C-X OPERATIONAL EFFECTIVENESS IN THE INTRATHEATER ENVIRONMENT

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

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B.S., UNITED STATES AIR FORCE ACADEMY, 1969

Fort Leavenworth, Kansas
1983

MASTER OF MILITARY ART AND SCIENCE

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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 government agency. (References to this study should include the foregoing statement.)

C-X OPERATIONAL EFFECTIVENESS IN THE INTRATHEATER ENVIROMMENT
by Major Donald M. Dessert, Jr., USAF, 114 pages.

The C-X has been proposed as the solution to both the intertheater and intratheater airlift shortfalls. It is primarily a strategic airlift aircraft capable of airlifting outsize cargo with the additional designed-in capability to allow it to perform the tactical airlift role. This paper analyzes the C-X's operational effectiveness in the European theater environment in terms of capabilities, mission, and survivability/vulnerability to the threat. C-X capabilities were evaluated through comparison of the proposed C-17 to the requirements stated in the Request For Proposal (RFP) and existing airlift capabilities. Doctrine for the C-X mission is nonexistent; therefore, existing airlift doctrine was reviewed for applicability. Survivability/vulnerability was assessed through application of the C-17's mission and design characteristics to the expected European Threat.

Although possessing the capability and supported by existing airlift doctrine, the C-X is found to be effective, both for direct delivery if restricted to the theater rear and for intratheater airlift no further forward than the divison rear in the main battle area.

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INTRODUCTION

Preface:

The Department of Defense and the United States Air Force are in the process of deciding the future role of airlift in the context of rapid global deployment. The size of deployment will be a function of the US level of involvement and could vary greatly in size and range. Airlift will be called on not only to deploy large forces but also to support employment and to provide theater supply.

The C-X is a widebody airlift aircraft capable of carrying outsize cargo. It was conceptualized to fulfill both the strategic airlift role of deployment and the tactical airlift role of in-theater employment and intratheater deployment/supply.(1) This concept was pursued to reduce the costs associated with the development of two separate aircraft. Although this dual role aircraft solution appears to be more cost effective, the combination of the distinct characteristics of a strategic airlift aircraft and a tactical airlift aircraft impacts the aircraft's operational effectiveness.

The C-17 is the solution proposed by McDonnell-Douglas to satisfy the C-X requirement. It is a predominately strategic airlift aircraft to which have been added features that allow it to perform airdrop, airland, and extraction missions in the tactical airlift environment.(2)

Problem Statement:

The C-17 is conceptually required to operate in the European tactical airlift environment. The C-17's combination strategic/tactical design may be inherently vulnerable to the threat and doctrinally unsupportable in this environment.

Background:

In the early 1970's, Tactical Air Command (TAC) began to establish the requirement for a new tactical airlift aircraft. This effort became to be known as the Advance Medium Shortfield Takeoff and Landing (STOL) Transport or AMST program. The aircraft was envisioned to be a follow-on for the Lockhead C-130 with the additional capability to carry outsize cargo. By 1975, the program had been shifted to the Military Airlift Command (MAC) due to the consolidation of airlift under a single Department of Defense manager. Under MAC's management, the AMST progressed to a fly-off competition between the Boeing YC-14 and the McDonnell-Douglas YC-15. Each company built two prototypes which served as technology demonstrators while competing in the flying test and evaluation.

Ultimately, the AMST program was cancelled since Congress failed to further fund the program in 1979. Congressional rationale for the cancellation of the program was the AMST's "lack of legs": its inability to carry a significant cargo load across strategic distances (3),e.g. across the Atlantic Ocean to Europe. The Congress was convinced of our general lack of capability to airlift strategically as well as tactically, or in other terms to support intertheater as well as intratheater mobility.

The Air Force had done its job in convincing the Congress of our total airift shortfall and maybe too well. In an effort to more fully understand the mobility problem, Congress directed DOD to conduct an in-depth study of mobility and report its findings. This study was titled the "Congressionally Mandated Mobility Study" (CMMS).(4) The Air Force assembled a task force to produce the airlift portion of the study. The study was presented to the Congress in April, 1981.

Simultaneously, the concept of rapid deployment, which was surfaced by the Carter administration early in its term, was gaining momentum. This concept highlighted our serious national shortcomings in rapidly projecting a force overseas.

The C-X requirements process was also ongoing during this timeframe and a Source Selection was subsequently completed in August 1981. The C-X was spawned by the failing of the AMST. Although the requirement was not traditionally stated, the selected aircraft was seen to require the capability to fly strategically between the Continental United States (CONUS) and Europe and to land at a short austere airfield (SAAF) while carrying outsize cargo. (5)

The Source Selection resulted in the McDonnell-Douglas C-17 winning the competition. (6) This aircraft has a significant strategic or intertheater airlift capability somewhere between the existing C-141 and C-5 and a tactical or intratheater airlift capability somewhere between the C-130 and C-141 with an added outsize cargo capability. Definite capabilities of the C-17 will not be known until a prototype is flying; however, this aircraft was designed using the existing YC-15 technology plus off-the-shelf systems that became available since the introduction of the YC-15. This provides low risk and a high probability its actual capabilities will at least equal the design proposal.

As previously stated, the Source Selection process was taking place against the backdrop of the national discussion of rapid deployment. Airlift plays a significant role in rapid deployment, especially in the first critical days of the deployment to the theater. Discussions in the 1980-1981 timeframe kept highlighting airlift and our shortage in capability to transport a joint deployment force over intercontinental ranges. The solution provided by the Air Force was the C-17. A long term acquisition program posed a timing problem. It did not satisfy the immediate deployment problem in a timely manner.

Political as well as aircraft industry pressure kept the immediacy problem at the forefront and over a short period of time forced the consideration of relatively near-term solutions. These solutions included increased procurement of KC-10 Tanker/Cargo aircraft; purchase of existing but idle commercial cargo aircraft such as the 747; reopening of the C-5 production line; or any combination of these solutions.

In June 1982, the Congress decided to pursue the near-term solution by opting for 50 additional C-5's and 44 KC-10's.(6) The first C-5 is programmed to be available in 1986. The C-17 is still being pursued and if produced the first will be available no earlier than 1990. Political as well as economic changes could force the total cancellation or further postponement of this program. Current debate is questioning the gap resulting from the claimed availability timeframes of the C-5 and C-17.

The addition of 50 C-5's to the inventory reduces the strategic airlift shortfall, but in the Air Force's opinion does little to reduce the intratheater shortfall, whether considering outsize cargo or not. This opinion is based on the stated requirement to fly outsize cargo to SAAF's in an intratheater role.(8)

<u>Significance</u>:

The commitment by Congress for 50 additional C-5's, coupled with the high cost of the proposed C-17 raises the general question of the need for both aircraft and the specific question of the need for buying the dual role C-17. The stated problem of this thesis naturally evolves into a twofold problem. It asks not only should a strategic airlift aircraft operate in the tactical airlift environment, but is an outsize airlift capability required up to the troops in contact along the forward edge of the battle area (FEBA)?

Hypothesis:

These questions can be explored through an assessment of the following hypothesis: A dual role airlift aircraft can be operationally effective in the tactical airlift role in the European theater.

Assumptions:

1. The United States will continue its emphasis on rapid deployment. Deployment will range from insertion of small forces into hostile environments to large scale deployment and employment in contingencies.

2. The US Army's mobility needs for cargo up to outsize will at least remain the same or grow as they are forecast.

3. The C-17 will be capable of satisfying mission requirements as proposed by its designer, McDonnell-Douglas Corp.

Limitations:

1. The theater of operations is limited to Europe.

2. Evaluation of the threat will not include consideration of base or terminal security operations.

3. Documentation for this study is limited to unclassified; however, classified material is referenced to provide a source of expanded detail.

Research Methodology:

Operational effectiveness is a measure of a system's capability to fulfill the mission for which it was designed.(9) This includes the system's operating characteristics and its ability to successfully complete its design mission. For this thesis, success is measured by the aircraft's ability to conduct sustained tactical airlift operations in the European (threat) environment.

Analysis of the C-X's operational effectiveness in the European theater airlift environment requires evaluation/study of the following areas:

Capabilities. The C-X requirement is generally stated in the System Operating Concept (SOC). The C-X Request for Proposal (RFP) (10) is the document that specifies the requirement in terms of aircraft operating capabilities. The specific design characteristics of the C-17 are best used for evaluation, since they are the best available data for the generic aircraft called for by the RFP.(11) In those areas where existing aircraft and mission overlap the proposed aircraft and mission, comparative evaluation measures will be used. All evaluation measures will be those factors salient to the operational mission the dual role aircraft is being evaluated against.

Mission. The C-X mission combines strategic and tactical missions in the requirement to airlift outsize cargo from CONUS Main Operating Bases (MOB's) and deliver it directly to SAAF's close to the battle area. Its mission also includes intratheater airlift between theater rear area MOB's and SAAF's. The mission analysis will include examination of both Army and Air Force doctrine to determine the doctrinal basis for the proposed C-X mission. Also, where supporting doctrine is not available, interview of subject matter experts and review of existing doctrine will be assessed. Finally, related Army doctrine addressing battlefield logistics will be reviewed.

Environment(THREAT). The European tactical airlift environment will be described in terms of the threat to tactical airlift. The C-X will be analyzed in terms of its vulnerability/survivability to the threat.

Organization:

This study is divided into six chapters. Chapter II is a discussion of existing literature impacting the problem. Chapters III-V comprise an evaluation of the C-X's operational effectiveness with the aircraft's capabilities, mission, and threat vulnerability analyzed in successive chapters. Chapter VI contains a statement of related findings, conclusions drawn from the analysis and recommendations.

Definition of Terms:

1. Aircraft Operating Weight: The basic weight of the aircraft plus the weight of the crew, equipment, and oil.

2. Airlanded: Moved by air and disembarked, or unloaded, after the aircraft has landed.(12)

3. Airdrop: The unloading of personnel or material from aircraft in flight.(13)

4. Airlift Control Center (ALCC): A command and

control center established for detailed planning, coordinating, tasking, and control of theater airlift forces.(14)

5. Allowable Cabin Load (ACL): The maximum payload which can be carried on a mission. It may be limited by the maximum gross takeoff weight, maximum gross landing weight, or maximum zero fuel weight.(15)

6. Allowable Gross Weight: The maximum allowable aircraft weight in takeoff condition for a specific flight.

7. Clean Configuration: The aircraft configuration when no drag-inducing systems, such as flaps and landing gear, disturb the airflow over the aircraft.

8. Combat Control Team (CCT): A team of Air Force personnel organized, trained and equipped to establish and operate navigational, or terminal guidance and communications, and aircraft control facilities in support of tactical operations. (18)

9. Computed Air Release Point (CARP): A computed air position at which parachutists, equipment or supply bundles are dropped to land on a specific point of impact. (16).

10. Commander Airlift Forces (COMALF): The individual in command of all airlift forces within a designated area or for a designated operation. In the overseas theaters, the COMALF is normally responsible for theater airlift management. The Air Force Component Commander exercises operational control of assigned or

attached airlift forces through the COMALF. The COMALF monitors/manages, for CINCMAC, MAC-assigned airlift forces operating in the theater. (17)

11. Drop Zone (DZ): A specified area upon which airborne troops, equipment, and supplies are dropped by parachute or upon which supplies and equipment may be delivered by free fall. (19)

12. Formation: One or more aircraft flying in visual or electronic reference to a lead aircraft. (20)

13. "G": The term used to describe gravitational forces when describing aircraft maneuvering characteristics.

14. Low Altitude Parachute Extraction System (LAPES): A low-level self-contained extraction system used on C-130's to deliver heavy loads into an area where airland is not feasible. (21)

15. Outsize Cargo: Cargo higher than 96" which is the limiting cargo height for both the C-130 and C-141.

16. Short Austere Airfield (SAAF): An airfield with the following characteristics: semiprepared surface runway between 3000-4000 ft. long by 90x150 ft. wide and a parking ramp 250 ft. by 350 ft. with taxiways at least 60 ft. wide running between the ramp and runway. (22)

17. Station Keeping Equipment (SKE): An aircraft avionics system which can be used to maintain formation position, or in conjunction with a ground zone marker, to make airdrops in IMC. (23)

Notes - Chapter I

1. C-X Systems Operational Concept (SOC) (U), Headquarters, Military Airlift Command (HQMAC), undated, SECRET, p.1.

2. " The C-X Requirement: Perspective on Airlift", LtCol T.D. Pilsch, Airlift Operations Review, Jan 81, p.9.

3. Ibid.

4. Congressionally Mandated Mobility Study (U), Department of Defense (DOD), April 1981. SECRET.

5. HQMAC C-X SOC, p.4.

6. The C-X Source Selection competition evaluated four candidates initially. One candidate, a C-5 derivative was eliminated from the competition. The three remaining proposals were entered by Boeing Military Airplane Co., McDonnell-Douglas Corp., and Lockheed, Aircraft Division. The Source Selection Authority, Secretary of Defense Weinberger, ultimately decided on the C-17.

7. " Budget Cutters Are Only Ones Likely to Win Battle Over C-5B/747F/C-17 Airlift Alternatives", Benjamin F. Schemmer, Armed Forces Journal International,July 82,pp 38-44.

8. HQMAC C-X SOC, p.4.

9. DOD Directive 5000.3, Operational Test and Evaluation, Definitions, Dec 26,1979, p.2.

10. C-X Acquisition Program Request For Proposal(RFP), Wright-Patterson AFB,OH:Headquarters Aeronautical Systems Division, 8 Oct 80.

11. The requirement did not specify aircraft characteristics but rather the missions the proposed aircraft must be capable of accomplishing.

12. MAC Regulation (MACR) 76-1, Vol 1, Ch. 1.

13 through 21 Ibid.

22. HQMAC C-X SOC, p.8.

23. MACR 76-1.

CHAPTER II

REVIEW OF LITERATURE

To more fully understand the problem of using a dual role airlift aircraft in both the strategic and tactical airlift roles, it is necessary to review a wide variety of literature. In order to focus the issues, I have limited the reviewed literature to recent works, mainly written within the last ten years. During this period the essentiality of airlift has been increasingly emphasized. Discussions have ranged from the need for a jumbo, outsize-capable strategic airlifter to the need for a STOL tactical airlifter. The introduction of the rapid deployment concept has also surfaced other issues regarding the need for airlift, especially the speed, range and direct delivery capability necessary for blunting probable conflict or halting conflict in its early stages. The development of the C-X added to these issues the viability of a dual role airlift aircraft and the resultant mixing of the strategic and tactical airlift missions.

The problem has been discussed in a framework of issues based on mission characteristics, stated needs (1) and the resulting stated requirement, advantages and disadvantages, and finally any additional factors that impact the need but not addressed in the stated need. Figure 1 is a matrix which generally aligns three literature categories with the issues and shows their source relationship.

CATEGORY	DOCTRINE	UNPUB'D OFF DOC	ARTICLES
ISSUE			
MISSION	MAIN	SUPPORTING	COMMENT
STATED NEED	SUPPORTING	MAIN	SUPPORTING
STATED REQT	SUPPORTING	MAIN	COMMENT
ADVANTAGES/ DISADVANTAGES	SUPPORTING	MAIN	SUPPORTING
ADDL FACTORS	SUPPORTING	SUPPORTING	MAIN

Fig. 1 Literature/Issue Relationship

In this chapter, I will primarily discuss the categories main relationships to the issues and secondarily their supporting relationships. First, doctrinal documents such as Air Force Manual (AFM) 1-1, USAF Basic Doctrine and Field Manual (FM) 100-27/AFM 2-4, Theater Airlift and Joint Airborne Operations were reviewed to form a conceptual framework for doctrinal airlift missions. These manuals do not address all of the problem areas. In this chapter, I will outline the problem areas these manuals address. I will also identify those problem areas that need to be addressed as revisions to doctrine and recommend changes in the final chapter.

Second, unpublished official documents, such as the Congressionally Mandated Mobility Study (CMMS), were reviewed to establish the requirements based on the stated needs for airlift and to define specific problems inherent in airlift. These problems include such things as vulnerability and other aspects of airlift that impact operational effectiveness, whether oriented on the system, the organization, or the operation of airlift.

Finally, articles and periodicals were reviewed to broaden my view of the problem and to seek the opinions of those both in and out of the military and the airlift business. Opinions gained through interview or discussions with experts in the field will fall into this category.

Doctrinal Documents

AFM 1-1 states:

> "Through our strategic and tactical military airlift, we can deploy our forces to any part of the world and support them there....We must be able to insert our forces directly into a combat area and then resupply them."(2)

This document generally states the role of airlift but does not specifically assign the role of inserting forces or resupplying them to either strategic or tactical airlift. Additionally, its treatment of these two activities is not addressed in further detail but is left to other doctrinal documents such as FM 100-27/AFM 2-4, Theater Airlift and Joint Airborne Operations (Draft). This document, as its title suggests, is primarily concerned with the use of theater airlift in airborne operations. It is a joint service document that addresses the use of airlift within a theater of operation in terms of organization and command, request procedures, movement and staging, and employment operations. This manual makes the distinction between theater (tactical) airlift and strategic airlift as follows:

> "Theater airlift is: 1. The immediate and responsive air movement and delivery of combat troops and supplies directly into objective areas through airlanding, extraction, airdrop, and other delivery techniques; 2. the air logistics support of all theater forces, required to meet specific theater objectives and requirements. Theater airlift more accurately describes the use of airlift resources previously referred to as tactical airlift." (3)

> "Strategic airlift is the continuous or sustained movement of units, personnel and material in support of all Department of Defense agencies - 1. between theater or area commands or - 2. between the

continental US and overseas locations. Strategic airlift resources possess the capability of airland or airdrop (of) supplies, personnel, and equipment for augmentation of committed forces when required."(3)

Although these definitions show a distinction between the two types of airlift missions, the statement that "strategic airlift resources possess the capability" to accomplish the theater airlift mission demonstrates a reluctance to completely separate the two missions. Theater considerations such as proximity of airfields to forces supported and delivery modes (airland, airdrop, extraction) are emphasized further in the definition of tactical air movement:

> "The air transport and delivery of combat personnel, equipment and supplies that facilitates the accomplishment of a tactical mission by a ground force....Contact with a hostile force may occur during delivery at the destinaton. The efficient use of aircraft cargo space is secondary to tactical considerations and the choice of optimal delivery techniques." (4)

In a discussion of airborne force limitations, vulnerability of the airlift resource is also included in the vulnerabilities of the airborne force during theater operations:

> "Selection of the aerial delivery system to be used must be made after consideration of the threat, aircraft crew proficiency, the requirement for accuracy, the locations of the landing zones (LZs) or drop zones (DZs), and time available to secure and prepare the zones." (5)

<u>Unpublished Official Documents</u>

The CMMS is the result of a study on mobility conducted within the Department of Defense by a task force comprised of mobility experts. It defines the country's needs in total mobility terms including sealift, airlift,and prepositioning requirements. Based on four scenarios of possible conflict, the CMMS arrives at estimates of the lift required to successfully apply our armed forces. Using mixes of airlift, sealift and prepositioning, the CMMS identifies an airlift shortfall of 25 million ton-miles per day (MTM/D). With this shortfall as a basis it analyzes two primary alternative solutions to the airlift shortall. Pivotal to the solutions is the use of direct delivery of both outsize and non-outsize cargo from main operating bases (MOBs) outside the theater of operations to short austere airfields (SAAFs) in the theater. The study states:

> "The time saved by direct delivery of material to forward airfields is equal to the time required to close that material between the port and the forward airfield, plus the transshipment time avoided by not transiting through the port."(6)

In two of the most critical scenarios, the study cites a productivity advantage of up to 15% for direct delivery. This productivity advantage is a result of time saving that can be applied to the total airlift effort and affects the amount of airlift support required:

> "Since flexibility and timeliness are dominant characteristics of airlift, these advantages are

> directly transferable to the amount of airlift which must be purchased to accomplish a given objective. Ability to operate in austere runway environments, particularly with aircraft that can transport cargoes up to outsize, improves the effectiveness of other mobility alternatives which deploy cargo to major air and sea ports of debarkation and thus require transshipment to forward locations." (7)

In its unclassified portions, the CMMS generally addresses the vulnerability problem of airlift in terms of cargo delivery capacity. It says the vulnerability to the airlift resource will have only a minimal impact on the cargo delivered into the theater due to a "relatively small concentration (of cargo) spread over a large number of airlift sorties." (8)

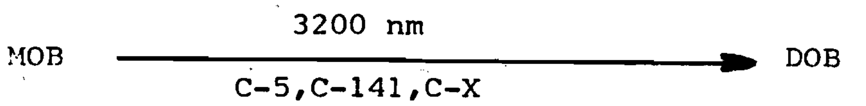
The Headquarters Military Airlift Command (HQMAC) C-X System Operational Concept (SOC) also emphasizes the importance of direct delivery. Additionally, it discusses the general types of cargo that future airlift will be required to carry based on the growth trend of the US Army firepower/support equipment:

> "This growth trend continues to increase that portion of US Army air movement requirements which are outsize....By 1986, the preponderance of US Army key firepower/ mobility equipment in a mechanized infantry or armored division will fall into the outsize category." (9)

Although not stated, the doctrinal manuals plus the CMMS and SOC infer the necessity to deliver outsize cargo to forward areas in close proximity to the FEBA. This study will attempt to refine this requirement in terms of what, if any, outsize cargo will be required to be airlifted to the combat area and how far forward in the combat area this cargo is needed. Airlift forward of the terminus of the ground Lines of Communication (LOCs) would appear to be counterproductive in addition to exposing valuable airlift assets to hazards.

The Air Force requirement for the C-X, as stated in the C-X Acquisition Program Request for Proposal (RFP) was based on an analysis of the airlift system and the key elements that drive the design of an airlifter. This analysis was conducted by the C-X Task Force and focused on five factors that are key to any airlift plan. These elements include the potential threat; the forces needed to counter the threat; onload bases; route structure to the theater; and potential offload bases.(10) Although the RFP specifications did not dictate specific design characteristics, the use of scenarios based on those used in the CMMS drove aircraft design parameters. Figs. 2 and 3 show the four mission scenarios used for the RFP. To illustrate derivation of design parameters you have to understand a combination of varying requirements was used to optimize the design. For example, closure for a representative force over intercontinental ranges drove one set of payload-range characteristics while the addition of in-theater unit moves drove a different set.

Mission 1: Mid-Range with Air Refueling Available

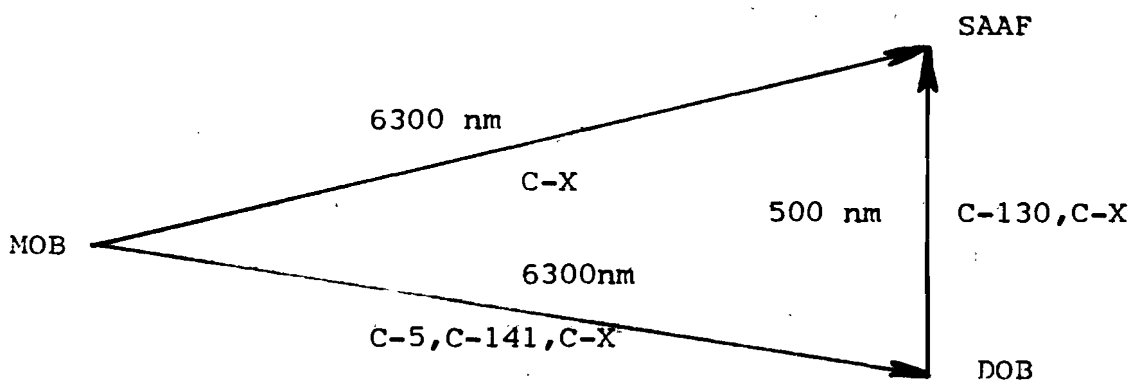


138,000 Tons in 11 days

Daily Missions Available:

C-5	48
C-141	119
C-X	TBD

Mission 2: Long-Range, Non-stop, with Air Refueling Available



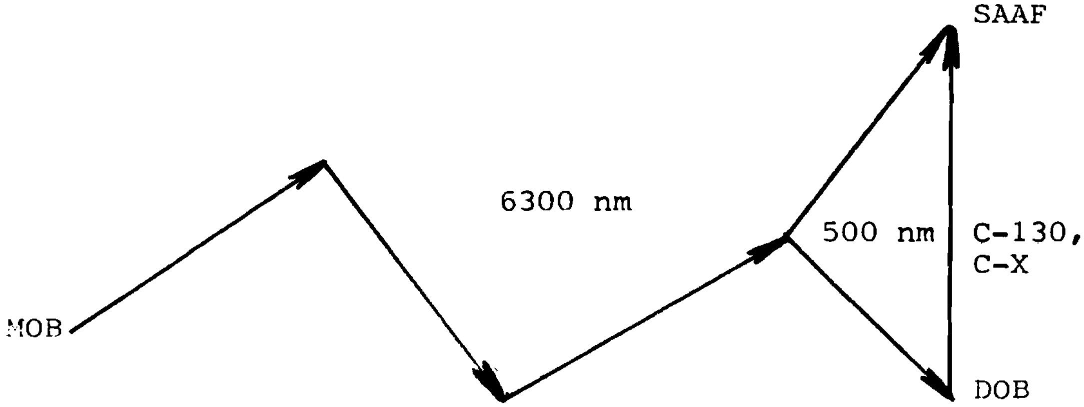
265,000 Tons in 25 days

Daily Missions Available:

C-5	25
C-141	64
C-130	200
C-X	TBD

Fig. 2 Mission Scenarios 1 and 2 (10)

Mission 2a: Long-Range with No Air Refueling



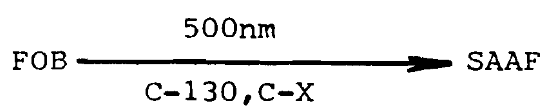
C-5,C-141,C-X:MOB-DOB/C-X:MOB-SAAF,DOB-SAAF

265,000 Tons in 25 days

Daily Missions Available:

C-5	24
C-141	61
C-130	200
C-X	TBD

Mission 3: Theater Deployment



42,500 Tons in 4 days

Daily Mission Available:

C-130	200
C-X	TBD

Fig. 3 Mission Scenarios 2a and 3 (10)

Fig. 4 shows the minimum range-payload specification arrived at by combining the various missiong range requirements with the likely payload weights for the different scenariors.

Mission	Payload (lb)	Range (nm)	Minimum Load Factor
Max Payload	130,000	2400	2.00
Heavy Logistics	120,000	2400	2.25
Intertheater Log	100,000	2800	2.50
High Performance Logistics	70,000	500	3.00

Fig. 4 Minimum Range-Payload Requirements (11)

This specification addresses the first four analysis factors to some degree and forms the first of three major considerations the RFP is based on:enroute capabilities, offload airfields and delivery techniques.

The fifth factor, offload airfields, was the second major consideration in determining design parameters. In addition to runway dimensions, maneuver space, runway and taxiway surface requirements, and ramp size requirements, the envisioned austere environment of the SAAF required the aircraft design to have the capability to land at the SAAF and operate near autonomously while servicing and conducting cargo onload/offload operations. The RFP specification requires the ability to land on a semiprepared runway 3000 ft long by 90 ft wide, taxi on 50 ft wide taxiways to park on 300 ft by 400 ft ramps. Once parked, the aircraft must be able to perform cargo loading operations with a single loadmaster using minimal ground cargo handling equipment. High reliability standards were required to preclude maintenance in austere conditions. In addition to these standards, accessibility to onboard systems is a key factor to insure quick turnaround times when maintenance is required at forward SAAF locations.

The third major consideration, delivery techniques, required the addition of tactical characteristics to the aircraft. Adverse weather formation flying, low altitude parachute extraction system (LAPES) delivery, and airdrop of personnel and equipment was specified in the RFP.

These three major considerations drove the design of the C-X to have the following characteristics: an aircraft capable of carrying outsize cargo over strategic ranges direct to a battle area and delivering the cargo by airland, airdrop or extraction. If delivered by airland, the aircraft must be capable of operating in the austere environment of the SAAF. The C-17 is the result of the RFP and source selection process. It has the following capabilities (12):

Maximum Takeoff Gross Weight - 570,000 lbs.

Payload-Range - 172,000 lbs for 2400 nm
129,200 lbs for 2800 nm
86,100 lbs for 500 nm
With fuel to return 500 nm
(Due to SAAF limitations)

Powered lift for short field capabilities

Survivability - Highly maneuverable design
Redundant flight controls
Independent fuel feed
Separated hydraulic systems

Airdrop - 108 paratroopers
55,000 lb extraction
Size to permit airdrop of
Infantry Fighting Vehicle

Other - Winglets to improve efficiency
Single loadmaster operation
Up to 16 pallets load capacity

Several other theses dealing with specific problems within airlift were also reviewed. These problems include the distinction between strategic and tactical airlift (13), the vulnerability of airlift aircraft to both air and ground based weapons (14), and how the limitations of airlift impact the total mobility problem (15). Discussion of these problems as they impact the C-17 will be addressed in Chapter IV, V, and VI respectively.

Articles and Periodicals

An article titled "The C-X Requirement: Perspective on Airlift" by LtCol T.D. Pilsch in the January 81 issue of Airlift Operations Review is a thorough description of the process by which the RFP was produced. Additionally, the author gives a good treatment of how the C-X is meant to fit into the total airlift perspective. He states the C-X is primarily a strategic airlift aircraft with tactical airlift capabilities:

> "Although...the C-X design specification will provide an outsize cargo capability and allow the C-X to supplement the C-130 in the intratheater mission, the primary role of C-X will be intertheater airlift." (16)

He also demonstrates how the C-X is envisioned to be integrated into the airlift force by the following:

> "A detailed analysis of the entire military airlift problem has identified those characteristics needed to fill the gaps in our current capability. C-X will provide long-range heavy outsize cargo lift to supplement the C-5. It will be an efficient outsize and bulk hauler in the intertheater role along with the C-141 and will be able to operate into airfields unavailable to our other long-range transports. It will provide our forces with a new degree of mobility. We will now have the potential to move outsize cargo within a theater of operations and supplement the C-130 in the battlefield resupply mission in coming decades. C-X will be able to move forward the huge quantities of men and equipment delivered into a theater by CRAF and provide the intertheater outsize cargo capability not available with these civil aircraft." (17)

The remainder of the articles primarily deal with the current issues surrounding the C-17 acquisition. Gen. T. R. Milton, in the October 1982 issue of Air Force Magazine, addresses the need for outsize cargo delivery to a combat force:

> "There is, of course, a requirement for outsize loads, but that tends to get out of focus....Designing a transport force for outsize loads loses sight of ailift's basic utility.
>
> A hard-pressed combat force dependent on airlift will need a wide variety of things, and few of them, if history is any teacher, will be the heavy items. What that force will mainly need is round-the-clock reliability, a supply line responsive to the shortages of the moment."(18)

Col. A.L. Gropman, in his article "The Compelling Requirement for Combat Airlift" published in the July-August 1982 issue of Air University Review, makes a strong argument for retaining a combat airlift capability. He cites examples in recent history, primarily during the Vietnam conflict, of the role tactical airlift played in fighting the war. He claims that "intratheater airlifters repositioned tens of thousands of troops to defeat widespread attacks and routinely delivered...thousands of tons of ammunition and supplies to sustain isolated forces."(20) An example of this statement is the effort performed by the C-130 to sustain the US Marines at Khe Sanh in early 1968 while they were besieged by enemy troops. Col Gropman points out the bulk of this support was munitions and rations. He fails to indicate the number of aircraft lost attempting resupply missions at sites such as Khe Sanh, An Loc and others. Col Gropman makes a good case for a fighting airlifter but fails to justify the need for delivery of outsize cargo directly to troops in contact. He proposes to replace the aging and comparatively inexpensive C-130 with a sophisticated, expensive outsize-capable airlifter:

> "While the C-130 can operate into small, austere airfields close to the battle, it cannot lift outsize loads. Enhancing the airlift fleet by building an outsized-capable airlifter that cannot be used in a combat tactical role is a mistake. Building an aircraft that can move cargo into small, austere airfields brings the supplies closer to the battle, vastly expands the number of available airfields, reduces major debarkation airfield congestion, eliminates the transshipment of cargo, and compounds the enemy's interdiction problem. An outsize capable airlifter with tactical capabilities is crucial to support the foreign and military policies...."(21)

This review of literature provides a basis for evaluation and discussion of the operational effectiveness of the C-17. In the main, the issues appear to be well supported save the need for direct delivery of outsize cargo to troops in contact and the resulting vulnerability of a large outsize-capable airlifter in a moderate to high threat environment to which direct delivery may expose it.

Notes - Chapter II

1. HQMAC C-X SOC.

2. USAF Basic Doctrine, AFM 1-1, Department of the Air Force, 1979, p. 2-11.

3. " Theater Airlift and Joint Airborne Operations (DRAFT)," FM 100-27/AFM 2-4, Departments of the Army and Air Force, p. 1-7, para 1-3a and b.

4. Ibid, p. 3-7, para 3-8a.

5. Ibid, p. 7-5, para 7-4a.

6. Congressionally Mandated Mobility Study, April 1981,p. 27.

7. Ibid, p. 37.

8. Ibid, p. 37.

9. HQMAC C-X SOC, undated, p. 14.

10. "The C-X Requirement:Perspective on Airlift", LtCol T.D. Pilsch,Airlift Operations Review, January 1981, p. 10.

11. Ibid, p. 15.

12. C-17 Fact Sheet, HQ MAC/XPQA, undated.

13. "Evolution of Airlift Doctrine", LtCol J.L.Jay, March 1977, Air Command and Staff College Research Project.

14. "C-5 Defensive Capabilities", Maj Stecklow, April 1978, and Airlift Vulnerability Studies, (U) USAF Airlift Center, 1978. SECRET.

15. "The National Strategic Airlift Dilemma", Gen H.M. Estes, April 1976.

16. "The C-X Requirement:Perspective on Airlift", LtCol T.D.Pilsch, Airlift Operations Review, January 1981, p. 9.

17. Ibid, p. 16.

18. "Airlift:The Name of the Game is Utilization", Gen T. R. Milton, Air Force Magazine, October 1982, p. 97.

19. "Budget Cutters Are Only Ones Likely to Win Battle Over C-5B/747F/C-17 Airlift Alternatives", B.F. Schemmer, Armed Forces Journal, July 1982, p. 38.

20. Ibid, p. 40.

21. "The Compelling Requirement for Combat Airlift", Col A.L. Gropman, Air University Review, July-August 1982, p. 11.

Chapter III

Operational Effectiveness

Department of Defense (DOD) Directive 5000.3 defines operational effectiveness as:

> "The overall degree of mission accomplishment of a system used by representative personnel in the context of the organization, doctrine, tactics, threat (including countermeasures and nuclear threats) and environment in the planned operational employment of the system."(1)

For this thesis, the operational effectiveness is the measure of the C-X's ability to perform its mission in the expected European theater environment using doctrine, tactics and organization of the military airlift system.

This paper is limited to analysis of operational effectiveness as opposed to operational suitability. Operational effectiveness is distinguished from operational suitability in DOD 5000.3 by the following definition:

> "The degree to which a system can be satisfactorily placed in field use, with consideration being given availability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability,logistics supportability, and training requirements." (2)

The definition of operational effectiveness asserts the accomplishment of a mission by a system in the expected environment as the basis for determining its effectiveness. This analysis of operational effectiveness will be divided into three main parts: Capabilities Evaluation, Mission

Analysis, and Vulnerability/Survivability assessment.

Part 1: Capabilities Evaluation

To evaluate the C-X capability to accomplish the mission, the airlift mission will be divided into two distinct subelements, namely deployment and employment. Generally, deployment is considered the primary mission of strategic (or intertheater) airlift while employment is the primary mission of tactical (or intratheater) airlift. Additionally, deployment can be considered a secondary mission for tactical airlift while employment can be considered a secondary mission for strategic airlift. Not all systems within each airlift category may have the capability to accomplish all subelements of the secondary mission. For example, the C-5 and C-141 strategic airlift aircraft are not capable of the extraction portion of the employment mission subelement. Figure 5 graphically describes the relationship of the airlift mission to its subelements. The C-X integrates both of these missions.

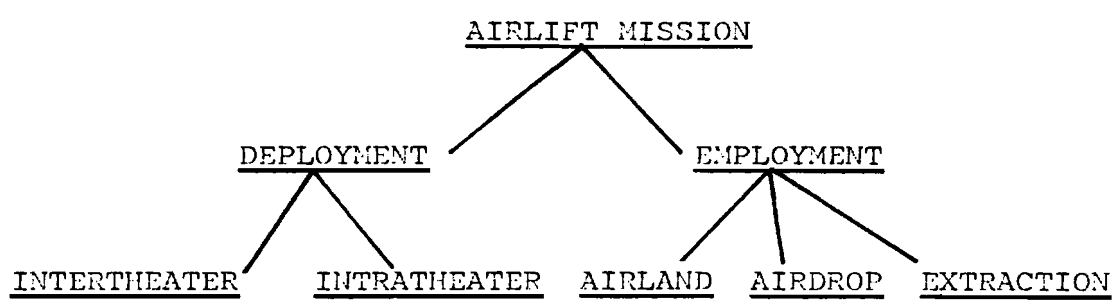


Fig. 5 Airlift Mission Elements

The subelements shown in figure 5 will be discussed using comparative measures for evaluating the capabilities portion of the operational effectiveness of the C-X. The measures for this evaluation will be divided into the main categories of deployment and employment. This is done for two reasons: First, as stated they are the logical divisions of the airlift mission and their integration by the C-X forms the basis for the thesis purpose. Second, the treatment of deployment is best handled in the sequential manner of a typical strategic airlift mission from onload to offload. Employment is best treated through discussion of the operational peculiarities of each of its subelements: airland, airdrop, and extraction.

Deployment

Deployment is generally considered the domain of strategic airlift for one key reason: the geographical position of the U.S. requires transportation over long distances when sending forces to fight outside its limits. The average distance from the east coast of the U.S. to the European theater is approximately 3200 miles. This distance can be flown in one non-air-refueled flight by today's strategic airlifters; however, at some point, the length (in hours) of the deployment flight may be limited by requirements of the aircraft or aircrew regardless of air refueling. These required distances can be further lengthened due to lack of or denial of overflight or landing rights. During the Israeli 6-day war in October 1973, Military Airlift Command's (MAC) strategic airlifters were denied overflight and landing rights by many of our allies.(3) The only base available enroute to Israel was Lajes Field in the Azore Islands. Without this enroute stop, a typical C-5 mission's ACL would have been severely limited. Also, the number of C-5 missions required to complete the airlift would have been far greater.

I have limited the measures of an aircraft's operational effectiveness for deployment to the following segments: onload, takeoff, cruise, approach, landing, and offload. Some of the factors affecting intratheater deployment (airland) will be covered in the discussion of the measures for intertheater deployment.

The specific design characteristics of the C-17 will be used as evaluation data for the generic aircraft called for by the RFP.(4)

MEASURE: ONLOAD

Description: Based on the criticality of cargo planned for rapid deployment to the theater, this measure has critical facets that include the time and resources required for preparation of cargo for loading; the availability and necessity of material handling equipment (MHE) to perform the loading operation; the time required to load; and other factors such as safety and required manpower to load. Deployment of outsize cargo tends to aggravate these problems. Timely loading with minimal dependence on MHE is desired.

Standards: No delays of the loading cycle due to unique aircraft preparation requirements or special cargo handling is necessary. The RFP Systems Requirement Document (SRD), paragraphs 18,a,e,f,i and k address the requirement and stipulate aircraft cargo loading characteristics required for an aircraft to perform loading operations without special cargo preparation.

The MHE will not exceed that available today; in other words, no unique MHE will be required to load the aircraft. The RFP SRD addresses this in paragraphs 20,20a and 20a.2. Simply stated, these paragraphs require the C-X to be compatible with "all current 463L material handling ground equipment." Both of the preceding standards apply to outsize as well as non-outsize cargo.

Evaluation: The C-17 cargo compartment has the following features: cargo compartment configuration and operation can be conducted by a single loadmaster from a loadmaster station at the front of the cargo compartment. It is capable of inflight reconfiguration thereby avoiding loading delays. Rail systems are compatible with existing DOD 463L cargo pallets and MHE. No kits, only integral rails and rollers (an on-board winch, if required) are needed to load cargo. The C-17 does not require any unique MHE to accomplish loading operations.(5)

MEASURE: TAKEOFF

Description: This measure is divided into maneuvering prior to takeoff, ACL/TOGW restrictions to takeoff and the takeoff profile. The takeoff profile includes runway length criteria for takeoff, climb rate at maximum TOGW and maneuverability at maximum TOGW. These are standard measures for any strategic airlifter's takeoff.

Standards: The standards for all of these measures will be based on the expected characteristics at a MOB. The standard for maneuvering on the ground will be the maneuvering requirements for a C-141B, since it is the only existing airlifter with comparable planform to the C-17. Maneuvering requirements include ramp space, taxiway size, and obstruction clearance, both vertically and horizontally. The rest of the standards for takeoff are directly from the RFP and are described in the System Specification (SS) in paragraphs 3.2.1.6.1 and in the SRD in paragraphs 50.2 and 50.2.1.

Evaluation: The C-17 has a comparable planform to the C-141B: 171 ft. long with a wingspan of 165 ft. (6) Landing gear configuration allows a smaller turn radius which allows the C-17 to operate in areas smaller than a C-141B is capable of operating. The C-17's wing and engines are higher off the ground than the C-141B and has comparatively less risk for collisions with any obstructions.

The C-17 meets or exceeds the RFP in all takeoff criteria. For example, at maximum TOGW (570,000 lbs) with a 172,000 lb ACL, the C-17 requires less than the 8500 ft. stipulated as the maximum allowable. The C-17 climb gradient is ten percent compared to the standard of greater than or equal to 2.5 percent. (7)

MEASURE: CRUISE

Description: This measure is critical to the deployment mission. As stated previously, range of the aircraft becomes increasingly important during times of crisis. Denial of airspace and/or airfields forces us toward optimum efficiency long range airlift. The efficiency of the total airlift mission in terms of tons delivered is a directly proportional function of the payload/range capabilities and cruise speed of the aircraft. A given number of fast aircraft with a payload/range capability equal to that of the same number of slower aircraft will deliver proportionately more cargo in the same amount of time. This also holds for larger payload/range capability at the same speed. Both should be optimized to realize delivery of the maximum amount of cargo over time.

Standards: The standard for payload/range and speed should be an increase over the C-141B capability but not necessarily as high as the C5A given the size limitations forced by SAAF operations. The RFP defines payload/range by describing average mission profiles (SS,Table 10.2.1) which have varying payload/range requirements dependent on the type of mission being flown. The mission profiles describe variants of the C-X strategic direct delivery mission plus all of the intratheater deployment and employment missions. Cruise speed is defined as a minimum requirement in SS paragraph 3.2.1.10 and 50.1.1b (2): "Cruise speed of at least 0.70 Mach number and an initial cruise altitude not less than 26,000 ft."

Evaluation: The C-17 payload/range capability is shown in Figure 6 as compared to the C-141B and the C-5A. (8) The C-17 approaches the C-5A payload/ range capability in the strategic airlift mission between 2300 and 3800 nautical mile ranges.

The C-17 is able to satisfy all the mission profiles in the RFP. For the critical missions, the C-17 can strategically airlift 129,200 lbs for 2800 nautical miles (NM), can ferry for 5,000 NM and can tactically airlift 86,100 lbs. for 500 NM with no refueling at the SAAF it operates into and out of. With an ACL of 172,200 lbs., the C-17 can fly 2400 NM unrefueled at 28,000 ft at 0.776 Mach. (9) All of these substantially exceed the standards.

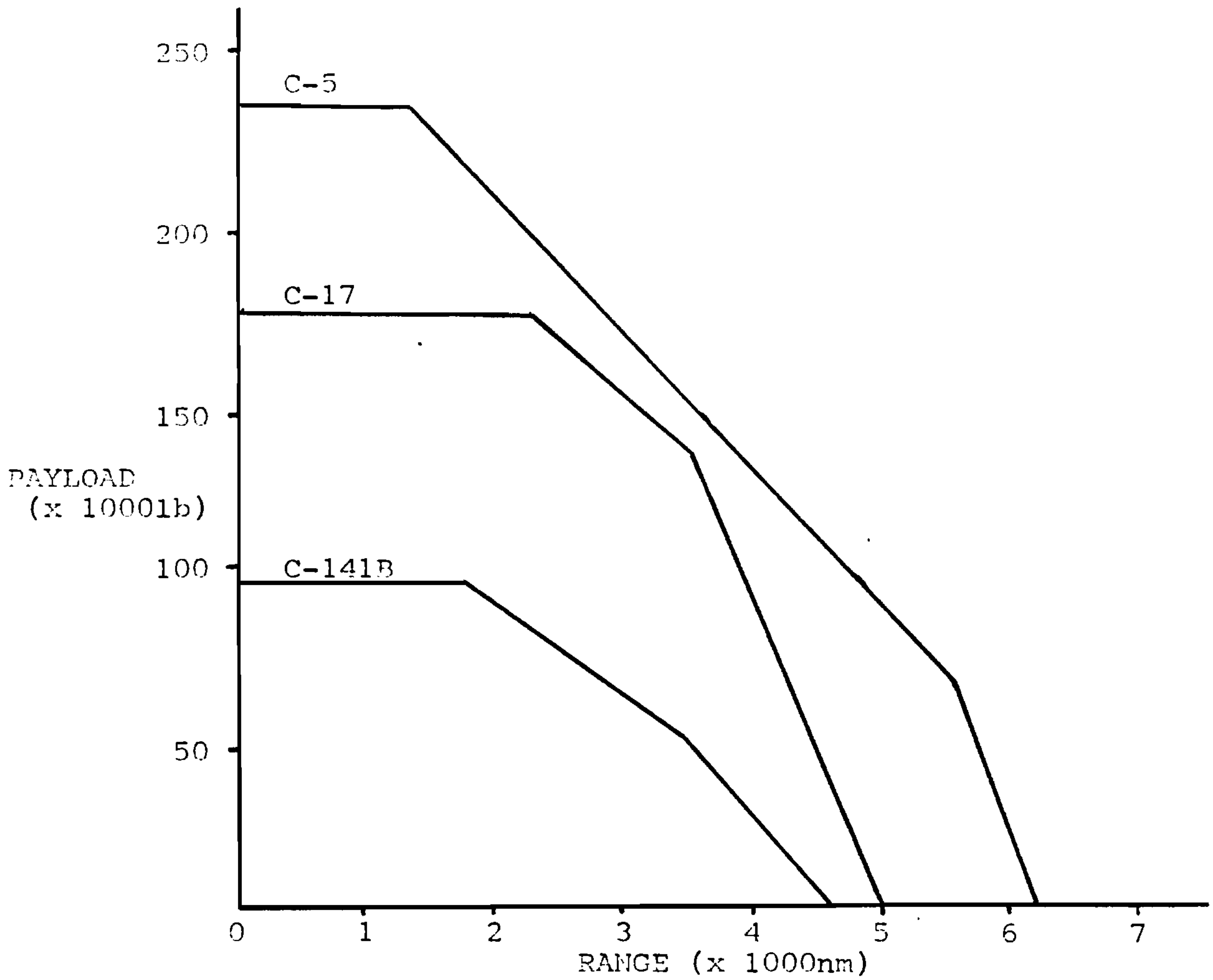


Fig. 6 Payload/Range Comparison (8)

MEASURE: AIR REFUELING

Description: Air refueling capability can dramatically impact the airlifter's cargo-carrying efficiency. For example, the ACL may be limited due to the maximum allowable TOGW for a given runway under given meteorological conditions. Air refueling may allow trading cargo weight for fuel weight since the fuel can be loaded on after takeoff during cruise. This tradeoff between fuel and cargo must be optimized to take into account the fuel efficiency (cost) or the system efficiency (time) or other resource needs such as air refueling tanker availability.

Standard: The standard includes not only the capability to air refuel but the rate of fuel onload: greater than or equal to 1100 gallons per minute, as stipulated by the RFP SS. (10) This rate should be at least equal to today's capability for like aircraft, namely the C-141B. SRD paragraph 3.14 requires the aircraft to further be "capable of aerial refueling to its capacity in a time equivalent to refueling 90% of its capacity at 1200 gpm."

Evaluation: The C-17 is equipped with the Universal Aerial Refueling Receptacle System Installation (UARRSI)(11), which is common to many of the Air Force's recent aircraft. This refueling receptacle has proven compatibility with the refueling nozzles of both the KC-135 Stratotanker and the KC-10 Extender. The C-17 air refueling rate of onload is 1200 gallons per minute. Its total fuel capacity is 27,310 gallons and this can be onloaded in twenty minutes exceeding the requirement to onload 24,500 gallons in twenty minutes. (12) The C-17 exceeds the air refueling requirements.

MEASURE: APPROACH

Description: This is the first deployment measure that significantly discriminates the C-17 mission from the existing strategic airlift mission. Strategic airlift delivery is generally limited to main operating bases (MOB) or deployment operating bases (DOB). These bases are relatively secure and serviced by approach aids, usually precision type, that allow approach and landing in extremely low ceiling and visibility weather conditions. The C-17's mission expands the strategic delivery sites to include forward operating bases (FOB) or worse to small austere airfields (SAAF). This direct delivery mode requires approach and landing at relatively less secure bases, depending on the level of enemy insurgence and proximity to the forward line of own troops (FLOT). Direct delivery to FOB's/SAAF's also may require approach and landing with approach aids somewhat less precise than those available at MOB's/DOB's.

Standard: No approach aids would be considered the absolute worst condition. The likely worst approach aids would be tactical nonprecision approach aids such as available with the insertion of a combat control team (CCT), including equipment such as the air droppable tactical navigation (TACAN) set. At best, the DOB/SAAF may be equipped with precision approach aids comparable to those at the MOB/DOB (13), although they may suffer some degradation in accuracy. On-board approach systems such as visual approach monitors (VAM) or station keeping equipment (SKE)/beacon approaches would fall somewhere between the two limits. The standard for approach is the capability to safely complete an approach under the likely worst condition.

Evaluation: The C-17 has a complete complement of precision and non-precision approach instrumentation.(14) The instrumentation is enhanced by the addition of a heads-up display (HUD) (15) allowing the pilot to view critical flight path and aircraft performance information through transition from the instrument portion of the approach to the visual portion including landing. The HUD is especially useful when flying approaches to the austere environment and relatively short runways at SAAF's. It allows optimal approach flight path and maximum use of the runway's available length. The C-17 is equipped with SKE (16); therefore, the aircraft can use other aircraft for approach guidance. A weather radar over-lay on the map and SKE formats of the horizontal situation display enhance the ability to safely complete approach in instrument weather conditions. (17)

MEASURE: LANDING

Description: This measure is a function of the runway at the destination base. Runway length and its ability to support operations are the primary elements of this measure. Again, the direct delivery capability of the C-17 to FOB's/SAAF's are likely to have more restrictive runways in terms of length, width, and surface composition. (18) The length of runway required for landing generally results from the same constraints that determine the length of runway required for takeoff. The principal constraints are aircraft weight and environmental conditions such as wind, precipitation, and pressure altitude.

The surface composition of the runway required for landing is indirectly a function of the aircraft's weight on the runway. Runways are measured by their capability to support the weight of the aircraft, measured in footprint pressure. High gross weights can be distributed by the design of an aircraft's landing gear resulting in lower footprint pressures.

Standards: The runway length is limited by the RFP definition of SAAF's. (19) The aircraft must be able to land on a 3000 ft. runway with a 50-ton payload and on a 4000 ft. runway with its maximum 2.25g payload of at least 65 tons.

The likely DOB/SAAF runway will be able to support the footprint pressure of C-130's at maximum gross weights and provide enough length for a C-130 to safely stop on the runway. This standard includes a footprint pressure less than or equal to the C-130 and a length less than or equal to the runway length necessary to safely stop a maximum gross weight C-130.

The RFP classifies runway requirements by load classification number (LCN) or group (LCG). The LCN is a numerical index of pavement stress caused by an aircraft at specified weights and considers that aircraft's footprint pressure and weight distribution. LCG is a grouping of airfields with similar stress capabilities or LCN's. SS paragraph 3.2.1.1.3 (Ground Flotation) requires the C-X to conduct "unlimited operation on LCG III fields." This equates to expected surface strengths at FOB's typically used by C-141 weight aircraft. This same paragraph also requires the C-X to have an LCN no greater than 40 "with a payload of 100,000 lbs...and fuel to fly a 500 NM range mission with zero payload." This equates to SAAF'S being used by C-130's. Additionally, the RFP requires the C-X to be "capable of operating on designated unpaved, semi-prepared compacted surface (sand, gravel, etc.) runways." This supports the capability to operate efficiently at SAAF's even when restricted by available taxiways, or an off-taxiway capability.

Evaluation: The C-17 meets or exceeds the standards for this measure. The C-17 can land in 2650 ft. with a 50 ton payload and 2700 ft. with the maximum 65 ton payload using maximum effort landing procedures. Using normal landing procedures it can land at this maximum payload in 3300 ft. (20) The C-17's landing gear design allows high sink rate touchdowns, therefore, shortening the landing run requirement. High sink rates are controlled throughout the approach and landing by the C-17's externally blown flap design. This design also reduces the approach speed which further shortens the required runway length.

The C-17 meets all of the LCN requirements. (21)

MEASURE: GROUND MANEUVERING

Description: This measure includes taxiing from the runway to the parking area and parking at the SAAF. Taxiing from the runway may require turning on the runway for back taxi to access taxiways or departing the runway surface to get to the taxiway. Turning radius available may be restricted by the runway width (22) if the off-runway surface is not capable of supporting aircraft or obstacle proximity is hazardous to the turning aircraft. The width of the runway may require extremely short radius turns or backing by the aircraft on the runway. Due to likely high frequency use of the runway, any maneuvering must be timely, therefore eliminating anything but self-maneuvering by the aircraft. Reliance on external means such as tugs is not realistic.

Parking space limitations posed by any combination of small parking ramps or number of aircraft on the ground in the parking area also requires small radius turn ability or even backing.

Standard: The standard for parking and maneuvering space is found in the FOB/SAAF definitions (23) and approximates the area required for a C-141. The strategic cruise capability demands an aircraft planform comparable to the C-141B. The defined width of DOB's/SAAF's runways and parking areas demands a turn radius less than 90 ft and a backing capability. SS paragraph 3.2.1.9.1 states the turning capability:

"It is desired that the C-X be capable of a 180 degree turn on a 90 ft wide LCN 40 paved runway with not more than three maneuvers and without external assistance."

The airfield characteristics in the airfield definitions describe parking at the FOB as "...restricted for large aircraft due to ramp size." while the SAAF's "...typically provide less than 100,000 square feet of ramp space". It goes on to say: "...access to the ramp via a single narrow taxiway (no parallel taxiway system), and no turnaround areas at either end of the runway." Backing up is addressed in SS paragraph 3.2.1.9.2: "The C-X shall be capable of backing up..."

Evaluation: Using its maximum nose wheel steering angle, the C-17 requires 73.5 ft to negotiate a three point K-turn. Additionally, either pilot can control ground maneuvering since nose wheel steering is actuated using the rudder pedals vice a wheel used in other large aircraft.(24)

The aircraft is designed to back up a 2.5% grade at maximum gross weight. Wing tip and tail clearance radius for a 180 degree turn is 125 ft, less than required for a C-141B. (25)

MEASURE: OFFLOAD

Description: This measure evaluates the capability to offload cargo at the destination airfield. The C-X direct delivery concept to FOB's/SAAF's limits the type of material handling equipment (MHE) to conduct offload operations. The likely equipment at the FOB will be 25,000 lb capable (25 K) loaders, adverse terrain K-loaders and forklifts. The SAAF's will likely have adverse terrain (A/T) forklifts but could have nothing to support offload operations. (26) Flat bed trucks at the FOB are the most restrictive operations in that environment and therefore the ability to offload to them should be considered. The SAAF's austere environment in early stages may require speed or combat offload operations until MHE arrives on the scene.

Standards: The RFP SRD, paragraph 20e, requires a combat/speed offload capability "...to offload in two minutes or less at least nine individual 463L pallet loads weighing 10,300 lbs. each."

The cargo compartment should be designed to allow loading/offloading of outsize cargo using the ramp alone. The ramp height must be compatible with MHE (including flat bed trucks) in the austere SAAF environment. (27)

Evaluation: The cargo compartment has a full width ramp with hydraulically deployable ramp toes allowing loading/offloading of outsize cargo using the ramp alone. If MHE is used, the ramp is equipped with two stabilizer struts rated at 50,000 lbs each for cargo transfer to flat beds, A/T K-loaders or A/T forklifts. Ramp height is 64 in insuring compatibility with MHE in the austere environments. (28) The C-17 can combat offload 9 pallets in less than two minutes. (29)

Employment

Tactical airlift has the primary responsibility for the three employment mission subelements of airland, airdrop, and extraction. Accordingly, the C-130, our only remaining tactical airlift aircraft, is designed to optimally operate in these three mission subelements. Strategic airlift aircraft are capable of operating in the first two employment mission subelements. The C-141 is routinely operated in the airdrop function; however, it does not have an outsize cargo capability. The C-5 is capable of airdrop but the crews are not trained, nor does the aircraft routinely airdrop. Neither the C-141 nor the C-5 is considered capable of extraction.

The C-X is required to perform the employment mission and fill the void of delivery of outsize cargo using the employment mission subelements. The following evaluations will cover airdrop and extraction since the airland subelement has virtually been evaluated in the direct delivery to SAAF portion of the deployment evaluation. The difference between direct delivery to SAAF and airland is difficult to distinguish. Direct delivery will primarily be used for resupply or reconstitution while airland is used for insertion of a tactical force. Both will land at a SAAF; the latter may be more concerned with tactics.

MEASURE: AIRDROP (GENERAL)

Description: Airdrop consists of various types: personnel, heavy equipment and container delivery system (CDS). (30) Each of these require different aircraft capabilities and must be exercised under different restrictions. Throughout the airdrop subelement, safety is an important consideration since it is inherently hazardous to airdrop, both for the aircraft with its crew and for the personnel or cargo that are dropping from the airborne platform. This evaluation will be conducted to determine the C-X airdrop effectiveness, considering safety throughout.

Aircraft positioning over the drop zone (DZ) is vital to allow the dropped personnel or equipment to land on or near the desired point of impact (PI). Visibility and winds at the drop altitude down to the DZ surface affect the accuracy and therefore, the safety of the airdrop. Airdrops are conducted either as single ship or in formations of aircraft.

Standards: The aircraft must be able to position itself or a formation of drop aircraft at the computed air release point (CARP) at the proper airdrop speed in weather and at night. (31) Drop accuracy must produce PI's within the current C-141 circular error probable (CEP).

Evaluation: The combination of the C-17's inertial navigation system, weather radar, station keeping equipment for formations and a full range of tactical radios allows the C-17 to meet and likely exceed the C-141 CEP criteria.

MEASURE: PERSONNEL AIRDROP

Description: Personnel airdrop is normally conducted out of the side (troop) doors using today's airlift aircraft. It is possible to jump from the open ramp, but the use of static lines for multiple paratroopers is hazardous when jumping from the ramp. The ease of dropping paratroopers and the drop airspeed directly affects the limit on the number of troops jumping in one pass on a given DZ. The DZ's length limits the time available to drop paratroopers if they are to safely land on the DZ. Various means are used to facilitate the rapid departure of paratroopers from the aircraft. The trooper must be protected from the slipstream blast when he jumps from the troop door to allow minimum spacing sequencing. Proper sequencing must be controlled, usually by lights, voice or hand signals.

Standard: The troop door should be equipped with blast deflectors and must be wide enough to allow the safe exit of a paratrooper without injury to the paratrooper or damage to the static line. The RFP SRD further states in paragraph 19c:

> "During the jump, the deployed deployment bags and static lines should not interefere with safe exit and parachute deployment of succeeding jumpers."

Additionally, airdrop peculiar hardware should be accessible, easy to install and not interfere with other mission configurations.

Evaluation: The C-17 is designed to safely airdrop up to 100 combat equipped paratroopers from doors on either side of the aircraft in 55 seconds or less at a speed of 115 knots. (32) All airdrop equipment is either integral to the aircraft or is easily installed/stowed to allow successful operations in other mission configurations.

MEASURE: HEAVY EQUIPMENT AIRDROP

Description: Heavy equipment airdrop is conducted by the C-130 from the ramp and door of the aircraft using parachutes to extract the load from the aircraft and then carry the load to the DZ. The aircraft is equipped with a remotely actuated release of the extraction parachute and with cargo rails that hold the palletized equipment in place. The rails hold the load in the aircraft until the extraction parachute's force overrides the rail's retention force. The load must exit the aircraft cleanly to avoid damage to either the aircraft or the load. Height of the load is restricted due to the fact that the delivery chutes ride on top of the load until the load is clear of the aircraft.

Standard: The C-X should be able to safely and efficiently airdrop heavy equipment using a system similar to that used by the C-130. An additional requirement to airdrop outsize cargo is not realistic for two reason: first, due to the severe design and performance penalties that this requirement would incur, and second, due to the fact most outsize cargoes are high value weapons or equipment that should be airlanded to insure survivability at delivery. The RFP does not address any equipment requirements peculiar to heavy equipment airdrop other than those described in the airdrop (general) evaluation. The RFP does require the ability to airdrop up to 35,000 lbs on a single platform and sequential airdrop up to 100,000 lbs on any combination of 8,12,16,20,24 and 28 ft platform lengths totaling up to a platform length of 60 ft. The C-X is also required to airdrop oversize cargo up to and including the M551 Armored Reconnaissance/ Airborne Assault Vehicle (AR/AAV).

Evaluation: The C-17 exceeds the standard. It uses a system similar to the C-130 for heavy equipment airdrop;however, its airdrop weight capacity is much greater than the requirement. The C-17 is designed to drop a maximum single platform load of 55,000 lbs and a maximum total sequential load of 110,000 lbs. (33) Although not a requirement, the C-17 is designed to drop outsize cargo.

MEASURE: CONTAINER DELIVERY SYSTEM (CDS)

Description: Airdrop by CDS is a gravity method of delivery in which containerized cargo free falls from the aircraft and descends by parachute to the DZ. CDS is primarily used for delivery of food and small equipment that fits in the containers. Each container (A-22 type) is limited to 2350 lbs. each. Delivery is either from high altitude (25,000 ft) or low altitude (600 ft).

Standard: The C-X should be able to safely and efficiently deliver CDS. The RFP does not address any equipment requirements peculiar to CDS other than previously described. The RFP does require the ability to deliver up to 40 A-22 containers at the maximum weight of 2350 lbs. (34) This is significantly more than the 16 containers the C-130 is capable of or the 28 containers the C-141 is capable of.

Evaluation: The C-17 meets the standard. It is designed to deliver 40 A-22 containers at the specified weight from the specified altitudes. (35)

MEASURE: EXTRACTION

Description: Extraction is conducted using the Low Altitude Parachute Extraction System (LAPES). This system is used for pinpoint delivery of cargo where a landing zone is not available and the load is not feasible for heavy equipment airdrop. LAPES uses the drag force created by extraction parachutes in the aircraft's slipstream to extract a loaded platform from a low-flying aircraft. The C-130 uses a 15 ft. drogue parachute to deploy one to three 28 ft extraction parachutes that pull loads up to 36,000 lbs from the aircraft at 5 to 10 ft above the extraction zone.

Standard: The C-X should be able to safely and efficiently deliver cargo using LAPES. The RFP does not address any requirements peculiar to LAPES other than those previously described for airdrop.

Evaluation: The C-17 meets the standard (36); however, the extraction level above the ground exceeds the 5-10 foot extraction height of the C-130 due to the combination of its landing gear, stroke length and ramp height. The C-17 must be flight tested in the LAPES mode to determine its effectiveness. Damage to the extraction platform or the extracted equipment will have to be assessed to determine the effectiveness of the C-17 for LAPES.

Summary: Capabilities and Operational Effectiveness

The proposed C-17 appears to have all of the design characteristics needed to operate effectively in both the strategic direct delivery mode and the intratheater shuttle delivery mode, including employment mission subelements. This assessment is made with the understanding that the proposed

C-17 is a "paper airplane" and is described in engineering and aerodynamics terminology as it applies to operations. This understanding can be tempered with the fact that the technology used for design of the C-17 has been demonstrated, albeit on a smaller aircraft, the McDonnell-Douglas YC-15. Additionally, many of the new articles on the aircraft, such as engines and avionics, are either off-the-shelf items or will have a significant history of experience once the C-17 is available. For example, the same engines being used today on the Boeing 757/767 are the Pratt-Whitney 3027 that are to be used on the C-17. The engine will have millions of flight hours by the time the C-17 is flying.

Notes - Chapter III

1. DOD Directive 5000.3, p.2.

2. Ibid.

3. Chronology of Airlift in World and National Crisis, HQ MAC/ XPD (Maj J.E. Goodwin), undated, item 22.

4. McDonnell-Douglas Proposal for the D-9000, Vol.2:Sec. 8.2 and Vol.4:Secs. 2.3.3 and 4.3, and Mission Scenario Analysis Document (MSAD).

5. C-X RFP.

6. Proposal, Vol.2, Ch. 1,p.1.

7. Ibid, Vol.2, Ch. 14, Sec. 14.2.2.2.

8. Douglas Brochure, undated.

9. Proposal, Vol. 2, Sec. 14.2 and Vol 4, Sec. 2.1.1 and 2.1.2.

10. RFP, System Specification (SS), para. 3.1.4.

11. Proposal, Vol 2, Sec. 5.2.2.2 and Vol. 4, Sec. 2.1.5.

12. Ibid.

13. RFP, SS para. 40.4.

14. Proposal, Vol. 4, Secs. 3.1, 3.2, 3.3, and 3.4.

15. Ibid.

16. Ibid.

17. Ibid.

18. A comparison of airfield definitions in RFP SS para. 40.4.

19. RFP, SS para. 40.4.

20. Proposal, Vol. 2, Sec. 2.1.5 and Vol. 4, Sec. 2.2.3.

21. Proposal, Vol. 4, Sec. 2.3.1.

22. SAAF is defined as being a minimum of 90 ft. wide by RFP SS para 40.4.

23. RFP, SS para. 40.4.

24. Proposal, Vol. 2, Sec. 3.1.3, 3.1.4, and 3.1.5, and Vol. 4, Sec. 2.3.2.

25. Ibid.

26. RFP, SS para. 40.4.

27. RFP, SRD para. 18h and 20a.2.

28. Proposal, Vol. 2, Sec. 8.2.6, and Vol. 4, Sec. 4.3.

29. Proposal, Vol. 2, Sec. 8.2 and Vol. 4, Sec. 2.3.3 and 4.3.

30. MAC Airlift Operation and Maintenance, Boeing Military Airplane Co., Feb. 1980, p. 24.

31. RFP, SRD para. 3.6.4.2 and 4.7.4.2.

32. Proposal, Vol. 2, Sec. 2.11.4.3, and Vol. 4, Sec. 2.4.4, 4.4.3.

33. Proposal, Vol. 2, Sec. 5.2.2.2 , and Vol. 4, Sec. 2.4.2, 4.4.

34. RFP, SS para. 3.2.2.3.1.

35. Proposal, Vol. 2, Sec. 5.2.2.2, and Vol. 4, Sec. 2.4.2, 4.4.

36. Proposal, Vol. 2, Sec. 7.2.2, and Vol. 4, Sec. 2.4.2, 4.3.4.

Chapter IV

Operational Effectiveness

Now that the capabilities of the aircraft have been evaluated, the second part of operational effectiveness to analyze is the mission of the proposed C-X.

Part 2: Mission Analysis

Prior to conduct of any mission analysis, the mission being analyzed must be defined. Once defined, the analysis may be conducted in the context of many parameters. To focus this thesis, the analysis of the mission of the C-X is conducted in the context of the following parameters: a general description of the European Theater environment without the threat impact; and, the existing and proposed doctrine which supports the intratheater airlift requirement as viewed by both the Air Force and the Army.

Mission Definition

The mission of the C-X is defined by several documents; however, the MAC System Operational Concept (SOC) (1) defines the mission succintly as having two parts:

> First, the aircraft will airlift cargo including selected outsize, heavy weapon systems over strategic distances using air refueling if required.
>
> The C-X will deliver this cargo directly to SAAF's which are close to the battle area and then recover to theater MOB's.

Second, once at a theater MOB, some C-X's will shuttle cargo, including outsize, to the SAAF before reverting to a strategic, intertheater role.

The key points of this dual mission are the strategic direct delivery and intratheater shuttle of outsize cargo to SAAF's which for both roles are close to the battle area. The intratheater mission may use any of the employment subelements to deliver the cargo in the theater.

The RFP prescribed the C-X capabilities in terms of strategic and tactical airlift mission profiles. The profiles include the ability to fly the tactical employment mission the SOC describes by requiring an intratheater shuttle capability. In a limited manner, the RFP addressed the closeness to the battle area issue by postulating the survivability requirements for the aircraft. (2)

Unfounded perceptions of the C-X mission exist, and should be clarified. The C-X is primarily a strategic airlift aircraft; the intratheater role is secondary. Dr. Harold K. Brown, as Secretary of Defense, emphasized that he considered the C-X to be a long range, outsize cargo airlifter with an intratheater role only to the extent this role did not get in the way of its strategic capability. He went further by saying its intratheater role was secondary; not used to determine its design; and only to be used after the intertheater lift was carried out. (3) The strategic mission requirement was validated by the CMMS documentation of our need to add 25 million ton-miles per day (MTM/D) of additional intertheater airlift, of which 10 MTM/D is outsize. (4)

The CMMS also documented the shortfall in intratheater outsize airlift. Today we have no intratheater outsize airlift capability in MAC.

Professional proponents of the C-X describe this intratheater mission as airlift to SAAF's close to the battle area. They have not stressed the level of hostility the C-X will operate in nor the forward depth of the battlefield it will fly to to provide logistics support. As a result, operation of C-X aircraft into SAAF's close to the battle area conjures visions of flying a DC-10 size aircraft routinely into airfields located in brigade support areas (BSA) in the main battle area. This perception does not appear realistic; however, it has not been discounted by the MAC SOC.

In the treatment of operational considerations that may affect the employment of the C-X, the SOC lists enemy threat as a consideration. The SOC describes this consideration in terms of the threat's impact on C-X route planning, tactics, delivery mode, and the type of supporting force required such as fighter cover or electronic warfare support. (5) This infers the C-X will airlift far enough forward to face at least a low level of enemy threat. This requirement for forward depth will be addressed later in this chapter. Survivability/vulnerability and threat will be addressed in Chapter V.

<u>The Environment - The European Theater</u>

Maj. Gen. Thomas M. Sadler presents a vivid picture of the European theater the C-X will have to fly in:

> "Envision if you will, over four hundred tactical airlift aircraft moving throughout Europe to over a hundred air fields supporting NATO air forces and to literally hundreds of secondary air fields, drop zones, extraction zones, and landing zones in support of land forces. Envision also, the simultaneous daily movement into and out of the theater of hundreds of strategic airlift and CRAF aircraft and the need to provide logistics support and guidance to these missions. Envision if you will, meshing transport flights with the movement of thousands of friendly and enemy fighters and bombers participating in the air war..."(6)

The congestion that airlift aircraft will face in the theater is evident and will be intensified in the early days of the war. The intense level of airlift required in the early days of a war is best illustrated by the U.S. airlift effort produced for the 1973 Israeli war with Egypt: 22,318 tons were delivered during the first 32 days on 145 C-5 and 422 C-141 missions. (7) By the time sealift could arrive with its cargo, the peace treaty had been signed. The total resupply prior to the truce was supported by airlift.

Airfields, even SAAF's, are large immovable targets for the enemy. Attriton of available airfields will effect all types of aircraft and competition for ramp space will be high. This fact alone will influence dispersal to SAAF's, even in the rear of the theater, by friendly aircraft capable of using their restrictive characteristics. Some surviving MOB's will offer runways limited in length by enemy air, missile or artillery attack and therefore will only be open to aircraft capable of landing on the remaining runway until repairs can be affected.

Ground lines of communication (LOC) including road, rail, and water will be limited and airlift may be the only means of supply. (8) The LOC's may be limited by point or area interdiction. Area interdiction due to the use of chemical or nuclear weapons may deny the surface movement of forces and their supplies from the rear forward. Airlift may be the best means of timely movement for introduction of forces into the tactical situation.

Unpredictable, rapidly developing combat situations will further stress the call for airlift. The ground commander will have a need for responsive airlift. (9) Efficient utilization of aircraft will suffer due to the need to respond to emergency or unscheduled airlift requests. The addition of these requests to scheduled airlift will place unknown demands on intratheater airlift. The magnitude of the additional demand will be a function of the intensity of the combat. The existing balance of power in the European theater heavily favors the Warsaw Pact and the disparity is projected to grow.(10) This too will increase demand for more and responsive airlift which will further exacerbate congestion in the air and at air fields.

Attrition of the airlift fleet will place further demands on the airlift system. As a planning factor, only 90% of the airlift fleet will be available at the onset. The Air Force predicts within 180 days airlift will suffer an approximate one third loss and this is based on the assumption that NATO can achieve effective air superiority.(11)

Doctrine

Doctrine is described as a stated belief or a statement of intent.(12) For the C-X, this statement should be expected to address the manner in which the Air Force will support both the strategic direct delivery and intratheater shuttle mission, including the interface of these missions using the dual role C-X. To date, no stated doctrine exists in the Air Force. (13) The first step toward development of doctrine for employment of the C-X lies in the document describing the C-X's operational concept: the MAC C-X SOC. This document states the mission in general terms for the purpose of initiating the acquisition process. Once the acquisition is approved and vigorously pursued, the proponency of the C-X will develop the airlift doctrine more fully. (14)

The C-X will provide a service whose primary customer will be the Army. C-X doctrine should also address the support the Army expects the C-X to provide. The Army is in the initial stages of developing this portion of the doctrine.(15)

In the absence of existing C-X doctrine, assessment of existing Air Force airlift doctrine and Army combat and logistics doctrine is necessary to establish the most likely course of doctrinal development for the C-X.

In Air Force Manual 1-1, Basic Aerospace Doctrine of the USAF, airlift is categorized into strategic and tactical lift. The manual states:

"Strategic airlift resources possess a capability to airland or airdrop troops, supplies and equipment to augment tactical forces when required."(16)

This logically supports the concept of C-X direct delivery through augmentation of tactical airlift. Strategic airlift doctrine is assessed by LtCol Sorenson in an article titled "Airlift Doctrine". In this article he treats the evolution of airlift doctrine through the present and projects the shortfall of existing strategic airlift doctrine for supporting operations in a "high threat, high intensity combat environment".(17) His hypothesis is that our current strategic airlift doctrine may not work in the combat theater:

> "While the tried and true specialized logistics doctrine has served the strategic airlift forces well for the last 45 years and will continue to do so when operating day-to-day air lines of communication, the doctrine is not up to the task of power projection into a combat situation."(18)

He goes on to assert that for strategic airlift to be useful in power projection, strategic airlift crews must be trained in the tactics required to fly in the threat environment. This statement is easily transferrable to the C-X since it will be a strategic airlift aircraft routinely operating in the tactical airlift domain rather than on the augmentation basis of today's strategic airlift.

It can be argued that MAC is currently addressing the viability of using strategic airlift in a power projection role through various training and test programs. A portion of today's C-141 crews are currently trained and maintained in the combat airdrop mission (CAM). The only tactical mission they are not capable of accomplishing is the extraction mission. Additionally, strategic airlift crews and aircraft are flying in Red Flag and other training exercises using various tactics and procedures to evaluate and improve strategic airlift augmentation of tactical airlift. Numerous studies, tactics development and evaluation (TD&E) projects, and test and evaluation of aircraft modifications to enhance tactical augmentation have been undertaken in recent years.(19) These efforts should be invaluable if the C-X becomes operational. Recognition of the fact that the C-X will be used in the combat theater is evident in the survivability/vulnerability aspects that were incorporated in part in the C-X RFP.

In describing tactical lift Air Force Manual 1-1 goes on to say:

> "Tactical airlift supports theater objectives through logistics support of all theater forces, including those engaged in combat, and is normally executed under the operational control of the air component commander. Tactical airlift provides the immediate and responsive movement and delivery of combat troops and supplies into objective areas through airland, extraction, airdrop or other delivery techniques."(20)

Tactical airlift doctrine solidly supports the use of tactical airlift resources well forward in the MPA as suggested by AFM 1-1's contract to provide logistics support to "...all theater forces, including those engaged in combat...." AFM 2-4, Tactical Airlift, contracts to provide this logistics support as far forward as the Brigade Support Area (BSA). (21) When reading AFM's 1-1 and 2-4, one important factor must be understood: although the tactical airlift forces are chopped to the Theater Commander as theater airlift assets, they are routinely under the operational control of his Air Force component commander. (In reality, the COMALF, who ultimately is a representative of CinCMAC.) (22) Subjection of airlift resources to a threat environment is routinely based in the judgement of the air component commander. Threat vulnerability is a function of proximity to the FEBA. Chapter V will address how the threat increases as proximity to the FEBA increases.

The C-X with its dual role mission can logically be supported by both strategic and tactical airlift doctrine. Its direct delivery mission neatly fits strategic airlift's augmentation role. Currently, the C-141 in its CAM role can be chopped to a theater commander to augment theater airlift employment if the need arises.

The C-X intratheater shuttle mission can be supported by tactical airlift doctrine. The question of how far forward the C-X would be used to support Army combat forces would fall within the theater air component commander's jurisdiction over tactical airlift employment. Although the C-141 could be used in this role, it lacks the capabilities of the C-X to routinely operate into SAAF's. This limits the C-141 to airfields not in proximity to the FEBA and therefore reduces its exposure to the threat. It is conceivable, with its capabilities, the C-X could routinely operate in close proximity to the FEBA based on current airlift doctrine.

Joint tactical airlift doctrine for airborne forces has recently been revised in the draft joint manual, FM 100-27/AFM 2-4, Doctrine for Theater Airlift and Joint Airborne Operations. The scope of the manual is "...to provide guidance for joint activities from the initial stages of an airlift operation until its termination." (23) This manual discusses the three tactical airlift employment subelements of airland, airdrop and extraction in detail. Description of the airland subelement underscores the contraints under which any tactical airlift aircraft must operate.

Employment by airland offers many advantages to the Army including more economical use of airlift, capability to deliver mission essential items that are not air droppable, plus enhanced tactical integrity. It also has the disadvantages associated with landing zones: clearance from obstructions, trafficability, increased delivery time over airdrop/ extraction, and command and control. In the likely event the Air Force is called on by the Army to airland in the objective area, the Air Force qualifies the support that will be provided:

> "The speed with which airland elements are delivered into the objective area depends largely on the availability, capacity, and <u>security</u> of landing zones or other land facilities." (emphasis added) (24)

Security of the landing zone includes determination of the security required, as a function of threat vulnerability and the security forces available whether it includes level of air superiority, ground forces already in the area, or whatever is necessary. In addition to being employed as tactical airlift to support Army combat units, the C-X will have to provide Army logistic support throughout the theater. Air Force doctrine for logistic support describes this support as routine, scheduled or unscheduled channel traffic within the theater (25) presumably to rear area supply points for further Army distribution.

Army doctrine for both combat and logistics is currently undergoing major overhaul to acconodate the Division 86 concept and will likely evolve further to support the Airland 2000 concept. Existing logistics doctrine was reviewed to determine the manner in which the Army logistical network for combat is operated and its level of reliance on airlift to provide transportation of supplies to the combat force. Neither concept will have a significant impact on the design of the in-being logistical network the Army uses for combat.

Existing Army logistics doctrine treats airlift primarily as an asset for providing transport to the theater. The bulk of the intratheater transport is described in terms of the Army's organic transport, surface and heavy lift helicopter, with only cursory attention to non-organic transport. This attention usually centers around description of terminal operations or the organizations required to effect transshipment from non-organic to organic transport. (26)

Descriptions of the use of non-organic transport is limited to barely more than a listing of the types of transportation modes available for in-theater use. For example, FM 54-7, Theater Army Logistics, includes airlift in a short discussion of theater transport (mode) operations among motor, rail and inland waterway operations. (27) The manual stops there and assigns intratheater airlift to MAC. It adds:

> "Army air transport units provide airlift support for Army forces in accordance with operational requirements."(28)

Additionally, reliance on airlift for in-theater support is described as available only on a tentative basis and is therefore reserved for priority cargo rather than routine movement:

> "During actual operations, the theater commander allocates a portion of the available airlift to theater army. For planning purposes, however, air movement capacity is an assumption based on coordination with...Air Force planners. This assumed capacity seldom exceeds the requirement for movement of priority cargo. If there is an excess, planners should use it for non-programmed priority movements...Therefore, plans should not provide for routine movements by air of other than priority cargo."(29)

Airlift presently plays a significant role in priority movement of bulk and non-outsize cargo within the theater using the C-130. The C-X is designed to fill the void of intratheater airlift of outsize cargo. Presumably, intratheater airlift for outsize cargo will also be lifted on the priority basis used for non-outsize cargo. (Priority cargo usually refers to items critical to the continued effectiveness of combat operations.)

The logistics network used for delivery of command regulated(30) Class VII (major end item) supply such as a tank is a good example of the present system for delivery of priority outsize cargo. The major end item may be shipped to the requesting unit's supporting service and supply unit (S&S Co (DS)) or directly to the unit.(31) The proximity to the FEBA will be determined by the location of the delivery point. Generally, the delivery point is no closer than the Division Support Area (DSA) but may be as far forward as the Brigade Support Area (BSA). The DSA is usually located in the division rear, approximately 20 km to 30 km from the FEBA.(32) The BSA is usually located in the brigade rear, approximately 12 km to 29 km from the FEBA.(33)

Corps transportation assets are required to move a tank from the Corps rear forward to the division. These assets may have to move a tank from the division rear forward to where it is to be issued to the receiving unit.(34)

When reconstituting a unit, the Army plans to use a system called Weapon System Replacement Operations (WSRO).(35) Replacing a tank using WSRO is a complicated process that increases in complexity as the number of replacement tanks increases. Transportation to the fighting unit is a significant limitation since transportation to the division rear is primarily dependent on heavy equipment transporters (HET) over distances that may exceed 100 km.(36) Waiting time due to non-availability of limited HET's added to the time to transport by surface increasingly delays providing needed tanks to the supply company, which in turn issues the tank to the armored unit. Use of the C-X in place of the HET will shorten the transport time but the delays incurred waiting for available airlift may exceed the queuing time for HET's. Availability of C-X sorties may be greatly more limited than HET's.

Once the tank is delivered to the supply company in the DSA/BSA, actions must be taken to get the tank to a "ready for combat" status:

> "The tank cannot be put into "ready for combat" condition at the DISCOM until all of the BII (basic issue items: radios, installation kits, etc.) and other items requisitioned individually are received...Responsibility for crewing, arming, and fueling the tank rests primarily with the tank battalion.
> The ability of the battalion to accomplish these tasks depends on the enemy situation and the availability of the tank, crew, ammunition, and fuel."(37)

The point here is that actions are necessary to get the tank ready to fight. If the C-X were to deliver the tank, either directly from the CONUS or shuttle it from a CORPS MOB/FOB, these same actions would be necessary: Today, a plethora of restrictions apply to airlift of weapon systems including quantity of fuel allowed in the vehicles and transportation of ammunition with or without a weapon. The weapon system may not be transportable with peripheral vehicle equipment (BII) such as antennas and machine guns installed due to their size or position on the host vehicle. These factors may preclude delivery of a tank in a "ready for combat" status and therefore incur preparation delays. Granted, this example used a tank as the major end item, an inefficient use for the C-X; however, the same problems would exist for other outsize cargo such as the Infantry Fighting Vehicle and other more efficient loads.

Summary

Both Air Force and Army doctrine are adaptable to the C-X mission; however, the merits of using the C-X are situation dependent. For the Air Force, use of the C-X will likely depend on the air component commander exercising his judgment in exposing the C-X to the forward area threat. For the Army, movement priority depends on criticality of need by the combat unit and will dictate their requirement.

AirLand Battle

The major impact on the C-X resulting from the AirLand Battle concept lies in the types, sizes, and weights of equipment the C-X will be tasked to airlift. An Air Force study titled "Airlift of Army General Purpose Forces", (Saber Size-Army) determined the impact of the Army's modernization program on the capability of the Air Force to airlift typical Army units.(38) The study was part of an effort to demonstrate the need for modernization of our airlift. The study illustrated that "our airlift is becoming increasingly incapable of rapidly moving the combat forces of the Army."(39)

The study compared the weights of 1978 Army forces to the weights projected for 1986 forces. For example, a mechanized division would grow in weight from 51,167 short tons to 63,768 short tons or an increase of more than 24 percent. Additionally, this same division's out-size equipment would increase by more than 63 percent.(40) This study effectively illustrates the task the C-X will face along with the C-5 once AirLand Battle is fielded.

Notes - Chapter IV

1. HQMAC C-X SOC, p.4.

2. RFP, SS Para 3.2.10.

3. "Brown Reclama: Put Back CX, MX money, Relax F/A-18 Curbs," Aerospace Daily, 106, No. 9 (14 Nov 80), p. 62.

4. "Budget Cutters Are Only Ones Likely to Win Battle", Schemmer, pp. 38-44.

5. HQMAC C-X SOC, p5, para 6a (1)(e).

6. The Airlift Challenge, Maj Gen Thomas M. Sadler, Feb 13, 1978. Delivered at the 1978 Air University Airpower Symposium, Air War College, Maxwell AFB, Al., p. 1.

7. Chronology of Airlift, HQMAC, undated, item 22.

8. The C-X and Command and Control, Student Research Report, Maj. Shaw, Air Command and Staff College, May 81, p. 25.

9. The Airlift Lessons of Vietnam - Did we Really Learn Them? Student Research Report, Maj. Underwood, Air Command and Staff College, May 81, p. 9.

10. National Defense, Department of Defense, Mar 1983.

11. Strategic Mobility: Can We Get There From Here - in Time?, Association of the United States Army (AUSA), Summer 1978, p. 6.

12. Airlift Lessons of Vietnam, p. 11.

13. Telecon, Maj Spitzer, HQMAC/XPPD, Feb 15, 1983.

14. Ibid.

15. Telecon, Col Meese, US Army Liason to Aeronautical Systems Div, Air Force Systems Command, Feb 15, 1983.

16. Basic Aerospace Doctrine of the United States Air Force, Draft Revision, AFM 1-1, 10 Jan 83.

17. "Airlift Doctrine", Airlift Operations Review, Jul 81.

18. Ibid.

19. HQMAC/XPQT, Operational Test and Evaluation Division Files.

20. Draft Revision AFM 1-1.

21. Tactical Air Force Operations, Tactical Airlift, AFM 2-4, 10 Aug 1966, pp 3&4.

22. Telecon, Maj Spitzer, 15 Feb 83.

23. FM 100-27/AFM 2-4, p 1-3.

24. Ibid, p 14-6.

25. AFM 2-4 and AFM 1-1.

26. Combat Service Support, FM 100-10, HQ Department of the Army, undated, p 8-4.

27. Theater Army Logistics, FM 54-7, HQ Department of the Army, 30 Nov 1976, p. 5-9.

28. Ibid.

29. FM 100-10, p. 1-13.

30. "Command regulated" refers to items whose control is dictated by the commander. These are major end items that are "larger, complex, expensive, and crucial elements of combat power." Extracted from CGSC course P 411, Fundamentals of Combat Service Support, Lesson 6, p L6-IV-1-7,1982.

31. Ibid.

32. New Approaches to Reconstitution In High Intensity Conflict on the Modern Battlefield, Part I, BDM Report, 14 Mar 1980, Fig VIII-2, p VIII-5.

33. Ibid.

34. Ibid, p VIII-38.

35. Combat Service Support Operations - Corps, FM 63-3, HQ Department of the Army, April 1982, p. 5-18.

36. BDM Report, p. VIII-5.

37. Ibid, p. VIII-39.

38. Airlift of Army General Purpose Forces (HQ USAF Saber Size-Army Study), Student Study Project, US Army Command and General Staff College, April 1981.

39. Ibid, p 25.

40. Ibid.

Chapter V

Operational Effectiveness

I have described the congestion and some of the operational problems that will plague airlift in the European theater war environment. The addition of enemy threat in the theater will tend to further complicate both the congestion and operational problems. The enemy threat includes threats either while airborne or while on the ground. Airborne threats include enemy air defense fighter aircraft, enemy attack helicopters in an air-to-air role, enemy air defense artillery or other ground based enemy weapon systems ranging from individually deployed surface to air missiles (SAM's) through anti-aircraft artillery (AAA) to small arms. Ground threats include interdiction of runways, taxiways and parking ramps, sabotage, or attack by enemy surface combat forces.

The level of intensity of the threat can be expected to increase as you near the battle and would likely be most intense at the FEBA. Use of intratheater airlift close to the battle area has been shown as doctrinally supportable up to and including the BSA. Therefore, it is realistic to deduce the C-X in an intratheater role may have to face the threat consequences in this area of the battlefield.

Part 3: Vulnerability/Survivability

In order to assess C-X vulnerability, the threat as it specifically affects tactical airlift in the vicinity of the

FEBA will be addressed. Survivability of the C-X will be assessed by review of the active measures required to enhance C-X survivability and a description of the survivability qualities designed into the C-17.

Attrition of the airlift fleet and the loss of airlift capability result from the vulnerability and survivability characteristics of the airlift fleet. As previously stated, the U.S. can expect up to a one-third attrition of its airlift fleet in the first 180 days of a war. (1) This is a conservative estimate based on the confident assumption that the NATO air forces can achieve effective air superiority in the theater. Regardless of the percentage of attrition and the assumptions used to derive them (2), any loss of airlift resorces further degrades the limited airlift capability available. Additionally, use of the C-X in its intratheater role removes it from its strategic role. A loss due to increased exposure to threat forces may permanently remove the C-X from the strategic arena, further degrading our limited strategic airlift capability. (3)

<u>Vulnerability Assessment</u>

JCS Pub 1 defines vulnerability as:

> "The characteristics of a system which causes it to suffer a definite degradation (incapability to perform the designated mission) as a result of having been subjected to a certain level of effects in an unnatural (man-made) hostile environment."(4)

C-X vulnerability is best assessed by the threat forces the aircraft will be exposed to when flying in the expected European environment. The threat is categorized into threats while airborne and threats on the ground. Description of the threat will be discussed in two planes: horizontally and vertically. The horizontal plane encompasses the distance from the FEBA the C-X could be exposed to any enemy threat whether surface weapons or aircraft. The vertical plane encompasses the altitude above ground level the C-X could be engaged and attacked by surface weapons or aircraft.

The flight regimes of the C-X as dictated by the mission determine its exposure. The specific characteristics of the C-17 will be addressed in the later survivability assessment, but some immutable flight regimes should be discussed as part of the vulnerability assessment. These include the airdrop, takeoff, landing and LAPES phases of tactical airlift operations. All of these phases place an aircraft in a highly vulnerable state.

During airdrop operations, the delivering aircraft must slow down in the vicinity of the drop zone at a low altitude to allow safe and reliable delivery of whatever is being dropped. Airspeed and altitude limitations are imposed by paratrooper safety, parachute capabilities and cargo extraction or delivery techniques. Airdrop is routinely accomplished with airspeeds ranging from approximately 110 knots to 130 knots. (5) Using 120 knots as an example, aircraft performing airdrop would take thirty seconds to fly one nautical mile. If the run-in to the DZ is considered, the typical airdrop aircraft must be at this slowed down speed at least two miles prior to the DZ and will hold this speed over the DZ for approximately two more miles until the personnel/ cargo has safely departed the aircraft. Acceleration to escape airspeed is not instantaneous and adds to this exposed distance flown. If the acceleration distance is limited to less than one mile, the total exposure distance could be as little as five miles. (6) At 120 knots, an aircraft performing air drop may, therefore, be exposed for up to 2.5 minutes at drop altitude.

( ). Personnel airdrop for combat is currently restricted to no lower than 750 feet above the ground while cargo airdrop can go as low as 500 feet above the ground for CDS and 1100 feet for other cargo. (7) Even lowering the drop altitude to less than 500 feet would still place an aircraft significantly above tree level while disregarding drop safety. This height above tree level adds to the exposure of the dropping aircraft to ground weapon systems and other low flying aircraft such as helicopters.

During landing, airlift aircraft are in a highly vulnerable flight regime. Exposure is a function of aircraft maneuvering. Even using high rate dives and climbs exposes the aircraft for significant periods of time at low altitudes. Although the aircraft's forward speed using high descent rates may be as high as 120 knots its forward travel rate over the ground may not be more than half or 60 knots. Using maneuvering and high rate descents in visual approach conditions, the aircraft may be exposed at altitudes less than

3000 ft for a time greater than one minute at distances up to a mile from the runway.

Under instrument conditions (in peacetime: ceiling and visibility less than 1500 ft and 3 miles, respectively (8)) the landing aircraft may be exposed for distances up to three miles at airspeeds ranging from 100 knots to 210 knots. Using 180 knots approach speed up to a one mile point and 120 knots landing speed for only the last mile of the approach as an example, a landing aircraft may be exposed for 70 seconds at altitudes from 3000 ft down to ground level.(9)

During take off, aircraft are again in a highly exposed flight regime. Until climb/maneuvering speed is reached, an aircraft taking off is usually at a constant rate of climb at a stable altitude. The ground distance covered, even if tightly spiraling over the takeoff airfield, will have a radius of approximately one mile and the aircraft may be exposed for periods of at least one minute and may easily exceed this.

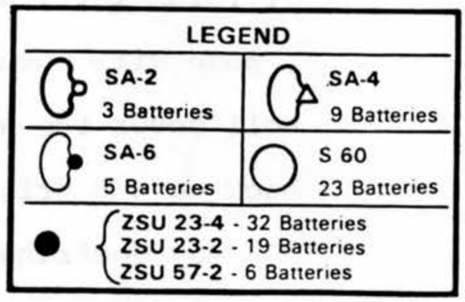
LAPES is a combination of landing, airdrop and takeoff. Typically this maneuver requires the aircraft to approach the airfield in a stabilized manner, deploying a drogue chute approximately 3 miles from the extraction zone (EZ) at an altitude of approximately 150 ft with an airspeed of 130 knots. On the last portion of the final approach to the EZ, the extraction chutes are deployed. The goal is to arrive over the EZ at 5-10 ft wheel height at an airspeed of 130 knots. Once the extraction is complete, the aircraft's performance (distance/timing/climb rate, etc.) approximates takeoff with the exception that the crew will have more aircraft configuration cleanup requirements and therefore checklists to perform. Total exposure will be from ground level to 1000 ft at airspeeds averaging 130 knots for a period of time approximately two minutes long. According to one recent study, LAPES provides the best chance of success for aerial delivery in forward areas. The following points made by the Assistant Division Commander of the 1st Cavalry Division support why LAPES can be considered the delivery tactic of choice for the Army.

> "1. delivery to the division rear allows The Division/ Brigade trains to move supplies.
> 2. provides mobile DZ's for maneuver ground commanders.
> 3. precludes concentrated supply targets of a fixed LZ.
> 4. provides increased flexibility (more LAPES) if directly delivered to DSA." (10)

These phases of tactical airlift operations are inherently vulnerable. If the operations are required to be conducted in forward areas the vulnerability increases accordingly. (10) As tactical airlift operations approach the FEBA, the aircraft become susceptible to more of the enemy's air defense package. (11) On the ground, the enemy air defense package is made up of anti-aircraft artillery (AAA) and surface-to-air missiles (SAM). Unlike previous wars with solid front lines, future conflicts will likely have highly irregular front lines. We likely will not have the relative degree of security for forward area airfields we have experienced in the past. (12) When enemy forces penetrate with their air defense weaponry, the vulnerability of theater airlines of communication will increase.

Current Soviet air defense coverage for motorized rifle and tank divisions is provided by organic air defense regiments. This regiment is equipped with either S-60 Automatic AA 57mm guns, SA-6 or SA-8 SAM's. (13) Motorized rifle and tank regiments within each division also have organic air defense batteries. These batteries are organized with a platoon each of ZSu-23-4 Quad 23mm Self Propelled AA Guns and SA-9 SAM's. (14) At batallion level, the mainstay is the SA-7 SAM which is a shoulder-fired missile for defense against low flying aircraft.(15) This combination of organic air defenses have a vertical coverage of as low as 20 meters for the SA-9 and up to 13,000 ft for the SA-6.(16) The effective anti-aircraft range for the Z Su-23-4 is 3 km (17), while the SA-9 has a range of 6 km, the SA-8 a range of 12.5 km, and the SA-6 a range of 30 km.(18) Guidance for the SAM's are either infrared (IR) homing or visually directed. (19) Figure 7 graphically depicts the horizontal and vertical coverage of Soviet Division-level AAA and SAM's.(20) Exposure to this air defense environment renders any aircraft flying in the area highly vulnerable to being shot down. Although their air defense is organized to protect Soviet forces from attack, given the opportunity, these weapons have the capability to fire on any aircraft within their range. Airlift aircraft may be considered highly lucrative targets when they are

WEAPON	TYPE	UNITS	WEAPONS LAUNCHERS
ZSU 23-4	AAA	32 Btry's	128
S-60	AAA	23 Btrys	138
SA-6	SAM	5 Btrys	15
SA-4	SAM	9 Btrys	27
SA-2	SAM	3 Btrys	18



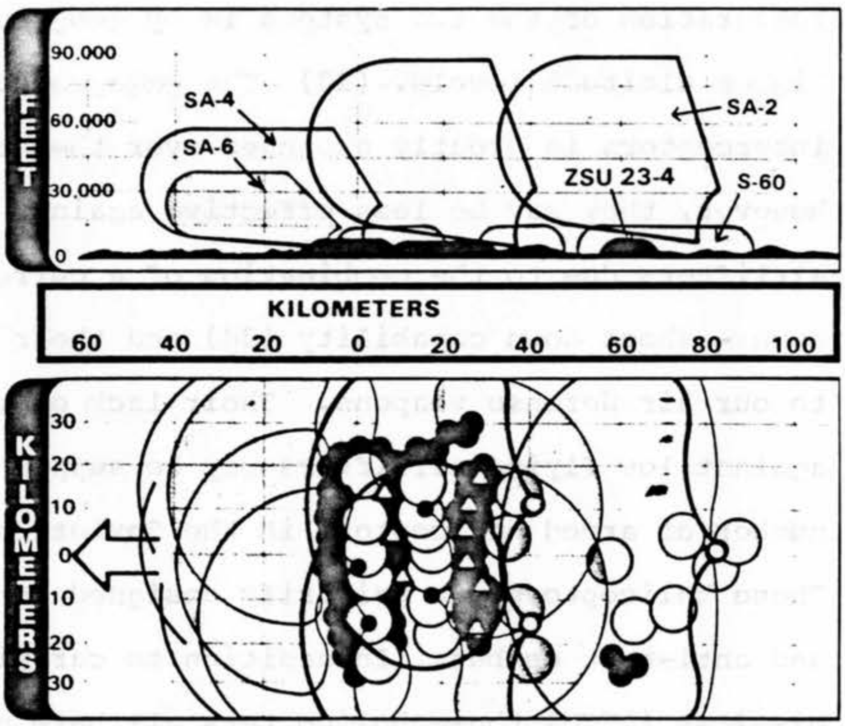


Fig. 7 Soviet Air Defense in Vicinity of FEBA (25)

resupplying combat operations.

The air defense forces listed are only those organic to divisions and regiments. Soviet Armies and Fronts above division level also have organic air defense weapons assigned , some with much greater ranges. The forces described can well cover the airspace over the main battle area all the way back to the brigade rear area. (21) As previously seen, the PCA may doctrinally be situated between 12-29 km from the FEBA.

Interceptor aircraft round out the Soviet air defense system. They have the mission to destroy enemy aircraft beyond the maximum range of the ground weapons. (22) Integration of the two systems is by geographical area and higher altitude levels. (23) The engagement envelope for interceptors is greatly expanded over the ground weapons; however, they may be less effective against low flying airlifters due to the combination of a current lack of look down - shoot down capability (24) and their own vulnerability to our air defense weapons. Their lack of effectiveness against low flying airlifters may be supplemented by the large number of armed helicopters in the Soviet Tactical Air Army. These helicopters are primarily designed for close air support and anti-tank combat. In addition to carrying anti-tank guided missiles (ATGM) these helicopters all have machine guns (26) that could be used against tactical airlift aircraft supporting tactical airlift operations. Soviet helicopter air-to-air capability is just now emerging. Both the U.S. Air Force and U.S. Army have evaluated Soviet helicopter air-to-air capabilities and tactics. (27) We can expect the enemy's armed helicopters, such as the Hind, to be a potential air-to-air threat to U.S. and NATO aircraft.

The previously mentioned irregular front lines not only increase the likelihood of exposure to air defense weapons, but render airfields in the forward area less secure to penetrating enemy ground forces. Any tactical airlift aircraft caught on the ground by advancing enemy ground forces would be highly lucrative targets as would the cargo they were delivering in support of combat operations. Aircraft may be immobilized at an airfield due to interdicton of the airfield's runways, taxiways or parking ramp. The limiting factor is the availability of a remaining runway segment long enough to allow takeoff. Consider interdiction of the already short runway length of a SAAF: A 3000 ft runway interdicted once at the mid-point will leave less than 1500 ft useable for takeoff. This may be prohibitive for takeoff at any gross weight.

ATGM and direct fire weapons used against aircraft on the ground could be devastating. It is more likely that these forward airfields would be increasingly exposed to enemy insurgent activities. A single insurgent armed with an SA-7 could easily be within 2-3 km of a forward airfield's approach or takeoff zone, and could therefore shoot down aircraft in the airfield's traffic pattern.

Of course, this picture of the threat environment in forward areas may be overstated since it does not address friendly air superiority, the protection of our ground forces or suppression of enemy air defense. Additionally, given an expected threat, the COMALF may not want to expose his tactical airlift assets to such a threat; on the other hand, the tactical situation may demand their support. Vulnerability to the threat is a profound argument for not using airlift aircraft in forward areas, regardless of their size and flying qualities.

Prior to assessing C-X survivability, the following, taken from a paper discussing the C-5's use in a tactical environment, foreshadows the discussion of C-X vulnerability:

> "The single, most important argument against employing the C-5 in resupply operations is its low probability of survival in a hostile environment and the resulting impact this would have on the airlift fleet. Smaller tactical transports with low-level, drag chute capability are not as vulnerable to ground fire as are large aircraft, due to their size alone."(28)

Also,

> "...The airlift aircraft, as presently conceived, is increasingly vulnerable to enemy aircraft defenses. Unless threat envelopes are avoided, suppressed, or screened, airlift cannot operate in the hostile environment on a sustained basis."(29)

Survivability Assessment

An aircraft's survivability in a hostile environment is determined by both active and passive measures taken to minimize vulnerability to the threat. Active measures may include operator-controlled tactics, use of the aircraft's performance capabilities, or offensive electronic counter measures. Passive measures may include design considerations such as system redundancy, shielding, fail-operative system design, or other designed-in safety factors that are also beneficial to survivability. The threat array in a forward area hostile environment has been shown to be staggering and its impact is magnified when flying large aircraft in a sometimes lumbering fashion to accomplish tactical airlift missions. To minimize C-X vulnerability to the threat, the aircraft must be designed with survivability as a dominating interest. Additionally, the aircraft should have designed-in performance characteristics available for use by the operator to increase survivability.

Tactical Operations

The C-17 is designed to maximize operator-influenced survivability, seemingly as much as can be for a wide-body aircraft during tactical operations. Prior to slow down for airdrop, airland, or extraction, the aircraft can be flown at low altitudes at high speed, 410 knots. (30) This speed combined with the comparatively low aural signature (31) of its engines reduces the enemy's detection capability approaching the DZ/LZ/EZ. Once near any of the zones, the aircraft has been designed to rapidly decelerate using inflight thrust reversers. Once the tactical operation is complete, the aircraft's engines have a high thrust to weight ratio allowing fact acceleration for escaping the DZ/EZ. The exposure time for stabilized flight over the DZ/EZ cannot be significantly altered by the aircraft's flying capabilties. Vulnerability reduction for these flight regimes must rely either on tactics, counter measures or passive design features.

The tactics used to accomplish either airdrop or extraction can be key to increasing survivability. Proper use of tactics can increase surprise and reduce exposure through random selection of routes and run-in headings to DZ's/ EZ's. Random use of DZ's/ EZ's decreases the predictability of the tactical operation and takes advantage of the enemy's unlikely capability to cover all routes, run-ins, and zones with enough firepower to stop the tactical operation.

As previously stated, LAPES is the delivery tactic of choice for the Army (32) in a threat environment. The advantages to the airlift fleet are gained by the ability to vary the direction of the approach, to fly the run-in at extremely low altitudes, and to spend minimum exposure time at the EZ. (33) These three factors if applied to any tactical airlift operation will reduce exposure and thereby increase survivability of the tactical airlift aircraft. (34)

Although LAPES combines these three factors effectively, there are times that airland will have to be used due to the perishability or value of the cargo being delivered. The route to the LZ may either be flown at high speed and low altitude, much like LAPES, with rapid deceleration for landing or at high altitude with a high speed spiral over the airfield and rapid deceleration for landing. The C-17 is designed to rapidly decelerate from 350 knots (cruise) to 113 knots (approach) in 55 seconds. (35) This is accomplished with the combination of high flap limit speeds and the use of inflight thrust reversers. (36) Additionally, the aircraft's automatic flight control system (AFCS) is designed for low altitude, high speed deceleration and acceleraion. (37)

For rapid descents to the LZ from cruise altitude, the C-17 can maneuver in a tight spiral or at descent rates of 15,000 feet per minute. (38) The ability for tight spiral is due to the combination of inflight thrust reverses and externally blown flaps. Figure 8 shows the descent capability claimed by the designer.(39) Note the time for descent from 10,000 feet to landing is 120 seconds and can be accomplished within a maneuver radius of 1500 feet from the landing point.

Figure 8 also depicts the takeoff/climb out capabilities of the C-17. The time to climb to 10,000 feet in a spiral is 160 seconds. Note the initial takeoff leg requires the aircraft to fly one-half mile from the field prior to its first turn. This is required for acceleraion and clean up. The spiral maneuver radius increases to approximately 2,000 feet for the climb. These comparatively tight maneuvers and short descent/climb times reduce the C-17's exposure and therefore increase survivability due to avoidance of threats.

In addition to the use of tactics and aircraft capabilities to avoid threats, other active measures have been used to protect airlift aircraft against heat seeking SAM's, although their effectiveness have not been sutstantiated. During the Southeast Asian conflict, C-130's routinely stationed crew members in the troop doors with flare pistols. The intent was to protect the aircraft against infra-red (IR) SAM's by firing a flare to cause the SAM to home on to the flare instead of the aircraft's engine exhausts. (41) Protection against heat-seeking SAM's using flares is an example of a defensive counter measure to increase survivability.

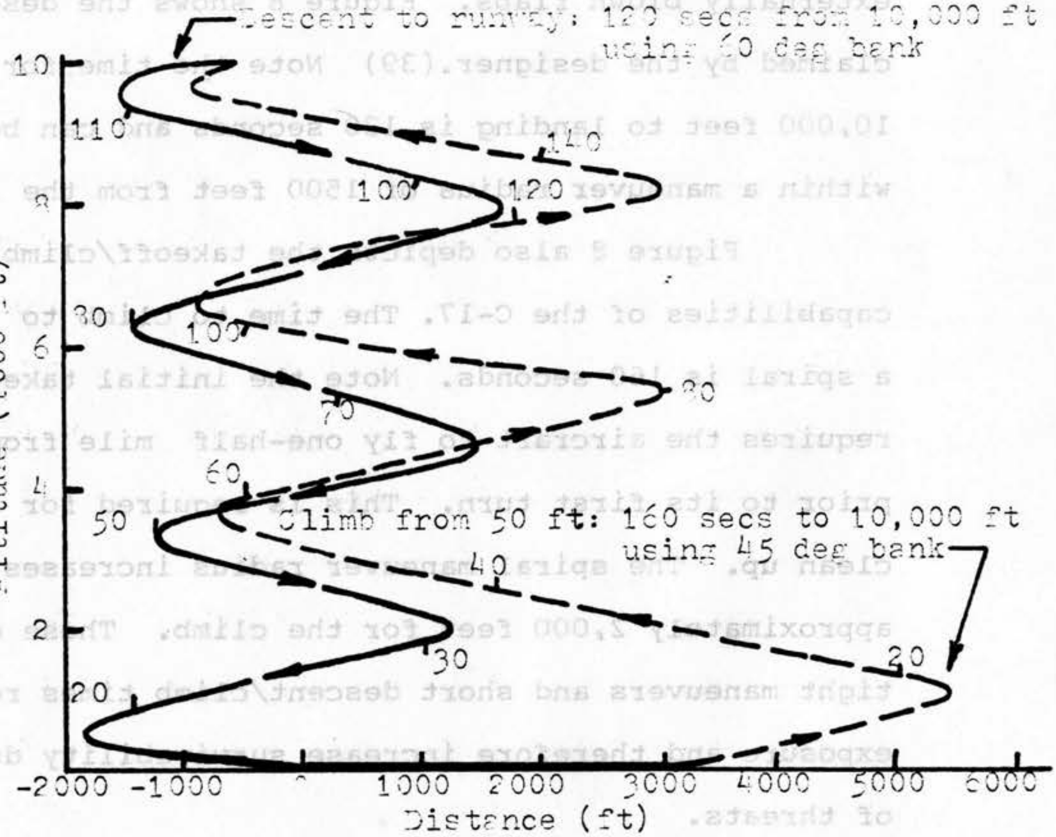


Fig. 8 C-17 Descent/Climbout Capability (40)

Electronic counter measures (ECM) such as jamming a SAM's radar acquisition and guidance could be adapted to airlift aircraft, although no current airlifters are so equipped. The C-17 has a designed in capability to carry ECM pods, including hard points on its wings, electronic wire routing provisions in its wings and control panel space in its cockpit. (42) Other systems, such as defensive guns, are not likely candidates for increaseing U.S. or NATO airlift survivability; however, the Soviets have set the precedent in this area by equipping cargo aircraft with tail guns. (43)

Airlift relies heavily on passive design features to increase survivability of aircraft. This approach acknowledges the risk entailed in operating airlift aircraft in a threat environment. Various design approaches are used to increase survivability but they can generally be divided into two areas: first, reduction of the likelihood a safety-of-flight system will be hit by the threat, and second, if hit, the system is either backed up by a redundant system, fails-safe to a manual system or isolates any effects to the location of the hit (suppression).

Reduction of the likelihood of a critical system being hit is accomplished by widely separating these systems. For example, the C-17's wide body allows wide spacing of flight control power systems, hydraulics, electrical systems, and avionics. (44) The electrical/avionics systems combine all of the design features to increase survivability as follows: (45)

> <u>Redundancy</u>: Four generators with redundants avionics for mission critical systems.
>
> <u>Separation</u>: Power centers and wiring separated to opposite sides of fuselage.
>
> <u>Isolation</u>: Pairs of generators isolated from each

other. Redundant avionics electrically isolated.

Shielding: Avionics racks and power centers located for maximum structural seidling.

Fail-safe: Mission completion with only one generator.

Fire/Explosion Suppression: Wiring separated from hydraulic and fuel lines.

Other features of the C-17 that have been designed to increase survivability are:(46)

Engines: The four engines are widely separated with fuselage shielding, and mounted well forward of the fuel tanks.

Flight Controls: The fly-by-wire flight controls have a redundant, mechanical flight control system. Safe flight possible with three of four elevators disabled.

Hydraulics: The aircraft has four independent, widely spaced hydraulic systems.

Bleed Air: On discharge from the pylon, the bleed air is below the auto-ignition temperature of fuel or hydraulic oil.

Oxygen: System lines, bottles and convertors are routed and located so that a ruptured system will not feed a fire in the vicinity of safety of flight components or combust flammable fluids. Additionally, a single hit cannot destroy both convertors and an interconnect permits crossflow if one system is lost.

Flight Control Surfaces: All primary flight surfaces are redundant with two power systems to each. Surfaces can lose one hinge and still function.

Fuel System: Tanks have inerting or explosion suppression systems. Some fuel lines are self-sealing.

Landing Gear: Multiple gear have dual brake and steering systems with free fall emergency extension capability.

Summary - Vulnerability/Survivability

Although the C-17 is designed to optimize survivability in a threat environment, the size of the threat and its reach from the vicinity of the FEBA pose significant hazards to any airlift aircraft operating in forward areas close to the FEBA. On those occasions when it is necessary to operate an airlift aircraft close to the FEBA, security measures such as combat air partrol (CAP) by fighter aircraft or suppression of enemy air defense (SEAD) will be required to insure the airlifter's survivability. The airlift aircraft with only passive defenses and design features remains vulnerable to enemy threat weapons close to the FEBA.

Given the high probability of exposure to the threat close to the FEBA and the decreasing intensity of the threat as you fly away from the FEBA combined with passive vulnerability reduction measures, the C-X should not conduct sustained operations in the forward area. Sustained operations should be restricted to no further forward than airfields supporting the DSA in the division rear area.

Notes - Chapter V

1. AUSA Special Report, p. 6.

2. There are vaious attrition studies, the bulk of which are classified.

3. CMMS documents the shortfall by theater and by cumulative days into the conflict.

4. Department of Defense Dictionary of Military and Associated Terms, Joint Chiefs of Staff, JCS Pub 1, 1 Jun 79, pp 367-8.

5. These airspeeds are the allowed minimum and maximum airdrop speeds for the C-130 and C-141.

6. Five miles is a conservative estimate based on experience flying the C-130.

7. Operations, C-130 Tactical Airlift Operations, MACR 55-130, Department of the Air Force, HQMAC, 1 Nov 78, Fig 23-2.

8. Flying, General Flight Rules, AFR 60-16, Department of the Air Force, HQ USAF, 5 Dec 80, p 7-1.

9. 3000 feet is an average start altitude for low altitude approaches.

10. Tactical Airlift in the European FEBA(U), AE Mras and JS Parmeter, May 77, SECRET- US Government Agencies Only, p.45.

11. Ibid, p. 39 and 41.

12. The Use of the C-5 in Forward Area Deployment and Support, Col L.B. Shuler, Air War College Research Report, Maxwell AFB, Ala., April 1969, p. 22.

13. Soviet Army Operations, US Army Intelligence and Threat Analysis Center, Department of the Army, April 1978, p. 5-22.

14. Ibid, p 5-24,25.

15. Ibid.

16. Organization and Equipment of the Soviet Army, HB 550-2, Combined Arms Combat Development Activity,

Department of the Army, 15 July 1980, table, 4-7, p. 4-7.

17. Ibid, table 4-6, p 4-6.

18. Ibid, table 4-7, p 4-7.

19. Ibid.

20. Tactical Airlift in the European FEBA, p. 15,16.

21. Ibid, p. 41.

22. Soviet Army Operations, p. 5-29.

23. Ibid.

24. The Soviets have shown increasing technological capability for look-down, shoot-down and are expected to have this capability in the near future.

25. Operations, FM 100-5, Department of the Army, 1 Jul 1976, p 8-3.

26. HB 550-2, pp 5-69 to 76.

27. "Helicopter Air to Air Combat Operations", Maj Gen C.H. McNair,Jr, United States Army Aviation Digest, Oct 81, pp 1,2.

28. Use of the C-5 in Forward Area Deployment and Support, pp 36-37.

29. Ibid.

30. Douglas Proposal, Vol. 4, sec 2.1.2.

31. The C-X aural signature is comparatively lower than the C-141 - a significant requirement for survivability in the tactical low level environment to reduce detection by troops on the ground.

32. Tactical Airlift in the European FEBA,p 45.

33. Ibid.

34. Ibid.

35. Douglas Proposal, Vol 4, sec 2.2.2.

36. Ibid.

37. Ibid, Vol 4, sec 2.4.5.

38. Ibid, Vol 4, sec 2.13.

39. Ibid, Vol 2, Ch 1, p 14.

40. Ibid, Vol 2, Ch 1, p 14.

41. Based on personal experience during flight operations into hostile environments.

42. Douglas Proposal, Vol 2, Ch 16, p 1.

43. "Jane's All The World's Aircraft, 1979-80", John W. R. Taylor, <u>Jane's Yearbooks</u>, pp. 175 & 187.

44. Douglas Proposal, Vol 2, Ch 16, Fig 2, p 3.

45. Ibid.

46. Ibid, p 1.

Chapter VI

Conclusions/Recommendations

The preceding analysis of C-X capabilities , mission expectations, and vulnerabilities defines problems peculiar to use of the C-X in a European intratheater environment. Other problems are induced by the C-X operational concept that are not directly attributable to the C-X's intratheater role, but result from the integration of the intertheater and intratherater roles. These include command and control planning and comparative effectiveness of using the C-X solely in an intertheater role.

Prior to discussion of these problems, a recognition of other problem areas not within the context of this study is necessary. The following problem areas, although important to total analysis of the C-X acquisition, are not within the context of analyzing the operational effectiveness of the C-X in the European environment and have therefore not been assessed but are left for other study:

Cost

The addition of a tactical employment capability to the C-X not only impacts its overall operational effectiveness but increases the cost of the aircraft. Some of these costs are obvious in terms of the hardware that must be added to the aircraft to allow it to conduct a particular tactical operation such as SKE for formation airdrop or all the mechanical devices necessary to perform the airdrop itself. Not so obvious are the costs in terms of penalties paid to allow a tactical capability. Typically these penalties are a result of weight added to the aircraft by the addition of the hardware needed for tactical operations. Every pound of added weight reduces the cargo carrying capability and decreases the fuel efficiency of the aircraft. Other penalties may result from design requirements. For example, insuring airdrop safety may alter the design of aircraft doors. The design differences usually increase weight and may affect the aircraft's aerodynamic efficiency.

Other areas for cost analysis include, but are not limited to, cost/benefits analysis of buying various mixes of airlift aircraft such as a combined buy of C-5A's, KC-10's, B-747's, C-141's and C-130's in addition to the C-X. Determining the optimum number of C-X's given existing airlift assets is also a cost factor. Additionally, the type and duration of the acquisition program impact the cost of the aircraft. Each of these is worthy of separate research.

Operational Suitability

Operational suitability was previously defined as a combination of the "-ilities" required to keep an aircraft in a satisfactory state of use in its operational environment. Typically, these are the maintenance requirements that determine the availability of a given aircraft to perform a given flight sortie. These maintenance requirements may adversely impact the operational effectiveness of the intratheater airlift system if the maintenance must be performed away from airfields where complete maintenance is usually available, such as MOB's. The impact is intensified if an aircraft needs maintenance at an austere airfield where even the most simple maintenance activity may be hampered by lack of commonly available maintenance stands or servicing equipment. Transport of such equipment to the austere airfield may require use of airlift, therefore, further detracting from the intratherater airlift system's cargo transport productivity.

Aircraft design can reduce the problems associated with maintenance in an austere environment by increasing the reliability of on-board systems, providing redundant systems that allow continued operations in less than a full-up mode, or making the systems accessible and serviceable without having to rely on equipment not integral to the aircraft.

Utility Tradeoff

When compared to other transportation modes, airlift's utility is far superior for the first days of a conflict due to its capability to rapidly respond. The C-X's direct deliver mode adds flexibility to early deployment scenarios especially to areas not served by large well-established airfields. The capability to lift outsize cargo increases this flexibility when responding to a need for a total force package. The C-X's tactical employment capability further increases flexibility where no airfields are available and troops, equipment and supplies can only be inserted by aerial delivery.

If certain restrictions are applied to the operation of the C-X, such as restricting it to a benign or low threat environment, what if any incremental gain is there over any other wide-body cargo aircraft? The main advantage the C-X will have is its ability to operate into and out of much smaller airfields than our current jumbo cargo carriers such as the C-5A, B-747, or DC-10. The C-X has been shown to be able to use not only shorter runways but smaller ramps for maneuvering and cargo operations while parked. (1) Even if restricted to the theater's rear area due to threat, the C-X should be able to take advantage of airfields that may remain after the theater MOB's have been interdicted. Additionally, the C-X may be able to continue use of interdicted MOB's after other widebody cargo carriers find them unusable. These types of tradeoffs under varying conditions must be thoroughly examined to determine the force mix for airlift.

Other tradeoffs have been adopted and continue to be examined. They include such plans as Prepositioned Overseas Material Configured in Unit Sets (POMCUS) and various alternatives for positioning of troops either close to or in prospective theaters. Once the rapid response requirement is satisfied, are there alternative modes of transportation that have more utility? Use of high speed surface transportation may be as beneficial. Use of lighter than air craft or surface effect vehicles may provide high tonnage input to the same areas where there are airfields accessible only to the C-X and smaller aircraft. These areas demand further study and may impact the C-X acquisition. aircraft. These areas demand further study and may impact the C-X acquisition.

Induced Problems

Command and Control(2)

This problem has been previously alluded to in the assessment of doctrinal supportability of the C-X in an intratheater role. When the C-X supports the theater commander, command and control relationships can take various forms. First of all, this control could be retained by the supporting command - MAC; second, control could be chopped to the supported command - the theater command; or third, some combination of these control frameworks might prove useful. The command and control issue comes under increased scrutiny when the C-X performs the shuttle role in the combat theater.(3)

Retention of control by MAC would keep airlift outside of the theater command and control structure; but would necessarily be responsive to theater tasking. This approach would allow MAC to remain responsive to crises worldwide. Additionally, MAC would retain the ability to reassign airlift resources without being constrained by theater boundaries.(4) Today, the MAC airlift force supports worldwide airlift requirements by conforming to the movement priority system approved by the JCS, thus providing a uniform method for controlling limited airlift capability. MAC manages the available airlift to fill the requirements using the most effective and efficient mix of assets. (5) JCS has the final responsibility to set priorities and allocate resources if the requirements exceed the capability. Although providing optimum flexibility to MAC, the theater commander will argue that this approach considerably impacts his flexibility in his theater.

Logically, the theater commander could exercise operational command (6) of the C-X while it performs its intratheater shuttle mission. Today, theater-assigned airlift forces are managed with traditional command relationships in which the theater commander exercises operational command of theater-assigned forces. The theater commander benefits in knowing he owns and controls his own airlift which is immediately responsive to his requirements. (7) If the theater requirements exceed the theater-assigned airlift capability, the theater commander turns to MAC for support in terms of supplemental airlift. If this still does not satisfy the theater requirement, the theater commander may request additional airlift by augmentation through JCS.

The C-X will have the capability to deliver directly to the theater forward areas and than revert to a shuttle mode. Current command relationships allow the C-X aircraft to be MAC-assigned for the intertheater mission and if directed by JCS or tasked by appropriate plans, selected aircraft, crews and support could be placed under the operational control of the theater commander(8); however, the flexibility costs to airlift management as a whole must be addressed.

Planning

Direct delivery to forward areas induces planning problems that have not been previously felt at the tactical unit level. Under existing deployment, individuals, equipment, and units all arrive in the theater to be allocated by the Theater Army to their receiving tactical units. With the advent of direct delivery, the Theater Army will have an additional requirement to coordinate through the Department of the Army (DA) more specifically where and when delivery must be accomplished. If units do not move with their equipment, linkup with their equipment could be a monumental problem. Additionally, if units are moved in a stream by C-X's with their equipment, airlift efficiency will suffer to some degree.(9)

To illustrate the magnitude of the problem, consider current means of deployment used in Reforger exercises. The bulk of troops are moved by passenger efficient airlift, namely CRAF, while their equipment, if not POMCUS, is moved by MAC in the early stages of the war. At the onload site, everything to be lifted is designated for delivery to a set few Aerial Ports of Debarkation (APOD) where the troops and equipment are linked up and marched to their respective areas. If direct delivery is used for the equipment alone, thereby retaining efficient use of CRAF for troops, the troops will land at an APOD that may be far distant from the direct delivery airfield. This is a result of the CRAF aircraft being restricted to theater rear MOB's. The linkup of troops with equipment, although not insurmountable, will require added coordination and transportation from the theater rear to the direct delivery site. If direct delivery is used for the troops and equipment, then the C-X will be taken from its prime cargo mission to support troop direct delivery. This is inefficient both in terms of CRAF and C-X. The CRAF passenger aircraft may sit idle while the C-X transports the troops required. Of course, each C-X used for troop direct delivery is one less that is available for critical equipment airlift.

A partial solution to the problem is to draw the equipment direct delivery back from forward areas near to the CRAF-capable APOD's. This has several benefits. It reduces the linkup problems of troops and equipment. It reduces saturation at the theater rear MOB's being used as APOD's for CRAF and aircraft such as the C-5A. It reduces the C-X's exposure to enemy threat. Finally, it allows retention of airlift efficiency for both C-X and CRAF. It does not solve the intratheater problems of delivery to forward areas.

C-X Intertheater Role

Although this paper has examined the C-X in its intratheater role, the C-X aircraft was originally pursued as an intertheater airlifter with a secondary intratheater capability. As previously referenced, the C-X will significantly supplement the intertheater airlift shortfall, especially for outsize cargo. Also, the direct delivery concept is meant to increase timeliness and flexibility of cargo delivery to forward areas. If the C-X is not used for delivery to forward areas due to threat, but is relegated to airfields in the theater rear or as far forward as the division rear, there are additional problems that surface. These problems are primarily found in transshipment of cargo between intertheater airlift and intratheater airlift or some other transportation means.

First, the sheer magnitude of the increment added by the C-X to intertheater airlift capability may overwhelm the capacity of the forwarding intratheater airlift. Second, it will certainly require many more personnel to conduct the cargo offload at the SAAF's, to prepare the cargo for further transport, and to transload it to forwarding transportation modes. Third, coordination with intratheater transportation modes will be multiplied due to the increased number of APOD's used for delivery. Additionally, in-theater receiving units may have their forwarding problems intensified especially in those instances where the receiving unit must provide the drivers or crews to move equipment to their forward areas.

Finally, using decentralized SAAF's as APOD's may compound problems of coordination and forwarding transportation when the SAAF is unavailable for use due to combinations of weather, limited approach aids, interdiction or insecurity of the field. Although direct delivery has benefits in terms of dispersal and resultant decrease in congestion, routine factors such as weather may force use of MOB's that will likely be able to continue operations when the SAAF's do not have this capability under the same weather conditions. Security of the airfield and air superiority may be concentrated in the areas of the MOB's while SAAF's are likely to have a lower priority and therefore may force C-X operations back to MOB's. Any of these factors may further congest the MOB.

Conclusions

The following conclusions are divided into the three parts used to analyze the C-X's operational effectiveness.

The dual role C-X may be inherently vulnerable to the threat; however, if doctrinally restricted to the theater rear areas, the C-X should prove to be operationally effective in the European theater environment.

Capability

The C-17 appears to have the necessary design characteristics to operate effectively in the direct delivery mode, the shuttle delivery mode and the tactical employment mode. Flight test of the C-17 will refine this rough assessment; however, the proposed design charactertistics clearly present a low risk of failure of achievement since the technology is either off-the-shelf or has been demonstrated by its predecessor, the Douglas YC-15. Two areas have not been proven and can only be validated by flight test: aerial delivery of outsize cargo and LAPES. For reasons previously stated, routine aerial delivery of outsize cargo may not be necessary or prudent. LAPES capability is still available by using the C-130. LAPES by the C-17 may have little additional benefit considering the typical cargo delivered by this method.

Mission

Although no doctrine has been proposed for the C-X, the dual mission of the C-X is partially supportable using existing doctrine for tactical and strategic airlift. In an intratheater role, the forward depth of the battle area the C-X should support may not be doctrinally based. With the exception of delivery of outsize cargo, the C-130 currently is responsible for the intratheater mission. The C-X will be able to supplement the C-130 in this responsibility with its ability to deliver outsize cargo to SAAF's. However, current Army doctrine does not appear to support acceptance of outsize cargo delivered as far forward as the BSA, the forward delivery point for the C-130. Joint tactical airlift doctrine for airborne operations can support use of the C-X in employment modes; however, the extent of the airland support provided may be constrained by such designated factors as security of LZ's in the objective area. Aerial delivery may also be similarly constrained since employment is also within the Air Force's jurisdiction.

In an intertheater role, direct delivery faces the same doctrinal problem for outsize cargo. Additionally, current concepts for marshalling and onload for deployment are based on delivery to theater MOB's rather than SAAF's. Use of strategic airlift assets as augmentation for intratheater airlift is doctrinally supportable. The change from an intertheater mode (direct delivery) to an intratheater mode (shuttle) back to an intertheater mode (redeployment/backhaul) is not clearly supportable by existing doctrine. Command and control of intertheater airlift forces used in an intratheater augmentation role is currently conveyed to the command to which the airlift resources are assigned. Assignment of these resources directly affects the mission flexibility of the command to which they are assigned.

Vulnerability/Survivability

The threat in the European environment is pervasive and its lethality is a function of the proximity of operations to the FEBA. Additionally, some threat may be found in proximity to forward area airfields. The threat may be composed of surface weapons, surface-to-air weapons, air-to-surface weapons, and air-to-air weapons or any combination of these weapons. The threat,therefore, can effectively cover from ground level to well above the service ceiling of the C-X. The threat has the ability to acquire, track and hit air traffic with visual, heat-seeking and radar controlled weapons.

The flight regime of the C-X is vulnerable to threats especially in the aerial delivery modes. Airland and LAPES possess the best characteristics to reduce vulnerability. LAPES is the preferred method due to not risking the exposure suffered by aircraft during ground operations. For this reason, airland operations require security of the airfield. The airfields used by the C-X should be no further forward than the DSA to provide this security. A wide-body cargo aircraft is inherently vulnerable due to its size and its comparatively slow operating air speed. Although the C-17 is considerably faster than the C-130, it does not have a significant dash speed compared to fighter aircraft. The C-17's acceleration and deceleration capability plus its climb, dive, and maneuvering characteristics are significant and may reduce its vulnerability. Tactics are useful means to reduce vulnerability. In combination with the C-17's flight characteristics, tactics may significantly reduce its vulnerability.

The C-17's design is optimized for survivability. Redundancy, structural shielding, suppression, and the ability to continue operations with minimum equipment all enhance the C-17's survivability. Although not equipped with specific offensive or defensive systems to protect itself, the C-17 has the capability to accept modification to give it an electronic counter-measure capability. The aircraft's design indirectly impacts survivability through its low aural signature and could be further protected through use of infrared protecting paint. Dispersion of main systems such as engines, avionics, fuel and hydraulics all enhance its survivability.

Recommendations

As described by the preceding conclusions, the C-X should be operationally effective in the European theater environment within certain limitations. Retention of this aircraft as a viable airlift force hinges on two pivotal issues that must be addressed doctrinally: mission requirements and the resultant threat exposure.

The following recommendations are proposed to concurrently take advantage of the aircraft's immense capability and optimize its effectiveness in the European theater. No effort is made to rank order these recommendations:

1. Intratheater operations, either in the direct delivery or shuttle mode, should be limited to the theater rear area and no further forward than the Division Support Area.

2. Tactical employment missions should be limited to those areas with no more than a low threat exposure.

3. If the aircraft is to be flown exposed to threat weaponry, it should be equipped with ECM gear.

4. If airdrop/extraction of outsize cargo is not doctrinally supportable by the Army, the need for the C-X to have the capability should be reevaluated.

5. The following issues should be studied further:

a. Command and control of the C-X force in its dual role.

b. The Army requirement for delivery of outsize equipment by air to forward areas.

c. Air Force and Army mechanisms to coordinate the timely and correct delivery of specific CONUS cargo to dispersed SAAF's in-theater.

d. Operational effectiveness in other theaters of operation such as South West Asian or Pacific.

Notes - Chapter VI

1. Discussed in Chapter III, Capabilities under the measure of ground maneuvering.

2. The impact of command and control is expanded in JCS Pub 1, DOD Dictionary of Military and Associated Terms, 1 Jun 79, p. 74, by the three distinct definitions:

a. Command - The authority which a commander in the military service lawfully exercises over subordinates by virtue of rank and assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel.

b. Command and Control - The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of a mission.

c. Operational Command - Those functions of command involving the composition of subordinate forces, the assignment of tasks, the designation of objectives and the authoritative direction necessary to accomplish the mission. Operational command should be exercised by the use of the assigned normal organizational units through the commanders of subordinate forces established by the commander exercising operational command. It does not include such matters as administration, discipline, internal organization, and unit training except when a subordinate commander requests assistance. (The term is synonymous with operational control and is uniquely applied to the operational control exercised by the commanders of unified and specified commands over assigned forces).

3. As previously discussed, when the C-X mission is changed to the shuttle role, it crosses the distinct command relationships of supporting and supported commanders. Unless the possible multiple transitions are clearly distinct, these relationships will be confused and adversely impact effective use of the C-X. See C-X Command and Control, Shaw, p. vi.

4. Ibid, p. vii.

5. Implementation Plan for the Consolidation of DOD Airlift Resources, 20 Sep 77, p. C-III-4.

6. See definition of Operational Command in 2c above.

7. C-X Command and Control, Shaw, p. vi.

8. Ibid, p. 20.

9. Using the outsize capable C-X to haul passengers is inefficient since it does not take advantage of its natural cargo carrying capability.

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