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TACTICAL RADAR TECHNOLOGY STUDY

Executive Summary

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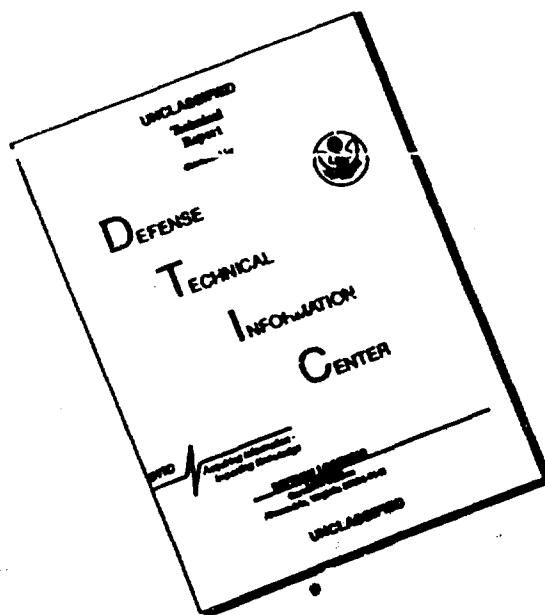
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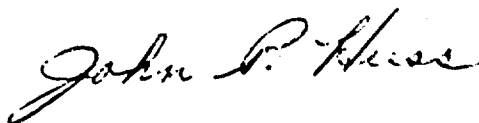
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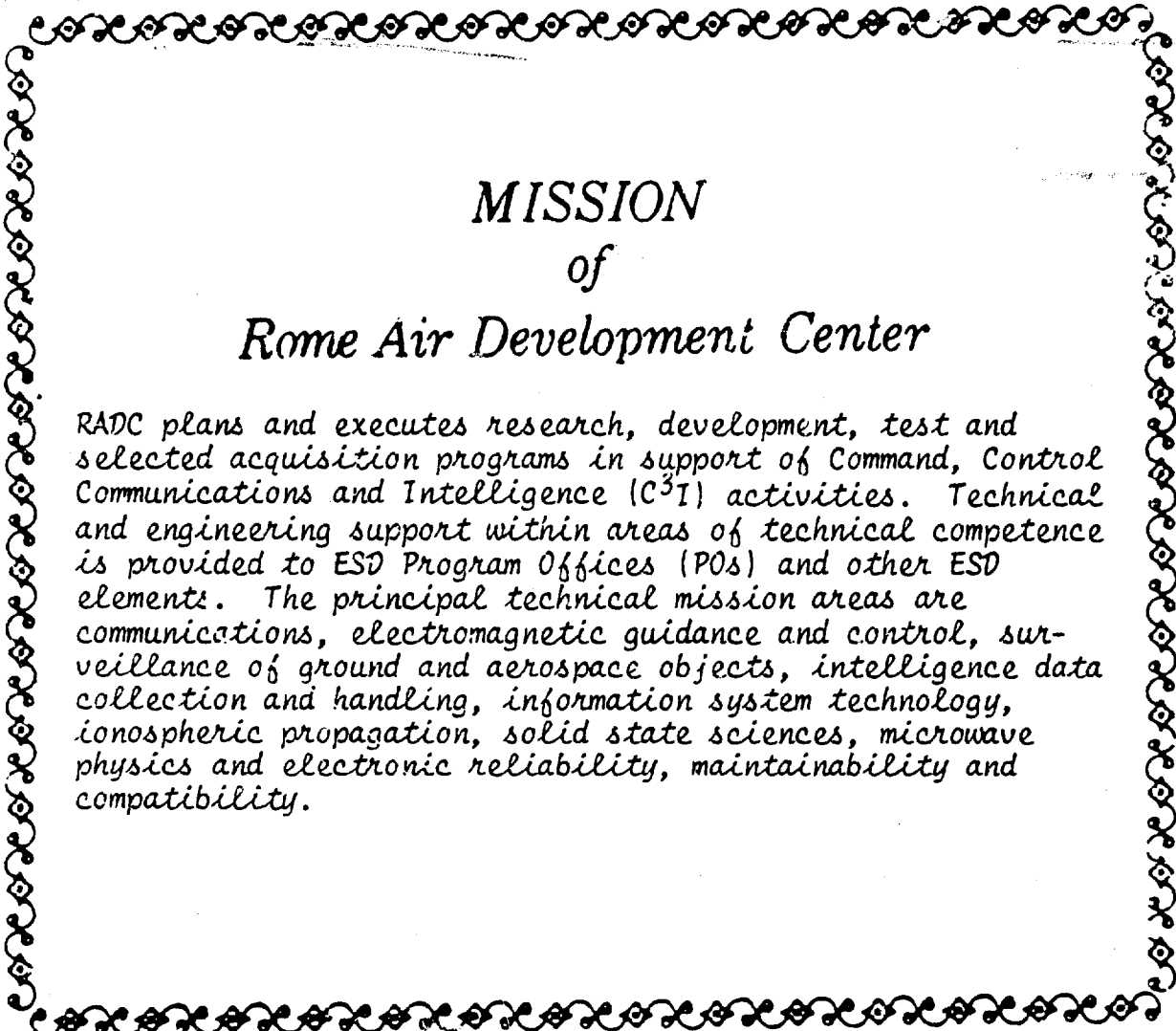
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report presents results of a study to identify new technology required to provide advanced multi-threat performance capabilities in future tactical surveillance radar designs. A baseline design with optional subsystem characteristics has been synthesized to provide both functional and operational survivability in a dynamic and hostile situation postulated for the post-1985 time frame. Comparisons have been made of available technology with that required by the new baseline			

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design to identify new technology requirements. Recommendations are presented for critical new technology programs including estimates of technical risks, costs and required development time.

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PREFACE

This document is a summary of the final report for a Tactical Radar Technology Study submitted to RADC under Contract No. F30602-79-C-0026.

The objective of the Study was to define the technologies which should be pursued to ensure that the performance of a tactical radar deployed in the post-1985 time frame will meet the anticipated threat.

The ITT Gilfillan study posted a baseline system, evaluated that baseline against the postulated threat, and identified essential technologies which are currently inadequate or non-existent. The study further recommends courses of action needed to reduce the technical risk in the development of a tactical radar.

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EVALUATION

This effort was initiated to identify new technology required to provide advanced multi-threat performance capabilities in future tactical surveillance radar designs. In order to effectively obtain this goal, the Tactical Air Control System (TACS) post-1985 mission requirements were examined, driving requirement established and a baseline system configuration designed. This effort fits into the RADC Technology Plan 4B, Surveillance ECCM.

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EXECUTIVE SUMMARY

1. STATEMENT OF THE PROBLEM

Current TACS ground radars cannot satisfy future TACS requirements based on projected threat environments. Consequently, the "Tactical Radar Technology Study" and other related studies are being directed to support the Air Force program to develop a tactical surveillance radar for the post-1985 time frame which will ensure both functional and operational survivability in the projected dynamic, hostile situation.

Current and projected mobility of ground forces and fluid tactical situations demand that emphasis be placed on very high mobility for all elements of the future TACS. It is unlikely that setup and teardown times exceeding 15 minutes will be tolerable for those TACS elements, especially the Advanced Tactical Radars (ATR) that will be deployed near the FEBA.

The future EW environment postulates active enemy ECM directed against TACS radars and communications/data links. Chaff will be deployed to disable radars without sophisticated signal processing and also combined with other ECM resources, to degrade radars utilizing advanced signal processing techniques. Direct physical attack on some or all friendly radiators (sensors and communications) is to be expected from cruise missiles, ARMs and RPVs.

The present TACS radars will not be able to provide surveillance coverage beyond the FEBA when subjected to the postulated hostile ECM. Coverage of sectors or corridors on both sides of the FEBA will be denied by enemy jamming and chaff. Although an upgraded AN/TPS-43E radar, outfitted with the ultra-low sidelobe antenna (ULSA), should improve surveillance somewhat and keep denied sectors to a minimum, it is most probable that full coverage in such sectors can only be provided by introducing new surveillance concepts that enhance TACS functional and operational survivability.

The synthesized baseline ATR design, detailed in this report, is based on a new surveillance system concept. This concept utilizes a sensor net of new ground based long range radars (ATRs) augmented by the Army Air Defense radars and further augmented by new ground-based gap filler radars and the E-3A as a means for obtaining low level coverage. For logistics effectivity, the new gap filler radar is envisioned as a lower module variant of the long range ATR. As such, both radars must have good ECCM and Anti-ARM capability. They must provide automatic track initiation and maintenance, and be able to store and exchange track information with neighboring radars as well as to report all tracks to operations centers.

The operations centers will be the primary command and control elements of the TACS and may or may not have radars colocated with them. However, residual control capability will exist at each radar site as a backup capability in the event that one or more operations centers are lost. Therefore, each radar site must be able to communicate with

aircraft and be capable of performing the functions of identification, GCI, air traffic control, etc. The number of radars (both long range and gap fillers) associated with each operations center, as well as the number of operation centers, will vary with the specific theater requirements. It is assumed in this concept that all of the TACS operations centers will be netted with each other as well as with the E-3A and the Army TSQ-73.

Certain required ATR performance characteristics can be deduced from the future TACS operational/configurational requirements. For example, emphasis must be placed on the development of highly jam-resistant short-to-medium range ATRs featuring waveform generation/processing flexibility to obtain long-range surveillance/identification data when possible. Also, the ATR design must utilize wide dynamic range, coherent transmissions and adaptive signal processing to effectively discriminate against clutter, chaff and weather. Another required characteristic is rapid ATR setup and teardown, on the order of 15 minutes or less, to ensure operational survivability.

2. STUDY METHODOLOGY

The methodology employed in conducting the "Tactical Radar Technology Study" was a top down process beginning with a mission analysis of the future TACS, a requirements definition for the ATR and establishment of a candidate baseline ATR design approach that could satisfy all requirements. The process then involved tradeoffs between requirements, alternative concepts/implementations, and cost. The study output was the identification of required technology advances and future tradeoff studies.

The Radar Technology Study was performed in accordance with the task flow network of Figure A. Essential study tasks were: 1) to formulate a baseline ATR design concept based on satisfying the functional requirements for air surveillance/identification and meeting the operational requirements for mobility, air transportability etc., and 2) to compare available technology with that required by the baseline ATR design in order to identify where new technology advances are required. The baseline ATR design, synthesized in Section 3 of the report, is summarized in the following section, and the technology advances required, summarized in Section 1.4, are identified and documented throughout the report.

The formal study was initiated by performing the requirements analysis task which necessitated a familiarization with the functions, operations and missions of the TACS in scenario and under present and future threats. The task was executed in general through a literature search and in particular through assimilation of information contained in the following Air Force Reports: "Project Seek Screen" RADC TR-75-320, "Tactical Air Forces Integrated Information System (TAFIIS) Master Plan" TAFIG-78-1, and "Tactical Air Control System; Alternative Surveillance System Concepts Study" RADC-TR-79-136. Completion of the requirements analysis task resulted in the quantification of the operational/configurational requirements for future TACS elements and permitted formulation of the ATR's design requirements based on the threat and the TACS requirements. The results of the Radar Design Requirements study task are detailed in Section 2 and Appendix A of this report.

Although three candidate ATR designs were initially postulated to obtain alternative levels of performance with attendant alternative levels of acquisition cost for relative evaluation, it was eventually decided to select/definitize and evaluate one configuration, a mid-level performance/mid-level cost candidate. This decision was prompted by the need for expediency, considering the short term of the study, and by the recognition that economic considerations will and must play a large part in determining the ATR configuration eventually selected for development/deployment. In this regard, the baseline design approach proposed for evaluation can not be a constrained design, conversely, it must be capable of providing either greater or lesser performance without requiring adoption of an entirely new design approach. Since this is the case for the baseline design selected it provides the needed reference to identify required new technology advances and to perform future cost-vs-performance tradeoffs that are essential in determining the optimum ATR.

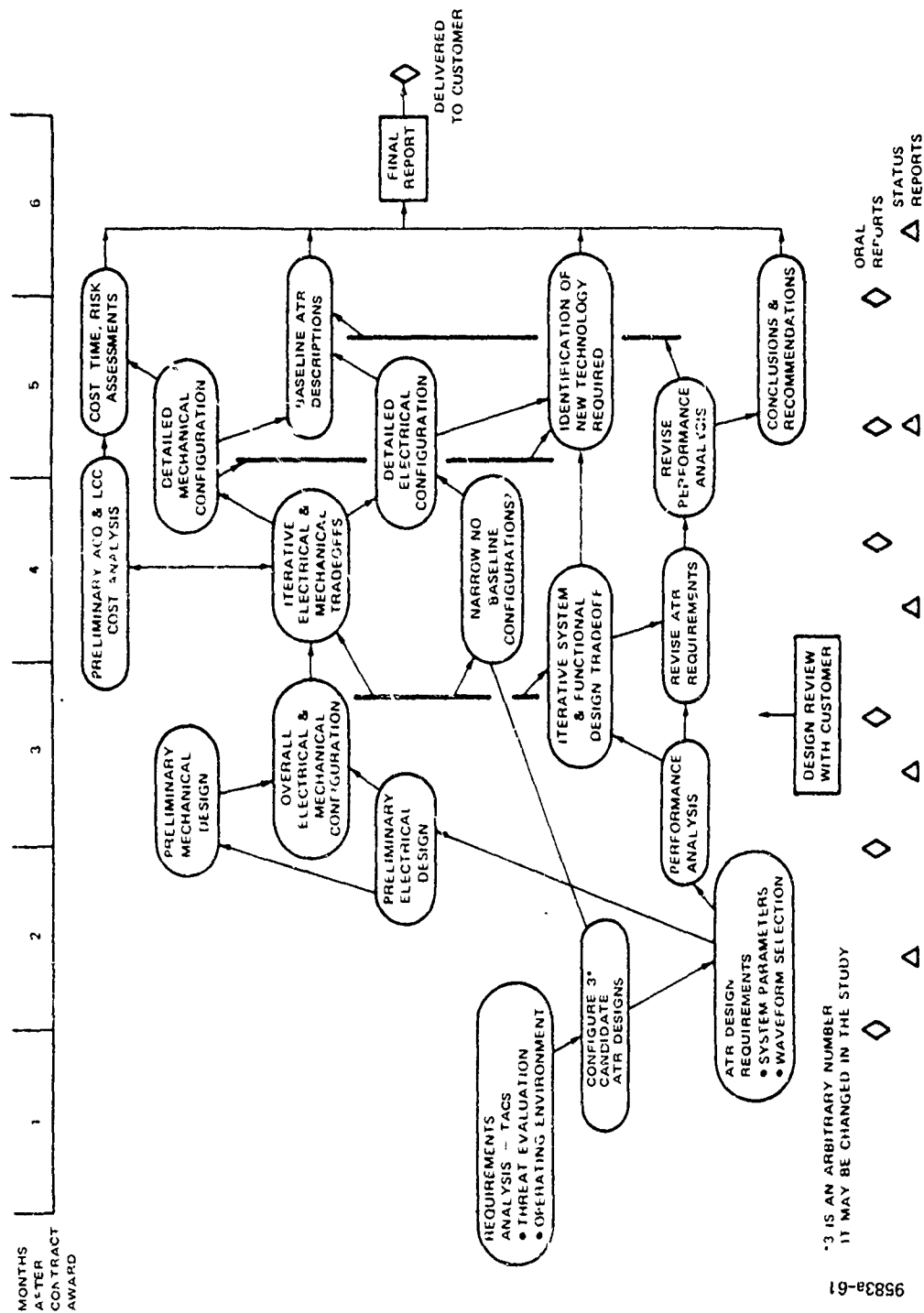


Figure A. Tactical radar technology study task flow network

The selected baseline ATR system configuration was subsequently analyzed in order to apportion specific requirements to the ATR's major subsystems (antenna, transmitter, receiver, signal/data processor, etc.). These subsystem requirements were then compared against what can currently be achieved by employing newly available technology implementations. The rationale for employing new technology implementation is that new technologies are typically on a steeper portion of the "capability improvements versus dollar expenditures" curve than are those based upon established older technologies. Where these new technology implementations were found lacking in capability, or were too large in volume, weight, power consumption, etc.; new technology advancements were identified and evaluated as to technical risk, cost, and required development time.

In parallel with these tasks devoted to identifying required subsystem technology advancements the ATR system requirements were further developed through studies concentrating on waveform and tracking requirements/implementations. These studies results in successfully bounding certain system parameters and in identifying additional tradeoff analyses that will be needed in order to define the optimum ATR. These studies can be found in Sections 4 and 5 of this report.

3. BASELINE ATR DESIGN CONCEPT

The design concept selected for the baseline ATR inherently provides the potential for satisfying all TACS/ATR requirements and is therefore the study reference needed to identify required technology advancements/cost reductions.

The baseline ATR design concept selected for the technology study is concisely depicted in Figures A and B. As shown in the figures, three self-propelled vehicles are used to transport the multifunction (search, track, and identification) ATR that provides long-range (200 nmi) hemispherical surveillance/identification coverage. Two of the vehicles transport identical equipments; two C-Band polarization agile antenna array faces with associated transmitters, receivers and signal/data processors. Since each array face provides coverage for a 90 degree azimuth sector, four array faces are needed to provide 360 degrees of azimuth coverage. The third vehicle transports a data/message processor, ground-to-air communications equipment, display(s) for autonomous back-up control, and the prime power source for the equipments on all three vehicles.

The baseline ATR's antenna design is undoubtedly the subsystem most strongly constrained by the TACS and ATR requirements. Perhaps the most important example of this premise is the high data rate requirement for track-while-scan (TWS) operation. Mechanically scanning antenna approaches were precluded by the data rate requirement and the desirability to inhibit visual detection. An electronically agile beam directing approach in both azimuth and elevation planes was therefore selected. Low sidelobes (-50 dB), particularly in the azimuth plane are needed to counter stand-off jammers and ARMs. Additional requirements for wide signal and operating bandwidths for IPI and non-cooperative target IFFN classification narrows the choice of design approaches considerably. Polarization agility on both transmit and receive should be implemented to afford improved performance in ECM and in non-cooperative target classification. To accommodate all of the above requirements/considerations the selected baseline ATR antenna design approach is a four face planar array having Rotman lens beamformers, and solid-state transmitters distributed in the elevation plane of each array face. Rotman lenses are used to achieve the true time delay beam steering necessary for wide signal bandwidth operation. This design approach has the capability of providing either single beam operation (the baseline implementation) or simultaneous multiple beam operation with adaptive beam shaping and null steering for additional capability. Null steering is an added ability to introduce well defined nulls (> -50 dB) in the antenna radiation/receive pattern in any arbitrary direction(s) for jammer nulling. This feature could be employed to minimize the ARM threat and significantly improve the ATR signal-to-jamming ratio.

The solid-state transmitter design selected for the ATR baseline accommodates the high data rate requirement by providing the capability for four simultaneous transmissions (and receptions), one from each face of the antenna array. It additionally provides the graceful degradation capability that is required and has the potential for providing "greater capability for fewer dollars expended," normally attributed to new technology implementations.

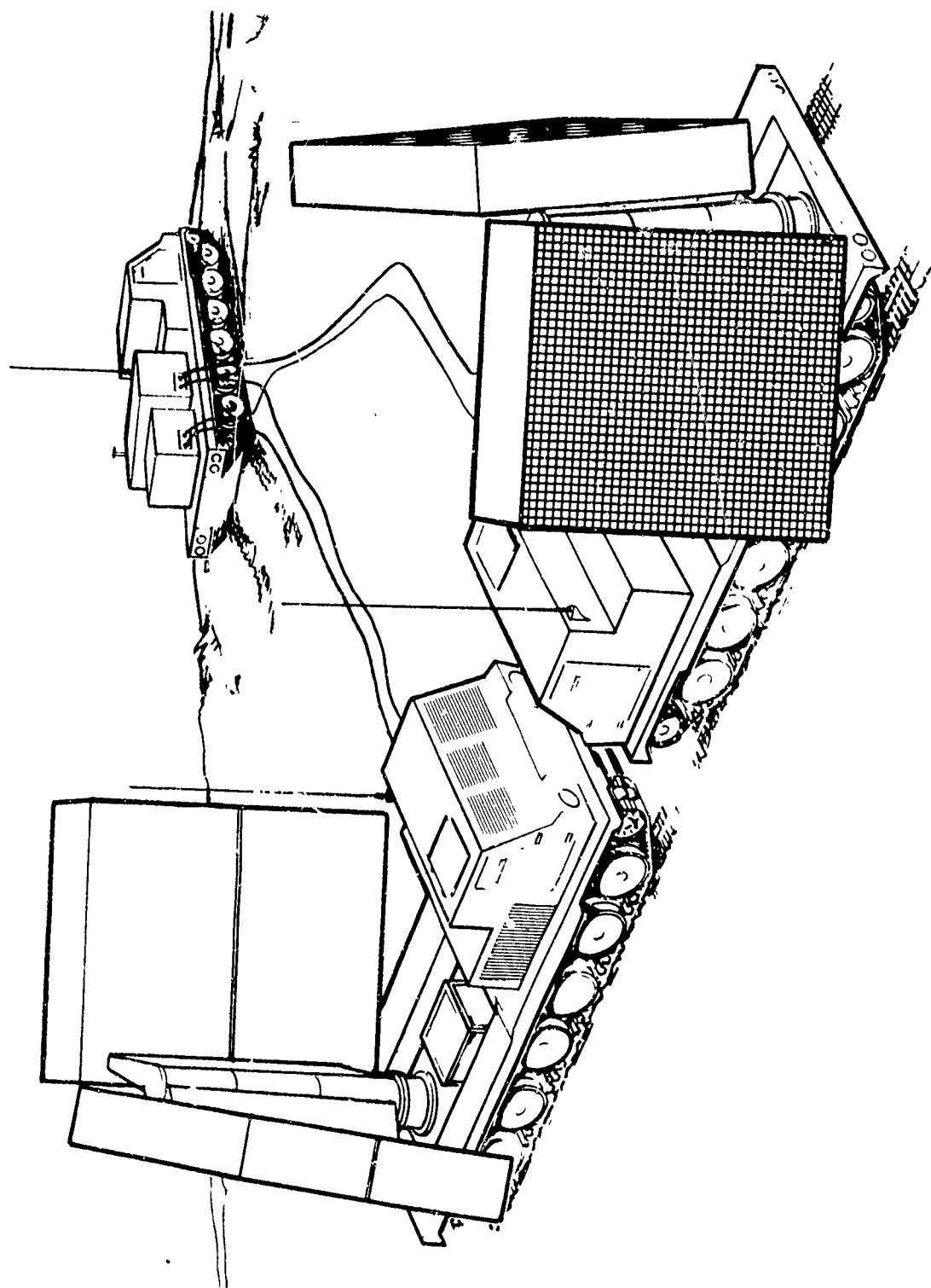


Figure A. Baseline configuration of the Advanced Tactical Radar

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It is to be noted that the baseline ATR design approach could also accommodate a centralized solid-state transmitter design (less efficient) or a centralized tube transmitter (also less efficient and having greater weight and volume) if future performance-vs-cost tradeoffs dictate these implementations are preferred.

The essentially redundant (one per antenna array face) receiver and signal/data processor configuration selected for the baseline ATR is based on the trend in new thin/thick film (analog) and integrated circuit (digital) hardware technology toward dramatically reduced size and relative cost. The consequence of this trend is that redundant systems are both feasible and cost effective. The signal processor subsystem provides dual channel (H&V) polarization processing, adaptive spectral filtering, hard limited CFAR processing and binary phase coded pulse compression. Implementation assumes the use of VHSIC technology. The data processor subsystem provides target parameter (R , θ , ϕ) extraction, target tracking (automatic track initiation and maintenance), and target classification. The need for the design of a cost-effective multisensor adaptive system tracker is established and additional studies recommended. Recommended data processor implementation is through the use of modular hardware/software units being developed by ESD/RADC for TACS C² elements.

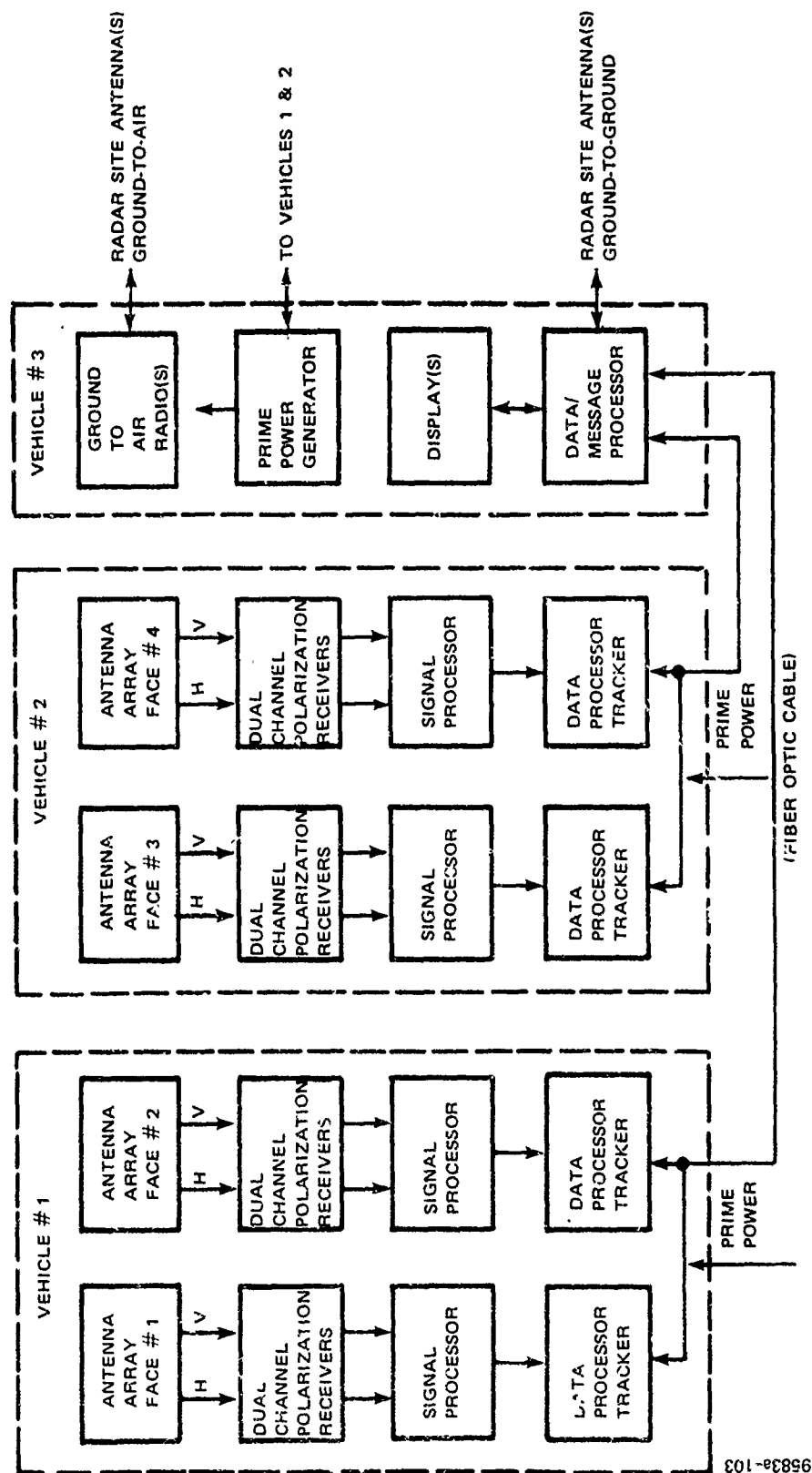


Figure B. Baseline ATR block diagram

4. REQUIRED COMPONENT TECHNOLOGY ADVANCEMENTS

Component technology advances are required for the Transmitter, Antenna and Signal Data Processor elements of the ATR in order to provide a cost-effective solution.

The purpose of this study was to identify the technology required to provide advanced multithreat performance capabilities in future tactical radar designs. To accomplish this, the baseline ATR system described in the previous section was assessed in terms of meeting the desired operational requirements utilizing existing technology. Deficiencies were noted either in meeting the operational performance and/or in achieving desired goals for size, weight, power consumption, and projected cost. It was concluded that advances both in component technology and in applied system methodology were required to bring these items into reasonable dimensions. The major component technology advances relate to solid state device development for the transmitter, correlator/memory/uncommitted logic arrays for signal and data processing, reduction of line and switch losses in the antenna, and lightweight material/armor development for general system weight reduction. Various trade studies were also recommended to evaluate alternate means of both hardware and system implementation to realize possible cost-benefit improvements.

The major radar elements related to the identified component technology requirements are:

- Antenna
- Transmitter
- Signal and Data Processor
- Mechanical Design

Table I summarizes the key component technologies for each radar design area, noting the particular devices involved, the desired requirement relative to existing performance, and a qualitative risk factor (low, medium, high) which indicates the inverse probability of success in meeting a post-1985 deployment schedule.

The antenna area lists three technology items needed to meet the desired performance in the field (-50 dB azimuth cardinal plane sidelobes, minimizing losses in the RF lines and switches, and maintaining and measuring electrical/mechanical tolerances). These issues are detailed in Section 6.1. The major risk item is achieving a less than 5 dB line/switch loss; roughly a 50 percent probability. The trade study required involves utilization of lower loss dielectric materials which will present potential packaging problems related to size and weight.

Table I. Component Technology Summary

<u>Element</u>	<u>Component</u>	<u>Requirements</u>	<u>Existing Technology</u>	<u>Risk</u>
Antenna	Rotman Lens	< -50 dB az cardinal plane sidelobes	-40 dB	Low
	Line/switch			
	Line/switch losses	< 5 dB	7 dB	Medium
	Component tolerance	2-4' random phase stability	10°	Low
Transmitter	Solid state module	10 watt peak	2 watts	Low- Medium
		Low cost	Very high cost	High
	Tube	200 kW peak 10 kW average increased power margin	100 kW peak 5 kW average	Low
Signal Processor	Correlator chip	512 bits 6.5 MHz 6 mW/bit	64 bits 6.5 MHz 12 mW/bit	Medium
	Memory chip	16 K-bit RAM 75 nsec cycle 0.05 mW/bit	4 K-bit RAM 75 nsec cycle 0.10 mW/bit	Low
	A/D Converter	11 bits 6.5 MHz	8 bits 13 MHz	Low- Medium
Data Processor	Uncommitted LSI Logic Arrays	1000 gates 6.5 MHz	MSI/SSI	Low- Medium
Wideband Signal Processor	A/D Converter	6 bits 100 MHz	6 bits 30 MHz	High
	Memory	Shift Register 1K-bit 100 MHz	256 bits 40 MHz	High
	Uncommitted LSI Logic Arrays	500 gates 2 GHz	--	High

Table I. Component Technology Summary (Continued)

<u>Element</u>	<u>Component</u>	<u>Requirements</u>	<u>Existing Technology</u>	<u>Risk</u>
Mechanical	Composite Technology Transfer	Need for min. weight	Exists in other industry areas	Low
	Stripline Feed Prod.	Need hi prod rate to hold down costs	Can hand build small units	Low
	Lightweight Armor	Minimum wt to effectiveness ratio	6 to 8 lb/ft ² for 100 grain @ 5000 ft/sec	Medium
	Threat Resistance Threshold	Need level specified to allow implementation	No specification exists	Low

5. REQUIRED SYSTEM TECHNOLOGY TRADE STUDIES

Various system trade studies are required to evaluate ATR variants permitted by the baseline concept.

While advances in component technology should lead to smaller, lighter weight, and more efficient ATR configurations, it is also reasonable to continue in the search for alternate means of implementation to improve cost/benefit performance. As noted in Section 1.2, the baseline concept should not be a constrained design. Within this context, various baseline technology issues have been identified as potential candidates for trade study evaluation. Most of these impact the waveform design and its related effect upon ATR performance and cost (see Section 4). Tracking technology also heavily influences system performance; this is detailed in Section 5. A summary of these and other related technology studies is presented in the paragraphs following and summarized in the Table.

System Technology Summary

<u>Study Area</u>	<u>Cost or Performance Goals</u>
Dual Channel Processing	Enhance clutter rejection 5 - 10 dB Reduce signal processor cost 50 percent
Spectral Filtering	Improve clutter rejection ~ 3 dB Enhance long range detection
Duty Cycle	Reduce processor cost 10 - 30 percent Improve multiple target discrimination
Wideband Processing	Potential for target classification and detection small cross sections in clutter
Monopulse Tracker	Increase update rate factor four balance against cost
Balanced Search/Track Design	Reduce processor cost 10 - 20 percent Improve track performance 3 dB
Multi-Sensor Tracker	Develop methodology for fusion of single sensor track data. Potential significant cost reduction radar module

Waveform Related Technology

There are four major waveform related areas identified for further study; namely, dual channel processing, spectral filtering, duty cycle reduction, and wideband processing.

Dual channel processing is designed to take advantage of the difference in the combined polarization and spectral scattering properties between targets and clutter, such that the probability of target detection is maximized. This could result in significant cost reduction in the Signal Processor configuration. Further study is required to determine the degree of target enhancement, and the trade between processor/receiver/antenna costs. The study would be followed by an extensive field test program. The technical risks in this area are considered low.

The general area of spectral filtering has undergone considerable study in efforts to enhance detection in clutter. This is particularly significant for the ATR in terms of long range detection and track through chaff. The list of specific study issues includes adaptive prf modes, beam forming techniques, and maximum entropy spectral estimation. Each of the above would entail a low risk study effort.

Duty cycle trade issues assume importance because the transmitted pulsewidth has a pronounced effect upon processor cost, as related to the waveform time-bandwidth product. Aside from cost considerations, the ambiguity plane responses for typical waveforms should also be evaluated in terms of performance associated with multiple target environments and raid size assessment. Selection of pulsewidth and duty cycle also impacts transmitter design, such that attendant trade issues involving solid state and tube type transmitters must also be investigated. As studies, these would also be considered low risk efforts.

Wideband processing is of interest in dealing with target recognition/classification, low probability of intercept waveforms, and in the detection of very small cross section targets in clutter. Although it was noted that a high risk exists for timely development of wideband logic devices, the evolution of techniques for wideband processing should proceed in anticipation of such development. With regard to detection in clutter, the trade issues involve the distributed nature of the target scatterers, and related effects upon false alarm and detection criteria in the various clutter environments. Target classification trade issues are discussed in the following paragraphs.

Single Sensor Considerations

In order to operate within the projected multithreat environment, the system must: (1) achieve a high level of automaticity, (2) possess a capability for adaptive resource management, and (3) capitalize on the synergism realized from netting of the system's sensors to obtain fast reaction to the threat. Target data and environment data must be used to continuously configure the system into a format which optimizes target extraction, target track, and target classification. In this manner, the processing resources are always balanced so that excessive demands will not have to be made on the performance measures of any one subsystem. Within this framework, a key factor is that operation of the autotrack process feeds back and directly impacts the operation of all of the other processes.

The major concern for the transmitter involves the availability of a device operating a C-Band, which will achieve the required power demands at reasonable cost in a solid state configuration. Existing modules have nominal 2 watt peak power capability, requiring 25,000 of these devices to deliver a peak power of 50 kW. It is expected that a 10 watt device would be available for post-1985 deployment. The concomitant risk of achieving a 10 watt module at an acceptable cost is, however, high. On the other hand, transmitter tubes currently exist which can supply the required baseline power. In addition, a low risk development effort should result in higher tube power capability for increased system performance and/or power margin. The relative merits of solid state versus tube designs are more fully explored in Section 6.2.

The signal and data processor advanced technology requirements noted in Table I, relate primarily to device development leading to reduced size and power consumption. It is noted in the processor description of Section 6.4, that the electrical requirements for baseline operation can be met with existing components. However, reductions in size and power consumption of 50 percent are necessary to meet desired goals. The major item noted is the correlator ship which involves about 35 percent of the signal processor architecture. This carries a medium risk label because specialized development would be required for the ATR system, although the DOD VHSIC program could possibly also contribute toward this development. The remaining items of A/D converters, memory chip, and LSI uncommitted logic arrays are in a lower risk category. Although some development is required, it is expected that other requirements for both the military and commercial markets will provide sufficient demand to spur production of these devices.

Wideband signal processor devices are concerned with special radar applications for target recognition and/or classification. It should be noted that these functions are desirable but not necessary to meet the baseline requirements. Although there are on-going efforts in this area, the risk of meeting the wideband processor requirements by 1985 is considered high because the devices will require gigabit switching speeds for proper operation. This is discussed in greater detail in Section 6.4.

The last set of items identified for component development is in the area of mechanical design. Three of the four technology improvements are needed to improve the mobility performance of the system. The establishment of threat resistance leads to armoring requirements and to a suitable mix ratio between advanced composite materials and armor, such that an equitable balance can be established between mobility and survivability. Lightweight armor development is currently under investigation within the industry, and represents a medium risk factor for producing material superior to the present ceramic/Kevlar combination. The remaining three items are low risk development/study efforts. Additional details can be found in Section 6.5.

The other critical aspect of the autotrack process is that its output represents the major radar sensor data interface with the tactical user. As such, an ancillary theme to the above is that single system tracks (SST) have to be established and identification determined using all target data derived from all sensors in a timely fashion. The netting or merging of target data is the final operation upon which the tactical user depends.

The issue of optimum energy/resources control becomes especially crucial for multifunction radar embodying both search and track. From the tactical user viewpoint, timely assessment of the threat is fundamental to the optimum allocation of weapon resources. In effect, the level of automaticity realizable is critically dependent on the efficacy of the target classification function. If the variances associated with the target classification outputs are minimal, then a high level of automaticity is feasible resulting in decreased system reaction time. However, a critical facet that impacts the efficacy of the target classification function is the degree of adaptiveness that the surveillance radar possesses, (e.g., variable track verification data rates).

It is essential, therefore, that track initiation be accomplished with a minimum of "looks" per target, and that false or redundant tracks be minimized. This can be facilitated by proper distribution of false return rejection among the various radar processes, and the utilization of special wideband waveform modes to enhance the classification of targets of interest.

The above discussion represents major technology radar design trade issues from which the following specific SST trade studies are recommended for further investigation.

- Reexamine allocation of search/track functions to provide balance resource operation. For example, optimization of the single sensor track function can result in a reduction of signal processor requirements such as false alarm and target detection figures-of-merit. Power requirements may also be reduced after track, permitting enhanced surveillance capability. Development of accurate state estimation techniques, association algorithms, and variable data rate capability is essential to this study effort
- Target classification is a key function for track verification and threat assessment (see Section 5.8). A study task is recommended for the development of target classification algorithms using wideband signature data including a polarization discriminant. The major objectives include determination of signature variation with aspect, required sampling rates, and feature selection for operation in chaff and in a multiple target environment.
- Investigate cost/performance relationship for monopulse tracker as compared to baseline sequential lobing technique, to increase rate of track update.

Multi-Sensor Tracker

The magnitude of the threat environment dictates the necessity for a multi-sensor network track function.

The requirement for a multisensor adaptive system tracker poses additional technology trade study possibilities regarding techniques for optimally combining the outputs of the individual radar sensors. The mechanization of a system track function will also influence the design of the local track process, which, as noted before, has an iterative effect upon the balanced design of the other radar processes. Consequently, the design approach for the system tracker will have major impact upon the requirements and costs of the individual radar (i.e., possible utilization of less than four antenna faces per sensor).

The underlying problem in this area is that the technology for adaptive system track functions has not as yet been developed in terms of a formalized methodology for generic track-while-scan surveillance radars. Formulation of this function should receive high priority (see Section 5).

The major tasks needed to be performed to develop a methodology for multisensor adaptive system trackers are:

- Perform operations analysis and develop performance figures of merit
- Perform data integration trade-offs
- Establish registration error budgets
- Coordinate system trade-off analysis
- State estimator optimization analysis
- Association optimization analysis
- Initiation and deletion optimization analysis
- Design computer simulations
- Perform cost-effectiveness trade-offs
- Perform military worth analysis
- Design system tracker
- Perform evaluation of system tracker.

The last five items are included to complete the process leading from operations analysis to an engineering design and the performance evaluation of that design. The complexity of the problems are such that computer simulations will be necessary to perform the operations and optimization analysis for each of the track functions. Additional computer simulations will be needed for the trade-off analyses and performance evaluations.

6. CONCLUSIONS AND RECOMMENDATIONS

The baseline ATR design can potentially satisfy TACS requirements for single multifunction sensor elements of an integrated multi-sensor net. Component technology advances and additional system trade studies are needed for this potential to be realized.

A summary of identified technology advancements required for post-1985 deployment of the ATR has been presented in the previous sections. As noted, the baseline design concept has the potential for satisfying the TACS/ATR requirements, where most of the identified required component advances relate to size, power consumption, and cost. Deficiencies in projected multi-function operation are more illusory, since the ultimate requirement for single sensor performance will be heavily weighted by the design concept of the multi-sensor network. It is, therefore, strongly recommended that the more global requirements be definitized as early as possible, since they will influence specific cost trade issues of the ATR. Regardless of this, there are various key component and/or system cost trade studies which should be undertaken for single radar sensor design. The recommendations that follow are associated with the more important and higher risk items noted previously.

Component Development

- Antenna line and switch loss reduction and packaging
- C-Band solid state transmitter module development
- Correlator and uncommitted LSI logic array development
- Gigabit logic development: A/D converters, memory, and uncommitted logic arrays
- Light processing or dev

System Studies

- Dual channel polarization processing techniques
- Spectral filtering enhancement
- Waveform selection, duty cycle trade issues in multiple target environment
- Wideband processing for target classification
- Multifunction search/track trade study to optimize radar resources
- Development of multi-sensor track methodology