



**EXPEDITIONARY AIRLIFT OPERATIONS:
AN ASSESSMENT OF THE C-5's FIRST DEPLOYMENT**

GRADUATE RESEARCH PROJECT

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AFIT/GMO/ENS/03E-10

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Abstract

Our military is undergoing a transformation into an expeditionary force. In order to stay relevant under the new military construct, a weapon system needs to be able to perform in an expeditionary environment.

The C-5 Galaxy's low reliability rates have not made it an attractive option for conducting missions into austere airfields using a deployed infrastructure. The C-5 normally operates on intertheater legs, flying between AMC enroute stations where routine maintenance can be accomplished before returning to home station, mission complete. In fact, the C-5 had never deployed as a unit to an enroute location with a complete leadership, maintenance, support, and aircrew package in support of combat operations. That is until July 2002, during Operation ENDURING FREEDOM, when the C-5 was tasked to support the redeployment of a Canadian Light Infantry Regiment from Kandahar, Afghanistan to Diego Garcia.

This graduate research project presents a case study of this deployment and assesses the performance of the C-5 weapon system from two perspectives: effectiveness and efficiency, in order to determine whether or not the C-5 can perform in an expeditionary environment.

EXPEDITIONARY AIRLIFT OPERATIONS:
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I. Introduction

Background

Based on changes in the international security environment, DOD's new strategic approach, and this transformed concept of deterrence, the U.S. global military posture will be reoriented to: provide sufficient mobility, including airlift, sealift, prepositioning, basing infrastructure, alternative points of debarkation, and new logistical concepts of operations, to conduct expeditionary operations in distant theaters against adversaries armed with weapons of mass destruction and other means to deny access to U.S. forces.

Quadrennial Defense Review Report
30 September 2001 (14)

The U.S. military has an existing shortfall in strategic transport aircraft. This shortfall is aggravated by continuing low readiness of the C-5 airlifter, which has had an average peacetime mission capable rate over the last five years of approximately 60 percent.

Quadrennial Defense Review Report
30 September 2001 (14)

Within these two statements, lies the impetus for this research effort:
expeditionary and C-5. A likely question that might come to mind is "how can the C-5, an aircraft that historically operates at 60 percent availability, be expected to perform in an expeditionary environment?" However, the real question that mobility experts should be asking is, "how can we **not** expect the C-5, an aircraft that provides half of our organic airlift capacity, to perform in an expeditionary environment?"

Problem Statement

According to the 2003 Air Force Posture Statement, our military must continue its transformation into an expeditionary force in order to defeat the challenges we face from the wide range of new adversaries. This requirement is not just for our front line forces, but applies to all military resources as highlighted by the following statement, “We are truly an expeditionary force - the nature of our business is deployed operations” (22:10). Therefore, the C-5, an aircraft that is not traditionally considered expeditionary will need to develop this capability if it wants to stay relevant in today’s and tomorrow’s Air Force.

Until July 2002, the employment of the C-5 Galaxy in Operation ENDURING FREEDOM (OEF) was similar to its use during previous large-scale contingencies. The C-5 has traditionally been used to move cargo intertheater distances from continental United States (CONUS) bases to large, overseas aerial ports of debarkation (APOD) where the cargo is transloaded onto an intratheater mission for delivery into the area of operations (AOR). This delivery method was used extensively during the airlift to Afghanistan for OEF to take advantage of the strengths and minimize the weaknesses of each airlift asset. The following statement by retired General Tony Robertson, former Commander, United States Transportation Command (USTRANSCOM) highlights this fact when he was referring to the employment of the C-5 during the initial months of OEF, “We were very cautious where we flew the C-5s” (40:3).

Then in July 2002, an opportunity presented itself to use the C-5 in a way that had never been attempted in its 33-year history. Over 780 Canadian soldiers and 1,100 tons of cargo needed transportation from Kandahar, Afghanistan to Diego Garcia. Until this time, the largest Air Mobility Command (AMC) aircraft to land at Kandahar International

Airport was the C-17. Instead of tasking the C-17 to support this mission, AMC decided to challenge the C-5 community to perform its first-ever expeditionary deployment in support of combat operations. The mission required C-5's to deploy to Diego Garcia for three weeks with a complete support and command structure. The C-5 would operate into and out of the recently captured Kandahar airport to airlift the Canadian soldiers and cargo back to Diego Garcia.

The purpose of this research is to assess the performance of the C-5, an airframe that is singled out in the QDR as having a low state of readiness, in its first attempt to embrace the concepts of today's expeditionary military posture.

Research Question

The overarching question this research will attempt to answer is: “Can the C-5 fit into the expeditionary construct of today's Air Force?” The decision to use the C-5 as an expeditionary asset during the OEF deployment represents a significant change in the way this airframe has been used in the past. Based on the historical performance of the weapon system, this choice may have appeared destined for failure. The research question will be answered by conducting a case study of the C-5s first deployment to reveal its performance in this type of environment. System performance will be assessed in relation to the common management dilemma of effectiveness versus efficiency and results in two investigative questions. (The term ‘system’ is being used to highlight the fact that C-5 performance is dependent on an entire system of support, to include, planners, maintainers, operators, and other support personnel.)

Investigative question 1: How effective was the C-5 system in performing its deployed mission? Several measures of merit will be analyzed to make this assessment,

including required delivery dates, departure reliability statistics, mission capable rates, and en route ground time.

Investigative question 2: How efficient was the C-5 system in performing its deployed mission. The measures of merit for this assessment focus on resource utilization and include the number of aircraft and personnel deployed as well as allowable cabin loads.

Summary

The remainder of this paper is divided into four chapters. Chapter 2 builds a foundation for understanding why this deployment was so significant to the C-5 community by addressing several pieces of valuable information. First, airlift doctrine is introduced to reveal the airlift shortfall, the need for effective and efficient airlift operations, as well as employment concepts aimed at achieving this end. Second, the C-5 weapon system is introduced. This discussion involves C-5 capabilities, historical maintenance performance, and traditional employment methods. Third, an overview of airlift operations during OEF shows how the concepts of the previously discussed airlift doctrine have been applied. Finally, the departure from these traditional employment methods will be introduced by providing the concept of operations for the C-5 deployment. Chapter 3 defines the case study methodology used for conducting this research. Reasons for choosing this method as well as a detailed description of the case study design are presented. Chapter 4 presents the analysis of the significant data relating to the main research question and investigative questions. Chapter 5 provides the conclusions from the research and makes recommendations for future C-5 operations.

II. Literature Review

The United States must and will maintain the capability to defeat any attempt by an enemy – whether a state or non-state actor – to impose its will on the United States, or our allies, or our friends. We will maintain the forces sufficient to support our obligations, and to defend freedom. Our forces will be strong enough to dissuade potential adversaries from pursuing a military build-up in hopes of surpassing, or equaling, the power of the United States.

**President George W. Bush
The National Security Strategy of the United States of America, Sep 2002 (49)**

The Requirement and Shortfall of Airlift

Our military's ability to support President Bush's statement is largely dependent on our capability to project, employ, and sustain our combat forces anywhere in the world with minimal delay. This requirement has become more critical over the past twelve years as we have seen a 30 percent reduction of our forces combined with a shift from forward-deployed forces to more continental United States (CONUS) based forces (22:10). Airlift combines the unique characteristics of speed, range, flexibility, and responsiveness that is necessary to meet the requirement laid out in the National Security Strategy (32: v). Numerous studies have been accomplished to determine the required airlift capacity necessary to support the warfighter. The most recent study, the Mobility Requirements Study-2005 (MRS-05), determined that AMC's airlift fleet would need to provide the 54.5 million-ton miles per day (MTM/D) to support winning two near simultaneous major theater wars (13:1). This strategy has since changed but an updated mobility study has yet to be accomplished. At the time of the study, MRS-05 estimated that AMC only had the capability to provide 48.3 MTM/D with a projected fleet of 120 C-17's and without C-5 modernizations (13:5). This shortfall represents a degradation of our ability to project U.S. military power and limits our ability to achieve our national

security strategy. As a result, airlift becomes a national asset that must be used judiciously.

Effectiveness versus Efficiency

Airlift is a critical component of the US military capability, and because of its low density/high demand nature, every effort must be made to ensure it is used as efficiently and effectively as possible.

**MGen Timothy A. Kinnan
Commander, Air Force Doctrine Center (18:i)**

Airlift doctrine is full of references like the one listed above declaring the necessity for airlift to be both effective and efficient. But what does this really mean? A brief explanation of these two terms in relation to logistics management concepts as well as airlift doctrine will provide a foundation for how the measurement of the effectiveness and efficiency for the C-5 deployment will be accomplished later in this research.

By definition, effective means, “having an intended or expected effect” (48). The intended effect of the logistical cycle in a supply chain is to produce a certain level of performance that will satisfy operational requirements (8:56). These requirements represent customer levels are traditionally referred to as the 7 R’s: “Getting the right stuff to the right place at the right time for the right customer in the right condition in the right quantity at the right cost” (45). Effectiveness is measured based on the ability of the supply chain to satisfy these requirements. If all requirements are met, the supply chain is effective in accomplishing its mission (8:56). This concept is no different for defining the term effective in relation to airlift. The intended effect of the air mobility system is to provide delivery of cargo and/or passengers according to the combatant commander’s requirements. The effectiveness of the airlift system can be measured in many ways. Perhaps the most common metric used to describe the performance of the airlift system is

the MTM/D figure. Million ton-miles per day represent how much cargo can be moved a certain distance per unit of time. According to mobility requirements studies, a higher MTM/D capability represents an increase in the ability to satisfy customer demand, thus equating to greater effectiveness. However, this measure does not account for several important logistics management concepts that apply to effectiveness. Maximizing MTM/D output assumes that the greatest amount of cargo is desired in the shortest amount of time. There are times when maximum velocity is not desired because of system constraints, such as aerial port limitations or airfield capacity. In this case, reliability of the delivery time may be more critical and will serve as a better measure of effectiveness. This concept of reliability will prove to be a key principle for measuring the effectiveness of the C-5 deployment.

Efficiency is defined as “acting or producing effectively with a minimum of waste, expense, or unnecessary effort” or in other words, “exhibiting a high ratio or output to input.” (48). Efficiency in a supply chain is the measure of resources expended to achieve the desired level of effectiveness (8:56). If the minimum numbers of resources are used to satisfy the requirements of the customer, this is an efficient use of the resource. This definition also applies to the measurement of airlift efficiency. Resource expenditure in airlift is important to manage because of the limited number of resources available. However, airlift doctrine does not provide a meaningful way of measuring airlift efficiency. The only reference that directly defines how to measure efficient airlift operations is from the following statement, “The throughput of forces and material is a measure of the effectiveness and efficiency of this system” (17:31). Throughput is the amount of cargo and passengers that can pass through a port in a given time (30:446).

This measure of efficiency does not relate the amount of resources expended with the level of throughput. Also, efficiency should be measured relative to the desired level of effectiveness. This doctrine definition once again assumes that maximum throughput is desired. For these reasons, tangible measures of efficiency are difficult to obtain. The methods this research uses to determine efficiency are fully explained in Chapter 3.

Airlift Classifications

Air mobility assets are tasked against missions supporting the entire spectrum of national, strategic, and theater objectives.

Joint Pub 3-17. Joint Doctrine for Joint Tactics, Techniques, and Procedures for Air Mobility Operations (31:xiii)

Airlift forces are allocated among the competing requirements of intertheater and intratheater uses and must be managed carefully and to ensure maximum effectiveness as well as efficiency (31:VII-I). For this reason, a brief discussion of the difference between intertheater and intratheater is necessary.

Airlift application is divided into two major classifications: intertheater and intratheater airlift. An additional classification, operational support, consists of specialized aircraft that provide airlift and passenger support and will not be addressed in this research. The boundaries between intertheater and intratheater airlift are defined by the geography the airlift serves as well as the command and control relationships established to exercise authority and direction over the forces and not the type of aircraft.

Intertheater airlift “provides the air bridge that links the theaters to the CONUS and to other theaters, as well as airlift within the CONUS” (15:55). Intertheater missions are generally global in nature and provide common-user airlift to the supported commander’s theater. Due to significant distances between theaters, longer-range aircraft

normally operate this mission. In most cases, the Commander of United States Transportation Command (USTRANSCOM), will retain combatant command (COCOM) authority over these forces (18:27). Operational control (OPCON) of AMC assets is normally given to AMC's Tanker Airlift Control Center (TACC) which plans, coordinates, tasks, and executes airlift missions in support of USTRANSCOM's requirements.

In contrast, intratheater airlift "provides the air movement of personnel and materiel within a theater commander's AOR" (15:55). The intratheater mission frequently requires an aircraft that is capable of operating under a wide range of tactical conditions, including into small, austere, unimproved airfields. Also, assets designated to perform this mission are normally attached or assigned to the theater commander (15:55).

Airlift doctrine makes a point of not designating particular aircraft into the classification of intertheater or intratheater. Rather, doctrine states that the classification is based on the mission and not the aircraft type (15:55). Therefore, it is feasible for any airlift aircraft to serve in either of the two roles. This is an important concept to remember and resembles the innovative thinking that was required for the use of the C-5 as a deployed asset.

Airlift Methods and Employment Concepts

The variety of aircraft, methods of delivery, and distances involved make it (airlift planning) a very complex planning process due to the limited airlift capacity and availability.

**Air Force Doctrine Document 2-6.1
Airlift Operations (18:39)**

This quote highlights the importance of understanding the concepts of airlift delivery methods and how aircraft are employed. The following section will provide an overview of the airland method of delivery as well as a discussion of the two airlift employment methods: hub and spoke and direct delivery. These concepts will also be important to help understand the significance of the C-5 deployment.

Airland delivery involves landing an aircraft at an air terminal and unloading/loading cargo and passengers on the ground. As a result, ground times are accumulated while ground personnel are performing their duties to move the cargo and prepare the aircraft for its departure. This method is a cost-effective way of delivering cargo when compared to the risk and complexity of an airdrop; however, efficiencies are decreased the longer the aircraft remains on the ground (18:14). One way to expedite the delivery of cargo off the aircraft is to perform an engine running offload/onload (ERO). This method of delivery greatly reduces ground time, allowing for greater utilization of the aircraft. The benefits of EROs will be further addressed in this paper by analyzing their impact on the C-5 deployment.

There are two distinct methods of employing airlift aircraft in an airland mode: hub and spoke and direct delivery. Hub and spoke operations integrate both intertheater and intratheater operations. This concept attempts to consolidate cargo at an aerial port of embarkation (APOE) for long haul, intertheater shipments destined for the aerial port

of debarkation (APOD). These aerial ports are known as hubs and are normally main operating bases with sufficient support facilities. Once at the APOD, intratheater airlift is used to move cargo to forward operating bases (FOB) within the theater, also known as the spokes. This employment method commonly requires the use of intermediate staging bases along the route of flight between the APOE and APOD where routine aircraft maintenance and servicing can take place. The AMC en route system provides this support as well as the support needed at the APOD. While great efficiencies can be achieved using this method of delivery, effectiveness can be degraded due to the ground times at the enroute locations as well as transshipment times at the APOD where cargo is transferred from intertheater to intratheater airlift. (18:15)

The second employment concept, direct delivery, alleviates these shortcomings by delivering cargo and personnel from the APOE directly to the FOB within the theater. Direct delivery can significantly reduce the transportation time required to meet customer demand. However, there are trade-offs when using this employment method. If larger aircraft are used in direct-delivery roles due to the distances involved, a larger infrastructure may be required at the FOB. This will include maintenance and aerial port operations and possibly even crew rest facilities. All of these functions are significantly more difficult when operating at a smaller, more austere airfield that may be in a significantly higher threat level than the APOD. (18:17)

Introducing the C-5 Galaxy

The C-5 is a challenge. It can do things no other airplane can do, but reliability is still a problem.

**Brig Gen Peter J. Hennessey
AMC Director of Logistics (40:4)**

In order to fully appreciate the significance of the first expeditionary use of the C-5, the following three areas concerning the C-5 will be addressed: C-5 capabilities, C-5 maintenance performance, and traditional C-5 employment methods.

The Lockheed Martin C-5 Galaxy began its operational service in the United States Air Force in June 1970 (19). The aircraft was designed to support Air Force and Army requirements for a heavy logistics jet transport that would replace and augment the capabilities of the Douglas C-133 and complement the existing fleet of C-141 transports (26). Today, the C-5 serves alongside the C-141 and C-17 as one of AMC's three heavy airlifters that routinely carry cargo intertheater distances. The C-5 is the largest aircraft in the Air Force inventory and is capable of carrying up to 291,000 lbs of cargo (34:5). The C-5 has 36 pallet positions, compared to 18 positions for the C-17 and 13 pallet positions for the C-141. When designed, the C-5 was the only aircraft in the Air Force inventory that could carry outsized cargo. This design feature allowed the aircraft to handle almost all the Army's combat equipment. Other unique features that were designed into the C-5 include: the ability to load and unload cargo through both the nose and aft doors which open fully to the height of the cargo compartment, a landing gear kneeling system that allows the aircraft to lower so the cargo floor is at truck bed height to facilitate loading and unloading, and a high floatation landing gear consisting of 28 wheels capable of landing on unimproved airfields (19). The C-5 has a fuel capacity of

332,500 pounds which allows it to fly over 6200 NM without landing for refueling and like all of the other heavy airlift aircraft, the C-5 is capable of mid-air refueling (19).

AMC's ability to provide airlift to meet the warfighter's needs are highly dependent on the C-5's ability to perform its mission. According to AMC's Strategic Plan, the C-5 fleet is responsible for half of the organic airlift requirement needed to support our national military strategy as defined in MRS-05 (1:2). For this reason, reliability problems associated with the C-5 have a tremendous impact on our ability to meet the 54.5 MTM/D requirement.

C-5 Maintenance Performance

There are several key measures of merit AMC uses to evaluate the performance of an airlift weapon system. This section will discuss a few of these measurements for the C-5. These measures will later be used to evaluate the performance of aircraft during the C-5 deployment.

C-5 Mission Capable (MC) Rate.

MC rate is the percent of aircraft possessed hours that were Fully Mission Capable (FMC) and Partial Mission Capable (PMC) over a given time period (2:25). This figure provides a good indicator of how available the aircraft is to perform its mission. It should be noted that when AMC reports MC rates, this does not include aircraft that are in depot status. According to the Mar 2003 *Health of the Fleet* report published by AMC/LG, 16 C-5s out of the 126 aircraft fleet are expected to be in depot status at any given time (3). AMC's goal for the C-5 is to maintain a MC rate of 75% (3). This is relatively low compared to the standard for other AMC aircraft as shown in Table 1 below.

Table 1. FY 02 AMC Standard MC Rates

C-5	C-17	C-141	C-130	KC-10	KC-135
75.0	87.5	80.0	75.0	85.0	85.0

Despite the lower standard rate, the C-5 has had great difficulty in achieving the standard 75% MC rate. The following graph in Figure 1 shows the annual MC rate for the entire C-5 fleet over the ten-year period of 1993-2002. These rates were manually computed using the monthly MC rates from the *C-5 History* spreadsheet provided by CMSgt Linda Sobell at AMC/LGQMA (4). The average MC rate during this ten-year period is 63.2%.

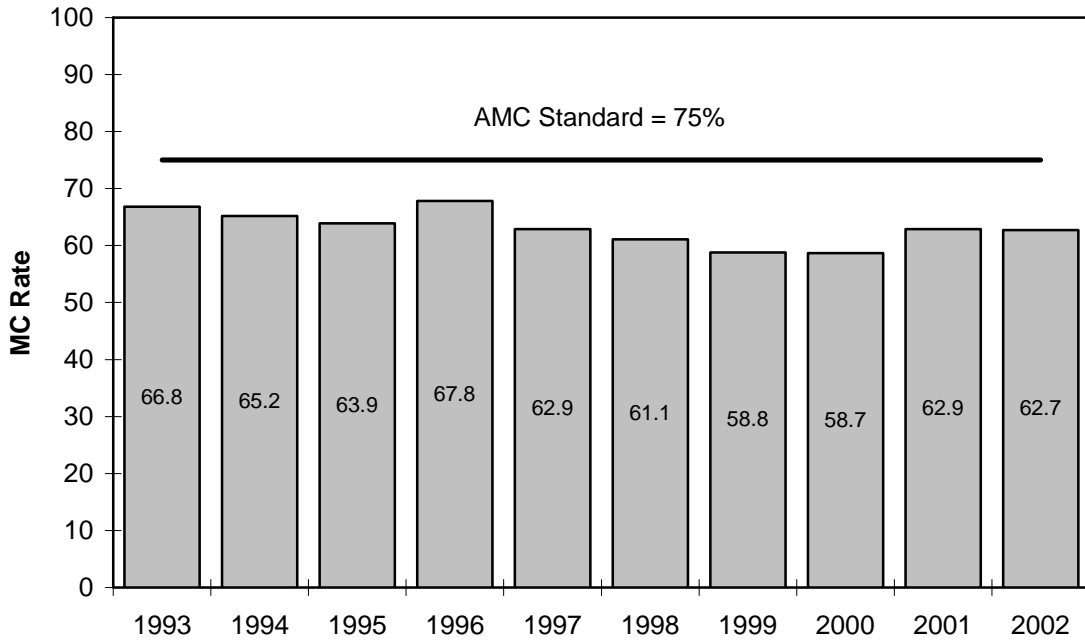


Figure 1. C-5 MC Rates CY 1993-2002

This graph highlights the difficulties in keeping the C-5 ready for duty. The delta between the AMC goal of 75% and the actual MC rate is a tremendous loss of potential airlift capability.

Departure Reliability.

Another measurement used in evaluating the performance of airlift aircraft is departure reliability. This figure is a measure of total departures that did not have a deviation from the scheduled departure time for any reason (2:21). An on time departure for AMC aircraft ranges from 20 minutes before until 14 minutes after scheduled departure time. Historically, the C-5 has had the lowest departure reliability rate of any AMC aircraft. As an example, the following table shows the C-5 departure reliability rate compared to other AMC aircraft during the 30-day period of 8 Apr 03 – 7 May 03. These figures were pulled from the “Mission Delay Report” on 13 May 2003 that can be found TACC’s external web site (7).

Table 2. AMC Departure Reliability Rates: 8 Apr – 7 May 03

C-5	C-17	C-141	C-130	KC-10	KC-135
50.4	76.9	60.7	82.4	64.7	76.8

As one can imagine, a 50% departure reliability rate for the C-5 severely limits the ability of AMC to meet its customer’s needs.

Logistics Departure Reliability.

There are many factors that contribute to a late take-off. AMC tracks the different causes for delays and breaks them into the following general categories: logistics, operations, higher headquarters (HHQ), transportation, and miscellaneous. During the 30-day period mentioned above, logistics delays had the greatest impact on the overall

departure reliability rate of 50%. Logistics delays accounted for 19% of the late departures compared to 11.8% caused by operational factors (7). Logistic delays have traditionally been the leading cause for the low departure reliability rate. A study conducted by RAND after Desert Shield/Desert Storm found that 40% of the mission delays were caused by logistics factors (35:50). Because logistics factors historically have been the leading cause for departure delays, a secondary measurement is used by AMC to more accurately describe maintenance's ability to generate aircraft for launch, logistics departure reliability.

Figure 2 measures the percent of total C-5 departures that did not have a delay caused by logistics factors for each month in the year 2002. Data for this graph was obtained from AMC/LGQMA (4). Once again, the C-5 falls short of meeting the AMC standard rate for reliability.

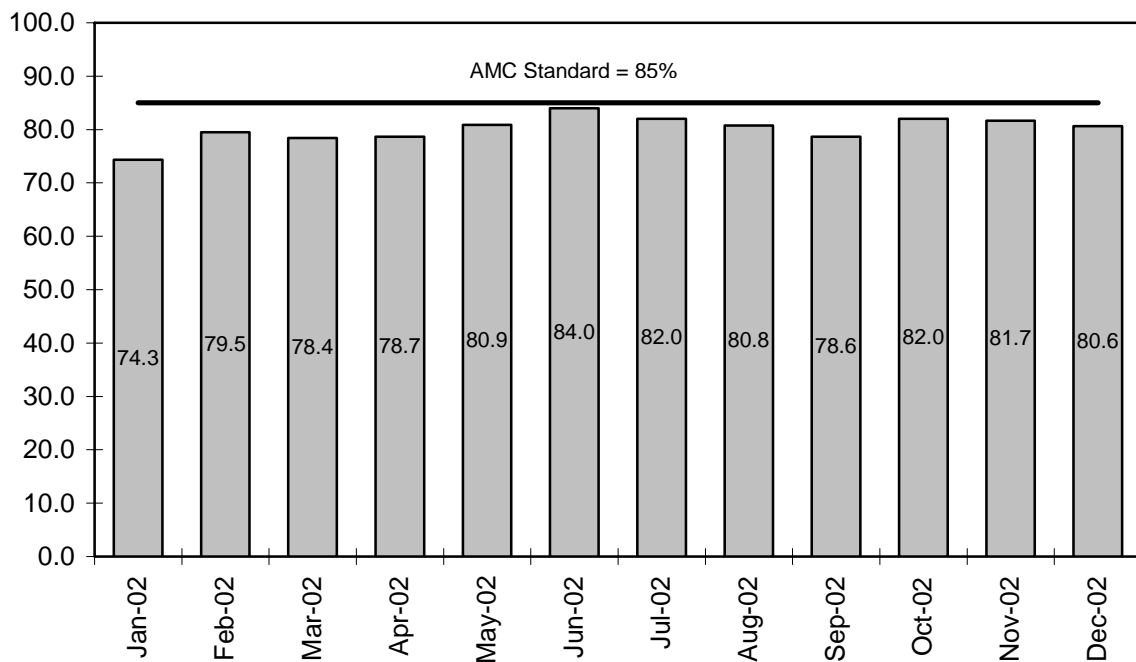


Figure 2. C-5 Logistics Departure Reliability 2002

The purpose of presenting the MC rates, departure reliability rates, and logistics departure reliability rates is to show the challenges AMC faces in employing the C-5, within or outside its normal support structure. The C-5 does not meet AMC standards for performance in critical areas yet we are dependent on the service it provides. The challenge for planners is to design concept of operations (CONOPS) that account for these shortfalls while still accomplishing the mission.

Traditional C-5 Employment

While the C-5 was originally designed to handle operations into unimproved runways, the actual use of the C-5 has traditionally been limited to larger, more robust airfields. The maintenance data presented above explains one of the reasons why the C-5 has been restricted in this manner. With a less reliable airframe, more support infrastructure and personnel are needed to receive and prepare the aircraft for follow on flights. At austere locations, this capability usually does not exist. Given the size of the aircraft, if a C-5 breaks at a small airfield, operations can be impacted for days until the C-5 is ready for flight.

The hub and spoke method of delivery accounts for the strengths as well as the weaknesses of the C-5 by normally only employing it on long, intertheater legs between the APOE and APOD. A typical contingency mission for the C-5 is to depart home station, fly to the APOE in the CONUS, onload cargo and passengers, fly through the en route system as necessary for fuel and aircrew changes, offload cargo at the APOD, and then return to home station. While maintenance support is available at the AMC en route locations, the level of service is not intended to be as robust as the home station

capability. For this reason, minor aircraft discrepancies that do not prevent the aircraft from accomplishing the mission are carried forward until the aircraft returns to home station where the major structure is present.

Aircraft that perform intratheater missions are typically deployed to an enroute staging base for the duration of their mission. These aircraft will fly cargo that has been transloaded from the intertheater leg to the FOB in theater and return to the en route base. Because the intratheater missions may involve landing at small, austere airfields, C-130 or C-17 aircraft normally support this requirement. The deployment involves basing aircraft, aircrews, maintenance and logistics support personnel, command and control, and a leadership package at the deployed location for the duration of the mission. The traditional hub and spoke system described above was used extensively during OPERATION Enduring Freedom in traditional and new ways, as will be described in the next section.

Airlift Support for Operation ENDURING FREEDOM

“Never before have we had to supply and support an operation so far forward completely by air.”

**General Walter Cross, Retired
Former Commander, USTRANSCOM (51:1)**

This quote highlights the challenges AMC faced in executing the air mobility bridge connecting the CONUS to Afghanistan beginning in mid-September 2001 for Operation ENDURING FREEDOM (OEF). Because of surface transportation constraints and the landlocked geography, most of the cargo needed for operations within Afghanistan had to be airlifted into the country. In addition, planners faced other

obstacles such as unimproved airfields, proximity to hostile forces, rugged terrain, and inhospitable weather (47:1).

To meet the requirements of US Central Command (USCENTCOM), AMC employed a combination of hub and spoke and direct delivery operations for airlift from the CONUS to Afghanistan. Large loads on long, overwater legs from CONUS to en route staging bases were primarily flown by the C-5 and commercial carriers. Cargo was then transloaded onto C-17 and C-130 aircraft for delivery into the shorter, unimproved airfields in Afghanistan. At times, the hub and spoke operation proved to be ineffective at delivering cargo to the AOR, partly due to C-5 reliability problems. Despite restricting the C-5 to larger bases, the airlift flow was so heavy that en route bases were initially overwhelmed with aircraft due to inadequate support thus creating bottlenecks. Cargo throughput suffered as valuable resources were being used to service and repair the additional aircraft. A prime example of this occurred at Andersen AFB, Guam, a common refueling stop for C-5's enroute from the CONUS to Diego Garcia. In late October 2001, 19 non-mission capable C-5's were on the ramp (47:4). Delays were also caused by the very nature of hub and spoke operations. The requirement to transload cargo at en route locations from intertheater to intratheater airlift adds time compared to direct delivery methods. Due to airspace restrictions within the AOR, slot times were required for aircraft to enter the airspace. As a result, cargo had to wait in a queue at the enroute station for movement to the FOB (47:3).

Direct delivery capabilities of the C-17 provided AMC a way to reduce the bottlenecks created at the en route stations by flying cargo intertheater distances directly into the FOBs in Afghanistan. The C-17 operated into airfields under combat conditions

that were riddled with craters, debris, expended artillery casings, and breaking up due to neglect (44:8). In addition to these capabilities, the C-17 was able to operate much more efficiently at smaller airfields. Efficiencies were realized because more aircraft could transit the location due to the C-17's smaller footprint and backing capability. The C-17's high reliability also enhanced direct delivery operations because the aircraft rarely broke down range away from its support infrastructure. For these reasons, the USTRANSCOM Commander, Gen John W. Handy said that the C-17 was the "weapon system of choice" for operations into Afghanistan (50:1). So much so, that its high demand provided the C-5 community an opportunity that it had never experienced in its 33-year history.

C-5 Expeditionary Operations

In July 2002, approximately 780 troops and 1,100 tons of equipment from Princess Patricia's Light Infantry Regiment needed transportation from Kandahar, Afghanistan back to their home in Edmonton, Canada. Transportation for this move would involve airlifting the Canadian troops and their cargo from Kandahar International Airport (OAKN) to Diego Garcia (FJDG) where the passengers would depart for Canada on commercial contract 747's and the cargo would travel to Canada via sealift. Until this time, the C-17 was the largest AMC aircraft to operate into Kandahar because of the poor runway conditions and medium threat environment. However, C-17's were not available to perform this mission due to their heavy taskings at time (41). As a result, USTRANSCOM and AMC had to develop an innovative plan to support the movement requirement from Kandahar to Diego Garcia.

Deployment Planning.

The first step in developing the plan began just three weeks prior to the deployment when the AMC/DO, MGen Roger Brady, asked the OEF director of mobility forces (DIRMOBFOR), BGen Cichowski, if it was feasible to get C-5's into Kandahar (29). Maj Terry Hestermann, an experienced C-5 evaluator serving as the DIRMOBFOR's executive officer, visited Kandahar to resolve inconclusive evidence provided by the airfield survey (29). Upon a positive review, AMC began rapidly planning all aspects of the deployment which involved TACC planners, numbered Air Force inputs, as well as leadership inputs from the deploying units. Shortly after, MGen Brady visited Travis Air Force Base where the majority of the members deploying to Diego Garcia were stationed to announce the plans for the first-ever C-5 deployment (23). MGen Brady's visit was a key sign to those deploying of the significance and unique opportunity they were going to experience.

Deployed Resources.

AMC deployed the following resources to Diego Garcia: five C-5B aircraft, six augmented air refueling qualified crews, a leadership package, and 44 maintenance personnel. Together, they were designated the 782nd Expeditionary Airlift Squadron (782 EAS) and were commanded by Lt Col Mark Dillon. The 782 EAS had the benefit of being a part of the 462nd Airlift Expeditionary Group (462 AEG) at Diego Garcia which had a robust infrastructure of fuel, aerial port, and command and control to support KC-135 and B-52 operations. Four of the six aircrews came from the 60th Air Mobility Wing (AMW) at Travis AFB and two came from the 436th AMW at Dover AFB. Due to the complexity and significance of the mission, at least one instructor was required in each of

the four crew positions (46:11). In addition, Dover AFB Special Operations Low Level II (SOLL-II) qualified navigators, equipped with night vision goggles (NVGs), became part of each crew complement. The navigators were well trained in nighttime, tactical operations and provided an extra level of situational awareness and safety. The 44 maintenance personnel deployed to Diego Garcia were from the 60th Aircraft Generation Squadron at Travis AFB (38).

30 members from the 615th Air Mobility Operations Group (AMOG) deployed to Kandahar to join members of the 615th Tanker Airlift Control Element (615 TALCE) who were already performing duties for other AMC missions. The composition of this team included thirteen maintenance personnel, ten aerial porters, and 7 command and control specialists (38). Lt Col Jim Spaulding served as the 615 TALCE commander and Col Frederick Martin, the 615 AMOG/CC, served as the overall C-5 mission commander for the deployment. The additional TALCE members were deployed for the sole purpose of supporting the C-5 mission so that the impact to ongoing operations at the airfield would be minimized (36).

Command Relationships.

According to doctrine, airlift command and control is based on the principle of centralized control and decentralized execution and is the key to effective and efficient airlift operations (31:III-I). These principles were followed when designing the structure for this deployment. The wiring diagram of the command relationships for the C-5 deployment is shown in Figure 3 and was provided by Col Martin but was designed by Lt Col Lee Burkett, AMC/DOV (37). Of particular interest is the fact that the two deployed units for the C-5 deployment, the 782 EAS and 615 TALCE, did not change operational

control (CHOP) to the respective theaters, PACOM (Diego Garcia) or CENTCOM (Kandahar). Since AMC retained OPCON, the experts in AMC who understood the strengths and weaknesses of the C-5 were able to organize and provide guidance to the deploying units and is an example of centralized control. Not seen in the wiring diagram, but also important, is that aircraft departure authorization from Diego Garcia was given to Col Martin at Kandahar. This ensured that the decision to launch was made at a local level by someone with the appropriate information and is an example of decentralized execution.

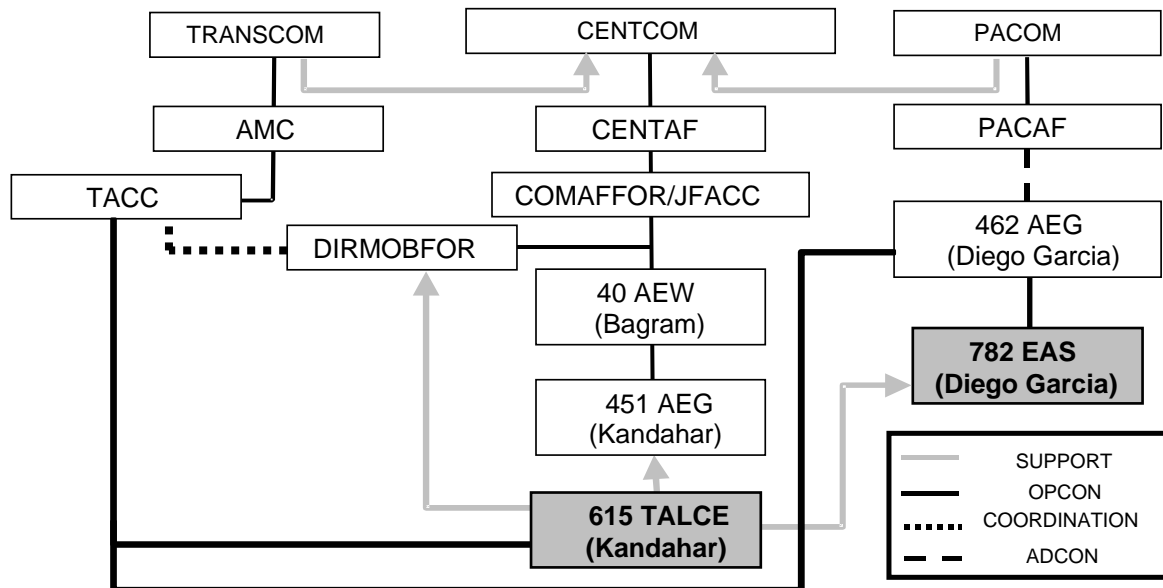


Figure 3. Command Relationships for C-5 Deployment

Mission Frequency.

With a ready to load date (RLD) from Kandahar of 20 Jul 02 and an available to load date (ALD) at Diego Garcia of 8 Aug 02, AMC had 20 days to airlift approximately 780 passengers and approximately 1,100 tons of cargo. Airlift of additional cargo and passengers would be required to deploy and redeploy the 615 TALCE for the Kandahar

operations. Considering only the Canadian cargo and passengers, this was not a tremendous task based on AMC's capability. However, with major airfield restrictions and limited aircraft availability, this would prove to be a very challenging mission.

Planners determined that two C-5 missions per day could be supported into Kandahar. According to Lt Col Lee Burkett of AMC/DOV, three key factors drove the two missions per day concept. First, ramp space at Kandahar was very limited due to other ongoing airlift operations involving C-17s, C-130s and Army aircraft. As a result, the plan was to have only one C-5 on the ground at a time for a working maximum on ground (MOG) of one, although there was room for a parking MOG of two. Secondly, due to the medium threat environment around the airfield, planners wanted to use the cover of darkness to help minimize the risk of hostile actions toward the aircraft. Finally, temperatures were much cooler at night which permitted the C-5 to depart with greater cargo loads than would be possible during the high temperatures in daytime (Burkett). Based on these factors, the C-5's received two slot times per day in the Air Tasking Order (ATO) to land at Kandahar. (9)

Number of Aircraft.

In order to generate two missions per day out of Diego Garcia, AMC deployed five C-5Bs. This is an interesting decision to analyze and Chapter 4 will address the effectiveness versus efficiency dilemma AMC faced in making this decision. According to Maj Wallace Kost, an airlift planner at AMC/XOP who developed the airlift plans for this operation, XOP initially recommended four aircraft to support the mission. Two aircraft would be used for the daily missions, and the remaining two aircraft would be

getting ready for the next day's missions. However, AMC finally decided five aircraft would be the right number to ensure mission success. (33)

Hot Spare.

Lt Col Dillon was given the task of launching two missions per day out of Diego Garcia with five aircraft and six aircrews. AMC left it up to him to develop the detailed plan of how to schedule the aircraft and aircrews. Together, Lt Col Dillon and Maj David Coley, the lead maintenance officer for the 782 EAS, developed an innovative plan that used all assets available to move cargo and fill the valuable slot times. Their plan called for a hot spare for all missions departing Diego Garcia. This meant that for every departure, two FMC aircraft and two augmented crews were prepared to launch. For the first mission of the day, two aircrews were alerted with one serving as the primary crew and the other as the backup crew. Each crew went through similar mission planning preparations and preflight aircraft preparations up until engine start procedures. When Col Martin at Kandahar gave launch approval, the primary crew would depart. If problems developed, the backup crew could take the mission with minimal delay because there was no cargo to transload. If the primary crew departed, the backup crew would wait approximately four hours and repeat the procedure as the backup crew for the second launch. (23)

Type of Aircraft.

Due to the medium threat environment at Kandahar, AMC required the deployed C-5 aircraft to have the aircraft defensive system (ADS). This equipment provides the aircrew notification of surface-to-air infrared missile launches and can automatically dispense flares to counter the threat. Only B-model C-5's are equipped with ADS.

Therefore, only B-model aircraft could be tasked to support this operation. Another advantage of tasking B-models is that they traditionally have a higher mission capable rate than the A-models. The C-5 B-models were built between 1983 and 1987 while the C-5 A-models were built from 1966 to 1970. AMC's B-models MC rate for 2002 was a modest 72.4% while AMC's A-model MC rate for 2002 was only 57.2% (6).

Allowable Cabin Load (ACL).

Two missions were to arrive and depart Kandahar each night: the first departure around midnight and the second mission would depart four hours and fifteen minutes later, just prior to sunrise. Because of the temperature difference between the departure times, two separate ACLs were planned for the departures. The midnight departure was planned for an ACL of 100,000 lbs while the pre-sunrise departure was planned for 120,000 lbs (38). These figures are below the standard C-5 ACL planning factor of 122,000 lbs (16:13). The relatively high pressure altitude of 2,000 ft and 80 degree temperatures at night contributed to this limit.

Mission Expeditors.

AMC deployed its top two C-5 standardization and evaluation members, Lt Col Lee Burkett and CMSgt Tim Reuning to Kandahar to serve as mission expeditors. Their purpose was to facilitate safe operations at Kandahar and provide on-scene waiver authorization if necessary (9). Chapter 4 will closely examine their contributions.

Fuel Availability.

Fuel was not available at Kandahar for the C-5 missions. While this reduced the requirements for ground servicing at Kandahar, it increased the complexity of the mission. As planned, C-5s were not able to depart Diego Garcia with enough fuel to

make both flights without air refueling. According to Lt Col Burkett, the CONOPS called for an onload of 40,000 pounds of fuel from KC-135's after departing Kandahar (9).

Engine Running Onloads (EROs).

As mentioned previously in the airlift doctrine discussion, EROs have the potential to greatly reduce the ground time required to onload cargo, thus increasing the cargo velocity. EROs are not typically performed on C-5 missions due to the increased safety hazards; however, they played a key role in this deployment. Planning EROs served two purposes. First, the time a C-5 spends on the ground can be reduced from four hours and fifteen minutes to two hours (16:15). This reduced time on the ground means reduced threat to the personnel and aircraft. Second, EROs reduce the chance of an aircraft maintenance problem occurring after the engines are shut down. According to Capt Aaron Sasson, a maintenance supervisor for the 782 EAS, EROs allowed the aircraft to keep moving and reduced the opportunity for the aircraft to breaking downrange (43).

Chapter 2 Summary

Now that sufficient background on airlift doctrine, C-5 performance and employment, and a discussion of the CONOPS for the C-5 deployment is complete, the research methods for analyzing the performance of this deployment can be discussed.

III. Methodology

This chapter describes the research methodology used to conduct this project: the case study.

Reasons for Choosing Case Study Methodology

The case study research method used for this project was designed after the concepts described in Dr Robert Yin's book *Case Study Research*. Case study methodology was chosen for this project for several reasons. First, according to Yin, case studies are the preferred strategy when answering "how" or "why" questions (52:6). The two investigative questions, "how effective and how efficient was the C-5 system in performing it's deployed mission?" are well suited for the case study approach.

The second reason for choosing the case study method is because case studies are useful when the investigator has little control over events (52:8). The C-5's first deployment was complete in August 2002 and the results cannot be affected by this research.

Third, when the focus of the research is on a contemporary issue, as opposed to a historical issue, case studies are more desirable (52:8). This issue is considered a contemporary issue because of its contribution to a recent military operation and its use of the expeditionary concepts that are dominating the shape of our future military. The lessons learned from this operation can hopefully be incorporated into the next iteration of expeditionary C-5 operations and case study research can aide in this process.

Finally, the case study method is well suited for dealing with a full variety of evidence (52:8). There is a large amount of evidence available for this case, including documentation, archival records, and interviews. The combination of these four factors:

research question, control over events, contemporary issues, and evidence, all contributed to the decision to use the case study methodology for this project.

Collecting Evidence

One of the benefits of using the case study as a research method is the ability to incorporate many different sources of evidence. This research incorporates three different sources of evidence: documentation, archival records, and interviews.

Documents.

Documents are an important source of evidence because they are capable of corroborating and augmenting evidence from other sources (52:80). Letters of memorandum, news articles, emails, and electronic copies of briefings are sources of documents used throughout this study. Other sources, such as daily situation reports (SITREPS) from 615 AMOG at Kandahar were unable to be included in this research due to their classification level.

Archival Records.

Archival records were key to providing the necessary mission and flying hour data needed for the analysis of the deployment versus historic C-5 operations and came from many sources. Lt Col Dillon provided a composite spreadsheet containing all the pertinent mission data for the C-5 deployment named *782 EAS Mission Tracker* (24). Comparing this data to each mission's Global Decision Support System (GDSS) Form 59 validated the accuracy of the *782 EAS Mission Tracker* information. Therefore, the *782 EAS Mission Tracker* will be the documented source for the mission data in the following chapter. CMSgt Linda Sobell, an analyst at AMC/LGQMA, provided an Excel spreadsheet, *C-5 History*, which contains raw flying hour data and aircraft reliability rates

for the C-5 (4). The data from this spreadsheet is currently used to generate the monthly *Health of the Force* briefing slides produced by AMC/LG. Mr. Jack Pugh of AMC/LGMA also provided historic C-5 flying hour and maintenance data. His data is in an Access database format and is available on the AMC/LG website (6). Finally, data from G081 was used to compute the mission capable rates of the deployed aircraft and remainder of the C-5 fleet during various timeframes. G081 is the software system AMC uses to manage and document maintenance activities and processes for its aircraft. Together, these pieces of evidence make up the primary sources of quantitative data used in the analysis of the deployment. With this data, departure reliability rates, mission capable rates, and utilization rates will be calculated and compared to expected values of performance.

Interviews.

Interviews are essential to the case study methodology because they provide insights that cannot be gained from archival or documented data (52:81). The researcher conducted interviews with many of the key leaders that were responsible for planning and executing this mission. The interviews were performed over the telephone or through email and were both open-ended and focused in nature. These interviews provided much needed qualitative data to complement the quantitative data obtained through the other two evidence sources. The list of personnel interviewed is shown in the table below with their role during the deployment as well as their normal duty prior to the deployment.

Table 3. List of Interviews Conducted for Research

Name	Job Responsibility during Deployment	Normal Job Title (as of Jul 2002)
Col Frederick Martin	Overall C-5 Mission Commander	615 AMOG/CC
Lt Col Mark Dillon	782 EAS/CC	22 AS/CC
Lt Col Lee Burkett	Mission expeditor, AMC/DO waiver authority, and CONOPS planner	AMC/DOV (Chief, Global Airlift Branch, C-5 Aircrew Standardization and Evaluation)
Lt Col James Oullette	Developed organizational structure for 782 EAS	AMC/DOOO (Chief, AMC Current Ops Policy Branch)
Maj David Coley	Head maintenance officer for 782 EAS	60 AMXS/CC
Maj Wallace Kost	Airlift planner for C-5 deployment missions	AMC/XOP (Global Readiness)
Maj Terry Hestermann	OEF DIRMOBFOR Executive Officer	21 AF/DOT (Training)
Capt Elliot Sasson	Maintenance supervisor for 782 EAS	660 AMXS/MXAB
Capt Nick Leonelli	Combat tactics planner for 782 EAS	22 AS C-5 instructor pilot

Case Study Strategy

Four different designs can be used to perform case study research (52:39). Figure 4 highlights the type of case study design used in this research: type 2, single-case, embedded design.

	Single-Case Designs	Multiple-Case Designs
Holistic (single unit of analysis)	Type 1	Type 3
Embedded (multiple unit of analysis)	Type 2	Type 4

Figure 4. Basic Types of Designs for Case Studies

There are several reasons why the single-case, embedded approach is being used. A single case approach is recommended if the case represents the critical case in testing a well-formulated theory or if it is a unique or extreme case (52 38). The C-5 deployment being studied in this project was the first of its kind and serves as a critical case in testing the well formulated theory that C-5's should not and cannot deploy. It was possible however, to conduct a multiple-case design for this research. A second deployment of C-5 aircraft, aircrew and support personnel took place in August 2002, the month after the first deployment. Aircraft deployed to Rhein Mein Airport in Frankfurt, Germany to conduct eleven missions into Kandahar from 26 August 2002 until 1 Sep 2002 (38). There were many similarities between the two deployments that would allow for a multiple case study design. However, there was one major difference which the researcher felt was critical to the fidelity of this case study. Seven of the eleven missions that flew into Kandahar originated from the CONUS. Frankfurt served as an intermediate staging base for these missions on the way into Kandahar instead of an origination base as was Diego Garcia. As a result, the concept of generating C-5 sorties from a deployed location is only truly valid on four missions. For this reason, the second C-5 deployment is not being analyzed.

The second feature in the design of this case is the use of multiple units of analysis versus a single unit of analysis. The remainder of this chapter will describe in detail the nine separate units of analysis that will be studied to help answer the main research question.

Case Study Design Methodology

The next step in pursuing the case study methodology is to develop a research design. “A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study” (52:18). In other words, the research design is the blueprint for getting from the initial questions to the conclusions. Five important components of the research design exist: research questions, propositions, units of analysis, linking data to propositions, and the criteria for interpreting the findings (52:20).

The overall research question, “Can the C-5 fit into the expeditionary construct of today’s Air Force?” serves as the motivation for conducting the study while propositions are intended to correctly guide the research to study those areas that will aide in answering the research question. Propositions therefore, serve as the hypotheses for the research question. In this case, the propositions are drawn from the two investigative questions concerning effectiveness and efficiency. The units of analysis, commonly referred to as measures of merit, are the data points collected during evidence gathering. Units should be chosen based on their relationship and correlation to the proposition so a clear link can be established. Finally, the data must be compared to an established criterion in order to make a credible determination of the answer to the original research question. These steps are described in detail as they apply to the C-5 deployment in the following section. (52:21-26)

Design for Investigative Question 1

How effective was the C-5 system in performing its deployed mission? Based on results the researcher observed after the deployment but before this research effort began,

the overall mission appeared to be very successful at accomplishing its objectives. For this reason, the first proposition follows the assumption that the C-5 was highly effective during the deployment. To determine effectiveness, five units of analysis will be measured against specific criteria and are explained below.

The principle criterion for evaluating the effectiveness of the C-5 deployment will be measured as AMC's ability to satisfy customer demand. Did AMC provide transportation from Kandahar to Diego Garcia that met the customer's needs? While USTRANSCOM was responsible for the entire transportation plan for the Canadian soldiers and cargo from Kandahar to Canada, this research is focusing on the mode assigned to the C-5. Therefore, the two most important units of analysis will be whether or not AMC met the customer's available to load date for passengers and cargo at Diego Garcia. By comparing the actual arrival dates with the required dates, the ability to meet customer demand and therefore effectiveness, can be determined.

Since meeting customer requirements is dependent on the reliability of service, departure reliability and logistics departure reliability rates during the deployment will also help measure effectiveness. These figures will be compared to the departure and logistics departure reliability rates for worldwide C-5B missions during the same time frame of 18 Jul – 3 Aug 02.

Also, the ground time at the enroute location will be analyzed because the ability to meet the available to load date is dependent on how well the Kandahar operation proceeded. The actual ground time at Kandahar will be compared against planned ground time.

Mission capable rates will be analyzed to determine how effective the maintenance personnel were in providing the maximum availability per aircraft. The deployed MC rates will be calculated from G081 data and compared to the MC rate for all other C-5B's during the same time frame. MC rates will also be used to determine whether or not the best performing aircraft were tasked to support the deployment. This is an item of interest because during several of the interviews, interviewees mentioned that the plan was to select the best aircraft to send on the deployment. The MC rates for the five deployed aircraft for the year prior to the deployment will be compared to fleet wide C-5B MC rates to determine if the best performing aircraft were actually deployed.

The full case study design for Investigative Question 1 is summarized in the table below.

Table 4. Case Study Design for Investigative Question 1

IQ 1: How effective was the C-5 system in performing its deployed mission?	
Proposition: The C-5 deployment was a highly effective use of airlift assets.	
Units of Analysis	Criteria
1. Actual delivery dates of passengers from Kandahar to Diego Garcia	Compare to ALD for passengers to Diego Garcia
2. Actual delivery dates for cargo from Kandahar to Diego Cargo	Compare to ALD for cargo to Diego Garcia
3. Departure reliability from Diego Garcia	Compare to departure reliability for all other C-5B missions during 18 Jul – 3 Aug 02
4. Ground time at Kandahar	Compare to planned ground time
5. MC rates for deployed aircraft from 18 Jul – 3 Aug 02.	Compare to MC rates of all other C-5B's during the same time period

Design for Investigative Question 2.

How efficient was the C-5 system in performing its deployed mission? Based on anecdotal assumptions, the second proposition states that employing C-5's in an intra-theater type role, away from the global mission, will result in an inefficient use of the asset. Efficiency will be measured by AMC's ability to use the minimum number of

resources to meet the desired level of customer service. The number of deployed aircraft, the number of missions flown, or the number of people deployed in support of this operation can all be considered resources. The following four units of analysis will incorporate these resources to make comparisons with normal planning factors: USE rates, allowable cabin loads (ACL), mission expeditors, and number of deployed personnel.

USE rates are defined as the capability of a subset of aircraft to generate flying hours. The figure is expressed in average flying hours per aircraft per day and is computed only for those aircraft applied to a specific mission (16:26). USE rates offer a way to measure the relative efficiency of an operation when related to output over input. This correlation can be made when the input value is considered to be the number of possessed aircraft and the output value is the flying hours generated by these aircraft. Assuming maximized cargo loads, a higher USE rate means the daily contribution per aircraft is greater. Therefore, each asset is being gainfully employed with minimal waste. As aircraft become unavailable due to maintenance or other problems, the USE rate and efficiencies decrease because the input remains the same (possessed aircraft) while the output decreases. However, USE rates as a unit of analysis must be used very carefully. There are many misconceptions and problems associated with using USE rates to determine aircraft performance. Airfield operating hours, weather, aircraft generation schedule, average mission flying and aircraft mission capable rates are just a few of the more than 23 factors that figure into the USE rate (39). As a result, it may be difficult to draw a comparison between two different operations to determine which one is more efficient. However, the researcher believes that the USE rate can be insightful into

showing how the utilization of deployed C-5's compares the utilization of C-5's employed in their traditional global mobility role.

Another method of evaluating the efficiency of the operation is to analyze the cargo load statistics. Maximizing the ACL will result in a higher efficiency rating for the operation because a greater output (cargo delivered) is generated with fewer inputs (aircraft sorties). ACL is defined as the maximum payload which can be carried on a mission and is limited by the maximum takeoff gross weight, maximum landing gross weight, or by the maximum zero fuel weight (16:23). For this analysis, the actual cargo load for each sortie departing Kandahar will be compared to the planned ACL to determine whether or not the aircraft was being fully utilized. A higher than expected cargo load equates to an efficient use of the airlift asset while a lower than expected represents a degree of inefficiency.

Another method of assessing the efficiency of the C-5 deployment is to look at how many manpower resources were used to accomplish the mission. When the number of deployed maintenance and TALCE personnel are compared to the numbers required during normal operations, an assessment can be made as to whether or not too many personnel were deployed to achieve the mission's objectives.

The final area to analyze in this operation is use of mission expeditors. For high priority missions, AMC has been placing a few highly qualified individuals at a location to facilitate the flow of aircraft by granting waivers or aiding in other ways. In this operation, two HQ AMC/DOV personnel were deployed to Kandahar, Lt Col Lee Burkett and CMSgt Tim Reuning. Their contributions will be examined from a qualitative perspective to determine the impact of their presence on the C-5 deployment. This is an

important area to study because with the addition of a few personnel (input), the possibility exists to generate a disproportionate increase in the output.

The full case study design for Investigative Question 2 is summarized in the table below.

Table 5. Case Study Design for Investigative Question 2

IQ 2: How efficient was the C-5 system in performing its deployed mission?	
Proposition: Using the C-5 as a deployed asset will result in an inefficient use of airlift.	
Units of Analysis	Criteria
1. USE rate of deployed C-5's	Compare to USE rate during worldwide operations.
2. Available Cabin Loads (ACL)	Compare to planned ACL
4. Number of deployed personnel	Compare to recommendations/comments from key players during the deployment
3. Mission expeditors at downrange location	Compare value added services to normal operations

IV. Data Analysis

Overview of Deployment Results

The graphical depiction of the airflow in Figure 5 provides a good overview of the operation. This graph was built using the actual times from the 782 *EAS Mission Tracker* spreadsheet for departures and arrivals from the two locations (24). On average, two missions per day departed Diego Garcia and landed at Kandahar to onload cargo and return to Diego Garcia. In all, 28 missions departed Diego Garcia for Kandahar. Two missions were non-productive because they had to return to Diego Garcia before reaching Kandahar. Mission 5 returned to base due to a report from Kandahar that the visibility would preclude a landing (24). Mission 19 returned due to an engine fire warning (24).

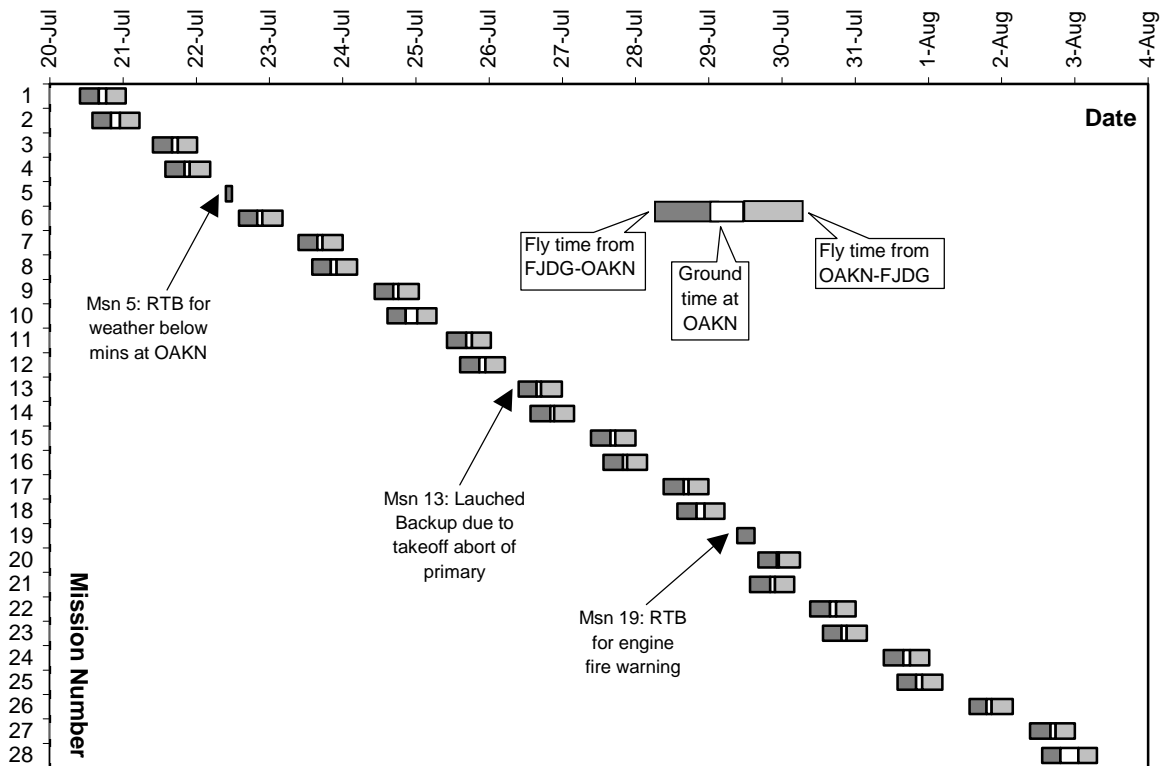


Figure 5. C-5 Deployment Mission Flow Timeline

The takeaway from this graph is the consistency of the airflow. The remaining portions of the chapter will explain in detail the results that were achieved by this airflow as they relate to the investigative questions of effectiveness and efficiency.

Investigative Question 1 Results

This section will measure the effectiveness of the C-5 deployment by examining the following units of analysis: available to load dates for passengers and cargo, departure reliability rates, ground time at Kandahar, and MC rates.

Passenger ALD Results.

Approximately 780 soldiers required airlift from Kandahar to Diego Garcia requiring a minimum of 11 C-5 sorties, assuming 73 passengers per mission. After arrival in Diego Garcia, the passengers were scheduled to depart for Canada on three contract Boeing 747 flights on 22, 24, and 26 July 2002. These three dates equate to three separate available to load dates. This schedule left very little room for error. In fact, in order to meet the customer requirements for the connecting flights, 11 out of the first 12 missions had to be accomplished on schedule.

787 Canadian soldiers were successfully moved from Kandahar to Diego Garcia meeting all three of the available to load dates for the contract airlift flights (24). An average of 71 passengers were carried on 11 of the first 12 missions out of Kandahar. Mission 5 returned to Diego Garcia shortly after takeoff due to poor visibility at Kandahar (38). Figure 6 shows the timeline of the passenger missions using a bar graph for the flight time to Kandahar, ground time at Kandahar, flight time to Diego, and

number of passengers delivered. The figure also depicts the time of departure for the three contract flights in relation to the arrival of the passengers. Notice that the last B-747 departed just after the 12th and final passenger mission arrived. Just-in-time delivery by the C-5 was a success.

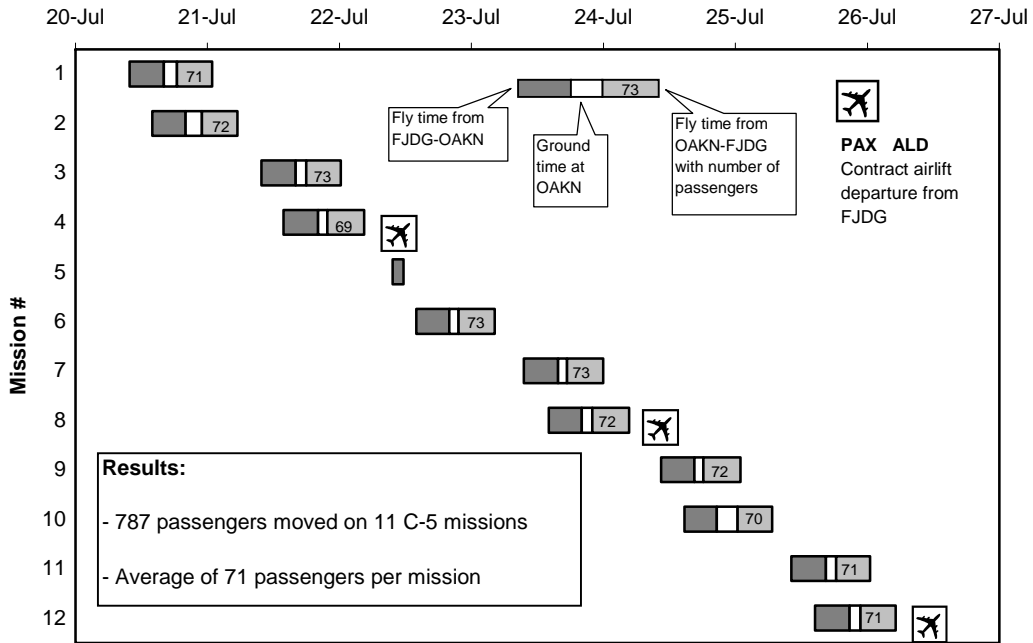


Figure 6. Passenger Movement from Kandahar to Diego Garcia

Cargo ALD Results.

The ALD of the Canadian cargo to Diego Garcia was 8 Aug 2002, which provided 20 days from the start of the operation. At the pace of two missions per day, a total of 40 missions could operate in this time frame. However, planners expected the lift could be done in approximately 27 missions with an ACL of 110,000 lbs. Thus, there was considerably more room for error in meeting the ALD for the cargo than for the passengers.

All of the Canadian cargo was successfully delivered to Diego Garcia before the ALD. 26 productive missions moved a total of 3,087,000 pounds (24). Cargo delivery was completed on 3 Aug 02, for a total mission time of 15 days. Figure 7 shows the timeline of cargo delivery from Kandahar to Diego Garcia. The vertical bars represent the cargo per mission with the scale on the left-hand side of the graph. The diagonal line represents the amount of cargo remaining at Kandahar with the scale on the right-hand side of the graph. As can be seen by the graph, all cargo was delivered five days before the ALD, in time for the transload to sealift. In terms of customer service, once again customer requirements were met by the C-5 resulting in maximum effectiveness.

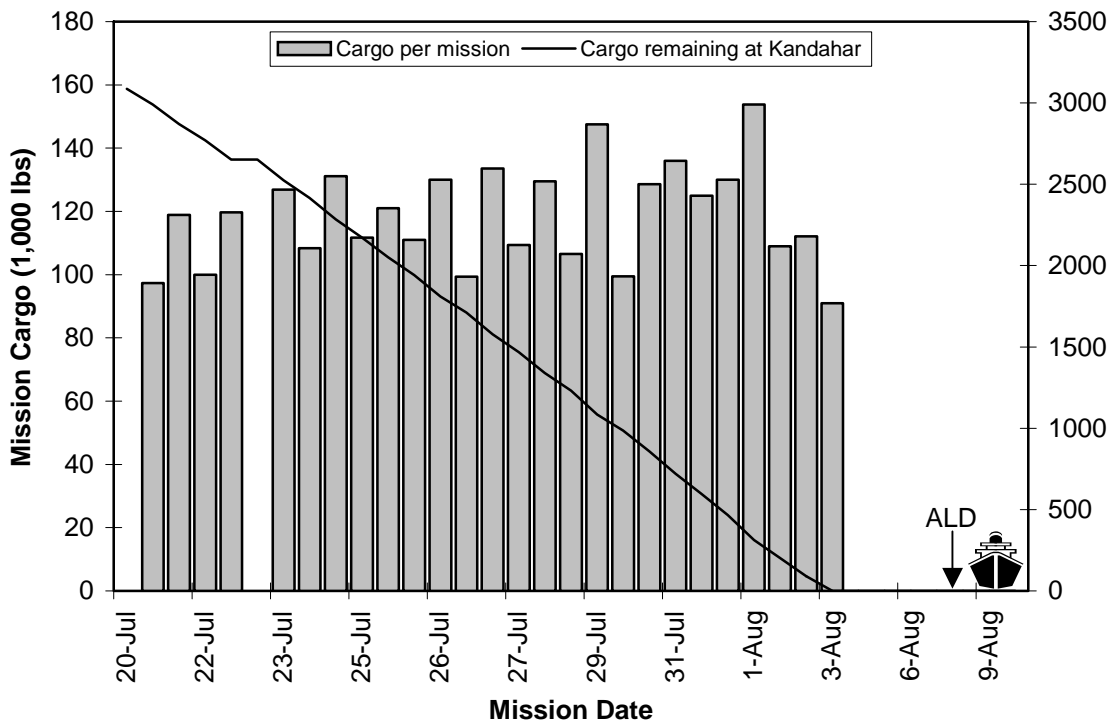


Figure 7. Cargo Delivery Timeline: Kandahar – Diego Garcia

The total cargo figure of 3,087,000 pounds is significantly more than the estimated requirement of 1,100 tons (2,200,000 pounds) for three reasons. First, the members of the 615 TALCE required airlift into and out of Kandahar. This was accomplished by the first two and last two C-5 sorties of the deployment (38). These cargo amounts were not included in the original Canadian requirement. Second, because the mission was running ahead of schedule, an additional customer, a US Marine Tactical Control Air Squadron, received transportation out of Kandahar (38). Third, the total cargo figure includes the passenger weights of the 787 Canadian soldiers plus an additional 56 passengers flown out in the final missions (24). The 1,100-ton figure did not include these passenger weights.

Departure Reliability Results from Diego Garcia.

The ability to meet the customer requirements mentioned above was highly dependent on the ability of the aircraft to meet the intended schedule. Departure reliability was critically important for the C-5 deployment because there were only two available slot times per day. If the aircraft was not able to meet the slot time window, there was no guarantee that another could be generated later that day.

Logistically speaking, 27 out of 27 missions departed on time from Diego Garcia. Figure 8 displays the departure deviations from the scheduled takeoff time for the missions out of Diego Garcia. Each mission is in order, starting from the top of the graph and continuing down. The dark vertical line represents the normalized scheduled takeoff time. Bars to the left of the vertical line represent missions that departed before the scheduled time and bars to the right indicate missions that departed after scheduled takeoff time. The length of the bar indicates the number of minutes the takeoff deviated

from the schedule and is also noted by the number inside the bar. The scale on the horizontal axis represents the AMC standard on time departure window of twenty minutes prior to fourteen minutes after scheduled takeoff time.

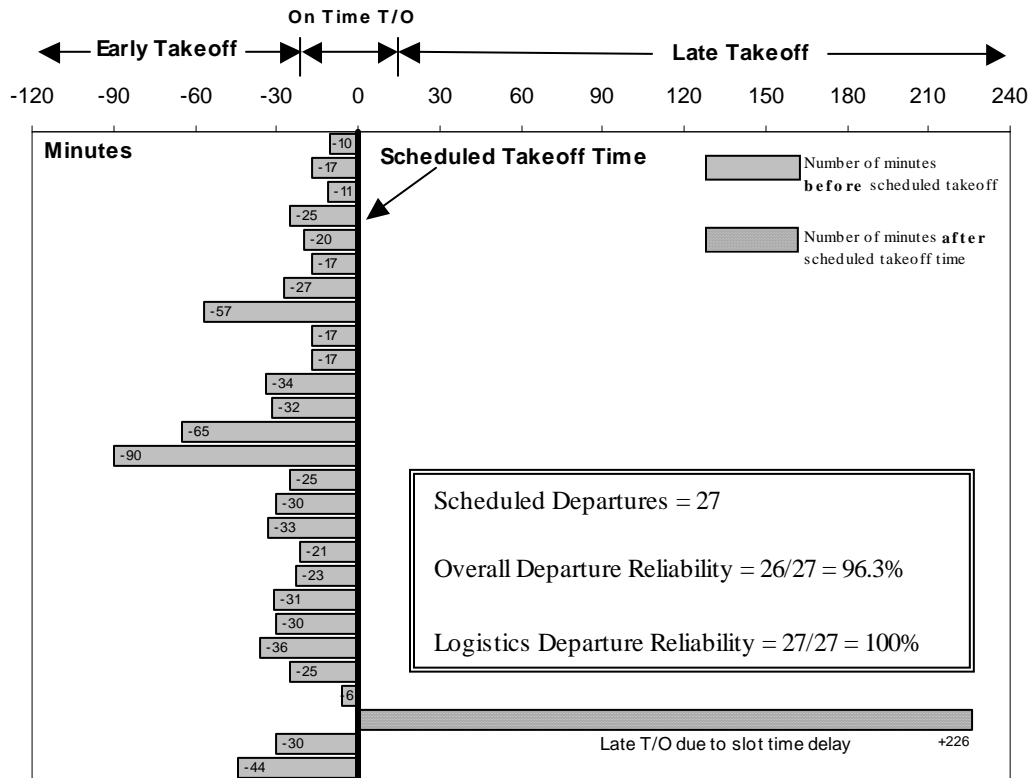


Figure 8. Departure Reliability at Diego Garcia, 20 Jul – 2 Aug 02

This graph highlights one of the most significant accomplishments of the entire deployment: a logistics departure reliability of 100%. The only deviation was caused by a change in the slot time resulting in a four-hour delay. The hot spare concept described in Chapter 2 saved one mission from going into delay and minimized the delay on another. On mission number 13 from Diego Garcia, the primary aircraft aborted during takeoff roll due to a compressor stall (24). The backup aircraft and aircrew were airborne

twelve minutes later, still departing earlier than the scheduled departure time (43). The hot spare concept also minimized the delay after mission number 19 had to return to Diego Garcia approximately three hours after departure for an engine fire warning indication (38). After coordination with the AMD to obtain another slot time, the backup crew successfully launched. The backup aircraft arrived in Kandahar 6.5 hours after the schedule but much of this delay was due to the fact that the second mission of the day departed on time. To prevent having two aircraft on the ground at Kandahar at the same time, the backup aircraft delayed its departure from Diego Garcia. Timing worked out perfectly as can be seen by the overall mission flow timeline in Figure 5 where only 37 minutes separated the departure of the second day's mission and the arrival of the backup mission into Kandahar (24).

Another item of particular interest is the amount of time each mission departed before the scheduled takeoff time. An on time departure for AMC aircraft is normally considered to be within the window of twenty minutes prior to fourteen minutes after scheduled departure time. However, 18 of the 26 missions that departed early were actually more than 20 minutes early. In fact, the average mission departed 30 minutes before scheduled departure time. Departing earlier than the normal window of 20 minutes was necessary many times because the scheduled takeoff times built by TACC did not meet the slot times from the Air Tasking Order (ATO). This highlights one of the significant differences between this operation and normal AMC airlift operations and was explained by Lt Col Dillon. "Airlifters are trained to takeoff within +20/-14 and that's the law...combat ROE (rules of engagement) says you take off as needed to meet slot

times” (25). This mindset added the much needed flexibility in this type of environment and contributed greatly to the effectiveness of the mission.

28 missions actually departed Diego Garcia. The extra mission was the backup aircraft launched after mission 19 returned to base for an engine fire indication. Many of the personnel interviewed for this research cited the logistics departure reliability rate as 28 out of 28, which includes an on time takeoff for the backup mission to replace mission 19. However, this research is only crediting 27 missions in the departure reliability statistics. Since the backup mission did not have a scheduled departure time, no baseline was found to measure departure reliability. This situation also highlights one of the weaknesses in the way AMC calculates departure reliability. The fact that mission 19 departed on time, yet had to return to base hours into the flight, does not count against the departure reliability rate. Added to this, if one counts the backup mission as an on time departure, then two sorties were credited with an on time departures even though the mission actually arrived to Kandahar over six hours late.

Nevertheless, a C-5 logistics departure reliability of 100% and an overall departure reliability of 96.3% from Diego Garcia was astounding in relation to normal operations. The departure reliability rates for all AMC C-5B global missions during the 18 Jul – 3 Aug 02 timeframe are compared to the deployed C-5 results as shown in Table 6 below. The global figures were obtained from Capt Tegwin Cain, of AMC/DOOC, with the use of the GDSS Aircraft History System (AHS) database (11).

Table 6. C-5 B Departure Reliability for 18 Jul – 3 Aug 02: Global vs. Diego Garcia

	Total Departures	On Time Departures	Overall Departure Reliability	Logistics Delays	Logistics Departure Reliability
Global AMC C-5B Missions	443	258	58.2%	82	81.5%
Diego Garcia Deployment C-5 Missions	27	26	96.3%	0	100%

Ground Time at Kandahar.

Another significant element of the deployment was the onload operation at Kandahar. If a C-5 were delayed at Kandahar, the operation would have been severely impacted due to parking, slot time, and resource constraints. For these reasons, the 615 TALCE at Kandahar needed to be very effective at recovering, loading, and launching the aircraft. The unit of analysis that can measure this effectiveness of this operation is the ground time spent at Kandahar. The following graph was built from data within the 782 *EAS Mission Tracker* and shows total ground time for each mission that landed at Kandahar compared to the scheduled ground time (24).

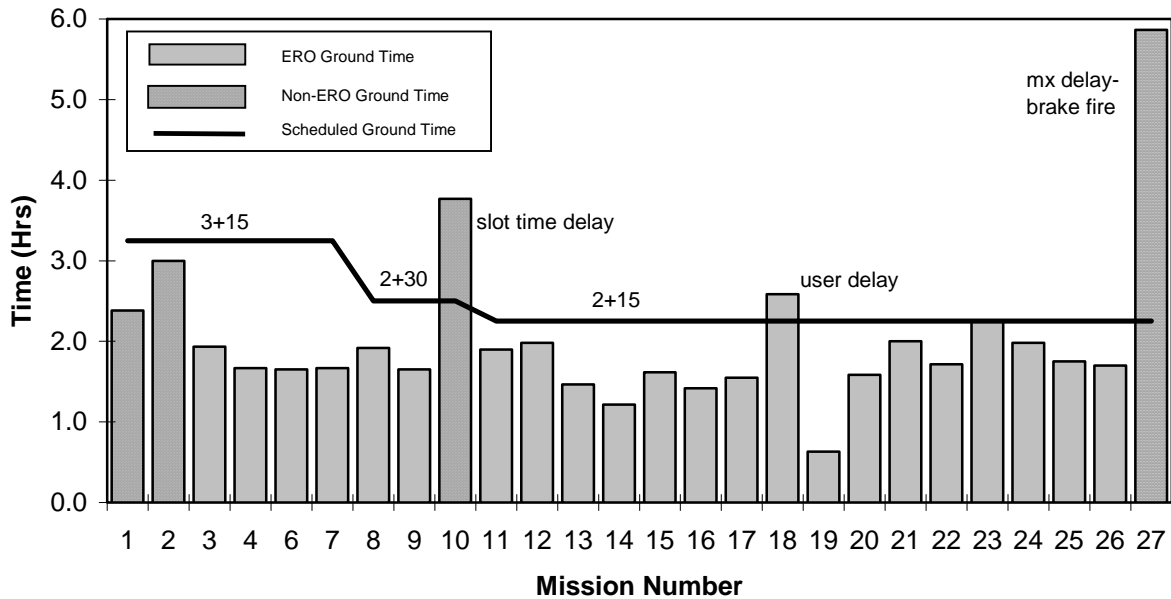


Figure 9. Average Ground Time during Missions into Kandahar

There are several items to note from this graph. First, the effectiveness of the operation at Kandahar can clearly be seen by the ability to meet the scheduled ground time on 23 out of 26 missions for an overall departure reliability of 88.5% (mission 5 did not arrive at Kandahar due to inclement weather at Kandahar). One mission was delayed in order to meet slot time requirements. Two missions were delayed for events that took place at Kandahar, a user delay for cargo not being ready and a maintenance delay caused by a brake fire that occurred after landing. The logistics departure reliability for Kandahar was 96.2%, as 25 out of 26 missions departed on time. Both the departure reliability and logistics departure reliability exceeded the global departure reliability rates presented in the previous section.

Second, the data show how much the ground time can be reduced by performing ERO operations. Missions that did not perform EROs are noted by partial shading. The first two missions were not scheduled for EROs because they delivered the additional members of the 615 AMOG needed to perform the ground operations at Kandahar. Mission 10 and 26 were scheduled but did not perform EROs because of the slot time and maintenance delays. The average ground time for all missions into Kandahar was two hours and one minute while the average ground time for ERO missions was only one hour and 43 minutes. These times were considerably lower than the scheduled ground times planners expected. As the operation continued, planners reduced the ground time to more closely match the results that the Kandahar team and aircrew were able to achieve. The one hour and 43 minute ground time is still below the planning factor in AMCPAM 10-1403 of two hours for expedited C-5 operations.

The results achieved at Kandahar are in large part due to the teamwork and professionalism of the 615 TALCE. Many of those interviewed compared the TALCE's efforts to that of a NASCAR pit crew. As they have done many times in the past, capability provided by the TALCE showed that they are the enabling force for global power projection.

Mission Capable Rate Results.

The C-5's historical MC rate prompted much concern prior to the deployment. The aircraft were required to operate away from home station for an extended period without the standard support for spare parts or repair facilities. Would the deployed maintenance team at least be able to maintain the aircraft at an availability level equal to that during normal operations? The following graph answers this question.

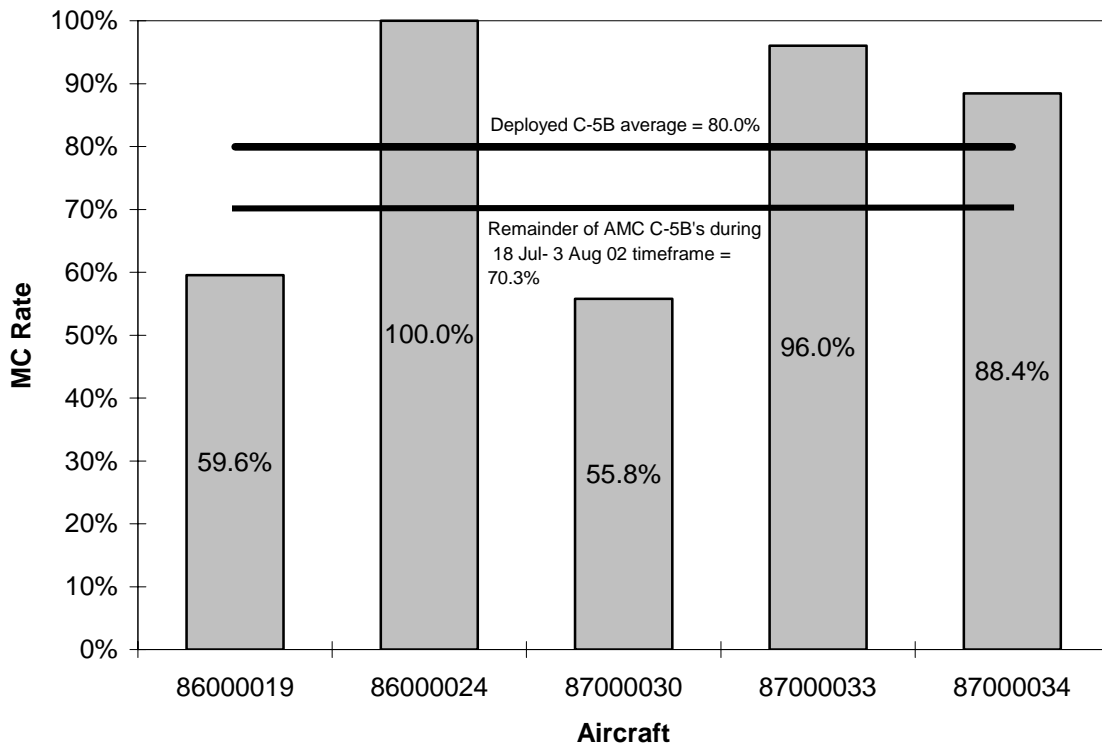


Figure 10. Deployed C-5B MC Rates from 18 Jul – 3 Aug 02

This graph shows the MC rates for the five C-5B aircraft during the 17-day deployment to Diego Garcia. These figures were obtained from G081 (28). The overall MC rate of the five deployed aircraft was 80% and is represented by the top horizontal line in the graph. The two aircraft with lower MC rates were both down for substantial time due to engine changes (42). The remainder of the C-5B fleet only achieved an MC rate of 70.3 during the same time frame and is denoted by the lower horizontal line. The ten percent difference is significant when put in the perspective of the number of hours of increased availability. The ten percent increase equates to 2.4 extra hours of MC time per day per aircraft versus the lower MC rate. This increased rate begs the question, “Why did the deployed C-5B’s operate at a higher MC rate than the average C-5B?”

According to Maj Coley, the plan was to select the five best performing C-5B aircraft for the deployment (12). One method for determining the best aircraft to deploy would be to run a MC rate report from G081 for all C-5B's over a particular time period and select the aircraft with the highest MC rate. Maj Coley was not able to go ahead with this plan because the aircraft he wanted were already on other TACC missions (12). Figure 11 shows the MC rate from G081 for the five aircraft chosen to deploy over the span of one year prior to the deployment (27). Data for tail number 87000034 only covers the six month period from Dec 01 – Jun 02 due to lack of data from G081. These figures are compared to the MC rate for all other AMC C-5B aircraft during the same time frame, Jul 02 – Jun 03.

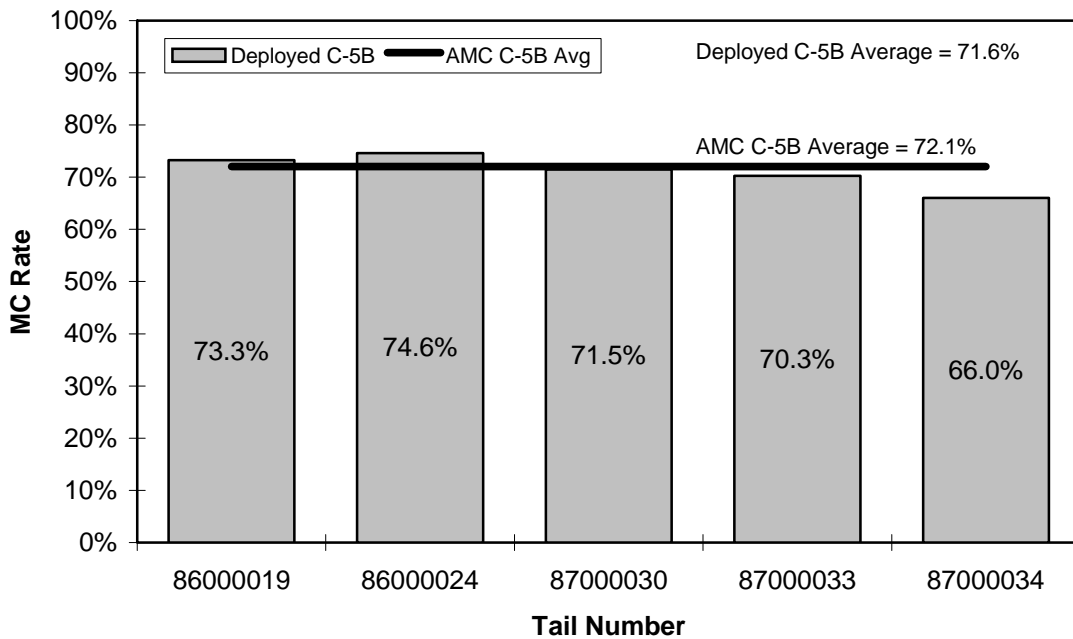


Figure 11. Deployed C-5B MC Rates Compared to all AMC C-5B Jul 01 – Jun 02

The AMC C-5B MC rate is 72.1% as compared to 71.6% for the five deploying aircraft (27). Essentially, the five C-5's that deployed had the same MC rate as the remainder of the AMC C-5B fleet. Therefore, any significant improvement in the performance of the deployed aircraft should not be attributed to the notion that the best aircraft were selected.

Based on information gathered during the interviews, the overwhelming reason for the increased performance of the aircraft was simple: teamwork at all levels. Maj Coley cited the spirit and camaraderie between the maintainers that was above and beyond any level normally exhibited at home station because his troops felt like they were "at the tip of the spear" (12). Capt Sasson commented on the unusually strong relationship that developed between the operations and maintenance functions (43). Lt Col Dillon mentioned the lean-forward attitude that every member of the team displayed and how his troops developed an expeditionary mindset which enabled them to get the job done under difficult conditions (23).

Summary of Investigative Question 1.

Was the deployment effective? The evidence gathered from the many units of analysis such as ALD, departure reliability, ground times and MC rates, show that the C-5 deployment was a highly effective use of the airlift assets.

Investigative Question 2 Results

Five C-5B's and the necessary personnel deployed half way around the world for almost three weeks to support this mission. While the C-5 was not CHOPed to a theater commander, its presence at a deployed location effectively limited its ability to be available for worldwide taskings. During research for this project, an officer in AMC/XP

made the comment that C-5's should not be taken away from the global mission because they will be used inefficiently. This section will measure the efficiency of the C-5 deployment by examining the following units of analysis: USE rates, ACL, number of deployed personnel, and mission expeditors.

USE Rate.

One of the many important factors that contribute to the USE rate is the number of aircraft used in the computation. For the C-5 deployment, five aircraft were deployed to support two missions per day. Does this represent an inefficient use of scarce resources in the attempt to guarantee effectiveness? This analysis will attempt to provide insight to that question.

The planned cycle time from Diego Garcia to Kandahar and back was approximately 15 hours.

FJDG – OAKN flying time =	5 hrs 45 mins
OAKN ground time (max) =	3 hrs 15 min
<u>OAKN – FJDG flying time =</u>	<u>6 hrs</u>
Total cycle time =	15 hrs

Assuming everything went according to the schedule, this left 9 hours for maintenance to turn the aircraft for departure at the same time the following day. Theoretically, this deployment could have been accomplished with only two aircraft. However, this plan would have failed the common sense test due to the historically low C-5 reliability.

Therefore, planners in TACC/XOP recommended deploying four aircraft (33). However, AMC/LGM, in coordination with 15 AF/LGM, chose to task 5 airframes (10). The fifth aircraft would provide an extra layer protection for the high visibility deployment, but at what cost? Five B-model aircraft represents 10% of the B model fleet, which seems like

a fairly significant amount to be deploying for a three-week period. It appears that a clear decision was made to emphasize effectiveness at the expense of efficiency.

One way to evaluate this decision with respect to efficiency is with the USE rate. The USE rate for the C-5 deployment was calculated from G081 data only using hours flown from Diego Garcia to Kandahar and back. This was done to eliminate the artificial increase in USE rate that would have occurred if the deployment and redeployment flying time were included from the CONUS to Diego Garcia. These flights were a necessary condition to the mission; however, they were not part of the Canadian airlift requirement. Table 7 provides the raw data for the deployed USE rate calculation.

Table 7. USE Rate for Deployed Aircraft

Hours Flown	Days	# of Aircraft	USE Rate
336.8	15	5	4.5

On average, each aircraft flew 4.5 hours per day from the deployed location. To determine whether or not this equates to an efficient use of the airframe, this number can be compared to the historical USE rate for a subset of the C-5 fleet. This method allows for a determination of whether or not the assets were used more in the deployed mode or the traditional global mode.

To make the comparison between deployed USE rates and worldwide USE rates, a subset of aircraft and a timeframe must be established. For this analysis, the subset of aircraft will be limited to AMC owned C-5's. This will eliminate Air National Guard (ANG) and Air Education and Training Command (AETC) owned C-5's. The reason for this is because the validity of ANG data obtained was suspect is and AETC aircraft are typically used in a training role and not a global mobility role. The following graph

shows the monthly flying hour totals for the AMC C-5 fleet since AMC's inception in June 1992 and provides several timeframes where USE rate comparisons can be made. The data to generate the graph came from AMC/LGQMA's *C-5 History* spreadsheet which tracks all C-5 maintenance performance for the monthly AMC/LG "Health of the Force" briefings (4).

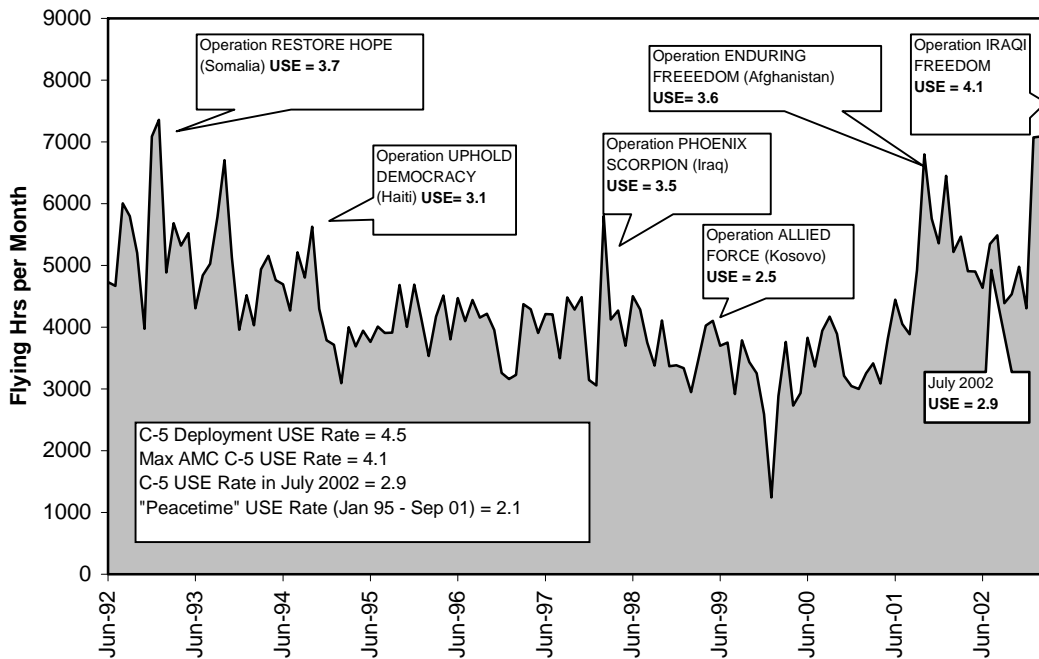


Figure 12. AMC C-5 Flying Hours and USE Rates: Jun 1992 – Mar 2003

As can be seen by the graph, Operation IRAQI FREEDOM has generated the highest monthly total of flying hours for the C-5 in AMC's 11-year history. Therefore, the USE rates from March 2003 will serve as a reasonable timeframe for comparison to the deployed USE rate. Table 8 provides the raw data needed for the calculation of the March 2004 USE rate and is typical of how the other USE rate figures were calculated for the graph (4).

Table 8. AMC USE Rate for March 2003

Mar 2003 Hrs Flown	Days	Possessed Aircraft	USE Rate
7,837.1	31	61.3	4.1

The C-5 deployment generated a USE rate of 4.5 which is higher than the 4.1 USE rate generated during the airlift surge for Operation IRAQI FREEDOM. Also, the graph highlights other interesting timeframes for comparison. During the month of the C-5 deployment, July 2002, the AMC C-5 fleet as a whole only flew 2.9 hours per day per aircraft as compared to the 4.5 hours for the deployed C-5s (4). Finally, between January 1995 and September 2001, when flying hours remained stable and relatively low, there was an average peacetime USE rate of 2.1 (4). The deployed C-5s generated over twice the flying hours per aircraft than during this period. There are many differences between all these operations that could question the significance of this data. However, the main point of this discussion is to show that despite being pulled away from the global spectrum, the five deployed C-5's were utilized at least as much as AMC's fleet during any period over the past 11 years, even during a war-time surge. Therefore, it is reasonable to conclude that the five aircraft were indeed gainfully employed while operating outside of their normal global environment and does not represent an inefficient use of the assets.

Allowable Cabin Load (ACL).

The CONOPS for the C-5 deployment called for two missions to arrive and depart Kandahar each night: the first around midnight (referred to as midnight missions) and the second mission four hours and fifteen minutes later, just prior to sunrise missions (referred to as pre-sunrise missions). This was done for threat avoidance and to take

advantage of the cooler temperatures. Two separate ACLs were designated for the departures. The midnight departure was planned for an ACL of 100,000 lbs while the pre-sunrise departure was planned for 120,000 lbs (38). Data to build to graph was obtained from the 782 EAS Mission Tracker (24). Figure 13 below shows the distribution of the actual cargo load versus the planned ACL and is divided into two sections, midnight departures and pre-sunrise departures.

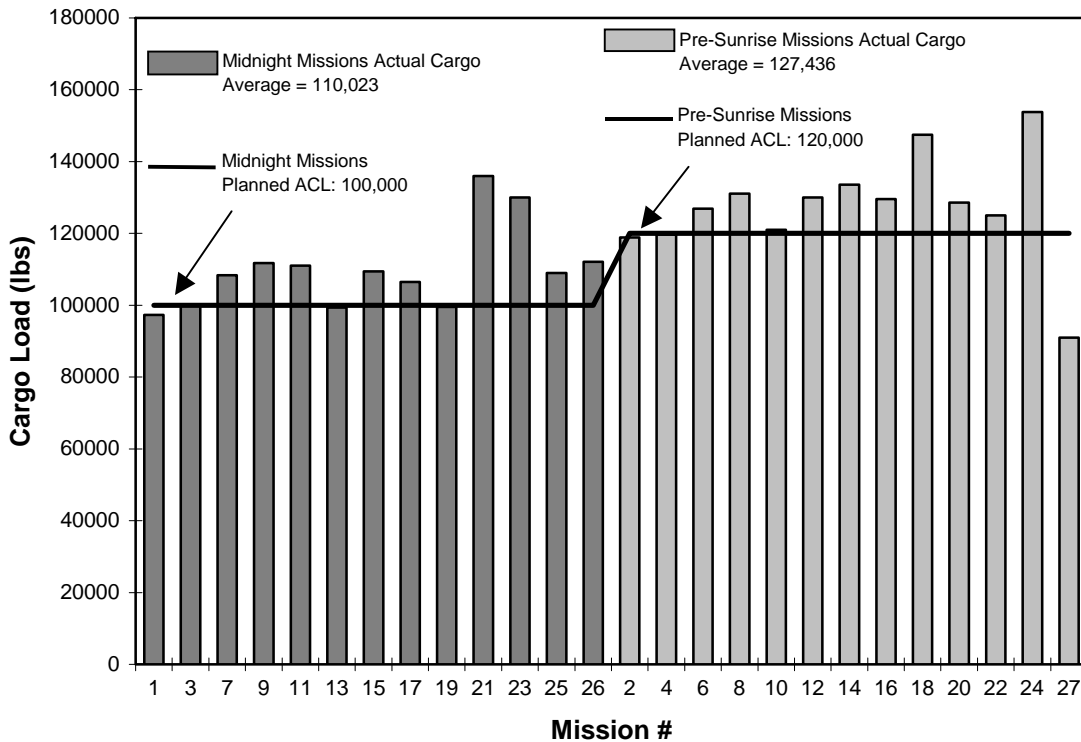


Figure 13. Actual ACL vs. Planned ACL

In almost every case, the actual departure cargo load from Kandahar exceeded the planned ACL. The midnight departures averaged over 10,000 lbs over the planned ACL while the pre-sunrise departures averaged over 7,000 lbs over the ACL. If the final

departure from Kandahar is discounted (because that was all the cargo remaining), this average is also 10,000 lbs over the planned ACL. Over 25 missions, this adds up to an additional 250,000 lbs of lift capability than previously planned and equates to two or three missions that can be eliminated from the flow. Clearly, this was an efficient use of the space available on the aircraft based on the operational constraints.

Number of Deployed Personnel.

Another unit of analysis for determining whether or not this was an efficient use of airlift resources is the number of deployed personnel in the maintenance and TALCE career fields. According to Capt Aaron Sasson, a 782 EAS maintenance officer, a typical maintenance unit type code (UTC) designed to support five aircraft in the en route system would have consisted of around 40 personnel (43). With 44 personnel at Diego Garcia and 13 in Kandahar, a total of 57 maintenance personnel deployed for this operation. Does this amount represent an inefficient use of a critical asset? This question is more difficult to answer because of the unique nature of the operation compared to typical en route C-5 maintenance. En route maintenance UTC's are primarily built to perform transient maintenance and refueling operations (43). This was the first time maintenance capability actually deployed to support aircraft generation. As a result, planners designed a considerably more robust maintenance package. Col Martin, 615 AMOG/CC and mission commander at Kandahar, also added that the "unique nature and high visibility of our operation resulted in the addition of specific C-5 maintenance personnel and C-5 maintenance equipment" (36). These extra bodies were instrumental in keeping the C-5 ground time at Kandahar down to a minimum despite having to accomplish numerous tire changes due to the deteriorating runway condition at Kandahar. Similarly, Capt Sasson

remarked that the extra manpower enabled the 782 EAS to accomplish two engine changes during the deployment and greatly contributed to the overall success of the mission (43). Also, as shown previously in this chapter, these maintenance personnel were able to keep the MC rates for the five aircraft at a level ten percent higher than the average C-5B. However, Lt Col Lee Burkett's after action report made a point of emphasizing the fact that almost 60 maintenance personnel were required to accomplish two missions per day (10). While it may appear that too many maintenance personnel were deployed to support this mission resulting in an inefficient use of resources, the unique nature of the mission makes it difficult to compare the deployed UTC package with a normal UTC package. For the assets deployed, they appeared to be utilized in an efficient manner. What is not known is how the effectiveness of the operation would have been affected if the additional personnel were not present. Therefore, the analysis of whether or not the use of these assets is inefficient is inconclusive.

The second area to analyze is the number of personnel that deployed to Kandahar to support the on load operations. Col Martin provided valuable insight for this analysis. The 451st Air Expeditionary Group (AEG) was already present in Kandahar when the additional members of the 615 AMOG arrived for the C-5 deployment. The 451 AEG had a well-established aerial port and command and control capability because of their requirement to support C-17 and C-130 operations. In fact, according to Col Martin, the 451 AEG "could have handled the additional C-5 support requirements" (36). However, due to limited planning time and poor communication links between the 451 AEG and the 615 AMOG, this arrangement could not be coordinated. Therefore, Col Martin and other leaders decided to go "conservative" and task additional command and control and

aerial port capability (36). This capability resulted in the deployment of ten additional aerial porters and seven command and control personnel (10; 38). These resources, combined with the additional maintenance support, fell under the existing AEG structure at Kandahar. Col Martin pointed out that it “was not normal for a full TALCE to fall in on an existing AEG, since sustainment personnel already existed” (36). With more advance notice and better communication, some of these additional personnel requirements may have been eliminated, thus reducing the large footprint required at Kandahar. Once again, it seems as if the emphasis on mission accomplishment led to a degree of inefficiency by deploying resources that could have been held in reserve. However, the data obtained through this research does not allow the full analysis of this topic and again is inconclusive.

Mission Expeditors.

Lt Col Burkett and CMSgt Reuning deployed to Kandahar “to provide on site C-5 expertise and when applicable provide appropriate AMC/DO and AMC/DOV waiver authority to enhance safety and ensure mission accomplishment” (10). Their contributions not only ensured mission accomplishment but also significantly increased the efficiency of the operation in three ways.

First, Maj Gen Brady, AMC/DO, granted these individuals with waiver authority for any operational C-5 issues that occurred during the deployment. This included crew rest waivers as well as minimum equipment list (MEL) waivers. Normally, waiver requests must be channeled through command and control networks to reach the AMC/DO at Scott AFB for approval and are expected to take at least one hour to process (21:32). Due to the limited communication ability at Kandahar, this delay could have

been longer and would have complicated the arrival and departure of missions from the field. Unfortunately, data was not available for the exact number of waivers and time saved by authorization of these waivers. However, in an interview with Lt Col Burkett, he recalled that he granted two waivers for crew duty day extensions which permitted the aircraft to return to Diego Garcia (9). Otherwise, the aircrew and aircraft would have had to remain overnight at Kandahar.

Second, the presence of the mission expeditors greatly contributed to the maximization of the ACL discussed previously. CMSgt Reuning, a highly experienced C-5 flight engineer, gave individual attention to each load plan in order to maximize the outbound cargo on each C-5. In addition to the pallets that were built for the next flight, CMSgt Reuning ensured that a few extra pallets were built and put off to the side of the marshalling yard. About two hours prior to departure, Lt Col Burkett and CMSgt Reuning went to the weather shop and received an update of the departure temperature. This allowed them to fine-tune the maximum takeoff weight for each mission. Temperature permitting, the extra pallets were uploaded along with the planed load. Once again, data for the exact amount additional cargo uploaded on each aircraft is not available but Lt Col Burkett confirmed that this technique eliminated the need for the three sorties mentioned in the ACL discussion. (9)

The mission expeditors served the mission in a final way by accomplishing a last look of the cargo that was ready for upload onto the aircraft. CMSgt Reuning, along with a 615 AMOG representative, visually inspected each load and identified improper load configurations and flat tires on vehicles that had already completed the joint inspection (10). These errors were corrected on the spot without impacting the mission. Left

unnoticed until loading, several pieces of palletized cargo and 7-8 pieces of rolling stock would have been frustrated during the loading process, causing delays or the inability to maximize the outbound lift (9).

The use of the mission expeditors not only contributed to the efficient use of the C-5 aircraft, but also it was an efficient use of the personnel. From the perspective of the cost of sending two individuals TDY for three weeks compared to the value they added to the operation, they provided a great deal of output relative to their input.

Summary of Investigative Question 2.

Did the use of the C-5 as a deployed asset result in an inefficient use of an airlift resource? Based on the evidence provided by the analysis of USE rates, ACL, and mission expeditors, the use of five C-5's in a deployed environment was not an inefficient use of the global mobility asset and in fact resulted in modest efficiencies in many areas.

V. Conclusion

Overview

The C-5 deployment served as a great challenge to the men and women of the C-5 community to test their ability to operate in the expeditionary environment required of today's Air Force. Until this time, C-5's had never deployed to an enroute base, performed their mission, and returned to the same base mission complete. Typical C-5 missions exploit the enroute system where transient maintenance is usually sufficient to allow the aircraft to complete its mission and return to home station where major maintenance can be performed. The nature of the Canadian redeployment mission required the C-5's to deploy away from home station with their maintenance and support package and operate in an intratheater-type role. One dilemma in permitting the use of traditional intertheater airlift assets in an intratheater role is whether or not they can be gainfully employed within the theater better than their use on a global scale. The purpose of this research was to make an assessment of the first-ever expeditionary employment of the C-5 to show whether or not this was true.

The research began in Chapter 2 by reviewing several principles of airlift doctrine that were necessary to help assess and understand the significance of the C-5 deployment. These included effectiveness and efficiency issues, intertheater versus intratheater airlift, and employment concepts and delivery methods. Next, the C-5 weapon system was introduced to highlight the tremendous capability of the C-5 but also to show how it is severely limited by its less than desired maintenance performance. Typical C-5 employment concepts were then explained, followed by the C-5's role in the major airlift

effort during Operation ENDURING FREEDOM. Finally, the chapter ended by presenting the concept of operations for the C-5 deployment to extract the Canadian Light Infantry Division from Kandahar to Diego Garcia. Chapter 3 presented the research methodology by describing the case study design for the investigative questions. This included propositions, the units of analysis and the criteria by which an assessment of the deployment would be made. Chapter 4 examined each unit of analysis and the findings for each investigative question are summarized below.

Findings

Investigative Question 1: How effective was the C-5 system in performing its deployed mission? The results from the deployment show that the C-5 was extremely effective in performing its mission. The most important criteria to measure effectiveness, cargo/passengers delivered prior to the ALD, met 100% of the requirement. The other measurements enabled this timely delivery and exceeded AMC standards in every category. The results show that this was a completely effective use of the C-5 resource and the related measurements are summarized in Table 9 below.

Table 9. Summarized Measures of Effectiveness

Unit of Analysis	Measurement	Criteria
Canadian soldiers delivered prior to ALD	787 passengers	100% of demand
Cargo delivered prior to ALD	3,087,000 pounds	100% of demand
FJDG Departure Reliability (criteria from 18 Jul – 3 Aug)	96.3 % (26/27)	Global: 58.2% AMC Standard: 80%
FJDG Logistics Dept. Reliability (criteria from 18 Jul – 3 Aug)	100% (27/27)	Global: 81.5% AMC Standard: 85%
OAKN Departure Reliability (criteria from 18 Jul – 3 Aug)	88.5% (23/26)	Global: 58.2% AMC Standard: 80%
OAKN Logistics Dept. Reliability (criteria from 18 Jul – 3 Aug)	96.2% (25/26)	Global: 81.5% AMC Standard: 85%
OAKN ERO Ground Time	1 hr 43 mins	AMC Standard: 2 hrs
MC Rate of Deployed Aircraft	80%	AMC Standard: 75%

Investigative Question 2: How efficient was the C-5 system in performing its deployed mission? The evidence provided supports the conclusion that while this was not a completely efficient operation, it certainly had modest levels of efficiency. Five aircraft were deployed to support two missions per day. In addition, extra maintenance and TALCE personnel were tasked to support the operation. These facts represent a reduction in efficiency. However, the USE rate shows that the five deployed C-5's were actually used more than the average C-5 during AMC's busiest flying period ever. This represents a relative degree of efficiency by showing that the deployed assets were in fact used in a judicious manner when compared to worldwide AMC operations. Also, the use of mission expeditors proved to be an efficient use of AMC personnel. A total of two individuals represent a very small input while their output, maximized cargo loads, reduced waiting times for waivers, and prevention of frustrated cargo, all contributed significantly to the mission. The measures of efficiency are summarized in Table 10 below.

Table 10. Summarized Measures of Efficiency

Unit of Analysis	Measurement	Criteria
USE Rate for deployed aircraft	4.5	Previous AMC Max: 4.1
Avg cargo for midnight missions	110,023 lbs	Planned ACL: 100,000 lbs
Avg cargo for pre-sunrise msns	127,436 lbs	Planned ACL: 120,000 lbs
Number of deployed personnel for maintenance/TALCE: Assessment of the number of deployed personnel was not conclusive in regards to efficiency. However, it can be generally stated that extra manpower for maintenance and TALCE operations was assigned to support this operation to ensure mission success.		
Mission expeditors: Two additional AMC personnel achieved the following: maximized cargo loads which eliminated the need for three missions, prevented frustrated cargo, and issued required waivers at Kandahar minimizing aircraft delays		

Based on the results from the two investigative questions, the answer to the overall research question of, “Can the C-5 fit into the expeditionary construct of today’s Air Force?” is definitely “yes”. The C-5 proved that it could operate in a demanding environment at higher levels of performance than in normal conditions. While many extra steps were taken to ensure mission success, this deployment proves that the C-5 will still be relevant and play an important role in our expeditionary military.

Recommendations

The success of the first C-5 deployment should not be forgotten. The results show that the reliability of the C-5 can be significantly improved over historical levels for short duration periods when extra planning, effort, and resources are allocated. This deployment opens the door for further use of the C-5 in two airlift roles: direct delivery and intratheater airlift, when the conditions dictate. Rather than relying solely on the hub and spoke concept to transload cargo to the C-17, the C-5 can provide direct delivery capability to an austere airfield, provided there is sufficient support. Also, doctrine

mentions that intertheater and intratheater airlift is not restricted by the airframe but rather is dependent on the geographic boundaries that the mission operates within. Even though the location of theater boundaries classified this as an intertheater operation (PACOM to CENTCOM to PACOM), the C-5 has proven that it could operate in an intratheater, deployed role during the Diego Garcia deployment. While doctrine states that most intratheater missions are under the control of the theater commander, this research does not recommend CHOPing C-5's to the theater commander due to the extensive C-5 planning experience residing within AMC. This operation showed that C-5's could be used in a deployed environment with effective time-definite delivery, modest efficiencies, all while AMC retained OPCON of the C-5 assets.

This research does not recommend deployed C-5 operations for continuous use. Substantial effort was required to make this mission successful. The footprint required in manpower for planning and execution, as well as the number of airframes, dictate this should only be done on a limited, short-duration basis. Conditions that could warrant the use of the C-5 in this role would be when the capability is needed to move a large amount of high priority cargo/passengers, with the fewest number of sorties possible, and/or when the C-17 is heavily tasked. The Diego Garcia deployment was designed to achieve 100% effectiveness with less emphasis on efficiency, as shown by the results. Future C-5 deployments should attempt to reduce the manpower and material requirements to the minimum level where the desired effectiveness can still be achieved.

The potential for the C-5 being able to perform in the expeditionary environment with a reduced footprint looks promising. Currently, the C-5 is undergoing two significant modernization efforts to improve the reliability of the airframe. The

Reliability Enhancements and Reengining Program (RERP) will replace many of the bad-actor systems with modern, reliable components. Most notably is the replacement of the current engine with a commercial off-the-shelf engine that is more efficient, more powerful, and meets current stage III noise requirements (34). The second effort is the Avionics Modernization Program (AMP). This modification will update the avionics suite so the C-5 can continue to operate under increasingly stringent performance measures as dictated by Global Air Traffic Management (GATM) requirements. AMP will also replace low reliability units of the automatic flight control system and aging mechanical instruments in the engine and flight system that will be unsupportable in the upcoming years (34). It is undetermined as of yet how many C-5's will receive these modernization efforts, but it is clear that these changes will certainly aid the C-5 in performing the expeditionary mission.

One of the success stories from this deployment has carried over to current operations for Operation IRAQI FREEDOM (OIF): the use of mission expeditors. Research for this project found that at least three locations were using mission expeditors to help smooth C-5 OIF airflow. Maj Terry Hestermann was one of the expeditors stationed at a C-5 en route location in Spain. His purpose was to provide on-the-scene experience above and beyond the aircrew's experience and issue AMC/DOV waiver authority. While no statistics were given, he stated that the use of mission expeditors prevented an accumulation of non-mission capable aircraft at the enroute locations thereby increasing the velocity of the C-5s (29). This is a very minimal manpower investment that has paid huge dividends and should continue to be used during high priority, large-scale contingency moves.

Areas for Further Research

The ability to use the C-5 as a deployed asset requires that current airlift plans be given a second look at how they employ the C-5. While this type of employment is not recommended for most time phased force deployment data (TPFDD) airflows, there are certain conditions where using a C-5 in the intratheater or deployed role could be beneficial. Such an example would be for non-combatant evacuation operations (NEO) on the Korean peninsula. If conflict erupts on the Korean peninsula, the need will exist to conduct a NEO to remove thousands of civilians from South Korea to safety in neighboring Japan. Commercial aircraft are usually tasked to support large passenger movements; however, if a chemical environment is present, these carriers will most likely not participate. One possible solution to this problem is to deploy C-5s to Japan to airlift passengers from Korea. With the cargo compartment troop palletized seat kit installed, the C-5 can hold an extra 267 passengers for a grand total of 340 (20:9). If the ERO concepts proven by the Diego Garcia deployment are used, improved reliability of the C-5 can be expected with shorter ground times while reducing the aircrew's and passenger's exposure to hostilities. A shorter cycle time of approximately 7 hours (2.5 hrs flying time in each direction + 2.0 hrs ground time in Korea) means that a C-5 could make multiple round trips each day, thus increasing the number of evacuated personnel. Modeling and simulation could be used to evaluate the potential throughput of passengers given varying numbers of deployed aircraft and reliability rates. This research could then be incorporated into existing operational plans.

Our future military will require innovative plans that maximize the capabilities of our valuable assets. The C-5 expeditionary deployment unlocked hidden capabilities

within our airlift system, and as Lt Col Dillon said, “The C-5 is only limited by those that fail to think outside the box” (23).

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Vita

Captain Daniel J. Oosterhous was born and raised in Texarkana, Texas. He graduated from Texas High School in 1989 and entered the United States Air Force Academy where he graduated in June 1993 with athletic distinction and a degree in Civil Engineering.

Capt Oosterhous began his active duty career as an assistant coach for the Air Force Academy's men's tennis team. He then attended Euro-NATO Joint Jet Pilot Training at Sheppard AFB in March 1994. Upon completion of pilot training in April 1995, he was assigned to the 457th Airlift Squadron at Andrews AFB where he flew the C-21 Learjet. During his tour of duty at Andrews AFB, he served as an instructor aircraft commander, scheduler, executive officer, and chief of training. His next assignment was to Travis AFB, Ca where he flew the C-5 Galaxy from November 1998 to May 2002. While at Travis AFB, he served as an instructor aircraft commander, current operations planner, and later chief of C-5 current operations.

In May of 2002, Capt Oosterhous was selected to attend the Advanced Study of Air Mobility program at the Air Mobility Warfare Center in Ft Dix, New Jersey. Upon graduation and receiving the degree of Master of Air Mobility, he will be stationed at Dover AFB proudly flying the C-5. Capt Oosterhous is married and has two daughters and one son.

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