(2)

THE JOINT SURVEILLANCE TARGET ATTACK RADAR SYSTEM: CAN PROCEDURES BE DEVELOPED TO SUPPORT THE REQUIREMENTS OF THE LAND AND AIR COMPONENT COMMANDERS?

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

LEONARD J. SAMBOROWSKI, MAJ, USA
B.A., Bucknell University, Lewisburg, Pennsylvania, 1976

Fort Leavenworth, Kansas
1992

18 pgs

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	4 MAY 1992	1982-1992

4. TITLE AND SUBTITLE
The Joint Surveillance Target Attack Radar System: Can Procedures be developed to Support the Requirements of the Land and Air Component Commanders?

5. FUNDING NUMBERS

6. AUTHOR(S)
Major Leonard J. Samborowski

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
1991/1992 Command and General Staff College Class
Fort Leavenworth, Kansas 66027

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree Master of Military Art and Science.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This thesis examines the warfighting capabilities of the Joint Surveillance Target Attack Radar System (Joint STARS). Joint STARS' effectiveness in DESERT STORM is examined as a case study. Additionally, an analysis of Joint STARS against the Department of Defense's Seven Threat Scenarios highlight the future potential of the system.

This thesis contends that Joint STARS did not simultaneously support the requirements of the Land and Air Component Commanders, during DESERT STORM. Although a contributor to success in the war, Joint STARS supported the Army and the Air Force at different times and with different radar products. The primary, but not exclusive, reason for this limitation was the technological immaturity of a weapon system still in Full Scale Development.

The strengths and weakness of Joint STARS are examined throughout this thesis. This study concludes that Joint STARS procedures can be developed to support the requirements of the Land and Air Component Commanders. Recommendations for the increased effectiveness of Joint STARS support to operational warfare is provided in the final chapter.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Joint STARS, Ground Station Module (GSM), Joint Operations, Operational Cycle, Seven Threat Scenarios	184
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassifed	Unlimfted

THE JOINT SURVEILLANCE TARGET ATTACK RADAR SYSTEM: CAN PROCEDURES BE DEVELOPED TO SUPPORT THE REQUIREMENTS OF THE LAND AND AIR COMPONENT COMMANDERS?

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

LEONARD J. SAMBOROWSKI, MAJ, USA
B.A., Bucknell University, Lewisburg, Pennsylvania, 1976

Fort Leavenworth, Kansas
1992

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of candidate: Major Leonard J. Samborowski, Aviation

Title of thesis: The Joint Surveillance Target Attack Radar System: Can procedures be developed to support the requirements of the Land and Air Component Commanders?

Approved by:

John D Skelton
COL John D. Skelton, M.M.A.S., M.P.A, Thesis Committee Chairman

LTC James L. Campbell, M.A., Member

Pamela H Senterfitt
MAJ Pamela H. Senterfitt, M.A., Member

BG Gerald A. Miller, Ph.D., Consulting Faculty

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and or Special
A-1	

Accepted this 5th day of June 1992 by:

Philip J. Brookes
Philip J. Brookes, Ph.D., Director, Graduate Programs

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE JOINT SURVEILLANCE TARGET ATTACK RADAR SYSTEM:
CAN PROCEDURES BE DEVELOPED TO SUPPORT THE REQUIREMENTS OF THE LAND AND AIR COMPONENT COMMANDERS?
by MAJ Leonard J. Samborowski, USA, 175 pages.

This thesis examines the warfighting capabilities of the Joint Surveillance Target Attack Radar System (Joint STARS). Joint STARS' effectiveness in DESERT STORM is examined as a case study. Additionally, an analysis of Joint STARS against the Department of Defense's Seven Threat Scenarios highlight the future potential of the system.

This thesis contends that Joint STARS did not simultaneously support the requirements of the Land and Air Component Commanders, during DESERT STORM. Although a contributor to success in the war, Joint STARS supported the Army and the Air Force at different times and with different radar products. The primary, but not exclusive, reason for this limitation was the technological immaturity of a weapon system still in Full Scale Development.

The strengths and weakness of Joint STARS are examined throughout this thesis. This study concludes that Joint STARS procedures can be developed to support the requirements of the Land and Air Component Commanders. Recommendations for the increased effectiveness of Joint STARS support to operational warfare is provided in the final chapter.

ACKNOWLEDGEMENTS

A special thanks to BG Gerald Miller, COL John Skelton, LTC James Campbell, and MAJ Pam Senterfitt, for the many hours that you devoted to this work. Your professionalism, thoroughness, and continuous encouragement made this thesis possible.

....

Four other officers were instrumental in my involvement with Joint STARS and I would be most remiss if I failed to express my gratitude to these professional soldiers.

Colonel Don Kerrick, more than any other officer in the Army, is responsible for "jump-starting" my career. I will always be indebted to this exceptional soldier and leader.

Colonel (Retired) Dempsey L. Malaney, trusted me to work the Joint STARS program at TRADOC Headquarters. Col Malaney consistently supported me during my learning phase as a Combat Developer. He and LTC Jim Winters ordered, cajoled, and directed me to achieve the high standards which they established for the program.

Additionally, Colonel Martin Kleiner served as the catalyst behind my deployment with Joint STARS to DESERT STORM. Col Kleiner alternated between being a boss, mentor, and friend during my two year involvement with the program. If the truth be known, Col Kleiner is the primary reason for any success that the Army has achieved with Joint STARS.

....

Last, but most importantly, my heart felt thanks and love go out to my wife Susan and daughter Stephanie. Thank you for your help with this thesis. You two kept me smiling, despite my periods of doom, doubt and hard disk crashes. Your patience and understanding were the keys to my success. This paper is as much your accomplishment as it is mine. I love you both very, very much!

P.S. Thank you Stephanie for your help on Figure 21.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

> In sending them to reconnoiter the land of Canaan, Moses said to them, "Go up there in the Negeb, up into the highlands, and see what kind of land it is. Are the people living there strong or weak, few or many? Is the country in which they live good or bad? Are the towns in which they dwell open or fortified?"[1]
>
> Numbers 13:17-19.

Since the earliest days of warfare man has sought to gain an advantage over his enemies by the proper use of reconnaissance and surveillance. Modern warfare is no different. Army doctrine mandates that a battlefield commander must see deep to strike deep.[2] A commander's ability to employ all the technological tools at his disposal will be paramount to his success. The Joint Surveillance Target Attack Radar System (Joint STARS) is a new surveillance and targeting tool that can be added to the arsenal of tomorrow's warriors. Joint STARS, if properly employed, can be a powerful contributor to future AirLand Operations.

Historical Background. The Defense Department directed the development of Joint STARS in May 1982. Two programs, the Air Force, PAVE MOVER and the Army Stand Off Target Acquisition System (SOTAS), were united under initiative # 27 in a joint Army/Air Force agreement.[3] Initiative #27 was one of thirty-one joint development recommendations to improve tactical coordination in future combat operations and eliminate duplication in weapons developments. Initiative #27 identified Joint STARS as a high-payoff, battlefield leverage system under the Department of Defense's "Competitive Strategies" concept.[4] As the executive service for the joint program, the Air Force took the lead in contract specifications and equipment procurement.

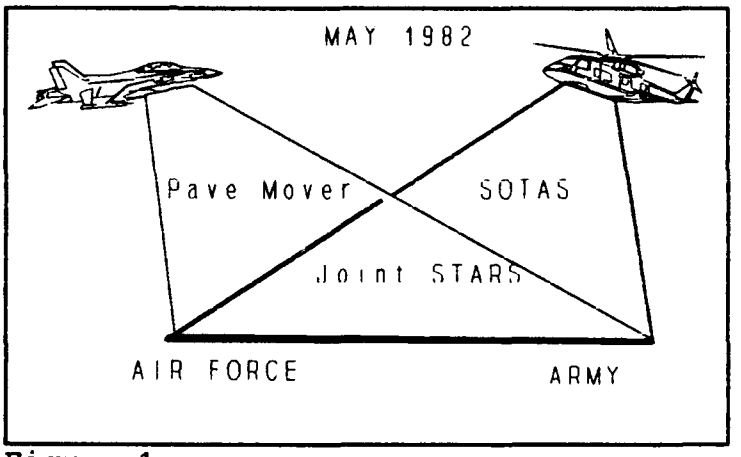

Figure 1
Program Evolution

Army Involvement. The perceived Soviet threat in the 1960-1980s, provided the impetus for the Army's interest in Joint STARS. AirLand Battle Doctrine developed in response to the possibility of a war in Central Europe.[5] One feature of this doctrine was the responsive application of battlefield

sensors.[6] For the Army this demanded the dedicated support of a battlefield moving target indicators (MTI) capability at corps level. Initially, the OV-1D Mohawk surveillance airplane provided this MTI capability.[7] However, the age of the OV-1D airframe and narrow coverage sweep and range of the plane's Side Looking Airborne Radar (SLAR), necessitated a change. SOTAS was developed to fill the growing gap between the short-range Mohawk product and the Army's expanding surveillance requirements.[8] However, after several years of concept and materiel development the SOTAS initiative was absorbed into the Joint STARS program.

The first Army specifications for Joint STARS, established in the Requirements Operational Capability (ROC) of 1989, were stringent guidelines for the system's development.[9] Joint STARS would be designed to provide Army commanders with near continuous, wide-area surveillance of an Army corps area. The system, using state-of-the-art radar technology, would detect, pinpoint, classify and track moving and stationary targets. These targets would include ground, moving target indicators (MTI), and slow-moving aircraft and rotating antennas.[10]

As designed, Joint STARS would satisfy the Army MTI requirement, thereby contributing to the identification of the enemy's first and follow-on echelons. The Army emphasis on this see-deep capability would answer the multi-echeloned Soviet forces threat in Europe.[11] A perfected Joint STARS

radar would make possible the detection of advancing Soviet armor columns.[12] Additionally, the location accuracies of the system would allow for the concurrent operation of Joint STARS for target development and battlefield situation management (intelligence operations).[13]

Program Challenges. Joint STARS endured several cancellation attempts due to budgetary concerns and technology delays in software development and airframe delivery.[14] Consistent throughout these challenges was the commitment of Army program managers to the requirement for a battlefield MTI capability. Early detection of the threat's second echelon forces in Europe was vital to the emerging Army doctrine of the 1980s.[15]

Technology Demonstration. In September of 1990, after meeting several crucial engineering milestones, Joint STARS showed its capabilities to key NATO and U.S. general officers in Europe. This six week deployment, was called "Operational Field Demonstration One," or OFD1. As the name implied, the focus of OFD1 was to demonstrate Joint STARS' technology.[16]

Two E-8A aircraft, militarized versions of the Boeing 707, and four Ground Station Modules (GSMs) deployed to Europe as part of OFD1. The aircraft and GSMs were displayed at key U.S. and NATO headquarters in various cities such as: Frankfurt, Stuttgart, Augsburg, Weisbaden, Paris and London.[17] Mission data, contained on computer tapes of test flights in

Melbourne, Florida, were run through the aircraft and GSMs and shown to officers during briefings. On occasion, actual surveillance missions were flown over the West German countryside. Collected information was passed down, via data link, to GSMs positioned at selected demonstration sites. For example, on the third flight in theater, Joint STARS flew in support of a VII Corps deep-strike exercise. This supporting flight was a great success.[8]

The intent of OFD1, to showcase Joint STARS capabilities, was achieved. U.S. commanders in Europe and their NATO counterparts witnessed, first-hand, the emergence of a new battlefield surveillance and targeting capability. They came away aware, if not impressed, of the potential of Joint STARS.[18]

DESERT SHIELD/DESERT STORM. On 2 August 1990, the Army of Saddam Hussein invaded deep into the nation of Kuwait.[19] Within 6 days the United States answered this Iraqi attack by sending 2300 soldiers from the 82d Airborne Division and 48 F-15 fighters from Langley Air Force Base, Virginia, to South West Asia.[20] Over the next several months, as President Bush established a united coalition of allies, the buildup of military forces in the Gulf continued.[21] Crucial in this

---

[8] It was during this mission that an Army staff sergeant, working out of a GSM, identified a "simulated" enemy convoy to the commander of VII Corps, LTG Fred Franks. Four months later LTG Franks would command the armor units in DESERT STORM.

escalation of power was the effort by Pentagon planners to provide the Central Command (CENTCOM) Commander in Chief (CINC) with the right mix of forces and equipment. Several officers on the Department of the Army Staff and offices throughout the Training and Doctrine Command (TRADOC) voiced concern about the absence of a wide area surveillance capability for the U.S. forces.[22] In an attempt to fill this void, and based upon the success enjoyed during OFD1, a Joint STARS briefing team went to Riyadh, Saudi Arabia in December of 1990 to present a series of briefings to the Central Command staff and to General Norman Schwarzkopf.[23] As a result, on 17 December 1990, General Schwarzkopf requested that Joint STARS be deployed to his theater. Consequently, on 11 January 1991, although still in full scale development, Joint STARS deployed to Operation DESERT SHIELD/DESERT STORM.

The Joint STARS contributions to DESERT STORM were noteworthy, significantly adding to the war effort. Following the war, the Air Force Chief of Staff stated, "We will never again go to war without a system like Joint STARS."[24]

Purpose of the Thesis. (**Identification of the Problem**) This thesis is an assessment of the use of Joint STARS for joint surveillance and targeting missions in support of operational warfare. An analysis of the effectiveness of the system during Operation DESERT STORM (Chapter Four) suggests that Joint STARS was sub-optimized in combat. The Air Force and Army separately generated targets with Joint

STARS, but seldom developed targets "jointly." Iraqi positions were engaged exclusively by Air Force fighters or by Army artillery. Army helicopters however, played no role in the attacks on Joint STARS generated targets, thereby missing an opportunity to fully exploit the "deep attack" intelligence of Joint STARS.

Additionally, as will be explained in Chapter Four, Joint STARS' capabilities were used in an "either/or" role in DESERT STORM. Either targeting missions were serviced with the Joint STARS radar or situation development was worked. The simultaneous use of the surveillance and targeting tools of Joint STARS rarely occurred.

Thesis Question. The goal of this thesis is therefore to offer solutions for improving the operational employment of Joint STARS. The primary question this thesis seeks to answer is: **Can Joint STARS procedures be developed to support the requirements of the Land *and* Air Component Commanders?**

Subordinate Questions. Before the primary focus of this thesis can be addressed several subordinate questions must be addressed. These questions include:

(1) What was Joint STARS' initial mission design?
(2) What current joint surveillance and targeting procedures are in effect?
(3) Can Army target development occur independently of Air Force target development?
(4) What service should control Joint STARS?
(5) What role(s) will Joint STARS play in future wars?

Answering these questions will provide needed insights to the operational tactics, techniques and procedures for Joint STARS. The answers and conclusions will remain consistent with doctrine and technologically attainable. The recommendations will continue to ensure that Joint STARS contributes to operational warfighting.

Assumptions. The importance of this thesis rests upon five assumptions:

(1) Joint operations will increase in importance as the military "builds down." *"Jointness" will be needed to accomplish what, in the past, was often achieved by a single service.*[25]
(2) Joint STARS will continue to receive adequate funding and support from the Army and Air Force.[b]
(3) Aircraft, ground station modules, data links, communication radios and mission equipment will be procured in sufficient numbers to ensure the system's capability.[c] *Reduction in Joint STARS hardware will reduce the possibilities for operational improvements.*
(4) Operational improvements for Joint STARS requires a balance of doctrinal, procedural and technological approaches.
(5) Joint STARS will remain an important wide area surveillance system for the detection and tracking of ground moving target indicators for the next 10-20 years.

DEFINITIONS. Many terms, used in association with the Joint STARS are system unique. Appendix A (Glossary) contains definitions of relevant terms and acronyms to this thesis.

---

[b] As of January 1992 Joint STARS is fully funded in the Program Objective Memorandum.

[c] In 1990 the projected procurement totals were 22 aircraft and 75 GSMs.

However, to help the reader several key terms are defined at the outset of this work. These three terms are: Joint STARS, Ground Station Module (GSM), and MTI.

Joint STARS - The Joint Surveillance Target Attack Radar System includes several components. Each of these system components is essential for conducting the Joint STARS mission. This is especially true in the linkage of the E-8A and the GSM.

The primary components of Joint STARS are:

- The Ground Station Module (GSM)
- The Air Force E-8A aircraft

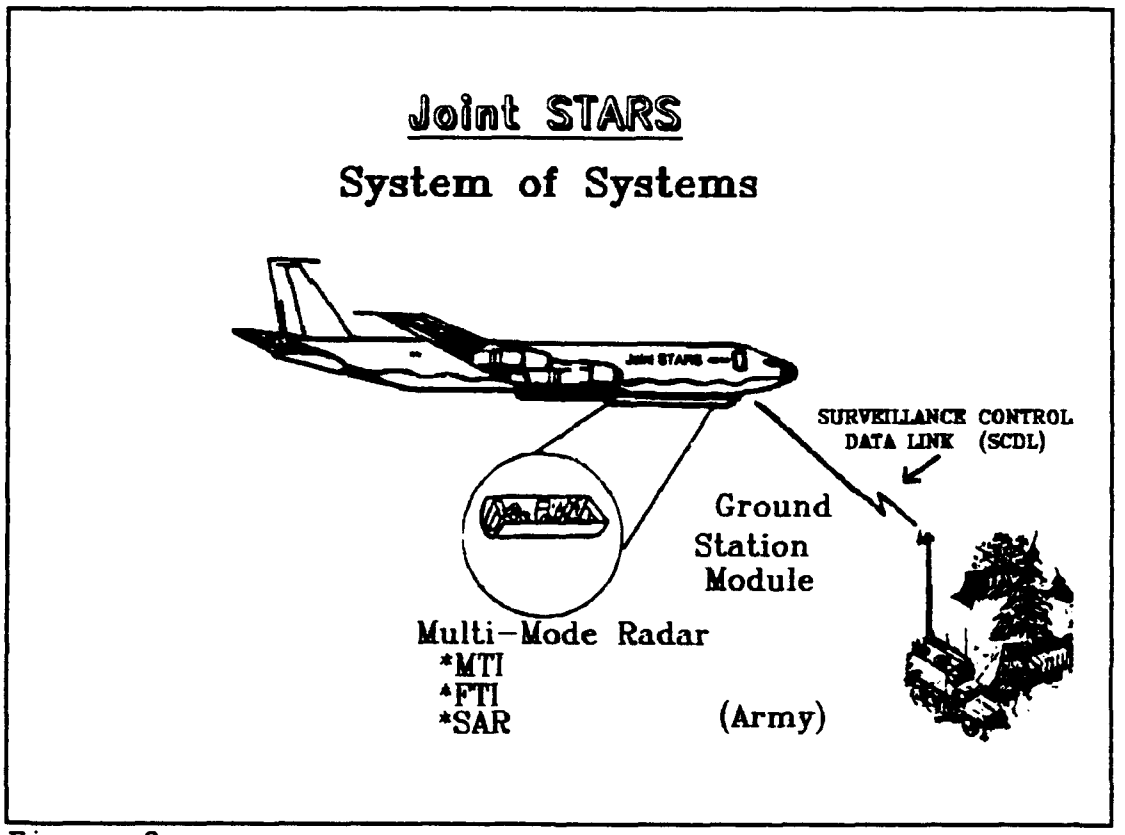

Figure 2

- The Surveillance and Control Data Link (SCDL)

- The multi-mode radar antenna

GSM - The Ground Station Module is the Army's Joint STARS link. Army operators in the GSM see the same display of MTI and fixed targets as that seen inside the E-8A aircraft. Technology improvements, after 1995 will allow the GSM to be positioned on the back of smaller, faster vehicles.

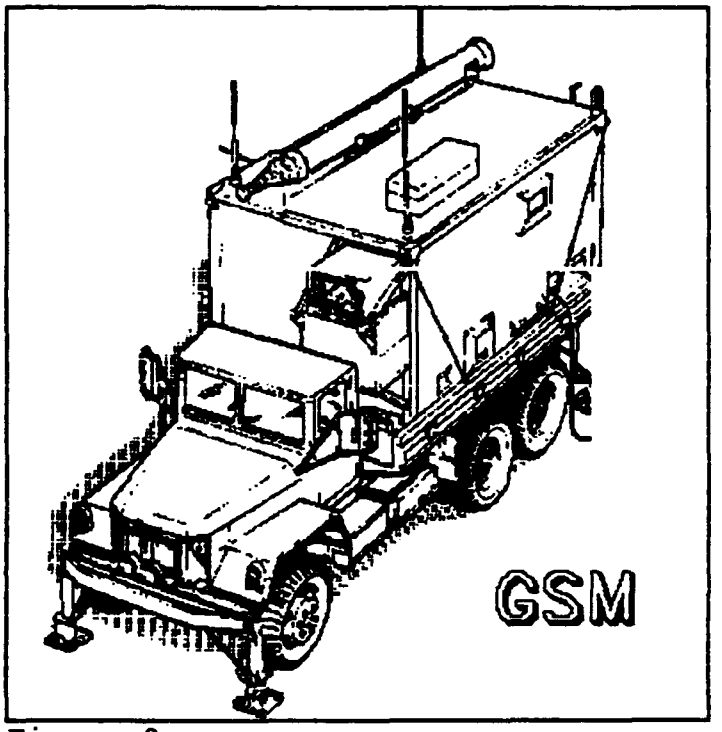

Figure 3

MTI - (Moving Target Indicators) These "dots" on a screen are indications of enemy movement that may be militarily significant. Joint STARS is able to track the direction and speed of MTI in a wide area surveillance mode. This capability distinguishes Joint STARS from all other fielded MTI system.

Delimitations. The scope of this thesis intentionally restricts discussion to an analysis of Joint STARS' place in the conduct of operational warfare. The following delimitations are established:

(1) Except for the historical background, provided in Chapter One, this study will not address the Joint STARS program or system capabilities before 1990.

(2) This study will not address Joint STARS reporting procedures below the brigade level.

(3) Because doctrine should drive the development and use of new weapon systems, this study will not recommend changes to the developing concept of AirLand Operations.

(4) This study will not examine the emerging competitors of Joint STARS. The concept of instantaneous target development and continuous wide-area surveillance are the crucial foci of this thesis. Joint STARS technology, by any other name, will still equal near real-time situation development and target engagement.

(5) This thesis does not rely upon classified material for the formulation of conclusions.

Limitations. The following limitations are established:

(1) This study will present an analysis of the Joint STARS missions in DESERT STORM as a case study to offer one look at system operational procedures. Care will be taken not to focus upon coincidental relationships which can occur with the introduction of a unique system into war.

(2) This study will examine those DESERT STORM questionnaires and surveys prepared by the Army's Operational and Evaluation Command (OEC), and analyzed by OEC in its

DESERT STORM After Action Report (AAR).

(3) This study will use a comparative analysis of current Army and Air Force doctrine as it pertains to operational warfare.

Thesis Methodology. The Training and Doctrine Command (TRADOC) problem solving model provides an analytical framework to serve as the methodology for this thesis. As espoused by former TRADOC Commander, General Maxwell R. Thurman, the model has nine steps. These steps are:

1. Identification of the Problem
2. Threat Analysis
3. Friendly Capabilities Analysis
4. Technology Assessment
5. Conceptual Alternatives
6. Operational and Organizational Plans
7. Analysis
8. Decision
9. Implementation[26]

The methodology of this thesis modifies the TRADOC model in the following order, with steps eight and nine deleted, as these steps are beyond the scope of this work.

Step 1.	Identification of the Problem	(Chapter 1)
Step 2.	Threat Analysis	(Chapter 3)
Step 3.	Friendly Capabilities Analysis	(Chapter 3)
Step 4.	Technology Assessment	(Chapters 3,4)
Step 5.	Operational and Organizational Plans	(Chapter 4)
Step 6.	Analysis	(Chapter 5)
Step 7.	Conceptual Alternatives	(Chapter 5)

Methodology Explained. Step 1 of the thesis methodology, The Identification of the Problem is expressed throughout Chapter One. The Army is committed to the Joint

STARS program and recognizes its capabilities as essential for victory on future battlefields. However, a decision is still needed as to the proper role and utilization of Joint STARS. A doctrinal consensus on Joint STARS' proper place in AirLand Operations is crucial in the current period of reduced defense resources. It is the intent of this thesis to determine the proper operational role for Joint STARS in the wars of the future.

Step 2, a current Threat Analysis is addressed at the beginning of Chapter Three. Levels of threat were developed from a review of current periodic literature and interviews with faculty members of the Command and General Staff College. An effort has been made to correlate the level of threat with the effectiveness of Joint STARS.

Step 3, Capabilities Analysis is covered in thesis Chapter Three. Open source briefing slides from TRADOC and the Tactical Air Command (TAC) Headquarters help clarify the components and capabilities of the system. These briefing aids provide a base system capability description. Once these capabilities are clearly described they are examined within the framework of the Army AirLand Operations.[27] The intent of this "cross-walk" of capabilities against the characteristics is to decide if Joint STARS contributes to operational war fighting as defined in TRADOC PAM 525-5B.

A further critical analysis of Joint STARS' capabilities will be provided in Chapter Four's look at the

results of DESERT STORM. A review of the OEC report and an examination of the mission log sheets from Operation DESERT STORM will help in this pursuit. Four criteria will guide the analysis of DESERT STORM mission results. These criteria are:

Value of Product
Timeliness
Accuracy
Simultaneous Support [28]

Value of product refers to the intelligence and targeting information that was produced by the Joint STARS aircraft and Ground Station Module. If the Joint STARS product caused a reaction, either immediately or delayed, from U.S. and Coalition Forces, that product was considered valuable, or relevant, to combat operations.

Timeliness relates to the detection and dissemination of Joint STARS information to U.S. and Allied Forces, over a short enough period, so as to allow for a decisive response by our forces. Depending upon the tactical situation this period may have been anywhere from several minutes to several hours.

Accuracy pertains to the ability of the system to pinpoint enemy activity. Joint STARS data is considered accurate if:

- An Air Force pilot found a target based upon Joint STARS information.
- The targeting data provided to operational fires was within the Circular Error of Probable (CEP) of a particular Army weapon system.[29]

Simultaneous Support denotes the ability of Joint STARS to concurrently service the requirements of the Army and Air Force. This final criteria measures the support provided by Joint STARS over the course of 49 combat missions. An attempt is made to quantify the coverage time given to each service.

The four criteria established above will be used to analyze the mission results as derived from the log sheets, prepared by Joint STARS operators. The analysis of these journals will also yield information on the technical performance of Joint STARS in the Gulf. As such, it will provide a transition point into a Technology Assessment, (Step 4) of Joint STARS. Step 4 will use two sources, the performance of Joint STARS in the Persian Gulf and an assessment of technical documents from the Grumman Corporation. These documents provide the most detailed account of technical information available on Joint STARS. However, an objective filter must be added to this evaluation of Grumman's data as Grumman is the prime contractor for this multi-billion dollar program.

Chapter Four will also address the Operational and Organizational Plans, (Step 5) of Joint STARS. The OEC report and AARs from DESERT STORM will help to explain the current operational procedures for Joint STARS. The reason for this focus on DESERT STORM is to assess whether established joint procedures were effective and efficient in the war. If they

were not, an analysis of the DESERT STORM experience may yield lessons learned for future operational uses of Joint STARS.

The final chapter of the thesis, Chapter Five, will cover Step 6, Analysis, and Step 7, Conceptual Alternatives. Chapter Five, explains the author's recommendations for Joint STARS operational procedures. These recommendations are a synthesis of the research of this thesis. The recommendations include a comparative analysis of the current procedures established in Army and Air Force manuals and numerous conversations with Joint STARS' action officers and program managers. Chapter Five holds the answer to the thesis question.

In summary, Chapter One introduces Joint STARS, alludes to joint operational problems, and establishes the thesis question. Chapters Three and Four provide the background information necessary to answer the thesis question. Finally, Chapter Five answers the thesis question and provides recommendations for future study.

Absent in the description above is mention of the contents of Chapter Two, Review of Literature. Chapter Two details the sources of information on the Joint STARS program. Due to the joint nature of the program, information is available from both Army and Air Force sources. In completing the literature review of Chapter Two, a balance of Army and Air Force sources were used to help minimize the parochial concerns of the respective services. Additionally, care was

taken by the thesis author to ensure the validity of the information collected and the qualifications of the women and men that provided input to this thesis.

Significance of the Study. This thesis provides an independent academic perspective to the issue of Joint STARS' employment during joint operations. Significant research was possible on this subject because, unlike Joint STARS action officers in the field, the author is unencumbered by the demands and restrictions of staff work at the Department of the Army (DA), Major Command (MACOM), or TRADOC staffs. Furthermore, the author, while familiar with the Joint STARS program, has no current programmatic affiliation.

Modern theorists and military practitioners agree that future wars involving the United States will be fought by joint forces using joint doctrine.[30] Joint STARS by its very name and expanded acronym should play a prominent role in all future conflicts. However, the right procedures to ensure that Joint STARS' pronounced capabilities help find, fix and destroy the enemy must be developed promptly. This thesis endeavors to contribute to that important effort.

ENDNOTES

1.The New American Bible, Saint Joseph Edition, (Catholic Book Publishing Co., New York, 1970), 146.

2.U.S. Army, FM 100-5 Operations, (Washington: Department of the Army, 1986), 16.

3.G. Goodman Jr., "New Airborne Sensors Look Deep, Allow Army/USAF to Strike Deep," Armed Forces Journal International, (January 1989), 84.
Dick Rasmussen, LTC, "SOTAS: The User has a Say," Aviation Digest, (May 1980), 2.

4.Ibid., 84.

5.Lieutenant Colonel Lester W. Grau, "Continuity and Change," Military Review, (December 1991), 15.

6.FM 100-5, 3.

7.Captain Ted D. Whitley, "SLAR's I&W Peacekeeping Role in Korea," Military Intelligence, (April-June 1979), 54.

8.CW3 Edward Jones, "Special Electronic Mission Aircraft," Aviation Digest. (February 1981), 3-9.

9.U.S. Army, TRADOC Headquarters Document, Joint STARS Requirements and Operational Capabilities (ROC), (1986).

10.Joint STARS Operational and Organizational Plan (O & O Plan), TRADOC Headquarters and TAC Headquarters Document, (23 February 1989).

11.S. Broadbent, "Joint STARS: Force Multiplier for Europe," Jane's Defense Weekly, (11 April 1987).

12.Edward Kolcum, "Test Aircraft, Radar Deliveries Cause Delays in Joint STARS Program," Aviation Week & Space Technology, (4 July 1988), 54-57.

13.Joint STARS ROC, 2-14.

14."Services Delay Contract for Joint STARS Radar System," Aviation Week & Space Technology, (22 April 1985), 27.

15.Colonel David M. Glantz, "Challenges of the Future," Military Review, (December 1991), 15.

16.Brigadier General Jay D. Blume, Jr. "E-8 J-STARS will Visit the Component," NATO SKYWATCH, Vol 6, No. 18, (28 Sept 1990), 1.

17.K. Gilmartin, "Joint STARS Goes Airborne," Hansconian (Hanscom AFB Newspaper), (6 January 1989), 1.

18.K. Gilmartin, "Joint STARS Takes Flight," Leading Edge, (February 1989), 4.

19.Caryle Murphy, "Iraqi Force Invades Kuwait, Tanks, Troops Storm Capital," Washington Post, (2 August 1990, #240),1.

20.Molly Moore and Patrick E. Tyler, "U.S. Sends Troops, Jets to Saudi Arabia, Iraqi Forces Pose 'Imminent Threat'," Washington Post, (8 August 1990, #246),1.

21.Rick Maze, "Bush to Put Plan to Public", Army Times, (26 November 1990), 16.

22.Numerous talks between Colonel Dempsey L. Malaney; Director of Combat Support Requirements Division, Fort Monroe, Virginia and Colonel Martin S. Kleiner; TRADOC Joint STARS System Manager, Fort Huachuca, Arizona, at Fort Monroe, Virginia, (August 13 1990).

23.Colonel Martin S. Kleiner, "Joint STARS Goes to War," Field Artillery, (February 92), 25.

24.General Merril A. McPeak, Air Force Chief of Staff, "Address at the United States Air Force, Tactical Air Command Symposium," Orlando, Florida, (31 January 1991).

25.Col (Ret) Harry Summers, "Snatching Victory Out of the Jaws of Defeat", Bradley Lecture Series at Fort Leavenworth (13 January 1992).

26.General Maxwell R. Thurman, "The Army's Long-Term Outlook," an address presented to the Electronic Industries Association at Alexandria Virginia on 12 April 1989, from Selected Works of the Sixth Commander, United States Army Training and Doctrine Command, (U.S. Army Training and Doctrine Command, Ft Monroe, Virginia, 1989), 142.

27.U S. Army, TRADOC Pam 525-5B, AirLand Operations, Fort Monroe, Virginia, (13 June 1991), 6.

28.U.S. Army, Field Manual (FM) 34-3, Intelligence Analysis, (Washington, DC: Department of the Army, March 1990),2-14 to 2-18.

29.Joint Pub 1-02, Department of Defense Dictionary of Military and Associated Terms, (Washington, DC: Office Chairman Joint Chiefs of Staff, 1 December 1989),66.

30.Colonel Peter F. Herrly, "Joint Warfare The American Way of War," Military Review, (February 1992), 10-15.

CHAPTER TWO

A REVIEW OF THE LITERATURE

"Knowledge is Power."
Francis Bacon 1620[1]

Although Joint STARS is a new and developing program, there is a substantial volume of literature available on the system. Descriptions of its capabilities, limitations and missions can be found in the following sources:

- Current periodicals
- Technical contractor reports
- Staff officer briefings and executive summaries
- After Action Reports of Joint STARS deployments
- Army and Air Force manuals

Periodicals. Numerous articles on Joint STARS have appeared in journals, magazines, and newspapers since May 1984.[2] This information is useful for the development of a historical perspective and for fresh points of view. Especially enlightening are the articles that appeared in newspapers during and after Operation DESERT STORM. These

newspaper writings succinctly explain the role and capabilities of Joint STARS to the public. However, several newspaper articles required careful evaluation because of known discrepancies.

Generally, the periodical writings on Joint STARS are more scholarly and technically correct than the newspaper columns. An article which ran in a January 1991 edition of the Sierra Vista Herald, Sierra Vista, Arizona, is an example of this statement. The Herald's reporter misrepresented the rank of the Joint STARS deputy system manager and wrote that the "development for the $9 billion dollar project began in 1986."[3] Both the year (1982) and the amount ($7.7 billion) are in error. In contrast the writings of defense related journals and magazines such as Aviation Week & Space Technology, were very accurate in their descriptions of Joint STARS capabilities and program problems.

Technical Reports. Most Joint STARS technical reports are prepared by government contractors. BDM Corporation, the Environmental Research Institute, the Institute for Defense Analyses, and the MITRE Corporation are among those contractors that have prepared extensive studies on various aspects of the Joint STARS program. The Army Missile Command and the TRADOC Systems Analysis Activity are further examples of agencies, within the Army, which have analyzed this full-scale developmental program.

Most of this technical data, contained in contractor

and governmental reports is classified. However, there are unclassified papers available that detail, with great fidelity, the capabilities and limitations of the Joint STARS. In these papers system components are dissected and analyzed; electronic interference, radar wave forms, and data-link band widths are explained and debated. The worth of this technical bombardment is the documentation of system engineering data. This data offers a base from which to examine any future changes to Joint STARS and the possibilities of its interface with tomorrow's weapon systems.

Staff Officer Papers. The dynamics of staff officer work make the information which they can provide to this thesis the most controversial and perishable input available. The data obtained from the papers and briefings of Army and Air Force action officers is constantly changing with the directions delivered by their general officers. However, even with this recognized prejudice, the captains and majors that work in the background in places like Fort Huachuca, Arizona; Langley AFB, Virginia; and the Pentagon, are valuable sources for current program information. These officers perhaps best understand the health and ailments of Joint STARS' funding and procurement issues. Therefore, primary and secondary source information from these staff officers is useful for a comprehensive understanding of the program.

Special consideration was given to verbal and written input from Joint STARS' action officers. The special

interests of their service or command often adds a special "spin" to the information that they provided for this thesis. Additionally, as in most governmental programs in full-scale development, what is accepted as the truth today changes with the latest Program Objective Memorandum (POM) update and budgetary cuts. For these reasons, the input from action officers is considered as subjective judgements, unless specifically supported in an Army or Air Force publication. Endnotes annotate all references in this thesis from Joint STARS staff officers to differentiate between opinion or fact.

After Action Reports. The After Action Reports (AARs) used for this research project came from the deployment of Joint STARS to Europe, during Operational Field Demonstration One (OFD1) and the deployment of the system to DESERT SHIELD/STORM. Army and Air Force officers, and enlisted from all ranks, contributed their insights in the preparation of the After Action Reports. The real value of these reports rests in the "user" description of the system's utility. Operators, on the aircraft and in the GSM, describe the success and failures of a developing surveillance and targeting system.

Most conclusions, about the role of Joint STARS in DESERT STORM, are drawn from an analysis of the AARs. The documented mission log sheets, personal journals, and debriefing forms, provide a readily available data base for the analysis of the system's surveillance and targeting

performance. In the future, DESERT STORM mission results will be a baseline from which other operations will be measured.

Military Publications Service manuals provide the doctrine for how the Army and Air Force conduct war. The Army centerpiece for all studies of land warfare is FM 100-5, Operations. For the Air Force the fundamental principles of warfare are contained in AFM 1-1, Basic Aerospace Doctrine. These documents provide service perspectives as to the role of Joint STARS on tomorrow's battlefield and the possible missions of the system.

Two other Army publications were also valuable in understanding the overarching concepts of tomorrow's military operations. These publications were TRADOC Pamphlet 11-9, Blueprint of the Battlefield and the Final Draft of TRADOC Pamphlet 525-5B, AirLand Operations.[4] These documents were crucial to the development of Step 5, Operational and Organizational Plans and Step 7, Conceptual Alternatives, of the thesis' methodology.

Additionally, the Air Force "2" series (Operational) and the "3" series (Tactical Operations) manuals served as solid sources for Step 7. Army field manuals on Corps and Division operations (FM 100-15 and FM 71-100, respectively) and intelligence (FM 34 series) and targeting procedures (FM 6-20 series) were also important to this thesis.[5]

Additional Resources. A review and analysis of previously completed Master of Military Art and Science (MMAS) theses were very useful in the completion of this work. These theses often provided relevant bibliographies and served as a catalyst for creative thought on the proper operational employment of Joint STARS. Three works were especially useful in the completion of this study; Detailed Planning Considerations for Attack Helicopters, Space and AirLand Battle, and Seeing the AirLand Battlefield ...[6]

Finally, interviews with key officers, soldiers, and Department of the Army civilians helped to provide a necessary human perspective for this study. Of special note were interviews with the chief Grumman program engineer; the Training and Doctrine Command (TRADOC) System Manager for Joint STARS; the Director, Department of Tactics, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas; and the Deputy Commanding General for Combat Developments, Combined Arms Command, Fort Leavenworth. The research for this thesis could not have been completed without their willingness to share their visions and system perspectives.

ENDNOTES CHAPTER TWO

1.H.L. Mencken, A New Dictionary of Quotations, (New York: Knopf, 196), 638.

2.Kozicharow, E. "USAF, Army Agree on Joint Initiatives," Aviation Week & Space Technology, (28 May 1984), 22-24. (This is among the first articles to appear alluding to the developing Joint STARS program.)

3.Joe Hinton, "Fort Huachuca Group Searching for Scuds." Sierra Vista Herald, (Sierra Vista, Arizona, January 1991).

4.U.S. Army, TRADOC Pamphlet 11-9, Blueprint of the Battlefield. Dynamics Research Corporation, Andover, Massachusetts (15 February 1991). and U.S. Army, TRADOC Pamphlet 525-5B, AirLand Operations, Fort Monroe, Virginia, (13 June 1991).

5.U.S. Army, FM 100-15 Corps Operations. (13 September 1989).
U.S. Army, FM 71-100 Division Operations. (June 1990).
FM 34-1 Intelligence and Electronic Warfare. (July 1987).
FM 34-3 Intelligence Analysis. (March 1990).
FM 34-10 Division Intelligence and Electronic Warfare. (November 1986).
FM 34-80 Brigade and Battalion Intelligence and Electronic Warfare Operations. (April 1986).
FM 34-130 Intelligence Preparation of the Battlefield. (May 1989).
FM 6-20 Fire Support in the AirLand Battle. (17 May 1988).
FM 6-20-10 Tactics, Techniques and Procedures for the Targeting Process. (March 1990).
FM 6-20-30 Fire Support for Corps and Division Operations. (October 1989).

6.Major John C. Bendyk, Detailed Planning Considerations for Division Attack Helicopters (AH-1) in the Division Deep Battle: A Defensive Operation Perspective. M.M.A.S. Thesis (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1989).
Major John S. Prall, Space and AirLand Battle, M.M.A.S. Thesis (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1991).
Major Brian A. Keller, Seeing the AirLand Battlefield: Can the Heavy Division Military Intelligence Battalion Do

Its Job?, School of Advanced Military Studies Monograph, (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1991).

CHAPTER THREE

THE KEY ISSUES

Section I

The Threat

As stated in Chapter One, the perceived threat of a multi-echeloned Soviet attack in Europe provided the impetus for the development of Joint STARS.[1] With the dissolution of the Soviet Union it is fair to question the continued requirement for this expensive weapon system. An analysis of future threat possibilities will help to endorse or negate the need for Joint STARS.

In today's world the clear identification of the threat is increasingly difficult. Prior to the political rise of Mikhail Gorbachev the Union of Soviet Socialist Republics provided a recognized, defined threat. The Soviets alone possessed the capabilities to jeopardize the American way of life. They had the ideology, technology, and military tactics to do us harm. The Soviet threat also extended to U.S. interests in Europe and other parts of the world. Recent

world developments however, have altered the prominence of Soviet political and military power.

The events set in motion by the "perestroyka" movement of Gorbachev accelerated with the fall of the Berlin Wall in December of 1989 and culminated one year later with the official demise of the Soviet Union.[2] With formation of the Commonwealth of Independent States (CIS) the former Soviets are searching for their proper role in the world community. Does this mean that they pose no danger to the United States? And if not, then who or what makes up threat? The answers to these questions will influence our nation's security strategy and in turn establish the requirements for future weapon systems like Joint STARS.

Although the former Soviets, *as a nation*, no longer pose a danger to the United States, the proliferation of weapons throughout the former republics is cause for concern. The need for hard cash to finance the future of the CIS will likely drive arms sales. Customers such as Iran, Iraq, Libya, Syria and North Korea stand ready with the monies necessary to upgrade their militaries with surplus equipment from the former Red Army.[3] These future arms sales to hostile world neighbors may yield a far greater threat to America's security than the CIS' use of these systems for self-preservation.

Arms sales alone however, do not translate directly into a threat against the United States. For a viable threat to be posed against our nation, a foreign country must possess

destructive power and hostile intent. This relationship of destructive power and hostile intent is illustrated by the following model. Obviously threat levels do not fit into

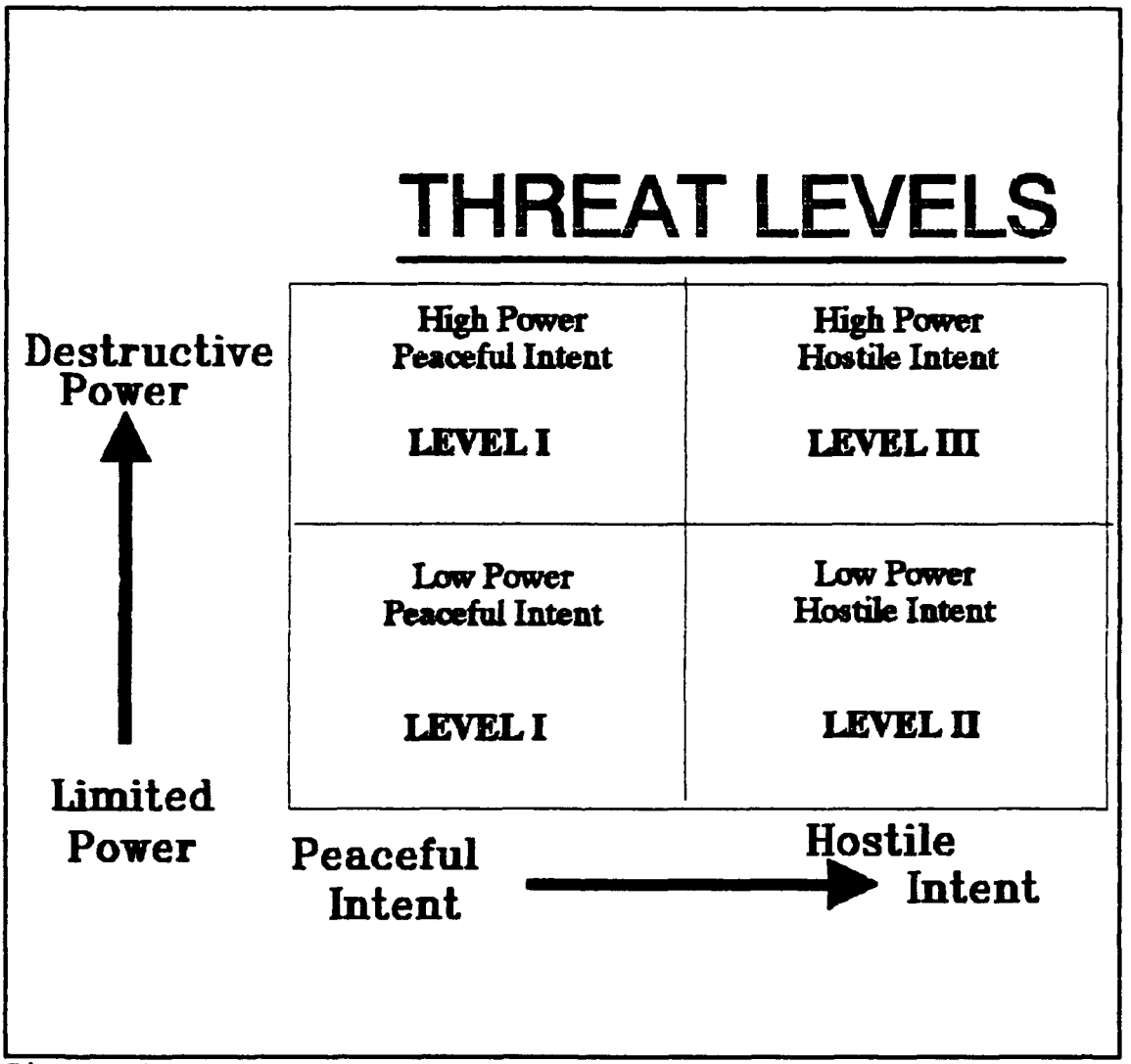

Figure 4

Threat Model 1

quadrants out of their respect for symmetry. In the absence of a Soviet Union the Level III quadrant could be eliminated. A more accurate depiction of reality is represented below.

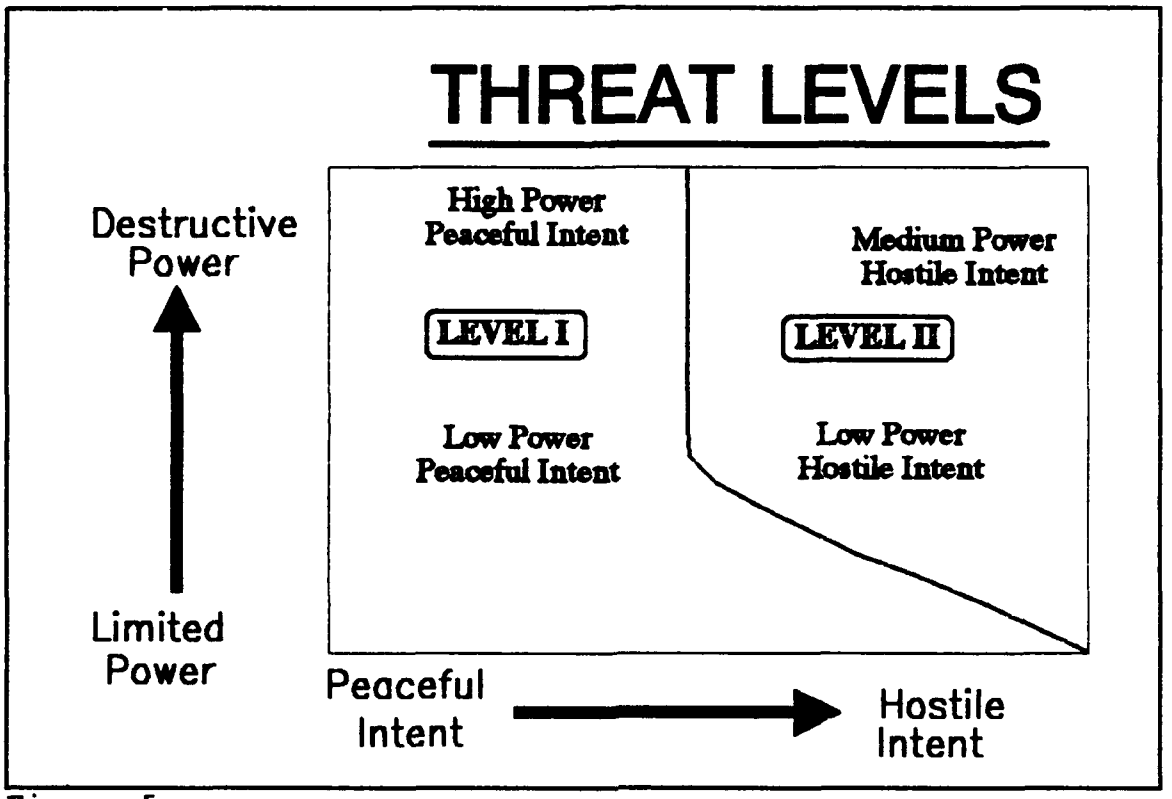

Figure 5

Threat Model 2

Threat Levels Characteristics. The following characteristics help to define the threat levels depicted above:

	LIC	MIC	HIC**
CHARACTERISTICS	LEVEL I	LEVEL II	LEVEL III
Destructive Power	X	X	X
Developed or Advanced Technology	X	X	X
Hostile Intent		X	X
Low Power	X	X	
Underdeveloped Technology	X	X	
Peaceful Intent	X		

** LIC Low Intensity Conflict
MIC Mid Intensity Conflict
HIC High Intensity Conflict[4]

In these threat models, Levels of Threat are delineated along a continuum defined by characteristics. Without question, Level III threats present the most serious challenges to America's security. Level III threats, possess the capability to destroy America, whereas, Level I threats offer low risks.

Unknown factors in this threat analysis are the impact of the future actions of the CIS and nonmilitary threats. Global crises such as environmental decay, overpopulation, and diseases such as AIDS will all serve to skew the threat continuum and add to increased world instability.[5]

The Seven Scenarios. In February of 1992, the Defense Department revealed seven scenarios that are "illustrative but not predictive" of future potential conflicts. These scenarios, defended as a justification for a 1.6 million member military, include:

1. War with a re-armed Iraq.
2. War with a nuclear-armed North Korea.
3. Simultaneous wars with Iraq and North Korea.
4. War between Russia and NATO caused by an attempt to re-establish Moscow's dominance over the former Soviet republics.
5. A Filipino revolution, with the added danger of thousands of U.S. hostages.
6. Chaos in Panama with the seizure of the Panama canal.
7. A new Soviet-like threat, created from a coalition of nations hostile to U.S. interests.[6]

These scenarios spread across the spectrum of conflict from Level I (Low Intensity) to Level III (High Intensity) threats.

As this thesis is written no clearly identified Level III threat challenges the United States. Currently, no nation is politically, economically, or militarily positioned to successfully wage war against America. In most cases this is because Level II nations (i.e., Iraq, Iran and North Korea) lack the destructive power necessary to battle the United States. With the procurement of former Soviet or Chinese weapons these nations may obtain the necessary means to achieve their ends.[7]

Future arms sales, amplified in their consequences by improvements in technology, will likely increase the threat risks to the United States. The acquisition of ICBMs, or improved SCUD[a] missiles, by nations such as North Korea or Iraq would present a clear and present danger to America.[8] The purchase of improved weapons systems by nations on the fringe of Level II would quickly upgrade a hostile nation to a Level III "status."[9]

Threat Summary. In the absence of a crystal ball an accurate prediction of a future threat is very difficult. As General Colin Powell, Chairman of the Joint Chiefs of Staff,

---

[a]SS-1 (SCUD) Battlefield Support Missile. Family of heavy artillery rockets. Land-mobile system, single missiles carried on an IS-III vehicle that combines the functions of transports and erector. SCUD B range 280 KMs. SCUD C range 450 KMs. Conventional, chemical or nuclear warhead.

wrote in the 1992 National Military Strategy, "The real threat that we now face is the threat of the unknown, the uncertain."[10] As a result, the United States must continue to defend against Level III threats and high intensity conflicts as it hopes for peaceful competition and the occasional outbreak of the low intensity clashes of Level I threats. The assumption for the future is that the world will continue to be a dangerous place, requiring the occasional commitment of U.S. forces in order to protect our national interests. If our military deploys to meet a threat they will need the type of capabilities provided by Joint STARS. An examination of the Joint STARS capabilities shows why its support is important.

Section II

Joint STARS Capabilities Analysis

"We are less convinced by what we hear than by what we see."
Herodotus 430 B.C.

"An eye like Mars, to threaten and command."
Shakespeare 1600

A proper system description is a logical starting point in understanding Joint STARS' role in future military operations. An examination of the functions and capabilities of Joint STARS will help to establish proper operational procedures for the system.

Scope. The Joint STARS program is "big," both in influence and dollars. With an estimated budget of $7.7 billion it is referred to by the Department of Defense as a "Major" Program.[11] As such, it is a system supporting the fiscal futures of several government contractors. Although Joint STARS is under the general supervision of the Grumman Corporation, there are fourteen diverse companies with a stake in the success of the program. The Joint STARS contractor team consists of:

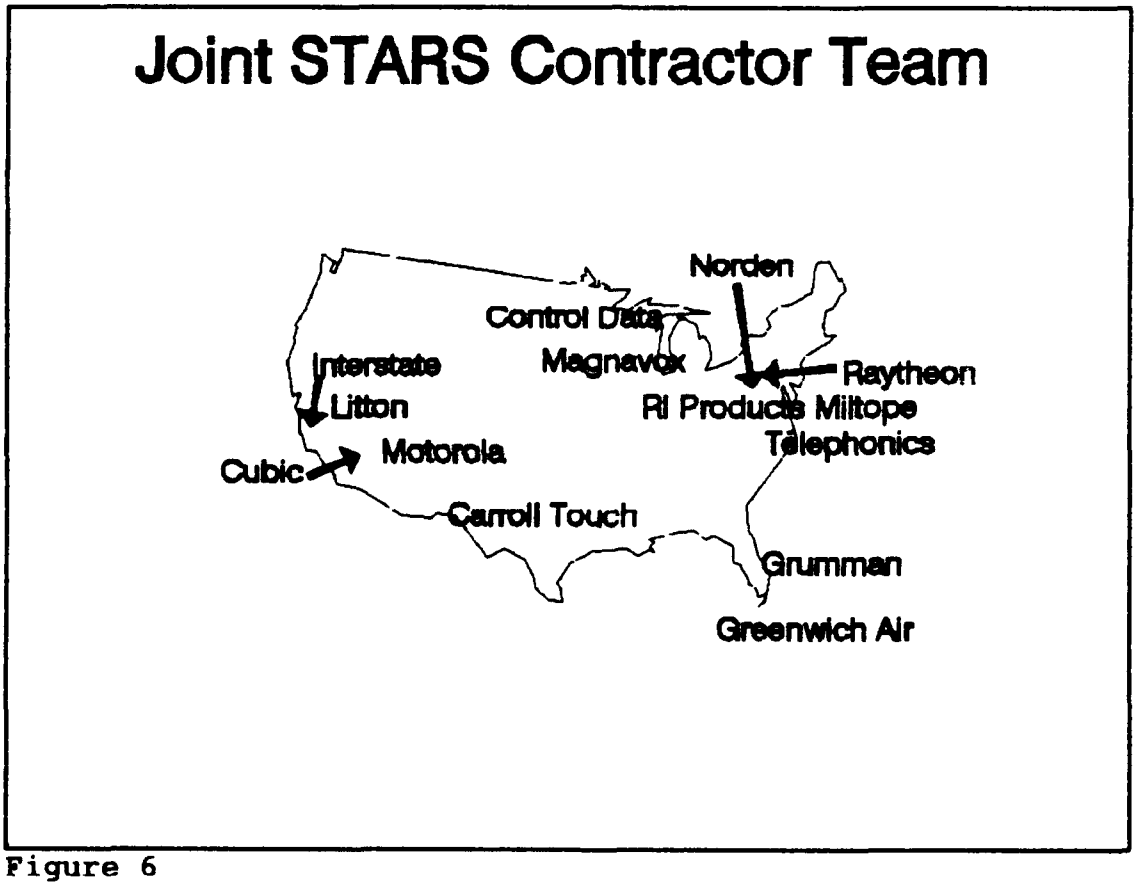

Figure 6

Contractor Team

* Grumman Melbourne Systems-Prime contractor, airborne system
* Motorola-Prime Contractor Army mobile ground station modules
* Boeing Company - Major Subcontractor, aircraft
* Norden Systems (UTC) - Major Subcontractor, radar
* Carol Touch - Programmable switch panels
* Control Data Corp. - Programmable signal processor
* Cubic Corp- Surveillance Control Data Link (SCDL)
* Hartman Systems - Displays
* Litton Guidance & Control Systems-Inertial measurement unit
* Magnavox - Ultra High Frequency (UHF) Communications system
* Miltope - Message Page printer
* RF Products, Inc. - Co-location filter
* Rolm Mil-Spec Computer Co-Gen. purpose computer disc storage
* Telephonics Corp. - Internal communications system[12]

Mission Statement. The mission of the system is addressed in the Joint STARS Operational Concept of February 1989. The implied mission is to support the battlefield commander with day/night, all-weather, wide-area and focused surveillance and targeting information of moving and stationary ground targets.[13] It is important to stress that the "battlefield commander" may be a Joint Task Force (JTF) Commander, an Air Force or Marine general, or Navy admiral. The battlefield commander need not be an Army officer.

The Joint STARS mission can be accomplished from a standoff orbit flown over friendly territory.[14] The mission profile of Joint STARS was originally devised, and ideally

suited for operational contingencies in Central Europe. As this thesis will show the role and missions of Joint STARS has expanded significantly from its original focus on Central Europe.

Concurrent Missions. As the Joint STARS aircraft flies along its orbit the system's multi-mode radar (radar that detects both moving and fixed targets) detects enemy activity. Once detected the direction, speed, and location of the enemy force is passed, via a secure data link, to U.S. or allied command and control nodes.[15] Due to the radar's precise location accuracies, targeting of enemy forces is possible. This targeting can occur, concurrently with surveillance sweeps of the battle area. In this manner, Joint STARS simultaneously supports target development and intelligence missions (situation development).[16]

Joint Requirements. The mission of Joint STARS grew out of program requirements, or Joint Operational Requirements. These joint operational requirements include:

- Moving target detection, location and tracking
- Differentiation between tracked and wheeled vehicles
- Rapid worldwide deployability
- Interoperability with Army and Air Force Command, Control, Communications and Intelligence (C3I) nodes
- Attack support to Army and Air Force weapons systems[17]

These requirements were formalized in the publication of a Joint Service Operational Requirements Document (JSORD) in

1989. This JSORD carries the approval signatures of the commanders of TRADOC and the Tactical Air Command, as well as the Army and Air Force Staffs. With the publication of the JSORD, Joint STARS program managers and government contractors had a baseline for program requirements.[18]

System Components

Aircraft. The radar platform for Joint STARS is the E-8A, or militarized version of the Boeing 707 airframe.[19] Of significance is the age of the 707s - they are old airplanes. In 1989, after a detailed Air Force analysis of three airframes, the C-141, MD-11(McDonald Douglas) and new versus used 707s, the Air Staff selected the used 707 option.[20] There were several logical reasons for this selection but the factor that carried the final vote was the low initial cost of the used 707 plan. It made fiscal sense to the Air Staff to choose a proven airframe[b], one with a relatively low maintenance and sustainability price tag.[21]

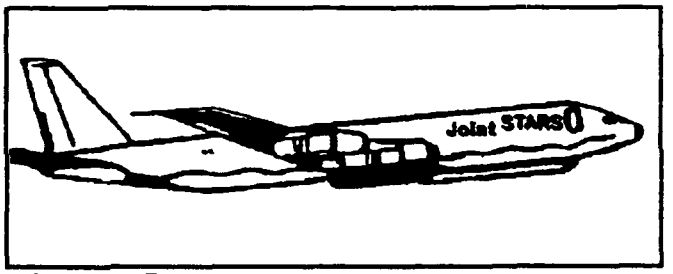

Figure 7

E-8A

Aircraft Advantages. Use of the E-8A as the aerial

[b]The Air Force AWACS program flies 707s.

platform allows Joint STARS to exploit the characteristics of air operations; **speed, range and flexibility**. As described in AFM 1-1, Basic Aerospace Doctrine, aerospace operations allow U.S. forces to apply combat power against all elements of an enemy's structure.[22] In a similar fashion the E-8A enables Joint STARS to apply its surveillance and targeting capabilities to multiple levels of the enemy's military structure. The **speed** of the aircraft affords for a rapid projection of surveillance and targeting capabilities. The **range** of the aircraft gives Joint STARS the ability to operate in any direction over great distances, unimpeded by surface features. The **flexibility** of the plane allows the combat commanders the ability to use the system as needed, according to changing battlefield conditions.[23]

One of the key features of the aircraft's flexibility is its ability for rapid deployment to any area of conflict. With aerial refueling it can stay airborne for twenty hours. This long flight time, combined with a cruise speed of approximately .78 mach (450 knots) suggests that the aircraft can, theoretically, cover more than 10,000 miles between takeoff and landing.[24] With room inside the aircraft for over 40 crew members the Joint STARS aircraft could easily self-deploy a functional mission crew into any area of interest in the world. Maintenance and support personnel would be required for missions in excess of 72 hours but for the initial stages of operations the Joint STARS aircraft could be

one of the first intelligence and targeting assets available in theater.[25]

In addition to deployability, the size of the E-8A is

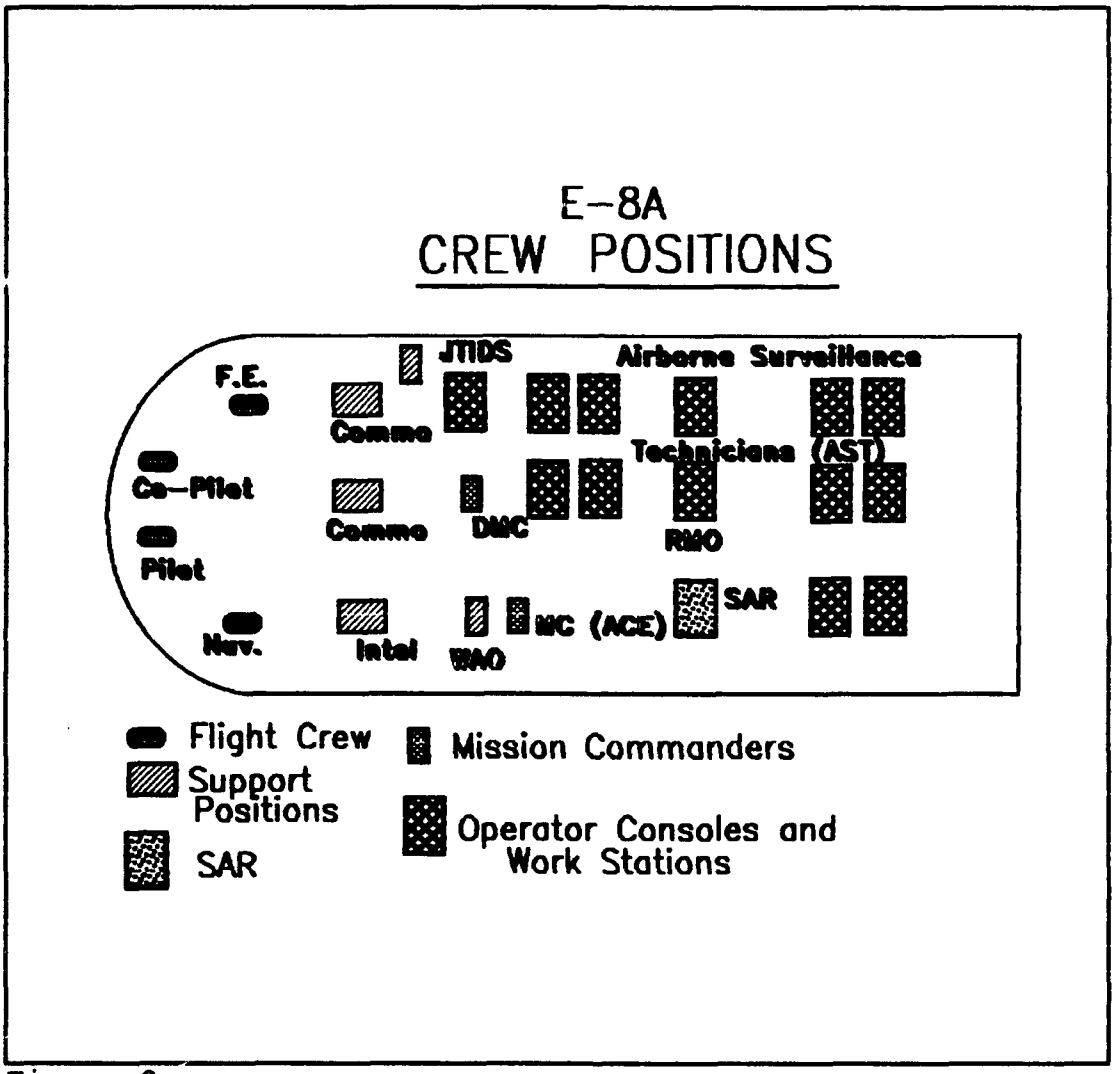

Figure 8

Crew Positions

a strength of the aircraft. Over 145 feet long, the plane is large enough to accommodate the required mission equipment and Joint STARS operators.[26] Fourteen operational consoles and workstations take up much of the interior floor space of the

E-8A. Additional room is occupied by a communications console and a self-defense station; both required positions in the plane. No less important to the Joint STARS mission is the "below deck" storage areas which house the computer processors and radar system components.

Crew member requirements are a further reason for the selection of the 707 as the aircraft of choice. The flight and mission crew encompasses about twenty-five personnel.[27] Each crewmember has an area for takeoff and landing and a mission work area. The space aboard also permits crewmembers to rest in four sleeping berth areas and numerous reclining "airliner-type" seats. To the rear of the plane are two restrooms and a kitchen galley for food and water. The arrangement of the E-8A for Joint STARS mission is modeled after the AWACs mission configuration.[28] Crew member comforts allow for the performance of missions well in excess of eight hours.

Aircraft Limitations. ***Supportability*** and ***survivability*** are two limitations of the E-8A. As the E-8A is a big aircraft it has, by Army standards big logistical requirements. A long, prepared runway is needed for flight operations of the E-8A. Aviation fuel, oil and aircraft support equipment are all required before the Joint STARS aircraft can fly to its surveillance and targeting orbits. These requirements usually equate to a prepared, instrumented airfield. In most parts of the world this requirement can be

met, if not in the immediate area of conflict, close enough to be within one to two hours flight time.

The second limitation, survivability, is a more sensitive and controversial issue. Sensitive because survivability is always a concern for Air Force pilots and crew members, and controversial because non-survivability on tomorrow's battlefield equals to program termination. As in most emotional issues the arguments are not well defined.

The E-8A is a large aircraft and as such reflects a substantial radar signature. Add to this signature the emission of radio transmissions and an active radar system and you have a lucrative target that is easy to pinpoint. If engaged by enemy aircraft or missiles the E-8A's lack of maneuverability would make it an easy kill.[29] The development of an aircraft self-defense suite (SDS) that includes electronic "black boxes," flares and chaff may help protect future Joint STARS aircraft.[30] How effective these SDS measures are is open to debate. It is difficult to realistically measure the effectiveness of countermeasures in simulations short of actual combat.

Two standard operational practices however, increase the combat survivability of the Joint STARS E-8A; stand-off and the High Value Airborne Asset Program (HVAACAP).[31] Stand-off is the normal operational procedure of establishing an orbit in friendly airspace. With the range of the Joint STARS' radar over 200 kilometers, the surveillance and

targeting orbit can be established well to the rear of friendly forces.

Additionally, U.S. fighter coverage, or HVAACAP, provides the system's greatest protection. Joint STARS' E-8A is worked into the Air Force's combat air patrols designed to protect High Value Assets. Within these patrols, the E-8A secures its orbit along side other low-density, and vulnerable platforms such as the Airborne Warning and Control System (AWACS), COMPASS CALL or RIVET JOINT[c]. These aircraft need escort protection and F16s and F15s provide that coverage.

Combat Air Patrol fighter jets loiter in synchronized orbits near the special mission aircraft to ensure that the work of Joint STARS and similar systems are not interrupted.[32] Of course, CAP cover is only effective when fighters are on station and therein lies another limitation. Jet fighter aircraft cannot maintain an "on-station" time much longer than one hour. The Joint STARS' E-8A, with a mission coverage period, often more than ten hours, requires an extensive CAP commitment to guarantee safety. Total CAP coverage is difficult to achieve and almost impossible before the Air Force has attained air supremacy.

However vulnerable, the Joint STARS' E-8A is no more or less survivable than similar Air Force special mission

---

[c] COMPASS CALL is an electronic countermeasures system installed on an Air Force C-130. RIVET JOINT locates ground based radar systems. The RIVET JOINT system is found on a modified Boeing 707 aircraft.

aircraft. If an aggressor fighter pilot is willing to sacrifice his life in return for a "Joint STARS kill" he may likely succeed. For that matter, one lone gunman with an SA-7 could serve the same end during the E-8A's takeoff or landing. The Joint STARS aircraft is not indestructible; it was never designed to be invincible.[33] Warfare and military operations are always marked by a certain amount of risk. Joint STARS' risk is equal to that of other theater High Value Assets.

Ground Station Module (GSM). The Army's link to the Air Force's E-8A is the GSM. The GSM receives and displays surveillance data from the aircraft's radar and distributes this data and developed targeting information to Army Command, Control, Communications and Intelligence (C3I) nodes.[34] The GSM mounts on the back of a five ton truck (Figure 3). The box-like, S-280 shelter for the mission equipment is called the AN/TSQ-132.[35] Inside the AN/TSQ-132 or GSM are two operations consoles and work stations (Figure 9). These consoles mirror the information received and processed by mission operators on the E-8A.

The GSM operators manipulate the pre-processed radar data received from the E-8A. Battlefield information of the coverage area enters the work station and is stored in the system's computers. Through the use of these computers operators tailor battlefield data, specifically to areas determined by their commanders.[36] Terrain features and enemy units are focused on, depending on the interest of the corps

commander. Once the operator focuses his attention on a confined set of geographic coordinates or area, the GSM computer can further assist his battlefield analysis by the techniques of *time compression* and *time integration*.[37]

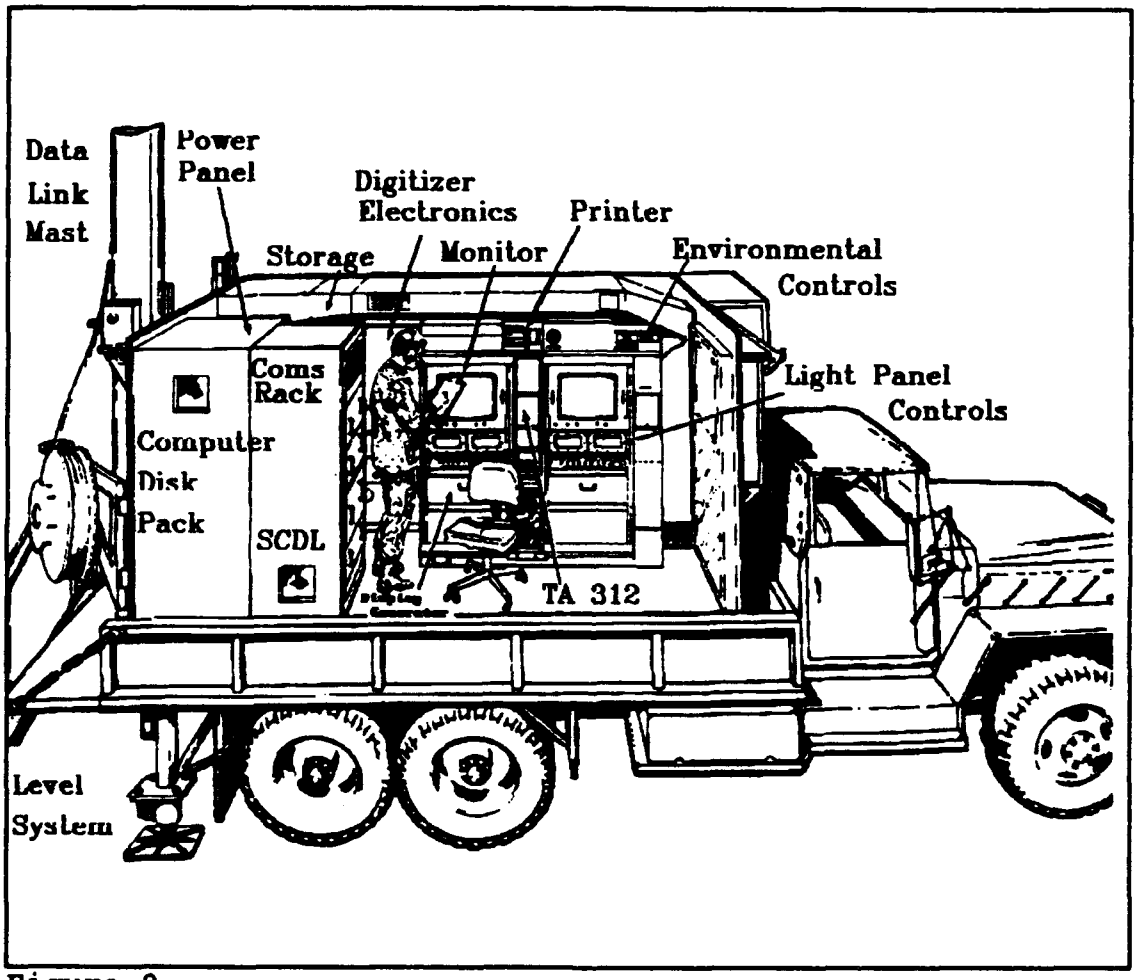

Figure 9

Inside the GSM

In the time compression mode, also known as history replay, the GSM's computer plays back detected movement at a rate selected by the soldier in the GSM. For example, the last two hours of radar coverage in a 5x5 kilometer box,

centered around Kuwait City could be compressed and played back over a 60 second interval of real time. This function could be repeated indefinitely by the operator as she or he varies the time compression windows to assist in analysis. The result of this technique is a fast-forward/fast reverse "movie" of enemy activity in an area of interest.[38]

In the time integration mode the GSM's computer overlays frames of imagery, one on top of another, until a direction or trend of activity is depicted. Time integration differs visually from time compression in that "fingers of activity" appear and grow on the GSM's video monitors, highlighting for the operator the areas of concentrated enemy activity. Time integration offers a different perspective on enemy activity which can be used in tandem with the time compression mode to determine enemy intent.[39]

Once targets are determined or probable enemy courses of action are recognized the intelligence can be passed via land-line or secure radio to Army command and control nodes. The exact communication network will vary with the mission of the supported unit but in most cases derived intelligence can be quickly transmitted to Army and Air Force weapon systems for suppression or destruction of the enemy force.[40]

GSM Strengths. Besides the GSM's mission capabilities of situation and target development the system is ***easily supportable*** and ***offers limited protection*** for Army operators. Mounted on the back of a M885, 5 ton truck, with a 60Kw

generator in tow, the GSM is a self-contained battlefield intelligence workstation. Maintenance on the standard vehicle and generator is not complicated and can usually be accomplished by the mechanics available in the supported unit.[41] Additionally, working inside a hardened, airtight S-280 shelter, provides the GSM soldier with a degree of safety against small arms fire and low level chemical attacks. Small arms fire directed against the external, kevlar-hardened components of the GSM, such as the SCDL mast, will do little to disrupt the surveillance and targeting missions of the system.[42] Internal air-locks and filters of the future, GSM Block I will permit soldiers to safely perform their surveillance and targeting missions while operating in a contaminated chemical environment.[43]

GSM Limitations. The GSM is limited by ***speed, range,*** and ***deployability***. Presently, the GSM cannot operate on the move. Limitations in the function of the GSM computer disk drive require the GSM to be stationary and level before "mission booting." From a cold start the process of leveling the truck, erecting the SCDL mast and loading up mission data files takes thirty minutes with a good crew.[44] In a fast-paced operation this half an hour could be excessive and the GSM would have to choose between monitoring the battlefield or moving with the supported unit. On the move, the GSM may find that it cannot keep up with the maneuver unit, especially if the combat force is a armor unit and the GSM is confined to a

wheeled vehicle. For this reason the GSM is likely to be located somewhere besides the front line forces where rapid mobility is not as crucial.

Data link range is the second limitation of the GSM. Presently the GSM can on`y receive battlefield information when the E-8A is within line-of-sight SCDL reception range. In a large theater, (such as Saudi Arabia) or in the absence of several Joint STARS aircraft the orbit of the E-8A is stretched to ensure maximum coverage of the Area of Operations (AO). In such a situation the GSM often "loses data-link" at the ends of the aircraft's orbit.[45] Smaller orbits or increasing the SCDL range are the only solutions to this limitation.

Another weakness of the GSM, deployability, is dependent upon the location of the conflict and the availability of airlift. In the years beyond 1997, 25 GSMs will be found at an Army Corps.[46] So, if war breaks in the area of a pre-positioned Army Corps deployment of GSMs is obviously unnecessary. The problem however is the increasing likelihood of a crisis developing in a part of the world where there is no forward U.S. presence. If this happens there will be a connectivity gap between the Joint STARS aircraft and the GSMs.

As was addressed in the discussion of the aircraft, the E-8A can rapidly deploy in response to a crisis. Once in country the aircraft and mission crew can conduct limited,

independent operations for a short duration without logistical support. The GSM does not have this capability. The Army ground station, relying upon airlift will always lag behind the Joint STARS aircraft.[47] Depending upon the Time-Phased Force Deployment Data (TPFDD) this time gap may be anywhere from several hours to several days.[48] The solution to this limitation is for joint planners to recognize the relationship between the E-8A and the Army GSM. The GSM must be programmed to deploy early in the TPFDD cycle. The GSMs' deployment must coincide with the arrival of the Joint STARS aircraft during the earliest phases of the operational campaign.[49]

Radar. The third important component of the Joint STARS system is the multi-mode radar. Although an integral part of the E-8A, its functions are important enough to warrant a special description. The multi-mode radar antenna is 24 feet long and lies under the forward fuselage of the E-8A aircraft. This radar, engineered by Norden Systems, can spot individual moving vehicles at ranges beyond 200 kilometers. This capability is made possible by using a large antenna (length), with high average and peak power. The radar antenna mechanically scans in elevation, meaning that it can swivel to look at either side of the aircraft. It scans electronically in azimuth and operates within the X-band, providing high fidelity resolution and long range.[50]

The sheer size of the antenna is important to the detection of slow targets. Shifts in ground clutter, due to

aircraft movement, are inevitable in airborne surveillance missions. As these shifts occur they often distort the Doppler changes of slow-moving targets. A large antenna reduces this effect by allowing for a reduced radar beam width. With a narrower beam the Doppler shifts are spread over a smaller velocity range which in turn reduces target distortion.[51]

Also crucial in design and function is the phased-array capability of the Joint STARS radar which provides accurate target locations of detected activity. A phased-arrayed radar can be understood by imagining a two radar system. It would take two, side-looking radar antennas mounted on the same aerial platform to equal the capabilities of a single, phased-arrayed system. The two radars, separated longitudinally by a few inches, would pulse at different intervals. Although their intervals would vary their aiming point, or target, would not. Consequently, static targets would give identical returns for each pulse, but a moving target would be different. Subtracting the static returns would reveal a "mover" in the radar's clutter.

The phased-array radar of Joint STARS simulates a two radar system through the use of a signal processor designed by the Control Data Corporation. In fact, this programmable radar signal processor allows the radar antenna to act as a three sub-array radar. This provides even greater location accuracies than a two sub-arrayed system.[52]

The result of Norden Systems' substantial engineering achievement is an antenna that detects both moving and fixed targets. The exact range of detection, called minimum and maximum detectable velocities (MDVs) is classified but the range falls between the movement of an infantry platoon and slow aircraft. In short, the radar antenna is powerful and capable enough to detect all significant movers for joint operational commanders.[53]

In addition to moving target indicators (MTI), the Joint STARS radar can detect fixed or stationary targets. This is done through the use of the antenna's synthetic aperture radar (SAR) capability. SAR gives the Joint STARS operator the ability to process a low to medium resolution image of static objects on the ground. The image appears in a vertical perspective, much like a photograph negative, of a fixed area of interest.[54] Vehicles and buildings show as bright but not necessarily recognizable objects. The SAR console operator look for distinguishing patterns, such as the characteristic layout of a surface-to-air missile battery, or the unique horseshoe image of a revetment.[55] Examples of good Joint STARS SAR targets include airfields, road junctions, assembly areas, logistics bases and river crossing sites.

The range of SAR is equal to that of the antenna's MTI mode. This similarity of ranges is by design, for SAR and MTI are complementary capabilities. SAR cannot see forces that move and MTI cannot detect stationary targets. The

capabilities of the radar are therefore used in tandem to monitor battlefield activities. If an operator sees a group of targets vanish off his console monitor while performing MTI surveillance, he can switch to the radar's SAR mode and confirm that the targets have stopped. Likewise, MTI can be used to determine movement at a fixed target site.[56]

A possible application of the Joint STARS' SAR capability is a future contribution to the problem of battle damage assessment (BDA). Although the SAR "shots" from Joint STARS are not of the same high fidelity of other Air Force systems, future radar enhancements may enable Joint STARS to fly BDA missions.[57] If this development occurs Joint STARS will provide a full circle capability; from situation development to targeting, to engagement, to damage assessment, and back to a revised situation estimate (Figure 10).

Operator Consoles and SCDL. Battlefield information, collected on moving or fixed targets, is viewed in "near-real-time"[d] by operators at system consoles in the airplane and in the GSM. Each operator console in the E-8A has a console screen (similar to a computer monitor), a track-ball to position the computer's cursor and a touch-sensitive keypad to input functions into the Joint STARS computer system.[58] The consoles also have a complete array of radios from FM to HF, depending upon mission requirements. Similar terminals are

[d] **Near-real-time** intelligence, in this example, means the systems's capability to detect a target and transmit that information to a user within 60 seconds.

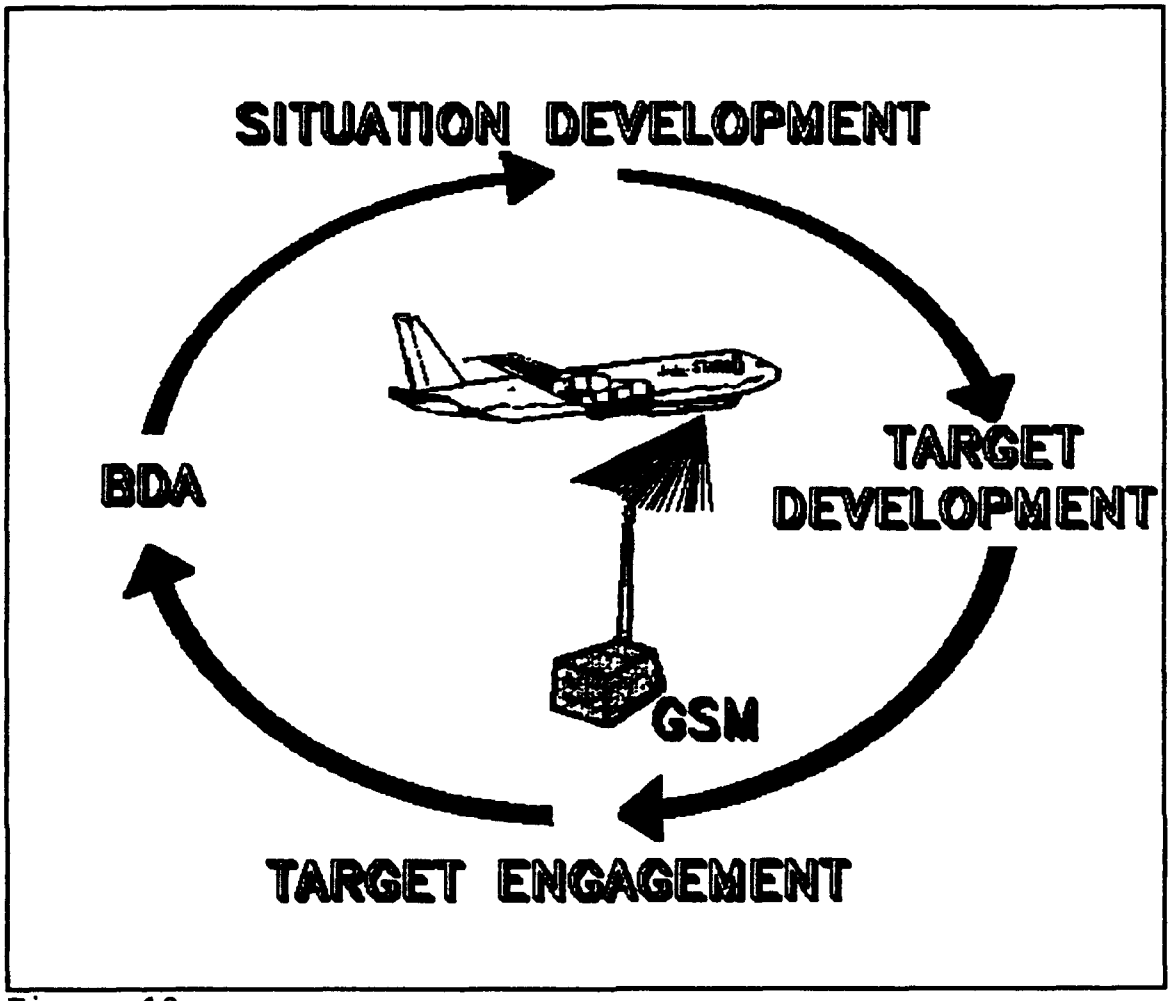

Figure 10

Intelligence and Targeting Cycle

installed in the Army ground station modules, developed by Motorola.[59]

Data Links. All battlefield data is broadcast over two data links. The Air Force data link is called the Joint Tactical Information Distribution System (JTIDS). The Army's link is called the surveillance and control data link (SCDL). Both data links channel battlefield information and targeting data, to critical Air Force and Army C3I nodes.[60]

The JTIDS passes developed targets and processed intelligence to Air Force C3I nodes and fighter aircraft. The Army receives only radar data over the SCDL, not processed reports. Processing of this data and the development of targets occurs in the GSM for the Army. The differences in the service's data requirements has so far required the maintenance of the distinct JTIDS and SCDL data links.[61]

The SCDL was developed by Cubic Corporation in response to the Army's requirement for a large radar data stream. The SCDL, analogous to a six-lane highway, moves a heavy volume of two-way traffic (data) over its secure link. Through the SCDL, each Army GSM, within line-of-sight reception of the airplane receives the entire MTI coverage of the battlefield. Additionally, SAR imagery can be sent down the SCDL to the GSM and printed out inside the Army workstation.[62]

Another important capability of the SCDL is that it allows for non-voice communication between the Army ground station modules, and between the GSMs and the aircraft. In a given theater of operations the GSMs can be separated by several hundred kilometers. This geographic separation between GSMs may prevent communications by line of sight radio transmission. In such a situation the Joint STARS aircraft serves as a relay for traffic passed over the SCDL. Messages are coded with a GSM "address label" and are sent over the SCDL to all GSMs within reception range. Because of the

message annotation, only the GSM with the proper address receives the message.[63] This capability helps to deconflict message traffic and prevent confusion.

The SCDL also facilitates in-flight mission changes. If an Army operator needs the Joint STARS airplane to fly a modified route or the radar to be switched from the MTI to SAR mode, the ground operator can request a change through the SCDL. The requests going up the SCDL are in message format and are received inside the airplane at the workstation console monitor. Once received the requests are evaluated by the radar management officer (RMO) and either acted upon, placed in queue or denied.[64] In any case the Surveillance Control Data Link serves as the intelligence lifeline between the air platform and the ground users.

Console Versatility. The capabilities of the Joint STARS workstations provide a unique degree of versatility for the Army and Air Force operators. The workstations can call up and display the entire radar coverage area or area of operations (AO) on the console monitor. This area can then be further subdivided into specific operational areas of interest for the Army or Air Force. In theory, each console operator could concentrate on a different segment of the AO, focusing their attention down to a smaller scale for a more detailed analysis of the battle. For example, a notional corps area could be subdivided into 128 equal parts or examined in "chunks," the size of which would be determined by a console

operator.[65] Detected units could be viewed in whole or in part and automatically tracked.

Usually, the GSM operators will receive guidance, either directly or indirectly, from field commanders concerning the division and corps sectors to monitor. With this guidance and through the SCDL interface with the Joint STARS E-8A, Army operators will send radar service requests (RSR) to the aircraft. Once prioritized aboard the E-8A these RSRs will be serviced by the Joint STARS' radar, providing battlefield surveillance and targeting data to the joint commanders.[66]

In addition to the individual manipulation of the AO's size, the ground and airborne console operators can request the following radar functions from the E-8A (Figure 11):

* **Wide Area Surveillance** - covers the entire AO in the MTI mode

* **Sector Search** - radar searches a particular area with a longer radar dwell time

* **Attack planning** - a target is viewed at higher resolution. Again, the radar beam is forced to dwell in one specific area to produce a higher fidelity target update. Accurate estimates of target directions and speed can be obtained in the attack planning mode.

* **SAR** - the radar "photographs" a fixed target site. The image is of low to medium fidelity and looks very much like a "grainy" negative of a high altitude photograph.[67]

As the operators task the radar with different "jobs," they share time on the radar. Tasks are assigned a priority and a "revisit interval"; as the radar completes one task, the

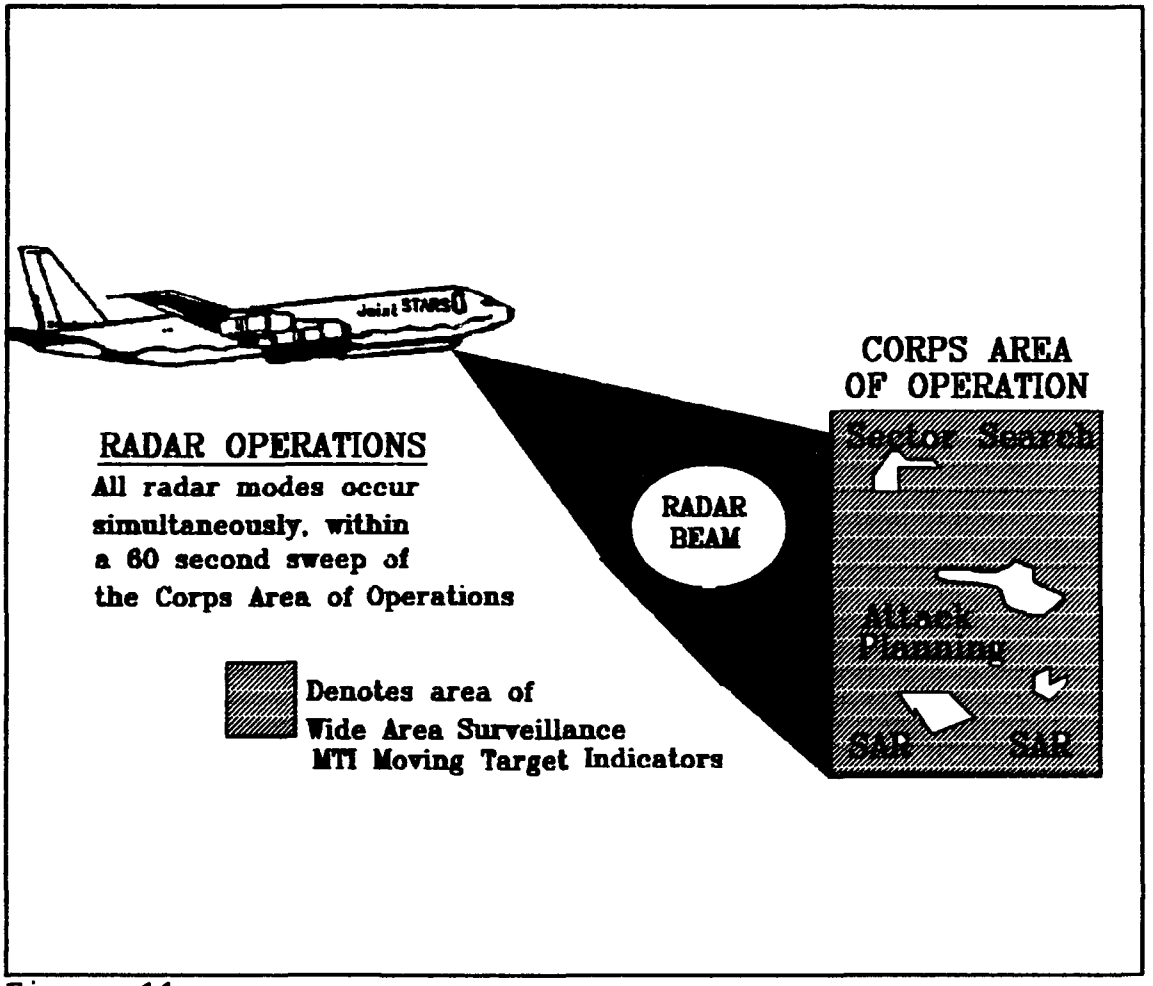

Figure 11

Simultaneous Radar Functions

control software sorts through the tasks that are due to be revisited and instructs the radar to do the job that has the next highest priority.[68] A radar management officer on board the plane assists the software in making the right allocation of time and radar taskings.[69]

Weapon Interface

Joint STARS provides *near-real time* and *precise* targeting data to a variety of U.S. long-range battlefield weapons systems. This precise targeting data can be defined as target location accuracies that fall within the Circular Error Probabilities (CEPs) of the bursting radius of new weapon systems. Timely targeting data speaks to Joint STARS capability to disseminate target locations in less than 60 seconds from the time of detection. Many new "killer" weapon systems will take advantage of Joint STARS targeting capabilities. Among them are:

* The Multiple Launcher Rocket System (MLRS) fired Army Tactical Missile System (ATACMS), with a range in excess of 200 KMs, gives the Army a capability to strike deep.

* The Air Force-Army Joint Tactical Cruise Missile System (JTACMS), launched from aircraft or MLRS launchers also provides a deep strike capability.

* The Air Force, F-15E aircraft in an interdiction role.[70]

Capability Summary. Joint STARS offers Army operational commanders an unprecedented capability to "see" deep into enemy zones in a conventional war, or during peace, in a reconnaissance and surveillance role. It provides a window of battlefield intelligence, pinpointing advancing enemy forces to allow for their engagement and destruction before they reach friendly troops. In short, Joint STARS

assists commanders to decide when and where to hit the enemy and assures them that the targets are really there.[71]

Joint STARS Capabilities Table[72]

Deployable	E-8A Self-Deployable GSM Deployable by C141
Radar Detection **Range** **Coverage Area** **Min Detect Speed** **Max Detect Speed** **Accuracy**	 Beyond 200 Kms from the Aircraft 512 Km Square Mission Box Speed of Infantry Platoon Speed of Slow Fixed Wing Aircraft Within 100 Meters
Radar Type	Moving targets (MTI) and limited fix target areas (SAR)
Weather Restrictions	None
Dissemination of Product	Within 60 seconds Simultaneous, multi-GSM reception
Mission Duration	About 10 hours
Squadron Coverage	24 hour coverage of AO

Table 1

Threat and Capabilities Synthesis. Now that the capabilities of Joint STARS have been described one may ask, what is their value against the threat of an "uncertain" future? The final draft of TRADOC Pam 525-B, describing the concept of AirLand Operations, holds the answer to that question. The evolving concept of AirLand Operations establishes the way in which the Army will fight to meet all future threats. The TRADOC pamphlet describes an Army that must be able to react "across the operational continuum" to a wide variety of threats.[73] The manual explains that the Army must be able to fight even though it will be smaller and largely CONUS based. To fight and win the Army of the future

must exhibit four characteristics. These characteristics are:

Deployable
Versatile
Lethal
Expansible[74]

If the Army must have these traits to contribute to success on tomorrow's battlefield it follows that our weapon systems should possess all or most of these qualities as well - does Joint STARS?

Deployable. Joint STARS certainly meets this criteria. As has been explained in this chapter the Joint STARS E-8A is self-deployable to any part of the globe within hours after notification. The GSM's deployability is more questionable, but only because of its reliance upon air or sea lift. There is no structural or equipment weakness that prevents the GSM from being rapidly deployed into a crisis, once the mode of transport has been obtained.

Versatile. The Joint STARS mission equipment and personnel can be tailored into specific mission packages or teams. The deployment to DESERT STORM, described in detail in Chapter Four, illustrates this point. Depending upon the crisis, the area of operations, the threat, and political considerations, a Joint STARS mission team could be made up of 2 to 20 aircraft and 5 to 75 GSMs. Depending upon air superiority and overflight rights, the aircraft orbits could be placed over the crisis area or at a standoff range which would allow for a measure of self-protection. The GSMs could

be placed at a Corps Headquarters, an Ambassador's villa, or with forward deployed units in the field. Such options illustrate the versatility of Joint STARS.

Lethal. By itself Joint STARS is a non-lethal system. The aircraft and GSM carry no weapons other than the sidearms and rifles of the airmen and soldiers. But Joint STARS is lethal - its lethality coming from its ability to pinpoint targets within the CEPs of the Army's weapon systems and Air Force strike aircraft. Developed targets by the aircraft or GSM can be passed to an artillery unit or MLRS equipped battalion and enemy forces can be engaged and killed with great accuracy, by long distance.

Expansible. Joint STARS can only be as expansible as the available number of aircraft and GSM. In the event of a global, Level III, war the full compliment of aircraft and GSMs would be required to meet operational requirements. With the projected aircraft and GSM buys the Joint STARS program should be able to support a two theater war.

Joint STARS vs. Army Characteristics

DEPLOYABLE	YES
VERSATILE	YES
LETHAL	CONTRIBUTES TO LETHALITY
EXPANSIBLE	FINITE ABILITY TO EXPAND PROBABLY LIMITED TO A TWO THEATER CONFLICT

Table 2

A similar evaluation can be made against the Air Force Characteristics stated in AFM 1-1.[75]

Joint STARS vs. Air Force Characteristics

SPEED	YES (E-8A)
RANGE	YES (RADAR AND AIRCRAFT)
FLEXIBILITY	YES

Table 3

A quick comparison of Joint STARS' capabilities against the basic characteristics of both the Army and the Air Force, highlights that the system is consistent with the doctrine of both services. From a purely Army perspective however, there is another way to determine Joint STARS worth, evaluating the system within the AirLand Operational Cycle.

The Operational Cycle. The Army conducts operations through four stages which are interrelated, mutually supporting and designed to focus all the elements of combat power. These four stages are:

I. **Detection/Preparation**
II. **Establishing Conditions for Decisive Operations**
III. **Decisive Operations**
IV. **Force Reconstitution**[76]

I. Detection/Preparation.

> "Stage I includes intelligence activities from national to the tactical level. Intelligence Preparation of the Battlefield (IPB) is crucial during this stage. The joint force commander tries to establish a detailed and reliable picture of the enemy disposition, capabilities and intent."[77]

Joint STARS can play a big part in this stage of the Operational Cycle. Flying in support of the J2, as part of a multi-echeloned intelligence network, Joint STARS can develop a battlefield situation. By monitoring an area over time, patterns of enemy movement will become apparent. Enemy strong points will be determined and possible courses of action will likely be discovered.

II. Establishing Conditions for Decisive Operations.

> "During Stage II the commander develops favorable conditions for combat. This is accomplished by shaping the battlefield with operational fires, positioning of maneuver and combat service support (CSS) forces and the conduct of deception operations. The objective is to attack, separate, isolate, and attrit enemy forces through deep operations. It is clearly possible with electronic surveillance technologies to plan and adjust air and ground precision fires."[78]

Joint STARS ability to pinpoint targets clearly is important in shaping the battlefield through fires. Monitoring the enemy's operational centers of gravity will help to coordinate and synchronize U.S. attacks on these key positions. The dissemination of enemy and friendly locations to the GSMs will provide commanders from theater to brigade with a battlefield picture which will be useful for the positioning of their forces. Planned routes into enemy territory can be checked against enemy buildups. Continued monitoring of enemy movement could provide visual confirmation that the enemy has accepted a developed deception plan.

III. Decisive Operations.

> "The focus of this stage is on culminating the effort of previous stages with tactical and operational decisions. Security remains an important issue. At the brigade level, the intense close combat maneuver actions are envisioned to last for short periods. Force agility is achieved by force tailoring and by using multiple routes and a detailed mobility plan."[79]

Joint STARS ability to see the entire Area of Operations allows for deep strike targeting missions to be conducted at the same time as surveillance missions. The surveillance of the AO is important to the continued need for security during the operation. Once again the dissemination of a battlefield picture down to the brigade level allows for Joint STARS use at the tactical to operational levels. Known enemy locations, movement speeds, and concentration will allow commanders at all levels to tailor his forces for decisive combat.

IV. Force Reconstitution.

> "The purpose of this stage is to restore optimum combat power. Force reconstitution spans activities from normal sustainment, through reorganization, and regeneration to redeployment. The first principal action upon completion of decisive operations will be to disperse the force and establish security..."[80]

Joint STARS, reverting back to a wide area surveillance mode can contribute to security operations during Stage IV. Visual warning can be provided along friendly flanks, and during rear operations. Deep enemy movements and threat reinforcement operations can be detected.

Operational Significance. Joint STARS capabilities demand its involvement in the Army's Operational Cycle. Joint STARS should be able to add to all stages of the cycle. Additionally, the consistency of Joint STARS capabilities with the characteristics of both the Army and the Air Force suggest that the system will successfully contribute to conflicts across the operational continuum. An analysis of Joint STARS' performance in Operation DESERT STORM will help to establish if this assumption is correct.

ENDNOTES CHAPTER THREE

1.Broadbent, S. "Joint STARS: Force multiplier for Europe," Jane's Defense Weekly, (11 April 1987).

2.LTC Lester W. Grau, "In the Wake of Revolution: Continuity and Change,", Military Review, (December 1991), 11-23.

3.Interview with LTC Robert Lee, Department of Tactics, Fort Leavenworth, Kansas, (7 February 1992).

4.Field Manual (FM) 100-5 Operations. Washington, D.C.: Department of the Army, (5 May 1986), 2-5.

5.Major General David Robinson's Address to the Aviation Officers of the Command and General Staff College, Fort Leavenworth, Kansas, (21 March 1992).

6.Patrick E. Tyler, "7 Hypothetical Conflicts Foreseen by the Pentagon," New York Times, (17 February 1992).

7.LTC Lee, 7 Feb 92.

8.Jane's Weapon Systems 17th Edition. (London, England: Jane's Publishing Company, 1986),42.

9.LTC Lee, 7 Feb 92.

10.William Matthews, "Greatest U.S. Threat: The Unknown", US Army Times, (2 March 1992), p.30.

11.Department of Defense Directive, 5000.1, Subject: Defense Acquisition, (23 February 1991), Washington, D.C., 2.

12.Horizons Staff, "The Joint STAR Advantage," Grumman Horizons, (Vol 23, No.1, 1987) : 10.

13.Joint STARS Operational and Organizational Plan, (23 February 1989). Signed by TAC and TRADOC Headquarters.

14.Goodman, G. Jr. "New Airborne Sensors Look Deep, Allow Army/USAF to Strike Deep," Armed Forces Journal International, (January 1989), 84.

15.Karen Walker, "Joint STARS: A Soldier's Spy," Flight International, (22 November 1986).

16.Michael B. Callaham, "Reconnaissance, Surveillance and Target Acquisition for Follow-On Forces Attack," Signal, (October 1987), 84.

17.Joint Service Operational Requirements Document (JSORD), TRADOC and Tactical Air Command Headquarters prepared document, (September 1989).

18.Author's talks with Colonel Martin S. Kleiner, TRADOC System Manager for Joint STARS, 26 December 1991.

19.James Bernstein, "A Flying Success: Grumman Radar Passes Test," Newsday, (6 January 1989).

20.Air Staff briefing attended by the author at the Pentagon in October 1989. As a result of this briefing, Mr. Kendall, the Deputy Under Secretary for Acquisition, chaired a Conventional Systems Committee (CSC) meeting at which the used 707 airframe option was selected.

21.CGSC Student Text 100-2, US Air Force Basic Data, U.S. Army Command and General Staff College, (May 1991), E-7.

22.U.S. Air Force Manual AFM 1-1, Basic Aerospace Doctrine, 2-2.

23.Casey Anderson, "Air Force Expected to send E-8A to Mideast," Air Force Times, (31 December 1991), 23.

24.Author's talks with Major Norm Johnson, Pilot of E-8A during Operation DESERT STORM, (5 March 1991).

25.Author's talks with Air Force, Brigadier General George Muellner, Commander of the 4411 Joint STARS Squadron during Operation DESERT STORM, 4-5 March 1991.

26.ST 100-2, E-7.

27.Muellner, March 1991.

28.Johnson, January 1991.

29.David A. Boutacoff, "Army Banks on Joint STARS for AirLand Battle Management," Defense Electronics, (August 1986), 85.

30.Callaham, 86.

31.Callaham, 87.

32.Johnson, March 1991.

33.Boutacoff, 85.

34.Motorola Incorporated, Public Domain Hand-Out, June 1990.

35.Marsha Adams-Day, "Joint STARS Program Underway," The Round-Up (Motorola Inc., 18 April 1985), 1.

36.Kleiner, Dec 91.

37.Author's interview with Major Robert Carr, U.S. Army Assistant to the TRADOC System Manager for Joint STARS. Discussion conducted at Fort Leavenworth, Kansas, 18 March 1992.

38.Carr, March 1992.

39.Carr, March 1992.

40.Author's talks with Major Michael Widener, U.S. Army Joint STARS Test Detachment Deputy Commander, (Airborne Surveillance Technician Operator during DESERT STORM), phone conversation 11 March 1992.

41.Carr, March 1992.

42.Final Design Plan, Volume II, Joint Surveillance Target Attack Radar System: Block I Ground Station Module, AN/TSQ-168(V), (Motorola Inc., Scottsdale, Arizona, 23 August 1991), XI-2.

43.Motorola Inc., Final Design Plan, GSM Block I, XIII-5.

44.Carr, 18 March 1992.

45.Comments by Captain Jim Nuemiller, Officer in Charge of the GSM located at VII Corps during Operation DESERT STORM. Statement made during the TRADOC System Manager DESERT STORM After Action Review, Fort Huachuca, Arizona, 10-11 April 1991.

46.Colonel Martin S. Kleiner, Briefing to G2s, Fort Leavenworth, Kansas, (February 1992).

47.Carr, 18 March 1992.

48.U.S. Department of the Army, FM 55-65 Strategic Deployment by Surface Transportation, Washington, D.C. (10 May 1989), Glossary 10.

49.Comments made by Captain Robert Carr and Major Shawn Griffith during the Joint STARS After Action Review in Melbourne, Florida, 17-18 April 1991.

50.Sweetman, B. "Joint STARS Approaches Crucial Test Stage," Interavia, (May 1989), 453.

51.Ibid, 453.

52.Sweetman, 452.

53.Walker, 22 November 1986.

54.Author's interview with Dr. Dale Burton, Chief System Engineer for the Joint STARS radar and operator console interface, Melbourne, Florida. One of the Grumman civilian crew members during Operation DESERT STORM. Phone conversation on 7 January 1992.

55.Bruce D. Nordwall, "Highly Integrated System, Versatile Radar Win Kudos for Joint STARS' Gulf War Role," Aviation Week & Space Technology, (24 June 1991), 49.

56.Widener, 11 March 1992.

57.Burton, 7 January 1992.

58.NBC News Report, January 1991, day unknown.

59.Glenn W. Goodman, Jr., "Joint STARS Slips Nine Months but Gains Endorsement of DoD Leadership," Armed Forces Journal International (September 1988), 118.

60.Boutacoff, 80.

61.Ibid, 80.

62.Brian Wanstall, "Joint STARS Fights to Stay on Target," Interavia, (November 1988), 1134.

63.Kleiner, December 1991.

64.Widener, 11 March 1992.

65.Ibid, 11 March 1992.

66.Carr, 18 March 1992.

67.Information taken from the briefing slides and text of the TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona, (26 December 1991).

68.Sweetman, B. "Joint STARS Approaches Crucial Test Stage," Interavia, (May 1989), 453.

69.Goodman, G. Jr. "New Airborne Sensors Look Deep, Allow Army/USAF to Strike Deep," Armed Forces Journal International, (January 1989), 84.

70.Boutacoff, 83.

71.Gilmartin, K. "Joint STARS Goes Airborne," Hansconian, (6 January 1989), 1.

72.Nordwall, 49.

73.U.S. Army, TRADOC Pamphlet 525-5B AirLand Operations, Training and Doctrine Command, Fort Monroe, Virginia (13 June 1991), 2.

74.Ibid, 6.

75.AFM 1-1, 2-2.

76.TRADOC Pam 525-5B, 15.

77.Ibid., 16-18.

78.Ibid., 19.

79.Ibid., 21-22.

80.Ibid., 23-24.

CHAPTER FOUR

THE STORM

Operational Analysis

Joint STARS in DESERT STORM

Figure 12
4411 Joint STARS Squadron Patch

Joint STARS flew in support of Operations DESERT SHIELD and DESERT STORM from 14 January to 4 March 1991.[1] Although still a technologically immature system, Air Force and Army general officers believed that the wide area surveillance and targeting capabilities of Joint STARS would add to the success of the Coalition Forces, by providing a near-real

time picture of the battlefield.[2] An analysis of its performance in Southwest Asia will demonstrate whether this belief was justified. Operations in the desert will be looked at in five sections, they are: overview, prehostilities, air operations, ground operations and general analysis. In the analysis section mission results will be evaluated against the criteria of: value of product, timeliness, accuracy and simultaneous support.[3]

Overview. Two E-8As deployed on the 11 January 1991 from the Grumman Joint STARS Division in Melbourne, Florida. The planes air-refueled enroute, and arrived at Riyadh airfield, Saudi Arabia, on 12 January 1991.[4] Concurrent with the deployment of the aircraft, five GSMs were airlifted, via C5, from Patrick AFB, Florida. These GSMs, routed through Dover, England, took a week to arrive in country. The first GSM landed on 8 January with the last GSM received on 15 January.[5]

Daily sorties began on 14 January with engineering test flights. Combat sorties started on 17 January and continued until 4 March.[6] One aircraft flew each day, from dusk to dawn, with operational missions averaging about 10.5 hours. Forty nine aerial surveillance and targeting missions were tasked by CENTCOM Headquarters and 49 missions were flown by the Joint STARS Team.[7]

Prehostilities (12-16 January). This short phase allowed time for pre-battle checks. Joint STARS personnel were briefed on the current enemy situation and order of battle. Iraqi dispositions and weapon capabilities were studied and committed to memory. Operational tactics, techniques and procedures (TTPs) were developed and tested. Additionally, three "shake-out" missions were flown. It was during these flights that crew responsibilities, in the air and on the ground were solidified and rehearsed. Those difficulties experienced were primarily caused by the integration of untested Army and Air Force mission procedures.[8] Most of these problems might have been resolved prior to departure from the United States had there been more time between the JCS notification and deployment. As it was, there was barely enough time to assemble the required personnel.

On 18 December 1990, the Air Staff was ordered to deploy Joint STARS to Saudi Arabia. As a consequence of this notification the Air Force formed the 4411 Joint STARS Squadron (JSS).[9] Over the next thirty days members for the 4411 JSS were recruited from throughout the Air Force with the primary core of the mission crew taken from the Joint STARS test facility in Melbourne, Florida. Likewise, the Army organized the Joint STARS Operational Detachment (JSOD) at Fort Huachuca, Arizona. This unit, under the command of the TRADOC Joint STARS system manager, pulled its operators from

among the instructors and soldiers at the Army Intelligence School.[10] The Joint STARS Team, made up of the JSOD soldiers and the 4411 JSS airmen, arrived in Riyadh with many questions and operational apprehensions about their role in the war. Consequently the pre-hostilities phase was important as it provided an intense dress rehearsal period to prepare the soldiers, airmen and equipment for the impending conflict.

As the Army and Air Force operators, worked side-by-side to refine the surveillance and targeting techniques several key decisions were made by the commanders of the JSS and JSOD. Due to Joint STARS's technical immaturity as a prototype system, it was determined that the MTI and SAR capabilities of the radar would be used separately to develop targets.[11] First the MTI mode would track enemy movement across the battlefield. Once a target location was developed the radar's SAR mode verified the location, further refining the overall picture of enemy activity. Battlefield reports were then passed to Army and Air Force command and control nodes. For the Air Force, targets were relayed via voice reports, over secure FM or UHF radios. For the Army, targets were moved to and through the Ground Station Modules (GSM).[12]

Between 14 and 17 January, GSMs were positioned forward with their supported corps. As there were not enough GSMs and E-8A orbits available to provide ***dedicated*** support to all forces, a theater concept was devised.[13] U.S. VII Corps received its own GSM, as did the Army's XVIII Airborne Corps

and the First U.S. Marines Expeditionary Force (I MEF).[14] Additionally, one GSM was placed at the Tactical Air Control Center (TACC), Central Command Air Force Headquarters; one GSM deployed with the forward ARCENT Headquarters; and one GSM remained at Riyadh. The GSM at Riyadh airbase supported the operations center of the Joint STARS Team under the control of

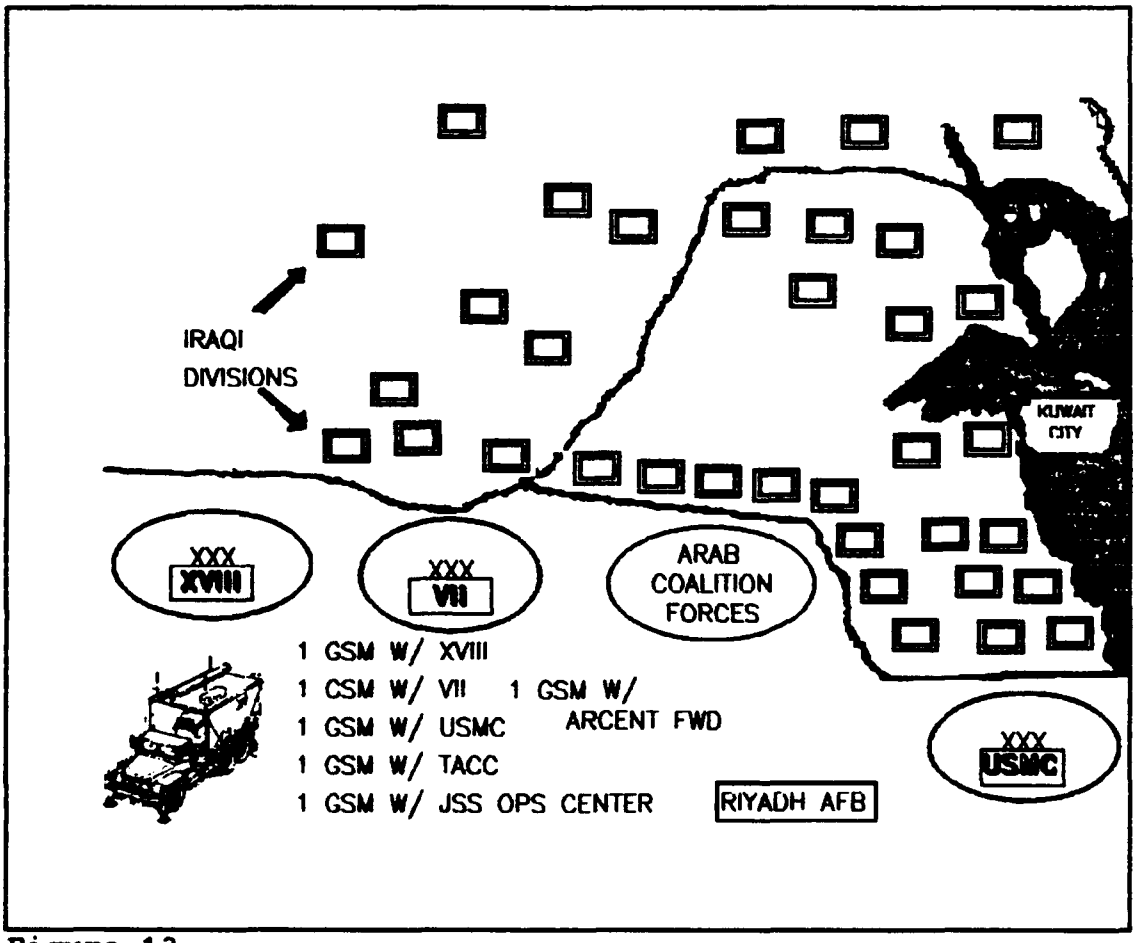

Figure 13

GSMs spread across the theater

the Joint STARS Squadron commander.[15]

The distribution of GSMs across the DESERT STORM theater allowed GSM operators to generate their own targets

from the battlefield data passed down from the airplane. Consequently, a key decision in the prehostilities phase was to cross-check these developed target sets as a measure against fratricide. Although redundant, nominated targets were confirmed between Joint STARS' Army operators in the plane and in the GSMs before a target strike. This was done by means of a secure UHF radio net.[16]

Another crucial development between 12 and 16 January was the integration of Joint STARS operations with higher headquarters. Mission planners from the Joint STARS Team coordinated with Army collection management cells at ARCENT and CENTCOM as well as with the command and control elements of CENTAF. The result was the formalizing of tasking procedures and the addition of the 4411 JSS to the Air Tasking Order (ATO).[17] These efforts, during the first few days in country paid off during the commencement of air operations.

Air Operations (17 Jan - 23 Feb). At 0300 hours, local time (2400 hours Zulu), on 17 January the Air Force launched the largest air operation in the history of warfare.[18] During this first night of air strikes and bombing, Joint STARS sat on the ground and watched the aerial show. As day two of the "Mother of All Battles" began Joint STARS was airborne.

Forty-eight hours into the air operations Joint STARS was fully incorporated in the air tasking order. Flight time, mission altitude, and collection priorities were established

in the instructions sent out by CENTAF. An example of the Joint STARS ATO mission summary is provided below:

> "Joint STARS will fly in the eastern orbit from 1400Z to 1800Z in support of MARCENT. Coverage will shift to the western track from 1800Z to 2200Z in support of SCUD kill missions and the XVIII Corps. After 2200Z Joint STARS will support VII Corps until return to base (RTB)."[19]

For the majority of missions, Joint STARS was tasked to validate enemy locations in the Kuwait Theater of Operations (KTO) and generate near real-time targets through a combination of the radar's MTI and SAR capabilities.[20]

To strike at these Iraqi targets each Joint STARS flight was assigned between 12 and 30 sets of fighter aircraft to respond to developed battlefield intelligence.[21] A Weapons Allocation Officer (WAO) aboard the E-8A was responsible for the target handoff between Joint STARS, attack aircraft and Air Force command and control systems. Targets not directly passed to fighters were relayed to the TACC, the Airborne Warning and Control System (AWACS), the I MEF, or the Airborne Battlefield Command and Control Center (ABCCC) for targeting.[22] At no time were targets passed between the Joint STARS aircraft and Army attack helicopters.

In some cases target handoff was not successful. There were two reasons for this failure. One cause was the inability of attack aircraft to respond to near-real time targeting data which required them to make inflight mission changes.[23] The other factor was the E-8A's desultory coverage

of the KTO. Quite often, during the first week of the air operations, Joint STARS shifted its coverage across the battlefield. This was frustrating for the ground based Joint STARS operators who were often unaware of the multiple requests being channelled into the airplane.[24] Additionally, because Joint STARS was still a true engineering prototype, there were frequent problems experienced between the radar system software, hardware and the Joint STARS data link. The result was system "down time." Sometimes this translated into three hours of surveillance time during a ten and one half hour mission.[25] Yet, even with those limitations, caused by the system's immaturity, Joint STARS contributed to air operations as sometimes it seemed like Saddam was playing into the hands of the coalition forces.

During the first 72 hours of the air war, Iraqi convoys of twenty to thirty vehicles were common. Joint STARS easily detected these ideal target sets.[26]

> 22 January - "Joint STARS crews find an Iraqi assembly area and a 60 vehicle formation moving toward Kuwait city. The aircraft calls in an airstrike of F15s. 58 enemy tanks are reportedly destroyed."[27]

Most of the Iraqi convoys moved at night and without the Joint STARS MTI capability, which was not restricted by light or cloud coverage, these convoys may have gone undetected.[28]

In a few cases Joint STARS was cued to look for specific convoys that carried special munitions (chemical, SCUD missiles). These cues came from a variety of sources.

Human intelligence reports, visual sightings from Air Force fighters, and overhead systems all contributed to the "tip-offs" that Joint STARS exploited. The free assistance allowed for Joint STARS' success in the detection of more than half of all convoy taskings.[29]

As air operations continued, the Iraqi army changed their movement techniques. Relocation of supplies and Iraqi troops were grouped into formations no larger than three or four vehicles. After the success of 22 January, convoys ceased to present lucrative targets.[30]

Standard Operational Procedures for Air Operations. The change in Iraqi tactics required a change in techniques aboard the aircraft. Flexibility and thoroughness were the catchwords used to ensure that Iraqi troop movements did not go undetected. This required close crew coordination between three separate flight crews. Three crews were required during DESERT STORM due to Air Force flight regulations, based upon the realistic physical limitations of pilots and crew members. As a consequence, the crew members of Blue, Silver, and Black Flights, planned together to ensure mission consistency.[31]

The composition of each aircrew or flight is provided in the table below.[32] It is interesting to note that civilians are listed among the crew members. These civilians were from the Joint STARS, Melbourne Systems Division of the Grumman Aerospace Corporation. These system engineers sat in the back of the E-8A aircraft during all missions, fine tuning the

radar software functions in order to optimize Joint STARS capabilities. In the future the position of system engineer will likely be filled by an Air Force officer.

Position			Rank	#
Pilot			O4/O6	1
Co Pilot			O3/O4	1
Navigator			O3	1
Flight Engineer			E8	1
Airborne Command Element	(ACE)		O6	1
Ground Liaison Officer	(GLO)	*	O4	1
Radar Management Officer	(RMO)		O4/O5	1
Airborne Surveillance Officer	(ASO)		O4/O5	1
Airborne Surveillance Technician	(AST)	**	O4/O3	7
Synthetic Aperture Radar Operator	(SAR)		O3	1
Weapons Allocations Officer	(WAO)		O3/O4	1
Self Defense Officer	(SDO)		O3	1
Communications Officer	(Commo)		O3	1
Air Force Intelligence Officer	(AIO)		O3	1
Grumman System Engineers			Civ	5
TOTAL[33]				25

Table 4 **ARMY*

***One AST is an ARMY officer*

The split of 4411 JSS personnel into three flights meant that most aircrew members flew every third day. When a crew was not flying it was involved in mission planning. A typical 72 hour cycle is shown below:

Blue Flight

16 Jan	**1630 to 0430**	**Surveillance Flight**
17 Jan	0430 to 0530	Mission Debrief
	0530 to 1630	Crew Rest
	1630 to 2200	Assist in Planning for Black Crew (Silver Flight in the Air)
18 Jan	2200 to 1630	Crew Rest, Targeting Meeting, Work at JSS Operations Center
18 Jan	1630 to 2200	Planning for 19 Jan Flight (Black Flight in Air) Breakout of the ATO, assignment of surveillance areas, callsigns, and mission code words. Preparation of mission sheets and mission kits. Review of enemy order of battle. Sort of all surveillance and targeting priorities.
19 Jan	2200 to 1400	Crew Rest
	1400	Bus ride from quarters to flight ops
	1430 to 1530	Mission Briefing
	1530	Check with supported units on updates to surveillance and targeting priorities via secure KY 68
	1600	Arrival at aircraft
	1600 to 1630	Pre-Mission Checks
	1630 to 0430	**Surveillance Flight**[34]

Once airborne, prioritized target lists from the supported Corps were divided among the seven airborne surveillance terminal (AST) operators by the Airborne Surveillance Officer (ASO). The ASO "choreographed" the terminal operations during the mission. He directed the surveillance and targeting operations from his console, monitoring the mission progress to ensure that no gaps occurred in the mission coverage. The ASO worked closely with the Army aircrew members and the mission commander, an Air Force colonel, deciding upon the optimum use of the Joint STARS' radar in order to best accomplish the mission taskings.[35]

Usually the surveillance and targets lists were divided by overlapping geographic coordinates, with each AST receiving a specific area of the battlefield. Often a particular Iraqi unit would be associated with the surveillance "box" monitored by an AST. This type of assignment was useful when a named division of the Republican Guards, the Medina Division for example, was the main focus of the Allied efforts.[36]

As the aircraft established itself in orbit the radar's MTI mode would be activated. A broad sweep of the KTO would be made as each AST worked their area. If significant activity was detected the AST operator would transmit an alert over the internal aircraft intercom net. In response, the Army aircrew members and the mission commander would confer with the ASO to assist in the refinement of surveillance assignments.[37] If an area of high interest was experiencing heavy activity several or all ASTs might be assigned to monitor the area. One AST could be assigned to work the area using the system's "time compression" capability. Another AST could be assigned to analyze the same area using the system's "time integration" mode. Other ASTs could monitor the identical coordinates using amplified scales of resolution (32 x 32 KM scale versus a 256 x 256 Km box). Almost simultaneously with these other radar "jobs" the Synthetic Aperture Radar Operator would take a "SAR shot" of the significant movers and display the result on any of the seven

console monitors in the aircraft.[38] The net result of this coordinated effort was a discussion and decision on the significance of the enemy activity.

If the MTI were believed to be a valid target, such as a convoy or SCUD site, the coordinates were passed to the WAO for assignment to an Air Force strike package.[39] If the MTI were being worked in response to an Army request they were passed back to the Army aircrew members who in turn relayed target location and a description of activity back down to the supported corps. On most missions the established procedures improved with each flight and worked to identify the disposition and activity of Iraqi forces.[40] A good example of efficient aircrew operations was Joint STARS' support to the Battle of Kafji.

> **5 Feb** - "Joint STARS passes to the USMC, fighting near Kafji that there are no reinforcements enroute to the city."[41]

As the Air Force continued to strike at the center of gravity of the Iraqi Army, the Republican Guards, Joint STARS helped to maintain the operational initiative at Kafji. As the first shots of the Kafji battle were fired, General Boomer, the USMC commander, worried about being drawn into a premature land battle.[42] The general knew that an early commitment of his forces would disrupt the overall campaign plan. Joint STARS wide area surveillance of Kafji and the areas to the north of the city showed no reinforcements poised

to exploit any Iraqi success in their attack. As this conclusion was reached in the aircraft it was passed down, via secure voice radio to the GSM at I MEF. This radio transmission confirmed what the GSM operators already knew from their console screens. With this reassurance I MEF confidently engaged the Iraqi forces with minimum disruption to the theater campaign plan.[43] As Joint STARS fixed the location of the Iraqi troops, AC-130 gunships and A-10 aircraft were called in on their positions. The reported result was a 70% kill of all Iraqi vehicles in the Kafji sector.[44]

These mission examples indicate that Joint STARS added to the success of air operations in DESERT STORM. The Air Force quickly adjusted to the introduction of a new weapons system into the theater with positive control of the unique asset. Position and timing of Joint STARS coverage was defined in each Air Tasking Order with immediate adjustments handled by the Tactical Air Control Center. Throughout the air operations phase, Joint STARS focused on targeting Iraqi second echelon forces and the collection of intelligence throughout the Kuwait Theater of Operations.[45]

Ground Operations (24 Feb + 100 Hours). On 24 February 1991 the third phase of Joint STARS' operations began with the initiation of ground operations. As Allied forces moved into Kuwait and Iraq the priorities for Joint STARS were slightly modified. The location and disposition of Iraqi

second echelon forces and the actions of the Republican Guards were still important but now an additional emphasis was given to the support of allied forces in contact.[46] To provide this simultaneous support to close and deep operations the Joint STARS' MTI radar mode was utilized. This allowed for an uninterrupted, wide area coverage of the Kuwaiti Theater of Operations.

The concept of the Joint STARS surveillance was to deny the Iraqis the element of surprise and maintain the initiative of U.S. and allied forces. Joint STARS and other surveillance systems would ensure that the Iraqis did not catch our forces in the midst of a breaching operation.[47] For Lieutenant General Frederick Franks and his VII Corps this would allow an unrestricted, high-speed advance up the Wadi al Batin, the area adjacent to the Kuwait and Iraq border.[48] This unimpeded movement was crucial to the Allied Coalition because the center of gravity for the ground operations was the U.S. VII Corps.

> **24 Feb** - "Joint STARS spots Iraqi forces moving into blocking positions as coalition forces attempt to breech Iraqi obstacles. Joint STARS calls in tactical airstrikes against the Iraqi positions."[49]

With the VII Corps moving into the attack, Joint STARS concentrated its coverage on the western border of Kuwait and Iraq. As the E-8A established its orbit, aircrew operators detected the movement of what appeared to be lead elements of

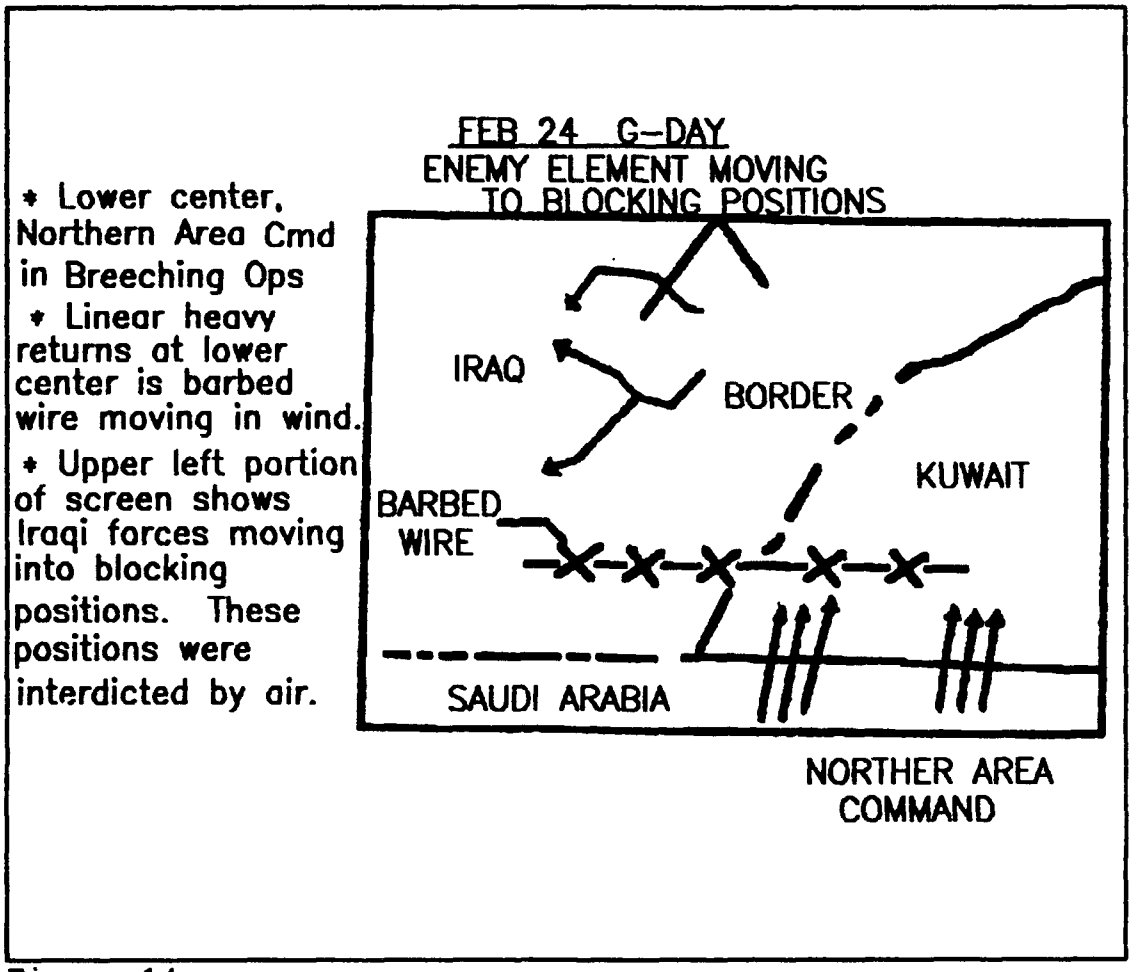

Figure 14

Depiction of GSM Screen #1

a division moving into the Wadi al Batin (Figure 14).[50] These movers originated from the previously known location of the Tawalkalna Division of the Republican Guards. The confrontation of VII Corps and the Tawalkalna was inevitable unless the Iraqis were stopped. This predicted meeting engagement of friendly and enemy forces was simultaneously monitored by the GSMs at ARCENT and VII Corps Headquarters.[51] Evaluating the danger in front of their advance, VII Corps

requested air support. Contact with the Joint STARS airplane and the Air Force mission commander resulted in the release of attack sorties of F-15E (Strike Eagles). As the Joint STARS console screens in the air and on the ground watched, chaff clouds appeared over the Iraqi formation and then the movement ceased.[52]

Later, during the same mission, a large Iraqi

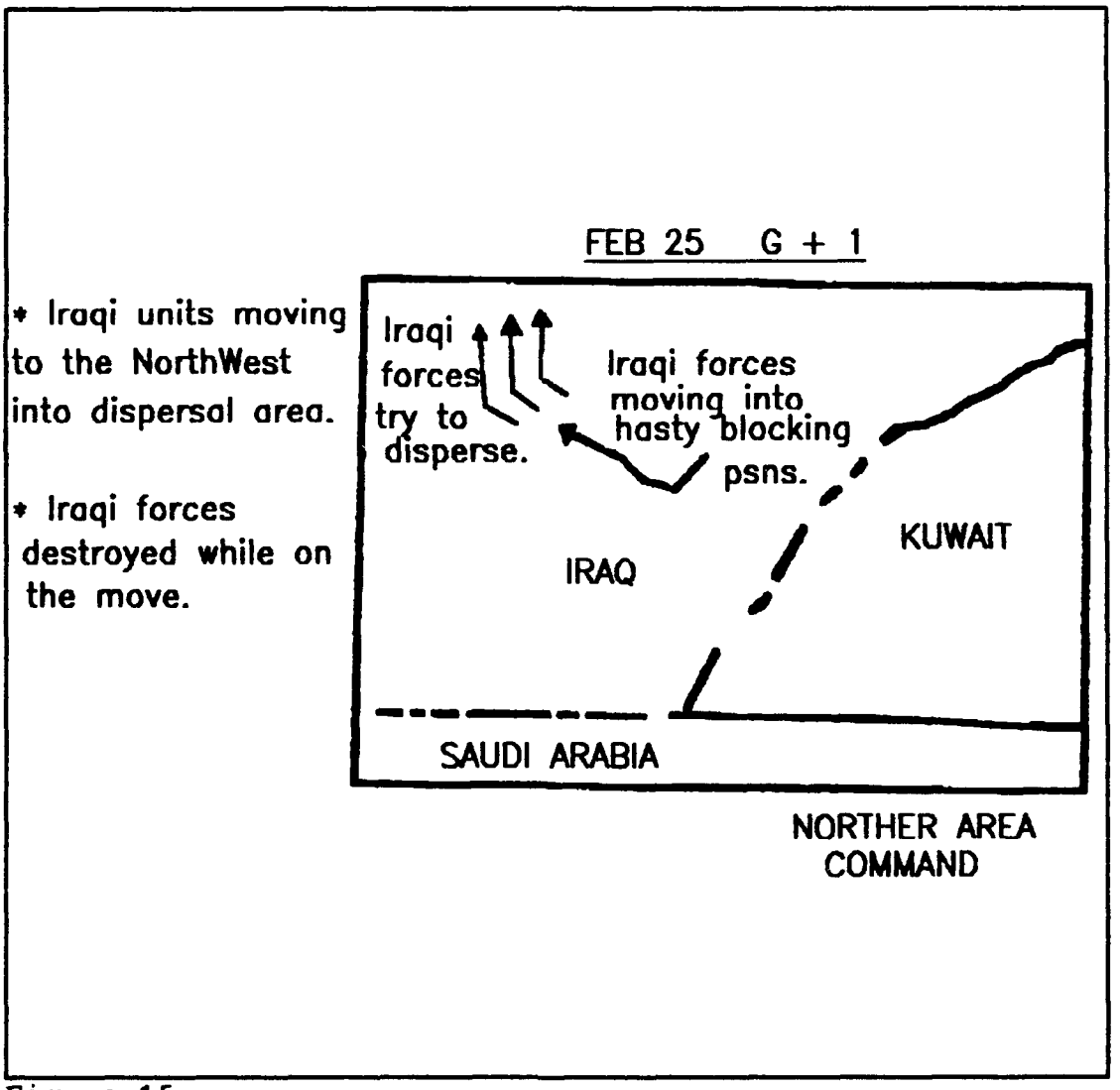

Figure 15

Depiction of GSM Screen #2

formation was detected along the Ipsa Pipeline Road, moving to the southwest, toward coalition forces.[53] This Iraqi formation was outside the established Fire Support Coordination Line (FSCL) and in accordance with pre-established procedures Joint STARS had no control over the engagement of targets beyond the FSCL. Accordingly, Joint STARS passed off these targets to the ABCCC. Air strikes were once again called in on the movement but this time a majority of the Iraqi movers continued their advance to just within Phase Line Smash, which was the FSCL.[54] Joint STARS monitored the movement as the Iraqis moved into what appeared to be a release point and broke up into company to battalion-size formations (Figure 15).[55]

As the SCDL passed the near real-time images to the GSM at the Tactical Operations Center (TOC) of the VII Corps, the decision was made to release the 2d Armored Cavalry Regiment (ACR). Based upon reports from the GSM at the VII Corps TOC the 2d ACR adjusted its direction of advance and intersected the Iraqi formations seven hours after initial detection.[56]

> **25 Feb** - Joint STARS detects heavy vehicle traffic moving north from Kuwait City toward the Iraqi city of Basrah. The Air Force is called in, turning the Iraqi escape route into the 'Highway of Death'."[57]

The third mission, in support of ground operations, is perhaps the most publicized of any Joint STARS mission.[58]

During the first hours of the flight a continuous and extremely heavy flow of traffic was detected streaming out of Kuwait City toward Iraq. The subsequent airstrikes began the final annihilation of the Iraqi Army and resulted in the decision by the National Command Authority to stop the unnecessary destruction of a powerless foe.[59]

The significance of the final, ground operations, mission of Joint STARS was that it influenced the movements of ground units down to the brigade level. Through the dissemination of the battlefield intelligence which was passed to the GSMs, situation and targeting data was shared across all echelons. At least one brigade of the 24th Infantry Division (Mechanized) used the Joint STARS provided information to adjust artillery fires and support the operational maneuver of brigade forces.[60]

On 26 February at 2330 hours the word was received in the Joint STARS aircraft that Kuwait had been liberated by the U.S. Marines. Several minutes later, ARCENT Headquarters transmitted a radio call. It was a message from General Norman Schwarzkopf:

> "Send in the First Team
> Destroy the Republican Guards
> We're Going Home."[61]

Although it would take two more days for the declaration by President Bush, hearing those words from the CENTCOM CINC told the Joint STARS Team that the war was over.

After the 26th of February the surveillance flights were uneventful. Joint STARS detected no Iraqi military buildups or reinforcement maneuvers. This surveillance of light activity was as important to the final mop-up operations of the Allied Forces as the Joint STARS targeting was during the air phase. Lack of activity was precisely the type of conditions needed for U.S. and Coalition Forces to consolidate and reconstitute their forces.

Standard Operational Procedures for Ground Operations. Throughout DESERT STORM, the operational procedures of the GSMs were marked by centralized planning and decentralized execution and mission input. Mission times and E-8A orbits originated with the Air Tasking Order (ATO) published by the Air Force Central Command (AFCENT), located in Riyadh. Input into the ATO was provided from Army Central Command (ARCENT) Headquarters and the G2s and G3s of the supported Corps.[62] This input usually came in the form of prioritized target lists and surveillance requests that were transmitted over secure radio or air delivered to Riyadh by helicopter. Once the theater priorities were received at ARCENT Headquarters, and at the AFCENT, Tactical Air Control Center, they were incorporated into the ATO process.[63]

Within twenty-four hours an ATO was published and the mission details were disseminated back to the six GSMs positioned across the theater. This final mission check, occurring three to six hours before take-off of the E-8A, was

accomplished via a secure KY68 field phone or STU III telephone. The entire process, from the establishment of Corps priorities, to the integration of these requests into the mission profile took about 72 hours. Due to this extended cycle it was important for GSM operators to continuously coordinate with the Joint STARS operations center to learn about last minute changes.[64]

Once the parameters of each mission were clearly understood by the GSM teams, final preparations were completed. This work was accomplished by a GSM team comprised of six soldiers and one civilian (see table below).

GSM Team Composition

Position	Rank	#
Officer in Charge (OIC)/Liaison Officer	O3	1
Non Commissioned Officer in Charge (NCOIC)	E7	1
GSM Shift Supervisor	E5	1
GSM Operators	E4/E5	3
Contractor (Maintenance)*	Civ	1
TOTAL[65]		7

Table 5

**** Maintenance performed by Army soldiers in the future.***

This low density of personnel on the GSM team required an around-the-clock operation at each site. A typical mission cycle is shown below:

Ground Station Module Team's 24 Hour Cycle

16 Jan	1630 to 0430	Surveillance and Targeting Mission
17 Jan	0430 to 0800	Post mission analysis of data and imagery reporting
	0800 to 1400	Daily maintenance of GSM, vehicle and generator

1400 to 1630	Pre-mission planning, review of call signs, code words, target lists, coordination with the G2/G3/Fire Support Element, update of mission maps and prioritization of surveillance coverage
1630	**E-8A take-off**
1630 to 1700	Establish SCDL lock with aircraft
1700 to 0400	Monitor mission
0400 to 0430	E-8A leaves surveillance orbit and returns to base

Operational Environments. Apparent in even a quick contrast of the GSM and E-8A mission crews and work schedules are the sharp differences in the operational environments of the Army and Air Force.

DESERT STORM Air Crew vs. GSM Operational Environment

Characteristics	Air Force	Army
Personnel Reqs.	27	7
Crew Composition	19 Officers	1 Officer
Multiple Crews	Yes	No
Location	Centralized - Located at Riyadh Airfield	Decentralized - Located across the theater
Mid-Mission Change	Accomplished in the E-8A	Accomplished thru the E-8A
Area of Interest	Theater	Corps or smaller
Radar Mode	Targeting	Surveillance and Targeting

Table 6

The GSMs, working in support of selected units, were often under the operational control (OPCON) of a ground commander. The officer in charge of the GSM team took his orders from the staff officers of the supported command.[66] Consequently, this

relationship defined the surveillance and targeting area of interest for the GSM team. The supported ground commander's area of interest became the GSM team's main focus.

In the E-8A, the Corps surveillance area was only a part of the total mission coverage area. The Joint STARS aircraft was often redirected by the ACC to support other priorities in the theater, beyond the confines of a one Corps zone. This caused problems for the GSM team, OPCON to a Corps. When the coverage shifted, the ability for decentralized manipulation and analysis of Joint STARS surveillance and targeting data was lost. Ground units were forced to accept the coverage area and radar mode selected by the aircraft.[67]

Additionally, the aircraft was forced to alternate radar capabilities between the wide area surveillance (WAS) and synthetic aperture radar (SAR) modes. This was required because the prototype system was not capable of interleaving (running the radar modes at the same time) WAS and SAR.[68] As a result, minutes of WAS would be worked followed by, possibly, a half hour of SAR shots. This technique was most productive for the generation of targets but it did not support the Army requirement of situation development. For proper situation development, continuous WAS is required.

Consistent wide area surveillance, builds a picture of the battlefield, broader in scope and richer in enemy information, than is possible in the SAR mode. The

disadvantage of WAS is that it initially requires patience and a fully functioning radar system.[69] ***Time*** is needed to develop patterns of normal and abnormal movement before proper exploitation can occur. Unfortunately for the Army this resource of time was not available, especially early in the war, as the Air Force sought to decisively achieve air supremacy. Additionally, movement patterns could not be ascertained with a radar system that would shut down for minutes or hours on end. The result of the conditions created by a prototype system and an Air Force controlled radar was that the Army was forced to settle for surveillance "snap shots" instead of a "movie" of Iraqi activity. This situation raised the topic of radar control as an issue requiring joint service resolution.

The concern over the control and use of Joint STARS (JSTARS) was echoed by the G2 of ARCENT Headquarters in his DESERT STORM after action report.

> "One issue brought up in the employment of JSTARS ... concerned whether they are targeting or intelligence (read situational development) assets. The Air Force continually claimed that JSTARS was actually a targeting system, and since their aircraft would attack the targets, the Air Force should retain control of JSTARS. This **was not an academic issue**. The JSTARS could "zoom-in" on targets using synthetic aperture radar, or it could look at the entire battlefield using its side-looking radar. The latter, for example, told us whether Iraqi units were moving or not and if they were moving precisely where and in what vehicular strength. The former allowed us, then, to focus precisely on those vehicles in order to determine their disposition for

> attack purposes. So JSTARS, to us, truly served its original purposes. **It provided a full view of the enemy situation, and it allowed us to select the key targets** (like units moving to blocking positions in the path of the main attack) for attack. Since we almost always cannot attack all targets, **the function of situational development is crucial to target selection.*** We need to ensure this message is clearly read and understood".[70]
>
> ***(* Author's emphasis)***

This comment made by Brigadier General John Stewart, highlights the major service differences in the employment of Joint STARS during DESERT STORM. The Air Force, generally saw Joint STARS as a <u>targeting</u> tool under the <u>centralized</u> control of the theater commander. The Army viewed Joint STARS as a <u>surveillance</u> system whose's value came from the <u>decentralized</u> application of situational development and target selection.[71] The next section of this thesis will discuss the impact of these service differences as Joint STARS' performance in DESERT STORM is examined.

<u>General Analysis.</u>

<u>I. Value of Product.</u> The post DESERT STORM user consensus was that Joint STARS provided a valuable product to both the Army and the Air Force. One of the strongest endorsements came from the ARCENT, G2, BG John Stewart.

> "The Joint Surveillance Target Attack Radar System (JSTARS) was the **single most valuable intelligence and targeting collection system in DESERT STORM**. JSTARS came here as another prototype, and when it was needed, it was there, in bad weather and during longer hours

> daily than anyone had predicted. JSTARS was instrumental in making "key reads" during the ground war. It showed the lack of movement just before the attack. It told us precisely where operational reserves would set up their blocking positions. It gave the first and continuous signs of Iraqi withdrawal from Kuwait and was the target development instrument we used for the Air Force attack of fleeing Iraqi convoys on the main road north of Al Jahra. JSTARS showed the Republican Guards heavy divisions establishing their defense of Basrah. There was other intelligence on all this, but JSTARS was absolutely instrumental."[72]

BG Stewart's comments are consistent with the majority of the discussion of Joint STARS. All supported commands thought that the system added to their operations. However, the view of Joint STARS was not without its detractors. After the DESERT STORM cease-fire was declared the Operational Evaluation Command (OEC) solicited comments from Joint STARS users. Of the 146 comments gathered by OEC, 9% were negative statements.[73] Among these complaints were:

> "... After a period of time the confidence level became lower as bad calls were made.... mid-point of campaign was lowest confidence point... Joint STARS information was beneficial 20% of the time... Joint STARS data was marginally useful, basically because of system errors (false hits) and inaccurate target count."[74]

Some of the negative phrases on Joint STARS were focused upon the lack of support, as defined by coverage time, provided to a specific command.

> "Joint STARS coverage did not allow for continuous tracking. Its theater support mission afforded a maximum of two hours

continuous coverage in the Marine's sector."[75]

In general however, Joint STARS seemed to provide a valuable product as measured by the majority of favorable comments on the system and the direct input it provided during the Battle of Kafji and the retreat of the Iraqi forces out of Kuwait City. As the commander of the USAF Electronic Systems Division would say:

> "The Joint STARS ... performed truly outstandingly. Providing real time, large area data to moving target and fixed targets to our forces on the ground."[76]

II. Timeliness. This appears to have been one of the strengths of the Joint STARS system. Only one user in the OEC survey felt that the Joint STARS data was not timely.[77] Additionally, an analysis of the 530 entries on the Joint STARS Army aircrew mission log sheets shows that on only two occasions did GSM operators believe that they were not being quickly serviced by the E-8A's radar.[78]

In the majority of cases the radar, when it was operational, was very responsive to tasking and intelligence dissemination. By design, the Joint STARS radar imaged the Corps area every 60 seconds. Consequently, data passed to the GSMs was usually less than a minute old. The immediacy of this data allowed for "near-real time" intelligence and targeting.[79]

During the early days of the air operations, near-real time targeting helped to kill mobile SCUD launchers.[80] The

Joint STARS E-8A was teamed with dedicated F-15 Strike Eagles to find and destroy SCUDS, located along the border of Iraq and Jordan. Tipped of a missile launch from other intelligence systems, Joint STARS would be directed to survey a "SCUD box;" usually several kilometers square. Once movement was detected in the surveillance area a SAR shot was made. This SAR picture would confirm or deny the existence of a SCUD launcher and if present, fix the location of the weapon system. The F-15s would then be called in and minutes later the SCUD would be destroyed.[81] From Joint STARS notification of a missile launch to the detection and location of the mobile launcher took no longer than six minutes. The speed of this search resulted in the identification and destruction of over one half of all SCUDs passed to the Joint STARS aircraft as a formal tasking.[82]

III. Accuracy. Accuracy of Joint STARS data was assisted by the incorporation of a Global Positioning System (GPS) with the E-8A's inertial navigation system. These two systems pinpointed Iraqi targets with great reliability. A final check of locations was performed by console operators as they checked moving target indicators (MTI) against the known roads and terrain features stored in the computer maps of Joint STARS. If a series of MTI "dots" was consistently moving along a linear axis of advance, yet was displaced by several hundred meters off a known road network, Grumman system engineers were called upon to recalibrate the radar

accuracies.[83] This situation rarely occurred however, and when it did it was readily apparent and easily corrected.

The combination of the technical and man-made checks in the navigation systems of Joint STARS provided remarkable location accuracies. Target location and enemy sightings were presented in ten-digit geographic coordinates. These coordinates ensured that target sets fell well within the Circular Error Probable (CEPs) of the Army and Air Force weapon systems.

IV. Simultaneous Support. If any area can be labeled a Joint STARS operational deficiency, it was the inability of Joint STARS to simultaneously support the mission requirements of the Army and the Air Force. There were three reasons for this; doctrinal, materiel and technical. Each of these areas contributed to the single vice multi-service exploitation of Joint STARS capabilities.[84]

As has already been discussed the doctrinal concepts of centralized (USAF) versus decentralized control (USA) was an initial reason for the alternating coverage of Joint STARS. The Army wanted the Joint STARS' E-8A to maintain a Corps orbit that would provide a constant stream of battlefield information to GSMs separated across the theater. The Joint STARS data that entered the GSMs would then be analyzed and disseminated on the ground and not in the air.[85]

The Air Force concept for the use of Joint STARS centralized the analysis and dissemination decisions in the

aircraft and then passed out intelligence for the decentralized execution by attack aircraft, or Army units. Overall, the subtle differences of the Army and Air Force doctrines interfered with simultaneous support to the services. This limitation was further exasperated by materiel shortages.

Between 15 and 25 GSMs are currently planned for assignment to the Corps, with several E-8As flying in support of these GSMs. Often, each Corps will be able to expect a dedicated orbit to cover their area of operations.[86] This extensive, overlapping coverage, however, was not available during DESERT STORM. Two E-8As flew, one per day, in support of an area which encompassed over three Corps.[87] Consequently, the capabilities of Joint STARS were metered out across the theater of operations. This meant that when the theater priorities required the establishment of an E-8A orbit in the east, the western most GSM was unable to receive Joint STARS data. Conversely, if Joint STARS was tasked to hunt for SCUDs in the west, the eastern USMC received no Joint STARS data. As an example, on 23 February 1991, the Joint STARS aircraft flew a ten hour mission in support of the initiation of ground operations. Radar coverage for the mission was divided as follows:

I MEF	4 1/2 hours coverage
XVIII Abn Corps	1 1/2 hours coverage

VII Corps 25 minutes[3]

In short, there were simply not enough airplanes or GSMs available to simultaneous support all interested Air Force and Army users.

The final problem, technical constraints, further limited the concurrent capabilities of Joint STARS. A look at the flight hours of the E-8A supports this statement. The Joint STARS' aircraft flew 467 hours in support of DESERT STORM. Seventy-Nine of these hours (17%) were required for the establishment of the flight orbit and enroute time, to and from the mission track. This left a possible 388 hours available (83%) for surveillance coverage of the KTO. Of these hours, fifty-four hours (14%) were non-effective for various technical reasons. The end result is that of the 467 hours flown in support of DESERT STORM, 334 hours (72%) were used for surveillance and targeting.[88] These hours, spread across 49 missions, yield an average coverage time of 6.8 hours a flight.

Out of a ten and one half hour flight, 6.8 hours is a reasonable period of radar coverage to expect from any system; however, this duration of coverage was never achieved. It was rare for the prototype radar systems to operate for more than five hours during any mission. Most significantly, these five hours, if achieved, were never continuous. The five hours of

---

[3]In reality the Joint STARS radar system was operational for less than 4 hours during this 10 hour mission.

coverage time was a cumulative total, combining 10 minute blocks of radar "up time" with 90 minute periods of system availability.[89]

This "strobe-light" radar availability prevented decentralized exploitation by Army GSMs. The Joint STARS aircraft and primary mission equipment (PME) were not technically able to produce continuous wide area surveillance of the battlefield. Additionally, as has already been stated, the PME was not able to interleave the WAS and SAR radar modes.[90] Finally, the aircraft and the GSMs were constantly experiencing trouble in maintaining a data link lock. Each time the GSM would "lose the SCDL", precious minutes would be lost as the Army operator would try to reacquire the airplane and reestablish SCDL lock.[91] These limitations combined to make it difficult for the Army to receive continuous wide area surveillance. The best that was possible was to piece together sporadic coverage periods in order to develop an understanding of Iraqi troop movement and intentions.

Although useful, as a general overview to the Army, the Air Force was the true beneficiary of this piece-meal coverage. For the USAF the sporadic coverage was "good enough" for target development. With fighter aircraft dedicated to respond to the directions of the E-8A, the Air Force attack assets were positioned to fully exploit the Joint STARS targeting information.

Targeting. During the 49 Joint STARS missions, 1839

targets were generated for the Allied Coalition forces. As Table 7 shows, most targets were developed and engaged by the U.S. Air Force. Only one target, out of the 431 that were engaged, was attacked by both military services. These figures highlight that, at least where targeting was concerned, the Air Force exploited the majority of Joint STARS targeting data.

Targeting During the 49 Joint STARS Missions

TARGET FILES DEVELOPED AND DISSEMINATED[92]		TGTS	ENGAGED	BY:
Targets developed by E-8A		ARMY	AIR FORCE	BOTH
Passed to GSM	471	7	117	1
Passed to other Air Platform Reported at debrief only Not reported from Joint STARS to ground	274 397 263		57 196 48	
Total Developed by E-8A	1405	7	418	
Total Developed by GSMs	434	3	2	1
Total Tgt Files Developed	1839	10	420	1

Table 7

Joint STARS and DESERT STORM - Key Factors. Joint STARS deployed to the Gulf as an engineering prototype, fully six years ahead of its initial operational capability date. It arrived in country with a crew assembled from throughout the services, pulled together and trained in less than thirty days. Additionally, the 4411 JSS and the Army JSOD had no formalized tactics, techniques and procedures for their

actions in the war. Finally, only six GSMs and two airplanes were available to support an area of approximately 440,000 square kilometers.[93] In spite of these limitations, Joint STARS was a qualified success in the desert.

Optimum Conditions for Success. As described by over 90% of the users of Joint STARS, the system provided a valuable intelligence and targeting product. The data from the system was accurate and timely. Information was distributed, in near-real-time to the CINC CENTCOM, and his Component Commanders and Army Corps Commanders. This valuable data was collected by Joint STARS during DESERT STORM in a optimum environment; albeit one that the U.S. and the Allied Coalition created.

Air Superiority. Because the United States Air Force controlled the skies, enemy aircraft did not threatened the Joint STARS E-8A or the associated Ground Station Modules. Consequently, the aircrew performed their mission in relative safety.[b] Neither Iraqi jets or Iraqi surface to air missiles were targeted against Joint STARS.[94] Additionally, no electronic countermeasures (ECM) were employed by the Iraqis against Joint STARS, to jam or confuse the system's radar.

---

[b]Except for periodic SCUD attacks, the Army GSMs also operated in relative security .

Identified Boundaries. The desert terrain also helped the Joint STARS mission. The surface of Saudi Arabia and Iraq is relatively barren, with flat to gentle rolling expanses of sand. There were no mobility corridors created by thick vegetation, flowing rivers or mountains to channelize movement.[c] Movement was expected, and monitored, from all directions in the Theater of Operations. Activity, not positively identified as U.S. or Coalition forces, was considered, by the Joint STARS mission crews, to be Iraqi units. This condition made the job of the Joint STARS operator easier. No attempts were made to differentiate between Iraqi combat forces and civilian personnel.[d] If movement occurred north of the Saudi Arabian border it was labeled as enemy movement.[95]

Proper Planning. It is important to emphasize that thorough mission planning and sound mission execution were the reasons why the Theater of Operations afforded optimum conditions for the employment of Joint STARS during DESERT STORM. Yet, even with these ideals conditions, Joint STARS was only capable of satisfying three of the four criteria established in this thesis' "DESERT STORM case study." To recap these results:

---

[c]Such conditions would be common in Europe or Central America.

[d]Other wars in other theaters may not present such a clear delineation of friendly versus enemy movement patterns.

RECAP OF JOINT STARS MISSION CRITERIA

Value of Product	YES	Positive User Comments
Timeliness	YES	Within minutes, when system was operational.
Accuracy	YES	Well within the CEPs of supported weapon systems.
Simultaneous Support	NO	A deficiency of the system during DESERT STORM. Caused by: (1) Loss of SCDL lock (2) Inability to interleave WAS and SAR (3) Limited #'s of aircraft and GSMs (4) Doctrinal differences between services.

Table 8

Joint STARS did provide:
1 - A valuable product
2 - A timely product
3 - Accurate locations of enemy forces[96]

Joint STARS did not provide:
4 - Simultaneous support to the Army and the Air Force.

Interleaved Multi-Mode Radar. The major reason for the lack of simultaneous support (S^2) was the developmental immaturity of the radar software and hardware. The Joint STARS components, deployed to Saudi Arabia were engineering prototypes and, as such, were not capable of interleaving the SAR and MTI modes of the radar.[97] The interleaving of SAR and MTI is, this thesis contends, an important way to provide S^2 to the services. Future employments of Joint STARS must have an available interleaved radar capability.

Adequate Numbers of Joint STARS Components. Without a multi-mode interleaved radar capability, the deployment of

additional Joint STARS components to Saudi Arabia would have been required to concurrently service Army and Air Force operations. More aircraft orbits, coupled with an extensive distribution of Ground Station Modules throughout the theater would have permitted the near-real-time support of multiple corps and the military services. However, the Joint STARS of DESERT STORM had neither the system level maturity nor the number of aircraft and GSMs necessary to provide this support.

Joint STARS and DESERT STORM - CONCLUSIONS. The centralized control of the Joint STARS' E-8A, the low density of aircraft and GSMs, and the technical limitations of an engineering prototype system prevented the services from enjoying simultaneous radar support. Although both services profited from the use of Joint STARS surveillance and targeting information, the data was passed, first to one service, and then to the other. Overall, the Air Force seemed to be the primary beneficiary of Joint STARS generated targets. For the Army, an attempt was made by ARCENT HQS to use the Joint STARS capabilities for the purpose of situation development. This mission was limited however, by the lack of continuous wide area surveillance.[98] In summary, although a contributor to victory during DESERT STORM, Joint STARS did not provide simultaneous support to CENTCOM's Land and Air Component Commanders.

In the final chapter of this thesis a recommendation is offered to the problem of simultaneous support. This

recommendation is one of several offered for the improvement of the employment of Joint STARS. Chapter Five represents the synthesis of the thesis research.

ENDNOTES CHAPTER FOUR

1.Grumman Aerospace Corporation, Joint STARS Briefing Booklet, prepared for Lieutenant General Billy M. Thomas, Deputy Commanding General for Research Development and Acquisition, U.S. Army Materiel Command, (20 March 1991), 12.

2.U.S. News and World Report, Triumph Without Victory. (New York, 1992), 347-348.

3.U.S. Army Field Manual (FM) 34-2, Intelligence Analysis, (Washington, DC: Department of the Army, March 1990), 2-14 to 2-18.

4.David Hughes, "Electronic Systems Div. Accelerates New Systems Deployments, Upgrades," Aviation Week & Space Technology, (4 February 1991), 58.

5.Author's interview with Major Robert Carr, U.S. Army Assistant to the TRADOC System Manager for Joint STARS. Discussion conducted at Fort Leavenworth, Kansas, 18 March 1992.

6.Hughes, 58.

7.Grumman Aerospace DESERT STORM VCR Tape (April 1991).

8.Major Shawn Griffith's After Action Report, (3 March 1991). Major Griffith is the Deputy Assistant to the TRADOC System Manager for Joint STARS. Major Griffith served as a Deputy Mission Commander aboard the Joint STARS E-8A during DESERT STORM.

9.Peter Grier, Joint STARS Does Its Stuff," Air Force Magazine, (June 1991), 40.

10.Author's talks with Colonel Martin S. Kleiner, TRADOC System Manager for Joint STARS. (A series of talks between December 1990 and March 1991.)

11.Author's talks with LTC George J. Cusimano, Deputy Director of Joint STARS Test Force, Melbourne Florida. A series of discussions between January and March of 1991.

12.Author's talks with Major Michael Widener, Assistant to the TRADOC System Manager, Joint STARS Test Detachment, Melbourne Florida. Series of discussions between December 1990 and March 1991.

13.Colonel Martin S. Kleiner, "Joint STARS Goes to War," Field Artillery, (February 1992), 26.

14.Peter Grier, "Joint STARS Does Its Stuff," Air Force Magazine, (June 1991), 41.

15.Carr, 18 March 1992.

16.Widener, March 1991.

17.Griffith, AAR, (3 March 1991).

18.Virginian Pilot, "Allies Rain Fury on Iraq," (17 January 1991, #38), 1.

19.Author's personal diary and mission journal sheets, written between December 1990 and March 1991.

20.Kleiner, 27.

21.Author's talks with Major Bud Williams, E-8A Weapons Allocation Officer during DESERT STORM. Series of discussion between January and March 1991.

22.Major Bud Williams, "DESERT SHIELD/DESERT STORM Trip Report," (5 March 1991), 7.

23.Kleiner, 27.

24.Griffith, AAR.

25.Author's mission journal sheets. On 17 February the E-8A ran two hours and twenty minutes of SAR and 30 minutes of MTI coverage for the seven hour flight.

26.Griffith, AAR.

27.Grumman's DESERT STORM video tape, April 1991.

28.Griffith, AAR.

29.Ibid.

30."'Filtering,' Helped Top Military Leaders Get Proper Intelligence Information," Aviation Week & Space Technology, (22 April 1991), 84.

31.Cusimano, March 1991.

32.Grumman Aerospace Prepared Briefing Package, "Eyes of the Storm," Handout of E-8A aircraft, (1992).

33.4411 Joint STARS Squadron Checklist, developed December 1990. Aircrew positions are described in this book.

34.Author's mission journal.

35.Cusimano, February 1991.

36.Ibid.

37.Widener, March 1991.

38.Cusimano, February 1991.

39.Williams, January 1991.

40.Author's mission journal.

41.Grumman's VCR tape, April 1991.

42.Kleiner, 28.

43.Grier, 41.

44.Kleiner, 28.

45.Ibid.

46.Ibid.

47.Ibid.

48.Ibid.

49.Grumman VCR tape, April 1991.

50.Illustration developed from briefing slides prepared by the TRADOC System Manager Office, Fort Huachuca, Arizona, (1992).

51.Carr, 18 March 1992.

52.Author's personal journal notes.

53.Kleiner, 28.

54.Ibid.

55.Figure developed from briefing slides prepared by the TRADOC System Manager Office, Fort Huachuca, Arizona, (1991).

56.Ibid.

57.Grumman Tape, April 1991.

58.Peter Turnley, "The Day We Stopped the War," Newsweek (20 January 1992), 23.

59.Turnley, 23.

60.Ibid.

61.Author's mission journal.

62.Carr, 18 March 1992.

63.Williams talks.

64.Carr interview, 18 March 1992.

65.Ibid.

66.Ibid.

67.Widener, March 1992.

68.William B. Scott, "USAF Officials Explain How War Altered Joint-STARS Requirements," Aviation Week & Space Technology, (14 October 1991), 58-59.

69.Widener, talks.

70.Brigadier General John Stewart, Operation DESERT STORM The Military Intelligence Story: A View from the G-2, 3d U.S. Army. (April 1991).

71.Griffith, AAR.

72.Stewart, A View from the G2.

73.LTC John Holmes, Operational Evaluation Command (OEC), "User Comments Section," DESERT STORM After Action Report, (August 1991), O-2 through O-18.

74.Ibid.

75.Ibid.

76.Comments made by Lieutenant General Gordon E. Fornell at the "Welcoming Home of the 4411 Joint STARS Squadron," Melbourne, Florida, (6 March 1991).

77.OEC report, O-6.

78.Aircrew mission journal sheets, "Sequence of Events/Chronological Narrative," No form number. Prepared and used by the aircrews of the 4411 JSS, (January 11 to March 1991).

79.Bruce D. Nordwall, "Highly Integrated System, Versatile Radar Win Kudos for Joint STARS' Gulf Ware Role," Aviation Week & Space Technology, (24 June 1991), 49.

80.Kleiner, 27.

81.Widener, talks.

82.Author's mission journal.

83.Author's mission journal.

84.Griffith, talks.

85.Carr, interview.

86.Colonel Martin S. Kleiner's briefing to Division Intelligence Officers, Fort Leavenworth, Kansas, (21 February 1992).

87.Grier, 41.

88.Figures taken from the OEC Report, J-1.

89.Aircrew mission chronological sheets.

90.OEC Report, "User/Operator Comments," N-12, N-53.

91.Ibid, 49 (7.1.3.5).

92.OEC Report, J-1 through J-6.

93.The Virginian-Pilot and the Ledger Star, "Special Map: The Middle East," (25 January 1991). Distances used: 400 kilometers by 1100 kilometers.

94.Major Shawn Griffith's After Action Report, (3 March 1991).

95.Author's interview with Major Robert Carr, U.S. Army Assistant to the Training and Doctrine Command (TRADOC) System Manager for Joint STARS. Discussion conducted at Fort Leavenworth, Kansas, (18 March 1992).

96.These criteria are consistent with the "Principles of Intelligence Quality" found in Joint Pub 2-0, Doctrine for Intelligence Support to Joint Operations, JCS Publications, Washington, D.C., (30 June 1991), II-10.

97.Author's talks with LTC George J. Cusimano, Deputy Director of the Joint STARS Test Force, Melbourne, Florida. A series of discussions between January and March of 1991.

98.Griffith talks.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

"Technologies and doctrine will take a thousand changing forms, but the only unchanging constant in the Army equation is the skill to master the complexities of men and weaponry..."[1]

Section I

The 7 Scenarios

Although, it is relatively easy to suggest recommendations for improving the Joint STARS' capability for simultaneous support during an operation like DESERT STORM, another war in Iraq is but one of the military's future mission areas. The Department of Defense (DoD) Seven Scenarios illustrate projected threats that the U. S. Armed Services might encounter and must prepare for. These scenarios establish a planning framework for the development of new doctrine and force structure to fight the wars of the future.[1] Because Joint STARS will play prominently in the

evolving Army doctrine, this next section of the final chapter will examine the *current* capabilities and operational procedures of Joint STARS against the requirements of the Seven Scenarios. After completion of this analysis improvements will be recommended to the system's components and procedures (Section II). These improvements will explain how Joint STARS can strengthen areas of weakness.

In the chart below the Thesis Threat Levels are overlaid on top of the threats illustrated in the Seven Scenarios. As initially proposed in Chapter Three, there are currently no Level III (Nuclear, mass destruction) threats poised to jeopardize the United States. This position is based upon the current absence of a nation with the necessary destructive power and hostile intent necessary for characterization as a Level III threat. This view does not however, rule out the future development of a Level III enemy. As described in the scenarios which detail a simultaneous war with Iraq and North Korea and a nuclear armed North Korea (Scenarios 6 and 7, respectively), the emergence of a Level III Threat is possible, given the right conditions.

An Overview

Comparative Effectiveness of the Current Joint STARS Capabilities Examined Against the DoD Seven Scenarios

Thesis Developed Threat Levels	Level I		Level II			Level III	
DoD "Seven Scenarios"	1	2	3	4	5	6	7
Timely (JS capability to provide a timely product)	+	+	+	+	+	-	/
Accurate (JS capability to provide accurate product)	-	-	+	+	+	-	+
Simultaneous Support (JS capability to provide multi-service support)	-	-	-	-	-	-	-
Value(of Joint STARS product)[3]	-	-	+	+	+	/	/
Effectiveness of Joint STARS capabilities	N	N	Y	Y	Y	N	N

Table 9

Table Key

1 - Chaos in Panama	+ (Positive effect)
2 - Filipino Revolution	- (Not effective)
3 - Re-Armed Iraq	/ (Neutral effect)
4 - Russia and NATO	
5 - New Soviet-like coalition threat	
6 - Simultaneous wars with Iraq and North Korea	N (No/Not effective)
	Y (Yes/Effective)
7 - Nuclear armed North Korea	

Chaos in Panama / Filipino Revolution. The effectiveness of today's Joint STARS in Panama would be restricted by the nature of the enemy. It is likely that the Level I (Low Intensity Conflict) type threats in these scenarios would conduct small-scale[4] insurgency operations designed to disrupt or harass the established governments of

[4]Battalion or below.

these countries. Joint STARS' capabilities to detect columns of moving vehicles, deep in an enemy's follow-on echelons would be of little value in this type of scenario. A further difficulty would be distinguishing between friendly and enemy forces in densely populated towns and cities. Boundaries between the governmental forces and the insurgent forces would be ill-defined. Therefore, the data derived from Joint STARS would not add as much to the operational intelligence collection efforts as say, HUMINT sources would.[b]

Finally, the targeting capabilities of the system would not be valuable; again because the insurgents would integrate their operations with the country's population.[4] Unless an area of insurgent activity could be clearly identified,[c] and enemy boundaries established, it would be hard to focus the capabilities of Joint STARS on insurgent forces.

Because of the lack of large unit movements with a Level I threat, the Synthetic Aperture Radar (SAR) mode of Joint STARS would probably be a more appropriate sensing capability than would the Moving Target Indicator (MTI) mode. But SAR would only be possible after a tip-off from another intelligence source. Signals Intelligence (SIGINT) or Human Intelligence information would be needed to help locate a

---

[b]HUMINT, an acronym for Human Intelligence.

[c]Such as the jungles or hills of Panama or the Philippines.

possible enemy strong point for confirmation by the Joint STARS' SAR. A hypothetical example illustrates this necessary integration of intelligence sources.

One Joint STARS orbit, flying off the southern coast of Panama, in the North Pacific Ocean, would be capable of covering the entire country of Panama, west of La Chorrera. A similar orbit, along the western coastline of the Philippines could cover the entire island of Mindoro.[5] If the Joint STARS' aircraft were operating in the moving target indicator (MTI) mode, a surveillance sweep of the countryside could be made at least once every 60 seconds. However, MTI surveillance would probably yield a confusing mass of dots for the Joint STARS console operators. The confusion would be caused by the difficulty in differentiating a handful of insurgents from among the local population. If another intelligence source, such as an Army C-12, GUARDRAIL COMMON SENSOR[d], aircraft was used in conjunction with Joint STARS, the possibility of finding the enemy would be geometrically increased.[6] The GUARDRAIL aircraft could intercept and pinpoint the location of an insurgent's radio transmitter. This location, coupled with confirmatory reports from local citizens could provide a specific area for the targeting of the Joint STARS' radar. The SAR and MTI modes could then be used interchangeably to help contribute to an all-source

---

[d]A Signals Intelligence Aerial Platform. Capable of providing extremely precise locations of radio transmitters.

picture of enemy activity. In this example it is important to note that the system's value is a part of an intelligence collection network.[7] With the present capabilities of Joint STARS it cannot be viewed as a single-source intelligence or targeting platform. In conclusion:

> ***the present Joint STARS capabilities, would be the wrong surveillance and targeting tool to use against Level I threats. Joint STARS, as a stand-alone system, would have an extremely difficult time in locating and fixing the threats, represented by the Panama and Philippines scenarios.***

Simultaneous Wars with Iraq and North Korea. At an opposite extreme, the scenario that deals with North Korea would stretch the capabilities of Joint STARS, yet offer only marginal contributions to joint operations. Of primary consideration is that the current system capabilities could not support simultaneous wars with Iraq and North Korea. Due to limited assets, one theater would have to be chosen over another for Joint STARS deployment. The value of Joint STARS would thus be split, providing timely, accurate and valuable surveillance and intelligence product to one area of operations and no support to the other. As will later be addressed, this limitation will not be valid in the future. The objective Joint STARS of 1997 will have an adequate number of aircraft and GSMs to support a two theater war. Currently however:

> ***in the simultaneous war scenario, Joint STARS could only provide single theater support.***

Nuclear armed North Korea. A nuclear armed North Korea provides one of the most challenging scenarios of the seven proposed. It also portrays some of the more difficult operational conditions in which to measure the effectiveness of Joint STARS, although some predictive contributions of the system are readily apparent. Joint STARS could furnish timely and extremely valuable location accuracies of North Korean, fixed and mobile, nuclear delivery systems. As demonstrated in DESERT STORM, Joint STARS was able to locate mobile missile systems, *after* being tipped by other intelligence systems to focus in on a confined geographical area. Likewise, in North Korea, a combination of MTI and SAR, concentrated on a small coverage area, would be able to pinpoint a military convoy or missile system. Additionally, the Synthetic Aperture Radar mode of the Joint STARS radar could help to determine if a fixed nuclear site was being prepared for launch by monitoring the enemy activity, in and around the site.

The limitation of Joint STARS in this scenario would be the surveillance range required for this type of targeting mission. Flying in a stand-off orbit from the border, (due to the effectiveness of North Korean surface to air missile systems) the coverage area of Joint STARS would be considerably shortened. Consequently, military units, positioned north of Pyongyang would fall at the outer detection range of the Joint STARS radar. Without flying a

penetration mission[e], mobile missile systems and other significant military activity, north of Pyongyang, would be hard to monitor. Due to this range limitation, Joint STARS would need to be viewed as a secondary or confirmatory source for other collection systems.

Once "in-range" sites were pinpointed however, Joint STARS could help to develop a targeting prioritization, based upon the level of activity in and around the missile sites. Those sites reported by Joint STARS as being readied for an imminent launch would be the first locations struck by the precise, but finite, South Korean and U.S. weapon systems. Such a technique could be used as a means to disarm or reduce the first strike shock of a North Korean nuclear attack. If this step failed, Joint STARS effectiveness would be questionable until the war could be stabilized. After stabilization, the system's capabilities could again be focused upon the North Korean mechanized forces that would be expected in an invasion of South Korea.

In general, the dangers, distances and weapon systems contained in the Nuclear North Korea scenario would likely surpass the present capabilities of Joint STARS. Although the system could be viewed as an active participant in surveillance and targeting missions it could not be viewed as a stand-alone platform. To have value, the intelligence and

---

[e]A flight to the north, across the border of South Korea.

targeting data provided by Joint STARS, tasked against a nuclear armed North Korea, would require fusion with the products from other collection systems. As with the analysis of Level I threats;

> ***the greatest value and effectiveness of Joint STARS would not be found in operational missions against Level III threats.***

Multi-Echeloned Threats. Chapter Four of this thesis described the work of Joint STARS in a war against Iraq. The ability of Joint STARS to detect the second-echelon divisions of the Iraq Operational Center of Gravity (the Republican Guards) significantly contributed to Operation DESERT STORM. Likewise, the final three scenarios:

- **War against a re-Armed Iraq**
- **War between Russia and NATO.**
- **War against a new "Soviet-like" coalition**[f]

provide conditions very similar to DESERT STORM and offer the greatest opportunities for the effective use of Joint STARS capabilities.

The common characteristic of these final cases is the Soviet-nature of the proposed threat. In the threat model of Chapter Three, such forces fall within the Threat Level II category. Level II threats involve an enemy that has modern, multi-echeloned, armored and mechanized units, operating from within defined territorial boundaries. These are the ideal

---

[f]These three scenarios illustrate modern, but **NON-NUCLEAR** threat forces.

conditions for which Joint STARS was developed.[g] In such an environment Joint STARS will be an especially relevant surveillance or target acquisition system. The system can look deep[g] to develop the battlefield situation, while providing ground commanders with enemy location accuracies needed to fight the close battle[h]. Additionally, the differentiation between civilian and military targets will be easier because of the number and formation patterns of mechanized forces.

In a comparison between Level I, II an III threats it appears that:

> ***Joint STARS' greatest contributions to operational warfighting will be made against the scenarios which deal with Level II threats.***

Summary. The Joint STARS of 1992 would contribute to operations against the threats of the Seven Scenarios in the following ranked order:

---

[g]Beyond 200 kilometers.

[h]Within hundreds of meters of friendly ground forces in contact.

Joint STARS Contributions to the Seven Scenarios: Rank Ordered

1	War with a Re-Armed Iraq	Threat Level II
2	War between Russia and NATO (Non-Nuclear)	Threat Level II
3	War with a Soviet-like coalition (Non-Nuclear)	Threat Level II
4	Simultaneous wars with Iraq and North Korea	Threat Level III
5	War with a nuclear armed North Korea, Post Nuclear Operations	Threat Level III
6	Chaos in Panama	Threat Level I
7	Threat of a Filipino Revolution	Threat Level I

Table 10

Rationale

1. War with a Re-Armed Iraq
   - Represents a Level II threat
     * Multi-echeloned mechanized units
     * Forces employed in accordance to doctrine
       > Employment of Combined Arms Teams
       > Artillery forward in the offense
       > Tanks used for exploitation
       > Armor supported by mechanized infantry
     * Modern equipment
     * Large logistical requirement for operations
   - Terrain relatively flat, with sparse vegetation
     * Movement can be expected from many directions
   - Distinct boundaries between threat and friendly forces
     * Easy distinction between friendly and enemy forces
     * Forward Line of Troops (FLOT) capable of being established
   - Joint STARS will help to support Close and Deep Ops
     * Detection of threat forces from the FLOT to beyond 200 KMs
   - Targeting capability will be very valuable
     * Follow-on echelons will be targeted
     * Logistical trains will be targeted
   - Surveillance capability will be very valuable
     * Development of enemy movement patterns and battlefield intentions will be very important

2. **War between Russia and NATO**
   - Joint STARS developed for this scenario
   - NATO military support available
     * Joint STARS will be part of a surveillance and targeting network of U.S. and NATO forces
   - Represents a Level II threat
   - Rolling terrain, light to heavy vegetation
     * Fought in the European Theater
     * Joint STARS would be focused on mobility corridors and movement choke-points.
   - Initially, clear boundaries can be expected between threat and friendly forces.
   - Support to Close and Deep Operations
   - Valuable targeting data
   - Valuable surveillance information

3. **War with a Soviet-like coalition**
   - Similar to the Soviet, Central-Europe scenario
   - NATO military support expected
   - Represents a Level II threat
   - Rolling terrain, light to heavy vegetation
     * Could occur in any theater of operations
   - Boundaries between threat and friendly forces can be defined
   - Targeting capability will be very valuable
   - Surveillance capability will be very valuable

4. **War Simultaneous wars with Iraq and North Korea**
   - Represents a Level III threat
     * Due to possibility of nuclear escalation
   - Flat to mountainous terrain, sparse to light vegetation
     * Mobility corridors and avenues of advance would be more wide-open and unpredictable in Iraq, more channelized in North Korea
   - Clear boundaries between threat and friendly forces
   - Deep targeting capability will be very valuable
     * Destructiveness of North Korean weapon systems would necessitate a first strike option
   - Surveillance capability will be very valuable
     * Discovery of enemy's intent will be crucial

5. **War with a nuclear armed North Korea (Post Nuclear Operations)**
   - Represents a Level III threat
   - Flat to mountainous terrain, light to heavy vegetation
   - Clear boundaries between threat and friendly forces
   - Targeting capability will be extremely valuable
     * Pre-nuclear and Post-nuclear
   - Surveillance capability will be very valuable
     * Identification of invading North Korean forces

6. **Chaos in Panama**

- Represents a Level I threat
- Flat to mountainous terrain, light to heavy vegetation
- Ill-defined boundaries between threat and local population
- Limited targeting value
    * Small unit movements
    * Difficulty in distinguishing enemy from friendly
- Moderate surveillance value
    * Patterns of activity could be established, especially if the government restricts the movement of the local population
- Surveillance mission would be better serviced by other assets (Army COMINT aircraft, Human intelligence sources)

7. **Threat of a Filipino Revolution**
    - Represents a Level I threat
    - For Joint STARS, similar to the Panama Scenario
    - Ill-defined boundaries between threat and local population
    - Limited targeting value
    - Moderate surveillance value
    - Joint STARS probably the wrong surveillance system to monitor internal country problems

Key Factors. In an examination of the Seven Scenarios several common factors appear important in the rank ordering of Joint STARS contributions. The first and most significant factor is an understanding of the nature of the threat. Joint STARS will be most effective when used against Level II threats (multi-echeloned, mechanized forces engaged in conventional warfare) and least effective against Level I threats (guerilla and insurgent operations).

Any threat force, following a formal doctrine or operational procedures will be vulnerable to the capabilities of Joint STARS. Common military practices such as standardized convoy vehicle separation and forward resupply operations will be detected by the moving target indicator

capability of Joint STARS. Predictions of the enemy's intent will also be possible after the location and identification of the threat's lead units (armored scouts or self-propelled artillery), and follow-on forces. Additionally, the location of fixed enemy positions will be possible. The patterns of threat artillery and air defense positions will be easily distinguished by the SAR mode of the system's radar.

Another key factor in the analysis of Joint STARS' effectiveness is the nature of the terrain in the area of operations. Flat terrain will afford the enemy less operational security from the visual capabilities of other, (non-Joint STARS) aerial imagery platforms. In a theater of flat terrain the utility of unmanned aerial vehicles (UAV) will be greatly enhanced. In such a situation, the use of UAVs or visual and photo reconnaissance aircraft may be a cheaper, and less risky, alternative to battlefield surveillance than the tasking of a Joint STARS E-8A.[9] Each situation will be unique, but if visual detection is possible in a theater of operations, the use of an airborne radar system such as Joint STARS may not be required.

Level ground also allows the enemy relative freedom of movement across the area of operations. Whereas, hills and thick vegetation channelize enemy maneuver, resulting in the identification of choke points and key terrain, flat terrain does not. Key terrain features become harder if not impossible to determine. The entire battlefield is open to

maneuver for the enemy (and friendly) forces. On such a fluid battlefield the requirement for a wide area surveillance (WAS) capability is crucial to combat operations. WAS is needed for its immediate detection and location accuracies as it simultaneously monitors the broad combat situation. Within these parameters, Joint STARS would be the system of first choice. No other system, presently fielded could provide the same, long term, wide area coverage as Joint STARS. Surveillance duration (in excess of 10 hours) and the size of the coverage area (512 Km Square) make Joint STARS unique.[10]

Vegetation must also be considered when examining Joint STARS capabilities against terrain features. Although the precise affect of thick canopy cover on the system's radar is not yet know, the effect of vegetation on mechanized forces and vehicles is known. Large units cannot move quickly through thick vegetation. Roads or trails must be cleared for movement of the types of formations that Joint STARS is designed to detect and target.

The alternatives are simple: the enemy can accept a slow rate of movement through thick woods or jungle or clear a path for high speed mobility. If the first option is taken the ability of a threat force to mass combat power would be significantly reduced. If the latter option is chosen Joint STARS can detect and contribute to the destruction of the enemy force.

Natural and man-made boundaries are also important

factors for understanding the effectiveness of Joint STARS. With a well defined break between friendly and enemy forces, targeting missions are expedited as the danger of fratricide is reduced. Presently, the Joint STARS radar, aircraft consoles and Ground Station Modules work stations cannot differentiate between a friendly mover and an enemy mover.[11] Both appear as identical "dots" on the Joint STARS' monitors. The only control in the system is the verification of friendly unit locations and the cross-check of detected movement against map coordinates. The importance of boundaries, be they national borders, rivers or a fire support coordination line (FSCL), is therefore readily apparent. Boundaries add a safety buffer for the surveillance and targeting missions of Joint STARS.

A final consideration in understanding the effectiveness of Joint STARS is the theater availability of complementary intelligence and targeting systems. Although a very powerful battlefield tool, Joint STARS will work best as part of an established intelligence and targeting network.[12] The integration of Joint STARS into the continuous operations of a collection management cell will be most beneficial.

Joint STARS, as an imagery intelligence and targeting system will provide significant radar information to collection managers. Joint STARS data, when combined with national systems, signals intelligence, and human intelligence reports will provide the most accurate and best use of the

systems's capabilities. This integrated employment implies that the system should not be used or viewed as a redundant capability. Joint STARS need not be flown in areas covered by the Army OV-1D, UAV, or the Air Force RF-4C [1] As an imagery system, Joint STARS can provide the imagery component of the developing battlefield situation.

The common factors discussed above:

- **Threat - Terrain - Boundaries**
- **Availability of Complementary Systems**

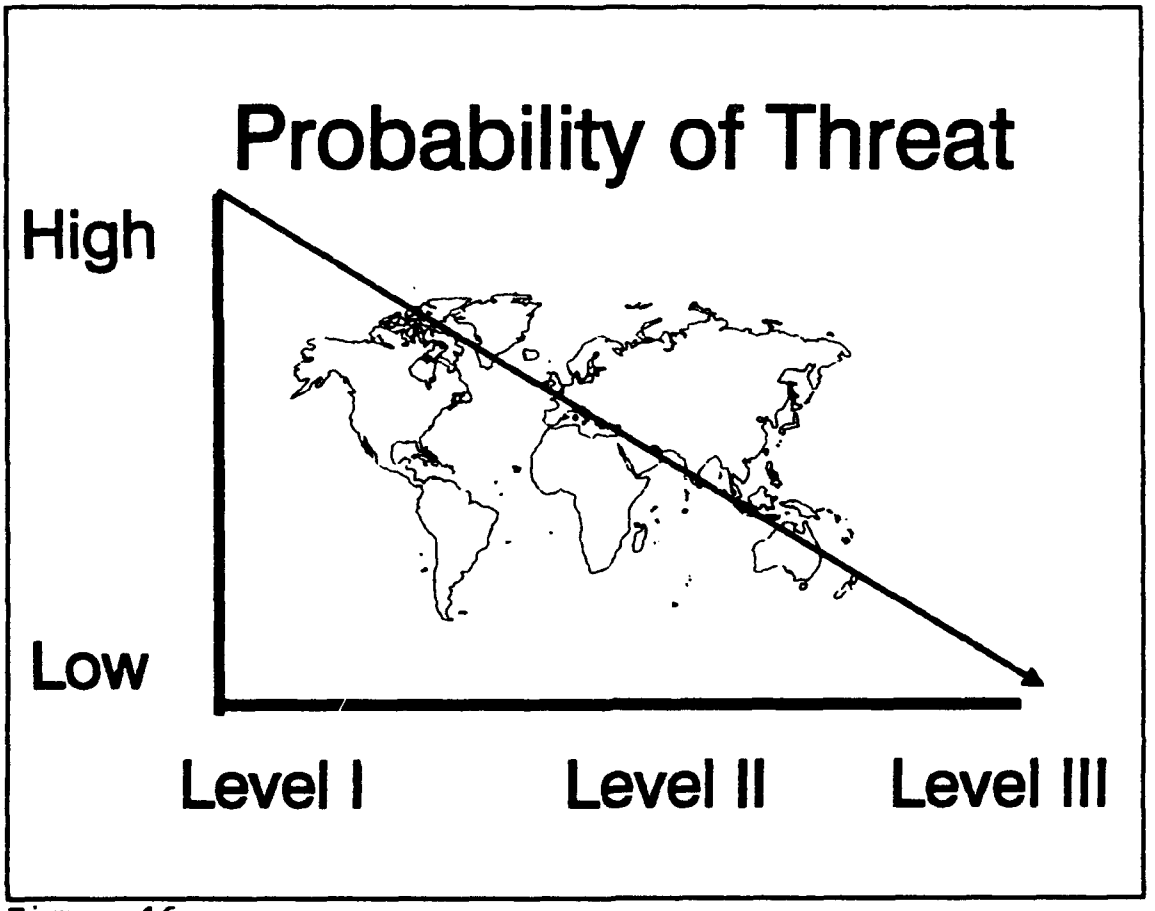

Figure 16

[1]These aerial platforms provide varying types of imagery products (see Appendix B).

are criteria which assist in the evaluation of Joint STARS' usefulness in operations against the "illustrative threats" of the Seven Scenarios. These factors could be equally helpful in future comparisons of the Joint STARS capabilities against new scenarios, not yet developed or written. This type of pre-hostility, system analysis, will help to ensure that the future employment of Joint STARS occurs at the right time and against the right threat.

Probability of Threat Levels. One final aspect of the Seven Scenarios, the probability or frequency of occurrence, needs to be addressed. It is generally accepted that the relationship between the frequency of occurrence and the danger of a threat level is inversely proportional (Figure 16).[13] That is, Level I threats (country revolutions, guerilla operations and terrorism) are the most probable and the ultimate threat of Level III, nuclear destruction, is the most unlikely. This thesis has established that Joint STARS' capabilities are best suited to support operations against Level II threats. Yet, Level II conflicts are not the most probable of the proposed threats. Why then should the U.S. military spend $7.7 billion dollars on Joint STARS? Is the cost worth the product? The analysis of this thesis suggests that Joint STARS is worth the expense.

In future wars Americans will expect victory to be quick, decisive and won while suffering the fewest possible casualties (Figure 17).[14] These expectations will influence

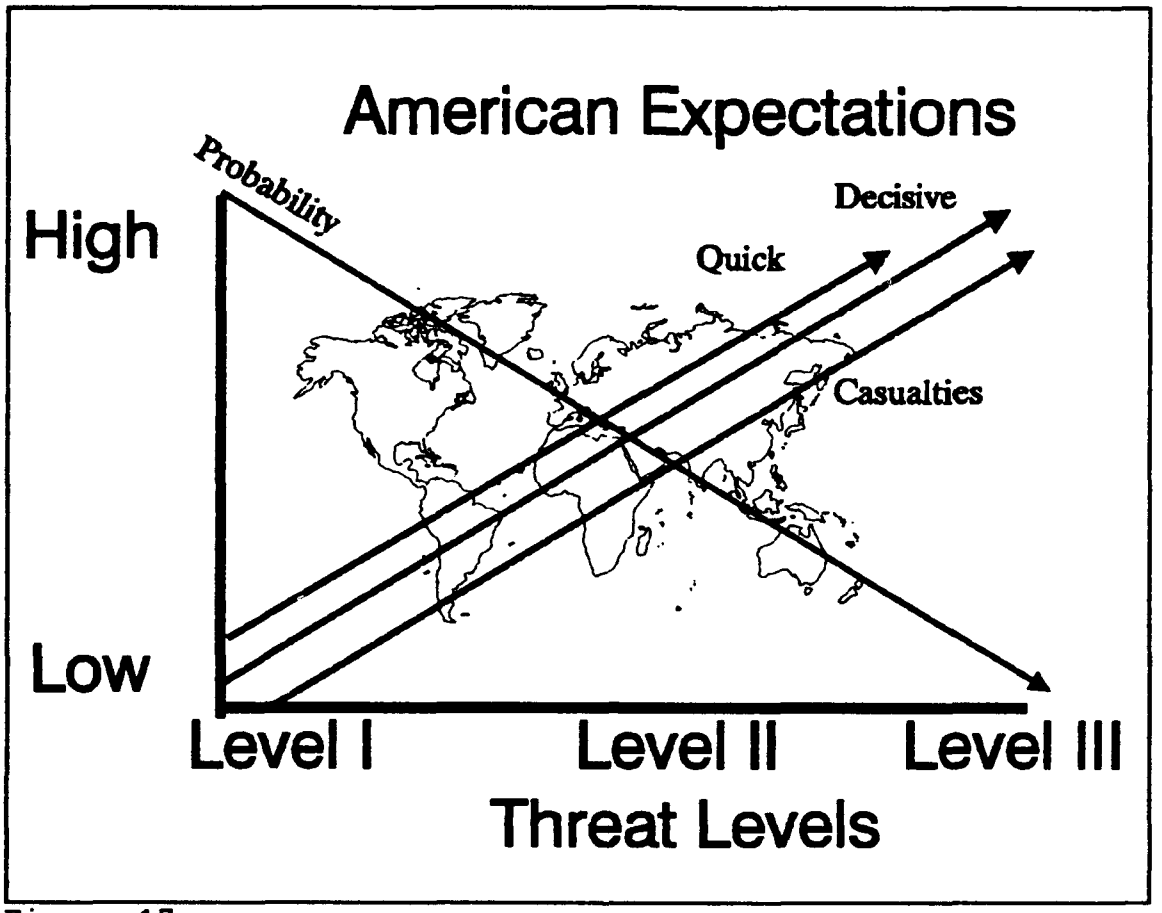

Figure 17

the fiscal commitment of the United States political leaders to fight future aggressors. In generalized terms, Level II threats seem to offer a middle ground enemy; an enemy with the potential for inflicting heavy casualties on U.S. military forces. The probability of a Level II conflict is likely, although at irregular times and places throughout the world.

A cost versus risk analysis would seem to favor the maintenance of a system like Joint STARS to protect against the probability of Level II warfare. The system can identify second echelon threat forces and develop a situation of the

battlefield to help a theater CINC or Joint Force Commander (JFC) plan for tomorrow's fight. The system's capability to detect enemy forces hours or even days out of contact would save thousands of American military lives. The problem then becomes the quantifying of this capability against the alternative, a battlefield without Joint STARS. Only computer simulations can objectively determine the difference in units lost and military objectives forfeited because of the absence of Joint STARS. Subjectively however, can a dollar amount be placed on the loss of a division, a battalion or the life of a single soldier? In all likelihood Joint STARS will continue to be funded because it has proven, as it did during DESERT STORM, that it can contribute to quick, decisive, and low casualty warfare.

Section II

Joint STARS Improvements

The present Joirt STARS capabilities will contribute to some but not all campaigns directed against the "illustrative" threats of the Seven Scenarios. In the final section of this thesis recommendations are offered for the increased effectiveness of Joint STARS, across the operational continuum.[1]

---

[1]APPENDIX A provides a Joint STARS' scenario of the future. This scenario, called DESERT STRIKE, illustrates the possible use of a fully capable Joint STARS.

Recommendations for Increased Effectiveness. Several equipment and procedural changes should be implemented to improve upon the future operational effectiveness of Joint STARS. These changes could expand the system's technical potential by providing enhanced surveillance and targeting capabilities to warfighters. With the implementation of these changes, Joint STARS would be able to contribute across the operational continuum; adding to the strength of peacetime surveillance, treaty verification and counter-drug operations.

Recommendations for Increased Joint STARS Support to Land and Air Component Commanders

Recommendation	Available During Desert Storm	Available in the Objective System
1. Adequate number of aircraft and ground stations	**No** 2 Airplanes and 6 GSMs	**Yes** 22 Airplanes and 75 GSMs
2. Adequate number of E-8A orbits	**No** - One plane could not support three Corps	**Yes - if the purchase of airplanes remains constant**
3. Interleave of MTI and SAR Radar Functions	**No**	**Yes - Essential for simultaneous, multi-service support**
4. Reliable Data Link	**No** - GSMs constantly lost "lock" on the E-8A	**Possible** - but will be costly, the range of the data link needs to be extended
5. Integration of GSM and E-8a with National Intel Systems	**Marginal** - worked during the SCUD missions, but little interface afterwards	**Probable** - recognized as a way to fully exploit the system's capabilities

Recommendations (Continued)

6. Placement of GSMs at key C2 nodes	**Yes** - but not enough GSMs	**Yes - should be enough GSMs**
7. Integration of E-8A with ABCCC and AWACS	**Marginal** - Communication Problems with interface	**Yes - important in the hand-off of Air Force targets**
8. Joint STARS Squadron and GSM analytical cell	**Marginal** - the need for this cell was quickly understood but never adequately resourced	**Probable** - this requirement is recognized as important for the full exploitation of Joint STARS capabilities
9. Proper Tasking	**No** - Tasking instructions were often sent via the ATO	**Possible** - Tasking should occur at the CINC or JFC level
10. Common Target # System between the E-8A and the GSM	**No** - The Army's identification of a target differed from the Air Force	**Possible** - Can be achieved with software adjustments
11. Adequate Army manning aboard the E-8A	**No** - Two positions were manned	**Probable** - Three to five positions are being discussed
12. Adequate Army rank structure aboard the E-8A	**Yes** - senior Army officer was a Major, rank did not interfere with the mission	**Yes - the senior Army officer may be upgraded to a LTC**

Table 11

The shaded cells of the right-hand column of Table 11 show the recommended changes that are programmed to occur with the fielding of the objective Joint STARS of 1997. If projected funding continues, and enough aircraft, GSMs and an improved data link are purchased, the system would be capable of supporting warfare across the operational continuum.

Although each employment of Joint STARS will be

different it is crucial that "adequate" numbers of E-8As and GSMs support mission requirements. "Adequate" quantities will depend upon mission requirements. In most cases, more than three aircraft will be required to maintain continuous surveillance and targeting coverage of an area of operations. Additionally, more than five Ground Station Modules (GSM) will be needed to support a Corps area.

Joint Concepts and Training. Funding and technical improvements alone will not produce the most effective employment of Joint STARS. As a departure point, warfighters will need to recognize the **JOINT** in Joint STARS. Joint tactics, techniques and procedures must be developed and supported by joint training opportunities to realize the system's full potential. Parochial service interests will have to be suppressed in the interest of joint warfare.[15]

The greatest contribution of Joint STARS will be its ability to support a CINC and his theater of war or when supporting a Joint Force Commander (JFC). The commander of these joint forces may be an Army, Air Force or USMC general. Service affiliation will be unimportant, as Joint STARS supports the surveillance and targeting requirements of joint warfare.

As the system's radar is mounted on an air platform, the control of Joint STARS will be by the direction of the CINC's Air Component Commander (ACC). This command and control relationship should not greatly concern the Ground

Component Commander (GCC) or his Corps commanders. With a technologically mature system and an adequate numbers of systems, the old argument for a dedicated Corps orbit is a moot issue.[k] The Ground Component Commander (GCC) and his Corps Commanders will receive a continuous surveillance and targeting product as the ACC provides for 24 hour Joint STARS coverage of the CINC's theater. The ultimate "control" of the Joint STARS product will always reside in the ground commanders' Ground Station Modules, distributed across the battlefield, from the theater to brigade level.

Joint Pub 2-"?". To standardize the employment of Joint STARS a joint publication is needed. A document defining, "Joint STARS Employment Procedures in Support of Theater Warfare," would contribute to uniting the present and future system capabilities with evolving doctrine. The joint doctrine could be practiced and refined in training exercises, both joint and service specific. The integration of Joint STARS in training at the U.S. Army's National Training Center and exercises such as the Air Force, Tactical Fighter Aircraft Exercise, RED FLAG, could identify operational weakness. During these training opportunities, Joint STARS capabilities could be integrated with other intelligence and targeting systems to provide the commander with a broad range of

[k]The Army OV-1D has provided Corps commanders with an organic IMINT asset since the early 1960s. This aircraft is to be replaced by Joint STARS, hence the argument for a dedicated Joint STARS orbit to Army Corps.

intelligence and target acquisition support.

The use of Joint STARS in joint exercises will further highlight many problems that require additional study. Future research on Joint STARS could be needed on the:

- ATACMS operational interface with the Joint STARS targeting cell
- Interface with Army attack helicopters
- Integration of Artificial Intelligence capabilities into the operational procedures of the Joint STARS work stations
- Implications of an over-the-horizon data link for use with Joint STARS

Section III

Conclusions

This thesis has examined the use of the Joint Surveillance Target Attack Radar System (Joint STARS) for joint surveillance and targeting missions in support of operational warfare. As discussed in this work, the present capabilities of the system's components (aircraft, GSM, radar, and data link) are useful to the conduct of current and future combat operations. The Joint STARS' capability to "see" deep (beyond 200 kilometers) and report accurate enemy locations (within 100 meters), in near-real-time (less than 60 seconds) will contribute to battle victory.

Today's Joint STARS is a system that is deployable, versatile, flexible and capable of adding to battlefield lethality. It is a responsive system that can fully support the Army's Operational Cycle of Warfare. It also meets all

three of the Air Force Characteristics of Combat Operations.

As the Joint STARS of 1992 is a system in the midst of engineering development, its capabilities are still maturing. As highlighted in the analysis of Joint STARS' performance in Operation DESERT STORM, improvements are still required in order to fully exploit the operational potential of the system. This thesis established that Joint STARS, during DESERT STORM, supported combat operations but did not simultaneously support the requirements of the Air and Land Component Commanders. A major reason for this lack of concurrent support was the technological immaturity of an engineering prototype weapon system.

This research effort has explained that with the projected system buys and normal technological advancements in the Joint STARS program, the limitation of simultaneous service support can be resolved. The presence of multiple aircraft and Ground Station Modules[1], and the capability of the Joint STARS' radar to interleave wide area surveillance with the synthetic aperture radar function will make this possible. Technical additions, such as an extended data link, and an enhanced communications package, will also help. These changes will improve the operational interface with Army and Air Force command and control centers, and national level, collection and targeting systems.

As these engineering improvements occur, an important

---

[1]More than 3 E-8As and more than 15 GSMs.

parallel action that must occur is the establishment of joint employment procedures for the system. These procedures must be developed and remain consistent with future joint warfighting trends and the evolving U.S. Army concept of AirLand Operations. The creation of a joint publication, defining Joint STARS' employment procedures will assist in the standardization of operational practices among the military services.

Future Joint STARS employment procedures will support the requirements of the Land and Air Component Commanders. Through this simultaneous support, the military services will mutually benefit from the full exploitation of the Joint STARS surveillance and targeting capabilities. Modern warriors will be able to see deep to strike deep, developing the battlefield situation in order to establish the conditions for decisive victory.

ENDNOTES CHAPTER FIVE

1.Cpt Mark D. Rendina, Military Review, (October 1990), 69.

2.William Matthews, "Greatest U.S. threat: The Unknown," Army Times, (2 March 1992), 30.

3.These criteria are consistent with the "Principles of Intelligence Quality" found in Joint Pub 2-0, Doctrine for Intelligence Support to Joint Operations, JCS Publications, Washington, D.C., (30 June 1991), II-10.

4.John Shy and Thomas W. Collier, "Revolutionary War," Makers of Modern Strategy: From Machiavelli to the Nuclear Age, Edited by Peter Paret, (Princeton University Press: New Jersey, 1986), 848.

5.World Book Encyclopedia, Volume 15, (World Book, Inc.: Chicago, 1991), 117 and 377.

6.Author's interview with Major Mark Perrin, U.S. Army C-12, GUARDRAIL COMMON SENSOR pilot. Discussion conducted at Fort Leavenworth, Kansas, (29 January 1992).

7.Brigadier General John Stewart, Operation DESERT STORM The Military Intelligence Story: A View from the G-2, 3d U.S. Army. (April 1991).

8.S. Broadbent, "Joint STARS: Force Multiplier for Europe," Jane's Defense Weekly, (11 April 1987).

9.Author's interview with LTC (Retired) Thomas Undercoffer, Training and Doctrine Command (TRADOC) Action Officer for the Unmanned Aerial Vehicle Program. Numerous discussions conducted at Fort Monroe, Virginia, between November 1990 and June 1991.

10.Bruce D. Nordwall, "Highly Integrated System, Versatile Radar Win Kudos for Joint STARS' Gulf War Role," Aviation Week & Space Technology, (24 June 1991), 49.

11.Author's interview with Major Robert Carr, U.S. Army Assistant to the Training and Doctrine Command (TRADOC) System Manager for Joint STARS. Discussion conducted at Fort Leavenworth, Kansas, (18 March 1992).

12.Stewart, A View from the G-2 ...

13.Col James R. McDonough, "FM 100-5 Update," Comments made during an address to the 91/92 Command and General Staff College Class, Fort Leavenworth, Kansas, (15 April 1992).

14.McDonough, (15 April 1992).

15.Major General Glossom, Comments made by the Director, Legislative Liaison, during a lecture, "Air Operations in DESERT STORM," presented at Fort Leavenworth, Kansas, 8 April 1992.

APPENDIX A

OPERATION DESERT STRIKE

A Joint STARS Scenario of the Future

Figure 18

General Situation.

1992-1994

- North Korea and China assist in rebuilding Iraqi military.

1995

- HIZBIRR party in Iraq overthrows the regime of Saddam Hussein.
- New government of Iraq signs economic and military treaties with the nation of Iran.

1996

- Saudi Arabia modernizes its ground forces, building a five division corps, stationed in King Khalid City.

- Iran and Iraq conduct joint military exercises. Twelve armor divisions, supported by flights of jet fighters conduct offensive operations, northwest of Baghdad, along the Euphrates River.

1997

- (*15 May*) National Intelligence Systems detect the buildup of 20 Divisions near Al Basrah and Abadan.

- (*22 May*) The National Command Authority (NCA) alerts CENTCOM to prepare to assist the Ground Component Commander of the Saudi Arabian forces. CINC CENTCOM is placed in charge of the Theater of Operations.

- (*23 May*) Two South Korean oil tankers are sunk by Silkworm missiles in the Strait of Hormuz.

- (*24 May*) Joint Task Force (JTF) Sword established. JTF Sword is told to secure the Straits of Hormuz, as part of Operation DESERT STRIKE.[a]

- (*26 May*) JTF Stone formed. JTF Stone is told to protect the Saudi Arabian capital and Holy cities of Mecca and Medina.

26 May 1997. The Joint STARS Squadron (JSS) at an Air Force base on the east coast of the United States, is alerted for deployment to the Persian Gulf. Two flights are formed; Flight Sword and Flight Stone. The JSS commander, an Air Force colonel deploys with Flight Sword. His operational airfield is Masqat, Oman with an area of operations (AO) that encompasses the Gulf of Oman, and the waters of the Persian Gulf, east of Bahrain.

An Army colonel deploys with Flight Stone.[b] His

---

[a]The idea for this scenario was adapted from a similar scenario written for Course, "C6000: Application of Joint Operations," Department of Joint Combined Operations (DJCO), Command and General Staff College, Fort Leavenworth, Kansas (1992).

[b]The Air Force remains in command of the E-8A for flight operations but for operational warfare considerations command rests with the senior officer of each flight.

operational airfield is Riyadh, Saudi Arabia with an AO covering the sands north of Kuwait and Saudi Arabia and the waters west of Bahrain. The Army colonel, like his Air Force counterpart is responsible for the operational employment of his flight. In regards to command and control, both colonels fall under the authority of the CINC CENTCOM, with normal tasking and reporting instructions received through the CENTCOM J2.[c]

Flight Sword and Flight Stone are comprised of four E-8C aircraft each, with approximately, 120 aircrew members and thirty support personnel.[d] Twenty, of 120 aircrew members, for each flight are Army officers and warrant officers.[e]

28 May 1997. Two Tactical Fighter Wings depart CONUS for missions in the Persian Gulf.

Five Common Ground Stations (CGS), queue up in Charleston, South Carolina, awaiting C-17 transportation to Riyadh, Saudi Arabia.[f] The CGSs, which operate off the back of a HMMWV,[g] are "up-loaded" with the most recent Defense

---

[c]Initially, the CINC will direct the tasking of Joint STARS through his J2.

[d]The E-8C is the production model of the old E-8A.

[e]A Lieutenant Colonel is the senior Army aircrew member on each Joint STARS mission.

[f]The CGSs have evolved from the old GSMs. They were developed by the Communications Electronic Command (CECOM), Fort Monmouth, New Jersey.

[g]M1038, High Mobility Multi-Purpose Wheeled Vehicle.

Mapping Agency (DMA) computer data of the DESERT STRIKE operation area. These CGSs are quantum leaps ahead of the GSMs used during the 1991 Operation DESERT STORM. The new CGS interfaces with the Joint STARS aircraft and multiple other Army intelligence systems. Additionally, the CGS ties into the all source intelligence fusion center, located at CENTCOM Headquarters.

29 May 1997. Throughout the Army, CGS operators assigned to Brigades through Corps, ready their equipment for possible deployment as part of a JTF.

Seventy-two hours after notification the first aircraft of Flight Sword departs CONUS. The E-8C's mission software is tailored for operations against Iraq and Iran. Updated DMA data, enemy order of battle, and friendly operational boundaries are stored in the aircraft's computers.

Forty JSS personnel, almost twice the normal mission crew, fill the E-8C for the 17 hour flight to Oman. The seven remaining planes of the JSS depart at random intervals, enroute to Southwest Asia. Each aircraft is escorted by two F-15 STRIKE EAGLES.

30 May. As the first E-8C approaches Musqat, Oman, the aircraft conducts a final aerial refuel and switches crews. Backup pilots and console operators, on "crewrest" during the deployment, man the operational positions aboard the E-8C. After coordination with the airborne ABCCC and AWACS, the fresh crew conducts a four hour surveillance

mission of the Gulf of Oman and the Strait of Hormuz.[h] In the absence of an available CGS, the intelligence developed during this mission is relayed back to CENTCOM headquarters via secure SATCOM radio. Surveillance data tapes from this flight are analyzed after landing to begin the study of enemy movement patterns.[i]

The lead aircraft for Flight Stone follows the same procedures during its entry into Saudi Arabian airspace. Its mission is to fix the locations of the Iraqi and Iranian divisions near Al Basrah.

1 June. The flight profiles, callsigns and radio frequencies of Flights Sword and Stone are incorporated into the theater's automated Air Tasking Order (ATO) system. ATO's are published and electronically disseminated across the CENTCOM Theater of Operations (CTO) every twelve hours.

The first ATO to include Joint STARS assigns the flights, block altitudes and surveillance areas. Takeoff and landing times are established with overlapping mission times to provide 24 hour coverage of the CTO.[j]

---

[h]This "Force Projection" mission has been practiced during CONUS training exercises.

[i]The computer tapes are analyzed at the JSS operations center. Continuous integration of current data with previously developed intelligence is crucial to fully exploit collected information.

[j]The ATO instructions are less restrictive than during Operation DESERT STORM. Airspace control and coordination is provided but surveillance coverage is not dictated or restricted.

The CINC directs Flight Sword to provide General Support of the Theater, initially assigned to support an amphibious assault by US Marines on the island of Qeshm, near the Strait of Hormuz.

Flight Stone is assigned in Direct Support of the Saudi Arabian (SA) Corps in King Khalid City.[k]

3 June. The first of five CGSs arrive in Riyadh. The distribution plan for the five CECOM CGSs is to place three stations at CENTCOM Headquarters and two with the Saudi Corps, to "assist in the battle management" of SA forces.

4 June. The war begins as Iranian jets strike at Kuwait and Saudi Arabian airfields. Iraqi armor divisions cross the Euphrates and move into Kuwait.

Although the E-8Cs are equipped with a Self-Defense Suite, in the absence of air superiority, the J2 restricts Joint STARS' flights to hours of darkness. Even these abbreviated, eight hour surveillance and targeting missions help to add to the Theater's situational awareness of enemy intentions.

Using a fully interleaved, MTI and SAR capable radar, Flight Sword identifies Iranian attack boats in the Straits of Hormuz. This information is passed to the carrier battle

---

[k]The CINC, through his J2, establishes the surveillance and targeting missions for the JSS. The mission priorities are transmitted every twelve hours via secure radio and hard copy message traffic. The JSS operations center receives and disseminates these priorities to Flights Sword and Stone.

group of Joint Task Force Sword.[1] Additionally, inflight tip-offs from national collection systems help Flight Sword focus its SAR capability on fixed Iranian air defense and surface to surface missile sites. SAR "photos" are analyzed on board the plane and data linked down to the five theater CGSs.[2]

7 June. Lead elements of the XVIII Airborne Corps and 2d Armored Division arrive in the theater. Four of the twenty-five CGSs, organic to the XVIII, land in Musqat, Oman.[3]

8-15 June. Lead elements of the U.S. III Corps arrive in theater. Four of the twenty-five CGSs, organic to the III, arrive in Riyadh.

Three maneuver brigades of the U.S. III Corps are placed under the operational control (OPCON) of the SA Corps. Each of the selected brigades attaches a CGS to its headquarters element.

11 June. The Air Component Commander declares that Air Superiority has been achieved.

The J2 directs the JSS to initiate 24 hour coverage of the CTO.

12 June. As the USMC begins operations to secure the Strait of Hormuz, the aircraft of Flight Sword surge to

---

[1]The E-8C is capable of communicating with Naval forces.

[2]Although 700 miles from Riyadh, the E-8C, flying out of Oman is able to maintain operational interface with CENTCOM HQS through the use of an over-the-horizon data link.

[3]The deployment of a base-line CGS capability has been factored into the development of the Corps' TPFDD.

monitor the southern coast of Iran. Two of the four E-8Cs that make up the Flight establish orbits over northern Oman and the United Arab Emirates. The two aircraft track the same area but from different perspectives.

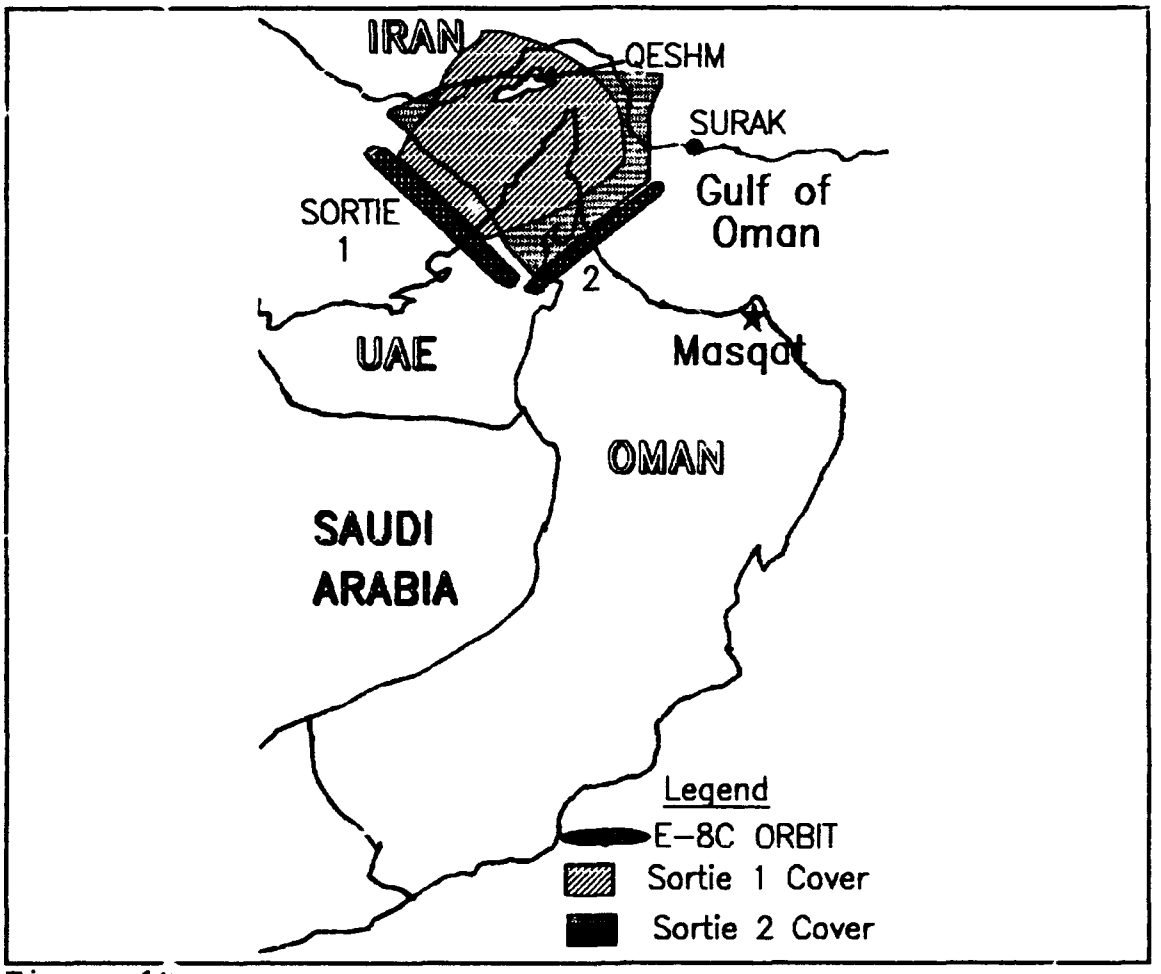

Figure 19

The USMC, having launched a deception operation to the southeast of Qeshm, hope to convince the Iranian forces that the U.S. will strike the city of Surak. Aircraft sortie #1, monitoring the battlefield, determines that the Iranian generals have not been fooled. In Musqat, this realization is

simultaneously made by the Army operators of a CGS located at the headquarters of Joint Task Force Sword. A decision is made by the Ground Component Commander of JTF Sword to delay the Marine landing. As the USMC landing craft reverse course and head back to the carrier battle group (CBG), sortie #2 monitors the waters of the Gulf to warn of any threats to the Marines.[0]

After the safe return of the Marines, Flight Sword switches its priority of coverage to targeting. Sortie #1 maintains a wide area surveillance of the AO while aircraft #2 narrows its focus on the Iranian forces poised along and on Qeshm island. Aircraft #2 passes its generated targets on Qeshm island directly to on station ABCCC and AWACS platforms. As the air to air target hand-off occurs, the CGS at the JTF headquarters work target development along the Iranian coast. These targets generated by Army operators in Musqat are turned over to the carrier battle group for servicing by naval fires.

Seven hundred miles to the west a different technique is used by Flight Stone as it supports the SA Corps. Three armor divisions of the SA Corps are moving along a northeast axis of advance which parallels the Kuwait and Iraq borders. While the divisions move forward, one E-8C from Flight Stone covers the axis of advance. As the Joint STARS' radar monitors the attack, five CGSs monitor the same battlefield

---

[0]The E-8C's radar is capable of maritime target detection.

picture that is seen on board the airplane, as modified by their mission parameters. The CGSs, attached to the lead brigades, monitor the areas of operational interest to their brigades. The ground station at the Saudi Corps headquarters focuses out in front of the brigades, looking at the lead division's area and the outer boundaries of the Corps' AO. Concurrently, the J2/J3 cell at CENTCOM watches significant movement to the front and flanks of the advancing SA Corps.

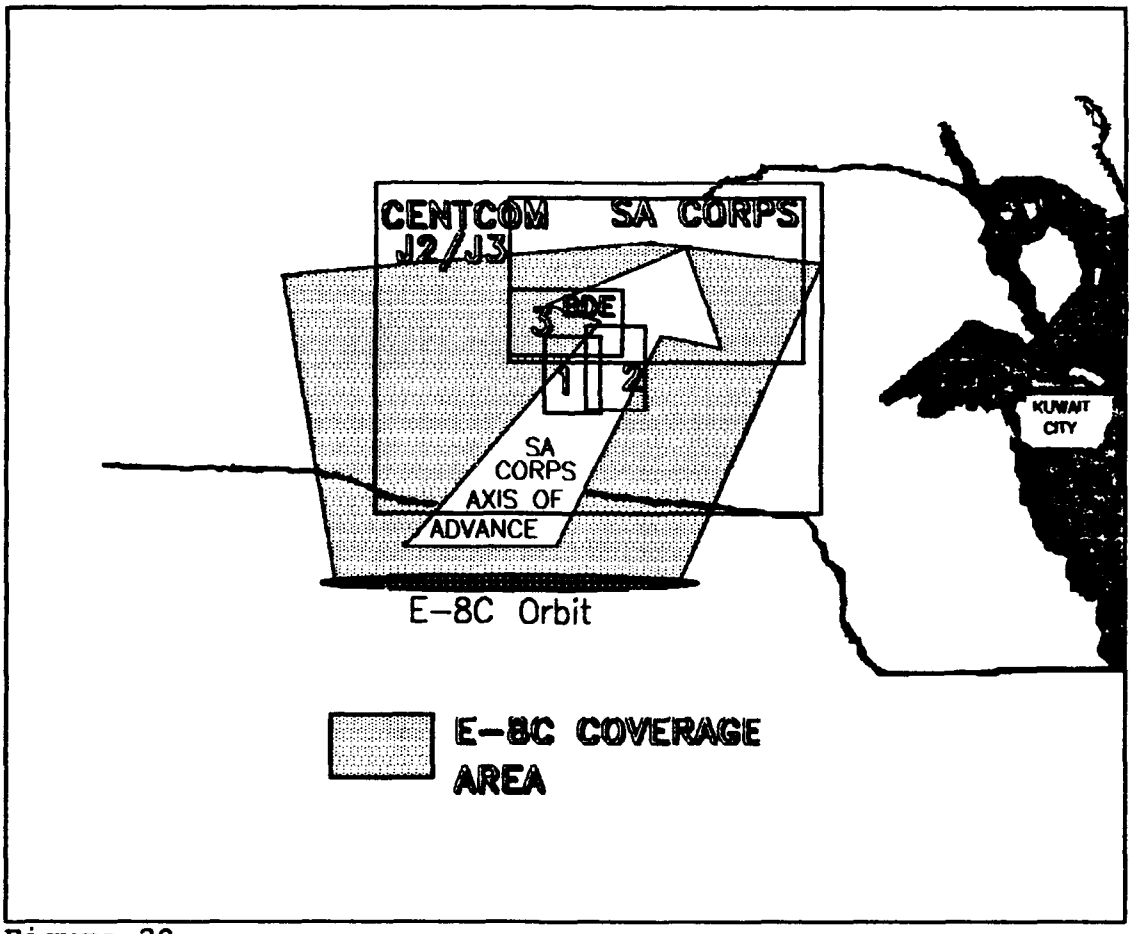

Figure 20

As this battlefield information is distributed across the Saudi Arabian Theater, an important new capability of the

E-8C helps to reduce the danger of fratricide. Software modifications of the system's target discrimination program detect signals from radar transponders, located on key vehicles throughout the U.S. and Coalition Divisions. These signals are depicted as color symbols on the monitors of the Army and Air Force console workstations. This capability combined with the operators' ability to interchange target identification numbers between the air and ground components of Joint STARS, provide the services with a "common picture" of the operational battlefield.

1 July. With the arrival of the majority of the U.S. XVIII and III Corps in the CTO and the Strait of Hormuz secured, the offensive initiative is regained by the U.S. and Saudi Arabian Coalition.

Both the XVIII and III Corps have deployed their full complement of Common Ground Stations and except for minor maintenance problems both the Joint STARS' aircraft and the ground stations appear fully functional. The E-8C's radar provides ground forces with 24 hour coverage of the CTO, distributing intelligence across the Theater. Both the Air Force and the Army exploit this Joint STARS data; independently for close-in strikes and jointly for deep attacks. The work of one service is transparent to the other, meaning that targets are developed and engaged without the fear of operational interference between the Army and the Air Force.

Remote CGS monitors have been established in selected brigade and divisional units that do not have an organic ground station.[p] Especially successful are the air terminals, recently installed in the Army's Apache helicopters. These terminals provide Army aviators with a readily available target list for planned missions or for use as targets of opportunity.

1 September 1992. The Royal Family of Saudi Arabia accepts the unconditional surrender of Iran and Iraq. DESERT STRIKE transitions into DESERT HOPE as U.S. and the Arab Coalition work to rebuild the security of the region. Joint STARS Flight Sword redeploys to CONUS, leaving behind Flight Stone to provide coverage of Iraq and Iran, flying in a peace keeping and deterrence role.

CINC CENTCOM states that Joint STARS was an important intelligence and targeting tool during DESERT STRIKE.

> "The distributed nature of the Joint STARS product sets this system apart from all others. The advantages of an 'open broadcast' of intelligence cannot be understated. Anyone with a CGS can receive the battlefield situation as an operational tool for planning and execution. The simultaneous support of Joint STARS to all U.S. forces spurred initiative and independent action among my commanders."

[p]These monitors offer a limited ability to manipulate the screen display. The scale of view can be changed with a zoom-in/zoom-out function.

SCENARIO CONCLUSION. Although fictitious, DESERT STRIKE illustrates several points. One is the force projection capability of Joint STARS. Future deployments should allow for surveillance and targeting information to be collected and passed to command and control nodes, as the aircraft ***approaches*** a theater of conflict. DESERT STRIKE also describes simultaneous support to multiple units in contact. It highlights the potential development of a "common picture of the battlefield" and a possible Joint STARS capability to contribute to the prevention of friendly fratricide.

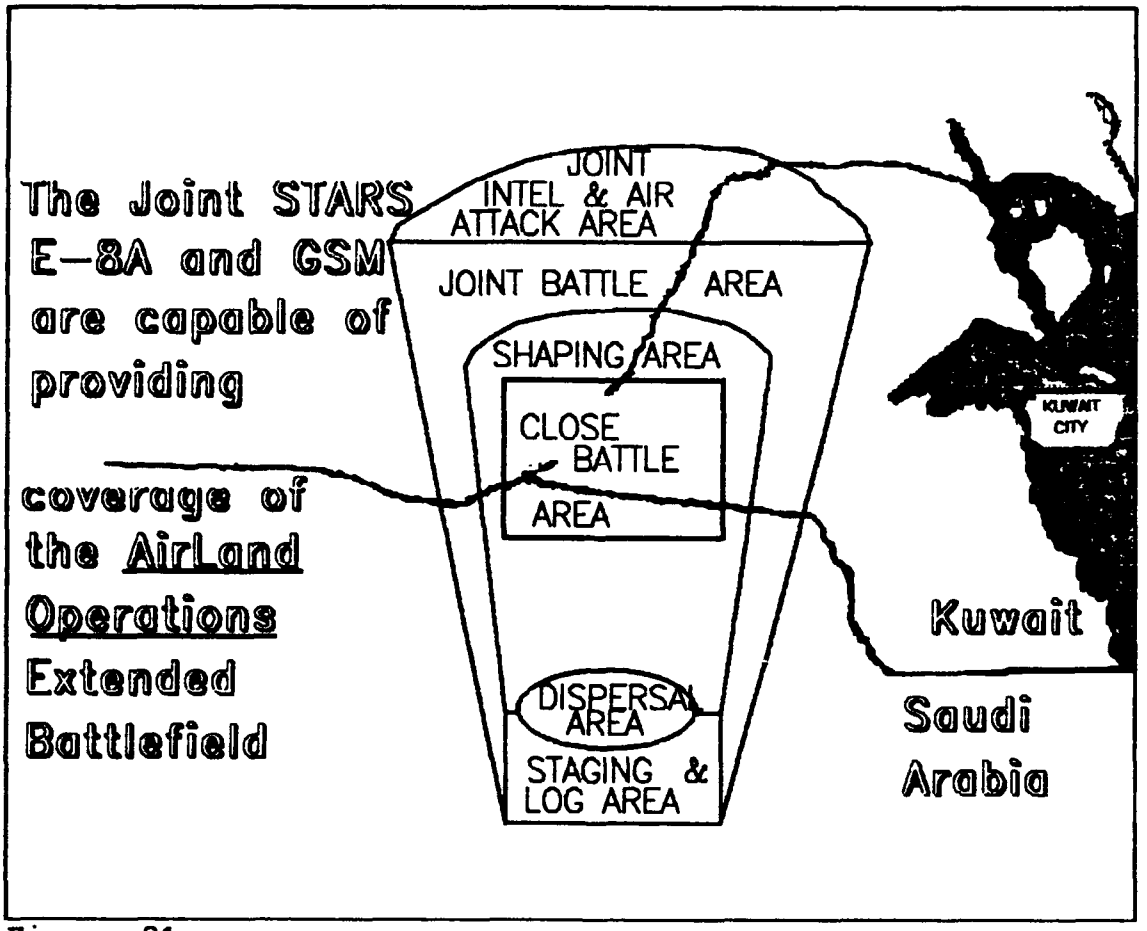

Figure 21

APPENDIX B

GLOSSARY OF TERMS

Circular Error Probable- An indicator of the delivery accuracy of a weapon system, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of a missile's projectiles are expected to fall.[1]

Close Air Support (CAS)- Supports surface operations by attacking hostile targets in close proximity to friendly surface forces .... requires detailed coordination and integration with the fire and maneuver plans of friendly surface forces. CAS missions require access to the battlefield, timely intelligence information, and accurate weapons delivery.[2]

Close Operations- At any echelon, comprise the current activities of major committed combat elements, together with their immediate combat support and combat service support. At any echelon, close operations include the close, deep, and rear operations of subordinate elements.[3]

Common track numbering system- Initially raised as an issue by the commander of the Tactical Air Command (General Russ). This phrase means the annotation of targets and target sets with a number that will consistently identify the same target for Army and Air Force operators.[4]

Common Picture of the Battlefield- A phrase synonymous with the development of a common track numbering system. In November 1990, the commanders of the Air Force Tactical Air Command (TAC) and the Army's Training and Doctrine Command (TRADOC) felt that it was important for the services to "see the battlefield" in the same way. This issue also raises concerns about the establishment of battlefield boundaries between the Army and Air Force.[5]

Deep Operations- Activities directed against enemy forces not yet in contact designed to influence the conditions in which future close operations will be conducted .... deep operations include efforts to isolate current battles and to influence where, when, and against whom future battles will be fought.[6]

E-8A Aircraft- An Air Force militarized version of the Boeing 707 aircraft. It carries the 24 foot long radar antenna which detects moving and stationary targets.[7]

GCC- Ground Component Commander

GSM- The Ground Station Module (GSM) is the Army link in the Joint STARS. Made by Motorola the GSM is mounted on the back of an standard Army 5 ton truck. In the future, technology will allow for the GSM to be positioned on the back of a smaller vehicle.

Initial Operational Capability (IOC)- The first attainment of the capability to employ effectively a weapon, item of equipment, or system of approved specific characteristics, and which is manned or operated by an adequately trained, equipped, and supported military unit or force.[8]

Interleaved Radar Modes- The ability of the Joint STARS radar to simultaneously run the wide area surveillance (or Moving Target Indicator [MTI]) mode of the system's radar along with the Synthetic Aperture Radar mode of the radar. This technique provides for location accuracies as it develops a picture of the battlefield situation.

Joint STARS- The Joint Surveillance Target Attack Radar System is made up of three major components. These components are: the E-8A aircraft with its associated radar, the GSM, and the SCDL data link. Failure of any one of these components substantial degrades or destroys the mission capability of the system.

Joint targeting- Target development and target engagement by elements from two or more distinct military services. (i.e., A target is developed by Air Force sensors and fired upon by an Army artillery unit.)

MTI- Moving Target Indicator, A radar presentation which shows only targets which are in motion. Signals from stationary targets are subtracted out of the return signal by the output of a computer memory circuit.[9]

OV-1D Mohawk- Two-place, twin turboprop aircraft featuring a mid-wing, triple vertical stabilizers, and a tricycle landing gear. The aircraft is capable of performing missions of observation surveillance and air control.[10]

Reconnaissance- Reconnaissance is concerned with three components: enemy, weather, and terrain. Reconnaissance is active; it seeks out enemy positions, obstacles, and routes. .... good reconnaissance uses stealth to avoid detection.[11]

RF-4C- Unarmed, multisensor version of the F-4C Phantom II. The RF-4 was the first tactical aircraft equipped with a forward-looking radar capable of simultaneous terrain-following and low-altitude navigation. The basic aircraft is

configured with conventional optical cameras for day operations and infrared (IR) sensors for night.[12]

SCDL- Surveillance Control Data Link (SCDL)- This secure data link transmits pre-processed radar data from the E-8A's radar down to the Ground Station Modules. In return the SCDL transmits radar service requests up to the Joint STARS aircraft.

Situation Development- The basic process by which intelligence is developed. Information is collected, then integrated into an all-source product to provide an estimate of the situation and a projection of enemy intentions in sufficient time to permit the commander to select the most effective friendly courses of action.[13]

Surveillance- Surveillance is passive. It implies observing a specified area or areas systematically from a fixed, concealed position.[14]

Synchronization- ... the arrangement of battlefield activities in time, space and purpose to produce maximum relative combat power at the decisive point.... the actual concentration of forces and fires at the point of decision.[15]

Synthetic Aperture Radar- Provides a radar "picture" of stationary targets. SAR is useful for mapping unknown terrain or for developing target folders of fixed sites, (military facilities, airfields, seaports).

Target Development- Based on situation development, it is the process of providing direct combat information, targeting data, and correlated targeting information to commanders and fire support means. Must be sufficiently timely and accurate to support effective attack by fire, maneuver, or electronic means.[16]

Timing and Tempo (AF Principle of War)- Similar to the Army AirLand Battle tenet of *Synchronization*. Executing military operations at a point in time and at a rate to optimize the use of friendly forces and inhibits or denies the effectiveness of enemy forces.[17]

Track- The term used by the Air Force to identify, what the Army would call a "target."

UAV- Unmanned Aerial Vehicle, capable of aerial observation of enemy units.

GLOSSARY ENDNOTES

1.Department of Defense, Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms. Office of the Chairman Joint Chiefs of Staff, (1 December 1989), 66.

2.Air Force Manual (AFM) 1-1, Basic Aerospace Doctrine of the United States Air Force, Department of the Air Force (16 March 1984), 3-4.

3.U.S. Army, (Field Manual) FM 100-5 Operations. Washington, D.C., (5 May 1986), 19.

4.Joint Program Review (JPR), Meeting of Army, Air Force, Navy and Marines, Four Star General Officers at Quantico, Virginia, November 1989. The concept of the Common Track Numbering System was first raised by General John Russ at this JPR.

5.Ibid.

6.FM 100-5, 19.

7.CGSC Student Text 100-2, US Air Force Basic Data, (U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, May 1991), E-7.

8.AFM 1-1, 2-9.

9.Joint Pub 1-02, 181.

10.JCS Pub 1-02, 240.

11.U.S. Army, TM 55-1510-213-10, Operator's Manual OV-1D/RV-1D Aircraft. (4 August 1978), Change 6, 1-1.

12.FM 34-2-1, 2-1.

13.ST 100-2, E-6.

14.U.S. Army, FM 34-1, Intelligence and Electronic Warfare Operations, 1-1.

15.FM 34-2-1, 2-1.

16.FM 100-5, 17.

17.U.S. Army, FM 34-1, Intelligence and Electronic Warfare Operations, 1-2.

18.AFM 1-1, 2-8.

APPENDIX C

BIBLIOGRAPHY OF RESEARCH AIDS

Books

Addington, Larry H. The Patterns of War Since the Eighteenth Century. Bloomington: Indiana University Press, 1984.

Hooton, E.R. Jane's Battlefield Surveillance Systems. Couldson, Surrey: Jane's Information Group; Alexandria, Virginia, 1989. 355.41/J33.

Jane's Publishing Company. Jane's Weapon Systems. 17th Edition, London, England, 1986.

MacIsaac, David. "Voices from the Central Blue: The Air Power Theorists." Makers of Modern Strategy, ed. Peter Paret, 624-647. Princeton: Princeton University Press, 1986.

Prentice Hall. Handbook for Writers. Prentice Hall, Inc. New Jersey: Simon & Schuster, 1988.

Rodgers, A.L. Surveillance and Target Acquisition Systems. Oxford: Brassey's Defense Publishers, 1983. CAL, Fort Leavenworth, Kansas 355.82/B3367.

Simpson, Alan. Mastering WORDPERFECT 5.1 FOR WINDOWS. San Francisco: Sybex, 1992.

Trager, James. The People's Chronology. New York: Holk, Rinehart and Winston, 1979.

US News and World Report, Triumph Without Victory, New York: 1992.

Woodward, Bob. The Commanders, Simon & Schuster, (New York: 1991), 369.

Zinsser, William. On Writing Well. New York: Harper & Row, 1980.

Zinsser, William. Writing With a Word Processor. New York: Harper & Row, 1983.

Contractor Publications

Adams, M. "Joint STARS Program Underway," The Round-Up, (Motorola Inc.), (18 April 1985), 1.

Field, P., J.A. Semrad, and G.D. Williams, Joint Surveillance Target Attack Radar System Intervisibility Final Report (SECRET). McLean, Virginia: BDM Corporation, 1984. C035851.

Franczak, D.B., W.H. Licata, J.M. Miller, Y.Morita, and M.B. Walsh. Joint Surveillance Target Attack Radar System (Joint STARS) Specification Review, Volume 1, Synthetic Aperture Radar Mode (SECRET). Ann Arbor, Michigan: Environmental Research Institute, 1985. C038271.

Garvey, P.R., R.A. Moynihan, K.W. Pullen, and P. Bradley. Joint STARS Life Cycle Cost Model. Bedford, Massachusettes: MITRE Corporation, 1985. B096351.

Greenwood, Ted. Reconnaissance, Surveillance, and Arms Control. London: International Institute for Strategic Studies, 1972. 341.73/G816r.

Grumman Melbourne Systems Division, Flight Reports. 18 Dec 1989 to September 1990.

Grumman Melbourne Systems Division, Joint STARS and UAV, Inter-operability. White Paper, 1990.

Grumman Melbourne Systems Division, VIP Briefing List. May 1989 to August 1990.

Horizons Staff, "The Joint STARS Advantage," Horizons, (Volume 23, Number 1, 1987), 8-14.

JSTARS Operational and Technical Assessment (SECRET). McLean, Virginia: BDM Corporation, 1983. C046410L.

Jones, J.L., P. Lert, and D.L. Ockerman. Tactical Reconnaissance, Surveillance and Target Acquisition Study (SECRET). Alexandria, Virginia: Institute for Defense Analyses, 1984. C953159L.

Moynihan, R.A., and A.E. Taub. Joint STARS System Readiness Analysis. Bedford, Massachusetts: MITRE Corporation, 1988. B143390.

Nordstrom, C.H. Stereographic Projection in the Joint Surveillance System. Bedford, Massachusetts: MITRE Corporation, September 1986.

Robertshaw, Gregory A. Constraints on Random Illumination Errors for the Joint STARS Antenna (SECRET). Bedford, Massachusetts: MITRE Corporation, 1986.

Robertshaw, Gregory A. Far Field Threshold for Joint STARS Array Testing (SECRET). Bedford, Massachusetts: MITRE Corporation, 1986.

Robertshaw, Gregory A. Range Corrections for Airborne Radar - A Joint STARS Study. Bedford, Massachusetts: MITRE Corporation, May 1984. A142363

Terry, D. "A Non-Nuclear Response to Invading Armor," Horizons, (Date Unknown), 4-8.

Military Papers

Buchanan, Paul, Major. "Information Retrieval," Leavenworth Archives, 8 September 1966.

Busico, Roger P., Major. Battlefield Air Interdiction: Airpower for the Future. M.M.A.S. Thesis. Fort Leavenworth, Kansas, U.S. Army Command and General Staff College, 1980.

Gumbert, G.E. Joint STARS. Maxwell AFB: Air Command and Staff College, 1985.

Hamilton, David, Major. Close Air Support and Battlefield Air Interdiction in the AirLand Battle. M.M.A.S. Thesis. Fort Leavenworth, Kansas, U.S. Army Command and General Staff College, 1983.

Henderson, James B. Jr., Major. The "Air" in AirLand Battle. M.M.A.S. Thesis. Fort Leavenworth, Kansas, U.S. Army Command and General Staff College, 1982.

Huot, Raymond P. A NATO Conventional Air Campaign Strategy for Central Europe - 1990s. Newport, Rhode Island: Naval War College, 1987.

Momyer, William W. Air Power in Three Wars (WWII, Korea, VietNam). Washington, D.C.: U.S. Government Printing Office, 1983.

Stewart, J.(BG). Operation DESERT STORM The Military Intelligence Story: A View from the G-2, 3d U.S. Army. April 1991.

Newspapers

"2 New Radar Planes Skip Tests, Join Fray," Dayton Daily News, (23 January 1991)

"Grumman Corp. to Expand Facility in Melbourne, Florida," Wall Street Journal, (14 October 1991), A7A.

Hinton, J. "Ft Huachuca Group Searching for SCUDS," Sierra Vista Herald. (January 1991).

"SCUD Hunter", L.A. TIMES, (Day Unknown) January 1991.

Magazine Articles

"Assessing the Victory," Aviation Week & Space Technology, (22 April 1991), 85.

Bernstein, J. "A Flying Success," Newsday, (6 January 1989).

"'Filtering' Helped Top Military Leaders Get Proper Intelligence Information," "Aviation Week & Space Technology, (22 April 1991), 84.

Fulghum, David A. "Desert Storm Highlights Need for Rapid Tactical Intelligence," Aviation Week & Space Technology, (11 February 1991), 18.

Gilmartin, K. "Joint STARS Takes Flight", Leading Edge, (February 1989), 4.

Greeley, H. Sgt. "The Joint STARS Advantage," The Defender Magazine, (February 1989), 24.

"Grumman's J-STARS Investment," Aviation Week & Space Technology, (7 October 1991), 13.

Henderson, Breck W. "Desert Storm Success Pushes Military to Build Advanced High-Tech Systems," Aviation Week & Space Technology, (18 March 1991), 169.

Hughes, David. "Electronic Systems Division Accelerates New Systems Deployments, Upgrades," Aviation Week & Space Technology, (4 February 1991), 58.

"Joint STARS Struggl s with Complexity," Aviation Week & Space Technology, (25 February 1985), 76.

Kolcum, E. "Joint STARS E-8A Return to U.S.; 20-Aircraft Fleet Believed Assured," Aviation Week & Space Technology, (11 March 1991), 20.

Kolcum, E. "Joint STARS Intensifies Reliance on Software in Development Phase," Aviation Week & Space Technology, (23 February 1987), 81-84.

Kolcum, E. "Test Aircraft, Radar Deliveries Cause Delays in Joint STARS Program," Aviation Week & Space Technology, (4 July 1988), 54-57.

Kozicharow, E. "USAF, Army Agree on Joint Initiatives," Aviation Week & Space Technology, (28 May 1984), 22-24.

Nordwall, Bruce D. "Highly Integrated System, Versatile Radar Win Kudos for Joint STARS' Gulf War Role," Aviation Week & Space Technology, (24 June 1991), 49.

Scott, William. "USAF Officials Explain How War Altered Joint STARS Requirements," Aviation Week & Space Technology, (14 October 1991), 58-59.

"Services Delay Contract for Joint Radar System," Aviation Week & Space Technology, (22 April 1985), 27.

"Shooting Star," The Economist, (25 May 1991), 77.

Smith, Bruce A. "Pentagon Weighs Key Reconnaissance Issues Highlighted by Gulf War," Aviation Week & Space Technology, (22 April 1991), 78.

Sweetman, B. "Joint STARS Approaches Crucial Test Stage," Interavia, (May 1989), 452-453.

Turnley, Peter. "The Day We Stopped the War," Newsweek, (20 January 1992), 16-25.

Walker, K. "Joint STARS: A Soldier's Spy", Flight International, (22 November 1986).

Wanstall, B. "Joint STARS Fights to Stay on Target," Interavia, (November 1988), 1133-1135.

Military Publications

"Air Force Ponders Single Air-Ground Early Warning System," Defense News, (15 April 1991), 77.

Anderson, C. "Air Force Expected to Send E-8A to MidEast,"

Air Force Times, (31 December 1990).

Blackwell, J. "JSTARS Could Save Thousands of Lives in a War With Iraq," Army Times, (14 January 1991), 25.

Boutacoff, D. "Army Banks on Joint STARS for AirLand Battle Management," Defense Electronics, (August 1986), 77-84.

Broadbent, S. "Joint STARS: force multiplier for Europe," Jane's Defense Weekly, (11 April 1987).

Callaham, M. "Reconnaissance, Surveillance and Target Acquisition for Follow-On Forces Attack," Signal, (October 1987), 83-89.

Davis, Wayne B., COL. "Army Aviation: Combined Arms Team," Aviation Digest, (May 1980), 4.

Defense Electronics. "Joint Surveillance and Target Attack Radar System," The C3I Handbook Edition Three, (1988), 109-110.

DeMeis, R. "JSTARS in the European Skies," Aerospace America, (February 1990), 26-28.

Dudney, R. "ESD Tunes Up for a Tactical Push," Air Force Magazine, (July 1988), 48-55.

Dudney, R. "The Battle Vision of Joint STARS," Air Force Magazine, (June 1989), 42-45.

Fulghum, D. "JSTARS Makes Breakthrough in Radar for Target Discrimination," Defense News, (19 June 1989), 28.

Gilmartin, K. "Joint STARS Goes Airborne", Hansconian (Hanscom AFB Newspaper), (6 January 1989), 1.

Goodman, G. Jr. "Initial JSTARS Flight Tests Favorable," Armed Forces Journal International, (August 1989), 24.

Goodman, G. Jr. "Joint STARS Slips Nine Months but Gains Endorsement of DoD Leadership," Armed Forces Journal International, (September 1988), 118.

Goodman, G. Jr. "New Airborne Sensors Look Deep, Allow Army/USAF to Strike Deep," Armed Forces Journal International, (January 1989), 84-87.

Grier, P. "Joint STARS Does Its Stuff," Air Force Magazine, (June 1991), 38-42.

Gumbert, G.E. Joint STARS. Maxwell AFB: Air Command and Staff College, 1985. B092974.

Hinson, Eric CPT and Berg, Clifford CW2. "On a Clear Day You Can See ...," Aviation Digest, (October 1980),30.

Huot, Raymond P. A NATO Conventional Air Campaign Strategy for Central Europe - 1990s. Newport, Rhode Island: Naval War College, 1987. B114639.

Intelligence for Commanders. Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1984. CGSC A152/83.

Joint Surveillance Target Attack Radar System. Executive Summary, (Joint STARS) (SECRET). White Sands, New Mexico: Army TRADOC Systems Analysis Activity, 1985. C036904L.

Kleiner, Martin S. Colonel, "Joint STARS Goes to War," Field Artillery, (February 1991), 25-29.

Leopold, G. "JSTARS Poses Challenge of Producing Software for Complex System Integration," Defense News, (16 April 1987), 3.

Otis, General Glenn K. "The AirLand Battle," A Message from the Commander of U.S. Army Training and Doctrine Command in Military Review, May 1982, 2.

]
Parrilli, Matthew M., Col, Operational Evaluation Command (OEC) Report, U.S. Army, 4501 Ford Avenue, Alexandria, Virginia

Pierson, J.R. Light Satellites: A Dilemma for the U.S. Army. Wright Patterson AFB, Ohio: Air Force Institute of Technology, 1988. NTIS 1985 (#14-26).

Rasmussen, Dick, LTC. "SOTAS: The User has a Say," Aviation Digest, (May 1980), 2.

Spaulding, W.G. "On the Air Defense Application of Joint STARS (SECRET)", Redstone Arsenal: Army Missile Command, 1984. C035885.

Starry, General Donn A. "Extending the Battlefield," Military Review, March 1981, 31.

Stewart, M. "Does Army R&D Pay Off? A Critical Assessment," Armed Forces Journal International, (May 1985), 66-73.

System Assessment of Joint STARS and Key Supporting Fire Support Systems. Fort Monmouth, New Jersey: Joint Tactical Command and Control and Communications Agency, 1988. B135950L.

Weinert, Richard P. A History of Army Aviation 1950-1962. Fort Monroe, Virginia: TRADOC Monograph, 1991.

Army and Air Force Manuals

CGSC C500. Military Use of Space. U.S. Army Command and General Staff College, September 1991.

CGSC Student Text 100-2. U.S. Air Force Basic Data. U.S. Army Command and General Staff College, May 1991.

Field Circular (FC) 100-26. Air Ground Operations. Command and General Staff College, Fort Leavenworth, Kansas, 31 July 1984.

Field Manual (FM) 1-111. Aviation Brigades. Washington, D.C.: Department of the Army, 27 August 1990.

Field Manual (FM) 6-20. Fire Support in the AirLand Battle. Washington, D.C.: Department of the Army, 17 May 1988.

Field Manual (FM) 6-20-10. Tactics, Techniques, and Procedures for the Targeting Process. Washington, D.C.: Department of the Army, 29 March 1990.

Field Manual (FM) 6-20-30. Fire Support for Corps and Division Operations. Washington, D.C.: Department of the Army, 18 October 1989.

Field Manual (FM) 17-50. Attack Helicopter Operations. Washington, D.C.: Department of the Army, 4 May 1984.

Field Manual (FM) 34-1. Intelligence and Electronic Warfare Operations. Washington, D.C.: Department of the Army, 2 July 1987.

Field Manual (FM) 34-3. Intelligence Analysis. Washington, D.C.: Department of the Army, March 1990.

Field Manual (FM) 34-10. Division Intelligence and Electronic Warfare Operations. Washington, D.C.: Department of the Army, November 1986.

Field Manual (FM) 34-80. Brigade and Battalion Intelligence and Electronic Warfare Operations. Washington, D.C.: Department of the Army, April 1986.

Field Manual (FM) 34-130. Intelligence Preparation of the Battlefield. Washington, D.C.: Department of the Army, May 1989.

Field Manual (FM) 71-100. Division Operations. Washington, D.C.: Department of the Army, June 1990.

Field Manual (FM) 100-5. Operations. Washington, D.C.: Department of the Army, 5 May 1986.

Field Manual (FM) 100-7. The Army in Theater Operations. Washington, D.C.: Department of the Army, 31 July 1990.

Field Manual (FM) 100-15. Corps Operations. Washington, D.C.: Department of the Army, 13 September 1989.

Field Manual (FM) 100-26. Air-Ground Operations System. Washington, D.C.: Department of the Army, 30 March 1973.

Field Manual (FM) 101-5-1. Operational Terms and Symbols. Washington, D.C.: Department of the Army, 21 October 1985.

Field Service Regulations 100-20. Command and Employment of air Power. Washington, D.C.: Government Printing Office, 21 July 1943.

Tactical Air Command Pamphlet (TACP) 50-29/United States Readiness Command (USREDCOM) and Pam 525-8/United States Training and Doctrine Command (TRADOC) Pam 525-45. General Operating Procedures for Joint Attack of the Second Echelon (J-SAK). 31 December 1984.

TRADOC Handbook. Corps Deep Operations (ATACMS, Aviation, and Intelligence Support) Tactics, Techniques, and Procedures. Fort Leavenworth: U.S. Army Combined Arms Command, April 1990.

Interviews

Mr. (PH.D.) Dale Burton, interview by author: Chief System Engineer for Research and Development, Grumman Melbourne Systems Division, Florida. Series of discussions September 1990.

Major Robert Carr, interview by author: U.S. Army Assistant to the TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona. (Major Carr served as the ground commander for GSM operations during the Joint STARS deployment to Saudi Arabia.) One hour discussion on to the TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona. (Major Carr served as the ground commander for GSM operations during the Joint STARS deployment to Saudi Arabia.) One hour discussion on 18 March 1992.

Col Stan Cherrie, interviews by author: U.S. Army Command and General Staff College, Director of Tactics, (former G3 of VII Corps) Fort Leavenworth, Kansas. Series of discussions, January through April 1992.

LTC Larry Corn, talks by author: U.S. Army Deputy Assistant, TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona. Series of telephone conversations February through March 1992.

LTC George J. Cusimano, talks by author: U.S. Air Force Deputy Director of Joint STARS Test Force, Melbourne, Florida. (LTC Cusimano served as the Radar Management Officer (RMO) and an Airborne Surveillance Officer (ASO) aboard the E-8A in DESERT STORM). A series of discussions between January and March of 1991.

Major Max DeSosa, talks by author: U.S. Army Staff Officer at the AirLand Forces Application Agency, Tactical Air Command Headquarters, Langley Air Force Base, Virginia. Three phones conversations between November 1991 and March of 1992.

Major Chris Erschen, interviews by author: U.S. Army Action Officer, Office of the Deputy Chief of Staff, Combat Support Requirements Directorate, TRADOC Headquarters, Fort Monroe, Virginia. Series of phone conversations between December 1991 and February 1992.

Major Shawn Griffith, talks by author: U.S. Army Assistant to the TRADOC Systems Manager for Joint STARS, Tactical Air Command Headquarters, Langley Air Force Base, Virginia. (Major Griffith served as an Army aircrew member and Deputy Mission Commander for the Joint E-8A during DESERT STORM.) Series of discussions November 1991 to January 1992.

Major Norman Johnson, talks by author: U.S. Army Joint STARS Test Detachment, Melbourne, Florida. (Air Force Officer and Pilot of the E-8A during DESERT STORM.) Series of conversations during January through March 1991.

Colonel Martin S. Kleiner, talks by author: U.S. Army TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona. Series of discussions, August 1991 through March 1992.

Major General Wayne Knudson, interview by author: U.S. Army Combined Arms Command, Deputy Commanding General for Combat Developments, Fort Leavenworth, Kansas. One hour discussion, 2 March 1992.

LTC Robert Lee, interview by author: U.S. Army Command and General Staff College, Department of Tactics, Fort Leavenworth, Kansas. One hour discussion, 7 February 1992.

Captain Norman McCollum, talks by author: U.S. Army Assistant to the TRADOC System Manager for Joint STARS, Fort Huachuca, Arizona. (Captain McCollum served as the logistics coordinator during the GSMs deployment to Saudi Arabia.) Series of discussions, November 1991 through March 1992.

Mr. Mike Mosser, talks by author: Grumman System Engineer, Grumman Melbourne Systems Division, Florida. Phone conversation 30 January 1992.

Brigadier General George Muellner, talks by author: U.S. Air Force Commander of the 4411 Joint STARS Test Squadron and Airborne Commander aboard the E-8A during DESERT STORM. Series of conversations during February and March 1991.

Col John D. Skelton, talks by author: U.S. Army Command and General Staff College, Advanced Operational Studies Fellowship, Fort Leavenworth, Kansas. Series of discussions, November 1991 through May 1992.

Major Mike Widener, talks by author: U.S. Army Joint STARS Test Detachment, Melbourne, Florida. (Army Airborne Surveillance Terminal Operator during DESERT STORM.) Phone conversation on 11 March 1992.

Major Bud Williams, talks by author: (U.S. Air Force, 4411 JSS, Weapons Allocation Officer (WAO) during DESERT STORM). Series of discussions between January and March 1991.

Lectures

Summers, Harry. "Forging Victory From Defeat," Bradley Lecture presented at the U. S. Army Command and General Staff College, Fort Leavenworth, Kansas, 3 December 1991.

APPENDIX D

INITIAL DISTRIBUTION LIST

1. Lieutenant Colonel James L. Campbell
   Department of the Air Force
   U.S. Army Command and General Staff College
   Fort Leavenworth, Kansas 66027-6900

2. Colonel Stan Cherrie
   Director, Department of Tactics
   U.S. Army Command and General Staff College
   Fort Leavenworth, Kansas 66027-6900

3. Combined Arms Research Library
   U.S. Army Command and General Staff College
   Fort Leavenworth, Kansas 66027-6900

4. Defense Technical Information Center
   Cameron Station
   Alexandria, Virginia 22314

5. Colonel Martin Kleiner
   TRADOC System Manager, Joint STARS
   Fort Huachuca, Arizona 85613-7000

6. Brigadier General Gerald A. Miller
   National Guard of Iowa
   Office of the State Adjutant General
   Camp Dodge
   7700 North West Beaver Drive
   Johnston, Iowa 50131-1902

7. Major Pam Senterfitt
   Department of Tactics
   U.S. Army Command and General Staff College
   Fort Leavenworth, Kansas 66027-6900

8. Colonel John D. Skelton
   School of Advanced Military Studies
   U.S. Army Command and General Staff College
   Fort Leavenworth, Kansas 66027-6900

9. Lieutenant Colonel James Winters
   Combat Support Requirements Directorate
   Fort Monroe, Virginia 23651