FTL REPORT R84-6

AUTOMATION OF AIRLIFT SCHEDULING
FOR THE UPGRADED COMMAND AND CONTROL SYSTEM
OF MILITARY AIRLIFT COMMAND

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Preface

This report is written to satisfy Task 2 of the current contract. Task 2 is entitled, "Analysis and Evaluation of Airlift Scheduling Functions", and its goals are to review the current problems in MAC scheduling, to identify potential automation aids and algorithms, to outline the global structure of databases and communications, to identify locations of scheduling functions, and to make recommendations for the conceptual design of airlift scheduling activities within the upgraded Command and Control system for MAC. The report is aimed at improving planning, scheduling, and execution processes throughout the several levels of command in MAC for a very dynamic wartime scenario where MAC resources are overloaded. Of course, a secondary aim is to create a scheduling system which is also useful in peacetime and which allows a smooth transition from normal, peacetime scenarios into the hectic, dynamic, and uncertain crisis scenarios. However, the critical test is to retain positive control over airlift scheduling in the dynamic scenario. Other tasks in the current contract are: Task 1-- Review; and Task 3 -- Develop Demonstration Software for Dynamic Airlift Scheduling.

It has been our privilege to travel widely throughout MAC, visiting all levels of command and control concerned with both strategic and tactical operations, and to engage in comprehensive and frank discussions with both headquarters and field personel responsible for scheduling and execution activities. We want to thank the dozens of dedicated MAC personnel who have been eager to devote hours of their time to explaining current scheduling problems. We hope that this report may contribute to solving some of the problems they described and to creating a modern Command and Control system for both peacetime and wartime airlift operations.

1. Executive Summary and Recommendations

1.1. Summary

This report describes a conceptual design for automation of the scheduling of airlift activities as part of the current upgrade of the MAC C^2 System. It defines the airlift scheduling problem in generic terms before reviewing the current procedures used by MAC; and then a new scheduling system aimed at handling a very busy and dynamic wartime scenario, is introduced. The new system proposes "Airlift Scheduling Workstations" where MAC Airlift Schedulers would be able to manipulate symbolic information on a computer display to create and quickly modify schedules for aircraft, crews, and stations. For certain sub-problems in generating schedules, automated decision support algorithms would be used interactively to speed the search for feasible and efficient solutions.

Airlift Scheduling Workstations are proposed to exist at each "Scheduling Cell", a conceptual organizational unit which has been given sole and complete responsibility for developing the schedule of activities for a specific set of airlift resources-aircraft by tail number, aircrew by name, and stations by location. A Mission Scheduling Database is located at each cell to support the Airlift Scheduling Workstation, and requires information communicated by Airlift Task Planners, and, Airlift Operators at many other locations. These locations would have smaller workstations with local databases, and database management software to assist Task Planners and Operators in viewing current committed and planned schedule information of particular interest to them, and to allow them to send information to the Mission Scheduling Database.

The Command and Control processes for Airlift have been structured into a three level hierarchy in this report: Task Planning, Mission Scheduling, and Schedule Execution. Task Planners deal with Airlift Users and Mission Schedulers, but not Airlift Operators. Task Planning has three sub-processes: Processing User Requests; Assigning Requirements and Resources; and Monitoring Task Status. Task planning does not create missions, schedule the missions, or route aircraft.

Mission Schedulers deal with Task Planners and Airlift Operators, but not Airlift Users. Mission Scheduling combines several sub-processes to allow efficient schedules to be quickly generated at the ASW (Airlift Scheduling Workstation). These sub-processes are: Mission Generation, Schedule Map Generation (for each type of aircraft), Crew Mission Sequence Generation, Station Schedule Generation, Management of Schedule Status, and Monitoring Schedule Execution and Resource Status. It is important that all these processes be co-located and processed by the Airlift Scheduling Cell.

Schedule Execution is performed by Airlift Operators assigned by the scheduling process. It has three sub-processes: Monitor Assigned Schedules, Report Resources Assigned to Schedule, Report Local Capability Status. The assignment of local resources such as aircraft by tail, and crew by name is actually another scheduling process, but has not been studied in this report. Airlift Operators do not deal with Task Planners, but may deal with Airlift Users to finalize details of the scheduled operations.

This three level hierarchy is compatible with the current organizational structures of MAC Command and Control. However, it is clear that both the current organizational structures and procedures of MAC Command and Control for both tactical and strategic airlift will be significantly affected by the introduction of the automated scheduling systems envisioned here. These changes will occur in an evolutionary manner after the upgraded MAC C^2 system is introduced.

1.2 Recommendations

1. Adopt the concept of developing an "Airlift Scheduling Workstation" to provide an interactive automated scheduling tool for the human airlift scheduler. The concept requires the existence of multiple mission databases at various locations in the MAC C^2 system and assumes that the principle of assigning the complete responsibility for scheduling a specific set of airlift assets to a "Scheduling Cell" will be followed. Scheduling Workstations can be placed at every ALCC (including the mobile versions), the MACAF Operations Centers, and HQ MAC.

There may be more than one ASW at Scheduling Cells with a high volume of activities where DOO, DOX, DOC, LRC and TR personnel might all be working simultaneously. Also, personnel associated with deliberate planning of deployments will require an ASW to create, modify, update, and store detailed schedules. If such a deliberate plan is pulled into action, it can be easily modified to match the starting positions of aircraft and crews, and passed electronically to Mission Schedulers for further adaptation.

The ASW provides a single, flexible solution for scheduling processes throughout MAC -- strategic, tactical, VIP, EDSA schedules can all be generated in peacetime and in wartime. It ensures that human intelligence and intuition remains in the scheduling process, and it provides an easy transition to a new C^2 system with a gradual introduction of automated decision support systems after initial deployment.

2. The preliminary review shows that there is a need to develop detailed descriptions of the Scheduling Workstation, since there is a wide variety of screen graphic displays and methods for manipulating scheduling symbols, and a need to demonstrate the successful operation of interactive

algorithms which would serve as decision support tools for the airlift scheduler. There also is an endless variety of situations which create scheduling problems, and thereby specify needs. It is recommended that a prototype demonstration workstation be fielded as soon as possible to learn real needs and problems, and to assist in defining the specifications of Airlift Scheduling Workstations. A "Tiger Team" approach to this field demonstration should be adopted.

3. It is recommended that the generic scheduling processes and sub-processes developed in this report be adopted as a basis for defining the Upgraded MAC Command and Control system. It creates a restricted role for Airlift Task Planners, preventing them from being involved in the scheduling processes. To achieve productive, efficient schedules, it is important to combine mission generation, aircraft and aircrew scheduling and routing, and station scheduling within one organizational cell. With automated support from the Airlift Scheduling Workstation, the Airlift Schedulers should be able to express the impact on the schedule of changing requests, resources, etc., within minutes to Task Planners. Airlift Schedulers should be in direct contact with the Operators under their command to understand their current capability status.

4. The current daily/monthly cycles in issuing schedule information for tactical/strategic operations should be changed to a continuous rolling process which shows committed/planned schedule information for the next 24 hours for tactical operations, and next 30 days for strategic operations. This will be possible when the upgraded C^2 system uses electronic media to make this data easily accessible throughout MAC. It creates a schedule generation process which works in both peacetime and wartime, and which transitions smoothly and easily to the critical "dynamic overload" scenario

which is the test for a successful scheduling system in the upgraded C^2 system.

5. It is recommended that the distributed database architecture described here be adopted for the MAC C^2 upgrade. It creates databases at MACAF Operations Center, and every ALCC. The current centralized system at MAC HQ (AIMS, MAIRS) is abandoned in favor of local systems which capture just the data necessary to their function, and only summarized data is passed upward regularly. Personnel at MAC HQ can query these distributed databases for special detailed data if it is required. Field personnel can make similar queries to databases closer to their location than MAC HQ. There is no single master database for scheduling and operating information in a physical sense. The new distributed system should operate in parallel to the current system for some period of time by ensuring communications between them. In the event that communications break down between Scheduling Cells in a wartime scenario, each Cell will continue to operate as best as it can with the current information available to it on its own database; and each Cell assumes complete responsiblity for scheduling the specific set of airlift assets assigned and available to it.

6. It is recommended that the Airlift Scheduling Workstation should be used by deliberate planners at MACHQ to create contingency and war plans. Such pre-plans can be easily updated from time to time in response to changing assumptions, and can be modified to match the initial state of MAC resources when the plan is initiated. The plans can then be transmitted electronically to the Scheduling Cell where further updating and modification can be made by schedulers. If the Tiger Team approach is taken to provide a working ASW in the next year (see recommendation 2), it will have an impact on current plans

for further development of FLOGEN products and other deliberate planning developments in the period before the C^2 upgrade is fielded. There is a need for coordination of these various activities to provide a rational development plan for this interim period.

7. The current scope of the MAC C^2 upgrade does not cover the concurrent development of C^2 systems by Logistics (LG) and Transportation (TR). Insofar as there will be information from these other C^2 systems necessary to schedule decisionmaking, it is recommended that further coordination be pursued by MAC SY to ensure that the necessary information will be available at the ASW or in the Scheduling Cells.

2.0 A Basic Description of the Airlift Scheduling Problem

2.1 Introduction

The purpose of this section is to provide an abstract description of the functional processes which constitute scheduling activities in Command and Control for Airlift. In general terms, it will define various concepts, show functional relationships, and trace the sequential steps in schedule processing for a given set of airlift resources "owned" by a single airlift planner, and scheduled by a single "scheduling cell". It is not based on the current description of airlift command and control processes in MAC with its procedures and organizational structures. Those will be reviewed in the next section using MAC terminology. Here we are interested in introducing a clear description of the basic processes by which a request for airlift service is converted to a scheduled mission and in defining various elements in those processes. This approach may identify opportunities for the restructuring of scheduling activities in MAC as the new C^2 system is adopted. These new scheduling processes will be developed in further detail in Chapter 4.

The scenario assumed for these processes is a wartime or major contingency where there is a large "dynamic overload" on airlift resources such that they would often be inadequate, thereby causing tradeoffs in accepting newer higher priority and rejecting older lower priority requests. Demands are dynamic in the sense that they are continuously arriving and changing. Available resources of aircraft, crews, stations are also assumed to be dynamically changing. In the face of all this, the scheduling processes of Command and Control are assumed to be continuously searching for an efficient schedule of missions.

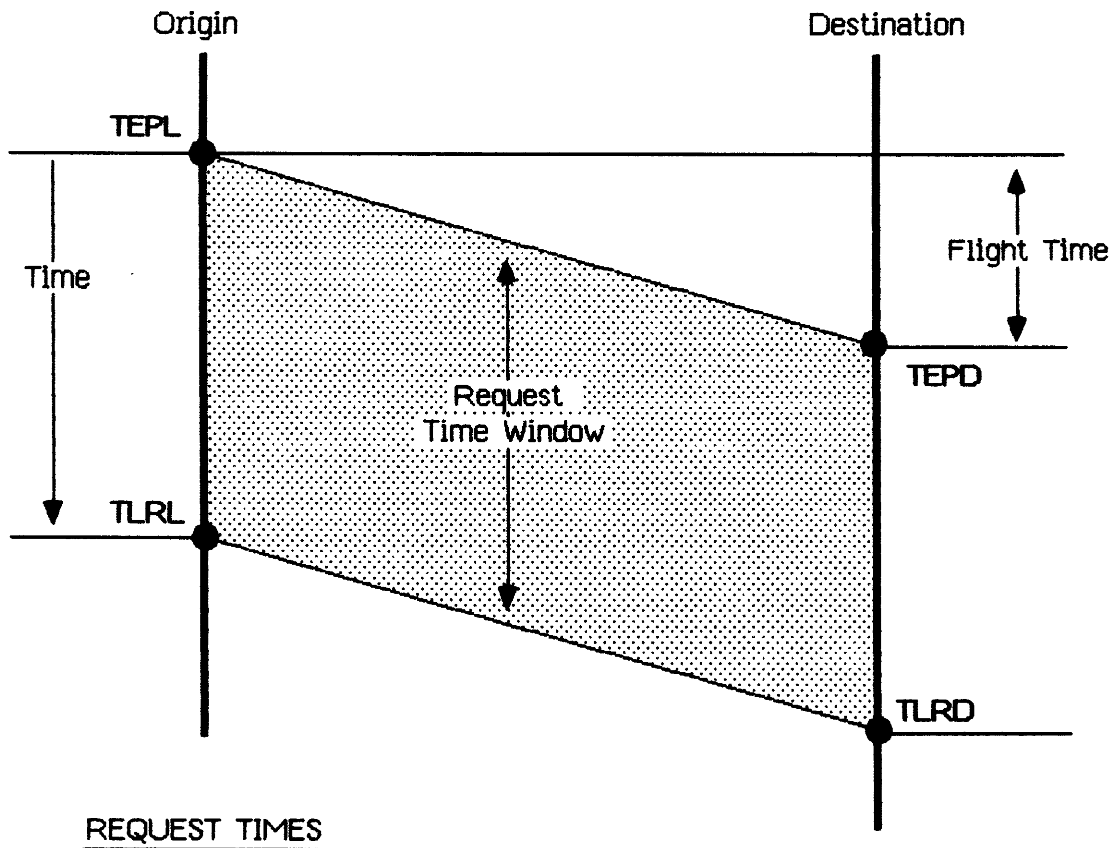
2.2 Processing Requests for Airlift

A request for airlift is initiated by a user. He wants to transport a certain volume/weight of cargo (or number of passengers) from an origin airfield to some destination. We assume he knows this information, although he may be redirected to another origin or destination by airlift planners. He also has some timing requirements ranging from "as soon as possible" to "when can you do it". We shall assume that an earliest and latest time for the transport can be established thereby creating a "time window" for execution of the request (See figure 2.1 which shows the set of times associated with the time window. The "window" can be very narrow, (i.e. an exact time), or very broad ("any time after---"). We shall assume that if the task is not done within the window, we have failed to meet the requirement; i.e., the user expects his request done on time. (If the user has no confidence in MAC's ability to deliver on time, he will avoid using its services in planning his wartime activities -- here we are placing a strict time requirement, which seems to upgrade the quality of service delivered by the new C^2 system since our discussions with MAC personnel indicate a current tolerance for late delivery when capabilities are overloaded.)

Even though the load may be small, the user may require the exclusive use of a particular type of aircraft. Otherwise the space onboard an aircraft can be shared, and requests which overlap in time and space will be aggregated to ensure efficient use of capacity (this is the mission generation process described next). A single request could also specify multiple plane loads from various origins/destinations with interrelated delivery times.

Requests are assigned a military priority which will determine their order of eligibility for a given mission operating at a certain time and place. In the overload scenario, the aircraft planner's objective is to accept as many of the higher priority requests as possible through efficient scheduling and routing of aircraft. In such circumstances, requests compete

FIGURE 2.1 : A HYPOTHETICAL AIRLIFT REQUEST



REQUEST TIMES

TREQ = time of request initiation/modification
TEPL = time of earliest possible load at origin
TLRL = time of latest required load at origin
TEPD = time of earliest possible delivery at destination
TLRD = time of latest required delivery at destination

REQUEST DATA - priority,user,load,special handling,specific aircraft type,etc.

against each other in time and space as well as priority. Lower priority requests may be lucky enough to piggyback on empty positioning/depositioning flight segments as aircraft are routed to higher priority requests. Also, since time windows exist in different sizes, a low priority request with a narrow time window may be handled now since a plan exists to handle the higher priority tasks later within their wider time window.

Airlift requests arrive continuously for processing by the airlift planner. Their time of arrival before desired execution may vary from weeks to hours, and the user may subsequently modify the request by changing its times, load size, priority, origin, etc., or may suddenly delete the request. Since the requests do not arrive in order of priority and since resource availability may be dynamically changing, it is impossible for the airlift planner to confirm absolute acceptance of the request to the user, especially when an overload scenario is expected. However, the user still desires an immediate commitment to plan his operations, and he may require a latest time for commitment at some time before departure if he is to deliver his load on time. There is a conflict between commitment and priority of late arriving requests.

On the other hand, the airlift scheduler may also desire a "cutoff" time for requests, so that he has sufficient time to generate an efficient schedule using the requests received and the forecasted resource capabilities. In an overload scenario, the schedule produced determines which requests can be handled, allowing confirmation messages to be sent to those users. We shall define a confirmed request to be a "<u>requirement</u>". Unconfirmed requests should be retained for consideration when a dynamically changing scenario is assumed since it may be possible to accept them later, even if only on positioning flights. Notice that our insistence on meeting the time requirement creates "unconfirmed" requests. Current MAC practice retains the request as a "requirement" which will be done late.

Unfortunately for the scheduler, the cutoff time does not appear to be absolute. The late arrival of a high priority request will initiate "rescheduling" unless the procedures for airlift planning absolutely refuse to accept any such requests. There are conflicts between "cutoff" time, confirmation, commitment, and priority of late arriving requests. If "rescheduling" is allowed, there is no absolute confirmation/commitment for any request, even if the aircraft is loaded ready to depart or is airborne enroute. (In the wartime scenario, the possible loss of resources prevents such an absolute commitment anyway).

In the dynamic overload scenario of a wartime/contingency, the rapid changes in requests and airlift resources may cause "dynamic rescheduling" to be the normal mode of activity in Command and Control and the existence of cutoff times, confirmations, etc. may have little significance. The ability of the C^2 system to "dynamically reschedule" quickly and efficiently using automated scheduling processes would improve the responsiveness of the airlift system to late requests while introducing the problems of confirmation/ commitment of all requests. If every request were "rescheduled" when it arrived, there would be a dynamically changing set of confirmed/ unconfirmed requests. Every requirement would be subject to "unconfirmation" in the days before its execution. If there were airlift resources in reserve, or capable of being reassigned, efficient dynamic "rescheduling" would assist airlift planners in quickly solving the re-allocation problem and deciding how they wished to minimize the sending of "unconfirmation messages". This section has discussed the processes of airlift planning associated with processing requests for airlift services. The next section discusses the two closely related scheduling processes associated with converting airlift requests into a schedule of airlift missions. These are called "Mission Generation" and "Mission Scheduling and Routing".

2.3 Generating Missions and Schedules

An Airlift Mission is defined here as the movement of a given type of aircraft with sufficient capacity to carry its assigned requests between their origins and destinations along a specified routing. It has a priority and time window derived from its assigned requests. Initially, it does not have scheduled times. It ends if all cargo is unloaded at any point. As defined here it does not contain positioning or depositioning flight legs. Missions may be linked together to serve a given request (such as a "connecting" or "transshipment" service where a smaller load is flown to a point for transfer to another mission).

Mission Generation is a process which selects a type of aircraft and routing to serve in an efficient manner some combination of one or more requests. The range and capacity of the aircraft must be sufficient to hold all onboard loads on any segment of the routing. The problem in Mission Generation has been described as "lumping and bumping" by MAC personnel, i.e. to decompose a large list of current requests into a collection of small combinations of requests which overlap in time and space and which can be efficiently flown by available types and numbers of aircraft. The simplest case is a "Single Request Mission" where one request creates its own mission, and the smallest aircraft with sufficient capacity is selected. The mission priority and time window derive from the single request.

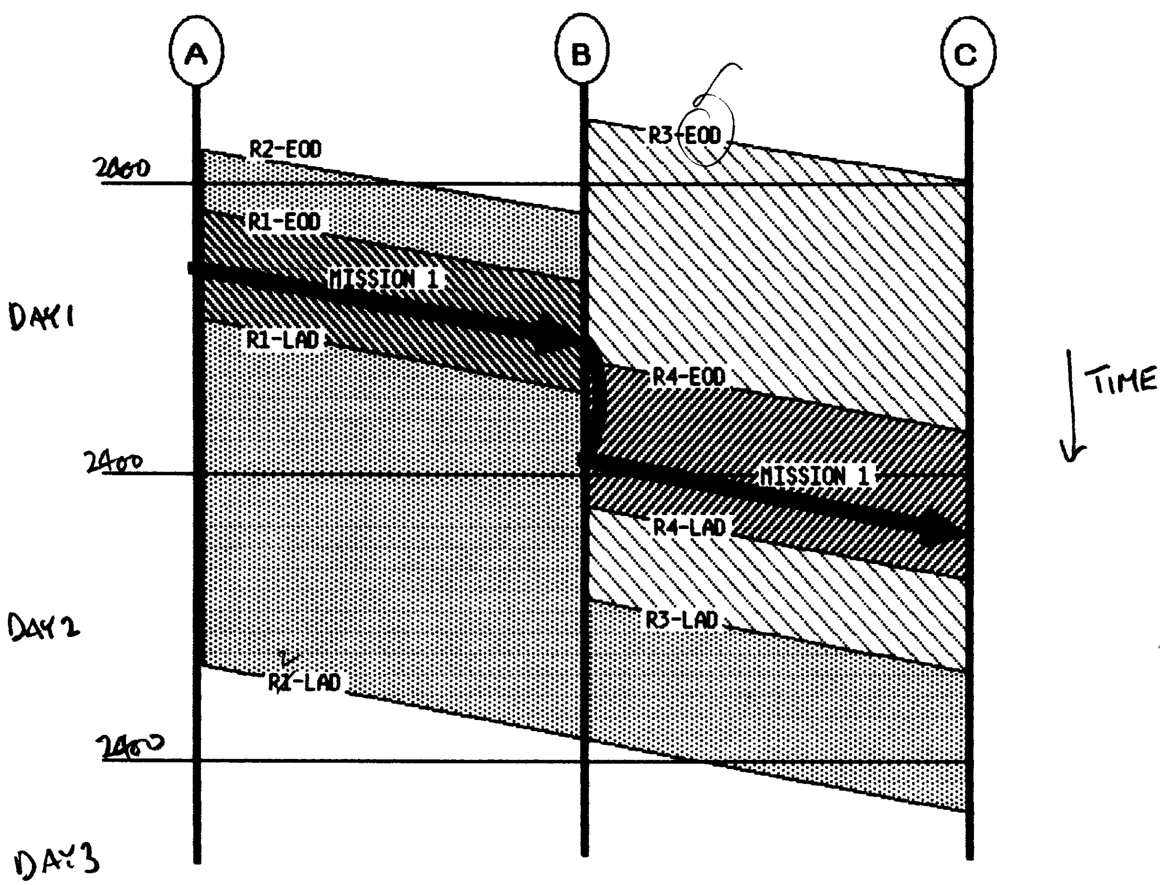
Alternatively, it may be possible to aggregate several small requests such as to keep the capacity of an aircraft efficiently used along a routing which serves those requests. This is called a "Multiple Request Mission".

See figure 2.2 where four requests are combined to be served by a single C-141 mission flying from A to B to C. Request 3, from B to C gives the total mission an "α" priority. The mission time window derives from the combination

FIGURE 2.2 **SINGLE MISSION FROM MULTIPLE REQUESTS**

Request R1, W1 tons from A to B, priority β, time window TW1
Request R2, W2 tons from A to C, priority β, time window TW2
Request R3, W3 tons from B to C, priority α, time window TW3
Request R4, W4 tons from B to C, priority β, time window TW4

Mission 1, priority α, C-141, serves all 4 requests



Mission 1 -- C-141 from A to B to C within reduced time window of time windows of all the requests. The mission, at this point, does not have a scheduled time, nor positioning/depositioning flights.

It is possible for the airlift planner to create a "channel" mission on the expectation of future requests which will fill the selected capacity. When such a user request arrives it is assigned to the mission if space is still available (where available means that there is not enough volume of user requests of equal or higher priority to fill the currently assigned capacity). Note that in this case the airlift planner may "bump" one or more lower priority requests to accommodate the new request. He needs to know the number and priority of currently assigned pallets to do this "bumping", and thereby avoids scheduling another mission and perhaps saves the use of one more aircraft. Finally, we have the case where a single request must be decomposed into a multiple set of missions, a "Multiple Mission Request", where a linked set of missions, all of the same priority as the request, are flown by one or more aircraft types between multiple origins/destinations. Now, the aircraft will all be full except perhaps for the last mission.

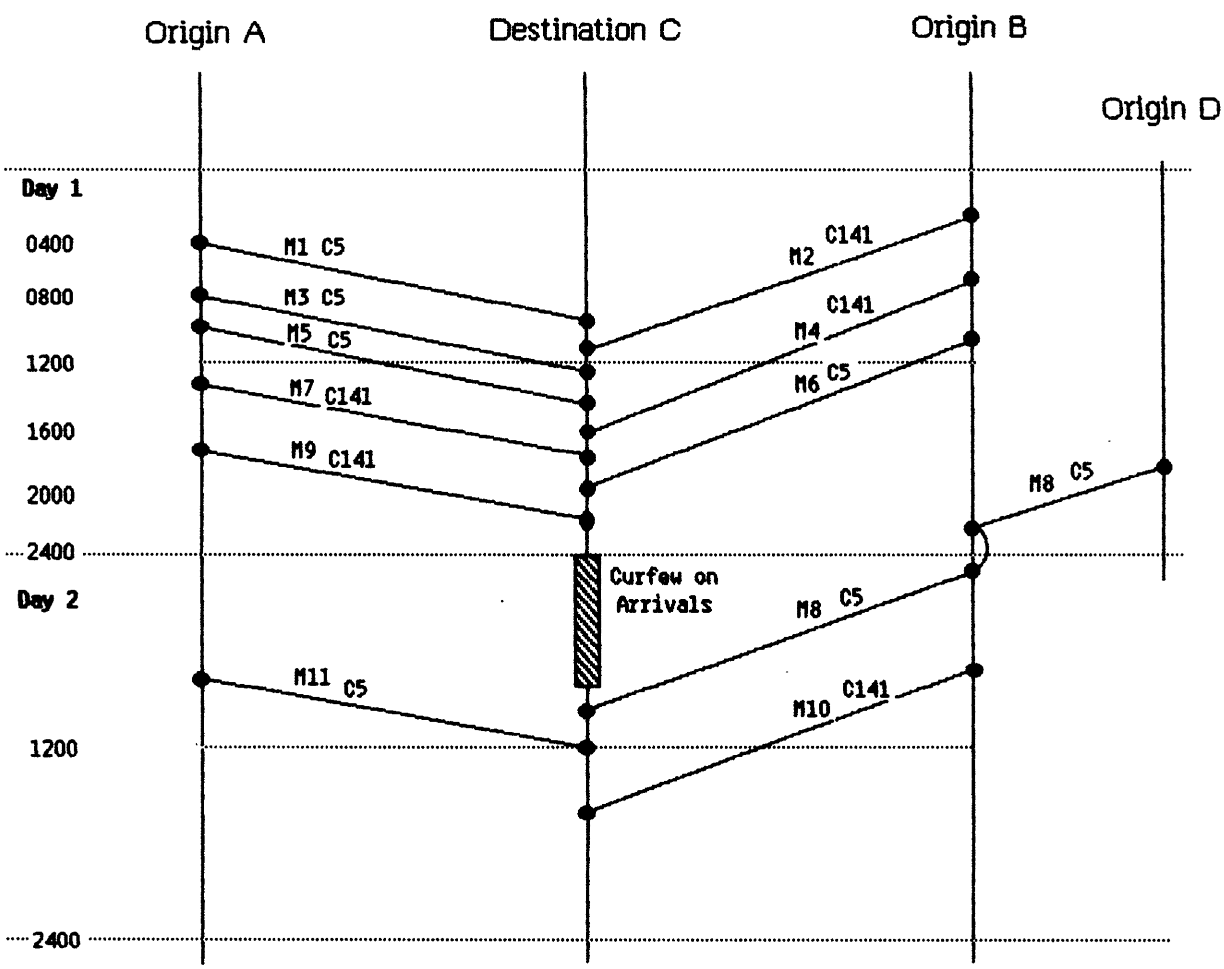
This decomposition is shown in figure 2.3 where one request has generated eleven missions from three origins by C-141 and C-5 aircraft. Note that the positioning/depositioning flight legs are not shown. The "Multiple Mission" does not result in a "deployment flow plan" as currently created by MAC planners, where a fixed number of aircraft are assigned to the request and shuttled back and forth between origins and destinations. These multiple missions may be generated with time windows and also with a restriction on arrival intervals at the destination.

The second closely related process is "Mission Scheduling and Routing". Along with Mission Generation, these two processes should be viewed as two parts of one process called "Mission Scheduling", since they should be done

FIGURE 2.3 MULTIPLE MISSIONS FROM A SINGLE REQUEST

Request R10

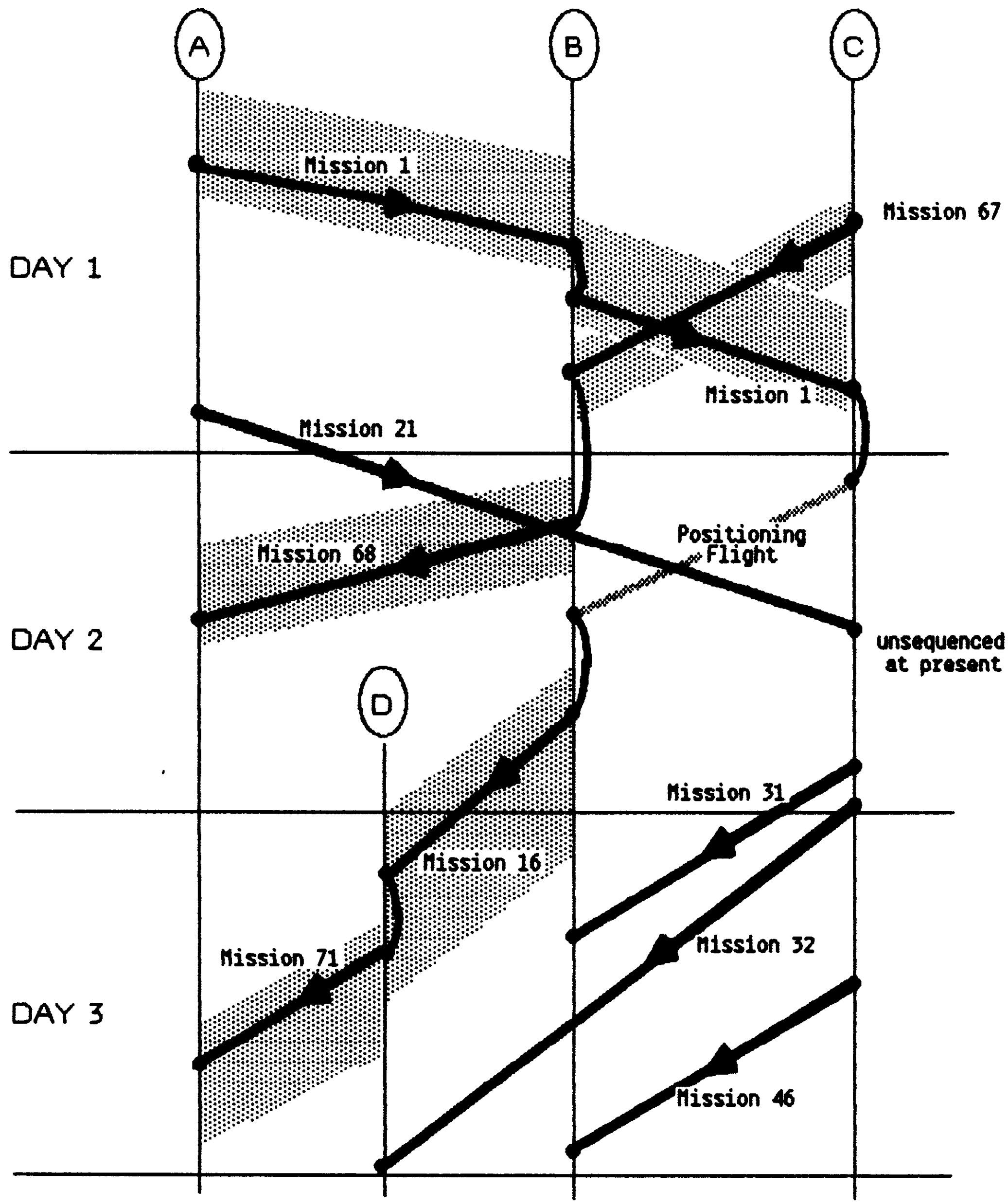
Priority α
Origins A,B
Destination C



simultaneously and should not be separated geographically or organizationally. The capability of executing these two processes with efficiency and dispatch is vital to ensuring highly productive operations for the airlift system. Given the list of current missions, the Mission Scheduling and Routing process creates a set of Mission Sequences or Mission Tours for each type of aircraft and its crews. It is at this point that a "deployment flow plan" is created.

An "Aircraft Mission Sequence" is a linked set of Missions (and positioning legs) to be successively flown by a given type of aircraft. Similarly a "Crew Mission Sequence" is the set of legs to be flown by a crew qualified in that type of aircraft. A "Mission Tour" is simply a mission sequence which starts and ends from the same maintenance or crew base. Such sequences must be feasible given aircraft and crew performance restrictions. The mission sequence may still have a "time window" derived from connecting its mission time windows. It is constructed using standardized times for flight legs and station ground operations. The collection of mission sequences for a given type of aircraft is called a "Schedule Map". (See figure 2.4). By examining it we can see the minimum number of aircraft required for its execution, and the complete schedule of planned movements for that type of aircraft. If there is a surplus of aircraft available, the Schedule Map is feasible. If not, the problem arises of selecting the best set of high priority missions/mission sequences which can be flown by the available aircraft. Because of the complexities of routing in time and space, missions of lower priority and positioning legs (hopefully filled with requests of even lower priorty) will be flown as the available number of aircraft/crews are routed towards the highest priority missions. The problem of making best use of an inadequate fleet is not an easy one to solve manually, and the use of automated scheduling tools is necessary to find

FIGURE 2.4 : MISSION SEQUENCES AND SCHEDULE MAPS FOR C-141 AIRCRAFT TYPE



Mission Sequences : M1 -> M16 -> M71 , M67 -> M68 .

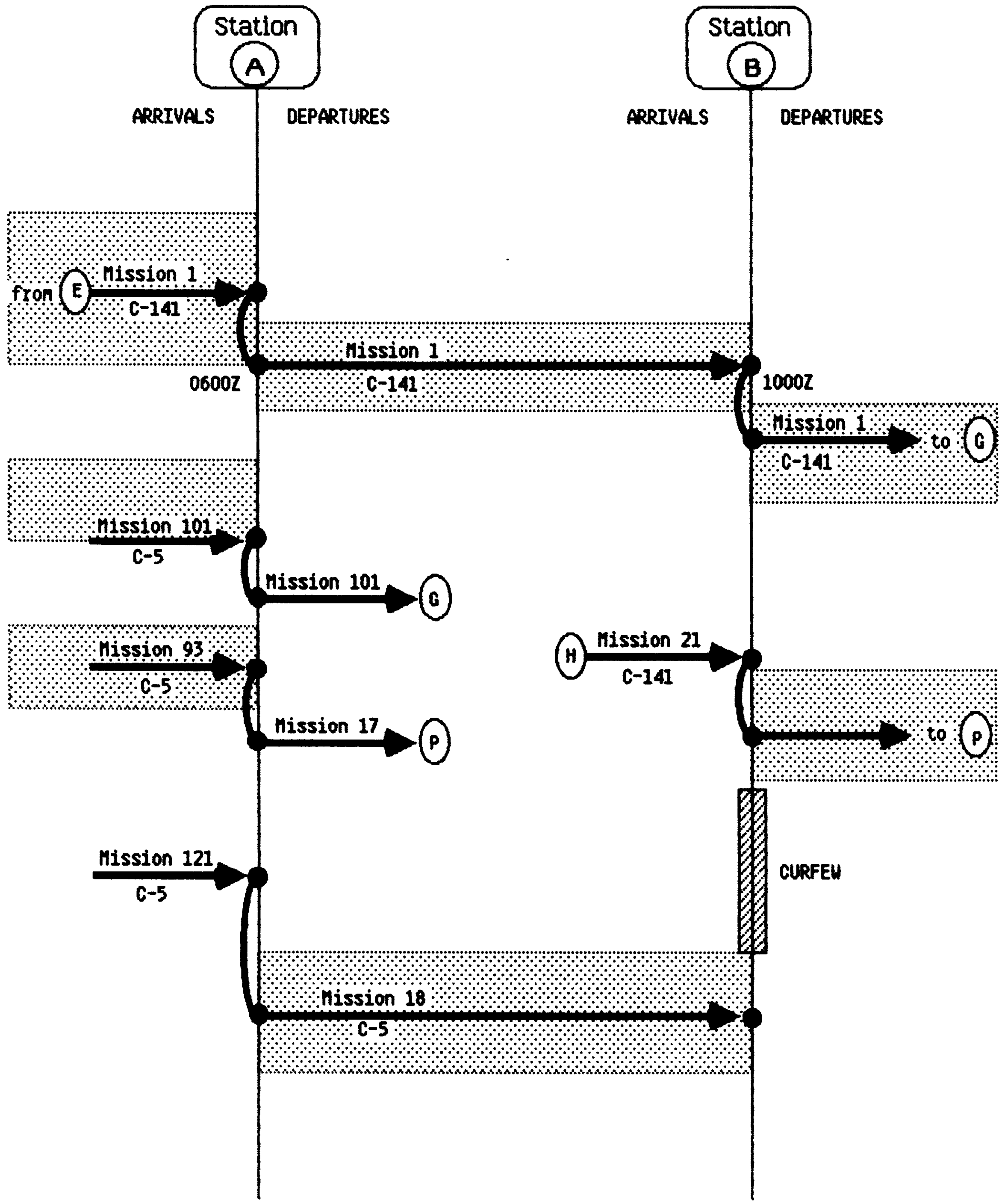
routing solutions which minimize the numbers of higher priority missions that cannot be flown. In finding these solutions, mission sequence time windows will narrow, and perhaps disappear.

Note that there will be a dual set of mission sequences (aircraft and crew) for the Schedule Map of a generic aircraft type. Crews will not follow the aircraft because of their restrictions on duty/rest times. Crew staging problems must be successfully handled in finding the crew mission sequences; otherwise, it will be necessary to change mission times in the Schedule Map. We must have feasible crew mission sequences to have a valid schedule map.

When Schedule Maps have been constructed for each type of aircraft, it becomes possible to combine them and produce "Station Schedules" (see figure 2.5) which show event times (or time windows) for arrivals and departures, load/unload/servicing activities, etc. If there are violations of station capability such as MOG's (Maximum aircraft On Ground), the event times must be moved within mission sequence windows, or reconciliation sought amongst the various Schedule Maps. There may also be fuel shortages as a result of the total scheduled station activity, or a fuel quota for MAC aircraft.

At this point, we may remind ourselves of our prior discussions on the late arrival of high priority tasks and the concept of rescheduling. When the various fleets are all busy it is not a simple quick task to undo the scheduling and routing solution, insert the new task/mission, reroute the aircraft and crews, and then reconcile any station constraints, especially if we wish to minimize the abandonment of currently accepted missions and requests. Yet in the wartime/contingency scenario, it is desirable to be able to respond within a few minutes to the issues raised by the potential insertion of a late task, and the offer of additional resources.

FIGURE 2.5 DISPLAY OF SCHEDULE DATA BY STATION



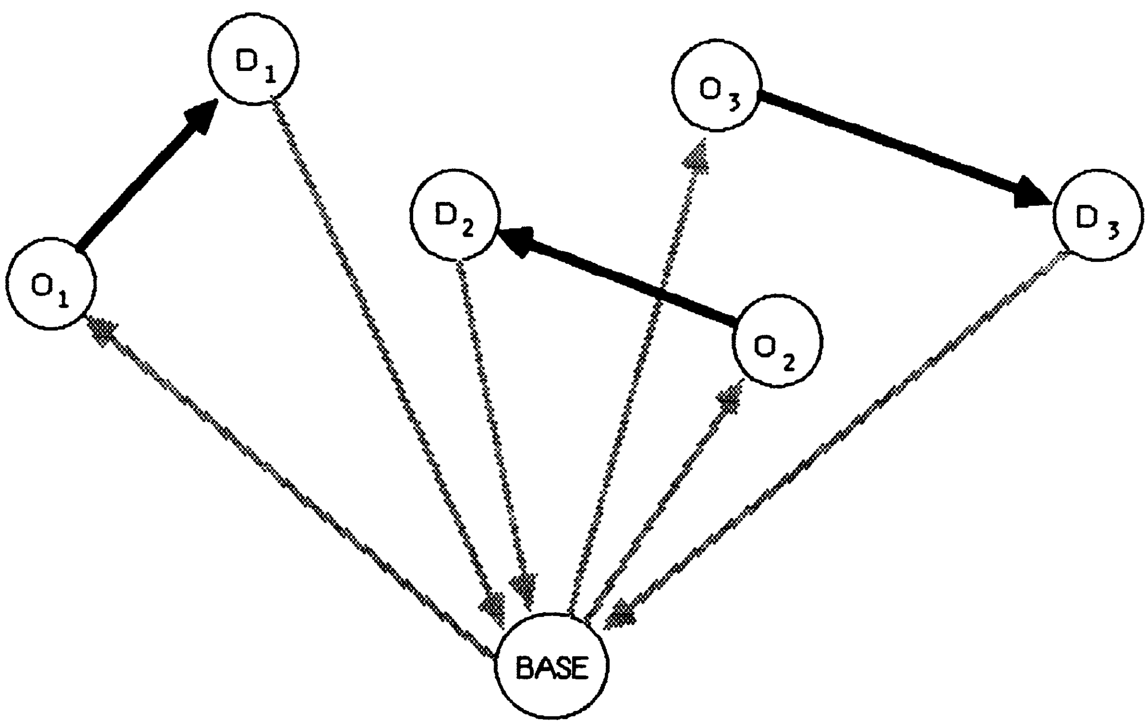
Solving the mission generation/scheduling/routing problem cannot be done totally automatically with computer algorithms to find optimal answers, especially at the scale of operations typical of MAC (thousands of vehicles and missions over several days). However, it would appear that a substantial improvement over the current manual implementation of these processes can be achieved by introducing MAC schedulers to current technology in computer science such as interactive symbolic graphics, database management systems,microcomputers and artificial intelligence machines, and decision support algorithms. This approach will be detailed later in Chapter 4. It has the potential for significant improvements in the productivity of the operations of the airlift fleet in the dynamic wartime/contingency scenario, as well as a reduced response time for handling late requests from users with high priority needs.

2.4 An Example of Mission Scheduling

Consider a tactical airlift scenario where aircraft are at a base, and are being assigned to missions in support of army operations in the battle area. Figure 2.6 shows three missions with separate origins and destinations which have been generated from airlift requests. They are imbedded amongst perhaps one hundred similar requests for that particular day.

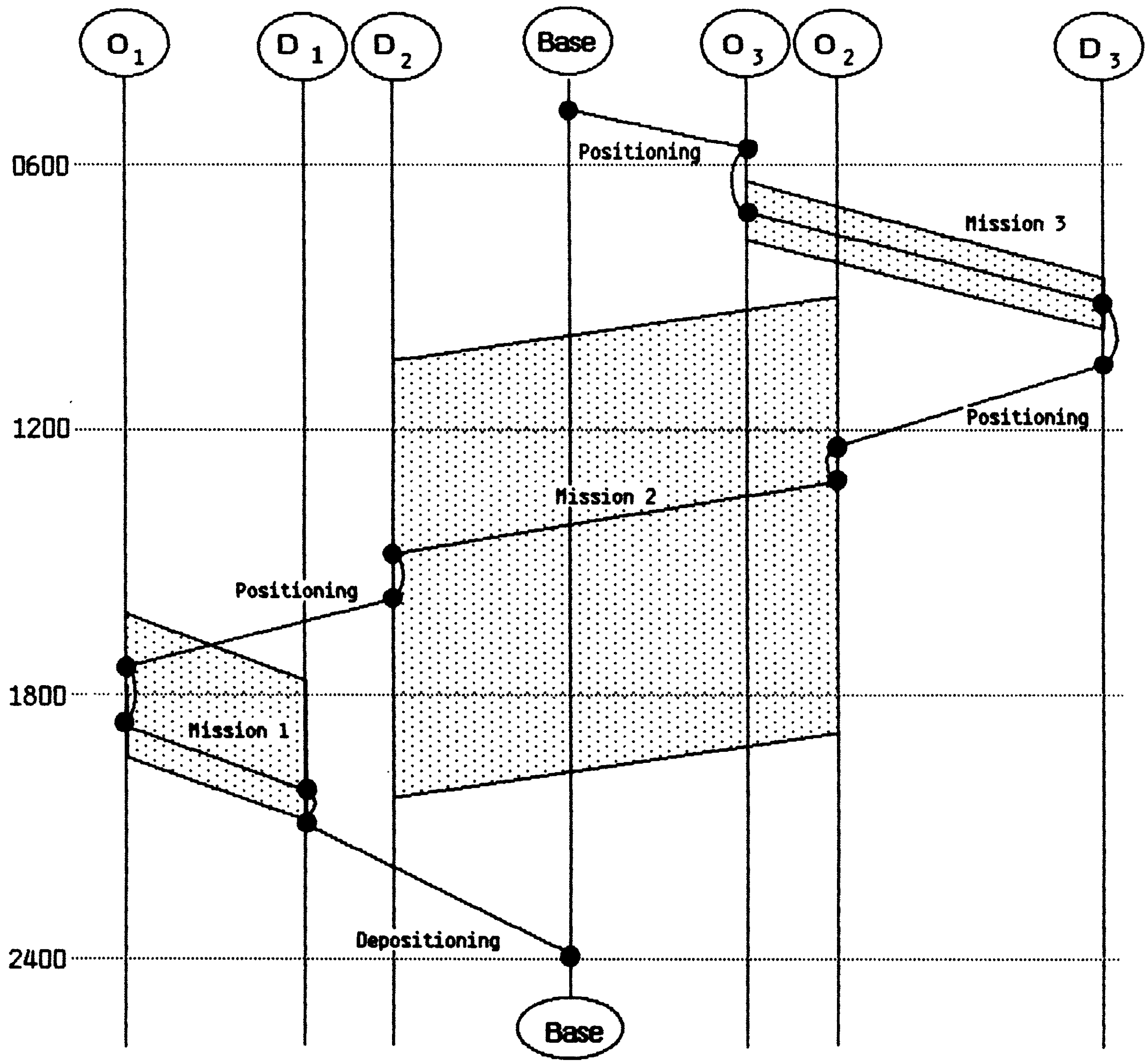
For each mission, a C-130 aircraft has been assigned with positioning/depositioning flight legs. But it is possible, given the time windows for each mission to use only one aircraft as the schedule map of Figure 2.7 shows. This may seem obvious, but the difficulty is to create a scheduling process which can find such combinations (and the best set of such combinations) amongst the hundreds of missions which exist, and which are being continuously added to the mission database. Efficiency in scheduling can significantly improve the productivity of airlift resources, and may be the equivalent of increasing these resources by more than 10%-20%. In this example, a rescheduling process would free two aircraft and crews. It is difficult to assess the efficiency of current MAC scheduling and routing processes when they are severely challenged by the dynamic wartime scenario, but it seems quite likely that significant improvements can be expected by investing in improved decision support software and hardware for the airlift scheduling functions of the MAC Command and Control upgrade.

FIGURE 2.6 : INEFFICIENT SCHEDULING OF AIRCRAFT



3 C-130 aircraft are assigned, each to a single request and mission, requiring 6 positioning/depositioning flight legs to/from base

FIGURE 2.7 EFFICIENT SCHEDULING OF AIRCRAFT



Partial Schedule Map for C-130

2.5 Executing the Schedule

When a schedule is issued, it represents a planned set of timed operations by various airlift units. The operators responsible for executing these scheduled operations are also responsible for reporting back to the schedulers certain information necessary for scheduling/rescheduling activities. Any deviations from the schedule should be reported since they may impact future scheduled operations, and consequently, the scheduler may decide to reschedule to minimize overall schedule deviations. These data include estimated and actual/departure times, aircraft diversions to other stations, aircraft unserviceabilities, etc. As well, the operators must report the forecast capability status of all operating elements. Finally, operators are responsible for scheduling tail numbers and aircrew names against scheduled missions, and ground crew names against station schedules, and then reporting additional detailed information on their capabilities and qualifications, etc. back to the scheduler. These data are important to the scheduling process as it carries out its monitoring of schedule execution and the impact of deviations on future schedules. For example, if there are MOG problems at downline stations, the report of an estimated early arrival time due to favorable winds may cause the scheduler to reschedule for a later departure to ensure on-time arrival at the MOG station. However, there may be other ways of solving the problem, and other factors in the scheduled operations which only the scheduler knows. All operating personnel can do is to report pertinent information and forecasts as soon as they are known.

2.6 Summary

This section has provided a brief analytical description of the problem of scheduling airlift in the dynamic wartime scenario. Its purpose is to describe the generic problem and to provide the reader with various concepts, a definition of terms, and a set of functional relationships before conducting a review of current MAC practices and procedures in peacetime scheduling, and before considering options for introducing automation into the scheduling processes for the upgrade of the MAC Command and Control systems.

3. Review of Current MAC Peacetime Airlift Scheduling Processes

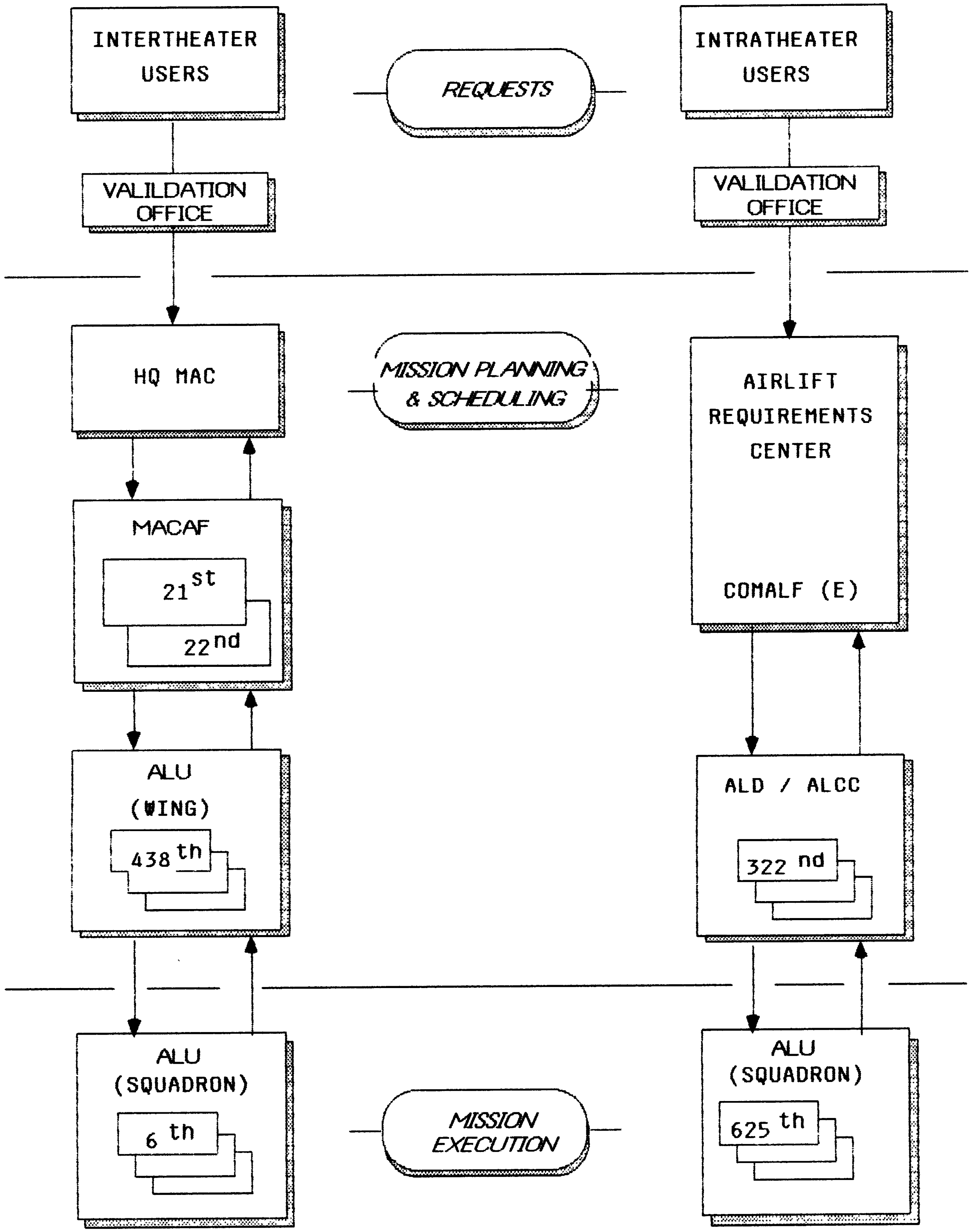
3.1 Introduction

The current airlift scheduling process is based on the principle of decentralized airlift and aircrew scheduling. Mission scheduling and execution responsibility are delegated to the lowest possible echelon. This principle is dictated by the world-wide scope of MAC operations, the multiplicity of operating locations, and the dynamic and cyclic employment of its resources. Three organizational echelons are directly involved in the scheduling of airlift resources. For (strategic) intertheater airlift they are: Headquarters MAC (HQ MAC), the Numbered Air Forces (MACAF's), and the Air Lift Units (ALU's). For (tactical) intratheater airlift they are: the Commander Air Lift Forces (COMALF's), the Air Lift Divisions/Air Lift Control Center's (ALD/ALCC's), and the Air Lift Units (ALU's). The ALU's are the Airlift Wings, Airlift Groups and Airlift Squadrons. Figure 3.1 illustrates the organizational structure for MAC airlift scheduling.

The peacetime airlift schedule planning process begins at HQ MAC/COMALF upon receipt of requests for airlift from intertheater/intratheater users. Airlift requests are initiated by the users, although in the case of the prepositioning or repositioning of a resource (an aircraft, a crew, or maintenance personnel or for training), MAC itself may initiate a request for its own airlift. The validation office at the user agency works with HQ MAC to establish a priority for the request, validate the use of airlift as the transport mode, and clarify or resolve any conflicts or constraints within the request. Modifications to validate any MAC requests are coordinated with the user's validation office.

FIGURE 3.1

ORGANIZATIONAL STRUCTURE MAC AIRLIFT SCHEDULING



At HQ MAC/COMALF, an initial assessment is made of the feasibility of satisfying these requests. This feasibility is predicated on the identification of the availability, operational status and location of generic MAC resources. This function requires HQ MAC/COMALF to have current information on the overall status of its air fleet and crews, to be aware of the total set of its airlift requests, and it requires information on the current and planned airlift schedule. This overall capability review is necessary to: identify nonsupportable requests, to augment its resources in crises and wartime by the Civil Reserve Air Fleet (CRAF), and to allocate its resources among the two MAC Air Forces (the 21st Air Force at McGuire and the 22nd at Travis), or various Airlift Divisions under a COMALF.

After the validated requests are reviewed and processed into MAC airlift requirements at the HQ MAC/COMALF level, the next step is the process of converting requirements into airlift missions. This process and the echelon which is responsible for generating airlift missions currently depends upon the type of requirement. We shall consider each type of requirement in turn and then review the current process of mission scheduling for each request.

3.2 Types of Requirements - Peacetime

There are five types of requirements: channel missions; SAAM's; JA/ATT's; JCS exercises; and internal MAC training. "Channel missions" are requests for regularly scheduled service (or as close to regularly scheduled as possible, given the dynamic nature of the MAC operating environment). They are flown by both MAC and CRAF aircraft and represent about 25% of all current MAC missions. Such missions are designed to support ports and U.S. forces world-wide (for example, delivering food, mail and supplies to ports in the zores). There are two types of channels: "frequency" channels are defined on the basis of the frequency or <u>number</u> of missions scheduled (e.g., 5 missions per week into Rheinmain); "requirements" channels are usually triggered by a volume or service requirement (e.g., a minimum of 5 tons capacity or perhaps 100 passengers).

SAAM's (Special Assignment Airlift Missions) are requirements for special "chartered" missions to satisfy a specific user's high priority need for a complete aircraft. SAAM's are frequently used in a crisis mode of activity. The user calls the MAC "bookie" or "barrelmaster" and negotiates for the use (rental) of airlift and crew. The user pays for the entire aircraft and crew expense. Some channel cargo may be added to the mission when space onboard and the logistics permits: the user still pays for the entire mission, however. An example would be a Navy request to air ship a high-priority part (an aircraft engine, a ship propeller) to some destination. The part usually is not at the aircraft's home base and will have to be picked up at an intermediate point. MAC may add channel cargo to the mission or combine the Navy's request with another user's request if the user who is "buying" the aircraft approves.

JA/ATT's (Joint Airborne/Air Transportability Training) are training missions (for example, advanced combat training for combat readiness, airdrop training, assault landings) which involves one or more users. These joint training requests are submitted to MAC at monthly JA/ATT conferences, which have been described to resemble "auctions", where the users bid for MAC airlift capability and services. The cost of JA/ATT missions are similar to the costs for SAAMs since JA/ATT's are also treated like "charter" missions.

JCS (Joint Chiefs of Staff) exercises are requests from multiple branches of the military for the deployment, redeployment, and employment of forces, and supplies involved in simulated war-time exercises. There are several exercises per month and a few major exercises per year. Exercises take place at specified geographic locations (theaters) around the world (e.g. Europe, Korea). The deployment and redeployment phases use strategic airlift (C-5's, C-141's) to position and bring home personnel and supplies between the home base and the theatre. The employment phase "employs" airlift within the theatre. JCS exercises are planned months in advance and MAC schedules JCS exercise airlift months in advance. Some priority airlift, intertheater as well as intratheater, may be handled as a SAAM request during an exercise.

The last type of airlift requirement is an internal MAC training request. MAC has its own requirement for crew training and keeping crews current on special procedures, such as aerial refueling. The requirement is specified in terms of hours per month and sorties per month for each type of crew member (aircraft commander, first pilot, copilot, engineer, loadmaster) and each type of special qualification. These requirements must be worked into the MAC airlift schedule.

3.3 Scheduling Channel Missions

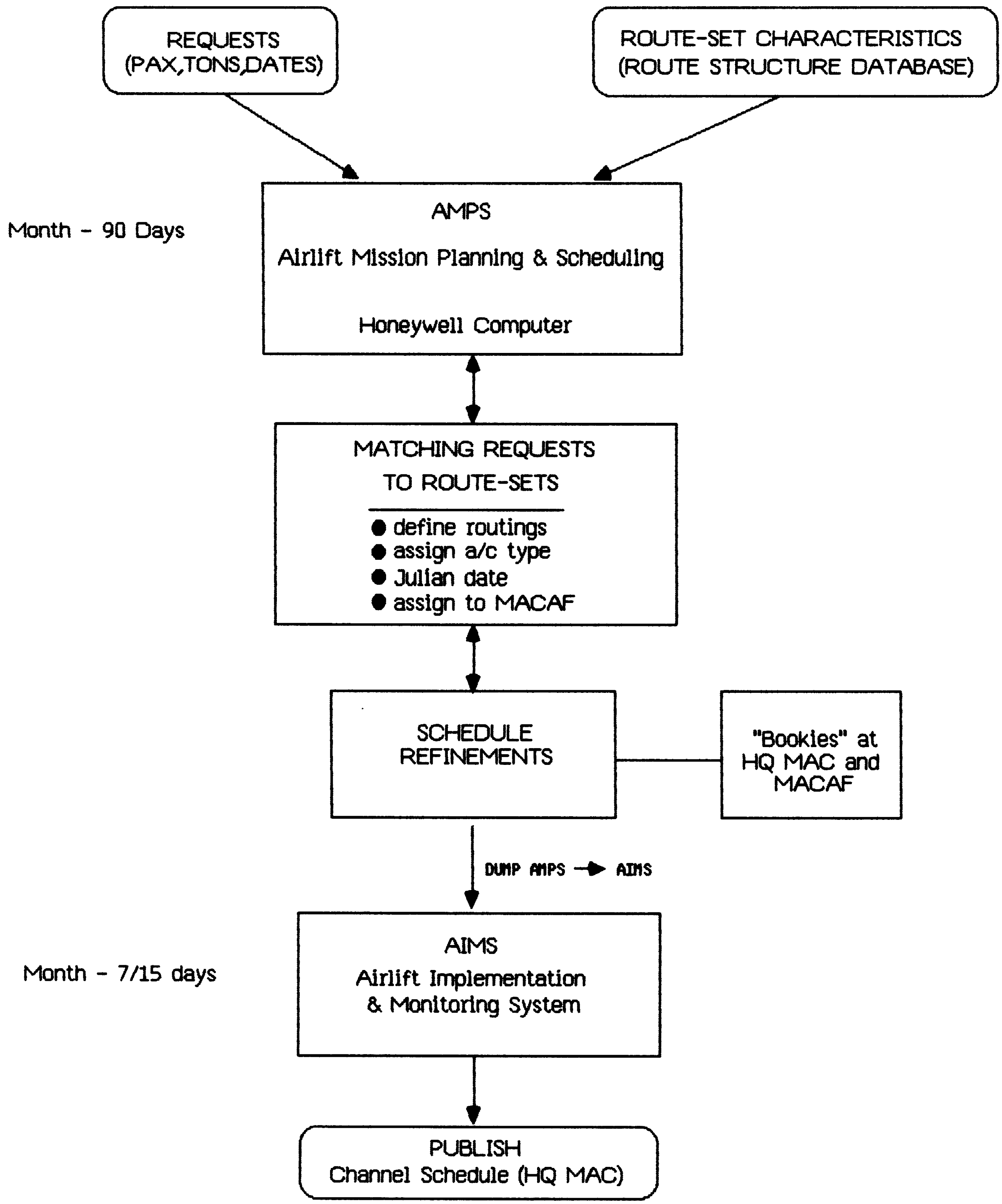
Channel missions are established when requests to serve specific ports occur on a frequent basis and the need then arises to set up regularly scheduled service to these ports. Both frequency and requirements channels are instituted and removed by authorization from the Joint Chiefs of Staff. The process of the scheduling of channels is performed by MAC. Some of the scheduling tasks are done by HQ MAC and some are delegated to the MAC Air Forces. The process is partially automated.

Channel mission scheduling is a continuous process which starts about 90 days in advance of the operating month (figure 3.2). Airlift requirements (requests) are matched against the characteristics of a set of routes. These routes either are serving existing channels or had been assigned to a channel sometime in the past. The route-set characteristics are stored on-line in a database, and the process of matching requirements to route-sets is performed within a computer system called AMPS (Airlift Mission Planning & Scheduling). AMPS resides on a Honeywell 6000 computer at HQ MAC. During the matching process HQ MAC assigns the task of flying the channel mission to one of the two MACAF's (21st or 22nd). Actually, the structure of the route itself determines the assignment, since routes serving points east of 95 degrees west longitude (roughly east of the Mississippi River) up to the eastern boundaries of Iran, Saudi Arabia and Africa, are assigned to the 21st Air Force, and points west are served by the 22nd Air Force.

From the time of the matching to about a week or two before the operating month, the scheduled times for the channel mission are established and refined. HQ MAC establishes the Julian date of operation, the initial set of departure and arrival times, and the generic aircraft assignment. Times and aircraft types are scheduled on the basis of prior route-set characteristics (found in the AMPS route-set database).

FIGURE 3.2

AMPS → AIMS FLOW



Departure and arrival times are basically controlled by three factors: time window limitations on the port of embarkation, home station characteristics (e.g., maximum aircraft on-ground), and arrival station characteristics. The scheduler at HQ MAC considers these factors when manually assigning the times. Modifications to these times are kept to a minimum. Any adjustments to accommodate a dynamic operating environment, especially if a change occurs close to the operating day are performed by MACAF.

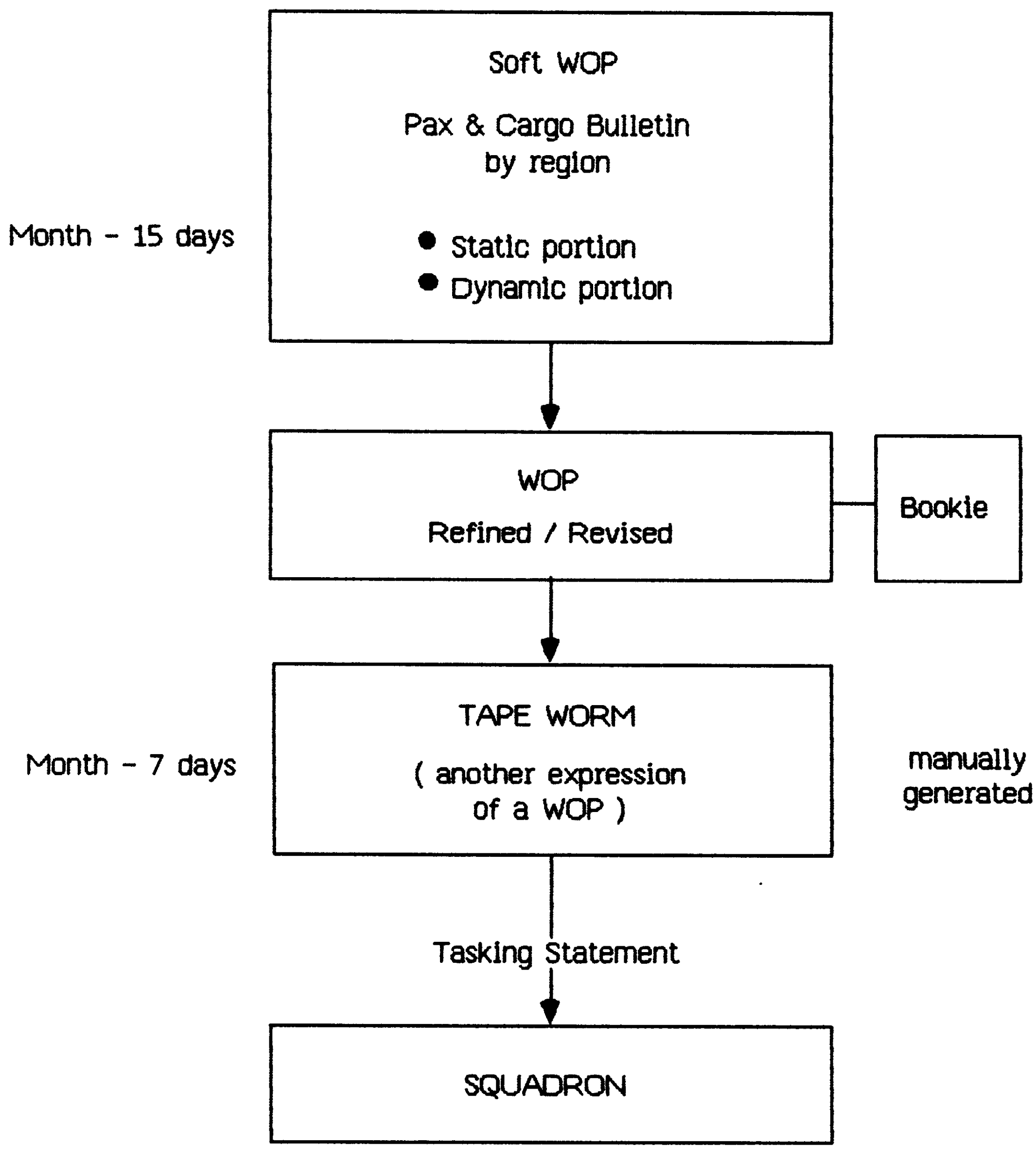
There is no automatic procedure on the AMPS system to assist in the schedule change decision-making process. The MACAF Bookie works out any changes by stubby pencil, communicates these changes to HQ MAC, and enters the change in the AMPS database. Also during this time the responsible MACAF assigns the task of carrying out the mission to the ALU's (Airlift Wings).

At a point one or two weeks prior to the operating month, the schedule is dumped from the AMPS database to the AIMS system (Airlift Implementation and Monitoring System). AIMS is an on-line information management system which contains the operating schedule for MAC. It is as complete a schedule as possible, containing dates, routes, aircraft assignments, times, load information etc. Missions operating other types of requests (SAAM's, JA/ATT's, etc.) are also on-line in AIMS, although some SAAM's may not be included because of the nature of their priority or security classification. AIMS information is available to all MAC echelons.

At about the same time that the AMPS database is loaded into AIMS, the channel schedule is published as four books: Passenger and Cargo bulletins for Atlantic and Pacific scheduled operations. The books are called Wing Operations Plans (WOPs) since they contain the schedule for each Airlift Wing (see figure 3.3). Usually the WOP has a static portion, which is the published schedule, and a dynamic portion, which contains updates and amendments.

FIGURE 3.3

SCHEDULING PROCESS AT THE WING LEVEL



At the Wing level, the WOP is refined and revised by the responsible bookie. The revisions are made on another version of the WOP (the Wing's version) called a "Tape-Worm". The Tape-Worm contains the latest information on a schedule -- the updates and changes. It is a hard-copy form which is not on the computer; however, changes are also made to the AIMS system database so that this information could be made available to all echelons. It is our perception that the field units do not use AIMS to any great degree due to difficulties in access. The Tape-Worm is used by the Airlift Wing to develop a task ordering form which tasks the squadrons to perform the missions. Squadrons primarily receive information on their tasking through the Tape-Worm or task ordering form. This form comes to the squadrons about a week in advance of the operating month. In addition, squadrons receive daily noticesof assigned tasks: these are called "coming your way" messages and are intended to alert the squadrons to the next day's activity.

3.4 Scheduling SAAM's

All SAAM (Special Assignment Airlift Mission) requests are manually worked. HQ MAC receives and reviews the requests and passes them on to the assigned numbered Air Force (MACAF). MACAF then works on the request to assign an aircraft type, determine a feasible routing, and it plans the general concept of operations. The Airlift Wing is contacted on its assignment. The wing is given a latest arrival date (LAD) for the request as well as other information pertaining to the task. Wings are free to coordinate the tasking directly with the user. The coordination is important in resolving conflicts and clarifying information about request.

The wing assigns the departure and arrival times. The times are controlled by time window limitations on the ports of embarkation (POE) and debarkation (POD), home base characteristics (e.g. maximum aircraft on-ground), and destination characteristics (curfew times, personnel, unloading equipment). Frequencies are driven by the volume of the payload (passenger or cargo) and the width of the time window (latest delivery time - earliest pickup time). A wide time window and a short flight stage length may permit a single aircraft to shuttle between POE and POD. Intratheater missions using tactical airlift typically involves shuttle operations, whereas strategic (intertheater) airlift cannot because of long flight times. Frequencies may also be driven by the availability of aircraft. When airlift capability is severly constrained, as in wartime, a request may have to be fulfilled by fewer aircraft operating shuttle missions. In peacetime, when airlift capacity is not severely restricted, a large request typically is fulfilled through the use of many aircraft.

The scheduling process for SAAMs is a manual process - there are currently no automation aids. A SAAM scheduler makes use of hardcopy spreadsheets similar to those of figures 3.4 and 3.5. The worksheet of figure 3.4 is used for recording detailed information: the priority of the request, available pickup date, delivery date, aircraft type, route itinerary, load (passengers or cargo), etc. The worksheet of figure 3.5 is an example of a form used to represent airlift flow. Airlift missions are itemized in the columns. Rows represent times: departure and arrival times, ground times, enroute times. Other information which schedulers place on the flow plan are aircraft types, mission numbers, and mission descriptors.

SAAM schedules are entered into the AIMS database at the Airlift Wing level of echelon. An AIMS entry message is generated at the Wing and sent to HQ MAC (or the COMALF in the case of intratheater). HQ MAC enters the information into the AIMS database. Not all SAAMs are entered into AIMS. Some immediate, high-priority requests and some classified requests are not listed on-line.

ACDL K G F E

FIGURE 3.4. SAAM WORKSHEET

OPERATING SQDN: 7 36 22 75 349 PREPARED BY--

I. MISSION IDENTIFICATION INFO	CLASSIFICATION U C S
SAAM NUMBER	AIRCRAFT C-5 C-141
JCS PRIORITY	CLOSE WATCH YES/NO
AVAILABLE DATE	AIR REFUELING YES/NO
REQUIRED DELIVERY DATE	DIPLOMATIC CLEARANCE YES/NO
FLIGHT PLAN REQUESTED	PASSPORT YES/NO

II. ITINERARY--- ALL TIMES ARE GMT----

STATION	ICAO	± Z	ARRIVE	GTME	DEPART	FLY	OPR HRS/PPR/ RESTRICTION
TRAVIS	KSUU						
TIME CHECKED BY			GTME=		LAUNCH		TOTAL=

III. CONTACTS/USER

STATION		NAME		PHONE NUMBER AVN/AREA CODE

IV. REMARKS/MEMO FOR RECORD/INDIVIDUALS CONTACTED

V. USER LOAD INFORMATION/SUPPORT REQUIREMENTS

LOAD BREAKDOWN:

LSI X X WT

DANGEROUS CARGO --	POWER UNITS REQUIRED:
WAIVERS REQUIRED--	LITE CARTS REQUIRED:
WAIVERS RECEIVED --	SECURITY REQUIREMENTS:

EXTRA EQUIPMENT REQUIRED--

SPECIAL REQUIREMENTS--

PAX NUMBER TYPE FROZEN/BOX

PAX NUMBER MEALS REQUIRED TYPE FFC

COFFEE/WATER

TRAVIS Form Mar 78 0-611 PREVIOUS EDITION WILL BE USED.

Figure 3.4 (continued)

VI. AIRFIELD COORDINATION				
21/22 AF SUMMARY/OPS POLICY/ENROUTE SUPPLEMENT.				
STATION ICAO	RESTRICTIONS	PPR#	SVCS NOT AVAILABLE	OPERATING HOURS

AIRFIELD WAIVERS	PARKING/FUEL

VII. CREW REQUIREMENTS.		
BASIC/AUGMENTED ADDITIONAL CREWMEMBERS		
CREW LIMIT	BACKUP/PREFLIGHT YES/NO	STAGE CREW YES/NO
AIRFIELD CERTIFICATION REQUIRED:		
SPECIAL STATEMENTS:		
BRIEFING TIME: PLACE:		

VIII. ACFT REQUIREMENTS/MAINT. C141/C5				
CHOCKS		JACK & PADS		CONFIG MODS---
GND WIRES		DIPL TAILS		BACKUP REQUIREMENTS---
PITOT/ENG COVERS		CREW CHIEFS		SPECIAL ACFT REQUIREMENTS
WINCH C-5/HVY DUTY		JACK TEAM		C141/C5 TOW BAR YES/NO

IX. AERIAL PORT/LOAD INFORMATION.		
FLEET SERVICE-- CREW PAX	MEALS--NBR TYPE	
PALLETS/NET SETS YES/NO	QTY NEEDED	COFFEE/WATER
ADDITIONAL TIEDOWN REQUIRED:	SPECIAL EQUIPMENT REQUIRED:	
OPPORTUNE CARGO YES/NO PAX YES/NO		

X. DOCP	
FUEL REQUIREMENTS:	OPPORTUNE CARGO/PAX YES/NO
SPECIAL INSTRUCTIONS:	

XI. SPECIAL SUPPORT COORDINATION/EQUIPMENT/PERSONNEL.						
AERIAL PORT	(3705)		C-5 CREW CHIEF	(3973)		
INFLIGHT KITCHEN	(5675)		C-141 CREW CHIEF	(3815)		
C-5 780 SECTION	(3291)		SECURITY POLICE	(2923)		
C-141 780 SECTION	(2408)					

XII. SPECIAL MISSION FOLDER NBR					
MIS.		ALTRV APREQ		MAC FORM 237	
MAC DIRECTIVE		ALTRV APRVL		22AF FORM 7	
22AF DIRECTIVE		DIP CLNC APREQ			
SPCL INSTRUCTIONS		DIP CLNC APRVL			

XIII. DIPLOMATIC CLNC INFO.
ACFT CMDRS NAMES
ACFT TAIL NBRS
DATE SUBMITTED

FIGURE 3.5. WORKLOAD/SCHEDULING CHART

LOCATION ______________________ MONTH ______________________

	LOCAL	GMT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	GMT
		0100																																0100
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			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	

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3.5 Scheduling JA/ATT's

Once per month MAC sponsors a Joint Airlift Management Conference (JAMC) involving all of the users of MAC airlift (Army, Navy, Air Force, Marines, MAC) to plan next month's Joint Airborne/Air Transportability Training requirements. The conference location shifts around within the CONUS (Continental U.S.) and usually involves 90 to 110 people. The conference is like an auction where the users bid for airlift capability. The result is a set of user - validated requests that are sent to HQ MAC. Much is decided at the conference. Aircraft type assignments are made as are the task assignments to the Airlift Wings. Also determined are times over targets, aircraft configurations, and route itineraries. Combat Control Teams (CCT's) and Airlift Control Center (ALCC) personnel are present to help validate the requests. A preliminary schedule is manually worked-out by HQ MAC and the schedule is published. A Special Tactics shop (DOST) at the MACAF/ALCC works with the Airlift Wings to refine the schedule. Departure and arrival times are established, and entries are submitted into AIMS (via HQ MAC).

Like SAAM requests, JA/ATT requests are scheduled manually. Most of the schedule information is determined at the conference. Refinements (tail numbers, generic crews, times) are made at the wing level. The tools of the scheduler are hardcopy spreadsheets and flow charts similar to those used for SAAM missions.

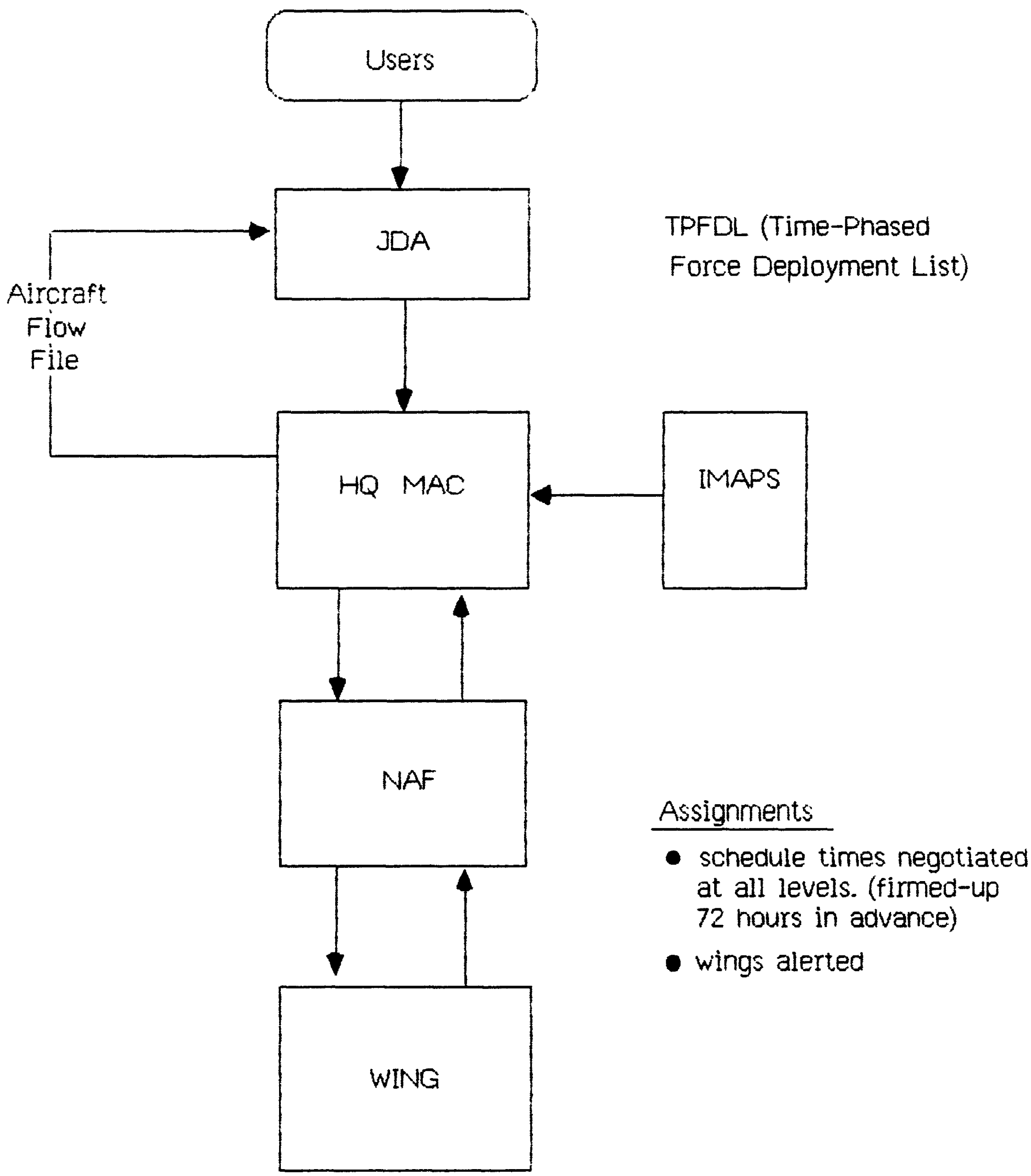
3.6 Scheduling JCS Exercises

JCS (Joint Chiefs of Staff) military exercises are planned months in advance at the Joint Deployment Agency (JDA). There are several per month, and a few major exercises per year. Requests for airlift to support the exercises are submitted to HQ MAC through a TPFDL (Time-Phased Force Deployment List) generated by the Joint Deployment System (JDS) computer. Requests are fed into a MAC system called IMAPS (Airlift Planning System) which resides on the Honeywell computer. The IMAPS system is used by MAC planners to aid in scheduling the airlift missions for exercises. There are three major routines in IMAPS: ARCS, FLOGEN and REPGEN. ARCS (Airlift Requirements Collector System) is a clustering (or "lumping") routine which combines similar requests based on the attributes of the requests. Some attributes are: POE (port of embarkation), POD (port of debarkation), earliest available time, and latest delivery time. By clustering it may be possible to combine requests into a single airlift mission. FLOGEN is a routine which generates an aircraft flow. Built within FLOGEN is a scheduler subroutine which takes the output from ARCS and combines it with numerous other decision rules to schedule missions automatically. SCHEDULER assigns an aircraft type, route itinerary, and departure and arrival times. The procedure is automated, but the schedule results often also have to be manually refined. REPGEN generates a series of output reports from IMAPS. The routine generates a file of the aircraft flow, lists the airlift requirements, and also gives the requirements which were not-flowed (perhaps due to capacity or time constraints).

The aircraft flow file generated by REPGEN is fed back to JDA for validation/verification (see figure 3.6). After approval, the published schedule is sent to the MACAF/ALD for tasking. Schedule times can then be

FIGURE 3.6

JCS EXERCISES
SCHEDULING PROCESSES



negotiated at all levels of echelons in MAC. The schedule is firmed-up about 72 hours before execution, and the Airlift Wings are alerted to their mission tasking.

This same process is used to prepare "packaged" or deliberate plans for potential deployments into various worldwide theaters. Given JDA/JCS deployment scenarios in terms of airlift requirements, a nominal schedule for airlift activities is created using a set of planning assumptions (such as initial aircraft locations, aircraft availabilities, standard winds, nominal fuel storages, etc.) These provide a basis for force deployment schedules as a function of airlift resources allocated, and provide guidance for JDA planners. If pulled off the shelf at any point, these plans must be modified to fit the initial status of MAC resources on "day zero" of the packaged plan, and any other discrepancies in the assumptions used for deliberate plannning.

3.7 Tactical Versus Strategic Airlift Scheduling

Tactical airlift operations are performed within a theater. They employ primarily C-130 aircraft on shuttle-type, short-haul, missions between the home base and a target zone or destination port. Strategic airlift operations are performed between theaters (for example, between the CONUS and Europe). They employ C-141 and C-5 aircraft on long-haul, sometimes multi-stop, missions. The processes involved in scheduling these two types of airlift are vastly different, and it is interesting to analyze these differences.

3.7.1 Tactical Scheduling

Tactical airlift scheduling is an isolated activity performed solely by an ALD/ALCC within a specific theater. Because of the short distances of the legs flown by tactical aircraft, missions are scheduled to be flown from the home base of the aircraft and crews to the target or destination point, and then they return to base. Tactical missions may require an intermediate, enroute stop to pickup the cargo and/or passengers required at the destination, but aircraft and crews generally return to base to fly additional missions or to overnight.

A tactical airlift schedule is constructed from validated airlift requests which emanate from HQ MAC/COMALF. (A sample request form is displayed in table 3.1). Each request is translated into a mission which may involve more than one sortie (departure) and performed with more than one aircraft. The process of scheduling tactical airlift is a manual one. Departure and arrival times are planned to coincide with the time window specified by the earliest available/pickup time for the cargo and the latest delivery/drop-off time. If resources are not constrained, as in a peacetime scenario, aircraft and crews may be assigned only one sortie per day. However, when resources are limited, aircraft and crews are routed into multiple tasks and are fully utilized.

A helpful tool to the tactical scheduler is an aircraft routing chart. These "spreadsheets" display the mission activity and routings of each aircraft tail number during one day. Columns in a route chart delineate the time of day. Each row represents an aircraft tail number. A sample routing chart is displayed in figure 3.7. Spreadsheets like this were observed being used in tactical exercises like BLUE FLAG, a Korean tactical airlift scenario. The charts were manually constructed each day. The TIMS (Theater Information

TABLE 3.1

CALO AIRLIFT REQUEST
(CALO-SOP)
연 합 공 수 신 청 서

1. REQUESTING UNIT/PROJECT NAME: 신청부대/계획명	2. OVERALL SECURITY CLASSIFICATION: 비밀구분
3. DESIRED MODE: 요망수송수단	4. PRIORITY/PRECEDENCE: 우선순위/우선권

5. ROUTE 노정

a. ONLOAD: 적재장소	b. ENROUTE: 경유지	c. OFFLOAD: 하화장소

6. DATE AND TIME 일시

a. AVAILABLE FOR PICKUP 적재준비완료		b. DESIRED PICKUP 적재요망		c. RDD 도착요망일	
DATE: 일자	TIME: 시간	DATE: 일자	TIME: 시간	DATE: 일자	TIME: 시간

7. PASSENGERS 인원

a. TOTAL: 계	b. FOREIGN NATIONALS: 외국인	c. BAGGAGE WEIGHT: 휴대품 중량

8. CARGO 화물

a. TOTAL WEIGHT: 총중량	b. TOTAL CUBE: 총용적	c. COMMODITY DESCRIPTION: 품명	d. WEIGHT/CUBE OF LARGEST SINGLE PIECE 최대 단일화물 중량/용적		e. DIMENSION OF THE LARGEST SINGLE PIECE: 최대 단일화물 규격
			lbs 파운드	cube 입방	

f. N.E.W./QUANTITY DISTANCE: 순폭약중량/폭안전거리	g. MATERIAL HANDLING EQUIPMENT REQUIRED: 물자 취급 장비 소요

9. CONTACTS 연락처

a. REQUESTING UNIT: 신청부대	b. ONLOAD: 적재장소
c. ENROUTE: 경유지	d. OFFLOAD: 하화장소

10. REMARKS: 비고

11. CALO USE ONLY

RECEIVED FROM:	RECEIVED BY:	RECEIVED AT (DATE/TIME):
PASSED TO:	PASSED BY:	AT (DATE/TIME):
RECEIVED MSN DATA AT (DATE/TIME)	FROM:	ONLOAD TIME:

REQUESTOR INFORMED OF MSN DATA AT (DATE/TIME)	BY:	STATUS:	AF MISSION NUMBER:

TYPE MSN:	DATE OF MSN:	REQUEST NUMBER:

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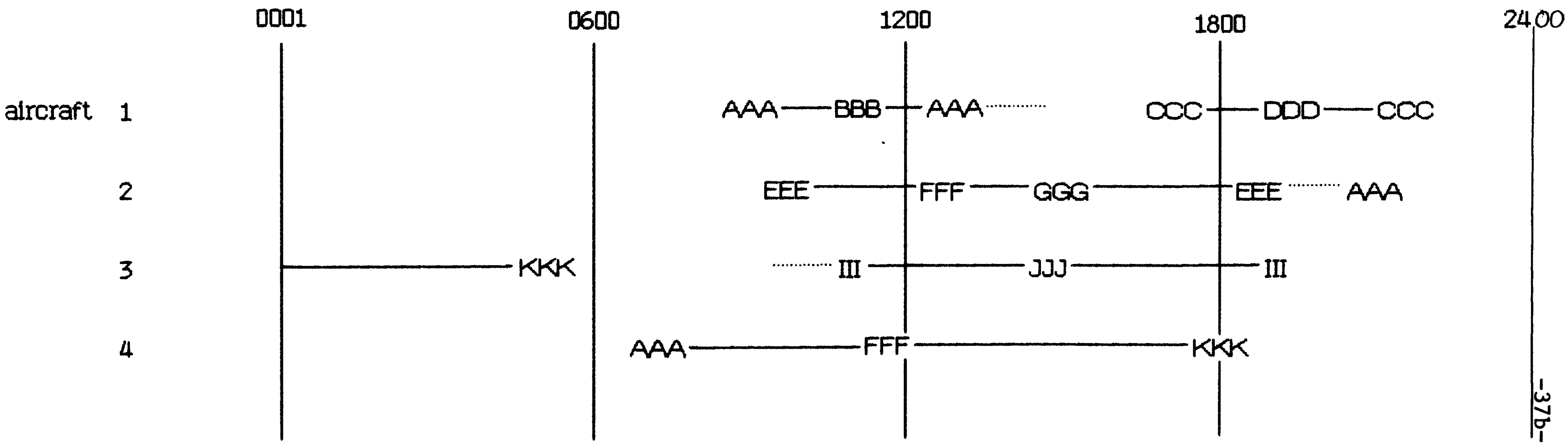
FIGURE 3.7

AIRCRAFT ROUTING CHART



Management System) program developed by MAC (322nd ALD) has a feature which prints aircraft flow charts based on the mission schedules that were input to the TIMS database. In tactical scheduling changes occur frequently, which means hourly changes to the daily schedule plan and frequent updates to the aircraft routing charts. Since the process is manual, it is difficult to keep current information when there are a large number of sorties per day, as would be expected in a wartime scenario.

3.7.2. Strategic Scheduling

Strategic airlift scheduling is a responsibility which is currently split betwen HQ MAC and the Numbered Air Forces (MACAF's). HQ MAC schedules all Channel missions and the preliminary deployment schedule for JA/ATT's and JCS exercises. A Special Tactics shop (DOST) at the MACAF level refines the schedule for deviations from the plan: changes in tasking, addition of new user requests, aircraft/crew constraints, maintenance problems, weather, etc. MACAF also schedules SAAM missions.

Strategic airlift involves C-141 and C-5 aircraft on long-haul, multi-stop missions. Typical missions for the 21^{st} Air Force would be from the CONUS to Europe and the Middle East with stops in the Azores and Europe. For the 22^{nd} Air Force missions fly from the CONUS to the Far East and South Pacific via stops in the Pacific islands. Aircraft and crews are away from home base for many days or weeks. It is common for missions to change both itinerary and crews to accomodate operational changes and additions to user requests. Because of the length of strategic flights, few changes occur while aircraft and crews are away from home base. Such enroute changes are the essence of the "dynamic" airlift rescheduling problem, a problem which is inherent to MAC.

Deployment scheduling for exercises is dominated by the IMAPS (Airlift Planning) computer system which resides on the Honeywell 6000 computer at HQ MAC. So, at least in the preliminary scheduling stage, the strategic process is more automated than the tactical process. But there is at least a 72-hour lead time requirement in producing a FLOGEN (flow generator) report because of the volume of work required to set-up a FLOGEN computer run. The schedule which comes out of FLOGEN must be manually refined and firmed-up. This manual rescheduling is performed at the MACAF and airlift wing levels, and from thier point of view consists of a complete rescheduling of the deployment schedule provided by FLOGEN.

3.8 Observations

Following are some general observations and conclusions concerning the current MAC airlift scheduling process.

a. The manual scheduling process employed in both tactical and strategic airlift leads to an inefficient allocation and utilization of resources. Often, airlift flies empty in order to position and reposition resources. The case of two empty aircraft passing each other in opposite directions is not an unknown occurrence.

b. Scheduling during peacetime is easy relative to a wartime scenario. A surplus of resources exists and no validated airlift requests are refused.

c. The process does not always recognize potential station constraints, like MOG's (maximum aircraft on ground).

d. Strategic scheduling is somewhat more automated than tactical scheduling since preliminary deployment schedules are produced by the FLOGEN computer program. However, the strategic schedule must be extensively reworked by hand by MACAF.

e. The scheduling process is organizationally unstructured and varies with location and personnel. Scheduling personnel are trained "on-the-job" in a haphazard manner even though the scheduling process is the kernel of airlift Command and Control. These problems lead to overstaffing and excessive handling of information via paper and telephone.

f. The FLOGEN automatic scheduler currently has major deficiencies in that it can only generate a flow for a single deployment while there might be two or more occuring simultaneously, and it ignores station or fuel constraints from other MAC schedules outside the deployment flow. The AIMS system collects information on all MAC airlift schedules, but it doesn't recognize conflicts or station constraints either.

g. At present, the maintenance logistics (LG) and transportation (TR) functions within MACAF/ALD and the airlift wings have separate C^2 systems which provide information needed by the scheduling functions.

4. Proposed New Processes for Scheduling Airlift in a Wartime Scenario

The purpose of this section is to explore various issues and alternatives in improving airlift scheduling processes in the MAC upgrade of its C^2 system. It details opportunities for introducing automated sub-processes, and creating interactive symbolic graphics displays for the airlift scheduler, describes information processing for scheduling functions, and outlines database structures and communications. It also raises various issues of procedure, organizational relationships, and operational policies for command and control which will be discussed and summarized in more detail in section 5.

4.1 Objectives for Wartime Scheduling Processes

In a wartime/contingency, dynamic overload scenario, the objectives for automating scheduling processes are:

a) to achieve higher productivity from a given set of airlift resources through;

   1) reducing positioning/depositioning flights

   2) creating missions and schedules for the aircraft fleets which minimize the rejection of higher priority requests

b) to respond quickly and efficiently to high priority requests for immediate airlift and to losses of resources such as aircraft, stations, and personnel.

4.2 Alternative Approaches for Automation in Scheduling

There are four options for the MAC C^2 Upgrade in the automation of scheduling processes. First, it could simply provide the airlift scheduler with a traditional DBMS (database management system) for manipulation of pertinent alpha-numeric data which he currently uses in generating missions and schedules. Secondly, the upgrade could introduce sophisticated graphical displays of the data, and interactive graphics methodology for symbolic manipulation of pertinent scheduling data. Thirdly, some of the sub-processes in mission and schedule generation could be automated and called into interactive use to support and speed the total decision making processes of the airlift scheduler in either of the first two options. Finally, the upgrade could call for complete automation of the mission and schedule generation processes, using computer algorithms and hardware which seek optimal schedules.

The first process is typified by the current TIMS project. The airlift scheduler can retrieve information quickly and easily to make decisions on schedule making, and can quickly enter simple missions and mission sequences with some automated support on flying times, ground times, time zone changes, flags for MOG's or curfews, etc. There is no automatic iterative review of past mission decisions to reorganize missions or mission sequences into more efficient arrangements, but the proficient scheduler, given sufficient time and proficiency in the DBMS could initiate such a review and rearrangement.

Since this iterative review process can substantially improve scheduling and airlift fleet productivity, it seems desirable for the C^2 upgrade to make the iterative search process simple and easy for the airlift scheduler by providing graphical displays with interactive symbolic manipulation of scheduling information. This second option is within the current state of the art. It is also feasible to introduce automated decision support sub-systems to assist the airlift scheduler as he seeks improved schedules, but it is simply not in the current state of the art to automate completely the MAC mission generation and scheduling process described in section 2, especially if optimal answers are expected. The problem is not size or speed of current computer hardware - it is the non-existence or poor performance of scheduling algorithms and operations research methodologies in solving such complex scheduling problems at the scale of operations of MAC. It is sufficient challenge to automate certain of the sub-processes in scheduling airlift and to make them interactive with the airlift scheduler.

Therefore, the approach we have adopted is to explore the application of interactive graphics and interactive decision support automation at an "Airlift Scheduling Workstation". This is viewed as a sophisticated scheduling tool for "bookies" and "barrel masters" at various locations in MAC, and may require their training in its use as they are assigned to these duties. It has the advantage of an easy transition from current practices and manual reversion (should equipment or communications fail, or personnel find themselves working at remote locations).

It also allows the application of human experience and judgement in creating schedules based on data other than that available at the time of schedule generation. The airlift scheduler may know that the probability of successful completion of certain schedules is small (even though they are theoretically feasible) and may avoid them, or he may have a "contingency backup schedule plan" ready in the event the schedule does begin to fail. Or he may have expectations from the general development of the wartime/ contingency scenario that other requests, while non-existent at present, are likely to be demanded of him shortly. A completely automated scheduling process would have no information on these expectations and would generate good schedules which the scheduler sees as undesirable should the expectations actually occur. His experience may lead him to prefer slightly less productive schedules which have higher chances of successful completion and/or easy adaptation to his future expectations. The "Airlift Scheduling Workstation" approach allows the C^2 upgrade to provide the airlift scheduler with a tool to generate mission schedules quickly and easily, and to have "contingency backup schedules" prepared for any situation which he expects. It leaves the airlift scheduler who is responsible for generating good schedules totally in control of the schedule generation process. He cannot blame a computer for bad scheduling decisions or for his inability to modify current plannned schedules. The Airlift Scheduling Workstation can be used by airlift planners to generate pre-planned deployments, and to interactively update them for changing scenarios or particular exercises.

4.3 Description of New Automated Airlift Scheduling Processes

The basic description of section 2 for airlift scheduling within Command and Control created three levels of activity and information processing:

1) Airlift Task Planning

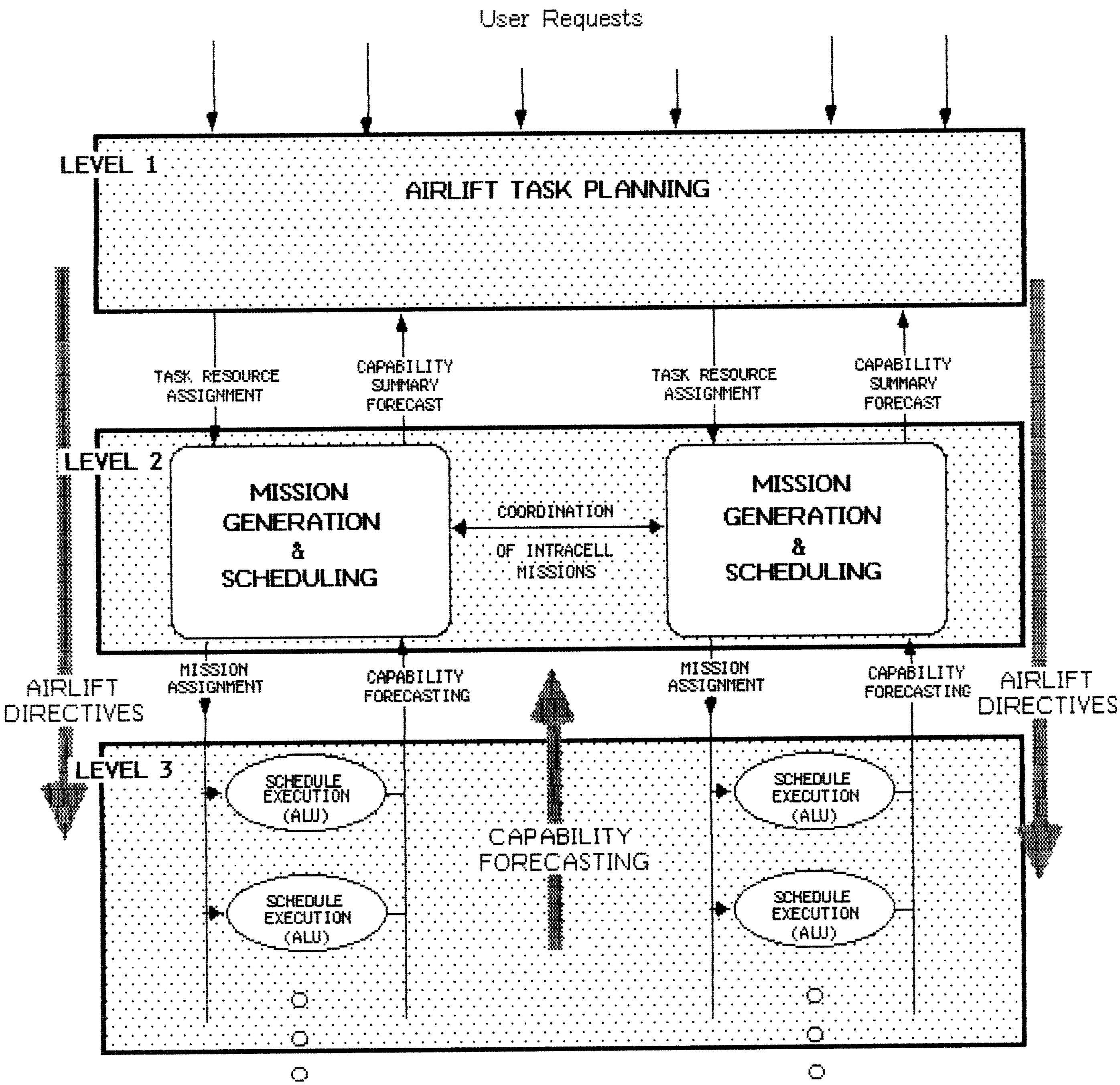
2) Mission Scheduling

3) Schedule Execution

The ideal hierarchical structure for these three levels is indicated in figure 4.1. All user requests for airlift in a given geographical area are channelled through one central agency which "owns" the airlift resources, and has the responsibility for assigning both tasks and resources to a "Scheduling Cell" which schedules the operation of the assigned airlift resources. These resources are a specific set of aircraft, aircrew, stations, and groundcrew. The operating personnel for each airlift unit report operational deviations and resource status directly to the scheduling cell personnel for rescheduling compatible with future schedule plans. Needs for additional resources, or resources available for further tasking are reported directly to airlift task planners by scheduling cell personnel. Task planners do not communicate with operating personnel. Users do not communicate with scheduling personnel.

In this report we are primarily interested in new automated processes for Mission Scheduling, but we necessarily must examine its interactions with Task Planning and Schedule Execution. Here we have used the word "agency" to describe the task planning organization, "cell" to describe the Mission Scheduling organization, and "airlift unit" to describe the Schedule Execution organization in order to avoid direct association with current MAC Command and Control organizational semantics. We have assumed in the hierarchical structure of figure 4.1 that the personnel of the Scheduling Cell have been assigned airlift resources by tail number, name, location, etc. and have total

FIGURE 4.1 : STRUCTURE FOR PROCESSES IN PLANNING, SCHEDULING, EXECUTION OF AIRLIFT



control of these assigned resources in terms of scheduling their operations. Task Planners, or Airlift Operators are not able to create or modify the schedule of operations for these assets. Only one organizational element can have the responsibility for determining the schedule of operations for the airlift resources assigned to it. Of course, since the Task Planners can reassign resources, they can create another specific set of resources and another scheduling cell, and assign airlift tasks to that new cell. These resources would be identified specifically by tail number, name, and location, and would not be an unspecified allotment of generic resources from other scheduling cells.

This assumed hierarchical structure requires that there be coordination between scheduling cells for prior approval when missions operate into locations in the jurisdiction of other cells. Airlift operators would report these missions to their scheduling cell which would then report to the other cell. If aircraft or crews are temporarily reassigned to another scheduling cell, the time and place of their return is established and updated to enable schedule planning based on their return to continue in the original scheduling cell. These organizational assumptions are assumed to exist in this section. It is vital to adhere to this definition of the Scheduling Cell, i.e. it is totally responsible for the scheduling of all operations by specific resources assigned to it, and there are no mission generation, or mission scheduling and routing decisions by Task Planners or Schedule Operators. The definition of a Scheduling Cell ensures that any specific resource is scheduled by only one Scheduling Cell. We now turn to a more detailed description of Task Planning, Mission Scheduling, and Schedule Execution in order to delineate database structures and communications, and the role of decision support algorithms.

<u>4.3.1 Description of New Airlift Task Planning Processes</u>

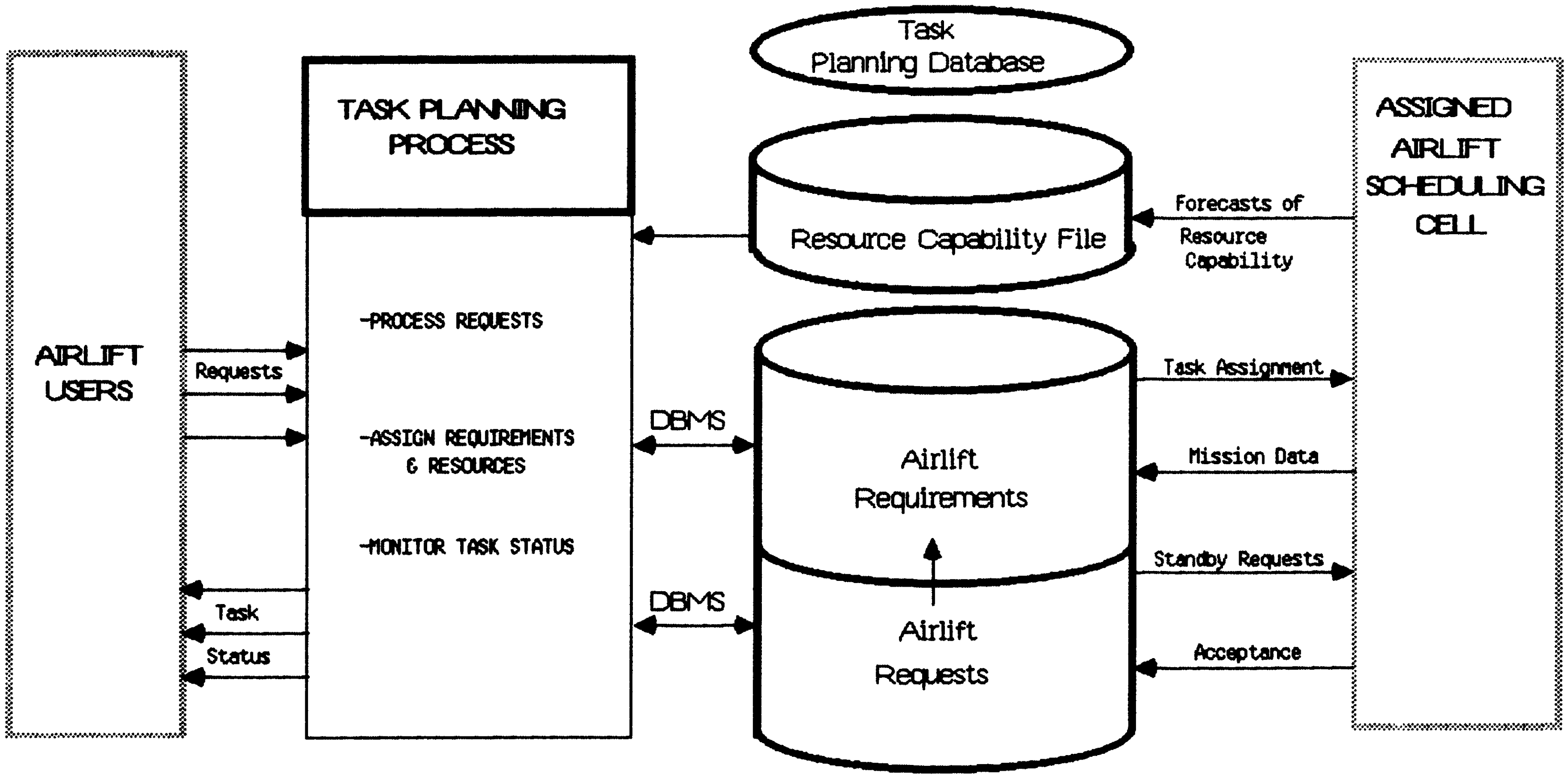
As described in section 2, the "dynamic overload" scenario creates the situation where not all user requests for airlift can be accepted, and where requests previously accepted are being "bumped" by late arriving requests of higher priority. We define a user <u>request</u> as a task whose acceptance has not been confirmed to the user by MAC, and define a <u>requirement</u> as a request which has been scheduled into a planned mission and therefore has been confirmed. The word "task" becomes a general descriptor for both requests and requirements. It is necessary to have both requests and requirements in the Task Planning processes.

In peacetime operations, a task planner can assign the request to a scheduler with the expectation that it will be successfully scheduled into a requirement. However, in the "dynamic overload" scenario, he will find that new requests of high priority may not be scheduled since they are not of sufficient priority for their location in time and space while others of lower priority but different locations are being accepted. He also finds that prior confirmed requests are being bumped. It is difficult for him to understand the scheduling problems which cause this apparent erratic behavior, especially when it is rapidly changing. This situation causes the task planner to negotiate spare resources with the scheduler by asking questions such as "how many more aircraft would it take ...?, or what could you do if I gave you three C-141's for two days starting Tuesday?" The task planner would like answers measured in minutes to such questions with the confidence that a feasible scheduling solution has been found by the scheduler to support the answer.

The task planner has the responsibility of working with the users to refuse or confirm requests, or to explain bumping of the requirement back to a request. The user may wish to continue his request in standby hoping that future changes in requirements/resources will allow the request to be accepted, and the scheduler also wishes to be aware of a backlog of requests which could be served by some of the options which he has in mission generation and routing. Thus, there is a need for a Task Planning Database containing both requests and requirements easily accessible by the Task Planner and easy to update, which prompts his actions in dealing with users and schedulers, and which logs the time history of his actions relative to each request. It will contain the time of confirmation and scheduled mission number, any subsequent changes, and a limited amount of current mission information deemed necessary for the user when it is subsequently available (scheduled/estimated/actual times, aircraft type, aircrew name, etc.). This Task Database exists at the Task Planner's location and communicates with users and schedulers. There will be a subset of this database duplicated at the scheduler's location for his assigned requirements and requests and the task information deemed necessary for the scheduler and operators. The messages exchanged between these duplicated files must ensure identical information at all times. See figure 4.2 showing a schematic representation of the Task Planning Database and its communications.

Also, the task planner may need a forecast of airlift resource capability in his database. This can be updated by messages from operators via the scheduling cell where a summary forecast of activity, capability, availability, etc. can be prepared and transmitted at regular times, or upon significant change. The Task Planner needs this information to guide his decisions in assigning resources and requests, at least in a strategic, longer term timeframe. The refusal and bumping of requests will provide him with direct and explicit evidence of the times and locations of insufficient

FIGURE 4.2 TASK PLANNING DATABASE AND COMMUNICATIONS



resources in the shorter term.

This description of the Task Planning processes is necessary to establish its relationships with the Mission Scheduling processes. In summary, we expect Task Planners will be performing three functions:

1) Processing Requests - receiving new requests, creating a datafile entry for the request, negotiating with user, receiving modifications of request data.

2) Assigning Requirements and Resources - reviewing forecasts of resource capabilities, negotiating with schedulers on assignment of requirements/resources, creating requirements file.

3) Monitoring Task Status - informing the user of scheduled/rescheduled times, missions, etc. for his requirements, or of the bumping back of his requirement to request status.

There is no need for algorithmic or graphic manipulation capabilities in Task Planning as described above. It does require a simple, efficient database management system with good external message handling capabilities.

4.3.2 Description of New Mission Scheduling Processes

There are several processes which constitute Mission Scheduling in the dynamic overload scenario:

1) Mission Generation

   - convert tasks to missions by selecting aircraft type and routing

2) Schedule Map Generation

   - create aircraft mission sequences which connect missions and positioning flights for each type of aircraft
   - find the set of missions which minimizes the number of higher priority tasks which cannot be flown by the available number of that type of aircraft

3) Crew Mission Sequence Generation

   - create crew mission sequences and crewstaging plans
   - modify aircraft schedule maps if required

4) Station Schedule Generation

   - generate station schedules from all schedule maps and transmit information to stations
   - review any MOG constraints, fuel availability problems, and determine needs for reassigning station resources and self-support missions
   - modify individual aircraft schedule maps and crew mission sequences if necessary due to above

5) Management of the Status of Schedule Information

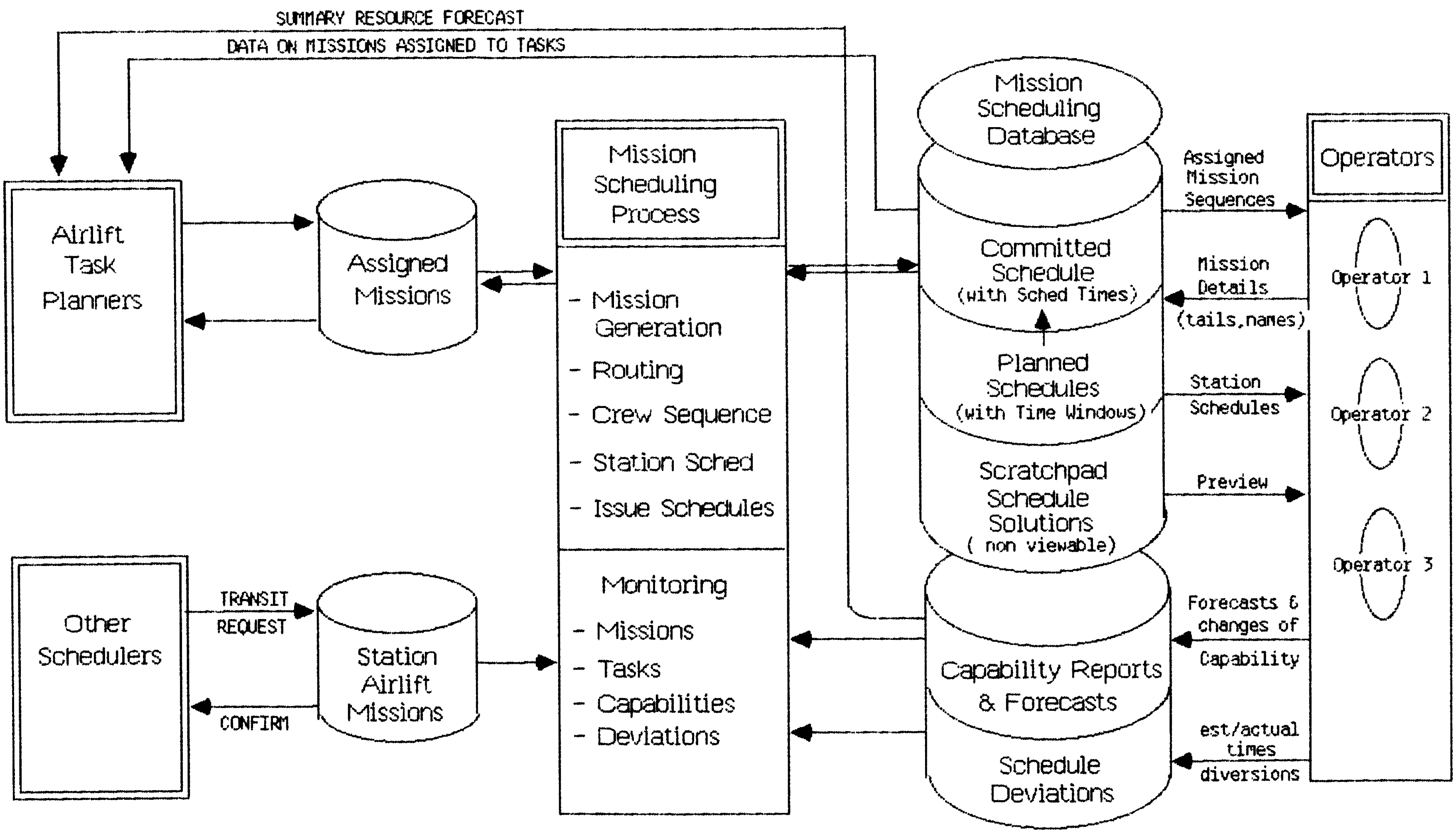
- issue planned schedules with time windows for preview by operator, pass assigned missions to Task Planning Database
- issue committed schedules at or before commitment time with exact operations times to operators, planners, users
- save alternate scratchpad schedules as contingency for subsequent changes in tasks/resources/operational deviations

6) Monitoring Schedule Execution and Resource Status

- review development of mission detailed data
- monitor new and modified tasks as assigned
- monitor changes in resource capabilities, review impact on schedules, and forward resource summary to Task Planner
- monitor operational deviations and review impact on schedules
- coordinate requests for transit operations from other schedulers

To support these activities, the Scheduling Workstation would require a "Mission Scheduling Database" which is shown schematically in figure 4.3 with its communications to Task Planner's and Operator's Databases. The Scheduling Workstation requires much more beyond the simple Database Management System of the Airlift Task Planner's workstation. The first four functions require graphics display of scheduling data with easy, quick manipulation of the scheduling graphics symbology, and decision support assistance in the form of computer algorithms to find good or optimal solutions to scheduling sub-

FIGURE 4.3 MISSION SCHEDULING DATABASE AND COMMUNICATIONS



problems. Some of the possibilities in these areas will now be described to initiate discussion and further analysis, and to allow consideration for inclusion of this type of scheduling support technology in the upgrade of the MAC C^2 system.

4.3.2.1 Mission Generation

This function aggregates task loads in time and space to create candidate missions for each type of aircraft. No automated decision support algorithm to perform this function exists, but it would appear possible to develop one. The problem can be stated in words as follows:

Given, various types of available aircraft with

1) payload capacity over stage lengths
2) block speed and ground times

and, at any point in time, a large set of tasks with:

1) priority
2) origin/destination
3) time windows
4) load weight and volume

Find an efficient set of missions, such that all tasks are done within their windows and the onboard load for any mission leg does not exceed payload capacity.

Mission Generation and Schedule Map Generation are interactive functions. They will be performed sequentially by aircraft type, starting with the largest capacity aircraft first (in order to make effective use of its capacity, and to ensure a minimum of empty positioning flights in its schedule map). Tasks not handled by the available number of largest type of aircraft are eligible for the next largest type (which would then be scheduled), and this process is repeated for each smaller capacity aircraft type. When there is surplus airlift this sequential process would tend to keep all of the largest aircraft busy, and not use the smallest aircraft. However, the allowable fleet sizes can be controlled in the Scheduling Process to distribute tasks such that, in general, the low load aircraft mission sequences are not flown by the larger capacity aircraft, thereby leaving more tasks for smaller capacity types of aircraft.

In the dynamic overload scenario envisioned in this report, there would be requests remaining after schedule maps have been constructed for all available aircraft, and it is necessary to ensure that the complete process gives priority to the higher priority tasks. This can be accomplished in two ways: first, a weighting value can be associated with each priority, and schedules generated which maximize total value; secondly, the given set of tasks for mission generation can be restricted to those above any selected priority level, with the remaining requests then loaded on a priority basis into any available capacity in the resulting schedules.

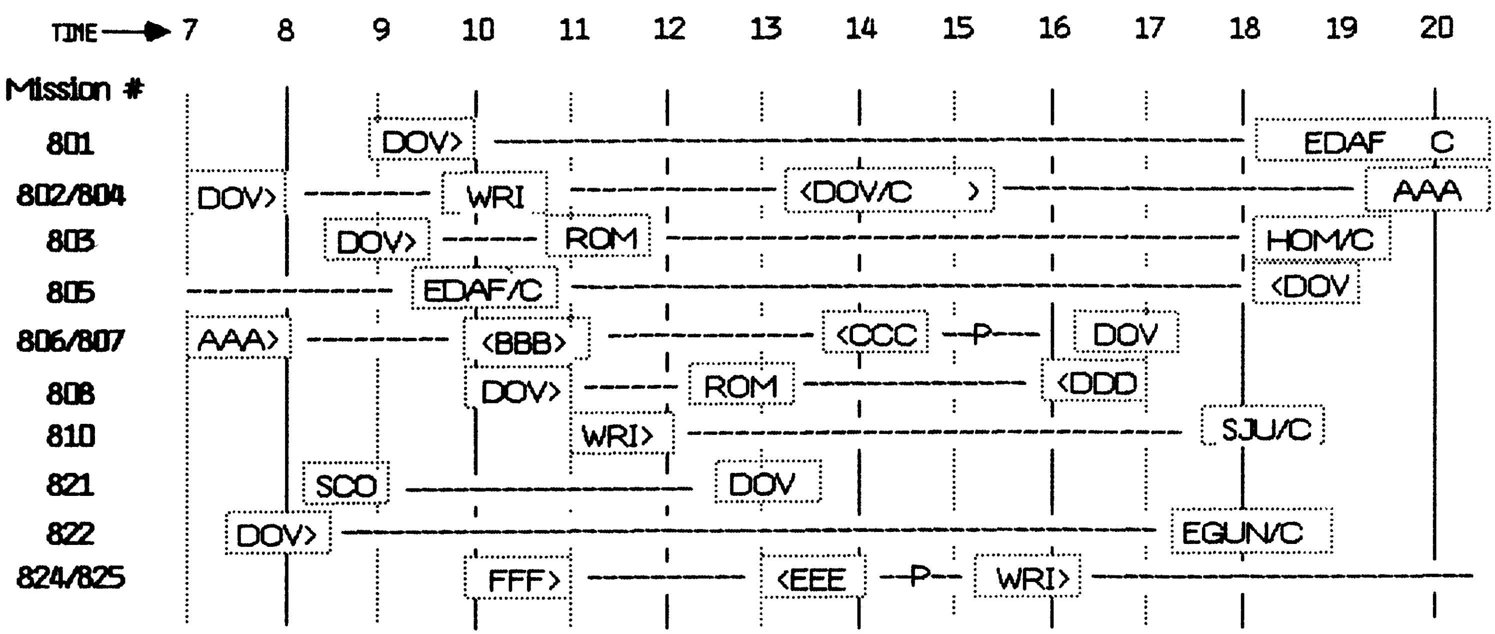
This second method creates the need for a "Load Reassignment" algorithm which would load a given set of tasks with varying priorities, origins/destinations, etc. into a given complete schedule such as not to exceed payload capacity. If a late request of higher priority arrives, this algorithm could be used to see if it "bumps" other tasks without requiring a new mission or schedule to be generated. This algorithm might split the new request's load amongst one or more existing missions and aircraft types, and might transship the new request at some point between connecting missions. The tasks which are bumped might unload segments other than the ones used by the new request, allowing yet other low priority tasks to be carried on those segments. A list of "assigned" and "bumped" tasks would be displayed. No such algorithm currently exists, but it does not seem difficult to develop one by modifying existing network flow algorithms and creating pre-processors and post-processors to make them interactive with the airlift scheduler.

A simple database management system is sufficient to manipulate and review mission data. However, figure 4.4 shows a typical graphics display for mission data which might be provided to allow symbolic manipulation of mission data by the airlift scheduler. By specifying origin, time, fleet, etc., the scheduler creates such a "quick-see" display for any desired subset of missions to show "short form" mission numbers and mission routings over the time period. Further detailed data can be accessed by "mousing" the graphics symbols called "icons". For example, mousing mission number 806 would return icons representing all the mission files for Mission 806 such as complete mission identification code, times, tasks carried, assigned crew names and tail number, etc. These might be displayed as sub-files to be further moused to direct the scheduler to the exact data he wants (see figure 4.4.1). On the other hand, mousing the "square" icon representing an intermediate stopping point might display only arrival/departure times, unloading/loading requirements, fuel pickup, crew changes, etc., which are pertinent only to that stopping point. Certain items could be specified to augment the basic display. For example, the "C" attached to station icons in figure 4.4 signifies a crew change or layover. Rather than display all such data all the time, the airlift scheduler can augment and erase the display elements as required to meet his needs.

FIGURE 4.4 GRAPHICS DISPLAY OF AIRCRAFT MISSIONS

Current Missions by Mission Number

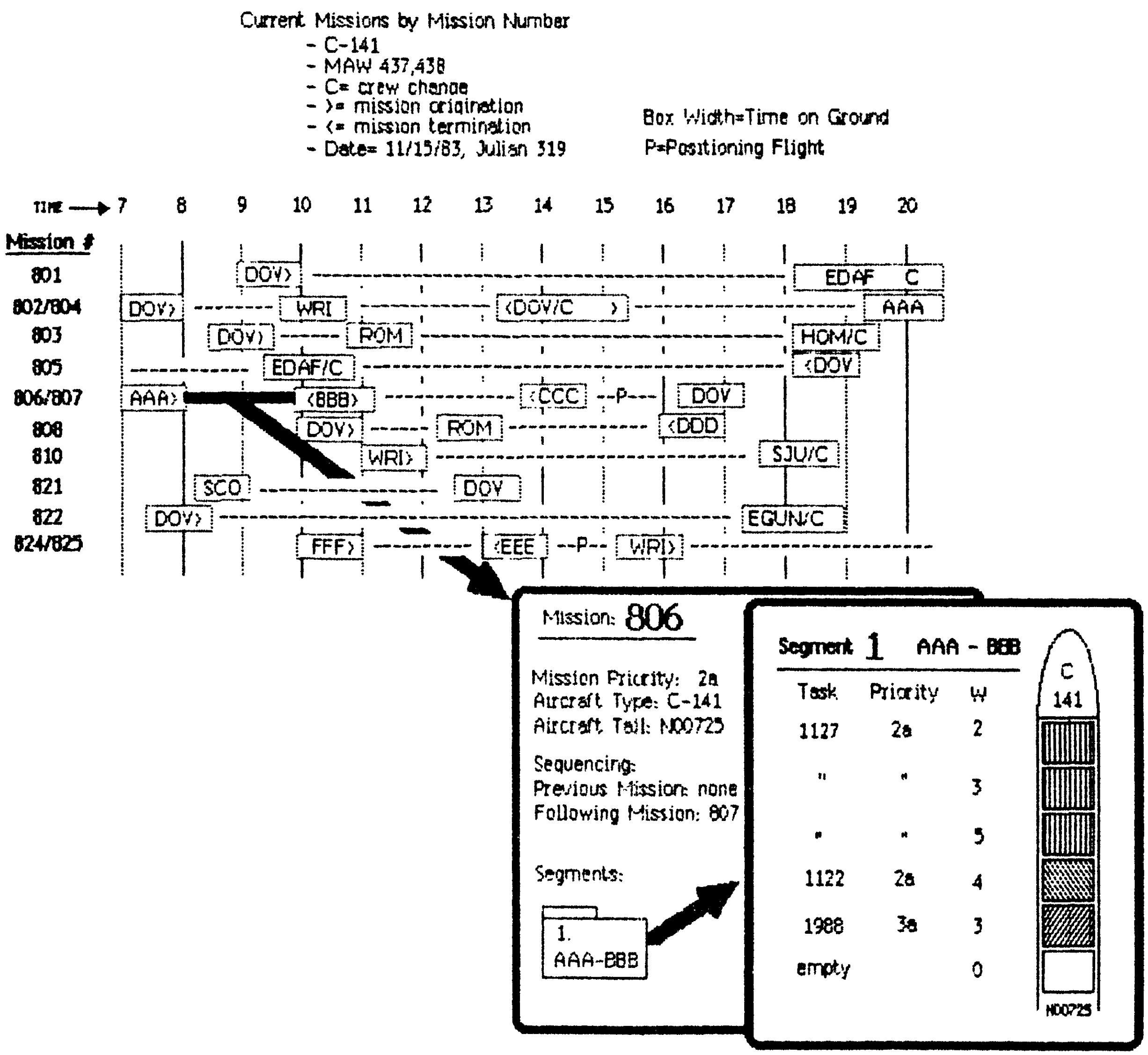
- C-141
- MAW 437/438
- C= crew change
- >= mission origination
- <= mission termination
- Date= 11/15/83, Julian 319



Box Width=Time on Ground

P=Positioning Flight

FIGURE 4.4.1 Nested Mission Information Overlays



4.3.2.2 Schedule Map Generation

This function performs the routing of a given type of aircraft by linking missions into mission sequences, adding positioning/depositioning flights where and when necessary, and creating a "Schedule Map" of the complete set of routings for that type of aircraft. The problem can be stated as follows:

Given a type of aircraft with:

1) block speeds (for positioning legs)

2) standard ground times by station for transit, loading, etc.

and, a large set of potential missions with

1) priority

2) origin/destination and routing

3) time windows

Find an operationally feasible schedule map which minimizes the number of aircraft required, or the number of high priority missions which cannot be flown by a specified number of aircraft.

Note that the schedule map may still have time windows associated with some arrivals/departures. There is no existing algorithm to solve this problem, although they exist for partial or simplified statements of the problem (e.g. for missions of identical priority, or missions with no time windows). However, it is possible to provide excellent graphics automation support which will allow the airlift scheduler to create a good schedule map quickly and readily for each type of aircraft. Figures 4.5 and 4.6 show a possible schematic display of a small schedule map for three stations and five C-130 aircraft, and illustrates one application of the graphics manipulation

FIGURE 4.5 EXAMPLE OF GRAPHIC MANIPULATION OF SCHEDULE MAP INFORMATION

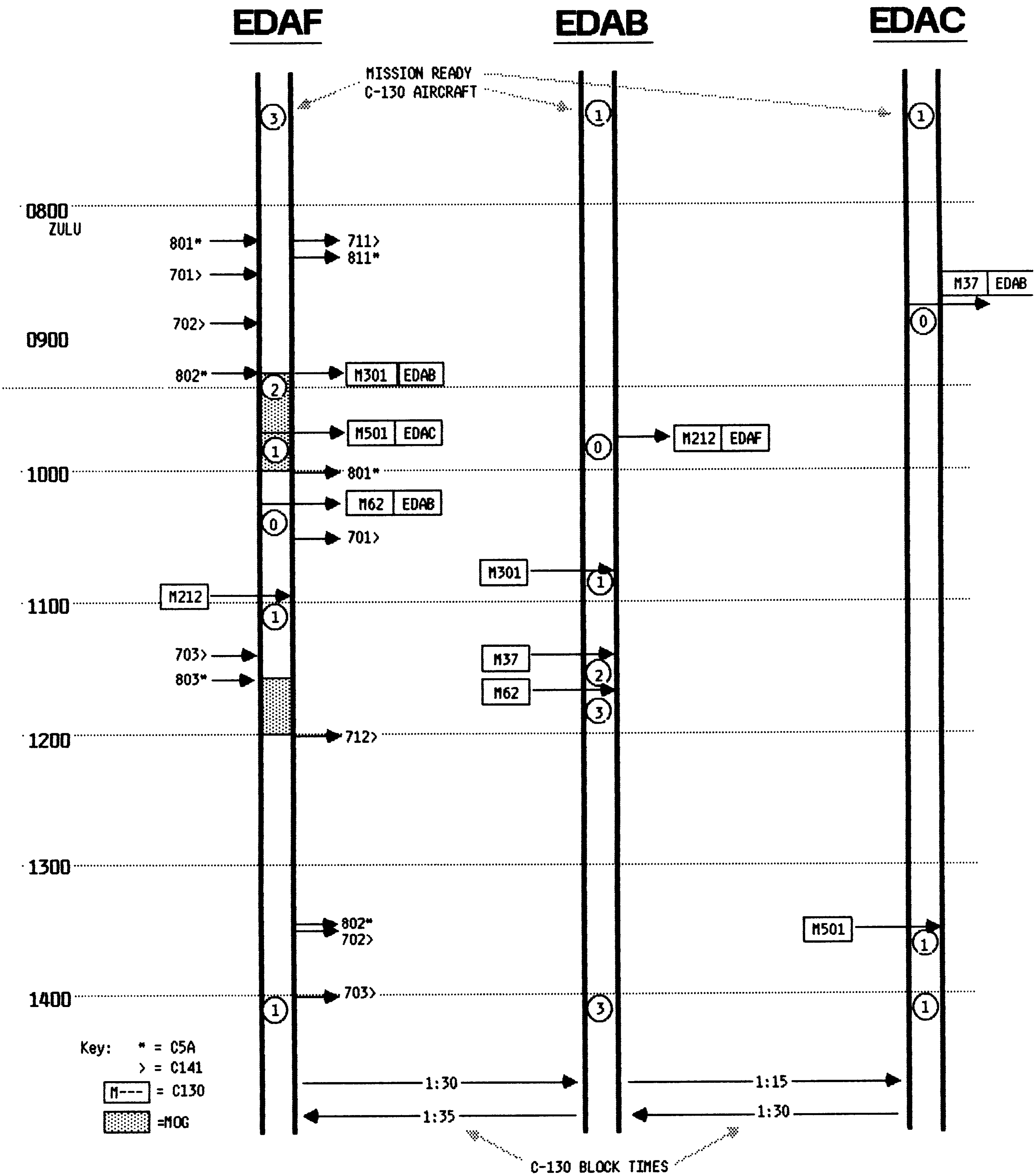
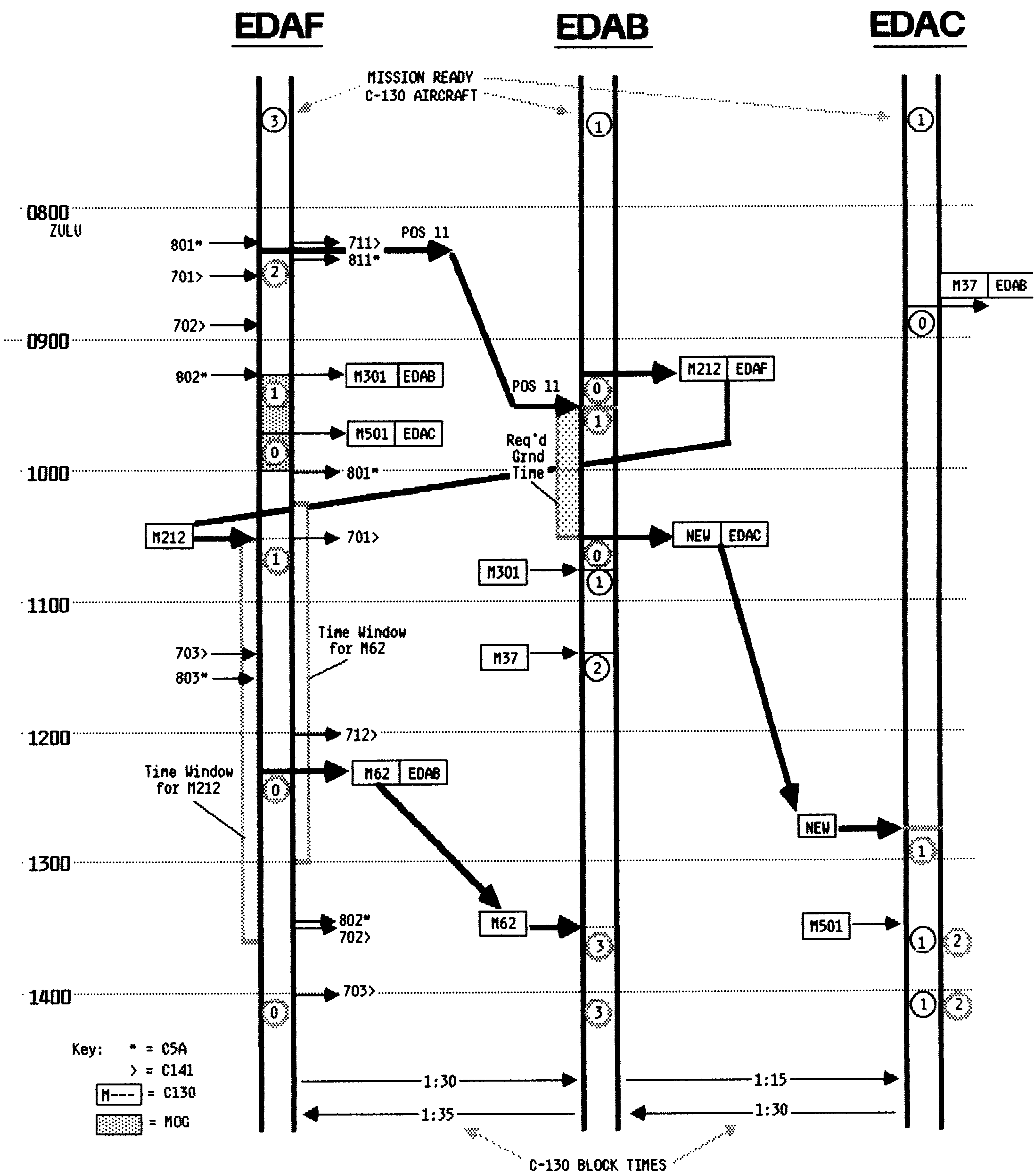


FIGURE 4.6 EXAMPLE OF GRAPHIC MANIPULATION OF SCHEDULE MAP INFORMATION



of the schedule map to solve the problem of adding one new mission.

In this example, the airlift scheduler has been given a new mission requiring a C-130 aircraft to fly from EDAB to EDAC, departing 1030Z, with a required ground time at EDAB of one hour for refuelling and loading. With the graphics support envisioned here for the C^2 upgrade, he calls up EDAB and EDAC activities between (0800-1400Z) as a vertical time line asking for C-130 arrivals and departures only. The display provides him with block times, station MOGS, etc., automatically. The display shows that there is no C-130 available for the new mission at EDAB around 0930 unless he cancels Mission 212 to EDAF. Knowing where C-130's might be available, he then decides to call up EDAF activities on the screen (all three stations would then appear as shown in figure 4.5 -- he could eliminate EDAC at this point). Since EDAF is a busy station, he asks for a simple format of C-5A and C-141 arrivals and departures (drawn from their current schedule maps) and a "highlight" of C-130 activities, including a display of "Mission Ready" C-130 aircraft along the vertical time lines of each station. This shows 3 C-130 aircraft at EDAF, one at EDAB and one at EDAC at 0800Z, and all seem to be busy during the day. If he were to use one of the EDAF C-130's, it would have to depart EDAF at 0815Z at the latest for EDAB, but then there would be no aircraft available for Mission 62 departing EDAF for EDAB at 1010Z. The next C-130 arrival at EDAF is Mission 212 at 1100Z from EDAB. By "mousing" the M212 icon, he can obtain data on this mission (and cause it to "highlight" at EDAB since it is already on the screen). Asking for its time window shows that he can "slide" it earlier by one-half hour, not sufficient to provide the aircraft for M62, especially since it nominally will require 1.5 hours ground time at EDAF between arrival of M212 and departure of M62. He then "mouses" M62 to see that he can "slide" Mission 62 (and in fact the subsequent missions in its current mission sequence, which are not shown on screen) as late as 1300Z. He tries to slide M62 to a 1300Z departure, but is "flagged" to indicate a parking MOG problem at one of the downline stations of the M62 mission sequence. Without looking into the problem, he then backs off to 1215Z where the "flag" disappears, and he has a ground time of about 2 hours at EDAF. (Although the scheduling workstation uses 1 1/2 hours as a standard ground time for C-130 aircraft at EDAF, he sees a flag on an expected servicing MOG at EDAF in the period 0915-0945Z and he is suspicious that more time will be required.) This seems to solve the problem of supplying an aircraft for the new mission. It creates a new mission sequence for the C-130 aircraft based at EDAB. Where it originally returned to EDAF, it now continues into the planned M62 mission sequence, and the airlift scheduler needs to check its mission capability and maintenance status. The crew mission sequences need not be changed except for times. The Mission 212 crew leaves EDAB one-half hour earlier and can still terminate at EDAF if desired. The Mission 62 crew departs two hours later, but since he knows it is originating at EDAF, this seems feasible. When crew mission sequences are reviewed later, there could be crew rest times violated and it may be decided to continue with the EDAB crew for other reasons, but at this point let us assume that the airlift scheduler has a feasible change of schedule to fly the new mission without requiring another C-130. He then can "validate" this graphic solution and transmit the changes to the planned or committed mission database, or he can "save" this solution and search for another C-130 at other stations which can position into EDAB by 0930Z.

In fact, there is a heuristic computer algorithm called "REDUCTA" available at MIT which "solves" this problem globally over the complete schedule map. It will minimize the number of aircraft required to fly a given set of missions within their time windows. It will not solve the inverse problem of flying the most high priority missions, given a fixed number of aircraft. It also cannot be "suspicious" about the ability of EDAF to turn M212 into M62 in 1 1/2 hours. To be useful, REDUCTA would have to be made interactive with the airlift scheduler, so that if he called for global minimization of the number of aircraft, it would display changes in times, mission sequences, etc. from his current solution, allow him to reject certain changes, and then ask for another solution.

This example shows how new, more efficient mission sequences can be found to keep a given fleet of aircraft productively flying missions by "sliding" missions within their allowable time windows. If the new mission had been at another time or place, it is quite possible that it could not be flown with the five C-130's shown in our example. In that case, some missions would have to be cancelled if the new mission were to be flown, and there would be a small set of solutions which cancel various other missions. The airlift scheduler could use the scheduling work station to explore such solutions, but there will be hundreds and thousands of them when the schedule map describes the activities of a busy fleet of fifty, or 100 similar aircraft. Again there is a computer algorithm available at MIT, called Fleet Routing (FR-4), which may provide some automated decision support. Unfortunately, it cannot handle time windows at present, although we are exploring a possible modification. Given a set of missions with committed times, it can solve the problem of finding the missions of total highest priority value which can be flown with a fixed number of aircraft. If the number of aircraft available to the scheduler is subject to negotiation with airlift planners, he could solve for various numbers of aircraft available over time and space to obtain lists of missions not capable of being flown (but always subject to the condition that no mission time windows exist, unfortunately).

This algorithm would have to be made interactive with the airlift scheduler to be useful. For example, for a given set of missions, it would be necessary to develop a method of identifying the need for positioning flights and adding a small set of efficient possibilities to the mission database. These would be treated as "positioning" missions and may carry lower priority tasks while retaining the status of an uncommitted positioning flight. The FR-4 algorithm allows the airlift scheduler to make an absolute commitment to certain missions being flown, and allowing the remaining missions to be chosen such as to maximize the value of total priority. This would be useful in allowing launches to proceed without interruption, or answering questions about what it would require to fly certain missions currently being rejected by the computer solutions as too costly in time and space, despite their assigned priority. It is also possible to place a restriction on the computer solutions which emulates the grounding of an unserviceable aircraft at some location for a certain time period, so that the loss of higher priority missions can be minimized in the schedule map of that type of aircraft.

There is the need for algorithmic support in handling the problems of delivering mechanics and repair parts to unserviceable aircraft in a busy, dynamically changing schedule. Given a current schedule of all types of aircraft, it is possible to find automatically the earliest delivery of mechanics and parts to the aircraft from various availability times and points, and to flag any subsequent changes in the selected delivery paths to indicate to the scheduler that he may affect the repair schedule.

The operation of "sliding" a mission leg or mission sequence will not be described in detail here. It is complex, and has not been fully explored at this time, as is the case with other operations, graphic manipulations, symbolic representations, etc., which might be desirable in working with a schedule map at the workstation. This section was written to give some inkling of the possibilities, and the kind of development work which needs to be done. It is desirable to field a prototype scheduling workstation to see what the airlift scheduler really needs in the way of screen graphics and symbolic manipulation. There are likely to be a variety of formats, interactive graphics operations, etc., beyond those shown throughout this report.

4.3.2.3 Crew Mission Sequence Generation

This process is closely related to the Schedule Map Generation process. When aircraft mission sequences are generated, they are tentative until a feasible set of crew mission sequences can also be produced for that schedule map. There will be only one entry for a mission leg in the database with two separate "pointers" which create the aircraft and crew sequences. The crew missions could be developed on a screen format similar to that shown by figures 4.5, 4.6, although it may also be useful to display complete aircraft mission sequences in the format shown for missions alone (see figure 4.4). Instead of counting mission-ready aircraft at each station, the number of mission-ready crews, and crews in rest would be displayed in the schedule map format. As crew mission sequences are created, the cumulative duty times can be automatically computed and flagged if illegal. As mission leg times are shifted to create feasible new sequences, flags can warn of any violations from the aircraft schedule map. The number of crews required will be computed in time and space, and crew sequences created which include the staging of crews away from crewbases. There may be two or more crews onboard some mission legs, and it will be desirable to know the crewbase for each crew in the schedule (i.e. a C-141 crew may be differentiated by its crewbase, unlike aircraft where we treat all C-141 aircraft as indistinguishable).

There is no known algorithm to create optimal crew mission sequences. There is a complex computational procedure used by some airlines for generating all possible crew mission sequences and selecting a good set to "cover" a given schedule map. This takes excessive computing time and power and is not recommended here as an interactive tool for the airlift scheduler. Instead it seems desirable to create interactive tools to assist him in manually creating good crew mission sequences and crew staging plans. This would require further exploratory effort than has been possible at this point.

4.3.2.4 Station Schedule Generation

As the schedule maps are generated and changed, the station schedules of arrivals/departures for all aircraft types are also generated and changed. Complete station schedules can be retrieved from the Mission Scheduling Database and displayed upon request of the airlift scheduler, and it is easy to automate the identification of station constraints (parking, servicing, and cargo handling MOG's), and the scheduled availability of fuel. Upon changing a schedule, these station constraint routines can automatically be initiated to display "flags" for the airlift scheduler. Station activities and availabilities can also be shown in various formats and levels of detail at the request of the scheduler.

The station schedules will also require MAC arrivals/departures scheduled by other MAC scheduling cells. These operations will be coordinated with the airlift scheduler who will enter them into a separate file and keep them updated. There also may be non-MAC activity from USAF, USN, and other allied forces. If fuel availability is to be estimated, the delivery schedules for fuel and the amounts of fuel uplifted by the MAC schedule and these other activities must be continuously updated. Unexpected changes in fuel delivery, or visitations by other forces may raise a flag for the airlift scheduler and cause rerouting of MAC missions. Station curfews or closures or "sterile times" will also be updated. It is easy to create Station Schedule routines which automatically raise flags and identify the affected missions, and the time and place of the problem when such station operations data is entered.

There are various formats for displaying station schedules which can be envisioned as necessary when the scheduler has various problems. He may wish to see a display of summarized daily activities over a longer period such as a month, or a simplified combined schedule map display showing arrivals and departures over a few days (see figure 4.7 for such a display, which shows three station schedules simultaneously). He may then wish to focus in on station operations in a busy period of hours within those few days. If he specifies a "box" containing such a busy period (see figure 4.7), it can be magnified on the screen to show more precise and detailed information. See figure 4.8 for an example of how the box in figure 4.7 might look. In this figure, there are simple "flags" raised on the timelines for both stations with the letter M signifying a parking MOG and the letter K signifying a K-loader MOG. Figure 4.8 assumes that the airlift scheduler is looking to put a mission leg in an EDAF departure window (0730-0930Z) between EDAF and EABC. Given station constraints at both stations, the shaded areas show him possible times, and he has selected a 0915Z departure time after looking in much greater detail at EDAF station activities scheduled for 0700-0915Z by repeating the "box magnification" process again. Figure 4.9 shows the details of the box drawn in figure 4-8, and shows the scheduled activity levels at EDAF for servicing crews, K-loaders, parking, etc. as a function of the station schedule and the normal pattern of arrival, departure, and launching operations. By examining this detail, the scheduler can decide that a 0915Z departure for Mission 891 is possible, although the K-loaders are fully utilized at points in the prior 1 1/2 hours. As he chooses various proposed departure times, the loads on station resouces can quickly be displayed.

These figures assume a committed schedule with exact times. If there are time windows for uncommitted missions, other display formats and methods would be used to identify possible station loadings and limitations. The scheduler may use these displays to choose schedule times within windows to smooth and avoid overloading station capabilities.

FIGURE 4.7 Wide Time Band Station Displays

DATE 11/3/83

Station/ Time Band Shown

EDAF (0400Z - 1600Z)
EDAB (0530Z - 1730Z)
EDAC (0645Z - 1845Z)

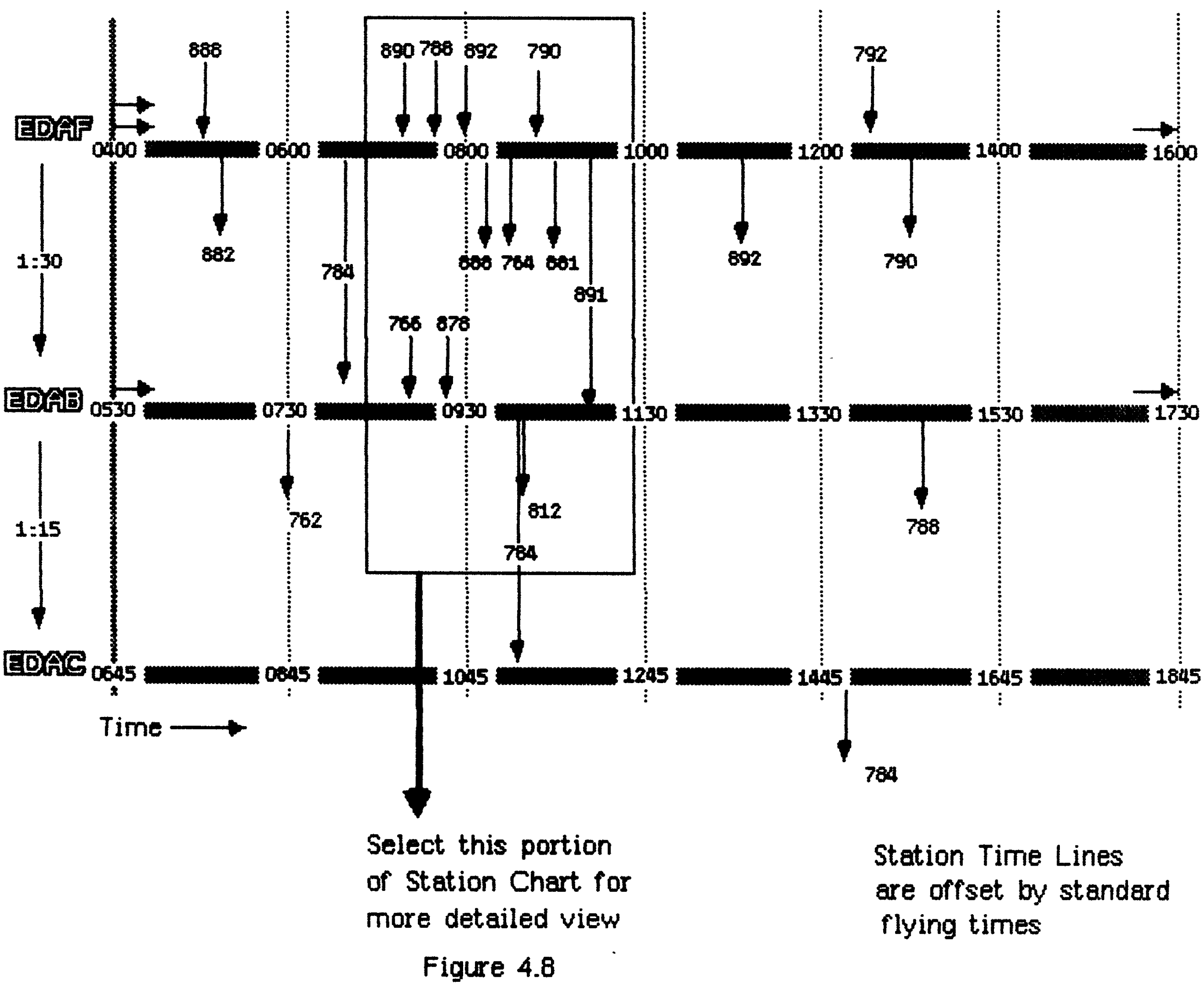


FIGURE 4.8

Narrower Time Band Station Schedules

(Magnification of box selected in Figure 4.7)

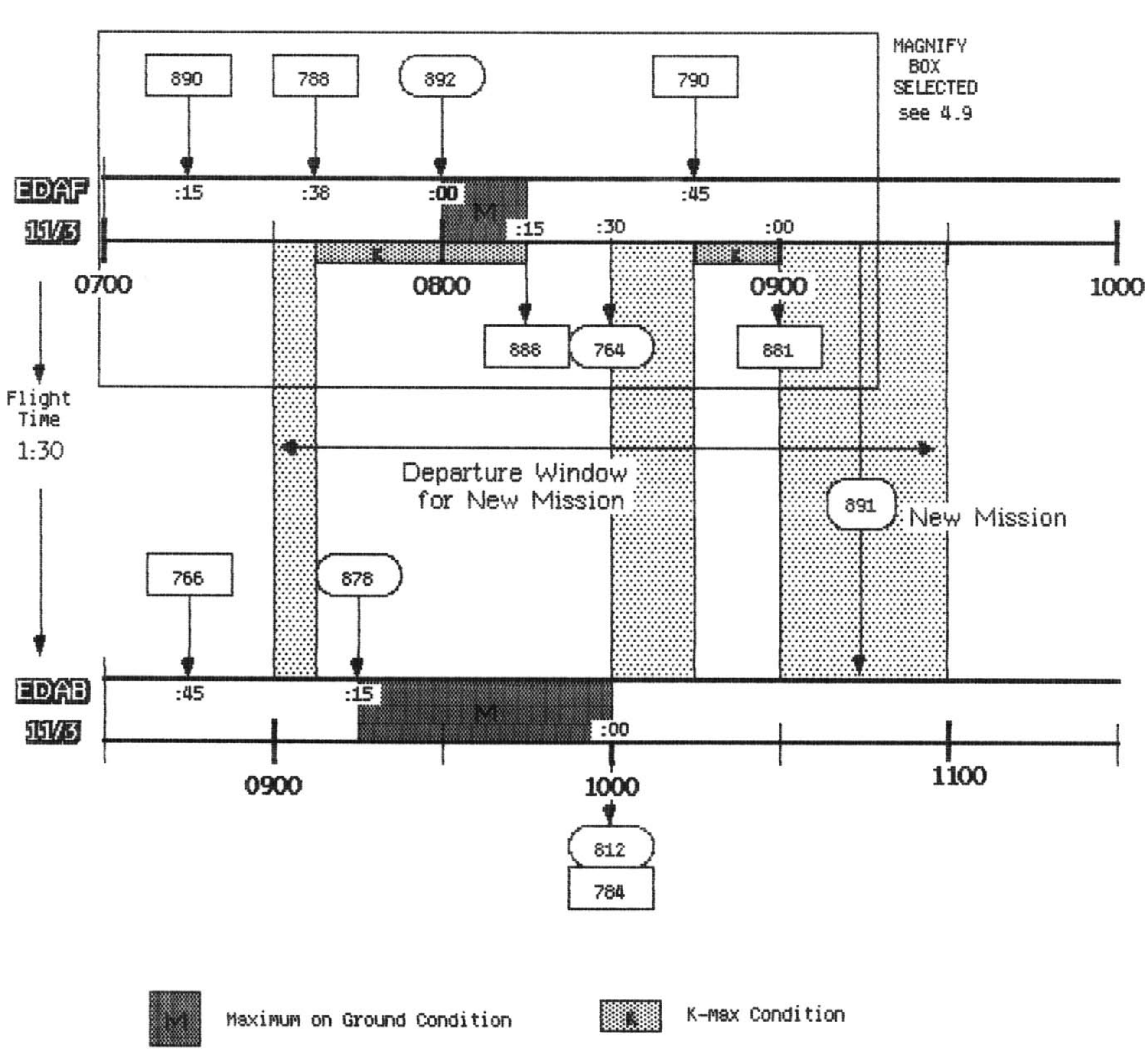
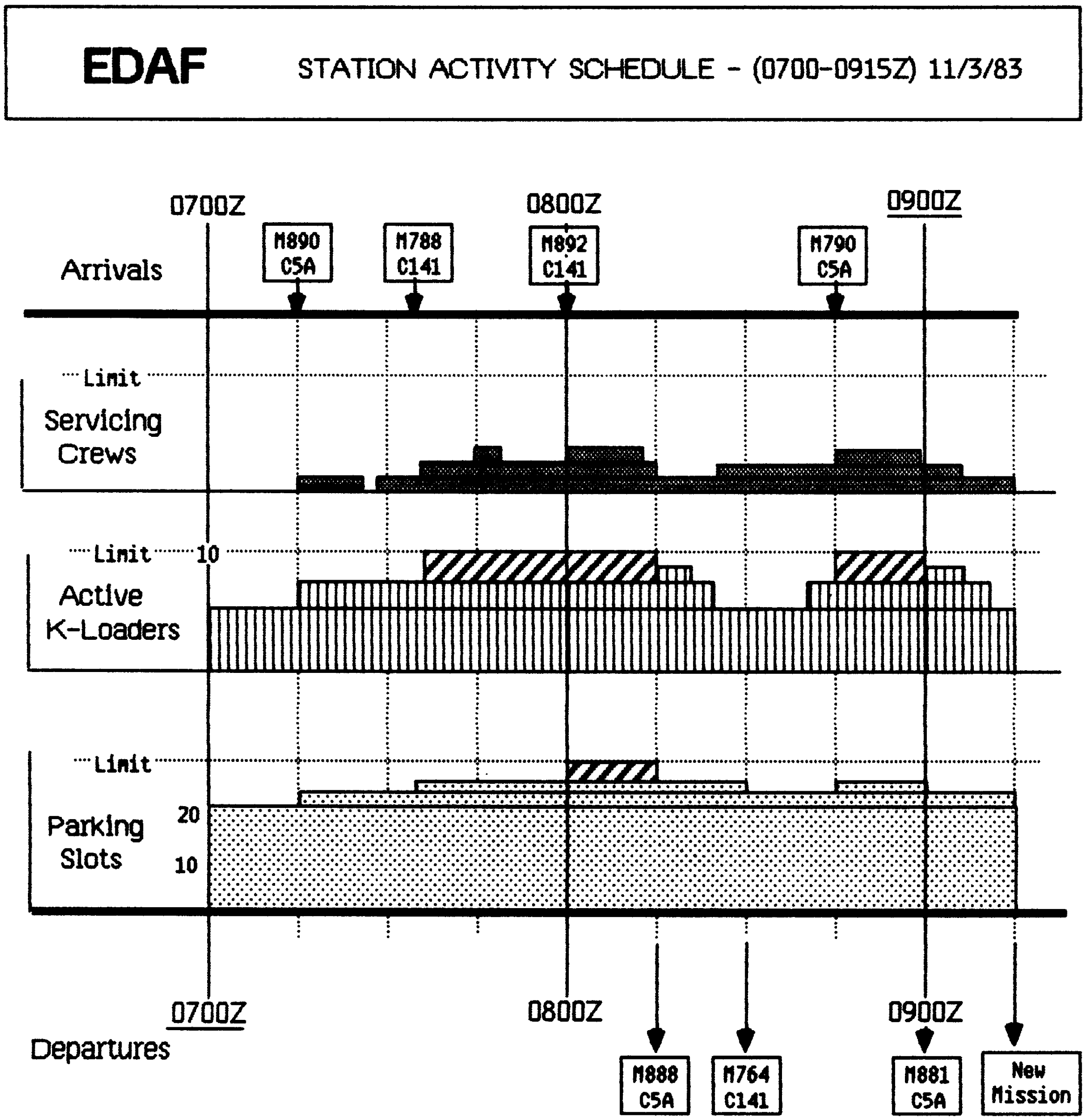


FIGURE 4.9 DISPLAYING DETAILED SCHEDULE OF STATION OPERATIONS



These detailed schedules of station activities are of interest to MAC station operators in previewing their workload and scheduling workshifts. They may negotiate changes in the schedule if there are problems they cannot solve at the local level. On the other hand, the local MAC or USAF station resources may be totally inadequate for the planned schedule of activities, or in some instances, there may be no MAC resources whatsoever at the planned POD (point of debarkation). In these cases, the airlift scheduler must create "self-support" missions to airlift the required personnel and equipment to the POD in advance of the required missions. In a "dynamic overload" scenario, it may be difficult to locate surplus station resources in time and place within the busy schedule, and station schedules elsewhere are likely to be revised as their personnel and cargo handling equipment are "commandeered" to support higher priority mission at the POD or enroute stations. Double or triple shifts of station resources may occur as stations nearer to the POD are able to send their resources in a lull period ahead of receiving surplus resources from other stations further away from the POD. Missions may be regenerated and rescheduled to create these "lull" periods at nearby stations. Aircraft must be found to fly these "self-support missions" probably causing cancellation or rescheduling of their planned missions, and creating new "positioning missions".

This self-support problem is a complex scheduling problem which may be amenable to algorithmic decision support, but requires further exploration at this point.

Note that there are now three types of entries in the wartime Mission Schedules Database; task missions, positioning missions, and self-support missions. There will be other types of missions in peacetime, and there is a need to identify each entry as to its type of mission.

At this point, the airlift scheduler has completely explored the operational feasibility of certain planned schedules, or schedule changes. He then can move these "scratchpad" schedules into a "planned" status, or directly into a "committed" status in the Mission Scheduling Database.

4.3.2.5 Management of Status of Schedule Information

Since requests arrive continuously over time, and there are needs for "cutoff" times for schedule generation, and "committment" times for users and operators, the scheduling process must be managed efficiently over time. Current procedures in the MAC C^2 system have been based on current capabilities of the current C^2 system to handle schedule data using paper media, with voice and autodin message communications. In the MAC C^2 upgrade, the switch to electronic media and better communications will change the procedures by which the scheduling process can be managed over time before execution.

There are three status levels of schedule data which necessarily must exist. The first can be called "scratchpad" schedule information where the scheduler is working to create one or more schedules which are operationally feasible, and he does not want anyone else to see this data. The second level is "planned" schedules where an operationally feasible schedule is issued for preview and comment by planners and operators. The scheduler intends to commit to this planned schedule although he may still have time windows on its execution times, and he may change it due to late arriving requests and unexpected operational deviations. He may obtain a latest commit "time" from users and operators for such planned schedule data. The third level is "committed" schedulers where execution times have been selected and forwarded to users and operators. There may be a rolling "cutoff" time for requests ahead of execution so that users are pressured into submitting requests in a timely fashion for the scheduler at some period ahead of "cutoff" times. Any request after "cutoff" time is treated as a "late" request, and procedures on its consideration, required priority levels, etc. may change. In this report, the same scheduler in the scheduling cell is assumed to handle late requests, and there is no organizational distinction between future and current operations. The processes are necessarily closely related and should be viewed as a single continuous process whether or not different personnel are responsible for handling early and late requests.

The Mission Scheduling Database will contain these three status levels for schedule data. Operators and Task Planners may be able to preview planned schedules or may be sent this data at periodic intervals to assist them in their planning and to get their concurrence or comments. Users and operators can be asked to submit a "latest possible committment" time for various tasks or operations if it is different from a nominal value. The scheduling workstation can be programmed to display uncommitted schedules at some time prior to "latest commit time" so that the scheduler is prompted to commit schedules on time.

If "rescheduling" occurs after cutoff and commitment, it is possible to display all the pertinent changes in the schedule and have automatic alert messages to affected planners and operators. Task Planners are then responsible for coordinating changes with affected users, and confirming concurrence to the scheduler.

The actual times for cutoff and commitment can be reduced from their current values as experience is gained with the improved scheduling tools and communications capabilities of the upgraded C^2 system. Strategic cutoff times should be reduced towards one day from the current three days, and tactical cutoff times towards 8 hours from the current 24 hours. It may be that cutoff times should be variable over time and place, and should be declared by task planners and schedulers. They also can be variable with task priority, e.g. commit to α tasks three days in advance, β tasks two days in advance, etc...

Note that it is desirable to delay commitment until there is something like a 90% chance that committed schedules will be executed as planned. Otherwise, operators begin to discount issued schedules (we had this experience in talking to Wing Operations Center personnel about the current monthly issuance of strategic schedules). It means little to issue a schedule when operators and users have learned from experience that there is less than a 50% chance that the schedule will come true. In a dynamic scenario, this argues for late cutoff and commitment if it can be achieved. It requires the ability to generate operationally feasible schedules quickly and correctly.

Note that this delineation of committed and planned schedules will be made explicit to operators. As time before execution decreases, a higher percentage of committed schedules is envisioned. The planned schedules can be considered as "coming your way" information (in MAC parlance) to assist the operators. It may be desirable at longer periods before execution to simply summarize this planned data for operators. Without looking at details, they could be made aware on a daily basis of the general level of currently planned future activity measured in launches per day, transit operations per day, tons loaded/unloaded, flying hours per day, etc. Given the planned schedule information, they may perform this summarization locally to suit their perceived needs.

For the scratchpad schedule files, there may be a need for schedulers to leave electronic memos and notes for each other as the shifts change. This practice will become widespread amongst C^2 personnel in all Command Posts and Operations Center after the upgrade and may replace (or reduce) the 45 minute debriefing at current shift changes. But for the schedulers there will be a need to explain some of the alternate backup schedule solutions sitting in the files, and some of the reasons for schedule changes made during the last two shifts. This will make it possible to change the present practice of placing a single scheduler in the "barrel" on alternate months. A small set of schedulers at each cell should be familiar with all factors contributing to the currently planned schedule, or capable of finding them in the scratchpad memo files. In particular, information gathered from telephone conversations with planners and operators should be committed to these files rather than remain in a single person's mind. This requires some discipline amongst schedulers. Its reward is the ability to retrieve such facts quickly, easily, and cross-referenced in various ways. Task planners should have similar scratchpad files obtained from the users with reference to each task.

At the Scheduling Cell, the current organizational division of responsibilities amongst DOO, DOX, TR, LG and DOC personnel can be maintained. Depending on the size of the cell, there may be a need for multiple workstations as these personnel work simultaneously on the local database. There will be a need for coordination between their activities and decision making as there is today. It is possible that the responsibilities will be divided differently at Scheduling Cells of varying size, and that one ASW with a single operator would interface with DOO, DOX, and DOC personnel. It is expected that scheduling and rescheduling problems will be solved much more quickly with the ASW than they are at present (assuming local databases are up to date with field activities).

4.3.2.6 Monitoring Schedule and Resource Capability Status

There are several activities which must be performed by the airlift scheduler in keeping the Mission Scheduling Database updated. They require a straight forward DBMS (Database Management System) with good message handling capabilities which alert the scheduler to incoming changes in detailled mission data from operators, new or modified tasks from task planners, and significant schedule deviations and changes in resource capabilities from operators.

Given the alerts, the scheduler can manually review its impact on future schedules, or certain aspects of such a schedule impact review can be automated. For example, suppose a mission has departed 2 hours late, and has an ETA which is 2-1/2 hours late on the first leg of a five leg aircraft mission sequence. Given this update, an automated review process could update the downline estimated times of arrival/departure given standard transit times at each station. Any slack would be removed until schedule times are regained, and MOG restrictions could be flagged under the new estimated times. Alert messages can be automatically generated for downline stations showing the new estimated times, and the scheduler's new expectations for transit times, with a request for confirmation of the stations capabilities to execute as expected. On the other hand, a manual review by the airlift scheduler may show that at the end of the mission sequence there is substantial slack time, and thus he can allow it to run a few hours late through the complete sequence without any impact on future schedules.

Similarly, changes in station resource capabilities would be automatically reviewed to display flags which declare MOG's and allow the airlift scheduler to call up a display of MOG problems; or alternatively, there may be improvements which remove current MOG restrictions which have already caused rescheduling. These reschedules should have a "tag" which identifies the cause of rescheduling as this particular MOG, and which allows the airlift scheduler to trace them for consideration of returning to the original schedule.

In considering certain rescheduling options for new missions, the airlift schedules will need detailed data on the mission capabilities of the particular airframe and aircrew. This can be submitted in summary form to his Mission Scheduling Database, but the airlift scheduler may suddenly need details. For example, he may simply have aircrew names, but in considering the reschedule of this aircraft and crew he may want to see the current qualifications of this crew for aerial refuelling, and their innoculation status, etc. This can be obtained by normal voice or autodin communications from their home squadron (which should be identified in the Mission Scheduling Database), or alternatively an automated query can return this information on his screen in a few moments. This requires an automated link between the Airlift Scheduling Workstation and the LAN (Local Area Networks) foreseen at each aircrew base. Before he commits to rescheduling this aircrew, the airlift scheduler may wish to discuss it with the squadron commander, but it is desirable to be able to quickly scan detailed aircrew qualifications to see the various options for rescheduling. Similarly, he may need to scan the current capability status of the airframe. This would require a constant updating from the field back to the maintenance base datafiles (as would the currency of crew qualifications). The point here is that detailed airframe and aircrew information is <u>not</u> in the Mission Scheduling Database, but is kept in the home base datafiles and can be accessible from the Airlift Scheduling Workstation.

In a similar vein, there is a need to link to the Task Planning

Database. New or modified tasks will be messaged to the airlift scheduler for review and scheduling, and assigned missions and times, mission details, etc. will be returned from the Mission Scheduling Database to the Task Planning Database. Given detailed resource capability files at the Mission Scheduling Database, regular summary reports of forecast capabilities will also be transmitted to the Task Planning Database.

There is an automated message link to the Mission Scheduling Databases at other Scheduling Cells in order to coordinate transit operations of aircraft from one cell into stations of the other, and to facilitate the details of time and location for handover and handoff of aircraft from one cell to the operational control of the other cell. Data from the field on aircrew and airframe status could be sent to the Mission Scheduling Database for forwarding to the other scheduling cell, and onward to airframe and aircrew databases, and data from those databases could be accessible to the scheduling cell which has operational control via this same message routing. While station operations data must be coordinated between the two scheduling cells, this airframe and aircrew capability status could be messaged directly between field operators and the other scheduling cells if the communications links are operational.

4.3.2.7 Summary of Automated Decision Support for Airlift Scheduling

This report is only able to explore and briefly describe the types of automation support scheduling processes which are possible for the MAC C^2 upgrade. The figures of the prior sections provide the reader with an introduction to modern graphics displays and some inkling of the type of symbolic manipulation of computer graphics which can be provided to the airlift scheduler. This summary section extracts the algorithmic decision support systems which were identified in the previous sections since they will require further work to define their requirements and to develop working interactive software. Briefly, these computer algorithms can be listed as:

1) Mission Generation Algorithm
   - lumping tasks in time and space
2) Interactive Load Reassignment Algorithm
   - bumping tasks given a schedule
3) Interactive REDUCTA Algorithm
   - minimize aircraft required by sliding within windows
4) Interactive Fleet Routing FR-4 Algorithm
   - maximize carriage of high priority tasks, given fleet size
5) Interactive Quickest Delivery Algorithm
   - find routings for mechanics and spare parts given schedule
6) Crew Mission Sequence Generation
   - given aircraft mission sequences, create crew mission sequences and crew staging plans
7) Self-Support Mission Generation
   - given needs for station support, generate aircraft missions to move available resources

The four algorithms listed as "Interactive" already exist in some partial form at MIT, but need to be upgraded for interactive use by the airlift scheduler. The others require further effort to design and test their operation in typical scheduling scenarios.

4.3.3 Description of New Schedule Execution Processes

We include a brief description of the activities expected to be performed by airlift operators in support of the scheduling processes described in the previous section:

1) Monitor assigned missions and station operations
   - review committed and planned schedule changes
2) Report assigned resources to Mission Schedule Database
   - aircraft tail numbers
   - aircrew names
   - groundcrew to shifts
3) Report Local Capability Status to Mission Schedule Database
   - aircrew, station
   - prepare forecasts of future capability
4) Report Operational Deviations
   - estimated and actual times
   - aircraft status, ETIC
   - report diversions of aircraft

The monitoring and reporting processes require a simple DBMS (Database Management System) capable of communicating with the Mission Scheduling Database. The assignment of resources, however, is actually a local scheduling problem. At the maintenance control center, aircraft tail numbers are being scheduled for maintenance activities and operational assignments. At each squadron, aircrew are being scheduled for rest between mission assignments. Both scheduling processes can be assisted by the provision of interactive graphics for the local schedulers. There also may be automated decision support algorithms to assist the local schedulers, but these have not been explored in this report.

5. Organizational and Procedural Issues for Upgraded Scheduling

The provision of new hardware and software scheduling capabilities in the MAC C^2 Upgrade will cause existing procedures and policies to change. It is not possible to design an upgraded scheduling system which uses improved communications, data processing, interactive symbolic manipulation of scheduling data, and imbedded decision support systems, and not have an impact on the current policies and procedures for MAC operations. This section raises certain issues in this area because of the need for clarification and resolution of potential differences between the automated scheduling system described herein and the document describing Airlift Concept of Operations, MAC Command and Control System Master Plan, dated 12 January 1981; and also because the new scheduling system is foreseen to be a rolling, continuous process rather than one with the daily/monthly cycles of current peacetime tactical/strategic scheduling.

5.1 Organizational Structure for Schedule Generation

This report has created a three level functional structure for Command and Control of Airlift Operations. First, there are "Task Planners" who interface with users and schedulers, have their own Task Planning database management system, and who assign tasks and airlift resources to various "Scheduling Cells". Second, there are "Schedulers" who interface with Task Planners and Operators, who have their own Mission Schedule Database and an Airlift Scheduling Workstation, and who generate missions, aircraft and aircrew mission sequences, and station schedules. Task Planners have been isolated from Operators, and Schedulers have been isolated from Users. Mission and Schedule Generation have been integrated because of the efficiencies in creating productive and responsive schedules through easy, quick, iterative reconsideration of all prior decisions.

The "Scheduling Cell" has been defined here to have total operational control over specific airlift assets; aircraft by tail number, aircrew by name, station and groundcrew by location. It should be clear that the scheduling process must control all these resources. Task Planners have assigned these resources, and have the capability of creating a new Scheduling Cell by reassigning specific resources. Scheduling Cells must interface amongst themselves to some small degree in coordinating the use of each other's stations and in the temporary handoff/handover of reassigned aircraft and aircrew resources.

The discussion to this point remains generic, and is in no conflict with the Concept of Operations. The difficulties occur when the issue of locating and identifying Scheduling Cells arises. In this report, the Scheduling Cell has its own Airlift Scheduling Workstation and associated computer hardware and software. It is viewed as a mobile set of equipment deployable with an

ALCC. The model of Task Planners at the COMALF, and a Scheduling Cell at the ALCC of each ALD is compatible with the Concept of Operations document. However, that document currently states quite clearly that all strategic airlift will be scheduled by the Operations Directorate at HQ MAC, and places the Operations Centers at the MACAFS in the position of a simple intermediary for messages between the Scheduling Cell and the Airlift Operators. When the only automated scheduling system is FLOGEN, and this is maintained at MAC HQ, along with the Mission Schedules database (currently called AIMS), there is some logic to this organizational arrangement. This need not be the situation after the MAC C^2 system upgrade.

At present there is some confusion amongst MAC C^2 personnel as to how and where the scheduling of strategic airlift is accomplished. In peacetime, much of it is done by the MACAF. In CAT operations, HQ personnel claim that it is done using FLOGEN with only small changes by MACAF Operations Centers. The Operations Center personnel claim however, that due to the limitations of FLOGEN and various operational factors unknown to CAT personnel at HQ, these changes are major, and constitute a complete rescheduling. From our visits, it seems clear that the principle of a Scheduling Cell at one location having complete control of scheduling is being violated at present in both peacetime and CAT operations for all strategic airlift resources. In particular, station resources are not being integrated in the scheduling processes because experience generally shows they have no constraints on the scheduling of aircraft and aircrews. This will not be the case in real wartime and high volume contingency operations. The issue for MAC is to decide whether Scheduling Cells and Airlift Scheduling Workstations are to exist at the MACAF Operations Centers, and how they are to operate relative to HQ MAC in both peacetime and wartime operations. Is there to be multiple Mission Scheduling

Databases for strategic airlift, or just an upgrade of the single centralized AIMS database? If the Scheduling Cell is to be at HQ MAC, what exactly is the role forseen for the MACAF Operations Centers and how are Operators to report to the Scheduling Cell? Is the scheduling cell to exist at the MACAF Operations Center in peacetime, only to revert to HQ MAC in a crisis/ contingency?

The successful creation of mobile Airlift Scheduling Workstations with their own Mission Schedulers Database allows an organizational structure where Task Planners for strategic airlift exist at HQ MAC while two scheduling cells exist, one at each MACAF. There would be no AIMS database at HQ, but two Mission Schedules Databases at each MACAF, both of which are accessible to Task Planners at HQ by remote query if necessary. This organizational structure can be maintained in both peacetime and crisis/contingency, and is then identical with the organizational structure for COMALF/ALCC for tactical airlift. It maintains the direct interfaces of the Scheduling Cell with Task Planners and with its own Operators. This would seem to be a preferable organizational structure for strategic airlift when successful Airlift Schedule Workstations have been demonstrated.

5.2 Management of Schedule Development

At the current time there is a 24 hour cycle of schedule development for tactical airlift, and a monthly cycle for strategic airlift. In both cases there is rescheduling after schedule data is issued. This process has evolved in a C^2 system which relies on paper media for disseminating schedule information. In the shift to electronic media, the need for an issuance of paper schedules disappears, and with it the need for discrete cycles in scheduling. It will be possible to have a rolling, continuous update of schedule information responsive to incoming requests and easily available to operators for preview at any time. The concept of committed schedule in the near term, and planned schedule in the far term has been introduced in this report and represents a new concept for MAC. It has the advantage of a natural transition between peacetime and contingency, and recognizes the current discounting of far term published schedules by operators in the field.

This report also formalizes the concept of standby requests which cannot be confirmed as requirements in the current schedule during a "overload" peak time. It would appear that a review of cutoff/commitment, standby requests, bumping procedures for late arriving priority requests, etc. is required to ensure that the Airlift Scheduling Workstation has sufficient automated decision support to meet the rescheduling activities expected of it, and to allow efficient scheduling to be achieved in the "dynamic overload" scenario.

5.3 Interface between Operations (DO) Logistics (LG) and Transportation (TR) in the MAC C^2 System Upgrade

This report has discussed the potential bumping of particular tasks to make room for higher priority partial load tasks within existing schedules. This allows the scheduler to avoid using excessive aircraft, or to ensure that existing aircraft are being scheduled and routed to handle the higher priority tasks and loads. It necessarily implies that it is possible for the scheduler to control the onboard loads of his scheduled missions (at other than aerial ports) and is kept informed of deviations in the planned onboard loads due to late arrivals for load, or missed transhipment. This requires that TR personnel in the scheduling cell are able to keep this loading data up to date, and can issue loading instructions to the field when "bumping" has been scheduled. It is not clear what procedures exist today in allowing DO personnel to specify desired loads in the schedule, nor what the interfaces will be with the developing C^2 systems for TR data. At this point, the MAC C^2 upgrade is predominantly focussed on DO activities. There is a need to coordinate its relationships to TR and LG activities and their plans for C^2 development to support their activities.