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IMPLICATIONS OF AUTOMATION FOR OPERATING AND STAFFING AND ADVANCED AIR TRAFFIC MANAGEMENT SYSTEM

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16. Abstract

The role of the air traffic controller in future system operations will be substantially affected by the introduction of new automated features. The number of human operators needed to man the system will almost certainly decrease as machines assume a greater share of the workload. Equally important, the delegation of more tasks to automated devices will also bring about a fundamental change in the nature of man's participation in air traffic control.

The Advanced Air Traffic Management System (AATMS) study conducted by DOT/TSC in 1971-73 advanced a system concept in which most surveillance, control and communication tasks are assigned to machine elements. This report, in support of the study, examines the implications of a high level of automation in terms of manpower requirements and operational procedures. Specifically, three topics are discussed: 1) a new concept of manpower utilization called a traffic-centered approach to air traffic management; 2) qualitative and quantitative requirements for operational and managerial personnel to staff the system; and 3) a typical flight to illustrate the workings of AATMS and the program of services available to future users of the system.

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PREFACE

In 1971-73 the U. S. Department of Transportation, through the Transportation Systems Center, undertook a program of study for an advanced air traffic system intended to accommodate the demand levels projected for 1990 and beyond. The program included investigation of advanced surveillance, navigation, and communication mechanisms and examination of automation as a means to constrain operating costs and to enhance the extent and quality of service provided to airspace users. The system concept which evolved from this study, known as AATMS (Advanced Air Traffic Management System) is characterized not only by a higher level of automation than in the present ATC system, but also by a greater degree of centralization and strategic control.

The automation applications portion of the AATMS program involved a detailed analysis of air traffic control functions and in-depth consideration of the comparative performance capabilities of men and machines for the entire spectrum of information processing, decision making, and control tasks. It was determined that, on theoretical grounds at least, a system which made extensive use of automated resources for the process of air traffic control was both operationally viable and economically beneficial.

The three studies presented here were undertaken by The Planar Corporation, under the direction of DOT/TSC, to explore some of the implications of an air traffic system design in which the major share of information processing and decision making is allocated to automated resources. Originally prepared as separate technical memoranda, they have been combined in a single report to provide a more unified picture of AATMS operational features and the role of man as operator and manager of such a highly automated system. Three major topics are discussed:

Section 1 - A traffic-centered approach to air traffic management examines the nature of man's managerial responsibilities in AATMS.

Section 2 - Proposed AATMS staffing and organization includes both qualitative and quantitative descriptions of how the system would be staffed.

Section 3 - Scenario of flight operations describes, from the viewpoint of the user and the operator, how a typical flight might be conducted in the future system.

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1. A TRAFFIC-CENTERED APPROACH TO AIR TRAFFIC MANAGEMENT

1.1 INTRODUCTION

The role of the air traffic controller in future system operations will be substantially affected by the introduction of new automated features. The number of human operators needed to man the system will almost certainly decrease as machines assume a greater share of the workload. Equally important, the delegation of more tasks to automated devices will also bring about a fundamental change in the nature of man's participation in the management of air traffic.

This paper examines some aspects of the qualitative change in man's role in the future air traffic system. It deals with a concept of manpower utilization called a traffic-centered approach to air traffic management. This way of looking at the role of the human operator is not new, although it does differ from recent custom. It has been explored before, and because of the major changes envisioned in the air traffic system as a result of automation, re-examination of the traffic-centered management concept seems appropriate now. Perhaps it is an idea whose time has come.

1.2 THE CONCEPT OF REMOTING

The changes in the air traffic control system that are now being developed and proposed encompass its most basic systems — surveillance, navigation, communications, and control. As a result, the future ATC system will be different in several ways. For example, aircraft will be equipped with an advanced form of transponder which will send aircraft data to the ground in response to discrete interrogation. Thus, surveillance will be in an "active" mode rather than in a "passive" (radar echo) mode. Navigation is to be accomplished in a way that will permit properly equipped aircraft much more freedom than the present scheme of air routes allows in selecting a path from departure to destination. Communications will feature the use of an automatic data link to carry routine control messages from the ground to the aircraft.

These changes will have a profound effect on the way human controllers on the ground interact with aircraft. To a very great extent, geography will no longer matter. Whereas in earlier systems a controller could only "see" aircraft that were in range of one or a few radar sites, the new surveillance concept and advanced technology of surveillance data systems permit thinking about a controller as being "remoted" from the immediate vicinity of the aircraft. In the same way, the controller no longer has to be thought of as tied to a communications transmitter that is tuned to a particular frequency, speaking only to those aircraft within transmitter range. Through ground relays and automatic switches, it becomes possible to "remote" communications as well as surveillance.

The remaining major ATC subsystem is control itself — the part of ATC that processes information and makes decisions about air traffic. In the control subsystem, a change is being planned that is perhaps the most fundamental and far-reaching of all in its implications. Plans are being formulated to increase the present level of automation in the control of air traffic to a point where almost all the routine, repetitive functions formerly done by human controllers will be automated. In other words, the basic tasks of air traffic control will be done by machines instead of by men.

This concept of automation in air traffic control is pivotal to the notion of traffic-centered air traffic management because it allows expanding the meaning of the term "remoting" to embrace decision making, which is the key aspect of man's participation in an ATC system. The kernel of the traffic-centered concept is that, just as human operators can be "remoted" from distributed ground sites by surveillance/communications links and relays, so also can the human operator be "remoted" from having to participate directly in every routine decision that is made about every aircraft in the system at any given time.

Another way to define "remoted" decision making in an automated air traffic control system might be to say that:

1) All decisions about aircraft are either routine or not;
2) Routine decisions will be automated;
3) Non-routine decisions will be made by human controllers;
4) While safety demands that every aircraft needing human attention get it, efficiency of manpower utilization likewise demands that controllers do not spend time scanning displays of aircraft that do not need human attention.

1.3 SYSTEM ENGINEERING AND OPERATIONAL IMPLICATIONS

At this point, certain apologies and disclaimers must be introduced. The foregoing discussion of automation and the concept of remoting has skirted many current and weighty technological issues or ignored them altogether. For instance, this paper is silent on whether surveillance should be accomplished by a ground-sited or a satellite system or perhaps by some hybrid of the two. It will remain silent for, while the competing approaches are and should rightly continue to be the subject of serious study and debate, the issue is largely irrelevant to traffic-centered management. The only aspect of the choice of surveillance methods that matters insofar as traffic-centered management is concerned is "remoting", i.e., that the ground system has the capability to relay surveillance information from widely separated collection points to centralized display points. The same holds true for communications, navigation, and much of the present thinking about control automation as well. Whatever the choices that are made, and however the choices are physically implemented and translated into actual hardware, all that really matters is "remoting" from ground-air geography and routine decision making.

The position taken in this paper is that, except as they may affect "remoting", the present technical issues related to surveillance, communications, navigation, and control are not crucial to traffic-centered management, i.e., the concept transcends technical options. In the same way, air-ground responsibility ("distributed management" vs. "centralized management" *) is largely transcended as an issue. While the <u>number</u> of tasks to be performed on the ground may be affected by changes in air-ground allocation of responsibilities, the <u>nature</u> of

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* Distributed management places more responsibility for system activities in the aircraft, while centralized management emphasizes the primacy of the ground-based system.

the residual ground-system tasks will be such that human controllers still must participate in the system, The logic of the traffic-centered management concept still applies; every necessary task will be done as required, with no unnecessary tasks being done by human operators.

Finally, it will be recalled that in the train of logic about automated and manual tasks the term "safety" was invoked. ("Safety demands that every aircraft needing human attention get it.") Using "safety" without qualification or addition in that context is, admittedly, an oversimplification. But it makes for a handy contrast between the routine, repetitive, things-are-going-the-way-they-should tasks that will be done by machines and the non-routine situations that, by their nature, require human intervention. Temporary indulgence is asked in this matter, and in the question of who will make sure the machines are running properly. These topics will be discussed later.

Invoking safety is thus revealed for what it was — an artifice designed to permit more rapid progress to the heart of the traffic-centered air traffic management concept. The rest of the phrase about safety was:

> "...efficiency of manpower utilization likewise demands that controllers <u>do not spend time</u> scanning displays of aircraft that do not need human attention."

When a man is between tasks, watching his display and waiting for the first indication that he may be needed, he is in some state of readiness. But he is not actually doing anything productive. He is a "monitor". The distinction between monitoring and doing something productive is that the human controller really is between tasks when he is monitoring. He is not engaged in any system-related activity. By contrast, the time spent by a controller studying a display and mentally checking trends of aircraft movement, weather,and so on is therefore not "monitor" time, but legitimate activity. Even though the controller may just be looking, and not talking on the radio, pushing buttons, or performing some other overt act, he is doing system-related work. Traffic-centered management as a concept is not intended to obtrude on this legitimate controller activity area. Instead, it deals only with the true "monitor" state, i.e., the situation which <u>does not</u> need attention by the human operator.

It might be argued with some merit that "monitor" is a good activity because it has rest and relaxation value -- a sort of break period in a very demanding job. Perhaps so, but if it can be assumed that needed "breaks" will still be available to any human controller in a traffic-centered system, then for purposes of this discussion "monitor" may be defined as unproductive controller time. As will be seen, the principal advantage of the traffic-centered concept stems from an increased ability to control and minimize unproductive "monitor" time, and thus help reduce the total human controller workforce. Traffic-centered management therefore has the same objective and ultimate payoff as does control automation itself -- cutting the payroll for the air traffic control system.

1.4 CONCEPT DEFINITION

The traffic-centered air traffic management concept will be defined by comparison with an alternative operating concept, which can be termed "airspace-centered manpower utilization". The airspace-centered concept is the way the ATC system has been looked at in the past, and it is basically the current operating concept. It must be pointed out that airspace-centered staffing has come about for good reasons. The comparison is made simply for illustration and implies no value judgment.

Figure 1 is a schematic map representing some volume of airspace. The dots in the figure represent aircraft. All aircraft using the ATC system at a given time are referred to collectively as "demand".

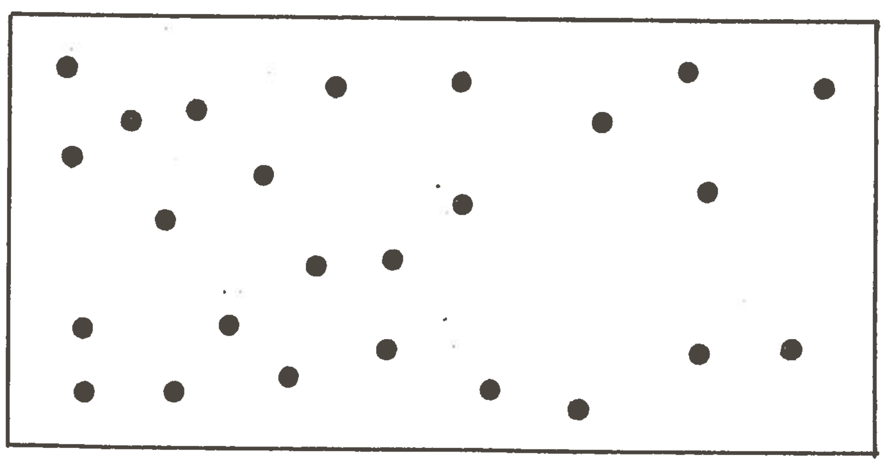

Figure 1. Schematic Illustration of Demand

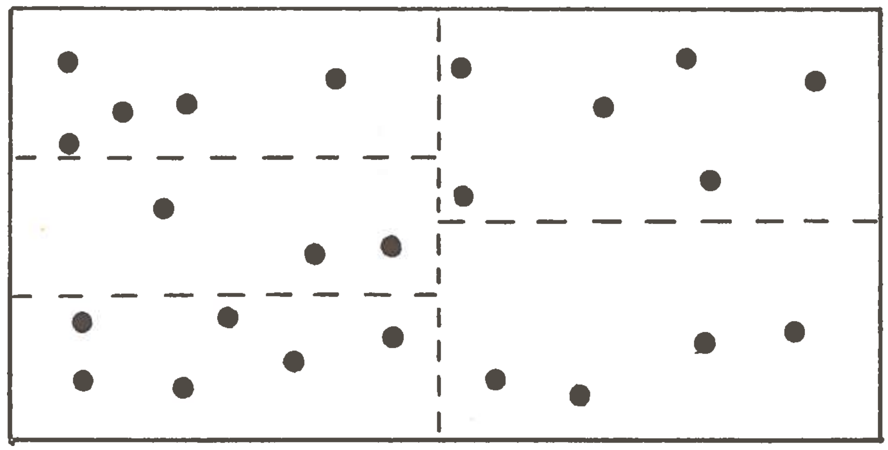

Figure 2. Airspace Sectorization

Figure 2 shows schematically a method for deploying controllers to handle demand. The method is sectorization. The whole volume of airspace is divided into subvolumes, or sectors, illustrated in the airspace map by dotted lines that indicate sector boundaries. Note that sectors may be of unequal size so that, where demand tends to concentrate, sectors are smaller. Similarly, where fewer aircraft go, sectors can be made larger.

Thus, the whole volume of airspace (for example, the whole controlled airspace over the continental United States) could be represented as an array of sectors, not necessarily of equal volume, but having contiguous boundary surfaces such that the total of their volumes equals the total controlled airspace over CONUS.

Sectorization is a very convenient device for assigning manpower. Controller A is responsible for Sector 1, Controller B handles Sector 2, and so on. However, it can be seen that this airspace-centered approach has a disadvantage. Controller A handles any and all aircraft needing attention in Sector 1, but not in any other sector. B confines his attention to Sector 2. Some degree of inflexibility is thus built in. If six aircraft in Sector 1 all need attention, but none in Sector 2 requires any controller action, then A may be very busy indeed while B has nothing to do.

To ameliorate the effects of this built-in inflexibility, two approaches are available, and both are indeed used singly and together in today's system. They are (1) make sector boundaries flexible so they can expand and shrink to meet changing patterns of demand, and (2) man sectors by two-man teams, solo controllers, and fractional controllers (i.e., one man handles two sectors in slack hours) to compensate for differences in demand. But both of these approaches are limited because, in the end, men are tied to specific volumes of airspace.

It has already been pointed out that the airspace-centered concept came about for good reasons. For example, in the illustration of unequal workload given above, Controller B (the one with nothing to do) might not be able to help A because, if the two are very far apart, B's display might not be capable of showing A's airspace. Another less obvious, but equally important reason, that might prevent B from helping A is that B does not "know" A's airspace or the present air situation in it. Finally, B may be unable to help A because, even though no aircraft in his sector needs attention at the moment, his own busy time may come soon. For instance, all the aircraft needing attention may be in motion from A's sector to B's.

A way around these obstacles, and indeed around the inherent inflexibility of airspace-centered manpower, is offered by the concept of "remoting".

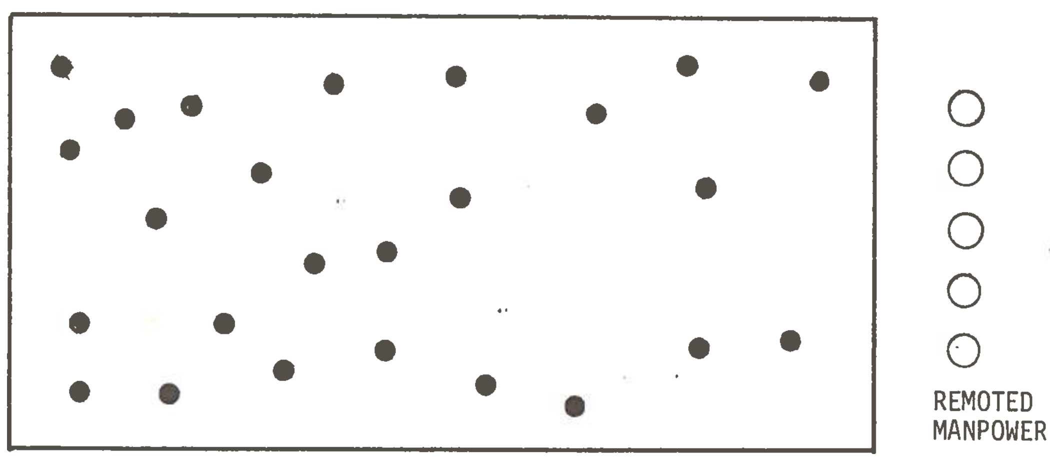

Figure 3. Demand and "Remoted" Manpower

Figure 3 represents a given airspace volume and a "remoted" pool of manpower associated with the entire volume. Note that an individual controller does not have to be tied to any particular subdivision of the total airspace volume, but that all are collectively responsible for the whole.

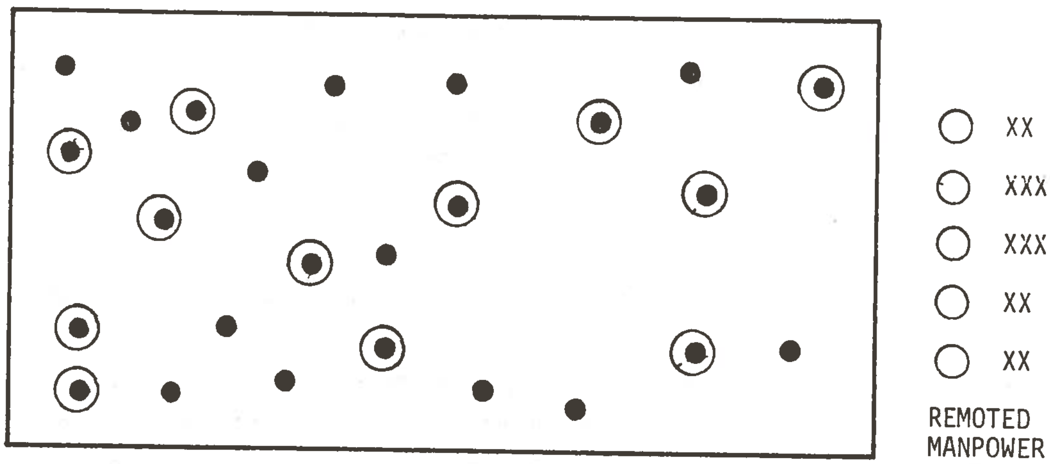

Figure 4. Workload Distribution for "Remoted" Manpower

In Figure 4, the encircled dots represent aircraft needing attention. The illustration suggests that, in the momentary situation depicted, twelve aircraft require intervention by a controller. The X's next to each manpower symbol represent assignments. Each human resource has been given responsibility for a share of the total workload. Note that the outcome of this method of manpower utilization is:

1) each aircraft requiring human attention and action will receive it, and
2) no aircraft not requiring attention are assigned to controllers.

Since the basis for manpower utilization is aircraft rather than airspace, and since aircraft collectively constitute air traffic, the scheme is termed a traffic-centered approach to the management of air traffic.

1.5 PRACTICAL APPLICATION OF TRAFFIC-CENTERED MANAGEMENT

At this point, some practical questions need to be answered. How do the individual controllers know which aircraft to handle? How can one be sure no aircraft needing attention is missed? Also, how can it be assured that the machines handling the rest of the traffic are running properly?

The answers to these questions lie in the concept of man as manager of the system, as distinct from man as an operational element of the system. Figure 5 below is a schematic representation of the initial state of affairs. A given portion of air traffic demand generates a total workload, which can be expressed as a requirement to perform some collection of ATC tasks. Some of these tasks are to be performed by automated resources; others are for human operators.

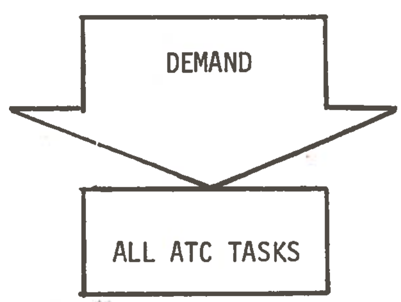

Figure 5. Demand-Task Relationship

The first step in manpower utilization is to sort, from the entire load of tasks, those that will be assigned to human operators.

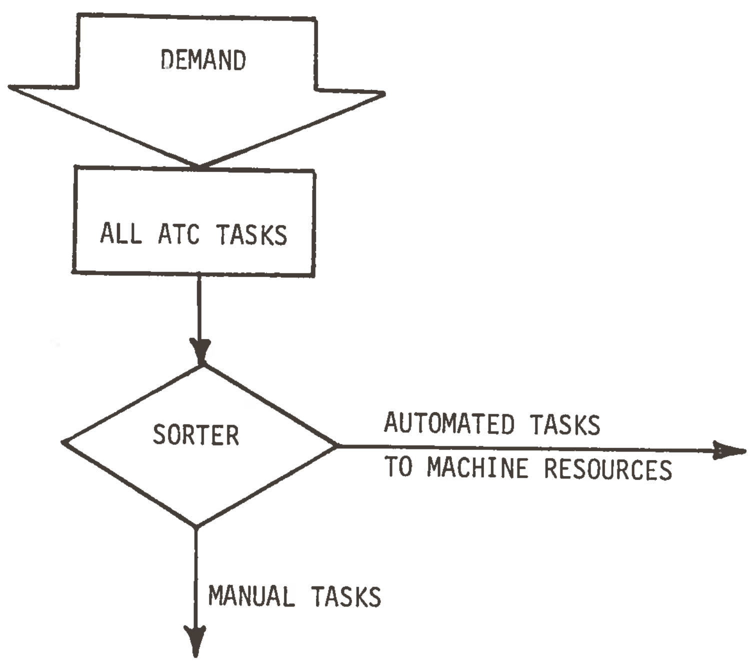

Figure 6. ATC Task Sorting

Figure 6 represents the sorting process. Automated tasks are sent to machine resources of the system for performance; manual tasks are segregated and directed to human resources. Thus, the human portion of the system resources receives its total task workload.

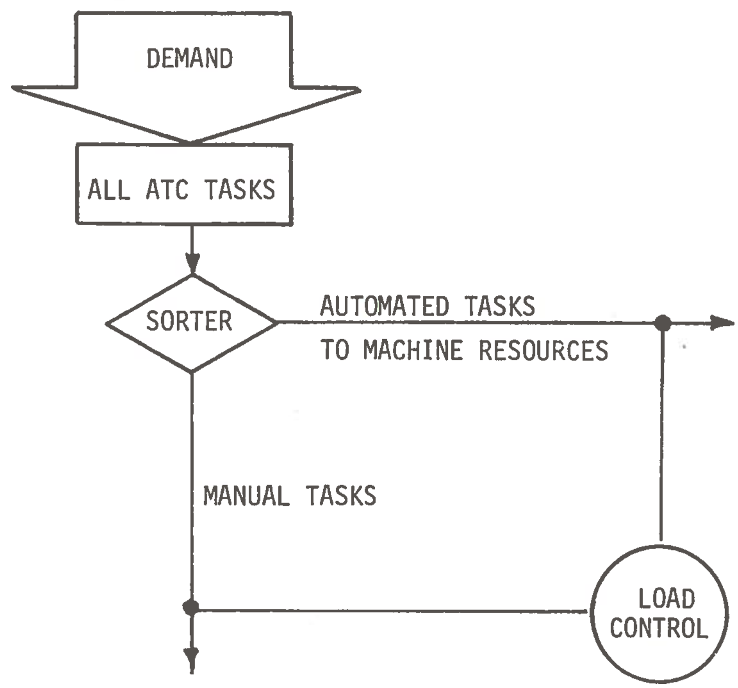

Figure 7. Air Traffic Workload Management

Figure 7 depicts an air traffic management function performed by a resource called "Load Control". Note that this is a managerial, not an operational element of the system. The responsibility of Load Control is not to perform any of the operational tasks generated by demand but to manage the automated and human resources of the system which, in turn, will perform the required tasks. Load Control's job is to match, on a dynamic basis, the capacity of system resources to the total workload imposed by demand. Load Control also ensures that no tasks are improperly sorted or missed; i.e., that no aircraft needing attention (of either machines or human operators) is neglected.

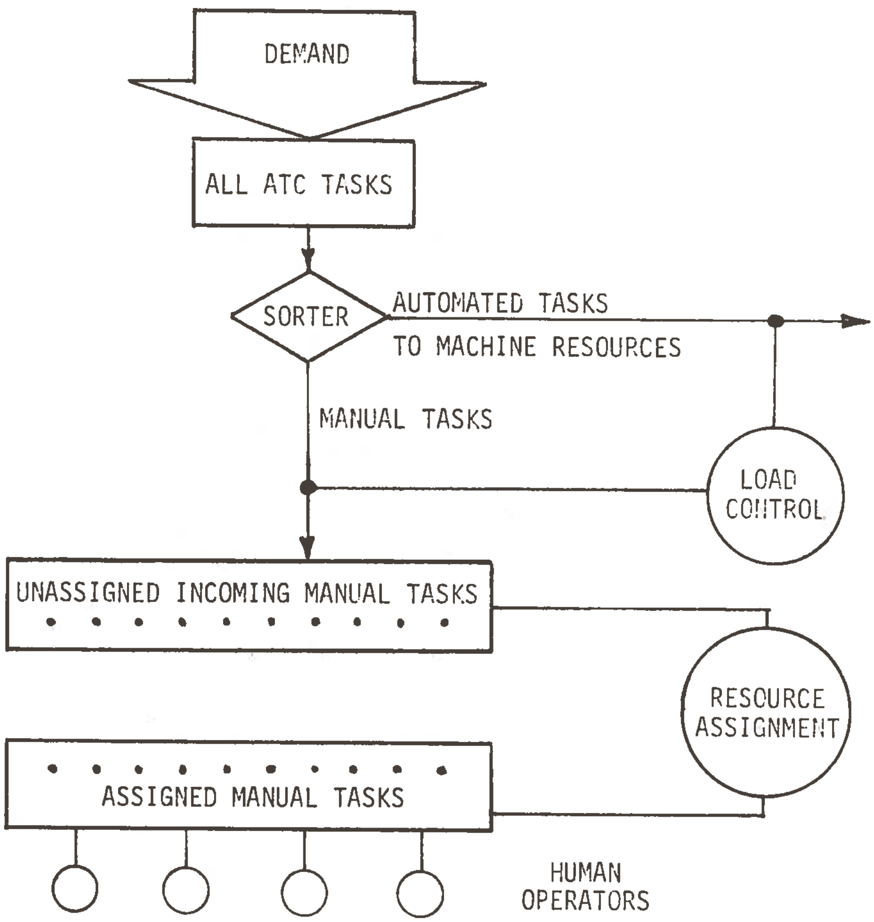

Figure 8. Air Traffic Resource Assignment Management

Figure 8 represents another air traffic management function, termed "resource assignment". Fundamentally, the job of Resource Assignment is to see to it that all incoming manual tasks are in fact assigned to a specific human operator (or team of operators) and that the workload is appropriately and equitably distributed among all the operators on duty. Note that ordinarily Load Control will anticipate peaks in traffic, high workload due to bad weather, and other events that entail the need for more operators, and take steps to augment the duty staff as needed. Resource Assignment, while he can certainly ask for additional manpower as required, is thus free to concentrate on the problems of operator assignment and workload distribution.

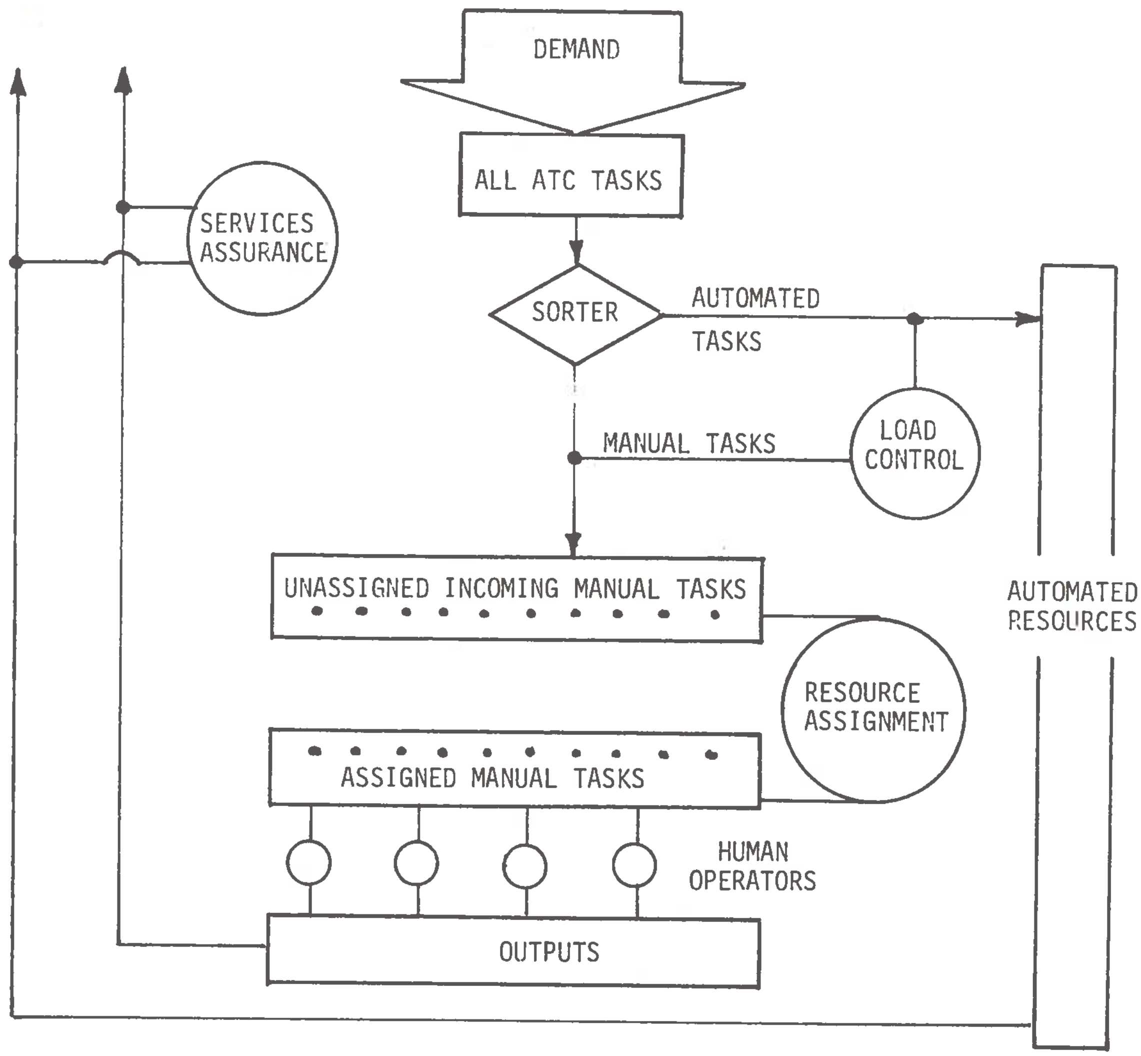

Figure 9. Air Traffic Services Assurance Management

Figure 9 illustrates a third air traffic management function — Services Assurance. A fundamental concept of the air traffic system is that it exists to provide services to airspace users and that services are delivered by carrying out operational tasks. Thus, Services Assurance is a management activity required to oversee the quality of system output. Load Control and Resource Assignment are mainly concerned with quantities of men, machines, and tasks. By contrast, Services Assurance (whose title is drawn from the services-tasks relationship) sees to it that the quality of performance is such as to guarantee each aircraft a safe, efficient flight.

Traffic-centered air traffic management is thus defined as a concept which permits a very great amount of inherent flexibility in assigning resources (human operators) to load, yet through the management functions of resource control, resource assignment, and services assurance also provides for necessary advance planning, positive control of human resource utilization, and overall quality assurance.

For the sake of clarity, the traffic-centered concept of manpower utilization has been treated as an isolated topic in this section. No attempt has been made to show how the concept would actually be put into effect or to place it in the realistic context of a system staffing plan. To do so, however, is vital to a complete understanding of the traffic-centered concept and its operational implications. This topic is taken up in the next section, which deals with the proposed AATMS staffing and organization.

2. PROPOSED AATMS STAFFING AND ORGANIZATION

2.1 INTRODUCTION

The advanced level of automation proposed for AATMS has far-reaching implications for man as an operator and manager of the system. In general, it can be said that automation of ATC processes will lead to a decrease in man's involvement with direct and continuous control of aircraft and to a corresponding increase of his participation in the higher-order concerns of system regulation and management. Man will still retain responsibility for a core of critical operational tasks (particularly those involving complex decision making, judgment, and non-routine interactions with aircraft), but he will not have the extensive role as a line element that he has in today's system.

As the bulk of routine operational tasks are transferred to automated resources, the role of man as manager of the system will gain in importance. The nature of these managerial activities is outlined in the previous section. The purpose of this section is to trace the implications of the man-as-manager concept in terms of system staffing and specific duties of personnel at each level of the manpower hierarchy.

2.2 THE MANAGERIAL ROLE

The essence of the man-as-manager concept lies in the distinction between this role for man and that of man as an operator in AATMS. As an operator, man is concerned with the operational tasks which have been reserved for manual performance. Man, like his machine partner, functions as a line element in the system to control aircraft and to provide services to airspace users. The focus of activity of man the operator is upon individual aircraft, with which he deals directly and for which he performs his share of the operational tasks necessary to accomplish system functions.

Man as manager, by contrast, is not concerned with individual aircraft *per se*. His activities are directed toward regulating the process of air traffic control and service delivery and toward utilizing the resources of the system to accomplish these ends. Some of the resources he manages are computers, but some are human, i.e., the line operators who man the system. Thus, managers and operators represent two distinct spheres of human activity in AATMS. Operators deal with aircraft as individual elements and carry out, in concert with machines, the work of air traffic control. Managers deal with aircraft in the aggregate sense of demand (or load) and with the disposition and direction of man and machine resources to handle demand.

Management of air traffic system processes embraces four broad classes of activity:

Load Control - This activity involves matching the capacity of system resources to the total workload imposed by demand. Load control does not perform any of the operational tasks generated by demand; these tasks are handled by human and machine operators. The function of Load Control is to assure that the resources available are adequate to service demand and that no aircraft requiring service is neglected for want of appropriate resources.

Resource Assignment - This activity is concerned with the appropriate and equitable distribution of task assignments to individual operators. As aircraft require service, Resource Assignment sees to it that an operator is designated to perform the necessary functions within appropriate time limits. There is a close working relationship between Load Control and Resource Assignment. The job of Load Control is to assure that the total resources are adequate to meet the total demand. Resource Assignment is responsible for managing those resources by distributing the workload among available operators and by making individual assignments of aircraft to operators.

Services Assurance - While the first two activities are essentially concerned with the quantitative relationships of demand and resources, Services Assurance is a quality-control activity. The purpose of this activity is to monitor the results of air traffic system processes and to assure that the standards of safety and efficiency are being met for each aircraft. Thus, Load Control and Pesource Assignment operate on the input side of the system to manage resources against demand. Services Assurance operates at the output side of the system to monitor and regulate the quality of services rendered.

Configuration Management - This activity is directed toward maintaining the operation of the system in the event that automated resources fail or malfunction. It is the responsibility of Configuration Management to detect and diagnose equipment faults and to take remedial action by calling on reserve resources or by reallocating functional assignments among machine components. Note that here, as in all other managerial activities, the function of Configuration Management is not to perform line operational tasks in back-up modes but to direct and manage the deployment of resources.

Managerial functions are exercised at three levels within AATMS. At the lowest level, managers oversee directly the human and automated resources carrying out operational tasks. This level is called supervisory and is roughly equivalent to the watch supervisor of today's system, although with somewhat expanded concerns. AATMS supervisors perform three basic types of activity -- load control, resource assignment, and services assurance.

The second level of managerial functions is executive in nature. That is, the concern is not with direct supervision of individual resources but with the coordination and management of all resources within a given facility, both in normal modes of operation and in degraded states. Managers at the executive level perform, on a facility-wide basis, the three basic activities of load control, resource assignment, and services assurance. They also perform the fourth type of managerial activity (configuration management) by arranging intra-facility and inter-facility back-up in failure modes of operation.

At the third, and upper, level of management are the system directors, whose scope of interest extends across regions or all of CONUS. The director level is concerned with the overall management of system resources and with the interrelationships of all facilities within the respective jurisdictions. Director-level personnel will be assigned in AATMS only at Regional Control Centers and the Continental Control Center, which by virtue of their centralized nature will be the seats of higher management authority.

2.3 STAFFING AND ORGANIZATION

The staffing plan presented in this section is based upon a configuration of facilities consisting of a Continental Control Center (CCC), two Regional Control Centers (RCC), twenty Terminal/Hub Centers (THC), and 492 Terminals (133 Primary and 359 Secondary). This configuration integrates control and flight service functions in a hierarchical structure as shown in Figure 10. The allocation of functional responsibilities to the various facilities for normal and back-up modes of operation is shown in Table 1.*

The managerial and operating complement of AATMS is made up of the following types of personnel:

MANAGERS
- Director
- Executive
- Supervisor

OPERATORS
- Data Base (IA)
- Flight Information Services (IB)
- Flight Plans (IIA)
- Flow Control (IIB)
- Flight Surveillance & Control (III)

SUPPORT
- Maintenance
- Automation Specialists

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* For a more complete description of AATMS facilities, See Future Air Traffic Managememt Operations (Planar TM 74-25C-1) and Automation Applications in an Advanced Air Traffic Management System, Vol. IV, (TRW Report No. 22265-W009-RU-00).

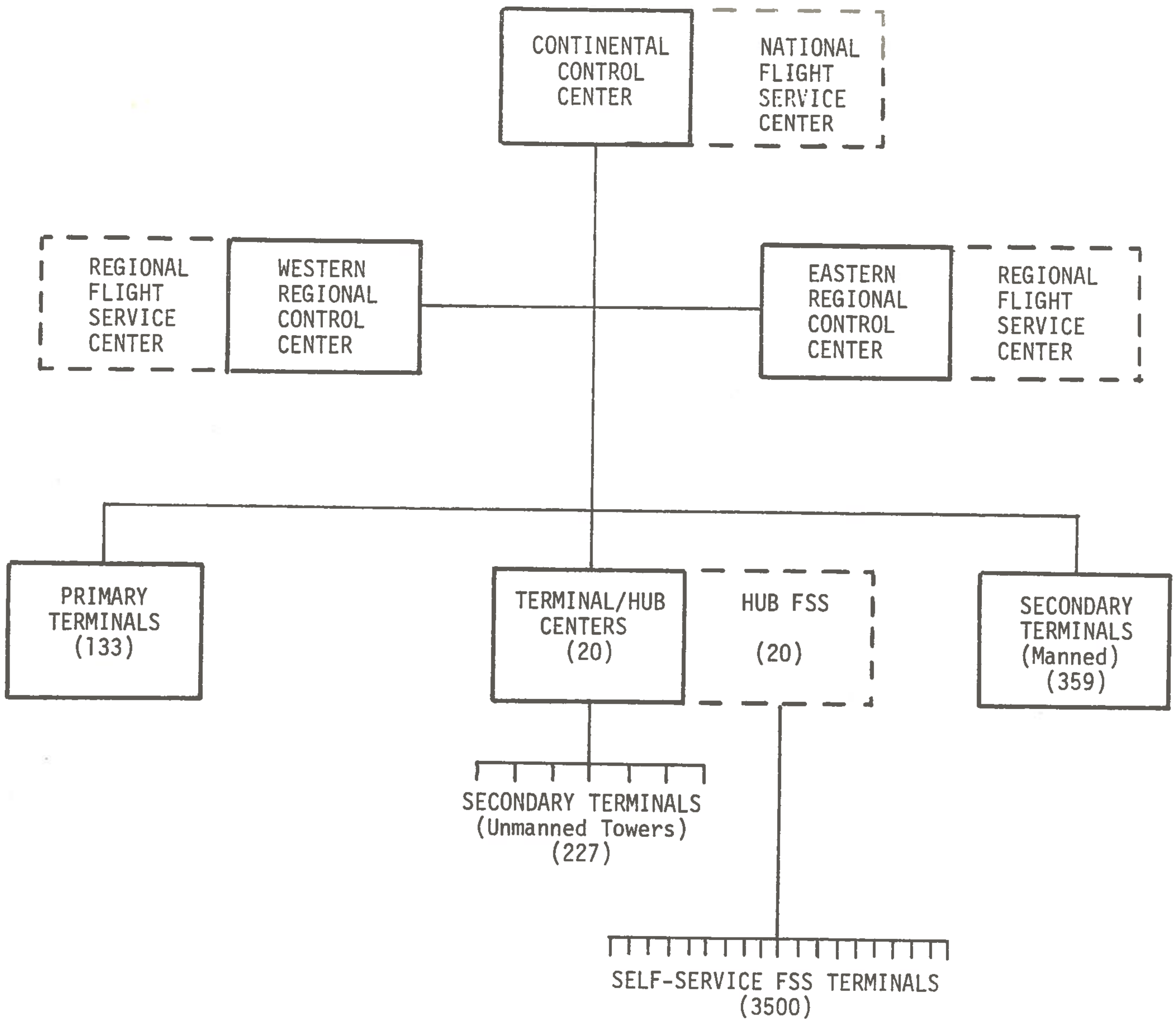

Figure 10 - AATMS Facilities Configuration

TABLE 1 - FACILITY RESPONSIBILITIES IN NORMAL AND BACKUP MODES OF OPERATION

Control Facility	Functional Responsibilities		Flight Service Facility	Functional Responsibilities	
	Normal Operations	Backup		Normal Operations	Backup
Continental Control Center (CCC)	° National Flow Control ° Management of system resources ° Coordination with colocated NFSC	° En route traffic services for RCC (extreme case)	National Flight Service Center (NFSC)	° Maintenance of system data base ° Provision of flight service data ° Coordination with RFSC	° Processing and distribution of flight plans for HFSC ° Flow control for CCC
Regional Control Center (RCC)	° En route traffic services for CONUS ° Coordination of traffic with adjacent oceanic region ° Coordination with colocated RFSC	° En route traffic services for other RCC ° Terminal air traffic services for ACC or THC	Regional Flight Service Center (RFSC)	° Flight service data support for oceanic traffic ° Flight service data support for RCC operations ° Coordination of HFSC activities	° NFSC operations ° Flight service data support for ACC or THC ° Processing and distribution of flight plans for HFSC
Terminal/ Hub Center (THC)	° Air traffic services for secondary airports with unmanned towers ° Coordination with RCC for en route transition ° Coordination with colocated HFSC	° Air traffic services for adjacent ACC (extreme cases)	Hub Flight Service Center (HFSC)	° Flight service data in support of ACC and THC operations ° Processing and distribution of flight plans ° Operation of remote FSS terminals	° Operation of remote FSS terminals for adjacent HFSC
Airport Control Center (ACC)	° Air traffic services for primary and secondary airports with manned towers ° Coordination with RCC for en route transition	° Air traffic services for adjacent ACC (extreme cases)	FSS Terminals (self-service)	° Weather data and flight planning assistance for users ° Flight plan acceptance and processing	

Since the focus of this paper is on the activities and duties of managerial personnel, detailed description of the other personnel categories will be omitted. The following general outline of responsibilities for operators and support personnel is provided, however, to assist the reader in understanding the division of duties among the three major classes of manpower in AATMS.

Operators, who correspond to the controller and flight service staff in today's system, are the personnel required to perform the various manual tasks in AATMS. The five types of operators, in cooperation with automated components, carry out the on-line operational tasks associated with maintaining the system data base, providing flight information services, controlling traffic flow, processing flight plans, and providing flight surveillance and control.

There are two types of support personnel: maintenance and automation specialists. The maintenance staff, as in the present system, is responsible for the upkeep and repair of data processing and display equipment and for restoration of equipment to service in the event of malfunction. Automation specialists are a new manpower category, created in AATMS because of the extensive application of automation. Automation specialists are responsible for overseeing the status of machine resources and for correcting machine performance where necessary. The role of the automation specialist is to ensure the completeness, consistency, and adequacy of automated operations. The skill requirements for this specialty are not those of air traffic operations but of computer science, programming, and automation technology.

2.3.1 Continental Control Center

The Continental Control Center (CCC) is a single, centralized facility which provides strategic flow control, maintains the system data base, and collates flight planning and weather data for all of CONUS. The CCC also serves as the central management authority for AATMS and carries out overall administrative supervision of air traffic operations in CONUS.

The staff organization and structure for the CCC is shown in Figure 11. Staff positions are identified by an alphanumeric code in the lower right corner of each box in the organization chart. The letter prefix indicates the facility to which assigned (C = CCC, R = RCC, T = THC). The first part of the digit code indicates the level of the position within the staff hierarchy (1-4 = Director, 5-7 = Executive, 8-9 = Supervisor, 10 = Operator/Support). The second part of the digit code denotes the particular position. Thus, Position C-3.2 is a staff position in the CCC at the third sublevel of the director level and is position number 2 within that sublevel. The staff code numbers have been assigned so as to be consistent across facilities. For example, a level 5 position at the CCC is approximately equal in responsibility and authority to a level 5 position at a THC or RCC.

The organization chart in Figure 11 also indicates by the number in parentheses at the lower left corner of each box the estimated number of personnel required to fill each position per duty shift.

The description of staff positions and duties in the CCC begins on page 29.

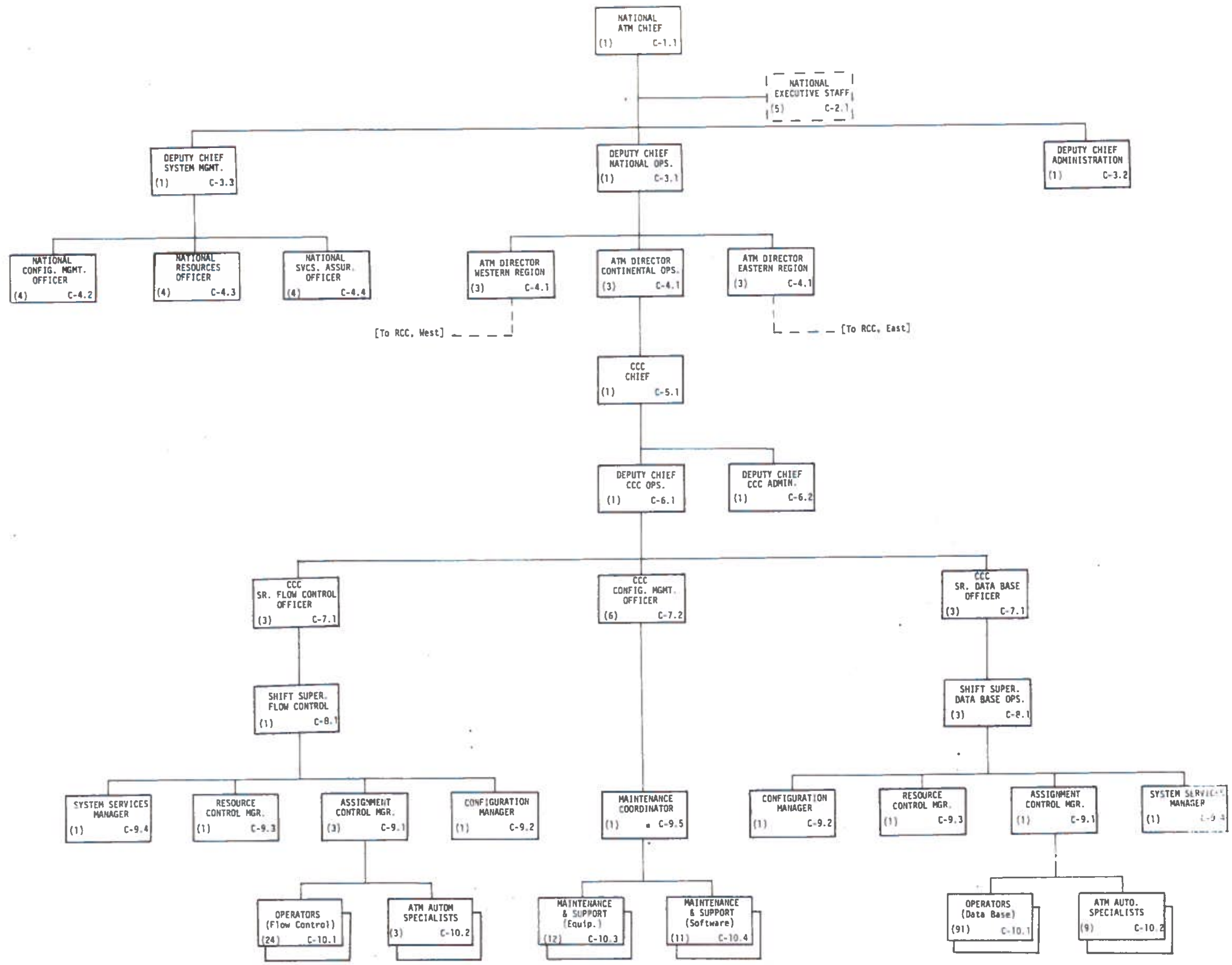

Figure 11 - CCC Staffing and Organization

2.3.1.1 Director-Level Management Personnel

C-1.1 National ATM Chief is responsible for management of the air traffic system throughout CONUS. He is the highest authority for operational, administrative, and support activities necessary to conduct air traffic control in AATMS.

C-2.1 National Executive Staff provides executive staff support to the National ATM Chief, e.g., public information, system user liaison, coordination with FAA, etc. (Since these are non-operational functions, no further expansion of staff positions and duties is provided here.)

C-3.1 Deputy Chief for National Operations acts as the principal representative of the National ATM Chief for air traffic system operations throughout CONUS. He is the highest authority in AATMS for operational matters.

C-3.2 Deputy Chief for Administration is the principal representative of the National ATM Chief for system administration. (While the administrative portion of AATMS will undoubtedly require an extensive hierarchy of supporting positions, the administrative structure is not developed here since the emphasis is on operational aspects of AATMS.)

C-3.3 Deputy Chief for System Management acts as the principal representative of the National ATM Chief for the management functions of resource control, services assurance, and configuration management on a system-wide basis. He is supported by a Level-4 staff as described below.

C-4.1 ATM Director Continental Operations,
ATM Director Eastern Region, and
ATM Director Western Region are co-equal staff positions which support the Deputy Chief for National Operations (C-3.1). Each is responsible for overall management of one of the three major

divisions of the air traffic system. All executive, supervisory, operational, and support personnel in AATMS report ultimately to one of these directors.

C-4.2 National Configuration Management Officer is responsible system-wide configuration management. He coordinates the activities of the Regional Configuration Management Officers (R-4.2) and the CCC Configuration Management Officer (C-7.2) in the event of failures in the system. The National Configuration Management Officer has three principal subordinates:

- Special Modes Officer, responsible for reallocation and reassignment of resources in failure modes,
- System Engineer, responsible for facilities, navigation, communication, and surveillance equipment,
- Control Automation Officer, responsible for procedures and data processing.

C-4.3 National Resources Officer coordinates the activities of Resource Control Officers at facilities throughout the system to assure the continuous availability of man and machine resources to match the level and nature of demand for air traffic services.

C-4.4 National Services Assurance Officer is responsible for system-wide monitoring of system services and for conformance of services to safety and efficiency standards. He is supported by subordinates responsible for monitoring automated resources, human resources, special airspace use and services, emergency operations, and airspace user liaison.

2.3.1.2 Executive-Level Management Personnel

C-5.1 Continental Control Center Chief is the operational and administrative head of the CCC. All activities within the CCC facility are under his jurisdiciton.

C-6.1 Deputy Chief for CCC Operations acts as the principal representative of the CCC Chief in the area of operations. All operational and support personnel in the CCC are under his direction.

C-6.2 Deputy Chief for CCC Administration is the principal representative of the CCC Chief for administrative matters in the CCC facility.

C-7.1 CCC Senior Flow Control Officer and CCC Senior Data Base Officer have direct operational responsibility for the two major areas of functional activity in the CCC — flow control and maintenance of the system data base.

C-7.2 CCC Configuration Management Officer is responsible for configuration management within the CCC. This includes not only internal reallocation of resources in response to failures within the CCC but also assignment of CCC reserves to support other facilities which have sustained failures. The CCC Configuration Management Officer also directs all preventive and corrective maintenance activity within the CCC. All maintenance personnel in the facility report to him.

2.3.1.3 Supervisory-Level Management Personnel

C-8.1 Flow Control Shift Supervisor and Data Base Operations Shift Supervisor provide direct supervision of the operator personnel on shift in their respective portions of the CCC. Each is assisted by a team of level-9 managers as described below.

C-9.1 Assignment Control Manager assigns tasks as required to individual operators. He maintains a balanced workload distribution, and establishes a periodic relief schedule for personnel on shift. He also coordinates with the shift supervisor and other members of the Level-9 management team to resolve specific operational situations and problems affecting CCC resource allocation.

C-9.2 Configuration Manager acts, under the direction of the CCC Configuration Management Officer (C-7.2), to meet unplanned and scheduled changes in system status and capability by carrying out reconfigurations of automated resources. He coordinates with other Level-9 management team members to ensure continued system operation and to provide smooth transition to and from contingency and failure modes.

C-9.3 Resource Control Manager plans and schedules the commitment of human and machine resources so as to ensure adequate CCC capability over each shift period. He is responsible for seeing that demand for services is met in a timely and appropriate manner. He also acts to anticipate requirements for resource shifts and reallocations in normal and degraded modes of operation.

C-9.4 System Services Manager monitors the quality of human and automated resource performance with respect to established standards. He coordinates as required with Assignment Control, Configuration, and Resource Control managers to maintain quality of service.

C-9.5 Maintenance Coordinator oversees the activities of maintenance personnel and technicians to ensure the continued operability of equipment and to diagnose and correct manfunctions when they occur. He acts under the direction of the CCC Configuration Management Officer (C-7.2) to schedule preventive maintenance and to assign personnel for corrective maintenance as the need arises.

2.3.1.4 Operational and Support Personnel

C-10.1 Operators perform the manual tasks associated with air traffic system operations. In the CCC there are two types of operators — Data Base Officer (Position IA) and Flow Control Officer (Position IIB).

C-10.2 ATM Automation Specialists oversee the status of task performance by machine resources and act as required to ensure completeness, consistency, and accuracy of automated operations.

C-10.3 Maintenance and Support (Equipment) personnel are responsible for preventive and corrective maintenance of all equipment in the CCC.

C-10.4 Maintenance and Support (Software) personnel conduct programming activities for all data processing equipment in the CCC.

2.3.2 Regional Control Center

En-route air traffic in CONUS is handled by two Regional Control Centers (RCC), each having responsibility for roughly half of the country. In addition, the RCC houses oceanic flight service activities and coordinates the flow of traffic to and from oceanic control regions. Apart from these operational activities, the RCC also serves as the administrative and managerial center for all THC and terminal facilities within its area of jurisdiction.

The staff organization and structure for the RCC is shown in Figure 12 on the following page. The identifying code for levels and positions is the same as in the previous CCC description. The positions and duties of RCC personnel are as follows.

2.3.2.1 Director-Level Management Personnel

R-1.1 Region Chief is responsible for management of the air traffic system in the region. All operational, administrative, and support activities in the region are under his cognizance. The Region Chief reports to the National ATM Chief (C-1.1) through the ATM Region Director (C-4.1) at the CCC.

R-2.1 Region Staff provides executive staff support to the Region Chief. It is the regional counterpart of the National Executive Staff (C-2.1).

R-3.1 Deputy Chief for Operations is the principal representative of the Region Chief for air traffic system operations in the region. All operational activities and facilities in the region come under his jurisdiction.

R-3.2 Deputy Chief for Administration acts as the principal representative of the Region Chief for administrative matters.

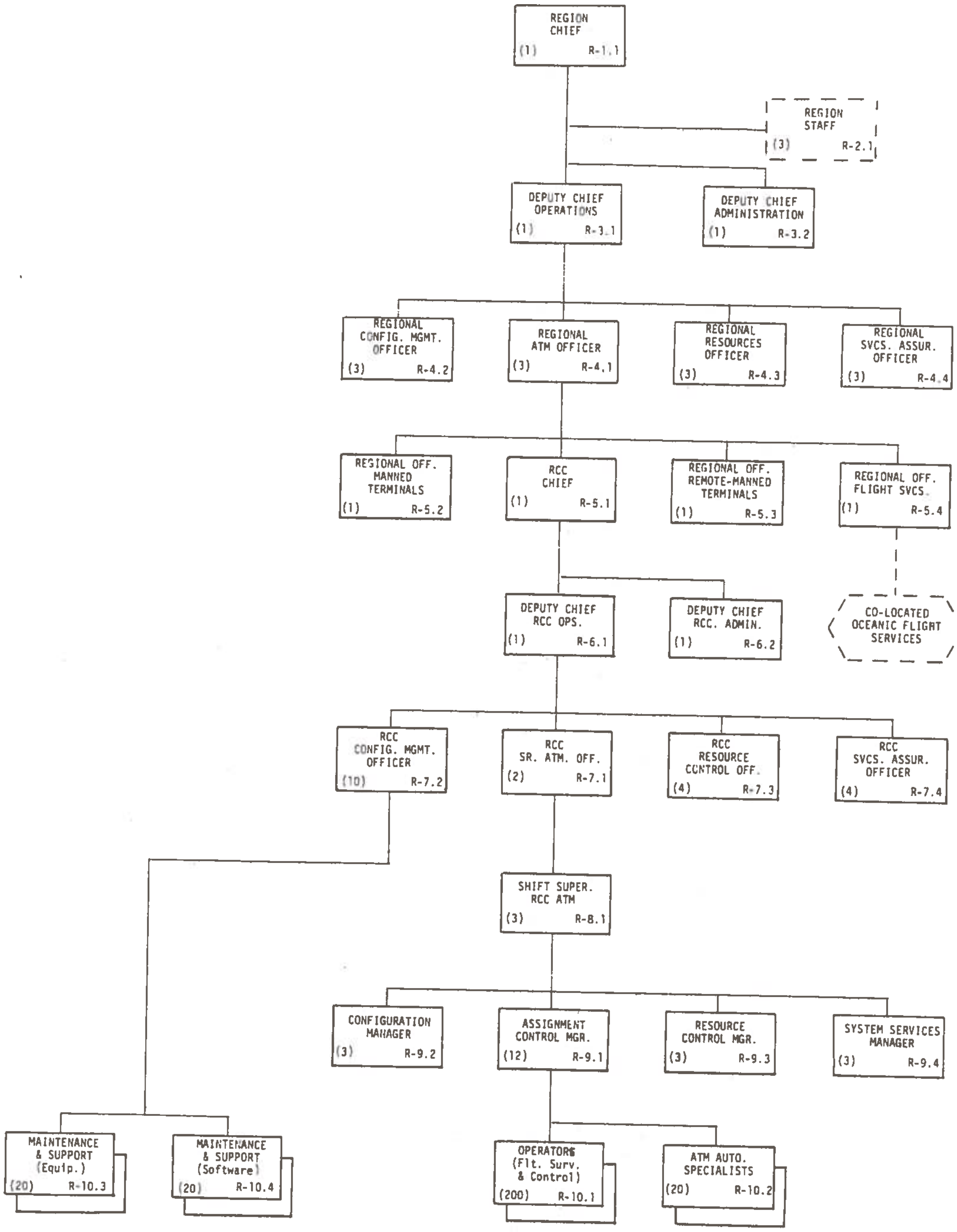

Figure 12 - RCC Staffing and Organization

R-4.1 Regional Air Traffic Management Officer is responsible for direction of air traffic management and services throughout the region. All executive, supervisory, operational, and support personnel in the region report through him to the Deputy Chief for Operations (R-3.1).

R-4.2 Regional Configuration Management Officer is responsible for management of system configuration within the region. He coordinates response to failures within the region and back-up arrangements outside the region with the National Configuration Management Officer (C-4.2). He oversees the activities of Level-7 Configuration Management Officers at the RCC (R-7.2) and the THC's within his region (T-7.2).

R-4.3 Regional Resources Officer coordinates the activities of Resource Control Officers at facilities within the region to assure the continuous availability of man and machine resources to match the level and nature of demand for air traffic services. He reports to the central system directorship through the National Resources Officer (C-4.3).

R-4.4 Regional Services Assurance Officer is responsible for monitoring air traffic services in the region to ensure conformance with established performance standards. He reports to the National Services Assurance Officer (C-4.4) and, in turn, serves as the channel of coordination for Services Assurance Officers (R-7.4 and T-7.4) at the various facilities in the region.

2.3.2.2 Executive-Level Management Personnel

R-5.1 Regional Control Center Chief is the operational and administrative head of the RCC. All activities within the RCC facility are under his jurisdiction.

R-5.2 Regional Officer for Manned Terminals acts as the regional overseer of air traffic management activities at primary and secondary airports with manned towers. All supervisory, operational, and support personnel at manned terminals throughout the region report ultimately to him.

R-5.3 Regional Officer for Remote-Manned Terminals is the regional executive in charge of air traffic management activities at secondary airports with remotely manned towers. He directs and coordinates the activities of the Deputy Chiefs for Remote Terminals (T-6.1) at the THCs within his jurisdiction.

R-5.4 Regional Officer for Flight Services directs and coordinates the activities of all Flight Service Centers within the region. He is similarly responsible for the Oceanic Flight Service Center which is co-located with the RCC.*

R-6.1 Deputy Chief for RCC Operations acts as the principal representative for the RCC Chief in the area of operations. All operational and support personnel in the RCC are under his direction.

R-6.2 Deputy Chief for RCC Administration serves as the principal representative of the RCC Chief for administrative matters in the RCC facility.

R-7.1 RCC Senior ATM Officer has direct operational responsibility for en-route air traffic management in the RCC.

R-7.2 RCC Configuration Management Officer is responsible for configuration management within the RCC. This includes both internal reconfiguration in response to failures within the RCC and external support of other facilities which have sustained failures. His activities are coordinated and directed

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* Oceanic system facilities were not studied as part of the AATMS program. However, their organization and mode of operation will probably resemble closely those of the Flight Service Center at THC for flight information services and those of the RCC for traffic surveillance and control.

through the Regional Configuration Management Officer (R-4.2) and, ultimately, through the National Configuration Management Officer (C-4.2). The RCC Configuration Management Officer directs and supervises all maintenance personnel.

R-7.3 RCC Resource Control Officer acts as the principal staff assistant to the Deputy Chief for RCC Operations in the area of matching human and machine resources in the RCC to the demand for en-route air traffic services. He coordinates the activities of RCC Resource Control Managers (R-9.3).

R-7.4 RCC Services Assurance Officer is the principal staff assistant to the Deputy Chief for RCC Operations in monitoring the quality of air traffic services rendered by the RCC. He coordinates the activities of System Services Managers (R-9.4) in the RCC.

2.3.2.3 Supervisory-Level Management Personnel

R-8.1 RCC ATM Shift Supervisor provides direct supervision of operator personnel on shift in the RCC. He is assisted by a team of Level-9 managers as described below.

R-9.1 Assignment Control Manager assigns tasks as required to individual operators. He is responsible for maintaining a balanced workload distribution and for establishing an appropriate relief schedule for personnel on shift. He also coordinates with the shift supervisor and other members of the Level-9 management team to resolve specific operational situations and problems affecting RCC resource allocation.

R-9.2 Configuration Manager acts, under the direction of the RCC Configuration Management Officer (C-7.2), to meet unplanned and scheduled changes in system status and capability by carrying out reconfigurations of automated resources. He coordinates with other Level-9 management team members to ensure continued system operation and to provide smooth transition to and from contingency and failure modes.

R-9.3 Resource Control Manager plans and schedules the commitment of human and machine resources so as to ensure adequate RCC capability over each shift period. He is responsible for seeing that demand for services is met in a timely and appropriate manner. He also acts to anticipate requirements for resource shifts and reallocations in normal and degraded modes of operation.

R-9.4 System Services Manager monitors the quality of human and automated resource performance with respect to established standards. He coordinates as required with Assignment Control, Configuration, and Resource Control managers to maintain quality of service.

2.3.2.4 Operational and Support Personnel

R-10.1 Operators perform the manual tasks associated with RCC air traffic operations (Flight Surveillance and Control Officer — Position III).

R-10.2 ATM Automation Specialists oversee the status of task performance by machine resources and act as required to ensure completeness, consistency, and accuracy of automated operations.

R-10.3 Maintenance and Support (Equipment) personnel are responsible for preventive and corrective maintenance of all equipment in the RCC.

R-10.4 Maintenance and Support (Software) personnel conduct programming activities for all data processing equipment in the RCC.

2.3.3 Terminal Hub Center

There are twenty Terminal Hub Centers (THC) in AATMS, each having two major areas of functional responsibility:

1) flight information services and flight plan processing,
2) flight surveillance and control services for secondary airports with unmanned towers.

As a flight information and flight plan processing center, the THC corresponds to the Flight Service Station of the present system, although considerably more centralized and with an enlarged scope of responsibility. Each THC supports approximately 175 remote, unmanned FSS terminals, which operate on a self-service basis. The THC processes pilot requests for weather and flight planning data received through the self-service network, provides displays and verbal briefings of the requested information, assists in flight plan filing, and processes and distributes accepted flight plans. The THC also acts as a centralized point for dissemination of flight advisories and for in-flight assistance to pilots (e.g., air files).

The second major functional responsibility of the THC is to provide terminal area surveillance and control services for secondary airports which do not have manned towers. The THC provides these services remotely, centralizing control of traffic at 10-15 low volume secondary airports in one facility.

The staff organization and structure for the THC is shown in Figure 13, page 41. The significant organizational feature of the THC is that it is staffed only with personnel at the executive level of management and below. Director-level management functions for the THC are exercised by personnel in the RCC having jurisdiction over the area in which the THC is located. Thus, the eastern and western Regional

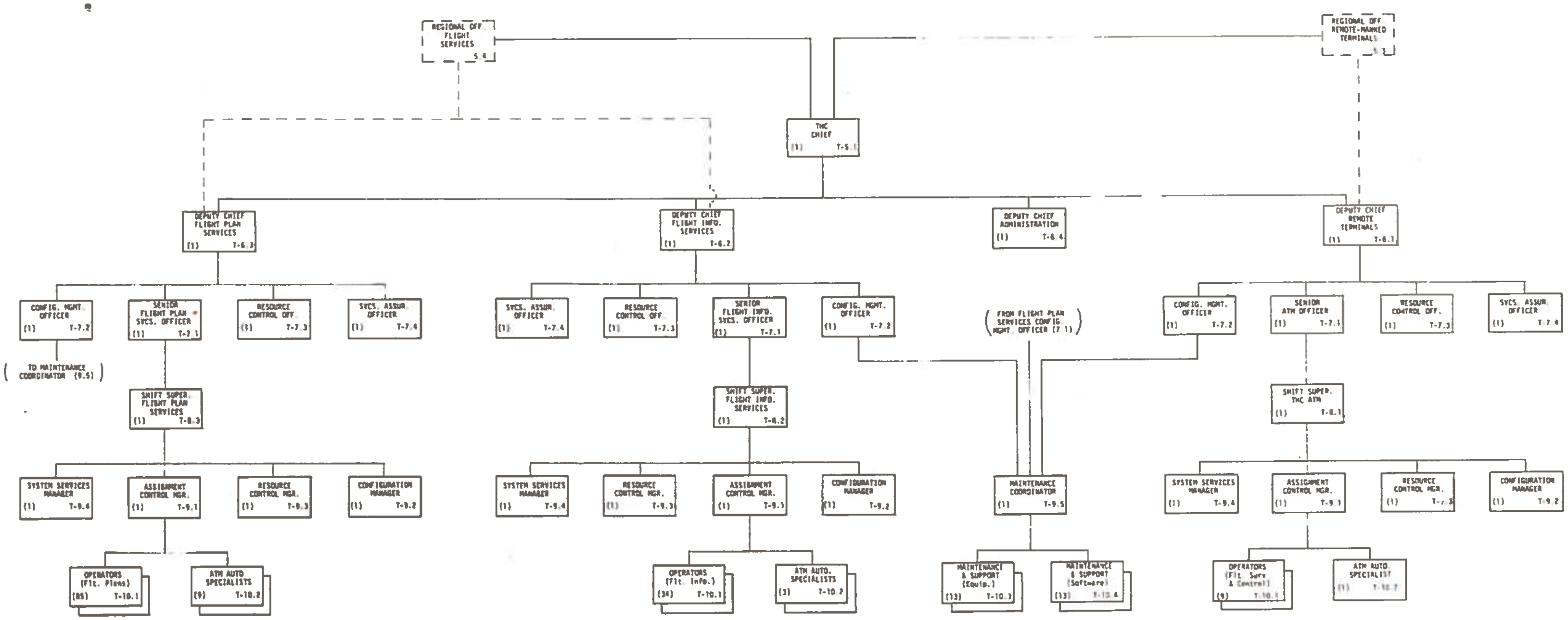

Figure 13 - THC Staffing and Organization

Offices of AATMS each direct and coordinate flight service and traffic operations at approximately ten THCs.

2.3.3.1 Executive-Level Management Personnel

T-5.1 Terminal Hub Center Chief is the operational and administrative head of the THC. All activities with the THC facility are within his cognizance. The THC Chief receives director-level management from the Regional Office along two lines of authority -- the Regional Officer for Remote-Manned Terminals (R-5.3) for traffic surveillance and control operations and the Regional Officer for Flight Services (R-5.4) for FSS operations.

T-6.1 Deputy Chief for Remote Terminals acts as the principal representative of the THC Chief for secondary airport traffic surveillance and control operations. He also has a liaison channel to the Regional Officer for Remote-Manned Terminals (R-5.3) for coordination of THC flight operations with the RCC and other THCs in the region.

T-6.2 Deputy Chief for Flight Information Services is the principal representative of the THC Chief for operation of the FSS network. He has a secondary channel to the Regional Officer for Flight Services (R-5.4) with whom he coordinates the information and advisory services that are supplied to airspace users by the THC.

T-6.3 Deputy Chief for Flight Plan Services serves as the principal representative of the THC Chief for flight plan filing and processing services performed by the THC. He also maintains liaison with the Regional Officer for Flight Services (R-5.4) for Coordination of flight plan activities with other THCs in the region.

T-6.4 Deputy Chief for THC Administration acts as the principal representative of the THC Chief for administrative matters in the THC facility.

T-7.1 Senior ATM Officer,
Senior Flight Information Services Officer, and
Senior Flight Plan Services Officer are the principal assistants to the respective Deputy Chiefs (T-6.1, T-6.2, T-6.3) for the three major divisions of THC operations. All supervisory and operational personnel in the THC, according to their occupational specialty, are the direct responsibility of one of these three executive-level managers.

T-7.2 Configuration Management Officer, one for each operational division of the THC, is responsible for configuration of THC resources within his area of concern. He works cooperatively with his counterparts in the other divisions of the THC to maintain the overall operational capability of the THC in the event of equipment failures. Preventive and corrective maintenance of equipment also comes under the collective jurisdiction of the three Configuration Management Officers, who direct (through the THC Maintenance Coordinator, T-9.5) the activities of maintenance and support personnel.

T-7.3 Resource Control Officer acts as the principal staff assistant to his respective Deputy Chief (T-6.1, T-6.2, T-6.3) in matching human and machine resources to demand for services in one of the three operational divisions of the THC.

T-7.4 Services Assurance Officer monitors on behalf of the Deputy Chief for each of the three THC operational divisions the quality of services rendered by the THC.

2.3.3.2 Supervisory-Level Management Personnel

T-8.1 THC ATM Shift Supervisor provides direct supervision of operator personnel engaged in flight surveillance and control activities for remotely manned terminals under the jurisdiction of the THC. He is assisted by a team of Level-9 managers as described below.

T-8.2 Flight Information Services Shift Supervisor provides direct supervision of operator personnel engaged in flight information service activities in the THC. He is assisted by a team of Level-9 managers as described below.

T-8.3 Flight Plan Services Shift Supervisor provides direct supervision of operator personnel engaged in flight plan filing and processing activities in the THC. He is assisted by a team of Level-9 managers as described below.

T-9.1 Assignment Control Manager assigns tasks as required to individual operators. He is responsible for maintaining a balanced workload distribution and for establishing an appropriate relief schedule for personnel on shift. He also coordinates with the shift supervisor and other members of the Level-9 management teams to resolve specific operational situations and problems affecting resource allocation within his division of the THC.

T-9.2 Configuration Manager acts, under the direction of the THC Configuration Management Officer (T-7.2), to meet unplanned and scheduled changes in system status and capability by carrying out reconfiguration of automated resources. He coordinates with other Level-9 management team members to ensure continued system operation and to provide smooth transition to and from contingency and failure modes.

T-9.3 Resource Control Manager plans and schedules the commitment of human and machine resources so as to ensure adequate capability within his division of the THC over each shift period. He is responsible for seeing that demand for services is met in a timely and appropriate manner. He also acts to anticipate requirements for resource shifts and reallocation in normal or degraded modes of operation.

T-9.4 System Services Manager monitors the quality of human and automated resource performance with respect to established standards. He coordinates as required with Assignment Control, Configuration, and Resource Control managers to maintain quality of service.

T-9.5 Maintenance Coordinator provides direct supervision of all maintenance personnel and technicians assigned to the THC. He coordinates with the Configuration Management Officers (T-7.4) for each of the THC operating divisions to schedule preventive maintenance and to assign personnel for corrective maintenance as the need arises.

2.3.3.3 Operational and Support Personnel

T-10.1 Operators perform the manual tasks associated with THC operations. Three types of operators are assigned to the THC: Flight Information Services Officer (Position IB), Flight Plans Officer (Position IIA), and Flight Surveillance and Control Officer (Position III).

T-10.2 ATM Automation Specialists oversee the status of task performance by machine resources and act as required to ensure completeness, consistency, and accuracy of automated operations.

T-10.3 Maintenance and Support (Equipment) personnel are responsible for preventive and corrective maintenance of all equipment in the THC.

T-10.4 Maintenance and Support (Software) personnel conduct programming activities for all data processing equipment in the THC.

2.3.4 Primary and Secondary Terminals

The AATMS facility concept includes 492 Airport Control Centers (ACC) — 133 at primary airports and 359 at secondary airports. Each provides air traffic control services for aircraft within a terminal area jurisdiction and coordinates with the RCC in its region for aircraft in transition to and from the en-route portion of the system. For short flights between nearby terminals, the ACCs coordinate the handling of traffic directly.

The staffing of ACCs, in terms of both the number and level of assigned personnel, will vary greatly as a function of the volume of traffic handled by the facility. The complement at small secondary airports would consist of only operators (10.1). Supervisory personnel would not be on site, but would oversee operations from a remote, central location. Medium-sized airports would have a reduced supervisory complement assigned on a site basis. That is, there would be a shift supervisor (8.1) but no Level-9 management support team. In this case, the management functions of assignment control, resource control, configuration management, and services assurance would be exercised either by the shift supervisor or by the shift supervisor aided by a single deputy. At large airports the staffing structure would include the full Level-8 and Level-9 complement, with perhaps some Level-6 and Level-7 executive personnel.

Because of the variability in the staff assigned to ACCs, no detailed organizational charts for these facilities are presented in this report. In general, however, it can be said that all managerial, operational, and support functions will be accomplished at the ACCs with a manpower complement of a size and composition which is consonant with the volume of traffic handled and the dictates of economy of human resource utilization.

2.4 MANPOWER ESTIMATES

This section summarizes the quantitative requirements for operational, managerial, and support personnel in AATMS. The number of operators needed to man AATMS facilities was derived from an analysis of manual task performance times and frequency of task repetition, based on a nominal 1995 demand level with a peak instantaneous airborne count of 33,750 aircraft throughout CONUS.* The estimates of managerial personnel requirements were derived from the facility staffing and organization plan presented in this report. In general, the managerial complement was sized so as to represent approximately 25% of the operator workforce, with appropriate adjustments to account for the overall management scheme and the demands of individual management positions. Support personnel requirements were also derived from operator workforce estimates, using a staffing factor of 20% for maintenance personnel and 10% for automation specialists. In all cases, adjustments were made to provide an integral number of personnel of each category per facility.

Table 2 on the following page is a summary of staffing requirements in each personnel category by site and peak-demand shift. The conversion from shift size to total manpower complement was made using a factor of 3.5, which accounts for three working shifts per day, schedule irregularities, vacation, and sick leave. Expressed as a percentage of the total workforce, the relative size of each personnel category is as follows:

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* See Automation Applications in an Advanced Air Traffic Management System, Vol. IV, TRW Report 22265-W009-RU-00, December 1973.

TABLE 2 - SYSTEM STAFFING BY PERSONNEL CATEGORY

STAFFING	SHIFT PER SITE					SHIFT ALL SITES					ALL SHIFTS ALL SITES e					
CATEGORY	CCC	RCC	THC	PRI	SEC	CCC	RCC	THC	PRI	SEC	CCC	RCC	THC	PRI	SEC	TOTAL
DIRECTOR (1.1 - 4.4)	30 [a]	18 [a]	--	--	--	--	--	--	--	--	30	36	--	--	--	66
EXECUTIVE (5.1 - 7.4)	15 [b]	26 [b]	17 [b]	c	d	15	52	340	67	90	45	152	940	194	261	1592
SUPERVISOR (8.1 - 9.5)	15	24	16	1	d	15	48	320	133	90	53	168	1120	466	315	2122
OPERATOR (10.1)	115	200	128	4	2	115	400	2560	532	718	403	1400	8960	1862	2513	15138
AUTO. SPEC. (10.2)	12	20	13	c	d	12	40	260	53	72	42	140	910	186	252	1530
MAINTENANCE (10.3 - 10.4)	23	40	26	c	d	23	80	520	106	144	81	280	1820	371	504	3056

a - Not staffed on a shift basis

b - Only positions 7.1 - 7.4 staffed on shift basis

c - Highly variable from site to site

d - Not assigned locally

e - Staffing factor = 3.5 (to account for three working shifts, schedule irregularities, vacation, and sick leave)

DIRECTOR	0.3%
EXECUTIVE	6.8%
SUPERVISOR	9.0%
OPERATOR	64.4%
AUTOMATION SPECIALIST	6.5%
MAINTENANCE	13.0%

Table 3, on the following page, presents the same data organized in terms of the number of personnel in each category required to man individual facilities. In this case, the staff required to carry out flight service functions at the THC is carried separately from the flight surveillance and control staff co-located at the same facility so as to provide a clearer comparison between the AATMS approach to Flight Service Stations and that of the present ATC system.

Table 4, page 51, is a summary of the estimated annual manpower costs associated with the staffing concept presented in this report. Estimates are stated in 1973 dollars and are based on nominal salary levels for each personnel category as listed in the table. The final column in the table indicates the proportion of the total manpower cost represented by each personnel category. It can be seen that, while the entire management complement constitutes about 16% of the workforce, the annual manpower costs for management amount to about 21% of the total. This suggests not only the importance accorded to management functions in AATMS (as reflected in a higher level of compensation), but also the degree to which personnel of higher skill levels will be needed to direct the operation of a future air traffic system.

TABLE 3 - SYSTEM STAFFING BY FACILITY

Facility	No. of Sites	Per Site Per Shift			All Sites Per Shift			All Sites All Shifts[c]		
		Operator	Support[a]	Manager[b]	Operator	Support	Manager	Operator	Support	Manager[d]
CCC	1	115	35	60	115	35	60	403	123	128
RCC	2	200	60	68	400	120	136	1,400	420	356
THC	20	9	3	2	180	60	40	630	210	124
THC (HFSC)	20	119	36	31	2,380	720	620	8,330	2,520	1,936
Primary Airport	133	_(e)	_(e)	_(e)	532	159	200	1,862	557	660
Secondary	359	2	_(f)	_(f)	718	216	180	2,513	756	576
TOTAL					4,325	1,310	1,236	15,138	4,586	3,780
					6,871			23,504		

(a) Assumed to be 30% of operator staff (20% maintenance, 10% automation specialist)
(b) Assumed to be approximately 25% of operator staff
(c) Shift size x 3.5 to account for three working shifts, schedule irregularities, vacation, and sick leave
(d) Not all managerial positions are staffed on a shift basis
(e) Variable from site to site
(f) Not assigned on a local basis

TABLE 4 - ANNUAL MANPOWER COST SUMMARY

Staffing Category	No. Personnel	Annual Salary (thousand $)*	Annual Manpower Cost (million $)*	Percent of Total Annual Cost
Operator	15,138	20	302.76	62.3
Support Maintenance	3,056	18	55.01	11.3
Automation	1,530	16	24.48	5.0
Manager Supervisor	2,122	25	53.05	10.9
Executive	1,592	30	47.76	9.8
Director	66	40	2.64	0.5
Totals	23,504	--	$485.70	---

* 1973 dollars

3. SCENARIO OF FLIGHT OPERATIONS

3.1 INTRODUCTION

This section of the report contains a scenario of a typical flight, as conducted in the 1995 time period under the Advanced Air Traffic Management System. The scenario has been prepared both to illustrate the workings of AATMS and to show a representative sample of the program of air traffic services available to future users of the nation's airspace.

The flight described here is by a general aviation aircraft. It originates in a primary terminal in a major metropolitan area (Washington National Airport - DCA). The destination is a secondary terminal (Kokomo, Indiana - OKK). For the sake of the illustration, it has been assumed that OKK will not have a manned tower in 1995 and that terminal area air traffic services will be provided remotely by a Terminal/Hub Center (THC) located in Indianapolis.

The pilot in this AATMS flight scenario is a businessman who has a pilot's license with instrument qualifications. His use of the airspace is for business purposes. He is an employee of a firm with home offices near Kokomo. He has been in Washington, D.C. for a conference with Government officials and now plans to return to the home office to report to his employer.

It has also been assumed that the general weather conditions are good enough to permit VFR flight if the pilot chooses. However, he elects to file an IFR flight plan to practice instrument procedures and to take full advantage of the air traffic services available to users of the system. Thus, while the scenario describes a general aviation flight, it also illustrates the way in which commercial aviation might make use of the system.

3.2 GENERAL SCENARIO

The scenario consists of two parts -- a description of the flight as seen from the pilot's viewpoint and a description of the flight as seen by the ground system. The major events in the air and ground portions of the scenario are as follows:

AIR	EVENT	GROUND
A-1	OBTAINING FLIGHT PLANNING INFORMATION	G-1
A-2	FILING THE FLIGHT PLAN	G-2
	FLIGHT PLAN DATA PROCESSING	G-3
A-3	PREPARING FOR DEPARTURE	
A-4	DEPARTURE	G-4
A-5	CLIMB AND CRUISE	
	TERMINAL TO EN-ROUTE TRANSITION	G-5
A-6	EN-ROUTE FLIGHT PLAN CHANGE	G-6
	THC FAILURE AND RECONFIGURATION	G-7
A-7	DESCENT AND LANDING	G-8

Within each portion of the scenario, information is presented under three headings:

EVENT

A description of the pilot or controller activities associated with the event

RELATED FUNCTIONS & TASKS

An identification of the generic system functions performed to accomplish the event or to provide the indicated services.

NOTES

An explanation of assumptions or operational conditions associated with the event.

The aircraft flight scenario begins on the following page. The ground system scenario begins on page 62. Table 5 at the conclusion of this section (page 73) is a summary of events, services, facilities, and system features which are contained in the scenarios.

3.3 AIRCRAFT FLIGHT SCENARIO

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-1 OBTAINING FLIGHT PLANNING INFORMATION		
As a preliminary flight planning step, the pilot wishes to obtain information on weather, airspace availability, and other related data for the expected time of his flight. He will travel if conditions are reasonable and airspace can be reserved, otherwise he will postpone the trip.		General aviation aircraft instrumentation will not be sufficient for true all-weather capability (Cat II and beyond).
From his office, the pilot calls the system, identifies himself and his aircraft, and requests a briefing for his tentative trip. He receives a preformatted, prerecorded briefing including: - Airspace availability (by time block) for departure from DCA - DCA, OKK, and mid-eastern region weather - Any unusual or exceptional conditions, e.g., system status, NOTAMS, etc.	1.1.1., Accept Telephone Requests, through 1.3.3. Transmit Requested Info. - The link will accept voice and data inputs - Each user has a personal identifier - Voice briefings are prerecorded or otherwise synthesized - A hard copy of the briefing can be obtained if desired	It is assumed that general avaition restrictions at Washington National Airport will not apply to business-related airspace usage. Aircraft identifying data will include type, performance data, and avionics on board. Pilot identifiers will include type of license and qualifications, as well as individual identity.
On the basis of the information he receives, the pilot decides to go ahead. He indicates this decision to the system, and receives acknowledgment in the form of a tentative departure/arrival reservation time block.		Procedures for early identification of intent to use airspace would include such tentative reservations. (If not confirmed by flight plan filing, the reservations would be cancelled.)

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-2 FILING THE FLIGHT PLAN At his convenience, within the time available for filing a flight plan, the pilot goes to a self-service flight planning terminal. As before, he calls the system and identifies himself and his aircraft. He receives a display of available routes and altitudes for the trip, and selects those he wishes for the flight.		Self-service flight planning terminals will consist of one or more individual carrels equipped with I/O devices to accept alphanumeric and voice inputs and to produce voice, video, and hard copy outputs.
He then works out, with the aid of the system, the ETOV/ETA data for the anticipated ETD to generate an intended profile for the flight which is consistent with aircraft characteristics and the anticipated weather. Thus, the flight plan data are simultaneously developed and checked for internal consistency.	3.1.1., Specify Desired Destination/Route Information through 3.3.3., Submitted Flight Plan	The aircraft navigation package will include a programmable storage device which can be detached from the aircraft and used at a carrel to develop all "command" navigation data.
When the flight plan has been compiled, checked, and reviewed for acceptability, it is approved. The pilot receives appropriate "hard copy" confirmation.	4.1.1., Determine points for which ETOVS are to be computed through 4.2.13. Determine Special Services Required.	

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-3 PREPARING FOR DEPARTURE		
At the airport, the pilot performs the necessary fueling and preflight checks on the aircraft. When ready, he starts the aircraft, switches to internal power, and activates his communications link to the system.		Assumed to be data link
From the system, he receives		
- A clearance to depart	Function 5	
- Taxi instructions	Function 11	
- Runway assignment and takeoff sequence number	Function 9	
At the pilot's discretion, he can receive prerecorded weather updates as he taxis to his assigned runway.		Note that airport design may feature dedicated runways, e.g., CTOL, STOL, General Aviation. Functional relationships are not sensitive to varying design concepts in this area.

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-4 DEPARTURE		
The pilot receives instructions to the run-up area, then to the active runway, then a guidance vector to commence rolling. As the aircraft becomes airborne, the takeoff time is transmitted to the system. All relevant ETOVS and the ETA at OKK are updated accordingly, both on the ground and in the programmable section of the aircraft navigation package.	Function 5 Function 6	It is assumed that the programmable navigation package of the aircraft is updated by data link.
The pilot is vectored through climbout, including a noise abatement maneuver, to a merge with his assigned airspace block for transition.	Function 6 Function 7 Function 11	Automated vectors are transmitted to aircraft via data link.
A-5 CLIMB AND CRUISE		
The pilot continues his climb to cruise altitude, establishing power settings, final trim, and engaging the autopilot. In addition to primary flight displays, he monitors two displays related to airspace use: - System data link (from which vectors are received) - Navigation package display	Function 6 Function 7 Function 8	Note that no frequency changes or handoffs have required pilot attention. Assumed that the data link will have an "everything's OK and no action is required" status indication.

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-6 EN-ROUTE FLIGHT PLAN CHANGE		
A rapidly developing weather front with associated changes in winds aloft has resulted in an increased headwind vector. The aircraft begins falling behind the planned time-position profile. The pilot is alerted by the system and asked what his preferences are.	Function 6 Function 7	
The pilot requests another en-route altitude, but none are available which do not have the same adverse winds or which would not produce a conflict with another aircraft.	Function 1 Function 4	
Rather than alter speed, the pilot elects to revise the flight plan to reflect a later arrival at OKK.	Function 3	Flight plan filing and approval en-route, as in the case of preflight, is an interactive and negotiative process between the pilot and the system.
Confirmation of the change and associated clearance are given to the pilot.	Function 4 Function 5	

EVENT	RELATED FUNCTIONS & TASKS	NOTES
A-7 DESCENT AND LANDING		
At the appropriate time, the pilot is cleared to descend and given descent vectors. As he enters the OKK area jurisdiction, he receives:	Function 5 Function 11	Failure in the ground system (see ground scenario) has no appreciable effect on the conduct of the flight from the pilot's point of view.
- Updated OKK weather		
- Landing information		
- A traffic advisory concerning VFR aircraft in nearby uncontrolled airspace	Function 12	
The pilot is vectored into the OKK approach pattern. He is behind a VFR aircraft which is slow on final approach. A speed vector is given to the pilot to maintain proper separation.	Function 9 Function 11 Function 8	
After touchdown, the pilot receives directions to his ramp area. He taxis to the ramp and shuts down. The act of shutting down aircraft power closes out his flight plan. The flight is complete.	Function 11 Function 4	

3.4 GROUND SYSTEM SCENARIO

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-1 OBTAINING FLIGHT PLANNING INFORMATION		
A telephone request for a weather and flight plan briefing is received at the Flight Service Center in the THC serving the Washington D.C. area. The request includes a statement of: - pilot identity - aircraft type & avionics - origin & destination - en-route altitude zone - type of proposed flight (IFR or VFR)		
The appropriate briefing is assembled automatically from preformatted and prerecorded data modules. The briefing is transmitted by phone, with a hard copy if the user requests it and is appropriately equipped to receive it. (See Event A-1 for general content of briefing.)	Function 17 provides the data bank for flight and weather info. Subfunction 17.11 prepares preformatted data modules. 1.1.1. Accept Telephone Request through 1.3.3. Transmit Requested Info.	
A tentative airspace reservation at DCA is made for the expected time of departure.	2.2.2. Process and Store Reservations	Procedures for early identification of intent to use airspace would include such tentative reservations. (If not confirmed by flight plan filing, the reservation would be cancelled.)

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-2 FILING THE FLIGHT PLAN		
At a self-service flight planning terminal, the pilot contacts the system and states his intent to file a flight plan. By an interactive process between the pilot and the Flight Service Center at the THC in his area, the route, altitude, ETD/ETA, and other details of the proposed flight are worked out and compiled in a flight plan.	4.1.1. Determine Points for Which ETDV's are to be Computed through 4.2.13. Determine Special Services Required.	It is assumed that flight plan filing assistance will be a mixture of automated and manual modes of operation. Routine requests and choices will be handled by automated resources within the system. The human operator will, however, be readily available to answer special pilot requests or to provide personal assistance if needed. The general method of operation will be to handle the routine work with automated resources, with human intervention or participation taking place only insofar as needed by the pilot to complete the flight plan filing successfully or to make special arrangements. Thus, for some flight plans the process might be entirely automatic. For others it might be entirely manual. In most cases, however, it will be primarily handled by machines with a few human operator inputs.
At each step of the planning process, the system checks the flight plan for compatibility with weather, route restrictions, rules of airspace use, other planned flights, terminal area conditions, aircraft capability, pilot qualifications, etc.	The data bank for this activity is maintained by Function 17 and transmitted, as required, to other portions of the system.	
When the flight plan has been compiled, checked, and reviewed for acceptability, it is approved and appropriate "hard copy" confirmation is given to the pilot.		

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-3 FLIGHT PLAN DATA PROCESSING		
The approved flight plan, which includes a detailed time-position profile for the movement of aircraft, is processed and distributed to the control facilities which will have jurisdiction over each portion of the flight.	4.4.3. Designate Responsible Jurisdictions 4.4.4. Designate Communication Links Between ATM and Aircraft.	Flight plan filing and processing for regular users (scheduled commercial flights) will make use of "canned" flight plans as in today's system. The method of reviewing, approving, and distributing the flight plan for scheduled flights, however, will be essentially the same as for the one-time flight in this scenario. Even though the flight plan is canned, it must still be checked each time for compatibility with flow control restrictions and other approved flights; and it must be distributed as flight plan data to the responsible control jurisdictions.
Flow Control is notified of the acceptance of the flight plan and reservations for terminal and en-route airspace are made (or confirmed) as appropriate.	2.2.2. Process and Store Reservations.	

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-4 DEPARTURE		
Upon receipt of a signal that the aircraft is ready for departure, the flight plan is activated. Appropriate clearances and guidance vectors for taxi and takeoff are issued. The departing aircraft is interleaved with arrivals according to the runway use schedule.	Function 5 Function 6 Function 11 Function 9	Vectors and clearances are transmitted to the aircraft by data link.
As the aircraft becomes airborne, the takeoff time is recorded and transmitted to the system. The expected time-position profile en route and the ETA at OKK are updated accordingly, both on the ground and in the programmable navigation package on the aircraft.	Function 6 Function 14	Track and time data (actual time-position profile) are continually maintained on the flight for both control and record purposes.
The aircraft is vectored through climbout to merge with the assigned airspace block for en-route transition.	Function 6 Function 7 Function 8 Function 11	Separation assurance and flight plan conformance monitoring are continuous once the aircraft receives its initial clearance to leave the gate.

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-5 TERMINAL TO EN-ROUTE TRANSITION		
As the aircraft leaves the terminal area and climbs to en-route altitude, responsibility for monitoring and controlling the flight is transferred from the DCA airport facility to the Eastern Regional Control Center.	Function 13	Because clearances and guidance commands are transmitted automatically by data link, the handoff from terminal to en route requires no special action by the pilot and has no appreciable effect on his conduct of the flight.
The RCC performs all surveillance and control functions for the flight from the time the aircraft leaves the departure terminal area until it enters the jurisdiction of the arrival terminal.	Function 5 Function 6 Function 7 Function 8 Function 9 Function 11	Depending upon sectorization rules in the RCC, intra-facility handoffs may or may not be required en route. If handoffs do occur, they will be "silent" as far as the pilot is concerned, just as in the case of terminal to en route handoff.

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-6 EN-ROUTE FLIGHT PLAN CHANGE		
A rapidly changing weather front has produced adverse winds aloft, causing the aircraft to begin falling behind its flight plan. The discrepancy between the flight plan and performance is detected by the system, and the pilot is alerted.	Function 6 Function 7	
With the assistance of the THC having jurisdiction over the portion of the airspace that the aircraft then occupies, the pilot examines the alternative flight plan changes and files a revised flight plan (See Event A-6).	Function 1 Function 4	Note that, while the surveillance of the flight and the alert of non-conformance to flight plan are performed by the RCC, the flight plan revision is handled by a Flight Plans Officer at a THC. During the time that the flight plan is being revised, surveillance and control authority remains with the RCC and all flight-following functions continue uninterrupted. Thus, two facilities with separate functional responsibilities are in contact with the aircraft at the same time.
The revised flight plan is checked and approved. Confirmation of the change and associated clearance are given to the pilot.	Function 4 Function 5	

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-7 THC FAILURE AND RECONFIGURATION		
The Indianapolis THC, which has responsibility for flight surveillance and control functions at the remotely manned OKK tower, has experienced a failure of some of its data processors. As a result, the capability of the THC to handle terminal area operations has been severely restricted. For the flight described in this scenario, the handoff from RCC to THC is delayed. The flight itself, however, progresses normally; only the transfer of control responsibility is deferred. Thus, the flight begins its descent to OKK under RCC surveillance and control, while under normal circumstances the THC would have taken over the flight at this point.	Function 13	Reconfiguration of the THC computer resources is under way. Computer reserves at the THC, and reserve units at the RCC as required, are being put on line to replace the units which have failed. In the interim, the RCC is supporting the Indianapolis THC by assuming some of the load for flight surveillance and control functions. The RCC is retaining control of flights inbound to the THC area longer than normally, and it is picking up outbound flights sooner. The THC is handling only takeoffs and landings at each of the remotely manned towers in its jurisdiction. Note that flight planning services and flight information services, which are also handled by the THC, are unaffected by the failure and are provided normally. Note also that ground system failure has no appreciable effect on the conduct of the flight from the pilot's viewpoint.

EVENT	RELATED FUNCTIONS & TASKS	NOTES
G-8 DESCENT AND LANDING		
As the aircraft descends from en-route altitude and enters the OKK terminal area, the appropriate clearances and vectors are provided.	Function 5 Function 11	The RCC retains responsibility for the aircraft while THC reconfiguration is in progress. Normally, RCC-THC handoff would occur here.
Updated OKK weather, landing information, and traffic advisories are also provided.	Function 12	This information is provided by the Flight Service Center located at the THC. These services are not affected by the failure described in Event G-7.
While in the OKK approach pattern, the aircraft is given a speed vector to maintain proper in-trail separation with a VFR aircraft ahead which is slow on final.	Function 9 Function 11	
Handoff from RCC to THC occurs as the aircraft turns onto final approach.	Function 13	This delay of handoff is the result of the failure described in Event G-7.
After touchdown, the aircraft is directed to the ramp area. Shutdown of aircraft power is a signal to the system to close the flight plan.	Function 11 Function 4 Function 14	Function 14 maintains a complete record of the flight from takeoff to landing.

3.5 SUMMARY

The preceding aircraft and ground system scenarios were prepared to illustrate the major operational features of an advanced air traffic management system with a high degree of automation. The general outcome of the system activities described here is a program of services intended to promote the safe and expeditious movement of aircraft through the national airspace. Table 5, beginning on page 73, is a summary of the services and functions associated with each event in the aircraft and ground scenarios. The table also identifies the Facility and the type of AATMS operator responsible for the designated functional activities and services.

In the course of the example presented here, certain operational characteristics of AATMS emerge. These characteristics derive primarily from the level of automation of air traffic control and management functions, but they also reflect a philosophy of operation which differs from that of today's ATC system. The major characteristics which distinguish AATMS as a system concept are itemized below.

STRATEGIC CONTROL	The system is characterized by a high degree of centralized, strategic planning. This not only governs the general flow of traffic, but also conditions the formulation and acceptance of individual flight plans. (Note Events A-2, G-2, and G-3.)
TACTICAL INTERVENTION	Because of the detailed pre-planning of the aircraft time-position profile and the close monitoring of performance in relation to the flight plan, the need for tactical (reactive) control is greatly diminished. Where it does

occur, tactical intervention is usually preventive rather than reactive. That is, the problem is predicted and resolved before it occurs instead of after it has actually manifested itself. (Note Events A-6 and G-6.)

CONTROL BY EXCEPTION	The mixture of strategic planning and preventive tactical action produces a system which does not require continuous interaction between the controller and the pilot. As long as the flight is proceeding according to plan, no intervention is required. The aircraft is closely followed by automated mechanisms, which alert the pilot and controller to deviations before they become serious. Thus, the flight proceeds on a gate-to-gate clearance, terminal area sequencing and spacing are worked out in advance and built into guidance vectors, and flight advisories are delivered according to the established flight schedule. (Note Events A-4, G-4, A-5, G-5, A-7, and G-8.)
SILENT SYSTEM	The control by exception philosophy and the use of digital data link for most ground-air and air-ground communications eliminates the need for extensive voice radio use by pilots and controllers. The system is also silent in the sense that controller-pilot communications are required only in exceptional circumstances (e.g., Events A-6 and G-6). As long as the flight is progressing according to plan, nothing needs to be said.

FLEXIBILITY

Although the conduct of the flight and the program of services are somewhat more standardized than in today's system, there is also more flexibility of system response than today. Individual preferences and special circumstances can be accommodated within the overall scheme of operations because of the enormous power of an automated system to handle details rapidly and to work out alternative courses of action. The flexibility afforded by computers also permits prompt reconfiguration of the system and reallocation of resources in the event of ground system malfunctions. (See Event G-7.)

FREEDOM AND SERVICE

The system provides considerable latitude to airspace users both in planning and in conducting the flight. Along with this freedom of airspace use, however, there is an expanded and improved program of services to assist in preparing for the flight (e.g., Events A-1 and A-2) and in carrying out the flight itself (e.g., Events A-6 and A-7). Both characteristics stem directly from the automated nature of the system, which allows rapid and accurate processing of large amounts of data and close monitoring of flight progress without human involvement.

TABLE 5 – SUMMARY OF EVENTS AND SYSTEM OPERATIONS

EVENT	ASSOCIATED SERVICES	RELATED FUNCTIONS	FACILITY	AATMS OPERATOR
A-1 G-1 OBTAINING FLIGHT PLANNING INFORMATION	Information Services	Function 1	THC	IB Flight Info. Services
A-2 G-2 FILING THE FLIGHT PLAN	Information Services	Function 4	THC	IIA Flight Plans
A-3 PREPARING FOR DEPARTURE	Flight Plan Conformance	Function 5	Primary Airport	III Flight Surveillance & Control
	Spacing Control	Function 5 Function 9 Function 11	Primary Airport	
G-3 FLIGHT PLAN DATA PROCESSING	Airport/Airspace Use Planning	Function 2	CCC	IIB Flow Control
	Flight Plan Conformance	Function 4	THC	IIA Flight Plans

TABLE 5 — SUMMARY OF EVENTS AND SYSTEM OPERATIONS (continued)

EVENT	ASSOCIATED SERVICES	RELATED FUNCTIONS	FACILITY	AATMS OPERATOR
A-4 G-4 DEPARTURE	Flight Plan Conformance	Function 5 Function 6 Function 7 Function 11	Primary Airport	III Flight Surveillance & Control
	Separation Assurance	Function 6 Function 8 Function 11	Primary Airport	III Flight Surveillance & Control
	Spacing Control	Function 5 Function 6 Function 9 Function 11	Primary Airport	III Flight Surveillance & Control
	Record Services	Function 14	CCC	IA Data Base
A-5 CLIMB AND CRUISE	Flight Plan Conformance	Function 6 Function 7	RCC	III Flight Surveillance & Control
	Separation Assurance	Function 6 Function 8	RCC	III Flight Surveillance & Control

TABLE 5—SUMMARY OF EVENTS AND SYSTEM OPERATIONS (Continued)

EVENT	ASSOCIATED SERVICES	RELATED FUNCTIONS	FACILITY	AATMS OPERATOR
G-5 TERMINAL TO EN-ROUTE TRANSITION	Flight Plan Conformance	Function 5 Function 6 Function 7 Function 11 Function 13	RCC	III Flight Surveillance & Control
	Separation Assurance	Function 6 Function 8 Function 11 Function 13	RCC	III Flight Surveillance & Control
	Spacing Control	Function 5 Function 6 Function 9 Function 11 Function 13	RCC	III Flight Surveillance & Control
A-6 G-6 EN-ROUTE FLIGHT PLAN CHANGE	Information Services	Function 1	THC	IB Flight Info. Services
	Flight Plan Conformance	Function 4 Function 5 Function 6 Function 7	RCC	III Flight Surveillance & Control
G-7 THC FAILURE AND RECONFIGURATION		Function 13	THC RCC	III Flight Surveillance & Control

TABLE 5 —SUMMARY OF EVENTS AND SYSTEM OPERATIONS (Continued)

EVENT	ASSOCIATED SERVICES	RELATED FUNCTIONS	FACILITY	AATMS OPERATOR
A-7 DESCENT AND G-8 LANDING	Spacing Control	Function 5 Function 9 Function 11	THC (RCC)	III Flight Surveillance & Control
	Separation Assurance	Function 8 Function 11	THC (RCC)	III Flight Surveillance & Control
	Flight Advisory Services	Function 12	THC	IB Flight Info. Services
	Record Services	Function 4 Function 14	CCC	IA Data Base