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Research Report

Maximizing Throughput at Soft Airfields

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RAND Project AIR FORCE

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Summary

The number of passes an aircraft can make on a soft field is limited due to the rutting that occurs with each successive landing and takeoff. To quantify the ability of soft fields to support aircraft operations, the California Bearing Ratio (CBR) can be used. In particular, aircraft performance charts often prescribe the number of passes that can be executed based on CBR and aircraft landing weight. As the landing weight increases, the number of allowable passes decreases. However, increased landing weight allows for increased payloads. We examine this trade-off between number of passes and payload in this document.

Calculating Optimum Landing Weight

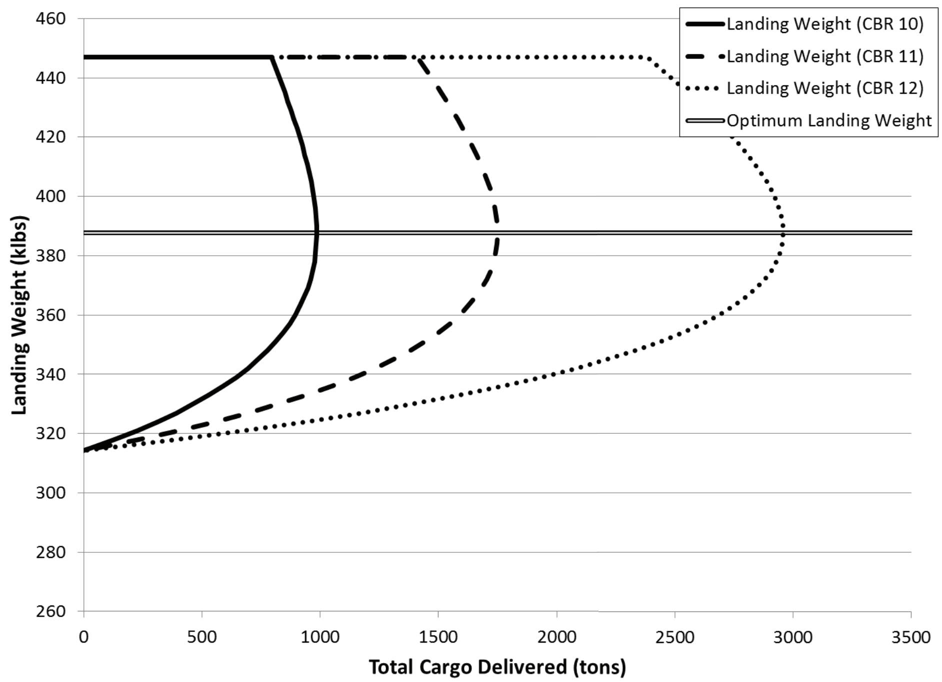
To the extent that a soft field is used for delivery movements, it is important to understand what aircraft landing weights will allow for a given total cargo delivery requirement to be met. This report shows that there exists an optimum landing weight that allows for maximum cargo delivery. This optimum landing weight, defined as the optimum cargo weight per sortie plus the ramp weight at the point of debarkation, is not necessarily the maximum aircraft landing weight. In fact, by landing with a less-than-maximum payload, it is possible that more total cargo could be delivered. The optimum cargo weight, defined as the cargo weight per sortie that yields the maximum total cargo delivery, is found to be constant and independent of both aircraft ramp weight (landing weight minus cargo weight) and field CBR. That is, the optimum cargo weight is independent of the return fuel load as well as the field CBR.

This report also presents the maximum allowable cargo weight given a delivery requirement. This is an important metric because, even though the field damage will be higher than if operations were conducted at the optimum cargo weight, it both minimizes the number of missions that need to be flown and reduces closure time.

Illustrative Calculation: C-17A

We illustrate these calculations using the C-17A, which was one of the options being considered in the joint future theater airlift analysis of alternatives. Figure S.1 shows the optimal landing weight to meet a given delivery requirement, assuming a ramp weight of 315,000 lb. The three curves represent the range of landing weights for various field CBRs, up to and including the maximum allowable landing weight. The figure shows that as the delivery requirement increases, the range of landing weights decreases until the minimum and maximum allowable landing weight converge at the optimum landing weight. Delivery requirements in excess of this optimum cannot be met. The figure also shows that as the CBR is increased, there is a very large increase in the amount of cargo that can be delivered.

Figure S.1. Allowable Range of C-17A Landing Weight Given a Total Cargo Delivery Requirement



In summary, the optimum cargo weight for a C-17A, to maximize the total delivery to a soft field, is about 73,000 lb, subject to aircraft limitations. For example, given a ramp weight of 315,000 lb, a landing weight of about 388,000 lb (73,000 lb of cargo) will allow the maximum cargo delivery to a soft field. If the ramp weight, defined as the aircraft ramp weight for the return leg, were to increase, then the optimum landing weight would increase by an equal amount, the optimum cargo weight would be unchanged, and the total cargo delivered would decrease, all subject to weight limitations of the aircraft.

Conclusions

In general, the optimum landing weight for a C-17A is less than the maximum aircraft landing weight. This optimum landing weight maximizes the amount of cargo that can be delivered to a given field or minimizes the amount of damage to the field for a given fixed delivery requirement. Even if the delivery requirement is less than the maximum capacity of the field, operating at the optimum landing weight may still be effective, since minimizing field damage increases the margin of safety and allows for future operations. Finally, we find that there is a maximum landing weight at which a given cargo requirement can be met. This maximum landing weight minimizes the number of missions that need to be flown while not exceeding the limits of the soft field.

While the analysis presented here is limited to the C-17A, a similar analysis was done by the author for the C-130J-30. The same functional fit was found for the C-130J-30, although the regression error was slightly higher. This indicates that the results derived in this work will likely apply to other aircraft.

These metrics are important for planning logistical movements to soft fields and can allow for better management and utilization of soft fields. In particular, they will allow planners to define the total cargo delivery capability of various soft fields, which can aid in deliberate and contingency planning.