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A DESERT STORM CREW FLYING HOUR MODEL

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ABSTRACT

Desert Storm was propelled by the largest airlift in history--an airlift built upon the resources of the Military Airlift Command (MAC). The crews who flew the airlift missions were one of the key resources which MAC had to manage throughout Desert Storm. In this paper we will describe a model which was widely used to support decisions on employment of aircrews.

We will begin by describing the Desert Storm scenario and defining the components of the airlift system and the rules for its operation. Next we will describe the model and its inputs and outputs. We will then discuss the application of the model to specific decisions and the validation of model results.

1 BACKGROUND

MAC supports American interests by operating an airlift system which can respond to a contingency anywhere in the world. The peacetime mission prepares the command for the wartime mission by refining procedures and positioning an infrastructure to support aircraft and crews enroute. This global system of aircraft, maintenance units, and aerial ports can support the movement of troops and their equipment wherever required. Much of the rapid initial response in Desert Storm was accomplished using MAC airlift resources. MAC was also at the forefront of the prolonged effort of moving troops and equipment to the Southwest Asia Area of Responsibility (AOR) and sustaining them while there.

Figure 1 is a notional look at the routes involved in moving an Army unit to the AOR. A typical mission begins on the east coast of the United States, say at Dover AFB, Delaware (KDOV) for a C-5 aircraft. The aircraft moves to the onload point, say Fort Riley, Kansas (KFOE), picks up the load and proceeds to an east coast base such as Westover AFB, Massachusetts (KCEF), to change crews and refuel. The aircraft proceeds to a European base, such as Rhein Main AB, Germany (EDAF), for refueling and another change of crew. From Rhein Main the aircraft proceeds into the AOR, delivers its load, refuels and returns to a European base such as Torrejon AB, Spain (LETO), to refuel and change crews again. Finally, the last leg of the journey returns the plane to the east coast where it is prepared for its next mission. Note that while the crews rest the plane and its valuable cargo are kept moving. As in the figure, four crews are required to move the aircraft around the cycle of bases.

Each of the bases where the crews are changed is termed a stage base. Crews are prepositioned at these stage bases in proportion to the magnitude of the flow of aircraft through these bases. Each "basic" crew is composed of a pilot, copilot, two flight engineers and one or two loadmasters. Seeding a stage with crews is part of establishing the infrastructure to establish a sustained airlift effort. The necessity to stage crews is driven by restrictions on the length of the duty day permitted by flying safety regulations.

When it is not possible to establish a stage base, it is possible to lengthen the permitted duty day by "augmenting" the crew with an additional pilot. In the case of Desert Storm it was not possible to establish a stage base in the AOR. Therefore, flights out and back between the European stage bases and the AOR were flown with augmented crews. Note the 23 hour and 40 minute duty day shown for the augmented leg. Since the legs between the continental United States (CONUS) and the European stage bases need not be augmented, it was necessary to establish a separate pool of augmenting pilots at the European stage bases.

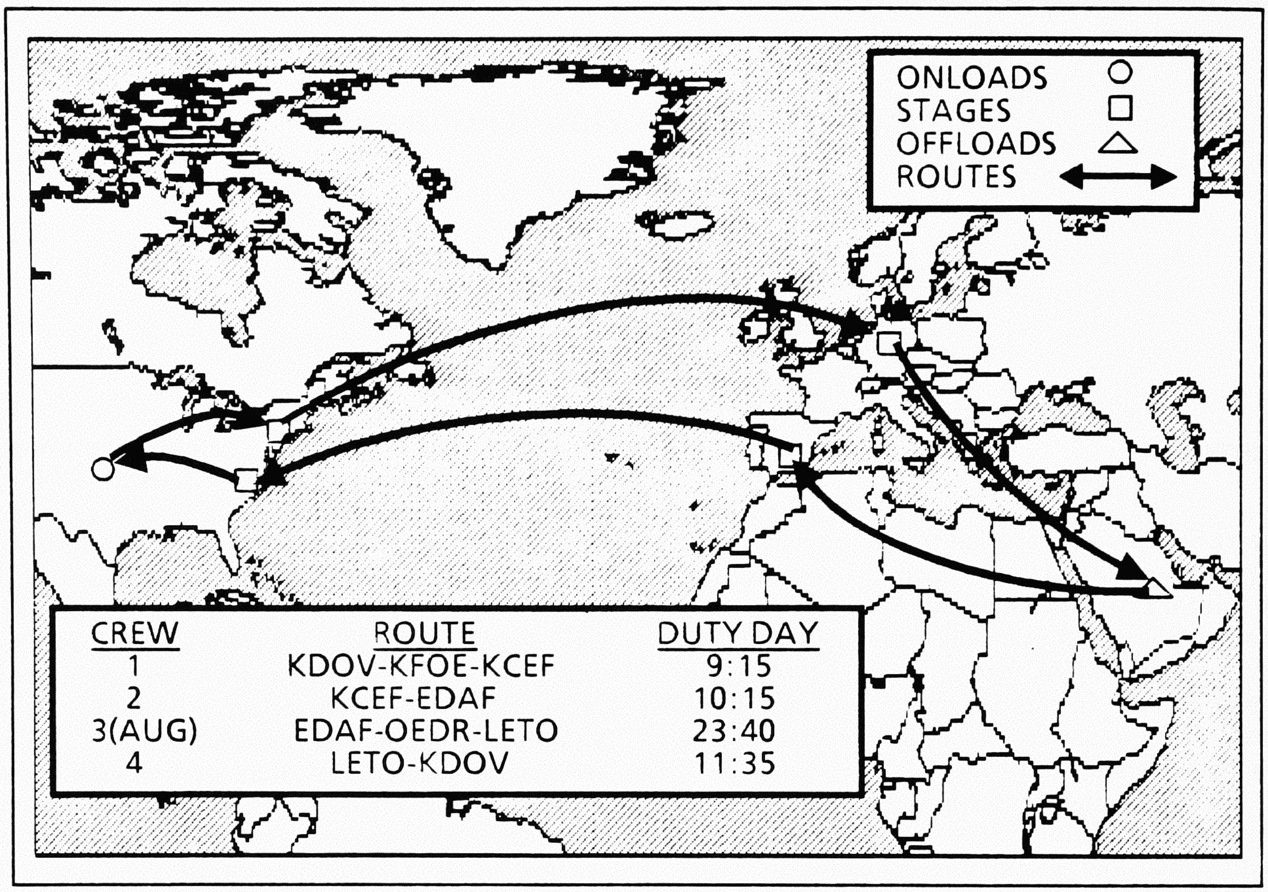

Figure 1: Desert Storm Airlift Network

Besides restrictions on the permitted length of a duty day, there are also restrictions on the number of flying hours crews can accumulate over 30, 60, and 90 day periods. Thirty-day flying time is normally limited to 125 hours, but was extended to 150 hours for Desert Storm. Ninety-day hours were managed to a 330 hour limit though this would have been extended to 400 hours if the situation had warranted. Flyers near one of the flying hour limits are said to be "burnt out" and cannot take a mission which would put them over that limit. If a significant portion of the crew force comes near the limits then it can become impossible to find a crew legally able to take a mission. On the other hand, hours are also falling off the tail of the flying hour history so flyers are eventually able to resume flying.

Not all flyers are from active duty units. About 50% of the crews for strategic airlift aircraft (C-5s and C-141s) are from Reserve and Air National Guard units. The wartime mission simply cannot be done without them. Until Guard and Reserve units are activated to support a contingency these crews are not available except on a volunteer basis. The callup and release of Reserve and Guard units are two of the decisions the model was designed to support.

Senior leaders were well aware of the impact their decisions had on the lives of reservists and they used every measure available to examine the need to call up the Reserve and Guard units. These decisions were always made in the context of a task which had to be accomplished. For instance, the decision to deploy an offensive capability within a certain timeframe required a careful analysis from the standpoint of aircrews and airframes. The level of flying for the C-141 or C-5 fleets was such that a day's worth of Desert Storm flying would equal a month's worth of peacetime channel missions in the European or the Pacific areas. Furthermore, after the "100 hour" war was over, six months of logistic effort remained. Airlift forces are always "first in, last out." Thus the drawdown of reserve forces also required a careful analysis.

2 MODEL DESCRIPTION

The objectives of the crew force model are:

1. Estimate average individual flying hour accumulation using historical flying hours.
2. Predict average individual flying hour accumulation based on a proposed future flying schedule.
3. Predict mission delays and cancellations which would result from a proposed flying schedule.
4. Test the effects of augmentation, crew rest, reservist callup/release, and staging policies on flying hour capability.

The initial model was developed in about two weeks and refined over the next month to reach its final form. SIMSCRIPT II.5 was the modeling language. Figure 2 illustrates the inputs and outputs of the model.

The originating locations, stage bases, and offloads are specified in a parameter file which also contains the size and composition of the crew force, e.g. number of pilots and copilots. Routes which connect the locations are specified separately along with the rules for staging, e.g. whether crew rest or staging occurs at a particular location. Additional parameters representing the duration of crewrest, ground times, flying times, augmentation requirements, etc. complete the specification of the network. The model is entirely data driven so the parameter files are simply changed to simulate a different aircraft type, scenario, and crew force.

The model computes the proper number of crews to place in stage bases as a function of the missions to be flown. Some smoothing is done in the model to prevent it from moving crews back and forth to stage bases in an unrealistic fashion. Given the total number of crews in the scenario it is possible to compute an optimal distribution of these crews to the stages by an extension of work by Chandra et al (1987). Optimal in this context means placement of crews to minimize the probability that a mission is delayed or cancelled due to lack of a crew. In most scenarios, however, we are dealing with large numbers of crews so that a very simple algebraic algorithm gives a good result for positioning crews in the stage bases.

The level of flying activity is dictated by two factors--historical hours and a proposed flying schedule. Missions are generated and flown which match the historical hours flown over each route in the contingency up to the current time. Flyers are assigned to planes and proceed around the network of bases accumulating flying hours, staging and resting as appropriate. Beyond the current time, missions are generated according to the contemplated level of flying activity. It is here that we begin to test the feasibility of carrying out the proposed flying schedule.

Each flyer is an individual model entity and begins with 90 days of flying history generated to match typical patterns prior to the contingency. The flying history is consulted prior to selecting a crew for an upcoming mission. All members of the crew must be able to complete the mission

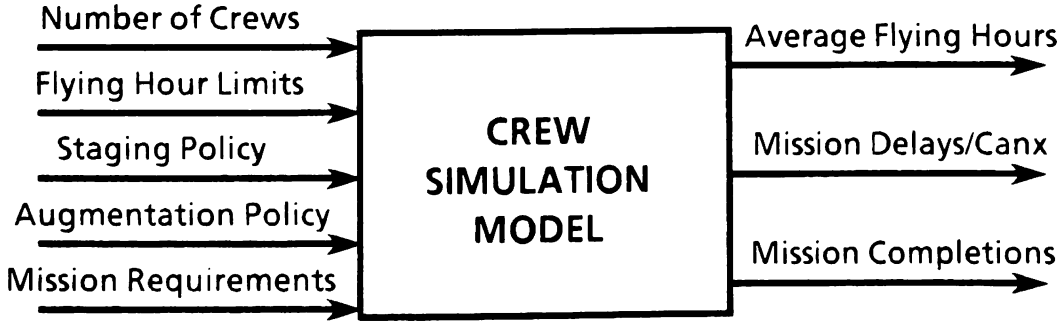

Figure 2: Model Inputs and Outputs

without busting the flying hour limits. Once formed, a crew remains together as it moves round the cycle of bases. Crews are marked as active or reserve to facilitate adjusting the number of reservists in the model when answering questions regarding (de)activation of Reserve or Guard units.

Missions are cancelled or delayed when a crew is not available. Missions that are enroute at a stage base can only be delayed for lack of a crew since once picked up cargo or passengers must be delivered. Originating missions for which a crew cannot be found are cancelled. The number of cancellations and delays are two measures of performance.

3 DECISIONS AND VALIDATION

The crew model was typically used to decide whether it was possible to fly at the level needed to deliver a certain force package while sustaining routine supplies to the AOR. The key input is the number of missions by plane type and route which would have to be flown to deliver the force package and sustainment. These missions were used to drive the crew model and make the capability assessment. A second application was

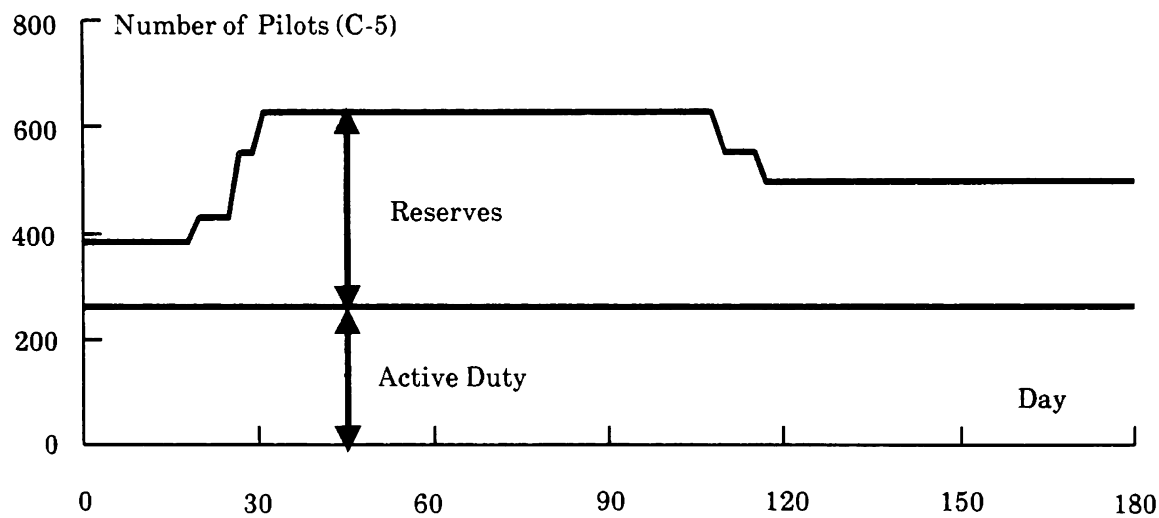

Figure 3: Callup and Release of Reserves

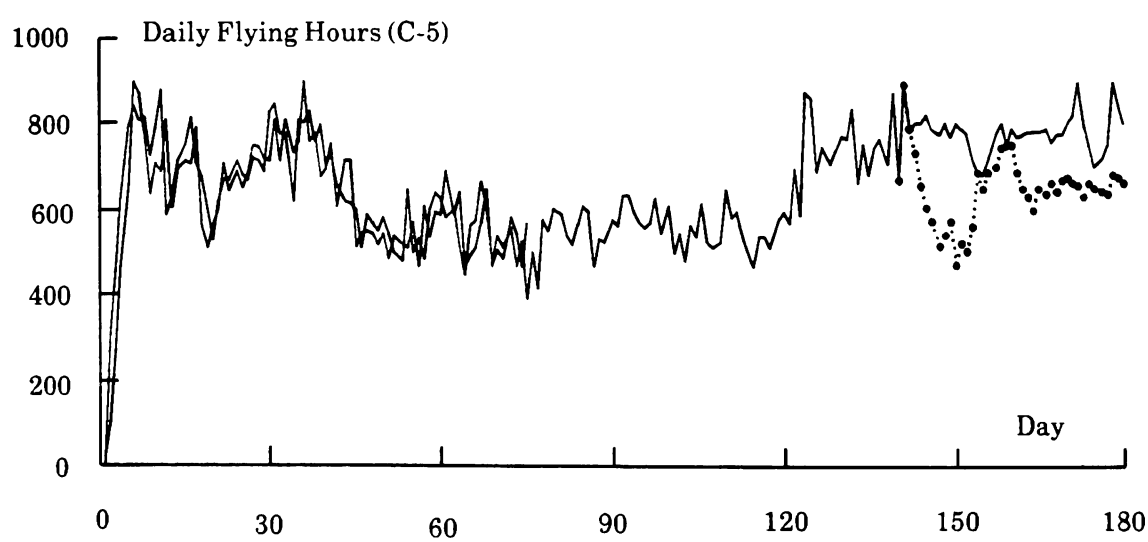

Figure 4: Daily C-5 Flying Hours

estimating the level of flying activity we could sustain or surge to as a function of reserve callups/releases. Model runs were also used to estimate flying activity that could be supported if an in-country stage were available (i.e., by avoiding the augmentation of crews). Other runs gauged the effect of a particular level of training activity and resumption of peacetime cargo missions subsequent to Desert Storm.

Figures 3 and 4 show a typical scenario examined. In Figure 3 we see the buildup of the C-5 crew force by callup of reserve units. This buildup is followed by a contemplated release of reservists 90 days after their initial unit callup. Figure 4 plots the number of flying hours attempted and accomplished by the C-5. In the initial portion of the graph there are two lines: one representing historical flying hours (ending about day 75) and the second representing hours "flown" in the model--showing good agreement. This particular run hypothesizes a surge of activity beginning about day 120. The dotted line at the end of the graph represents accomplished hours which fall short of attempted hours due to mission cancellations. The cancellations are attributed to insufficient numbers of crews and crews reaching their flying hour limits and would argue against release of reserve crews.

The detailed reasons for cancellations can always be discovered by examining the model's daily status report. Figure 5 is an excerpt from a status report. Some of the key indicators shown are a histogram of the 30 day flying hours for pilots, the status of crew availability in the stage bases, the number of crews in end-of mission crew rest and awaiting replacement in the stages, and

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------------------------------------time is 50.00--------------------------------------------

-----------------------------summary of daily flying activity----------------------------

enroute = 46  max enroute = 48  inair = 33  max inair = 41

missions: sched = 30  canx = 0  flown = 24  total hours = 715.00

missions in delay status: currently = 0  maximum = 0

----------------30 day flying hours by pilot type: 0 to 150 by 50-------------------

                 0-50    50-100   100-150   >150

pilots:          103     114      119       0
first pilots:      5      34       53       1
copilots:          4      31       52       0

----------------status of stage and originating locations-----------------

KDOV  In the window = 98   In crew rest = 40   mog = 23
KCEF  In the window =  8   In crew rest =  2   mog =  3
EDAF  In the window = 36   In crew rest =  8   mog =  0
LETO  In the window = 66   In crew rest = 60   mog = 15
first pilots: EDAF In the window = 10    In crew rest =  4
first pilots: LETO In the window = 31    In crew rest = 22

----------------status of the pilot pools-----------------

naf = 1   pilot pool = 13    eomcrewrest = 4
naf = 2   pilot pool = 14    eomcrewrest = 2

successful replenishment = 54  awaiting replenishment = 0
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Figure 5: Detailed Model Output

the daily flying hours attempted. This particular run shows that crews are available in the stages, and there is no backlog of crews awaiting replacement in the stages. A sure sign of impending problems is a backlog in replacing crews which have reached their flying hour limits. The reason for missions in delay status can sometimes be attributed to a bad choice for the number of crews to place in the stages. So analysis of a scenario usually involves several runs and detailed examination of the model's status variables.

We were also able to conduct an objective validation of the model's flying hour estimates by comparison to a database of actual flying hours. The database allowed us to compare average flying hours from the model with something approaching reality. Figure 6 shows the results of the comparison for the C-141 pilots on average thirty day flying hours. The dots represent the average as reported by the database at the month's end. The curves represent average hours as predicted daily by the model. Generally the agreement is good. Note that between day 30 and 60 the model accurately reflects the tremendous surge in flying hours which was damped in large part by the callup of reserve units.

4 CONCLUSIONS

This paper has described one of several models that supported Desert Storm/Shield decision making. The model was developed rapidly using SIMSCRIPT II.5. It was data driven so that a new scenario could be specified by changing parameter files. The model examines the effect of crew augmentation, staging, increased flying hours, and reserve callup/release in meeting mission requirements. Level of detail was sufficient to capture the key features of the scenario and to establish points of reference for decision makers. Mission cancellations, mission delays, and average flying hours were the response variables of interest.

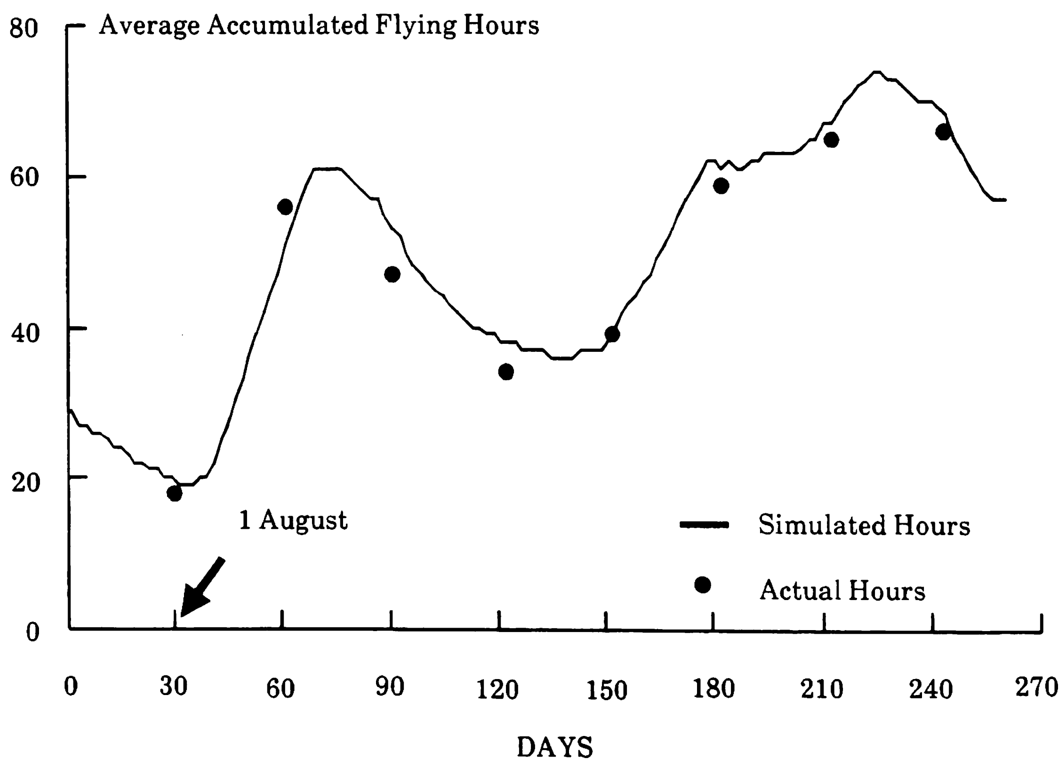

Figure 6: C-141 Validation Run

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AUTHOR BIOGRAPHIES

Joseph R. Litko heads the optimization cell within the Command Analysis Group. He also serves as an Adjunct Professor of Operations Research for Air Force Institute of Technology. His research interest is in combined simulation-optimization modeling of airlift systems.

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