Air Force Studies And Analyses

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Tons, Time and Turf

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BACKGROUND

In wartime, airfield congestion may cause airlift aircraft queuing and may slow delivery of badly needed combat equipment and supplies. When many aircraft are competing for limited space to maneuver and park, a theater commander who is relying heavily on airlift would prefer an airlift aircraft that:

- Carries large payloads of the right combat equipment;
- Requires only a short while to offload and be serviced;
- Occupies a small amount of ramp space.

(Other desirable airlift aircraft characteristics, not addressed here, include all-weather capability, capacity for outsize cargo, ability to operate on unpaved surfaces, long range, mechanical reliability, airdrop capability, short landing ground run, etc.) This paper will discuss a technique for modelling airlift operations at a congested airfield, assuming no constraints on manpower or loading equipment.

SCOPE & PURPOSE

Some mobility models display saturation at an airfield by allowing only a predetermined daily number of airlift missions or tons to arrive there. This paper attempts to refine this technique by portraying arrivals as normalized to the payloads, ground times, and ramp space associated with the C-130 aircraft. The daily saturation point of an airfield can then by described in terms of C-130 equivalent tonnage and/or C-130 equivalent sorties, by utilizing a ramp factor that captures both airfield operating hours and use of scarce ramp space. A sample calculation illustrates the interaction with a C-5 aircraft and suggests additional applications in the measurement of sortie avoidance achieved by direct delivery to forward airfields.

DISCUSSION

Tons

Although it is unlikely that any two aircraft, even of the same model, will ever carry exactly the same tonnage, the Airlift Loading Model can compute average payloads, for each deploying unit and cargo aircraft type, from a large-scale deployment simulation. The average payload approach to mobility analysis has appeared previously in the 1981 Congressionally Mandated Mobility Study and the 1983 DOD Sealift Study.

It is believed that loading aircraft in sequence adds realism to the loading efficiencies achieved in a simulation. Depending on the aircraft mix, analysts may select any scheme they believe reflects the order airlift aircraft would use to onload in an actual deployment. For example, in an early draft of the Sealift Study, cargo aircraft were available as follows: 215 C-141s, 12 C-17s, 108 C-5s, 61 KC-10s, 61 747s. The loading sequence selected was: 8 C-141s, 1 C-17, 4 C-5s, 2 KC-10s, 2 747s, 8 C-141s, 0 C-17s, 4 C-5s, 2 KC-10s, 2 747s. With the sequence established, the loading model next simulated the loading of each type of deploying unit, tracking numbers of sorties, average payloads and loading efficiency. This information is useful for modelling both short-range and long-range missions.

Time

Time and ramp space can both be modelled in terms of C-130 equivalents. An aircraft whose planned offload time is double that of a C-130 would represent two C-130 equivalents, in terms of scarce space utilization, assuming it required the same area as a C-130 to maneuver and park. For aircraft modelled in the DOD Sealift Study, planned ground times (in hours) at offload points are: C-130 - 1.5; C-17 - 2.0; C-141 - 2.3; C-5 - 3.3; Wide-bodied civil-type - 3.0.; Narrow-bodied civil-type - 1.0. Clearly, reducing ground time increases the potential for greater airlifter productivity, frees valuable ramp space for other aircraft, and reduces vulnerability to hostile activity.

Turf

Modelling usage of ramp space may be the most difficult task. If an analyst knew precisely when different types of aircraft would arrive at a given airfield, he could model the situation minute-by-minute using scale models, standard obstacle clearances, aircraft backing (where appropriate), and the effects of prop/jet blast. But with the airlift aircraft mix constantly changing, the likelihood of non-airlift aircraft operations, and the unpredictable effects of non-flying operations (temporary storage of cargo/pallets, vehicle parking, ramp damage from hostile action, etc.), the best available modelling technique may be to examine a number of different parking ramps, each of which can accommodate a maximum number of airlift aircraft of one type. Analysts from the Douglas Aircraft Company have tried to do this as shown in the figure below. But their results have not been validated for consistency and accuracy, especially regarding the treatment of aircraft manufactured by a major competitor.
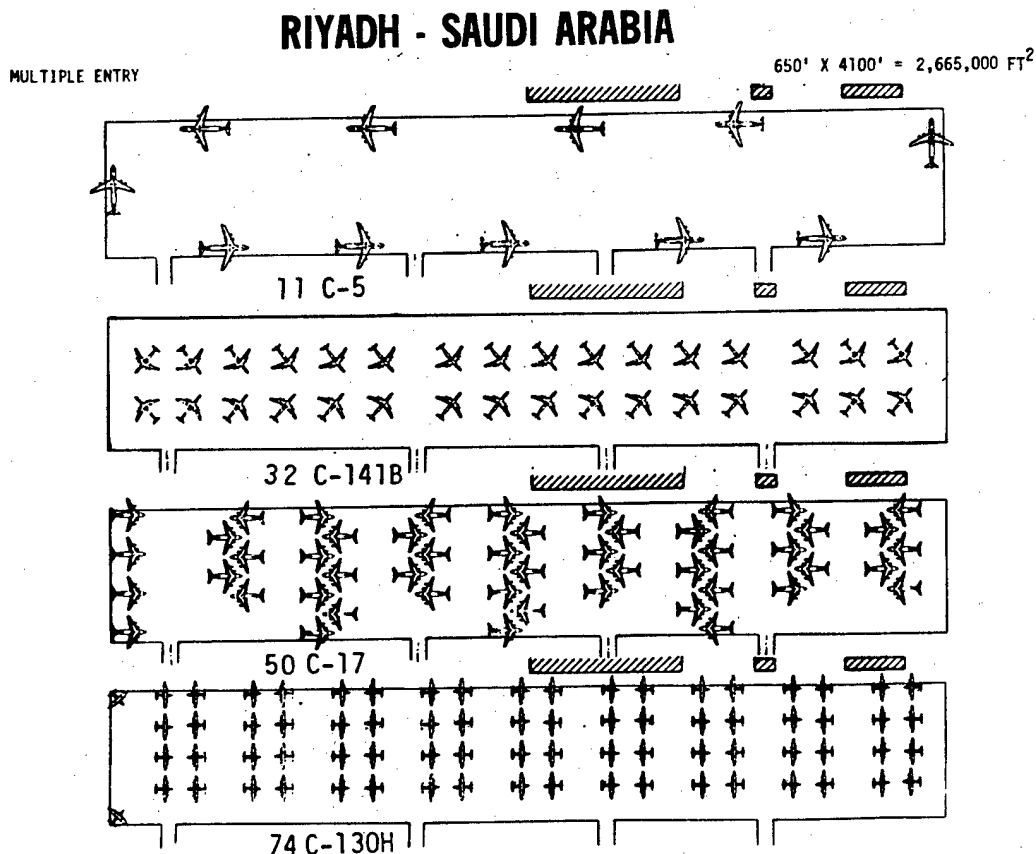

Figure 1. Sample Douglas Parking Diagram

An even less sophisticated method of modelling aircraft parking may be found in Air Force Manual 86-2, Standard Facility Requirements. Although the manual gives no consideration to aircraft backing, jet/prop blast, or queuing on narrow taxiways, it does account for maneuvering, directing that apron estimates be computed as 3.5 times aircraft wingspan times length. Headquarters, MAC uses a similar method for their planning and analyses. The method of AFM 86-2 was recommended for use in the Worldwide Intratheater Mobility Study (WIMS), being conducted by OSD and expected to be completed soon. (A refinement of the factor, 3.5, may be the subject of a further paper.)

WIMS uses two computer simulation models: Simulator for Transportation Analysis and Planning (SITAP) and Scenario Unrestricted Mobility Model for Intratheater Simulation (SUMMITS). SITAP treats explicitly 13 different cargo commodity types, planned onload and offload times, and ramp space occupied (in terms of C-130 equivalent parking spaces). The table below describes the ramp space calculations.

	Length (L) (ft)	Width (W) (ft)	3 1/2 X L X W	Space in C-130 equiv
C-130	98	133	45,619	1.00
C-17	165	173	99,908	2.19
C-141	168	160	94,080	2.06
C-5	248	223	193,564	4.24
DC-8	189	148	97,902	2.15
B-747	232	196	159,152	3.49

Table 1. Calculations IAW AFM 86-2

(One might argue that a space factor fractionally greater than N can be, in reality, no less than N + 1. While this is certainly true when aircraft are replaced one-for-one, a broader aircraft mix probably eliminates the perceived need for rounding the space factors upward. A C-17 and a C-141, for example, occupy just over four C-130 spaces, considerably less than the six spaces derived from upward rounding.)

SUMMITS, on the other hand, is less data-intensive and models payloads as outsize, oversize, and bulk cargo, only. In addition, SUMMITS combines ground time and parking space into one C-130 equivalent ramp factor as shown in Table 2 below.

	A Gnd Time (hrs)	B Ramp Space (C-130 equiv)	C-130 Equiv Ramp Factor (A X B ÷ C-130 Gnd Time)
C-130	1.5	1.00	1.00
C-17	2.0	2.19	2.92
C-141	2.3	2.06	3.16
C-5	3.3	4.24	9.33
DC-8	1.0	2.15	1.43
B-747	3.0	3.49	6.98

Table 2. Airlift Aircraft Ramp Factors

A useful technique is to examine a given airfield's ramp space and operating hours. From this information, one may compute the maximum number of daily C-130 equivalent sorties that can be accommodated at that location. Each

distinct airlift aircraft arrival will reduce the remaining C-130 equivalent sorties supportable at that airfield on that day. When all sorties have been accounted for, the airfield closes to further airlift traffic until the next day. For a hypothetical airfield, a sample calculation of daily sorties is shown in the figure below, using the SUMMITS method.

Alpha AB   Operating hours: 0300Z - 1500Z
                Aircraft ramp space: 800,000 ft^2

Computing daily C-130 equivalent sorties:

$$\frac{800,000 \text{ ft}^2}{45,619 \text{ ft}^2/\text{acft}} = 17.54, \text{ which rounds to 17 aircraft at one time}$$

$$\frac{17 \times 12 \text{ hrs/day}}{1.5 \text{ hrs/sorties}} = 136 \text{ aircraft sorties/day}$$

Checking C-5s at 9.33 C-130 equivalents per C-5 sortie:

$$\frac{136}{9.33} = 14.58, \text{ which rounds to 14 C-5 sorties/day}$$

Figure 2. Sample Sortie Calculation

    This technique may be used not only for quantifying airfield sortie limitations but also for measuring sortie avoidance achieved when airlift aircraft overfly a main operating base and proceed directly to a forward-area base. Further treatment of sortie avoidance will appear in a later paper.

OBSERVATIONS

At a congested airfield, saturation may be modelled in terms of arriving daily tonnage, daily sorties, or both. Because it is small relative to other airlift aircraft, the C-130 may be a useful reference aircraft for quantifying ground times and ramp space utilization.

When larger aircraft operate into the airfield, their contributions to congestion may be displayed in terms of C-130 equivalents.

This technique is potentially useful in modelling saturation at any airfield as well as measuring sortie avoidance achieved when some airlifters overfly a main operating base and proceed directly to a forward-area base.

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