A CRITICAL EXAMINATION OF 3,500 NM LEGS FOR STRATEGIC AIRLIFT EN ROUTE AIRFIELDS

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ABSTRACT

Post September 11th, 2001 mobility deployment requirements have demonstrated the need to adopt a more global en route capability to support the on-going Global War on Terrorism (GWOT). Consequently, the United States Transportation Command has been assessing the need for additional en route infrastructure to provide a truly global reach capability for its strategic airlift. This research presents recent findings in regard to meeting this need and addresses important aspects that should be considered in devising new en route strategies and establishing new en route airfields. The main objective of this research was to examine the basic strategic airlift assumption that 3,500 NM legs are "optimal" down range distances to locate en route airfields.

INTRODUCTION AND BACKGROUND

En route airfields are used by the Air Mobility Command (AMC) throughout the world to service airlift aircraft and, if needed, replace aircrews limited by maximum crew day requirements. An en route base is defined as an airfield that can be reached from the Continental United States (CONUS) and exists to service AMC aircraft to continue their missions downrange. The purpose of an en route base is to maximize cargo movement, while minimizing the delay in getting the cargo, either troops or equipment, to the intended destination. Current strategic airlift aircraft movement in support of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) rely heavily on Ramstein Airbase (AB) and Rhein-Main AB in Germany as en route airfields. In addition to getting fuel, aircraft arriving from the CONUS and headed downrange to Afghanistan or Iraq are generally operated by replacement aircrews. Replacement aircrews rotate through a "stage" which operates on a first in, first out basis. Deployed from home station for up to 45 days, the stage aircrews will remain overseas and pick up missions arriving from the CONUS and headed downrange. After returning from downrange, aircrews re-enter the stage until they are called out of the queue to return home.

In 1998, The United States Transportation Command (USTRANSCOM) and United States European Command (USEUCOM) commissioned and directed the European En Route Infrastructure Steering Committee (EERISC) to determine the optimal en route support basing scheme for strategic airlift operations. One important factor in base selection is the "lens" concept. The lens is formed by drawing two overlapping 3,500 nautical mile (NM) arcs, one originating from the east coast of the CONUS and the other from Southwest Asia [2]. In theory, locating an en route airfield inside this lens allows the efficient movement of cargo from the CONUS to Southwest Asia with only one en route stop for refueling and a potential crew change. Similar to the EERISC, the Pacific En Route Infrastructure Steering Committee, or PERISC, exists in the Pacific theater and was commissioned in 1999 by USTRANSCOM and the United States Pacific Command (USPACOM) [2]. The 3,500 NM lens concept does not work as well in the Pacific due to the larger geographic area of the overall theater.
The key to maximizing use of strategic airlift assets is maximizing payload, commonly referred to as

Available Cabin Load (ACL), for the planned range of the mission. ACL is the maximum payload which can be carried on a mission after accounting for takeoff conditions, routing, and fuel requirements, and may be limited by the maximum takeoff gross weight (MTGW) of the aircraft. Too much payload or ACL, and the range is diminished to an unacceptable level. On the other hand, too much range capability results in zero ACL. AMC plans for a C-17 flying a 3,200 NM route to carry 90,000 pounds of cargo and a C-5 to carry 122,600 pounds of cargo. The 3,200 NM flight is based on air mobility planning factors found in Air Force Pamphlet (AFPAM) 10-403, *Air Mobility Planning Factors*, and differs slightly from the 3,500 NM lens concept [1]. A great circle route from Dover AFB to Ramstein AB, which represents the furthest distance in the European lens, is 3,450 NM.

Multiple factors affect actual range and ACL. All aircraft have maximum takeoff gross weights as well as maximum cargo and fuel weights. If an aircraft is loaded with a maximum cargo weight it cannot carry a full fuel load without exceeding the maximum takeoff weight of the aircraft. To illustrate this point, the first production model C-17 has a maximum takeoff weight of 585,000 pounds. The maximum cargo weight is 170,900 pounds with a maximum fuel weight of 180,000 pounds. Operating weight is the weight of an aircraft without cargo or fuel onboard. Because the operating weights can vary between aircraft of the same type, for the purpose of this research the operating weight of all C-17s is a constant 282,000 pounds. An aircraft's Zero Fuel Weight (ZFW) is the cumulative total of the operating weight and loaded cargo and in this example is 452,900 pounds. This leaves 132,100 pounds for fuel. On missions requiring more than 132,100 pounds of fuel, cargo needs to be off loaded proportionately to the fuel on-load required.

Takeoff temperatures can cause the aircraft's takeoff distance to be so long it becomes unsafe, (i.e., warm days) thereby forcing a delay in the mission or an off-load of cargo. Conditions at takeoff, distance of the flight, combinations of wind conditions, temperature deviations (i.e., differences in standard temperature lapse rates with an increase in altitude) and adverse weather conditions at cruise altitude, as well as alternate airfield requirements all affect the amount of fuel required.

PROBLEM STATEMENT AND SCOPE

The main objective of this research was to examine the basic strategic airlift assumption that 3,500 NM legs are "optimal" down range distances to locate en route airfields. This objective is driven by the need to examine new worldwide en route locations for strategic airlift aircraft supporting the Global War on Terrorism. An additional motivation for this assessment is the addition of the centerline fuel tank on the C-17. This fuel tank extends the range of the aircraft for a given payload weight compared to non-centerline fuel tank equipped C-17s. Moreover, the C-5 has different range-payload characteristics than the C-17. Accordingly, optimal en route distances should also consider the affects of different aircraft types.

The research was limited to C-5 and C-17 strategic airlift aircraft as they are the primary strategic airlift aircraft used by AMC. A 3,450 NM European route between Dover AFB, Delaware and Ramstein AB, Germany was examined since this is longest route of flight from the east coast of the CONUS to inside the European lens. In the Pacific, a 3,370 NM Pacific route from Hickam AFB, Hawaii to Yokota AB, Japan was examined. Differences in total fuel consumption as a result of the differing route distances, 80 NM, are not accounted for. In a worst case scenario, a C-17 or C-5, would use approximately 3,000 and 4,000 pounds less fuel respectively on the Pacific route. While this fuel difference could easily be translated to additional payload, for the scope and time frame of this research it became impracticable to reproduce completely new data for a route 80 NM shorter. In the end, while the Pacific route is not specifically highlighted by the PERISC and is slightly shorter than the European route, the study still provides a stark contrast in range/payload capabilities between the two routes.

ANALYSIS AND RESULTS

The ACL capabilities of the, C-5, C-17 extended range (ER), and C-17 non-ER, were analyzed by each aircraft flying two different routes, one across the Atlantic Ocean and the other across the Pacific Ocean. These six categories were further analyzed by considering different aircraft flight altitudes or levels. For each of these resulting permutations, exact fuel requirements and maximum payloads were computed based on the previously mentioned flight conditions. The detailed methodology to accomplish these computations are presented by Greenstreet [2].

The results show a distinct difference in aircraft ACL that primarily depends on the direction of flight. That is, historical weather data shows strong headwinds going west and strong tailwinds going east. Headwinds decreased the ACL of the C-5 and C-17 on the Pacific route while tailwinds increased the ACL for the European route. Additionally, the C-17 ER aircraft's ACL was able to meet the AMC planning factor of 90,000 pounds more often than the C-17 non-ER aircraft. Figure 1 compares the C-17 non-ER to the C-17 ER and European and Pacific routes respectively.

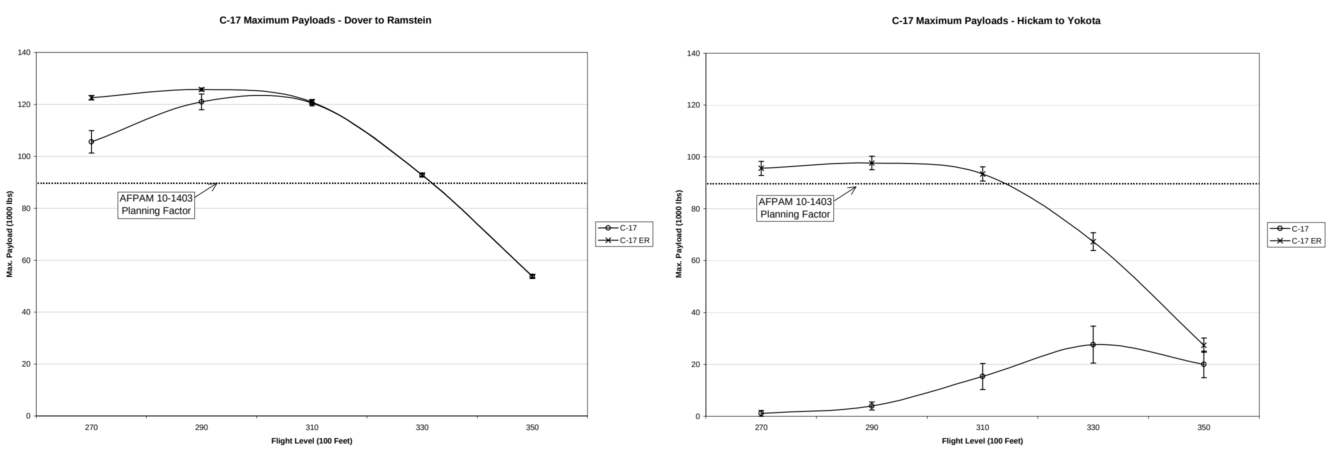

Figure 1. C-17 Maximum ACL – European and Pacific Routing

These charts primarily reflect the affects of wind and altitude on ACL. These graphs also show 95% confidence intervals for the average maximum ACL for each flight level. As seen in Figure 1, a C-17 non-ER or ER aircraft can carry their planning factor payload across the Atlantic to a European en route by selection of the appropriate flight level. The drop off in ACL at higher altitudes results from an increase in the fuel burn rate required to achieve the higher altitude which in turn requires additional fuel at the expense of payload. Judicious choice of flight levels by experienced operators makes this a non-issue. Figure 3 shows a serious problem for the C-17 non-ER across flying across the Pacific. In fact, such a non-ER aircraft will never achieve its planning factor payload. However, the C-17 ER can meet its planning factor payload by the fact that it can simply carry more fuel. In examining the C-5, it can carry its planning factor payload across either the Pacific or European routes with no problems, again with choice of the appropriate flight levels [2].

CONCLUSIONS AND RECOMMENDATIONS

The overall results of this study provide a methodology to determine accurate maximum payloads that can be carried by strategic airlift aircraft across different routings and realistic flight conditions that account for historical weather conditions. Based on these results, we conclude that the planning factors contained in AFPAM 10-1403 and used by the USTRANSCOM and AMC are valid with the exception of the C-17 non-ER aircraft on routes going west across the Pacific Ocean. Since 70 C-17s are non-ER aircraft, any movement of cargo in a direction dominated by headwinds should be closely examined regarding delivery and closure estimates. Moreover these results provide justification to modify these first 70 production C-17 aircraft. The data also show a trade-off between fuel burned and cargo carried. With rising fuel costs, research to find the optimal altitude that maximizes ACL and minimizes fuel cost using historical weather and cargo data is worthwhile. Lastly, the data show that the C-5 and C-17 ER aircraft are capable of carrying their planning factor payloads beyond the 3,500 NM "lens" in most cases. Accordingly, the EERISC/PERISC should consider the possibility of longer route distances to potential future en route airfields. Indeed, we are researching potential en route airfields around the globe, many of these exceed the 3,500 NM distance. Estimated throughput via these en routes will be computed and compared to shorter en route distances. Other factors such as fuel and infrastructure capabilities at these airfields are also being considered to determine the "best" potential en route airfields.

REFERENCES

[1] Department of the Air Force, *Air Mobility Planning Factors*, AFP 10-1403, Washington, D.C., HQ USAF (March 1998).

[2] Greenstreet, K.M., *Examination of Optimal Range/Payload Metrics for Strategic Airlift Aircraft*, Graduate Research Project, Graduate Program in Operational Sciences, Air Force Institute of Technology, (2004).