a detection subsystem, an imaging subsystem and an entry control subsystem. The overall program objective is to perform technical feasibility (exploratory development) and system validation (advanced development) and provide Type B product specifications and support data for electronic equipment and system segments which are to constitute a DOD standard Physical Security System. The functional role is to provide an adjunct to man-oriented security and defense methods through surveillance and detection as well as identification and control of entry to secure areas.

Efforts under the imaging and entry control subsystem were completed during FY85. No future work under these subsystems are anticipated.

The detection subsystem encompasses Defense Nuclear Agency (DNA) funded exploratory development of concepts to enhance the detection capability and reliability of ported coaxial cable sensor systems by the addition of an antenna(s), and the development of RF sensor concepts to provide a lightweight all-weather intrusion detection sensor. Additionally the detection subsystem encompasses Physical Security Systems Directorate (PSSD) funded advanced development involving technical support to the Waterways Experiment Station for ported coaxial cable sensor test and evaluation and the analysis of vulnerabilities of developing RF sensors with future efforts involving recommendations to PSSD on RF advanced development work and effective transition to other agencies.

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FACILITIES

Summary: Over the years, RADC has acquired a number of unique research and development facilities. These facilities, located on Griffiss and Hanscom Air Force Bases and throughout New York State and Massachusetts represent a significant investment and as new programs and technologies emerge, they are updated, replaced, and expanded. The major existing facilities are discussed below.

GAFB: ON-BASE

Cartographic Research Facility - This facility has been created to determine the effects and interplay of new prototype equipment introduced into the automatic cartographic process. This facility, in fact, simulated a major portion of the cartographic functions, permitting realistic evaluation and improvement through advanced automation, equipments and techniques.

RADC Surveillance Laboratory (RADSL)

The primary objective of the RADSL is to provide a multi-domain programmable adaptive surveillance radar environment to experimentally and analytically evaluate how the performance of radar systems and processing concepts vary as a function of parametric variation of frequency, polarization, waveform, signal bandwidth, etc. The RADSL presently contains two transmitter-antenna- receiver systems covering the L and S frequency bands 1200 to 3700 MHz. The L-Band is a surveillance system and the S-Band is a dual Polarized Tracking system. An additional system, a Phased Array, operating at C-Band (frequency range from 5.5 to 5.9 GHz) will be installed in early 86. The simulation, analytical and data processing capabilities presently consist of two VAX-11/780 PUs with 4.5 megabyte memory, and a Hewlett Packard 1000 series mini-computer which controls the programmable radar hardware and software.

RADC High Power Laboratory - This facility, a national one-of-a-kind facility, provides for the design, fabrication and evaluation of extremely high power switching devices; pulsers and entire RF transmitters for application to radar and other technologies. A transmit/receive module evaluation facility incorporates the latest state-of-the-art for measurement of module parameters.

Digital Communications Experimental Facility (DICEF) - This is a highly flexible and unique system evaluation facility to conduct experimentation in digital communications network technology. DICEF uses simulated multiple media paths for real time testing of equipments and networks, with subsequent indepth analysis. Voice packet and message switching is integrated with DICEF transmission networks to provide a system level experimentation capability. In addition to simulated paths, real communication paths originated at off-base sites are used by connecting

DICEF to the RADC Satellite Terminal, the Ava/Stockbridge HF Test Sites, Autovon Terminals, the RADC Tropo Range, and the GAFB Verona-Stockbridge EHF Microwave Range.

Reliability Analysis Center - This facility, used in conjunction with the Equipment/System Reliability and Maintainability program staffed by personnel under contract from the Illinois Institute of Technology Research, is the DOD focal point for the collection, analysis and dissemination of reliability experience information on solid state devices, non-electronic parts and systems/equipment. This DOD Information Analysis Center is funded by the Defense Logistics Agency.

Solid State Device Reliability Laboratory - This complex consists of specialized facilities, each unique in their capability for reliability testing of solid state devices.

The Product Evaluation Laboratory provides for the development and application of the chemical and structural product evaluation methodology required to assess the factors affecting the quality and reliability of solid state devices.

The Failure Analysis Facility is the focus of detailed analysis of microcircuits which have failed during systems acquisition or field operation. In addition, new methods of analysis are developed to permit accurate assessment of the failure mechanisms affecting emerging device technologies.

Facilities are also available for Environmental Stress Testing and Automated Electrical Testing of a wide variety of developmental and mature technology microcircuits. Data generated in these test facilities is used to develop more effective accelerated stress reliability tests, identify device operating limits, evaluate inspection and quality assurance procedures and provide direct guidance to various military electronic system designers and users.

The Microcircuit Testability Laboratory provides RADC with the capability for simulating, testing and analyzing the electrical properties of complex devices. In addition to hardware testing equipment, software tools are used to model device architectures and thereby establish effective reliability testing procedures.

Electromagnetic Compatibility Laboratory - This facility is equipped with a complete line of State of the Art microwave and millimeter wave RF instrumentation equipment and anechoic and reverberation type chambers necessary to support both the exploratory and advanced development and support activities within the Compatibility and Measurement Division. The Electromagnetic Compatibility Analysis Facility (EMCAF) provides a simulated high power electromagnetic radiation environment to support susceptibility/vulnerability testing and analysis of Air Force C3 and weapon systems. The EMCAF consists of a large anechoic chamber and two shielded rooms which house the high power RF sources and signal monitoring equipment. In FY87, a newly developed reverberation (or mode stirred) chamber capability will be added to the facility. The EMCAF is capable of testing weapon systems up to 20 feet long over a frequency range of 50 MHz to 18 GHz. All functions including RF sources, instrumentation, and data reduction are under computer control. The EMC laboratory also supports EM effects measurement and analysis of advanced digital (VLSI/VHSIC) and RF (MIC/MMIC) type microcircuit technologies.

RADC OPTICAL ENGINEERING LABORATORY

The OCS Optical Systems Engineering Lab (OSELab) is an applied research facility which performs advanced electro-optical surveillance technology development, and provides technical program support for the Electro-Optical Surveillance Directorate and other government agencies. The lab supports investigation of basic technology design, fabrication, and testing of optical surveillance subsystems. The current technology thrusts include control of wide field-of-view (WFOV) adaptive optical surveillance devices, optical phased arrays and advanced passive conventional and unconventional imaging systems including spare arrays. Other thrusts include technology for spare optical arrays, large optics polishing and surface measurements and demonstrations of adaptive optical systems technology. The lab provides 2000 square feet of space divided into functional areas and interfaces with a VAX/780 minicomputer, Hewlett-Packard 9836-6944 data acquisition microcomputer, a Masscomp MS-560 computer, and single board computers. IMSL, optical design and optimization, optical analysis and interferometric analysis, optical system scattering, system optical quality, and generic and specialized electro-optical system modeling computer codes are available.

Command and Control Technology Laboratory (CCTL)

RADC's C nand and Control Technology Laboratory brings together a distributed C3I laboratory environment into a test and demonstration capability unequalled at any other Air Force facility. Netted together are specialized laboratories in the Center's Surveillance, Intelligence and Reconnaissance, Command and Control, Communications, and Reliability and Compatibility Directorates.

In the battlefield environment of today and the future, the ability of military commanders to make effective use of continually and rapidly changing information is a critical requirement. At RADC, research is underway to develop artificial intelligence and decision aid techniques to facilitate the information sorting and data manipulation procedures supporting the commander's decision process. This technology is also being integrated into and transitioned through the Command and Control Technology Laboratory in support of strategic, tactical and space battle information management.

The Command and Control Technology Laboratory is a showcase of high-speed computer hardware, including several main-frame processors, high-resolution color graphics, and large-screen displays.

Symbolic processors are used to incorporate artificial intelligence into the demonstration/test and evaluation process. Decision aids implemented on various personal computers are also key ingredients to the process.

Research at RADC will focus on demonstrating technology tools in the Command and Control Technology Laboratory, with the intent of rapidly transitioning these capabilities to potential users for development of, and deployment in, operational systems. Vital to the overall technology development and transition process is effective interaction between the user and the developer in foccusing technology directly on operational requirements. The goal and ultimate worth of the CCTL is predicated on this accomplishment.

MOBILE COMMAND AND CONTROL TECHNOLOGY LABORATORY:

A mobile extension to the facility, the Mobile Command and Control Technology Laboratory, is equipped with militarized computers, color graphic displays and support equipment. Deployed with this mobile unit is a satellite communications terminal to provide the communications with the Command and Control Technology Laboratory.

The Mobile Command and Control Technology Laboratory can provide an interactive link to operational forces around the globe. The operational user can obtain firsthand experience in state-of-the-art C3I developments available through the laboratory environment. This mobile capability significantly enhances the opportunity for user involvement in the research and development process.

GAFB: OFF-BASE

Forestport Research Site - This facility contains the VLF Experimental Site which is a unique facility for pursuing survivable communications techniques of vital importance to MEECN.

Newport Research Site - This facility is a truly one-of-a-kind facility which provides for versatile and accurate measurement of free space antenna characteristics. The facility is a combination of several ranges in a relatively quiet radio frequency (RF) environment and in an isolated area away from traveled roads and industrial complexes. RADC has full sized shells of an F-4, F-111, A-10, F-16, F-15, and B-52 sections available for mounting on 3-axis positioners with their associated antenna systems. A fully qualified evaluation facility at 500 MHz and below for communications countermeasures, satellite communications, communications ECCM and UHF location systems is also available. A second range for antenna pattern measurements of tactical aircraft F-4, F-15, F-111, F-16 and the A-10 allows RADC to perform simultaneous measurements.

Stockbridge Research Site - This facility provides the environment for evaluation of antenna systems installed on large airframes. A full size B-52 airframe is mounted on a single axis positioner with vertical measurement capabilities being obtained by positioning vertically an elevator with receivers on a tower located 200' away. Elevation coverage up to +90 and multiple interrogator capability for evaluation of electronically steerable and phased array antenna systems are inherent capabilities of the range. KC-135 C-130 Air Frames are also available for antenna measurements.

The Northeast Test Area (NETA) is also located at Stockbridge and provides a capability to evaluate Reconnisaince, Seekers, etc. in a Northeast environment. Tactical and Strategic, both Dynamic and Static targets are provided on the range.

Verona Research Site - This is a highly instrumented facility which supports engineering evaluation of C3 techniques, equipment and systems in the areas of ECCM, radar, communications, millimeter wave research, optical surveillance, electromagnetic vulnerability and airborne antennas. Major capabilities include search, height finder, and tracking radar systems; an advanced optical facility; a precision antenna measurement facility; an experimental troposcatter facility, and a data reduction center.

Ava Research Site - This facility houses a unique, high power HF transmitting facility capable of transmitting up to 300 KW (600 KW peak) through fixed Rhombic antennas, and up to 20 KW (40 KW peak) through both fixed and rotatable antennas in the 4 - 30 MHz band with a variety of radar waveforms. A companion wideband/narrowband receiver system is currently installed at the Verona Test Annex. It operates with both an in-house fabricated 12 element Beverage antenna and rotatable log periodic antenna. The Ava/Verona HF complex supports a wide variety of

HF radar surveillance and communications testing as well as ionospheric propagation research.

HAFB: ON BASE

Materials Synthesis and Development Facility - This facility contains the most up-to-date equipment, and auxiliary apparatus in the Air Force for the preparation of electromagnetic materials. These include conventional Bridgman, Czochralski, and other well-known techniques, as well as new methods being developed, such as skulling, automated Czochralski, hot forging, CVD, Hydro-Thermal, etc. These equipments, which operate over extensive temperature and pressure ranges, are sited in three special buildings designed with gas leak detectors, blow-out walls, and other safety features. This facility, located at Hanscom AFB MA is devoted to the synthesis and growth of new and/or improved electromagnetic materials for C3 applications and directly supports the device activities of the Directorate.

Radiation Effects Facility - This facility is a modern, fully equipped laboratory containing major irradiation sources used for the test and evaluation of electronic materials and new prototype devices. This facility consists of a collection of powerful and sophisticated instruments for irradiating materials and devices for the purpose of evaluating the effects of radiation on these devices and their ability to perform to satisfactory military standards during and after such irradiation.

The facility includes a 23 MEV linear accelerator, a 40 kilocurie gamma ray source, a flash X-ray machine, a 3 MEV Van de Graaff accelerator, a 2 MEV high current dynamitron accelerator and other miscellaneous sources. The facility is unique within the Air Force and is involved in a wide variety of studies for systems offices within the Air Force (ARBES, MX, SATIN IV, MEECN, etc.).

HAFB: OFF BASE

Ipswich Electromagnetic Measurement Facility - This facility is located approximately forty miles northeast of Hanscom AFB and consists of 65 acres and three buildings.

Its mission is threefold: first, to investigate electromagnetic techniques that promise to yield novel antennas and antenna scanning systems of potential value to Air Force communications and radar systems; second, to experimentally investigate the radar reflecting properties of model vehicles and aircraft in order to evaluate their electromagnetic signatures for identification purposes and to experimentally evaluate clutter properties; and third, to provide field test/support for evaluating new electromagnetic sensor concepts.

The site contains an excellent half-mile range for the measurement of microwave antenna patterns. The facility includes an anechoic chamber with a ground screen for precise impedance and antenna coupling measurements and for investigations of radar reflectivity and signatures of scaled vehicles. The Ipswich Site is excellent for field measurements as it provides a wide range of sea and land clutter environments. The facility has low sidelobe antenna evaluation capability.

Prospect Hill Millimeter Wave Facility - This facility, a sophisticated tropospheric propagation facility, is located approximately five miles south of Hanscom AFB MA. It supports the R&D program on the limitations imposed by the troposphere on Air Force systems operating at microwave and millimeter wavelengths. The effects of the troposphere on propagation are studied so that the performance of millimeter wave earth-to-space wideband data links and terminal guidance systems can be addressed. Prospect Hill is one of the few facilities in the world with a capability to conduct accurate refractive bending, troposcatter and millimeter wave attenuation and emission measurements at elevation angles down to the horizon.

Remote Site:

Air Force Maui Optical Station

The Air Force Maui Optical Station (AMOS) is an Air Force Systems Command resource managed by RADC and provides measurement support to various government agencies and to the scientific community. The AMOS complex includes the Maui Optical Tracking and Identification Facility (MOTIF) and the Ground Based Electro-Optical Deep Space Surveillance System (GEODSS) which are sensors of the USAF SPACETRACK network. AMOS and MOTIF share resources and are part of a state-of-the-art electro-optical facility which combines large tracking optics with visible and Long-wavelength Infrared (LWIR) sensors to collect data on sub-orbital, near earth and deep space objects. Equipment at AMOS/MOTIF includes 1.2 m telescopes; a 1.6 m telescope; a 0.6 m laser beam director; two 56 cm acquisition telescopes; infrared sensors; a ruby laser; conventional and contrast mode photometers; compensated and uncompensated imaging systems; IR imaging camera; Low Light Level TV (LLLTV) systems; video, alphanumeric, and graphic display equipment; and data processing systems. AMOS unique measurement capabilities and geographical location makes it an excellent site for observing out-orbital vehicles and rocket experiments launched from Vandenberg Air Force Base (VAFB).

The following other existing facilities complement the major RADC facilities:

AMOS has been instrumental in several successful Strategic Defense Initiative demonstration experiments. The complex continues to expand its sensor suite and support to DOD agencies.

GAFB

Reconnaissance Exploitation Facility, Experimental Photogrammetric Facility, SIGINT Support Facility, Advanced Sensor Exploitation Facility, Speech Processing Laboratory, Advanced Optical Test Facility, Integrated RF Communications Laboratory, Command and Control Guidance Test Facility, Digital Communications Switching and System Control Facility, Adaptive Array Laboratory, Satellite Communications Experimental Facility, Digital Microwave LOS Transmission Range, Experimental Tropo Scatter Range, R&D Computer Facility.

HAFB

Radiation Hardened LSI/Microprocessor Characterization Facility, Experimental Device Fabrication Facility, Electro-Optical Facility, Materials and Devices Characterization and Evaluation Facility, Frequency-Time Test Facility, Microwave Acoustics and Magnetics Fabrication Facility, Antenna Test Range, Speech Research Facility, COMSEC RDT and E Facility.

TABLE 1

RADC Technology Planning Objectives (TPOs)

TPO 1 C3 INTEGRATOR- F. HARITATOS/XPX/3046

A. Common C3	H. Crowley/DC/3401
1. Communications	H. Crowley/DC/3401
A. Long Haul Comm. Networks	J. Pape/DCLD/7751
B. Satellite Communications	M. Messineo/DCCR/3091
2. Communication Security	J. Vetrano/EEV/478-5411
B. Strategic C3	L. Doubleday/DCC/3171
1. Enduring Strategic Communications	D. Spector/DCCL/3077
2. Survivable C3	R. Metzger/COTD/2066
C. Tactical C3	A. Snyder/COA/4175
1. Communications	J. Kelly/DCL/7667
A. Optical Communications	B. Hendrickson/DCLW/4092
B. Advanced Survivable Comm Technology	Lt M. Weir/DCCD/3224
C. Distributed C3	D. Griffith/COAA/4494
D. C3 System Design & Analysis	D. McAuliffe/DCLF/4567
2. Surveillance	F. Rehm/OC/7703
A. Advanced Tactical Radar (ATR)	J. Massoud/OCDR/7684
B. Advanced Airborne Surveillance Radar (AASR)	J. Clancy/OCDE/7559
C. Surveillance Internetting/ID	J. McNamara/OCDS/4441
D. System Support	G. Tippie/OCDR/7684
3. Command and Control (C2)	A. Snyder/COA/7978
A. Constant Watch	D. Griffith/COAA/4494

B. Ground Attack Control Center (GACC) J. Dussault/COAA/4361

INTEGRATOR - N. DIFONDI/XPX/3046

4. Intelligence	R. Cwirko/IRAP/3207
A. COMINT Exploitation	J. Loughnev/IRAA/7672
B. ELINT Exploitation	W. Ziesenitz/IRAP/4581
C. Combat Sensor Management & Correlation	L. Converse/IRRP/2217
D. Electronic Combat	J. Cruskie/COAA/4361
1. C3CM	J. Cruskie/COAA/4361
A. Battle Information Management and Execution	N. Marples/COAA/4361
B. Intelligence C3CM Integration	B. Rydelek/IRAA/7672

TPO 2 RECCE/INTEL INTEGRATOR- N. DiFONDI/XPX/3046

A. Surveillance

B. Correlation/Fusion — C. Clark/IRAE/3037

1. Data Handling — D. Clark/IRAE/3037

A. S and T Data Base — J. Camera/IRAE/3037

B. Analysis and Correlation — L. Kessler/IRAE/7151

C. DOD I and W — G. Barringer/IRD1/3628

D. IDHS — W. Emlen/IRDE/7791

2. Imagery Exploitation — L. O'Dell/IRRE/7787

3. Precision Guidance and Strike Products — J. Palmero/IRRP/7090

4. Special Intelligence

TPO 3 STRATEGIC SYSTEMS INTEGRATOR- D. TARAZANO/XPX/3046

A. Atmospheric Surveillance & Warning	R. Schneible/OCSA/2814
1. Space Based Radar	R. Schneible/OCSA/2814
2. Low Observable (Cruise Missile) Surveillance	W. Wolf/OCTM/4431
3. Intel/Special Radars	V. Coyne/OCS/4157
B. Space Surveillance and Warning	T. Pitts/OCSE/4157
1. Electro-Optical Surveillance	T. Pitts/OCSE/4157
2. Ducted Ionospheric Propagation	R. Cormier/EEPI/478-2968
C. SDI	
1. SATKA	T. Pitts/OCSE/4157
2. DEW	T. Pitts/OCSE/4157
3. BM/C3	Lt Col Anderson/CO/7285
D. ADI	
1. Surveillance	D. Schneible/OCD/7126
2. Command & Control	D. Griffith/COAA/4361

TPO 4 TECHNOLOGY INTEGRATOR - D. NAWOJ/XPX/3046

A. Surveillance	F. Demma/OCT/4016
1. Thermionics	F. Welker/OCTP/4381
2. Signal Processing	J. Graniero/OCTS/4437
B. Communications	W. Richard/DCCR/3224
1. Adaptive Processing for Comm	W. Richard/DCCR/3224
C. Electromagnetics	LTC P. Fairbanks/EE/478-3705
1. Antennas	Dr. R. Mailloux/EEAA/478-3710
2. RF Components	Dr. P. Carr/EEAC/478-3686
3. EM of Targets and Environment	Dr. R. Newburgh/EECT/478-3723
4. Propagation	Dr. T. Elkins/EEP/478-2900
D. Solid State Devices	Dr. F. Shepherd/ESE/478-2224
1. System Timing Components	Dr. N. Yannoni/ESES/478-2224
2. Signal Processing Devices	Dr. F. Shepherd/ESE/478-2224
3. Electro-Optical Devices	Dr. A. Yang/ESO/478-5810
4. Electromagnetic Device Materials	J. Kennedy/ESM/478-4034
5. Device Radiation Hardening	B. Buchanan/ESR/478-4051

INTEGRATOR - N. DiFONDI/XPX/3046

E. RECCE/INTEL	R. Vonusa/IRRA/2263
1. Wideband Recording	A. Jamberdino/IRAP/4581
2. Speech Processing	E. Cupples/IRAA/4024
3. Knowledge Based Intelligence Systems	I. Plonisch/IRDT/3628
4. C3I Data Base Techniques	P. Langendorf/IRDA/7105

INTEGRATOR - D. NAWOJ/XPX/3046

F. Reliability Maintainability and Compatibility	J. Bart/RB/3064
1. Solid State Device Reliability	J. Brauer/RBR/2945

2. Equipment/Systems Reliability and Maintainability	A. Coppola/RBET/4726
3. EM Compatibility	W. Frank/RBCT/2519
4. VHSIC Technology	
G. Command and Control Technology	S. DiNitto/COE/7507
1. Software	S. DiNitto/COE/7507
2. System Architecture	R. Metzger/COTD/2066
3. Decision Aids/Artifical Intelligence	Y. Smith/COAD/7978
A. Decision Aids	Y. Smith/COAD/7978
B. Artificial Intelligence	D. Roberts/COES/3851
4. Command and Control Technology Laboratory	J. Tremlett/CO/7285

TPO 5 SPECIAL PROJECTS INTEGRATOR - J. LIPA/XPX/3046

A. Systems/Equipment Evaluation	R. McGregor/RBC/3076
1. HAVE NOTE	W. Frank/RBCA/2841
2. C3 and Protective Systems	R. McGregor/RBC/3076
3. Techniques and Systems Evaluation	R. McGregor/RBC/3076

INTEGRATOR - R. POLCE/XPX/3046

B. Physical Security	N. Karas/EECS/478-3193
C. Computer Support	L. Comito/ACD/7009
D. Office Automation (LONEX)	J. McNamara/ACM/7204

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RADC plans and executes research, development, test and selected acquisition programs in support of Command, Control, Communications and Intelligence (C^3I) activities. Technical and engineering support within areas of competence is provided to ESD Program Offices (POs) and other ESD elements to perform effective acquisition of C^3I systems. The areas of technical competence include communications, command and control, battle management, information processing, surveillance sensors, intelligence data collection and handling, solid state sciences, electromagnetics, and propagation, and electronic, maintainability, and compatibility.