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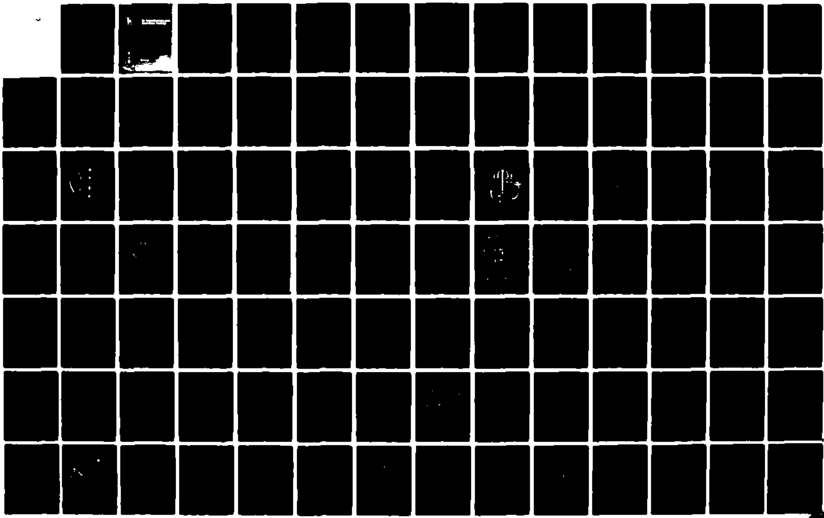

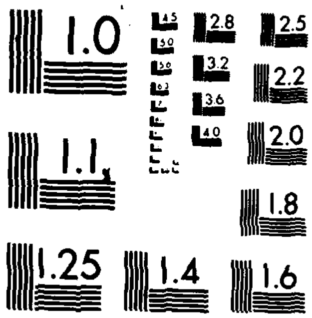

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16. Abstract This document captures in one place the information processing tasks of the en route and terminal controller. This will serve to aid the engineer and designer of the future Advanced Automation System (AAS) with some insight into the why, what, and how of current Air Traffic Control operations. The AAS will see the integration and consolidation of terminal and en route processes into what is termed the Area Control Facility (ACF).

This document takes an operational view of the current systems and presents data on how the controller does his perceptual, cognitive, and motor functions. The analysis approach is to treat the controller as a human information processor who interacts with a variety of ATC systems to perform the tasks of expediting, separating, and controlling air traffic. Specific methods and techniques are employed to rigorously identify and characterize these functions, or "information processing/handling tasks." From this one can infer, study, analyze, and eventually develop in the AAS the capabilities for aiding and improving controller productivity.

In addition, this document preserves, for the purposes of transition to the ACF, the design information that is applicable to the activities of a controller. These are the set of activities and information processing tasks performed at the Radar Positions in terminal approach control and en route centers. The focus of this document is on the composition and analysis of controller tasks, and not on the machine functions described in NAS Stage A3d2 and ARTS II, III Technical documentation.

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This document is the first of a series to be used for the development and test and evaluation of man-machine interface requirements for the Advanced Automation System. It's purpose is to aquaint people involved in the Advanced Automation System man-machine interface design with an understanding of Air Traffic Control and the job of the air traffic controller.

The effort put forth by the Air Traffic Service Sector Suite Requirements Validation Team, Computer Technology Associates and the Advanced Automation Program Office has produced a very accurate and comprehensive description of the air traffic control system and the tasks of the air traffic controllers.

The value of this document far exceeds its original intent. It is more than applicable only to the development of the Advanced Automation System. It will provide the private sector and our own internal organizations with a better understanding of air traffic control concepts and the tasks that the air traffic controller performs in his endeavor to provide a safe, orderly, and expeditious flow of air traffic in the finest air traffic control system in the world.

R. J. Van Vuren
Director, Air Traffic Service

FOREWORD

The documentation of current NAS en route and terminal controller operations is critical to the success of the Federal Aviation Administration's (FAA) Advanced Automation System (AAS).

Why? Studies to date have not adequately addressed how both the en route and terminal controllers do their job in terms of tasks and interactions with the NAS Stage A and ARTS II,III Systems. Tomorrow's system, the AAS, will see the integration and consolidation of terminal and en route processes into what is termed the Area Control Facility (ACF). The purpose of this document is to capture, in one place, the information processing tasks of the en route and terminal controller. This will serve to aid the engineer and designer of the AAS with some insight into the why, what, and how of current NAS operations.

This document, of necessity, takes an operational view of the current systems and presents data on how the controller does his perceptual, cognitive, and motor functions. Our approach is to treat the controller as a human information processor who interacts with a variety of ATC systems to perform the tasks of expediting, separating, and controlling air traffic. Our view is to rigorously identify and characterize these functions, or better termed "information processing/handling tasks," in such a way that the engineer can understand the job of a controller. From this bank of knowledge one can infer, study, analyze, and eventually develop in the AAS the capabilities for aiding and improving controller productivity.

In addition, this document preserves, for the purposes of transition to the ACF, the design information that is applicable to the activities of a controller which must be implemented in the initial implementation step of the sector suite. Here we refer to the set of activities and information processing tasks performed at the radar positions in terminal approach control and en route centers.

Note that the focus of this document is on the composition and analysis of controller information processing tasks, and not on the machine functions described in NAS Stage A3d2 and ARTS II,III technical documentation.

This document also serves the secondary purpose of representing the body of knowledge about controller operations which has been evaluated and validated by the community of Air Traffic Controllers through their Air Traffic Service representatives on the Sector Suite Requirements Validation Team. This validation process will serve the purpose of improving the accuracy and validity of documenting how the controller does his job. It is also the basis for synthesizing and identifying the requirements and operating concepts for the AAS man-machine interface (MMI).

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LIST OF ACRONYMS

AAPO	Advanced Automation Program Office
AAS	Advanced Automation System
AATMS	Advanced Air Traffic Management System
AFTN	Aeronautical Fixed Telecommunications Network
AMIS	Aircraft Movement and Information Service
ASR	Airport Surveillance Radar
ATCT	Airport Traffic Control Tower
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ANK	Alphanumeric Keyboard
ACF	Area Control Facility
RNAV	Area Navigation Route
ARAC	Army Radar Approach Control
ARTS	Automated Radar Terminal System
BUEC	Backup Emergency Communications
BANS	Brite Alphanumeric Subsystem
CARF	Central Altitude Reservation Function
CCC	Central Complex Computer
CFCF	Central Flow Control Facility
CD	Common Digitizer
CDC	Computer Display Channel
CTA	Computer Technology Associates, Inc.
CUE	Computer Update Equipment
CRD	Computer Readout Device

LIST OF ACRONYMS (Cont'd)

DCCU	Data Communication Control Unit
DEDS	Data Entry and Display Subsystems
DOE	Department of Energy
DOT	Department of Transportation
DARC	Direct Access Radar Channel
DF	Direction Finder
DME	Distance Measuring Equipment
EARTS	En Route Automated Radar Tracking System
E-MSAW	En Route Minimum Safe Altitude Warning
ETG	Enhanced Target Generator
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FPA	Fix Posting Area
FDEP	Flight Data Entry and Printout
FDP	Flight Data Processing
FF	Flight Following
FSS	Flight Service Station
FSP	Flight Strip Printer
FC	Flow Control
FAD	Fuel Advisory Departure
FDB	Full Data Block
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions

LIST OF ACRONYMS (Cont'd)

INSAC	Interstate Airway Communications
LORAN	Long Range Navigation
LORAN-C	Later Version of LORAN
MMI	Man-Machine Interface
MLS	Microwave Landing System
BASOPS	Military Base Operations
MOA	Military Operations Area
MSAW	Minimum Safe Altitude Warning
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NATAC	National Air Traffic Automation Coordinating Committee
NATCOM	National Communications Facility
NAVAID	Navigational Aid
NDB	Nondirectional Radio Beacon
NOTAM	Notices to Airmen
NORDO	No Radio
VORTAC	Omni-Directional Range/Tactical Air Navigation
OJT	On-the-Job Training
PEM	Peripheral Entry Module
PIREP	Pilot Report
PVD	Plan View Display
PDAR	Preferential Departure/Arrival Route
PIDP	Programmable Indicator Data Processor
QAK	Quick Action Key
RATCF	Radar Air Traffic Control Facility
RAPCON	Radar Approach Control

LIST OF ACRONYMS (Cont'd)

RDP	Radar Data Processing
RML	Radar Microwave Link
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival
SFP	Stored Flight Plan
SDCS	Supervisory Flight Data Communications Specialist
TACAN	Tactical Air Navigation
TCA	Terminal Control Area
TML	Television Microwave Link
TRACON	Terminal Radar Approach Control
TRACAB	Terminal Radar Approach Tower Cab
TRSA	Terminal Radar Service Area
TAS	True Air Speed
VOR	Very High Frequency Omni-Directional Range
VLF	Very Low Frequency
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
WC	Weather Coordinator

Chapter 1.0

Introduction and Executive Summary

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

1.1 ORGANIZATION OF DOCUMENT CONTENTS AND STRUCTURE

Major sections in this analysis are arranged to provide the reader with an understanding first of:

a. the history and evolution of Air Traffic Control (ATC) systems, from the use of airway radio stations to recent automation efforts.

b. the concepts of airspace navigational aids and route structure, and notions of controlled airspace.

c. the concepts of terminal approach control and en route ATC centers.

d. the elements of air traffic control (e.g., flight plans, separation standards/procedures, advisory services).

e. current NAS Stage A and ARTS system capabilities and machine support, special aids and functions.

f. current controller operational organizations.

Items a through f are covered in Chapter 2.0, entitled "Air Traffic Control Operational Environment. Chapter 3.0, "Air Traffic Control Operational Events", provides the reader with a description of events involving single aircraft and multiple aircraft. Furthermore, descriptions are provided for contingency situations such as missed approaches, runway changes, and conflict alert. From these descriptions, controller actions vis-a-vis each event are identified as activities and sub-activities in Chapter 4.0.

Chapter 4.0, "NAS ATC En Route and Terminal Operations Activities," translates events onto the man-machine activities performed by the controller. Although the controller constantly is anticipating and planning actions, the premise of this section is that controllers are "event responsive" human information processors (in the engineering sense). To support this premise, the controller activities and sub-activities identified in Chapter 4.0 are associated with ATC events. Also associated with ATC events are the NAS messages and information obtained from radio and interphone communications, situation displays, and flight strips used by the controllers. The notion of defining controller activities is to identify (at the conceptual level) the man-machine pairs (which involve controller actions and machine actions) to provide a direct mapping between events and current NAS Stage A and ARTS II, III operations.

In Chapter 5.0, "NAS ATC En Route/Terminal Controller Information Handling and Processing Tasks," the reader is provided with a more detailed composition of controller activities. These activities and sub-activities defined in Chapter 4.0 are decomposed into controller tasks and may represent en route unique, terminal unique, or common methods used by controllers regardless of the type of event. This low level of analysis includes details of controller task sequences, his information requirements, and the man-machine dialogue.

Chapter 6.0, "NAS ATC Position Operations and Workload Assessment," provides human factors analysis of tasks. This analysis shows how tasks are performed by the radar and manual controller positions to share and reduce individual workload. Also, preliminary qualitative workload assessments of the perceptual, cognitive, and motor facets of the controller job are provided.

Chapter 7.0, "Significant Observations, Issues, and Conclusions," leads to a synopsis of CTA's observations and significant issues. Finally, the report examines areas which require further investigation and analysis.

Please note that Chapters 2.0 through 5.0 are presented as levels of knowledge or information about the ATC system and the job of a controller. Figure 1-1 provides a "technoglyph" of how these levels are structured. This document was structured for several types of readers, i.e., those who are completely unfamiliar with air traffic control and those with varying degrees of knowledge. For the engineer or designer who is not familiar with the ATC system, this document is structured to first give a broad understanding of the ATC system (Chapter 2.0), then provide a description of events as they might occur in an operational scenario (Chapter 3.0). Chapter 4.0 provides a high level description of the activities and sub-activities of a controller. This is intended to give the reader a conceptual picture of what the controller does. In Chapter 5.0, details of the controller's job are given at a level that is observable in either a radar approach control or en route facility. Chapter 5.0 provides a detailed description of the interaction between the controller and his workstation. Chapter 6.0 describes the job of a controller in terms of terminal radar, en route radar, and manual controller positions.

The more knowledgeable reader can use the table of contents to select portions of this document both for quick reference and detailed review. Information contained in Chapters 4.0 and 5.0 is structured hierarchically to permit the reader to map from a set of controller activities, to sub-activities, to detailed tasks.

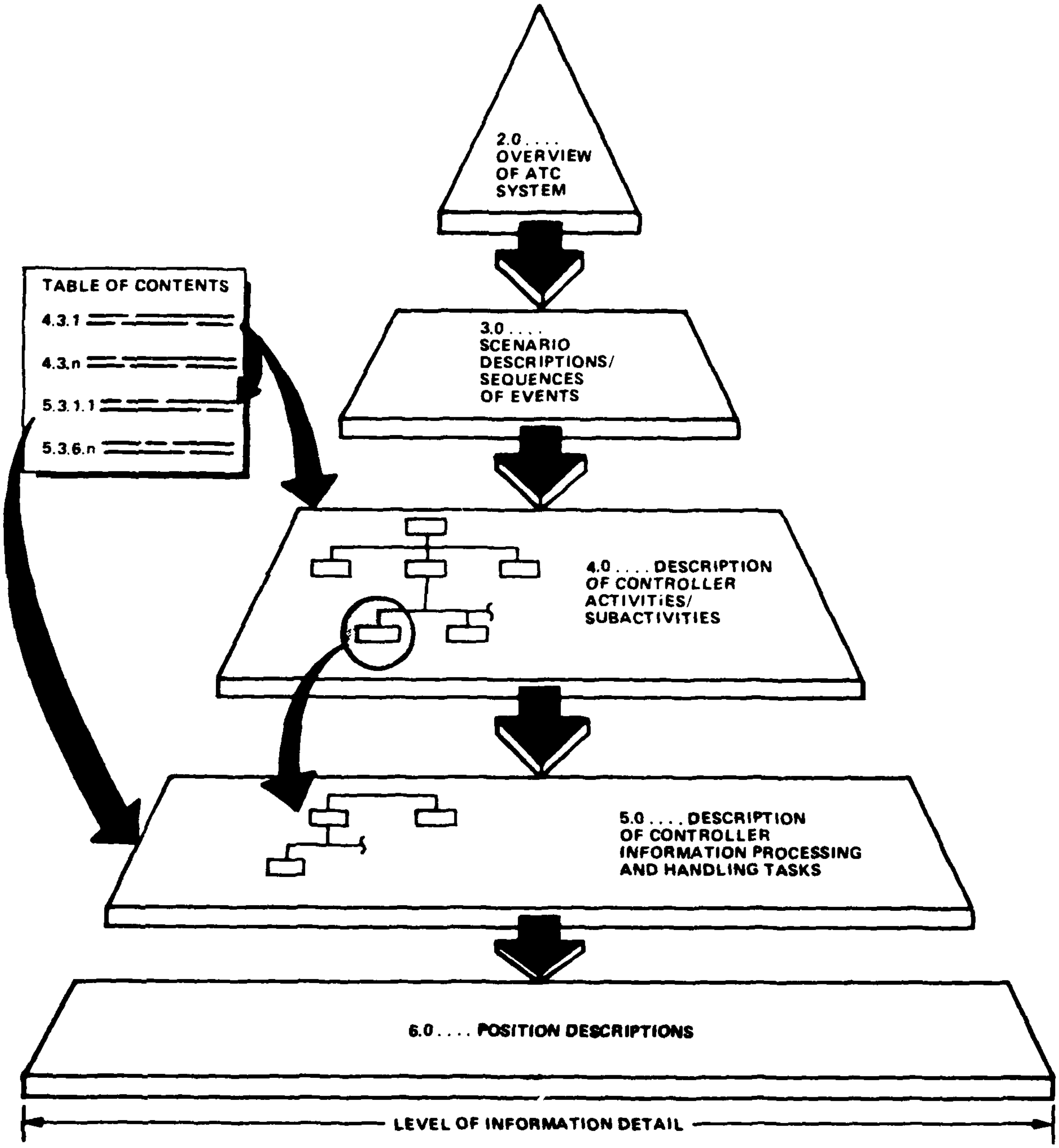


Figure 1-1 Levels of ATC Knowledge Described in This Document

1.2 OBJECTIVES

The purpose of this analysis is to document en route and terminal controller operations and information processing tasks. This effort has involved:

- integrating CTA observations of controller tasks and incorporating the results of earlier studies and data collection efforts (See Annotated Bibliography in Appendix A),
- focusing on similarities and differences among the various terminals and centers,
- reviewing/debriefing results with controllers and FAA Headquarters offices,
- verification of "current *operations*" procedures and methods for man-machine interface by the FAA AAS Sector Suite Requirements Validation Team and Air Traffic Service.

The objectives of this analysis are three-fold:

1) Communicate to the AAS contractor designers the "core" of ATC operations which must be implemented for Initial Sector Suite and Final Sector Suite.
2) Provide a knowledge base from which design concepts for the AAS man-machine interface can be derived.
3) Establish an AAS contractor knowledge base and understanding of current NAS controller operations.

The documentation of current NAS en route and terminal controller operations is critical to the success of the FAA's AAS. As noted in the Foreword, the purpose of this document is to capture in one place the information processing tasks of the en route and terminal controller. This will serve to aid the engineer and designer of the AAS with some insight into the why, what, and how of current NAS operations.

A follow-on effort will be to produce an operations concept for the AAS Man-Machine Interface. We use the term "operations concept" to mean the following:

- A functional description of a system's operational requirements from the operator's view, assessment of workload and human performance levels, and associated information requirements by user/operator position. (Information processing requirements incorporate cognitive and perceptual components of displays, viewability criteria, information presentation/interaction techniques, and dialogue definitions.)

The operations concept is viewed as task oriented, not data-processing function oriented. The operations concept will formally record the interfaces and allocation of requirements between man and machine. This notion is the opposite of a system level specification, which stipulates requirements independent of allocation to people, hardware, and software. The operations concept defines what the system looks like to the user.

We use the term "task" to denote a "meaningful unit of work performed by the controller" which has the properties of task closure, specific human performance indices or goals, single event stimulus, and multiple response or output possibilities. The supposition is that, if one can define what the controller does in terms of sequences of actions, then the dialogue between the controller and the workstation is a logical derivation.

CTA plans to work closely with the Sector Suite Requirements Validation Team to define and structure Man-Machine Interface (MMI) requirements for controller positions in such a way that:

1) MMI operations concepts developed to date are evaluated and incorporated as appropriate;

2) MMI requirements definitions are based on proven techniques used in current operations; and

3) Sufficient detail is available to the AAS contractor to understand explicitly the man-machine interface for each controller task.

   It is recognized that controllers interface with pilots and controllers, but the term MMI is meant to include those interchanges that involve messages and/or communication.

1.3 SCOPE: TERMINAL AND EN ROUTE OPERATIONS

The scope of this analysis is limited to the on-line controller operations at en route and terminal radar approach control facilities. This includes the radar, manual, and assistant controller positions at the en route centers, and the radar positions at the terminal facilities. The types of sectors/positions which have been studied include:

- High Altitude } En Route Center
- Low Altitude } En Route Center

- Satellite } Terminal
- Arrival/Feeder } Terminal
- Final } Terminal
- Departure } Terminal

Here we are using the term sector/position to denote the workstation for which the controller has responsibility to actively monitor the activities and maintain separation of aircraft.

This document also examines both a range of routine and non-routine events which the controller, in performing his usual tasks, will react to and/or anticipate. Descriptions have not been provided for events such as catastrophes, hi-jackings, or sensitive U.S. Government in-flight operations.

This document does not consider the specialized activities of the supervisory controller, flow controller, and center meteorologist.

1.4 ASSUMPTIONS

Our basic human information processing model of a controller assumes that we can characterize controller activities as being "event sensitive." It is also assumed that tasks can be characterized as shown in Figure 1-2.

Events which are the result of the interactions between aircraft, airports, airspace, weather, and the ATC environment represent the input stimulus to the controller. Included in the ATC environment are controller/controller, pilot/controller, controller/staff, and controller/machine interactions. A controller task is the sequence of interactions which is either triggered by a previous task or an event, and which results in a detectable controller action. An example of a task is: "generate a clearance for speed control, altitude change, or heading change" (e.g., climb and maintain flight level 330).

Note, in Figure 1-2, that the event stimulus can be characterized in terms of some message input via a situation display, voice contact with pilot or controller, flight strip, or weather report. This stimulus causes the controller to integrate system parameters such as separation standards, geographic references, route structure, and situation. This leads to the generation of control responses (such as coordination actions, clearance delivery, message acknowledgement, flight strip marking, or transition to a next task), and the requesting and generation of further information on such issues. Furthermore, characteristics which represent the controller action or response can be correlated to the completion of a task and the time or effort required for task accomplishment. Supporting this fundamental assumption are the underlying formalisms of decomposition, control theory, state space theory, information flow, and concurrency which are described in Axiomatic Requirements Engineering, a TRW technical report authored by Mack Alford in 1978 [References 1,2].

Other specific assumptions include:

- the assertion that formal *rules of decomposition* (or refinement of controller activities into lower levels of detail) can be used to describe the breakdown of controller activities into sub-activities and, finally, controller information processing tasks and subtasks,
- the assertion that the composition of controller activities and information processing tasks can be described using a graph which preserves the human information processing properties of concurrency, decision-making, sequential execution of tasks, and mental iteration, or closed loop repetitive task execution. The graphs are called composition graphs and are described in Fig-

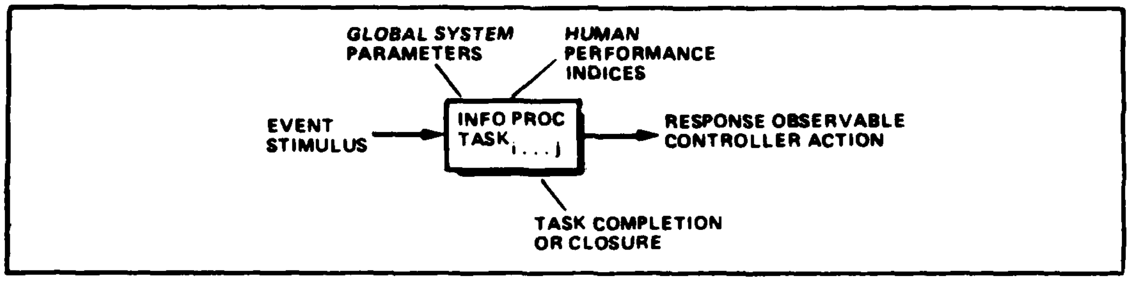
ure 1-4 in Section 1.5,

- the assertion that controller subtasks are the lowest level of analysis and reflect the direct, observable interaction between the controller and his workstation situation, including those cognitive and perceptual actions which can become "observable" through controller report of the action taken,

- there exist activities and tasks which are both common and unique to terminal approach control and en route operations,

- the assertion that most of what is available in the literature regarding the controller's job is in terms of his motor tasks, e.g., generate clearance, depress quick action key, locate aircraft flight data block, etc,

- the inference that the controller performs "manually" many activities that could potentially be automated.



DEFINITIONS:

INFORMATION PROCESSING TASK	–	A PERCEPTUAL, COGNITIVE OR MOTOR UNIT OF WORK WHICH HAS THE FOLLOWING PROPERTIES
EVENT STIMULUS	–	OCCURRENCE OF AN EVENT WHICH CAN BE CHARACTERIZED IN TERMS OF SOME MESSAGE INPUT VIA A SITUATION DISPLAY, FLIGHT STRIP, INTERPHONE/RADIO COMMUNICATION OR WEATHER REPORT
GLOBAL SYSTEM PARAMETERS	–	SEPARATION STANDARDS, PROCEDURES, GEOGRAPHIC REFERENCES, AND OTHER ADAPTATION DATA
RESPONSE	–	OBSERVABLE CONTROLLER ACTION. MAY ALSO REPRESENT THE INITIATION OF AN EVENT
HUMAN PERFORMANCE INDICES	–	TIME OR EFFORT REQUIRED FOR TASK ACCOMPLISHMENT
TASK CLOSURE	–	COMPLETION CONDITION SUCH AS A TRANSITION TO NEXT TASK OR TASK ACCOMPLISHMENT

Figure 1-2 Controller Information Processing Model

1.5 METHODOLOGY AND LOGIC FOR PREPARATION OF THIS DOCUMENT

CTA followed a rigorous method [Reference 3] for preparing this document to assure completeness and consistency and also present the results of our analysis in a logical fashion.

Our logic process begins with the initial premise that terminal and en route controller operations can be characterized in terms of the relationships between the ATC external environment and the operations at the en route and terminal facilities. This concept is illustrated in Figure 1-3. This figure shows that the ATC external environment is composed of airspace, weather, aircraft, airway/airport facilities, and surveillance capabilities. Figure 1-4 provides a set of formalisms for specifying these relationships in a rigorous manner.

Airspace is bounded by elements such as the geography, terrain, obstacles, airway route structures, and weather. Aircraft is functionally related to airspace in terms that aircraft navigate through airspace using random routes or the formal airway route structures. Aircraft can be characterized as IFR (Instrument Flight Rules) or VFR (Visual Flight Rules) and designated as either commercial, general aviation, or military. The term Airway/Airport Facilities here is used to denote airports, runways, ATC equipment, and navigation aids. These facilities are directly related to aircraft and airspace in the sense that aircraft flying published routes rely on navigational aids for en route and arrival/departures at airports which may be affected by terrain or man-made obstacles and weather.

Surveillance Capabilities fall in the category of radar coverage of aircraft and weather. For the application of non-radar ATC procedures as defined in ATC procedures for control of aircraft, see Air Traffic Control, 7110.65, plus standard operating procedures and agreements at each ATC facility.

The importance of the relationships among airspace, aircraft, facilities, and surveillance capabilities from the controller perspective is that events (which trigger controller actions) can be characterized in terms of these elements, e.g.:

- Airway route configuration and composition, traffic volume and complexity, and weather affect the manner in which controllers expedite and separate traffic. Weather related events may include IFR minimums which affect facilities and, thereby, result in reducing runway capacity. Obstacles and terrain force the controller to maintain aircraft at safe minimum altitudes.

- Aircraft movement may trigger events such as inflight amendments to plan, preferential routing, request for direct route segments, missed approaches, loss of radio con-

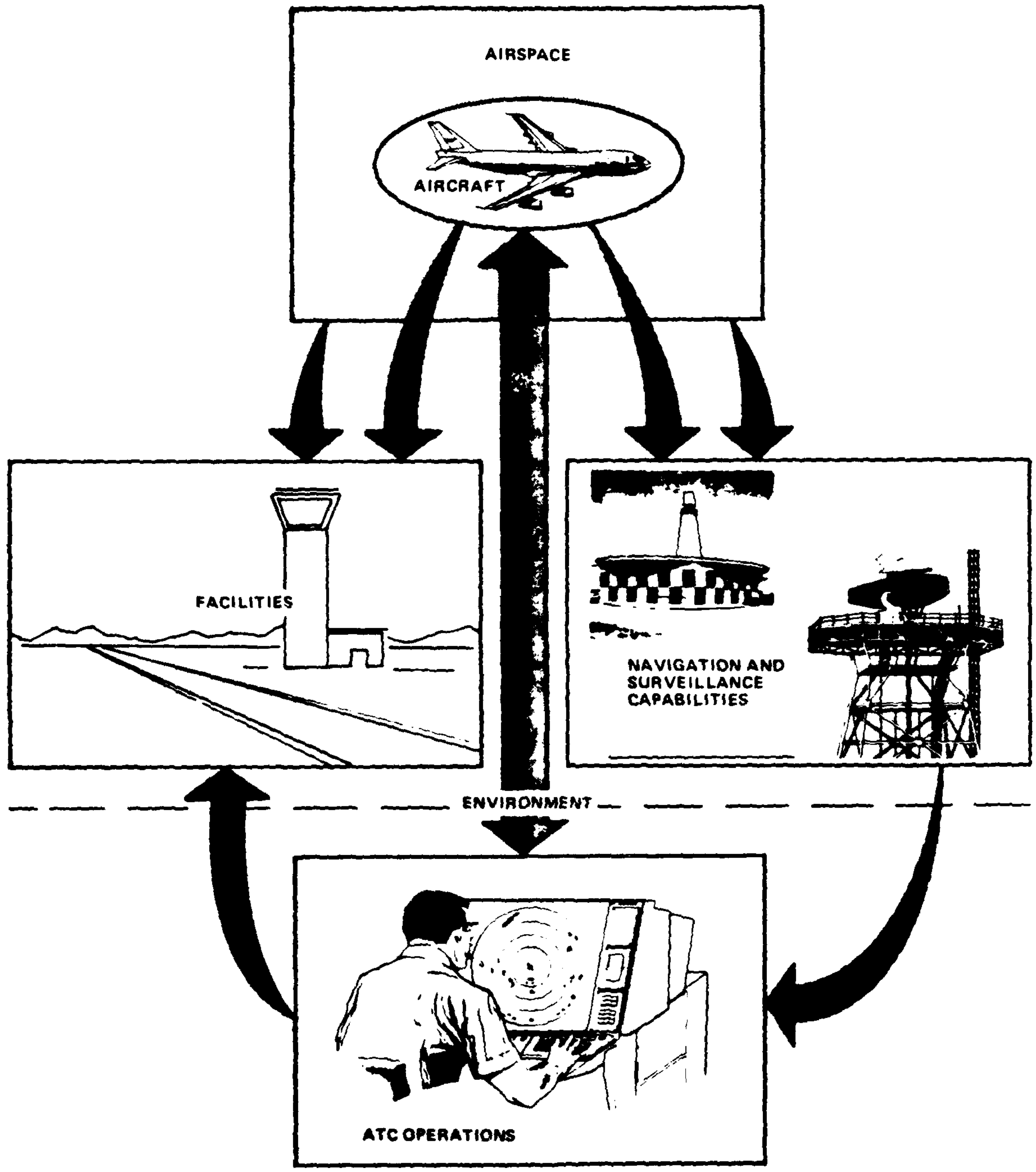


Figure 1-3 ATC Environment vs ATC Operations (Refer to Figure 1-4)

ATC ENVIRONMENT AND ATC OPERATIONS RELATIONSHIPS

ATC ENVIRONMENT:

ENVIRONMENT = AIRSPACE ∪ AIRCRAFT ∪ FACILITIES ∪ SENSOR CAPABILITIES

WHERE:

AIRSPACE = {GEOGRAPHY, AIRWAY ROUTE STRUCTURE, OBSTACLES, WEATHER}

AIRCRAFT = {(IFR, VFR CAPABILITIES), (COMMERCIAL, GENERAL AVIATION, MILITARY)}

FACILITIES = {AIRPORTS, FLIGHT SERVICE STATIONS, RUNWAYS, ATC EQUIPMENT}

NAVIGATION/SURVEILLANCE CAPABILITIES = {RADAR SURVEILLANCE AND NAVIGATION AIDS}
= ϵ (SENSOR TYPE)

ATC OPERATIONS

ATC OPERATIONS = f(SEPARATION/CONTROL PHILOSOPHY)

SEPARATION/CONTROL PHILOSOPHY = f(CONTROL PROCEDURES, SEPARATION STDS, ENVIRONMENT ADAPTATION, DIVISION OF RESPONSIBILITY)

DIVISION OF AIRSPACE RESPONSIBILITY = f(EN ROUTE, TERMINAL, AND TOWER OPERATIONS)

EN ROUTE/TERMINAL ATC OPERATIONS = {SECTOR/POSITION TYPES}

SECTOR/POSITION TYPES = {ARRIVAL, DEPARTURE, TRANSITION, FEEDER, HIGH ALTITUDE, FINAL, ETC.}

EVENTS, SECTOR/POSITION, ACTIVITY RELATIONSHIPS

EVENTS = ATC ENVIRONMENT INTERACTIONS ∩ ATC OPERATIONS, ERGO:

$\text{EVENT}_{i \ldots j}$ = AIRSPACE ∪ AIRCRAFT ∪ FACILITIES ∪ SURVEILLANCE CAPABILITIES ∪ ATC OPERATIONS

WHERE:

$\text{EVENT}_{i \ldots j}$ = f(SINGLE AIRCRAFT, MULTIPLE AIRCRAFT, FACILITY CONSTRAINTS, SURVEILLANCE STATE, AND ENVIRONMENT STATE)

SUCH THAT $\text{EVENT}_{i \ldots j}$ OCCUR IN PARALLEL AND SIMULTANEOUSLY WITHIN PURVIEW OF A SECTOR/POSITION

MESSAGE TYPE OR CONTROLLER INFORMATION = f($\text{EVENT}_{i \ldots j}$)

WHERE: $\text{EVENT}_{i \ldots j}$ ARE ACTIVITY STIMULI

SECTOR/POSITION TYPE ⇒ CONTROLLER ACTIVITIES

WHERE:

ACTIVITIES = f(EVENTS, SECTOR/POSITION TYPE, ADJACENT SECTORS/POSITIONS)

SUCH THAT ACTIVITIES MAY BE COMMON TO SEVERAL SECTORS/POSITIONS

IF MESSAGE TYPE_i = INPUT STIMULUS

MESSAGE TYPE_j = OUTPUT STIMULUS + TASK CLOSURE

THEN ACTIVITY (INPUT MESSAGE TYPE_i) ⇒ MESSAGE TYPE_j

THUS ACTIVITIES REPRESENT THE OPERATIONAL (CONTROLLER) TRANSFORM ON INPUT MESSAGES OR INFORMATION INPUT STIMULI [WHICH ARE A FUNCTION OF EVENT(s)] TO PRODUCE AN OUTPUT (MESSAGE TYPE_j) OR SUBSEQUENT EVENT_j

LEGEND:

∩	INTERSECTION OR PRODUCT OF
∪	UNION OF
{ }	AGGREGATE OF

Figure 1-4 Logic for Analysis and Description of Current NAS Operations and Controller Information Processing Tasks

ACTIVITY–TASK DECOMPOSITION

$ACTIVITY_{i \ldots j} \Rightarrow \{$HUMAN INFORMATION PROCESSING TASKS, MACHINE FUNCTIONS$\}$

WHERE ACTIVITY REPRESENTS THE ACTIONS PERFORMED BY A MAN–MACHINE PAIR, THUS ACTIVITY $\in$ NAS SYSTEM FUNCTION

AN ACTIVITY COMPOSITION ($ACTIVITY_i$) IS SAID TO BE A DECOMPOSITION TO TASKS IF:

1) $EVENT_i \downarrow EVENT_{i_1}$	INPUT/OUTPUT SEQUENCES PRESERVED
2) $RESPONSE_{j \ldots k} \downarrow RESPONSE_{j_1 \ldots k_1}$	
3) IF $ACTIVITY_i\ (EVENT_i) \rightarrow RESPONSE_{j \ldots k}$ THEN $TASK_1\ (EVENT_{i_1}) \rightarrow RESPONSE_{i_2 \ldots k_1}$	MAPPING PRESERVED
4) $CLOSURE = CLOSURE_{i_1}$	CLOSURE/COMPLETION CRITERIA PRESERVED
5) $PERFORMANCE_i = PERFORMANCE_{i_2}$	PERFORMANCE TRACEABILITY PRESERVED

TASKS $\Rightarrow$ SUBTASKS IF TRANSITIVITY IS PRESERVED

THUS THIS METHOD DEMONSTRATES THE PRESERVATION OF MAPPING BETWEEN EVENTS → ACTIVITIES → TASKS → SUBTASKS AND IS ALSO CORRELATABLE TO SYSTEM FUNCTIONS AND MESSAGE TYPES

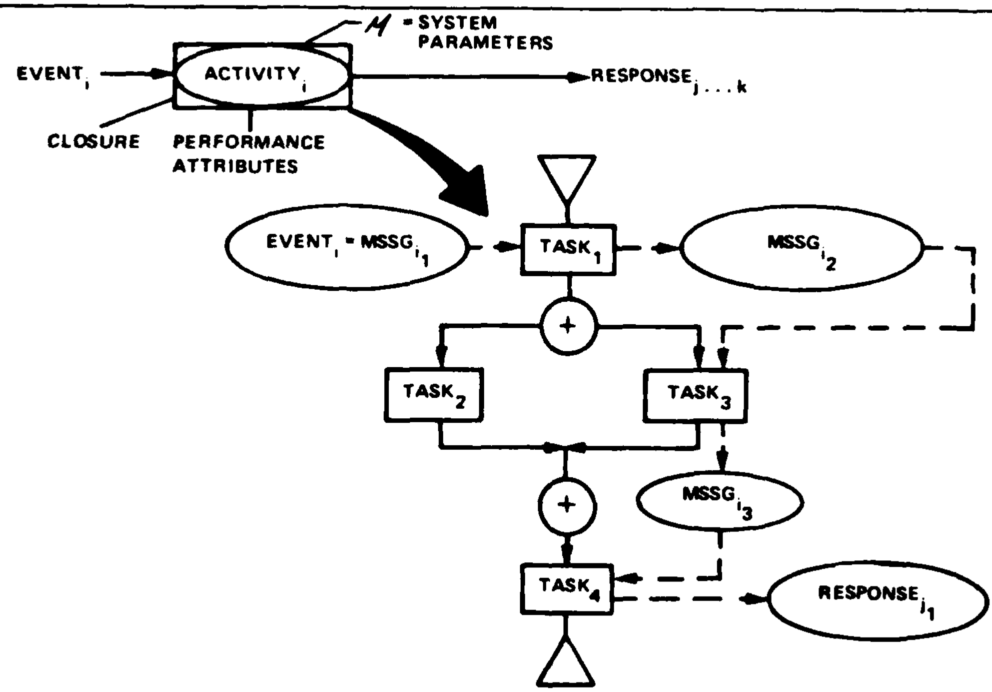


Figure 1-4 (cont)

tact, and potential conflicts with terrain, aircraft, or restricted airspace. Aircraft are "controlled" as a function of weather, airspace, and sensor coverage; and use the available services of airports, flight service stations (FSS), and navigation aids.

- Facilities such as airports/runways are resources affected by the weather to which ATC operations are restricted or metered. FSSs and navigation aids are services offered to aircraft pilots.

- Surveillance capabilities and flight progress strips provide the Air Traffic Controller with the capability to "see" the situation and take action to provide safe and expeditious flow of traffic.

The existing system was designed around the notion that airspace can be partitioned into airspace volumes (i.e., sectors/positions) such that the controller can monitor aircraft in his assigned airspace or area and maintain separation between aircraft, and aircraft obstacles. Sectors and positions are grouped into clusters or ATC facilities.

Fundamental to ATC operations is the concept of the aircraft Separation/Control Philosophy, i.e., the conduct of ATC operations is an implementation of that philosophy by the controller to assure safe and expeditious flow of traffic. The Separation/ Control Philosophy in ATC operations is a function of FAA separation standards, specific facility ATC procedures and interfacility agreements, division of airspace responsibility, and adaptation to the external ATC environment.

Division of airspace responsibility is related to an ATC Separation/Control Philosophy in that the controller "manages his airspace" in accordance with FAA ATC separation standards and procedures. In addition, this philosophy transcends a single sector or position by first requiring the formal transfer of aircraft control from sector to sector within a center, between centers, between centers and terminal approach control facilities, and between positions within an approach control facility; and, secondly, by requiring the uniform application of separation/control standards by all ATC facilities.

This introduces the premise that "ATC operations at sectors and positions carry out procedures to achieve safe/expeditious flow of traffic and are designed to respond to events which occur in the environment." Thus, one may conclude at this point, that the critical focus for analysis of ATC operations must be on sector/position types (e.g., low altitude, transition, final, arrival, etc.)

Furthermore, controller position types are normally a function of expected events and anomalous events (where events can occur simultaneously) within the area served by the sector. The second assertion is that "events are a function of single or multiple aircraft and their interaction with weather, airports, geography, and facilities." This leads to the conclusion *that the air traffic controller is an event-sensitive human information processor.*

The actions that a controller performs at his sector and position (in response to an event such as an air file flight plan or conflict alert) are defined as "activities."

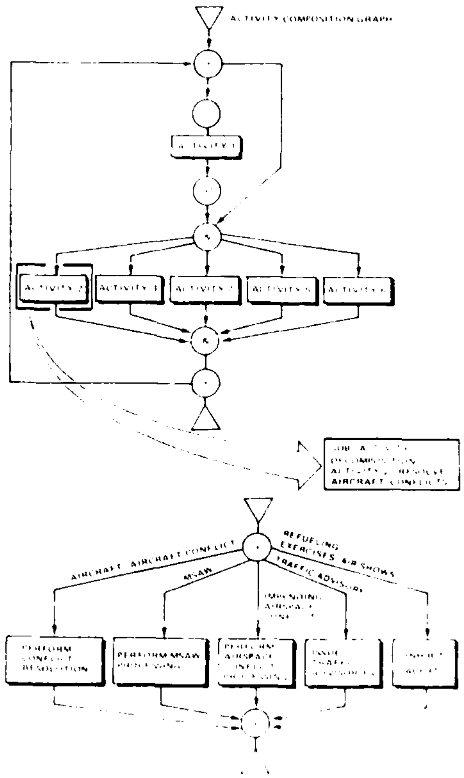
Activities represent the top-level functions or actions performed by the controller-machine pair. The term "controller-machine pair" is used in this context to denote the actions that a controller performs at his workstation in response to an event or events such as an aircraft that is departing his sector (which is an input stimulus to the controller), the handoff interaction sequence between the man and the machine, and the resulting output or response such as controller acknowledgement that he has accepted the handoff. In short, an activity is a subset of an en route or terminal controller function.

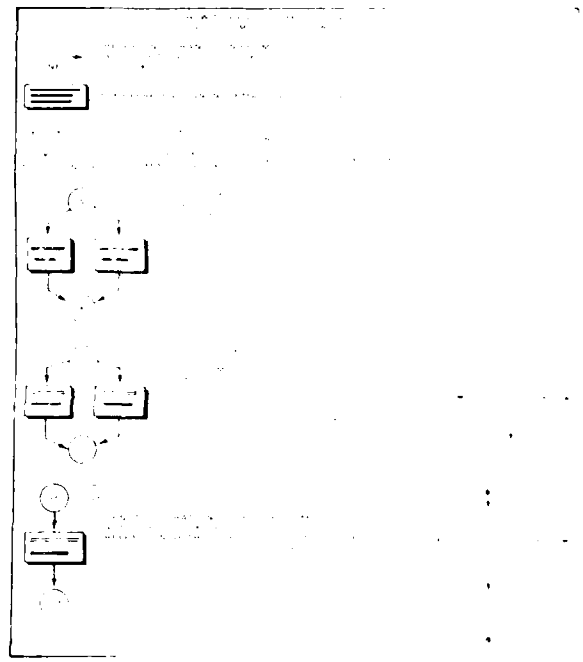
Activities are a function or the result of external events, the coordination among members of a controller sector suite team, or coordination between adjacent sectors/positions. Here the term "sector suite" refers to the controller's workstation.

Events can be associated with the type of information displayed, printed, or verbally communicated to the controller. For example, a conflict event between two aircraft may appear as a conflict alert message on the controller's display. Again, one can assume that events can be correlated in many cases to NAS message types. (Thus, if one can characterize the occurrence of events at a sector/position, one can derive or assess aspects of controller workload.)

The composition of an activity is an orderly arrangement of human information processing/handling tasks. Furthermore, the decomposition of an activity into sub-activities and, finally, into tasks preserves the transitivity or traceability of the event stimulus (via message type and input) and resultant response (message type and output, or controller acknowledgement of task closure). This diagramming technique is illustrated in Figure 1-5. Note in Figure 1-5 the discussion of composition graph symbols which define the sequential, concurrent, interactive, decision-making (path selection) flow of sub-activities and further decomposition of related information processing tasks. The composition graph is the diagramming technique we have selected because of its capability to preserve the multiprocessing attributes of the controller.

Composition graphs employ special symbology to reflect the parallel, conditional, and iterative manner in which the controller job may be performed. These symbols are located on a graph at both the beginning and ending point of that


ACTIVITY COMPOSITION GRAPH
ACTIVITY 1
AIRCRAFT CONFLICTS
AIRCRAFT - AIRCRAFT CONFLICT
MSAW
REFUELING
EXERCISES AIR SHOWS
TRAFFIC ADVISORY
PERFORM MSAW



particular process. Thus, there must always be a pair of the same process symbol, opening and closing that process on the graph. This pairing can be noted in Figure 1-5 and the graphs of Chapters 4 and 5.

Human Information Processing Tasks are meaningful units of controller work, and are referred to in Figure 1-2. Information processing tasks are decompositions of activities. Examples of tasks include: project future position/altitude of an aircraft, generate clearance, and evaluate traffic sequencing alternatives.

Controller tasks may be characterized as perceptual (visual), cognitive (mental) or, motor (voice, tactile) processes which can be qualitatively and quantitatively assessed. The controller performs multiple cognitive, perceptual, and motor tasks simultaneously. In addition, he is able to handle different priority levels on an interruptible basis.

Therefore, one can expand the characterization of a controller to that of: "an event-sensitive, interruptible information processor with the capability of handling multiple priority levels."

The current view is that much of what has been descriptive of a controller task has been in terms of controller motor actions which are easily observable, e.g., generate clearance, amend flight plan, force data block, etc. In fact, these tasks usually represent "closure" or completion of a task sequence. Closure denotes completion of a task and/or transition to next task.

A composition graph of tasks reflects linkages among the tasks, not a hierarchical arrangement that implies the "level" of the task. The first task is not an "overall task" to be accomplished by performance of the tasks that follow on the graph. Nor is a composition graph a flowchart in the usual sense, though a sense of task sequencing is inherent in the graph portrayal.

Tasks (and subtask descriptions) are stated to a functional level of what is accomplished by the controller. Low-level procedures or precise steps of how a task is performed on the current equipment are not detailed. Rather, their intent is to reflect what gets done without unduly restricting them to a particular version of equipment or specific procedure. Nor are local facility procedures stated, but only a functional statement of the controller's action. It may also be noted that a task is stated and numbered only once, with the sub-activity where it appears to have most meaning. Thereafter, in other composition graphs where it may also be relevant, the original task (or activity or sub-activity, as appropriate) is merely repeated in a dashed graph box (Refer to Figure 1-6). The reader may wish to refer to the original graph source for related tasks. Task numbering within its principal sub-activity is arbitrary and has no sequential meaning.

Information Processing Subtasks are the lowest level of decomposition of tasks and represent the direct implementation of the interaction between man and machine. An example of this is shown in Figure 1-6.

Task level compositions and associated information flows are then used to perform analysis of crew-team factors within a TRACON and en route center. In addition, preliminary assessments of human performance and controller workload can be derived.

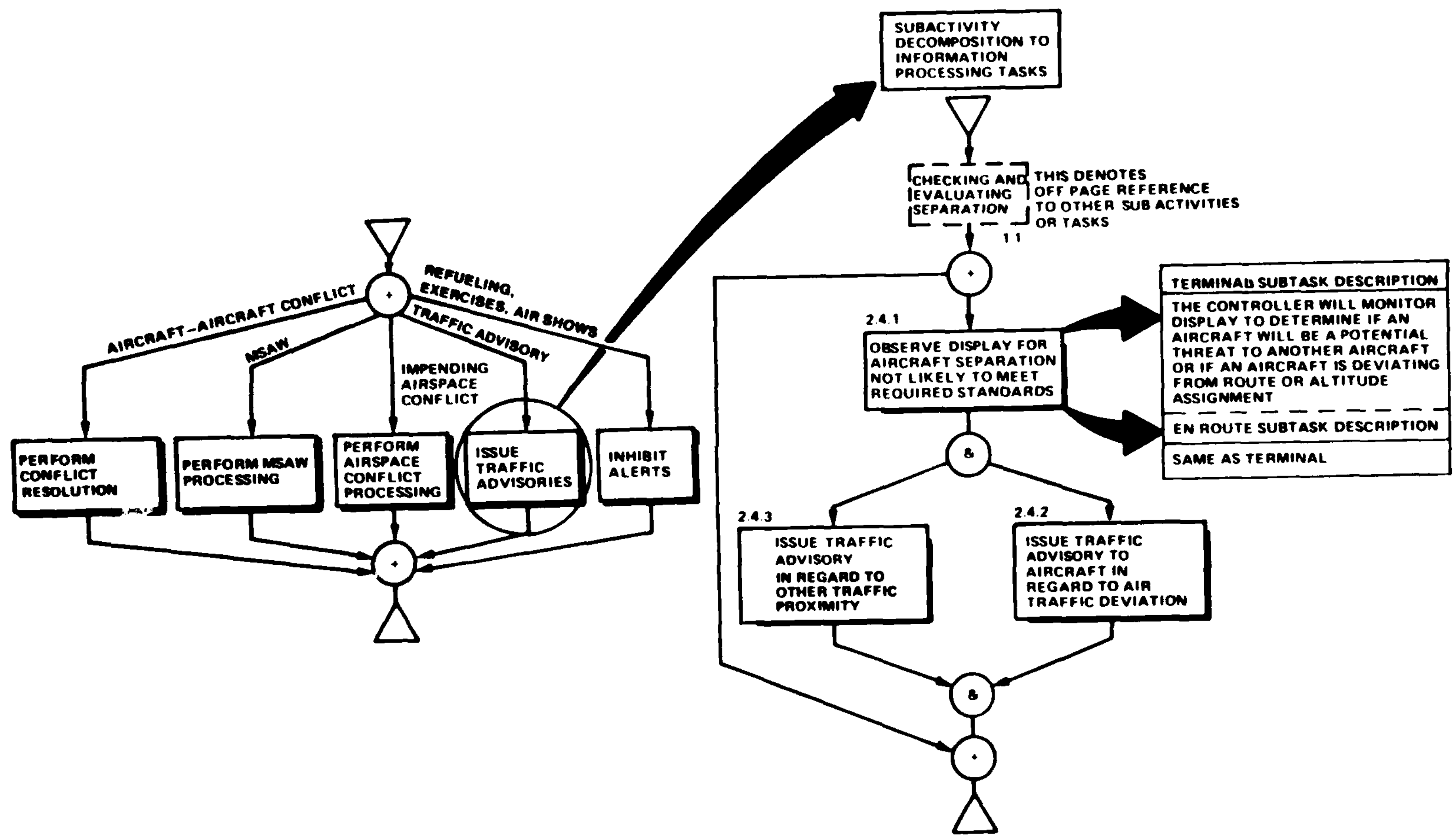


Figure 1-6 Sample Decomposition of Controller Sub-Activity Into Information Processing Tasks and Subtasks

1.6 REFERENCES

[1] Alford, M.W., Burns, I.F., et al. Axiomatic requirements engineering, Volume I (Final Report prepared for Ballistic Missile Defense Advanced Technology Center, Contract No. DASG60-78-C-0015). TRW DSSG, September 1978.

[2] Alford, M.W., Smith, T.C., & Smith, D.L. Formal decomposition applied to axiomatic requirements engineering (Final Report prepared for Ballistic Missile Defense Advanced Technology Center, Contract No. DASG60-78-C-0158). TRW DSSG, December 1979.

[3] Kloster, G.V., & Rosati, J.J. Draft and guidelines for the development of the MMI design guidebook (TRW Independent Research and Development Report), 1981.

Chapter 2.0

Air Traffic Control Operational Environment

2.0 AIR TRAFFIC CONTROL OPERATIONAL ENVIRONMENT

The purpose of this chapter is to provide the engineer with a comprehensive description of the environment that is external to the operations at the Air Route Traffic Control Center, the Airport Traffic Control Towers, and the Terminal Radar Approach Control facilities. This includes a description of controlled airspace, airway facilities, navigation aids, surveillance systems, air route structures, separation standards, and advisory services.

2.1 SUMMARY AIR TRAFFIC CONTROL SYSTEM DESCRIPTION

The National Airspace System (NAS) encompasses the common network of U.S. airspace; air navigation facilities, equipment, and services; airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information, manpower, and material. Included in the NAS are system components shared jointly with the military.

Within the NAS is a service that promotes the safe, orderly, and expeditious flow of air traffic (including airport, approach, and en route air traffic control). This organized system of service is called Air Traffic Control (ATC). The ATC system incorporates a combination of control equipment, techniques, procedures, and skills that have evolved over 40 years. This evolution has produced a mixture of equipment of many ages, technologies, and types. It is the safest, most efficient system in the world but it is very expensive to operate and maintain, expansion capability is limited, and adaptability is difficult.

Figure 2-1 provides an overview description of the operating elements of today's ATC system. As shown in the figure, the primary manned operational elements include the Air Route Traffic Control Center (ARTCC), the Airport Traffic Control Tower (ATCT) Terminal Radar Approach Control (TRACON), and Terminal Radar Approach Control in the Tower Cab (TRACAB). Note that this figure does not show nonradar approach control facilities; however, these are addressed later in this chapter.

The surveillance systems are composed of airport surveillance and long range radars and common digitizers which provide digital input into the air traffic computer systems. The en route computer system is referred to as NAS Stage A and provides automated tools to the controllers in the form of radar data displays and printed flight progress strips. The terminal computer systems are either Automated Radar Terminal System (ARTS) II or ARTS III. The ARTS provides for aircraft identification, tracking, and associated data display. Facilities are interconnected either by the National Communications (NATCOM) facility or by local Telecommunications interfaces. Pilots and controllers communicate through air/ground radio frequencies.

2.2 HISTORY OF AIR TRAFFIC CONTROL

2.2.1 Airway Radio Stations - First Center Towers

The earliest form of Air Traffic Control was the Airway Radio Station, which was later redesignated in 1938 as the Airway Communications Station. These early stations were normally used to communicate weather observations. The radio was shared by other government agencies such as the Department of Agriculture which reported on crop marketing. The stations were later called (INSACs) for Interstate Airway Communications which grew into the FSS facilities.

The first three en route ARTCCs were established by the airlines and were taken over in 1936 by the Bureau of Air Commerce. The number of centers grew to 29 before being consolidated into 20 continental U.S. and 3 offshore ARTCCs. Also, by the late 1930's at least 20 cities had established airport traffic control towers equipped with light guns for signalling and low powered radios. By 1941 the Civil Aeronautics Authority started taking over the towers. All three facility types which had their start as the experimental Airway Radio Station were now governed by the Civil Aeronautics Administration.

2.2.2 Results of Grand Canyon Crash

For many years air traffic controllers provided separation of en route air traffic by communicating with the pilot through a third party, either an airline company or an agency communication station. There was heavy dependence on visual separation or separation using low frequency airways.

A significant growth in the number of controllers, use of remote air/ground communications, and use of radar began after the collision of two airliners over the Grand Canyon in the late 1950's. Soon controllers were working with long range radar, direct pilot contact, and Very High Frequency Omni-directional Range (VOR) navigational aids. These improvements in the system, along with increased controller productivity, and the introduction of air carrier jet aircraft led to the establishment of the Positive Control Area, initially at 24,000 feet. The concept of the positive control area is to exercise control and insure separation of all air traffic at or above 18,000 feet (flight level 180).

2.2.3 First Automation Efforts - 1960's

By the early 1960's the agency began efforts to apply automation techniques to its flight data processing systems. By using UNIVAC and IBM equipment in six centers in the Northeast and later the UNIVAC ARTS at Atlanta Tower, the agency established that computers could be used to improve safety and increase the productivity of controllers. The computers used in the centers produced flight progress strips that required support by flight data personnel. The initial systems did not have any updating capability. The early ARTS featured a radar tracking system which was very dependent upon controller keyboard entries.

In 1968 a plan to automate many of the functions of the en route air traffic control system was approved. The system was called NAS Stage A, which contained several models for staged implementation. The first model was tested at Jacksonville ARTCC. This system was an important development, but was not implemented nationally. A National Air Traffic Automation Coordinating (NATAC) Committee, comprised of air traffic facility data systems specialists (who were former journeyman controllers) and air traffic headquarters specialists, was formed to assist the contractor in defining air traffic requirements and specifications. This led to the successful merging of the flight data processing (FDP) and radar data processing (RDP) in subsequent models of NAS Stage A. By 1973 all centers had implemented flight data processing programs and by 1975 the centers were operational with the radar data processing computer program.

Automation in the terminal facilities was accomplished by implementing the ARTS III at 63 large to medium facilities between 1971 and 1975. This system proved to be so successful that another contract was awarded to automate radar functions in an additional 87 medium size terminals by the late 1970's. This system is known as the ARTS II and differs from the ARTS III in that ARTS III predicts and tracks aircraft while ARTS II displays the reported aircraft position and does not predict/track the aircraft position.

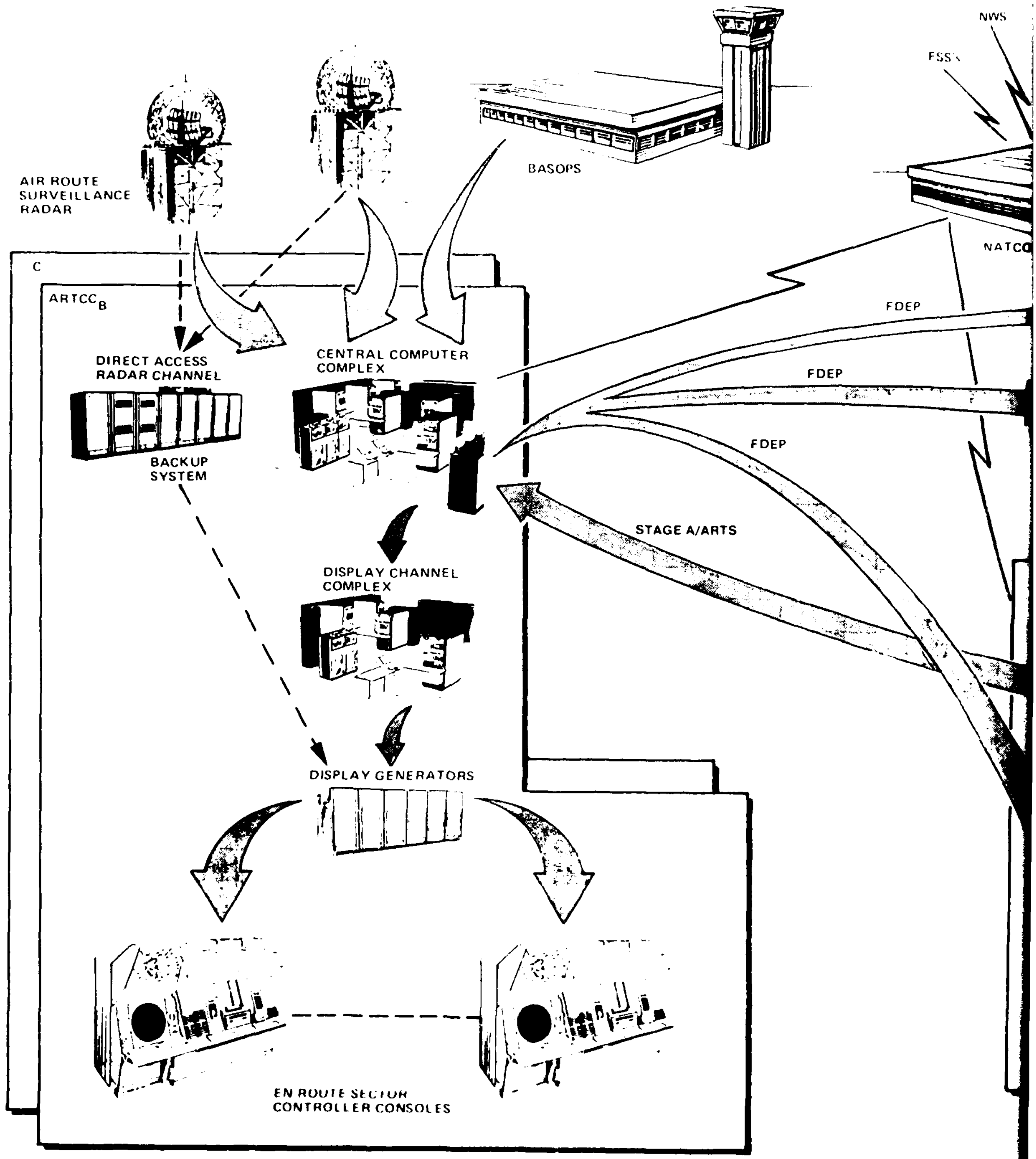
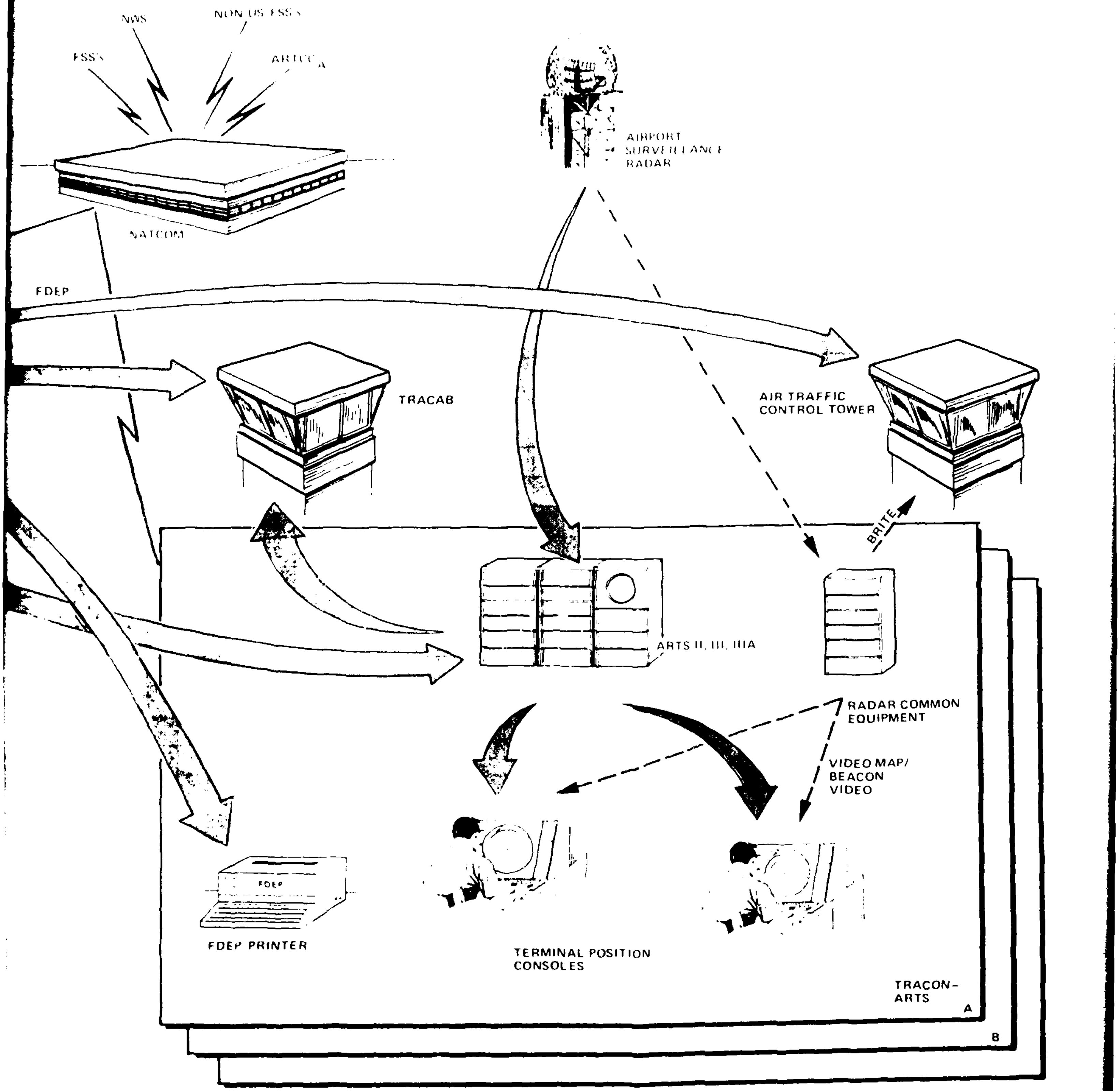


Figure 2-1 Operational Elements of Current ATC System


NWS
NON US FSS'S
FSS'S
ARTCC
NATCOM
AIRPORT
SURVEILLANCE
RADAR
FDEP
TRACAB
AIR TRAFFIC
CONTROL TOWER
BRITE
ARTS II, III, IIIA
RADAR COMMON
EQUIPMENT
VIDEO MAP/
BEACON
VIDEO
FDEP
FDEP PRINTER
TERMINAL POSITION
CONSOLES
TRACON-
ARTS
A
B

2.3 AIRSPACE CATEGORIES AND ROUTE STRUCTURE

This section describes the concept of controlled airspace and the airway route structure. This is descriptive of the current operational environment. Note that many details are described in figures and tables in this section.

2.3.1 Controlled Airspace

The controlled airspace over the United States consists of areas designated as Continental Control Area, Control Areas, Control Zones, Terminal Control Areas, Positive Control Area, and Transition Areas. When an area is designated as a controlled area, it is supported by air traffic control services, communications, and navigational aids. All other areas are designated as uncontrolled airspace. Air Traffic Control has neither the authority nor the legal responsibility for exercising control over air traffic in uncontrolled airspace. See Figure 2-2 for the various types of airspace and Table 2-1 for a description of controlled airspace categories.

2.3.2 Route Structure

Airway navigation today still uses the low (victor) airways and the high (jet) airways that were established in the 1960's. The use of Area Navigation routes (RNAV) is minimal. The accuracy of the navigation systems and the capability of aircraft to accurately navigate on the prescribed routes and landing systems are a major factor in any future consideration to reduce separation standards.

2.3.2.1 Low Altitude Airways

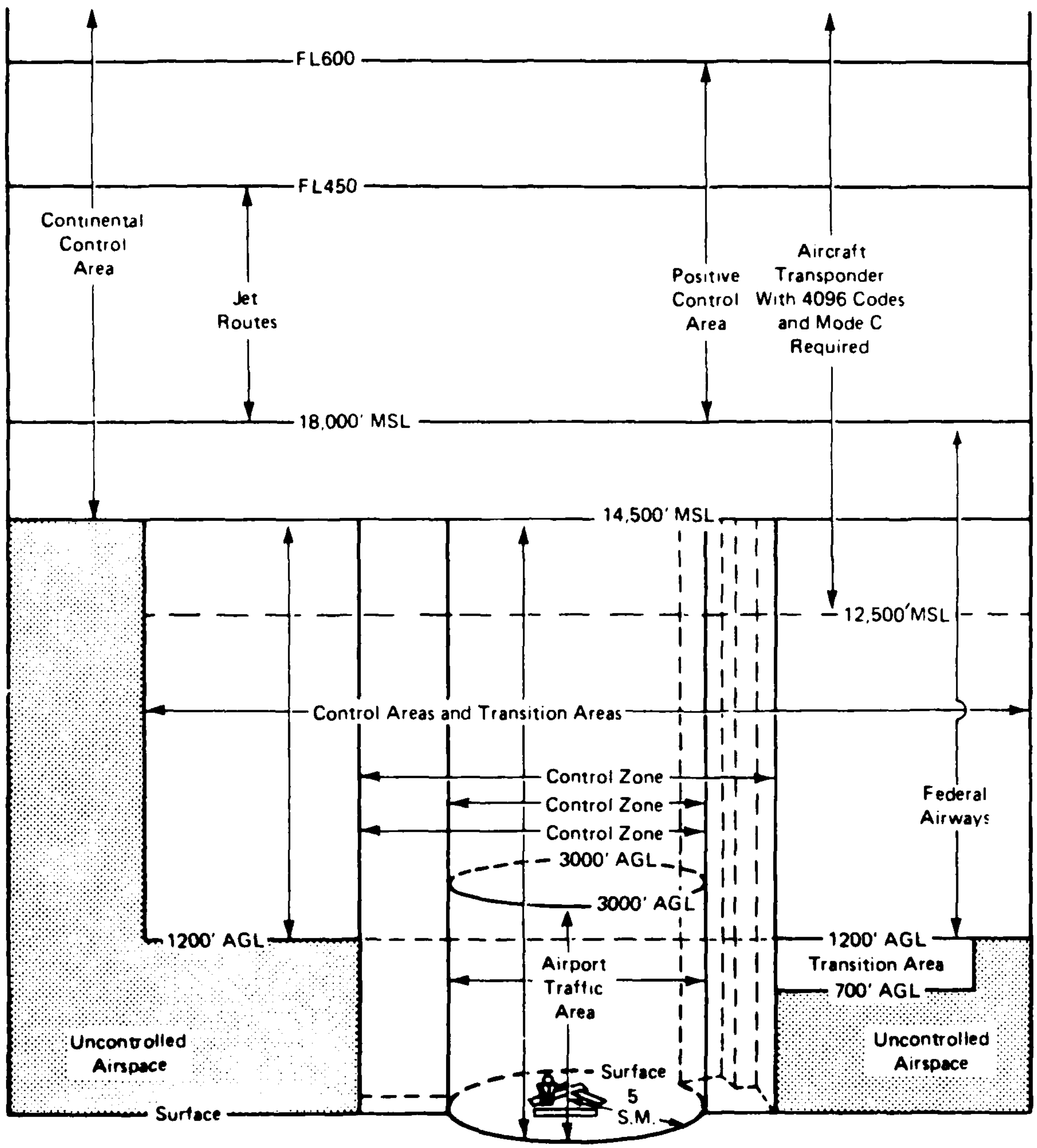
Normally, the low altitude airways are designated from 1,200 feet above ground level up to 17,999 feet. The azimuth feature of the VORs and VORTACs is used in the establishment of the route structure. The VOR, "V" or Victor, airways are even numbered east/west and odd numbered north/south. The "V" is followed by a discrete number to form a specific airway, e.g., V2, V137, etc. Normally, the lateral limits are up to 4 nautical miles on either side of the center line. See Figure 2-3 which depicts in chart form a low altitude airway.

2.3.2.2 Jet Routes

The high altitude or jet airways are designated at or above 18,000 feet. The azimuth feature of the very high frequency Omni-directional Range/Tactical Air Navigation (VORTACs) is used for the establishment of the jet route structure. The "J" airways are also even numbered east/west and odd numbered north/south. The "J" is followed by a discrete number to form a specific airway, e.g., J60, J102, etc., as is seen in Figure 2-4.

2.3.2.3 Standard Instrument Departure (SID)/ Standard Terminal Arrival (STAR)

Certain airports may have special published terminal routes. The SID/STAR is an ATC coded departure/arrival procedure which is established at airports to simplify clear-



ACL - Above Ground Level
FL - Flight Level
MSL - Mean Sea Level

Figure 2-2 Controlled Airspace

TABLE 2-1. DEFINITION OF AIRSPACE CATEGORIES

Continental Control Area	The continental Control Area consists of airspace above 14,500 feet, or 1,500 feet above surfaces higher than 14,500 feet, of the 48 contiguous states and part of Alaska.
Control Areas	Control Areas include the airspace associated with all federal airways.
Control Zones (CZ)	Control Zones extend from the surface up to the Continental Control Area and include one or more airports. The control zone is normally a circular area within a 5 mile radius and may include an extension necessary for an instrument approach or departure.
Terminal Control Areas (TCA)	Terminal Control Areas are controlled airspace which require all aircraft to comply with special operating rules and equipment requirements. The airspace extends from the surface to specified altitudes in the TCA. The lateral limits of the TCA are based on distance from the primary airport, and vary with altitude, often giving the appearance of an upside down wedding cake.
Positive Control Area	Positive Control Area is designated in the 48 contiguous states and parts of Alaska as airspace within which all aircraft are subject to operating requirements.

TABLE 2-1 DEFINITION OF AIRSPACE CATEGORIES (Cont'd)

Transition Areas	Transition Areas are designed to contain IFR operations in controlled airspace transitioning the terminal and en route environment. These airspace designations extend from 700 feet, in conjunction with an instrument approach or 1,200 feet in conjunction with an airway, upward to the base of the overlying controlled airspace.
Special Use Areas	In addition to controlled airspace are several special use areas. These areas are Prohibited Areas and Restricted Areas. Prohibited Areas are defined as areas where aircraft flights are prohibited. Restricted Areas are not wholly prohibited but may only be entered with authorization from the controlling agency. Other special use areas, such as Military Operations Areas, (MOAs), can be transmitted without an ATC clearance if operating under VFR or with a clearance if operating under IFR.

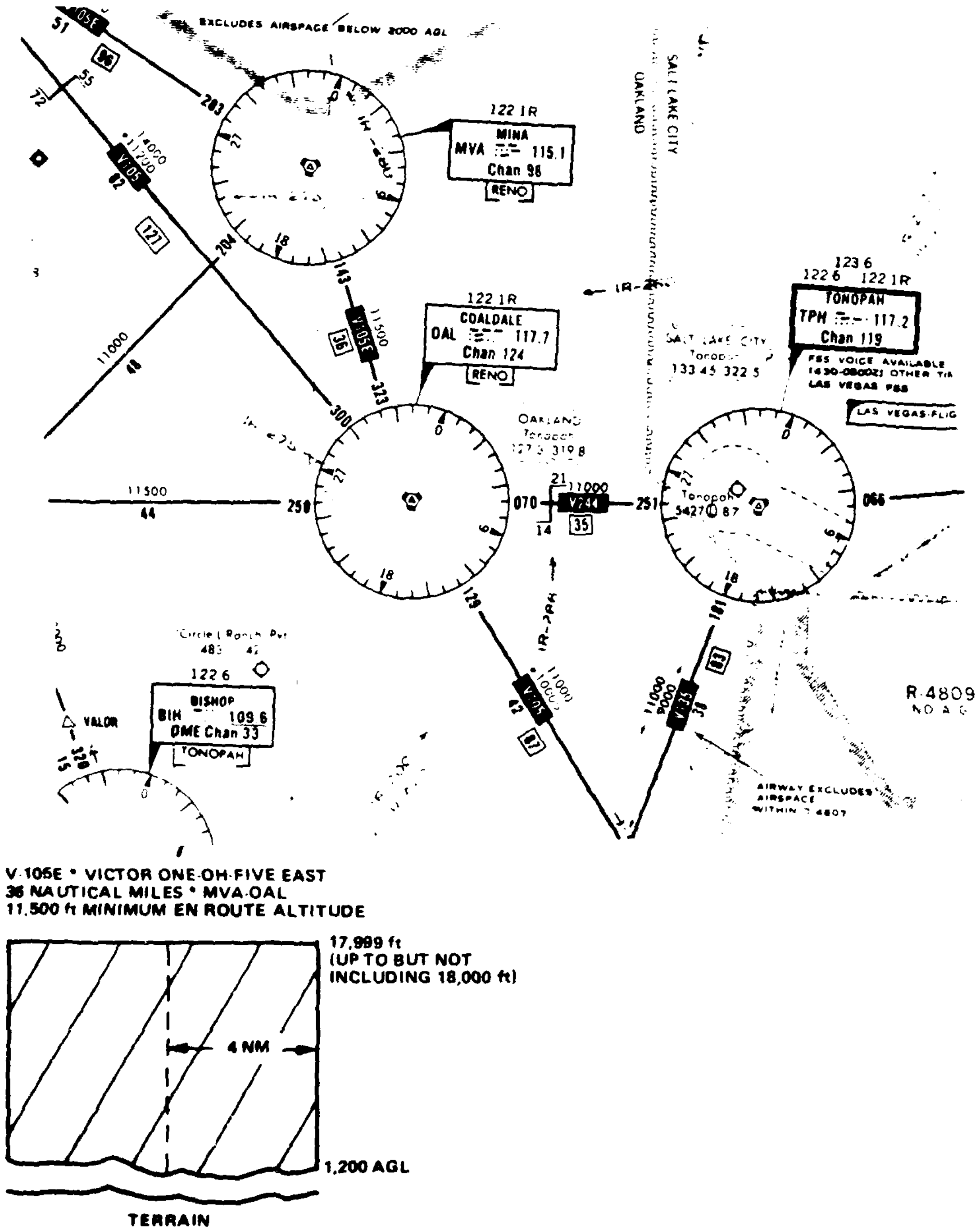


Figure 2-3 Low Altitude "Victor" Airway

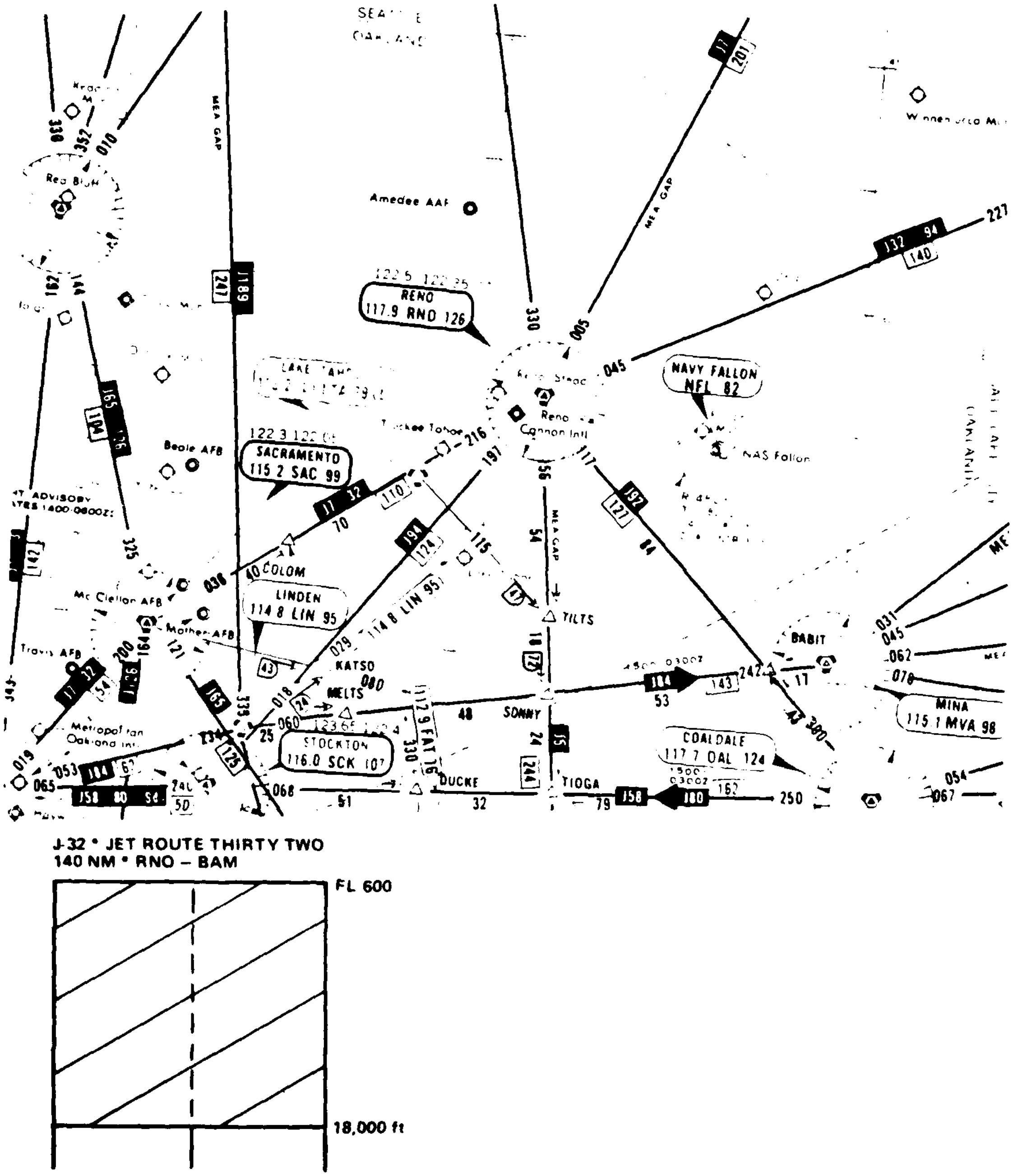


Figure 2-4 High Altitude "Jet" Airway

ances. SID/STAR routes are important tools at major airports for flights transitioning from/to the terminal/en route environment. See Figure 2-5 for an example of a SID and Figure 2.6 for an example of a STAR.

2.3.2.4 Holding Patterns

Normally, whenever a delay is required for an airborne aircraft, the controller may elect to clear the aircraft to hold at a fix where the aircraft will enter a holding pattern. The most commonly used holding patterns are depicted on en route and STAR charts. Otherwise, the controller will issue the holding fix; direction of holding to or from the fix; and direction and duration of turns. See Figure 2-7 for example of a hold at a fix. One of the uses of a holding pattern is to hold aircraft at common points in proximity to an airport awaiting weather improvements. Aircraft are held in a stack, separated by altitude as shown in Figure 2-8. Holds also may be used for delaying en route aircraft to help regulate the flow of traffic.

2.3.2.5 Area Navigation (RNAV) and Other Systems

Area navigation (RNAV) routes have been designated which allow properly equipped aircraft to fly directly from point to point without directly navigating toward or away from a navigational aid. These direct routes use waypoints which are defined as bearing/distance fixes from specified navaids.

Omega is a network of eleven transmitting stations located throughout the world to provide signal coverage. These stations transmit a Very Low Frequency (VLF) signal which can be received at a distance of over one thousand miles.

Long Range Navigation (LORAN) is a navigation system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. A later version of LORAN, LORAN -C, is used in offshore areas where VOR/VORTAC is not available.

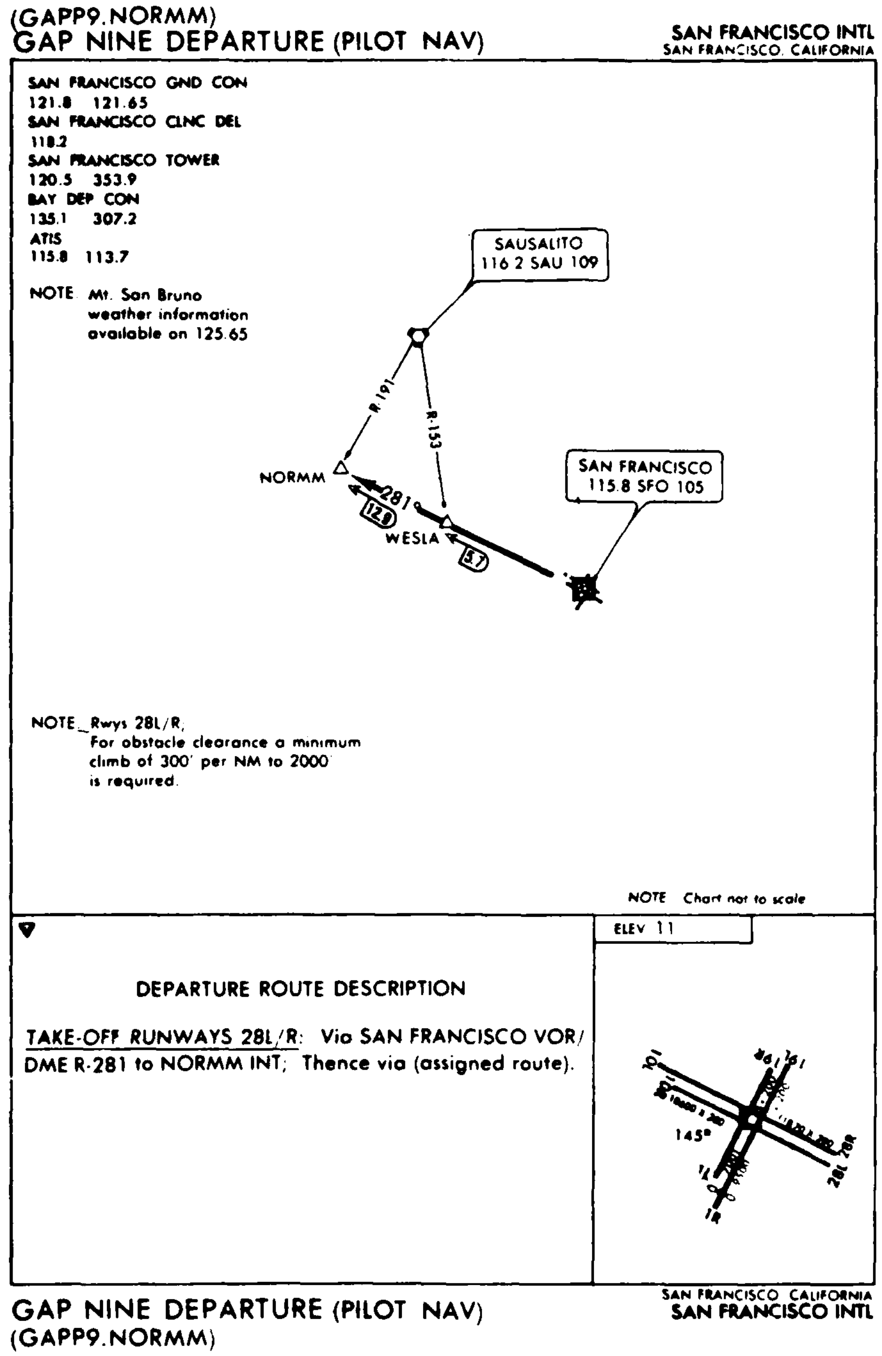
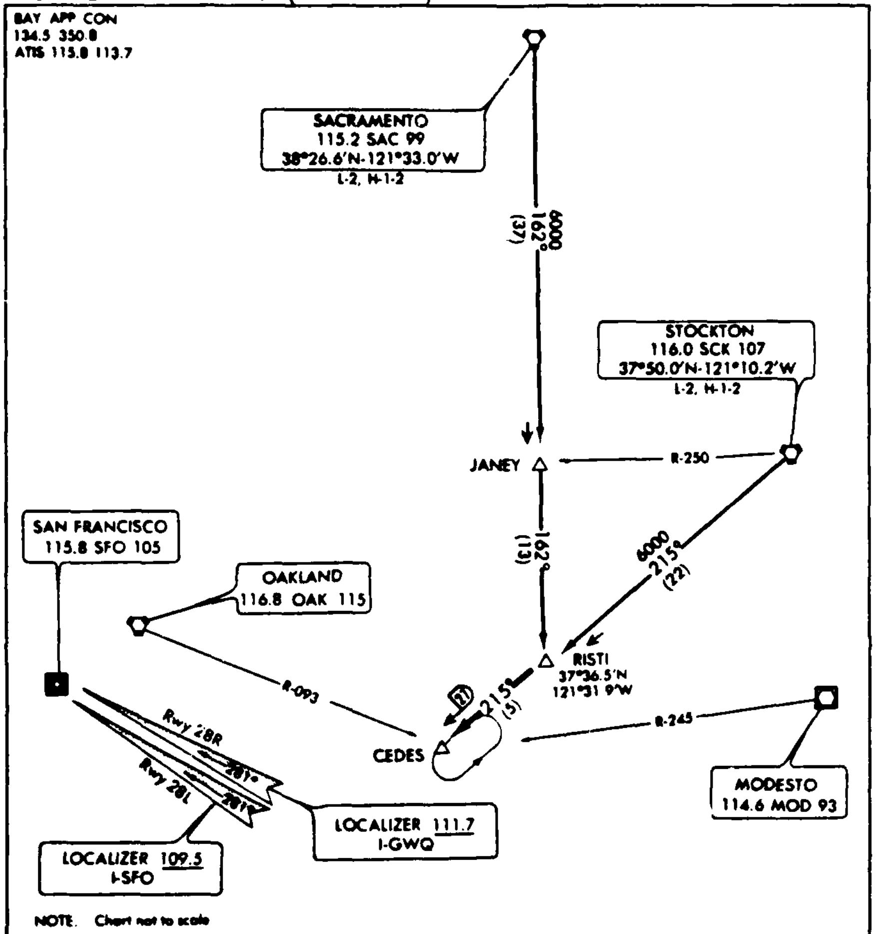


Figure 2-5 Standard Instrument Departure (SID)

SAN FRANCISCO INTERNATIONAL

RISTI ONE ARRIVAL (RISTI.RISTI1)

SAN FRANCISCO, CALIFORNIA



SACRAMENTO TRANSITION (SAC.RISTI1): From over SACRAMENTO VORTAC via SAC R-162 to RISTI INT. Thence . . . .

STOCKTON TRANSITION (SCK.RISTI1): From over STOCKTON VORTAC via SCK R-215 to RISTI INT. Thence . . . .

. . . . From over RISTI INT via SCK R-215 to CEDES INT, then via radar vector to San Francisco Intl Airport.

RISTI ONE ARRIVAL (RISTI.RISTI1)

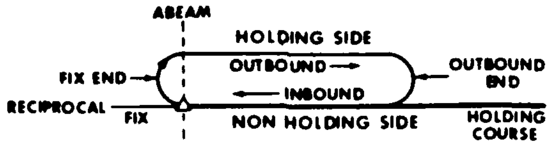
SAN FRANCISCO, CALIFORNIA

SAN FRANCISCO INTERNATIONAL

Figure 2-6 Standard Terminal Arrival (STAR)

Holding pattern airspace protection is based on the following procedures. They are the only procedures for entry and holding recommended by FAA.

(1) Descriptive Terms



(a) Standard Pattern : Right turns *(illustrated)*

(b) Nonstandard Pattern : Left turns

(2) Airspeeds (maximum)

(a) Propeller-driven ---------- 175K IAS

(b) Civil turbojet

1. MHA through 6,000 feet ---------- 200K IAS

2. Above 6,000 feet through 14,000 feet ---------- 210K IAS

3. Above 14,000 feet ---------- 230K IAS

Figure 2-7 Holding Fix

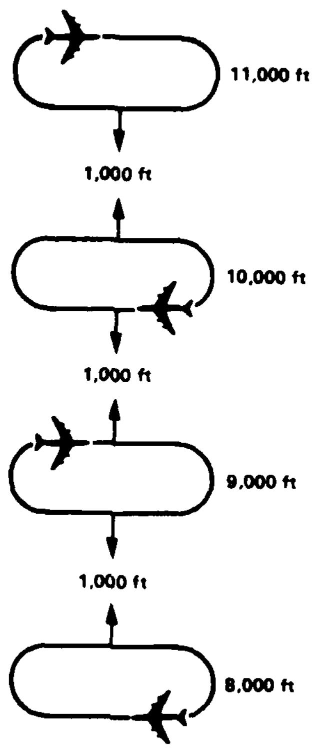


Figure 2-8 Holding Stack

2.4 NAVIGATION AND SURVEILLANCE FACILITIES

The ground-to-air system comprises navigation and surveillance facilities. Navigational facilities provide guidance to aircraft. Surveillance facilities consist of remote sensors for ARTCCs, ATCTs, and TRACONs.

2.4.1 Navigation Capabilities

The present civil en route navigation system consists of VHF omni-ranges (VOR), a radio station that provides point-to-point azimuth guidance. Distance information is obtained from distance measuring equipment (DME). Military aircraft use a UHF tactical air navigation system (TACAN) for azimuth guidance. Air routes may be thought of as line segments connecting the various navigation facilities.

The disadvantage of air route navigation is the lack of flexibility in routing. Aircraft equipped with area navigation can select direct routes within coverage of the ground stations. However, area navigation is limited in the present system due to the cost of avionics and limitations of the air traffic system's ability to handle aircraft flying outside the route structure. The non-directional beacon is a lower cost, lower capability alternative to the VOR station and is used where there is no VOR coverage. Beacons are used for en route guidance and fixes as well as part of landing systems. See Table 2-2 for description of en route Navigational Aids (NAVAIDs).

The present airport precision approach and landing system is the Instrument Landing System (ILS). See Figure 2-9 which describes the components of ILS. A precision approach uses both azimuth and elevation guidance from a ground facility as well as marker beacons and compass locators which enable equipped aircraft to fly by instruments along the approach path to the runway. Non-precision approach with azimuth guidance only is available at many airports using the localizer portion of an ILS, VOR, or beacon. There are other approach aids at airports that are based on visual reference to lighting systems.

The Microwave Landing System (MLS) is currently under engineering development and will augment and then eventually replace the ILS.

The direction finder (DF) is used to guide lost aircraft and for other emergencies. The aircraft's bearing is determined on the ground by using radio transmissions from the aircraft. The guidance information is then transmitted to the aircraft on a voice channel. The majority of the present DF systems are located at flight service stations.

2.4.2 Surveillance Capabilities

Surveillance of the airspace is provided by two types of radar: primary radar and the radar beacon system, sometimes known as secondary radar. They are generally located at the same site. Primary radar relies only on

TABLE 2-2 EN ROUTE NAVIGATION AIDS

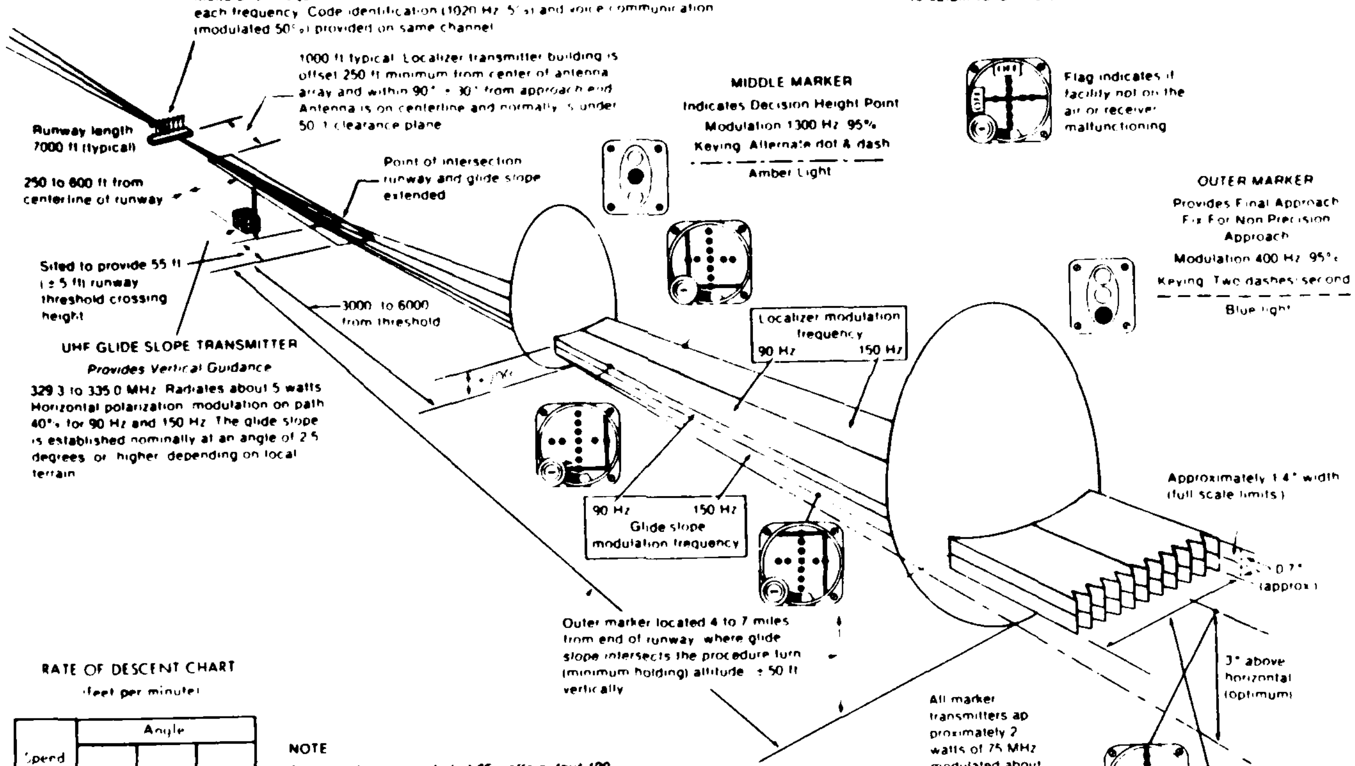
Beacon	The Nondirectional Radio Beacon (NDB) transmits nondirectional signals that give relative bearing information to a station. When a radio beacon is used in conjunction with the Instrument Landing System (normally at the outer marker) it is a Compass Locator.
VHF Omni-Directional Range (VOR)	The VHF Omni-Directional Range (VOR) provides a 360 degree signal for navigation. The accuracy of the VOR is excellent and it is generally within one degree of the course alignment. The VOR is one of the two mainstays of the airway structure.
Tactical Air Navigation (TACAN)	The Tactical Air Navigation (TACAN), which is peculiar to military operations, transmits an Ultra High Frequency signal of both azimuth and distance information. It does not operate through conventional VOR equipment.
VHF Omni-Directional Range/Tactical Air Navigation (VORTAC)	The VHF Omni-Directional Range/Tactical Air Navigation (VORTAC) consists of two components, VOR and TACAN. The VORTAC provides VOR azimuth, TACAN azimuth, and TACAN distance. It operates on more than one antenna system and incorporates more than one frequency but it is considered to be one navigational aid. The VORTAC is the other mainstay of the ATC airway route structure.
Distance Measuring Equipment (DME)	The DME provides the distance signal at VOR. DME can also be used in an Instrument Landing System installation.

ILS

[FAA INSTRUMENT LANDING SYSTEM]

STANDARD CHARACTERISTICS AND TERMINOLOGY

ILS approach charts should be consulted to obtain variations of individuals systems



RATE OF DESCENT CHART

(feet per minute)

Speed Knots	Angle		
	2½°	2¾°	3°
90	400	440	[illegible]
110	485	535	585
[illegible]	[illegible]	630	690
[illegible]	665	730	795
[illegible]	[illegible]	778	849

NOTE

Compass locators, rated at 25 watts output 190 to 535 KHz, are installed at many outer and some middle markers. A 400 Hz or a 1020 Hz tone, modulating the carrier about 95%, is keyed with the first two letters of the ILS identification on the outer locator and the last two letters on the middle locator. At some locators simultaneous voice transmissions from the control tower are provided, with appropriate reduction in identification percentage.

* Figures marked with asterisk are typical. Actual figures vary with deviations in distances to markers, glide angles and localizer widths.

Figure 2-9 Instrument Landing System

signals reflected from aircraft and also from weather. The beacon system receives reply signals transmitted from airborne electronic equipment called transponders. On aircraft equipped with altitude encoders, the transponder automatically transmits the plane's altitude. The beacon system is presently the main source of surveillance information used for air traffic control. Primary radar supplements beacon and gives weather information.

There are two types of primary radars. The en route system consists of long-range radar, while airport terminal radars are of shorter range. The long-range radar is called the Air Route Surveillance Radar (ARSR). The coverage normally extends out 200 miles. In some instances the ARSR enables a center to provide arrival/departure radar service. The Airport Surveillance Radars (ASR) provide coverage out to a maximum radius of 60 miles. There are some areas where long-range radars do not overlap. This occurs more frequently in the western and remote areas of the U.S. Also, mountain ranges may block radar signals from the valleys on the far side of the mountains.

2.5 AIR TRAFFIC SEPARATION/ CONTROL PHILOSOPHY

ATC is a service provided by the FAA to promote the safe, orderly, and expeditious flow of air traffic. This section describes the concepts and philosophy underlying ATC.

The essence of ATC is the application of approved separation standards as found in FAA Order 7110.65, Air Traffic Control. This order prescribes the ATC procedure and phraseology in providing ATC services. Oceanic separation standards are contained in FAA Order 7110.83, Oceanic Air Traffic Control.

This section is structured to provide the reader with a description of flight rules followed by a summary of separation standards. Finally, this section is also devoted to discussing techniques employed by the controller to maintain separation.

2.5.1 Flight Rules

Instrument Flight Rules (IFR) govern the procedures for conducting instrument flight. General ceiling and visibility conditions for Instrument Meteorologic Conditions (IMC) apply. Visual Flight Rules (VFR) govern the procedures for conducting visual flight. The term VFR is also used to indicate Visual Meteorologic Conditions (VMC) weather conditions. Before flying, pilots must determine from weather briefings or the airspace within which they will be flying as to whether they will be operating under VFR or IFR flight rules. A pilot may file IFR in VFR conditions. There are many subsets of VFR operation.

If operating under IFR, the pilot is provided separation from other aircraft operating IFR. He is provided separation from special use airspace and given advisories on weather and other phenomenon. If operating under VFR, the pilot may request and be provided with air traffic and weather advisory services, depending on controller workload.

2.5.1.1 Flight Plan Filing

For all IFR and certain VFR flights, the pilot introduces his aircraft into the ATC system by filing a flight plan. Normally, the flight plan is forwarded to the Air Route Traffic Control Center, since the center is the pivotal facility for almost all IFR flight plans, even those flights that proceed under tower en route control. The reason for this is that the center assigns a discrete beacon code, transmits the appropriate flight progress strips to Flight Data Entry and Printout (FDEP) equipment located at terminal facilities, and transmits ARTS interface messages. This is done automatically, thus reducing manual input by controllers at the various facilities.

Military Base Operations (BASOPS) receive en route flight plans from pilots and transmit them directly into the en route center's computer via Teletype. After the computer has processed the flight plan, it is transmitted to the controllers in the form of flight progress strips. Local

training mission flight plans may be prefiled in a center's computer system.
General aviation pilots normally file their flight plans, if needed, through the local FSS for Teletype transmission to a center's computer. Towers, on occasion, may accept flight plans for entry into the system.

Flight plans for many air carrier operations are frequently prefiled in a center's computer via the Stored Flight Plan (SFP) program. Another common method is to transmit the flight plans from the air carrier's operation room directly into the ARTCC computer via Teletype. A less frequently used method is the air carrier calling the center or the local FSS for relay to the center.

2.5.1.2 Flight Plan Clearance Request/Delivery

After the pilot has completed his ground check and is ready for IFR flight, he will request a clearance from the tower, if appropriate. In some instances where there is neither a tower nor FSS, the pilot may communicate directly with the center or TRACON via air/ground frequency, or the pilot may take off VFR and contact the center for a clearance.

Separation is assured by the issuance of controller instructions and ATC clearances. A clearance is a tactical action by the controller to prevent collision between known aircraft and is also authorization to proceed under specified traffic conditions within controlled airspace.

Clearance items may include:

a. aircraft identification or call sign

b. clearance limit

c. route of flight, including special procedures

d. altitude data in the order flown

e. holding instructions

f. radar heading

g. beacon code and transponder data

h. frequency or communication data

i. speed

j. release data and restrictions

At an airport with a tower, the clearance will be either pre-coordinated between the center and the tower in a Letter of Agreement or the tower will request a clearance from the appropriate sector within the center. The tower will generate a clearance for aircraft remaining in the terminal area. The clearance is normally to the destination airport and is subsequently issued to the pilot via the terminal clearance delivery position. Prior to the issuance of a clearance the center controller will examine the departure flight progress strip, with emphasis on the requested altitude and route. The center controller will then issue clearances with additional instructions to insure separation from other aircraft. The terminal controller will add any necessary restrictions to clear traffic in the terminal area.

The flight plan which was in an inactive or proposed status becomes active once the aircraft is airborne. The departure time is inserted into the en route computer system by either the terminal computer, the terminal FDEP equipment, or a controller keyboard entry into the en route computer system. The en route computer system will automatically post flight progress strips at a specified time prior to the calculated time over each fix (navigational aid or airway intersection). The computer will also forward the flight plan data prior to the aircraft's arrival at the next adjacent center or at a specific time.

2.5.1.3 Flight Plan Amendments

The pilot may request to amend his flight plan at any time, active or inactive. If the flight is still inactive, an amendment message will be entered into the computer system by the FDEP terminal or the center sector. If a route change will conflict with prescribed preferential routes (routes that have been preestablished for predominant traffic), the amendment may be rejected. Otherwise, new data will be stored in the computer. If the flight is active, coordination between controllers or facilities may be required before the change is approved and entered into the system. Once entered, the amended data replaces the original data for all subsequent interfaces. Amended data are produced for all facilities and controllers that had already received the original flight plan data.

2.5.2 Separation: The Essence of Air Traffic Control

Separation is provided by establishing approved longitudinal, lateral, or vertical distance between aircraft. Longitudinal separation is the spacing of aircraft at the same altitude by a minimum distance expressed in units of time or miles. Lateral separation is the spacing of aircraft at the same altitude by requiring operation on a different route or in a different geographical location. Vertical separation is established by assignment of different altitudes or flight levels. The following separation minima apply to domestic and not oceanic control.

2.5.2.1 Longitudinal Separation

Longitudinal non-radar separation is established by using minimum distance, time, speed, or combination of items. The most common application of longitudinal separation is 10 minutes between aircraft.

The following are other examples of longitudinal separation, with some of the separation conditions omitted for brevity:

a. 5 miles using DME or 3 minutes when the leading aircraft is 44 knots faster.

b. 10 miles using DME or 5 minutes when the leading aircraft is 22 knots faster.

c. 10 miles using DME or 5 minutes when the leading aircraft is descending or the following aircraft is climbing.

d. 20 miles between aircraft using DME.

2.5.2.2 Lateral Separation

Lateral, non-radar separation is established by route structures, with protected airspace that does not overlap, to keep aircraft at a particular altitude on different routes.

Lateral separation is established by one of the following methods:

a. Clear aircraft on different airways or routes whose widths or protected airspace do not overlap.

b. Clear aircraft below 18,000 to proceed to and report over or hold at different geographical locations determined visually or by reference to navigational aids.

c. Clear aircraft to hold over different fixes whose holding pattern airspace areas do not overlap each other or other airspace to be protected.

d. Clear departing aircraft to fly specified headings which diverge by at least 45 degrees.

2.5.2.3 Vertical Separation

Vertical separation is established by assigning 1,000 feet between aircraft up to and including 29,000 feet (flight level 290). Above FL 290 2,000 feet separation is required. A special VFR flight may be separated from an IFR flight by requiring the VFR flight to maintain special VFR conditions at or below 500 feet from the IFR flight. Vertical separation of 500 feet is allowed for VFR aircraft operating in TCA airspace.

2.5.2.4 Radar Separation

Radar separation may be applied between aircraft by establishing at least a 3 mile separation between identified aircraft when they are less than 18,000 feet and fewer than 40 miles from the antenna. However, 5 mile separation may be required by a facility directive if multiple radar sites are adapted in the computer for a specific area. Five miles separation is required if the aircraft are at or above 18,000 feet, or if 40 or more miles from the antenna. If the aircraft is at or above 60,000 feet (flight level 600), then a 10 mile separation is required. These minima are specified in FAA order 7110.65, Air Traffic Control.

Radar separation may be reduced for aircraft departing from the same airport, depending on the runway alignment and direction flown after departure. As an example, radar separation may be one mile if aircraft are departing the same runway, or parallel runways less than 2,500 feet apart, if the aircraft courses diverge immediately after departure.

When non-radar separation standards are used, greater emphasis is placed upon the pre-planning of separation activity since the distances required for longitudinal separation are much greater than normal radar separation. The aircraft's progress is maintained by position reports forwarded by the pilot and marked on the flight progress strip by the controller.

2.5.2.5 Adjacent Airspace

Aircraft are to be separated or provided a buffer from adjacent airspace unless coordinated. Dependent on the distance from the antenna, 3 mile separation is normally required in the terminal area and 5 miles is normally required in the en route environment. This also applies to tracking aircraft to the edge of the radar display. See Table 2-3 for a listing of separation standards. Note that this table is mapped to 7110.65 paragraphs. This list is not intended to be all inclusive. See Order 7110.65 for specific details.

2.5.3 Separation Techniques

2.5.3.1 Airspace Separation Techniques

Just as vehicular traffic moves on one way streets, major airways sometimes are structured for one way traffic flow, especially in major airport areas. Departing aircraft are normally tunnelled under arriving aircraft on one way departure routes, through the low altitude center sectors, onto high altitude jet routes, if appropriate. This is illustrated in Figure 2-10.

Major airport areas have identified SID and STAR routes which are published for pilot/controller use in transitioning from the terminal/en route air route structures. In addition, the NAS Stage A software employs logic to provide Preferential Departure/Arrival Routes (PDARs).

Through the use of the the route structure, aircraft in opposite direction are separated laterally, e.g., on different airways whose airspace does not overlap, while aircraft in the same direction are separated vertically (altitude) or longitudinally by time or distance. Altitude assignments are made based upon the direction of the flight. See Figure 2-11 for an ATC altitude assignment.

Considerable thought is given to the airspace definition of a control sector or position. By proper pre-planning and alignment, coordination can be reduced and the traffic flow expedited. This is especially true in terminal transition areas.

2.5.3.2 Controller Techniques

There are a variety of techniques available to the controller. Some are taught in training classes, in on-the-job training sessions, or learned from experience. The common separation techniques involve speed control, holding or 360 degree turns, and radar vectors including "S" turns.

Speed control is a valu-

TABLE 2-3. SUMMARY OF SEPARATION STANDARDS

* SEPARATION BY TIME

SEPARATION (MINUTES)	AIRCRAFT	REMARKS	7110.65 PARAGRAPH REFERENCES
Simultaneous	X	Parallel departure 3500 ft.	340
Simultaneous	X	Diverging departure/ diverging runways	340
1	X	Diverging departures	340
2	X	Diverging departures	340
2	X	Landing behind departing heavy	1425/ 1426 1427/ 1428
3	X	44 knots lead A/C, DME/RNAV	271
3	X	Departing climbing above lead	341
3	X	Arriving/Departing	345
3	X	CAT I/II behind CAT III	1113/ 1114
3	X	Landing/Takeoff heavy jet	1402/ 1404
3	X	Small behind heavy	1425
5	X	22 knots lead A/C, DME/RNAV	271
5	X	Lead descending/following climbing	271
5	X	Arriving/departing	345
10	X	Standard	272

<u>AIRSPACE:</u> not applicable

* See Order 7110.83 for Oceanic Separation

TABLE 2-3. SUMMARY OF SEPARATION STANDARDS (Cont'd)

SEPARATION BY ALTITUDE

ALTITUDE (FEET)	AIRCRAFT	AIRSPACE	REMARKS	PARA.
500	X		Special VFR below IFR	474
500		X	Below FL 290	224
500		X	Above surface	474/ 481
500	X		Special IFR below IFR	481
500	X		Stage III/IFR	1282
1,000		X	FL 290 & above	224
1,000	X		Below FL 290	222
1,000		X	Above highest obstacle	474/ 481
2,000	X		FL 290 & above	222

(See Special Military Operations above FL600.)

TABLE 2-3. SUMMARY OF SEPARATION STANDARDS (Cont'd)

SEPARATION BY DISTANCE

SEPARATION MILES	AIRCRAFT	AIRSPACE	REMARKS	PARA.
Runway	X		(Radar) parallel/ diverging runways, arrival/departure	744/ 798
Runway	X		CAT I/II/III departures	1110/ 1120
Runway	X	X	Helicopter	1130
1/2	X		Helicopter/fixed wing	1141
1		X	Radar diverging departures	742
1		X	Helicopter	1141
1 1/2		X	Radar less than 40 mile/antenna	750
1 1/2	X		Helicopter	1141
1 1/2	X		Helicopter/CAT I/II	1282
1 1/2	X		CAT I/II VFR/IFR	1282
1 1/2	X		Parallel CAT III VFR/ IFR	1282
2		X	Radar departing/ arriving	743
2		X	Helicopter & fixed wing	1141
2		X	Radar adjacent courses ILS	797
2 1/2		X	Radar 40 miles or more from antennas	750
3		X	Diverging departures	340
3	X	X	Radar less than 40 mile/antenna(broadband)	740/ 751/ 757
3	X		Radar narrowband, below FL180 within 40 mile/ antenna	740
3		X	Radar less than 40 mile/antenna	750
3		X	Radar, special use airspace	750
3	X		Radar, arrival, turn on final	797/ 798
4	X		Arriving/departing	345
4	X		Radar, heavy behind heavy	1420

TABLE 2-3. SUMMARY OF SEPARATION STANDARDS (Cont'd)

SEPARATION BY DISTANCE (Cont'd)

MILES	AIRCRAFT	AIRSPACE	REMARKS	PARA.
4	X		Radar, small behind large	1420
4		X	Either side of route, Below FL180	281
4		X	Within 51 miles of NAVAID	281
4		X	RNAV route 8 mile or less	284
5	X		44 knot lead DME/RNAV	271
5		X	DME arc 35 mile or less/NAVAID	283
5	X		Departure climbing above lead	341
5	X	X	Radar, broadband 40 miles or more from antenna	740/ 751/ 757
5	X	X	Radar, narrowband, FL180/600	740/ 751/ 757
5		X	Radar, above FL600	750
5		X	Radar, 40 miles or more/antenna	750
5	X		Radar, small/large behind heavy	1420
6		X	Radar, edge of scope within 40 miles	720
6		X	Radar, special use air-space above FL 600	750
6	X		Radar, small behind heavy	1420
9		X	RNAV route, expanded, less than 130 miles	284
10		X	51 to 130 miles of NAVAID	281

TABLE 2-3. SUMMARY OF SEPARATION STANDARDS (Cont'd)

SEPARATION BY DISTANCE (Cont'd)

MILES	AIRCRAFT	AIRSPACE	REMARKS	PARA.
10		X	Either side of route FL180/600	281
10	X		DME/RNAV, above FL600	750/ 751
10		X	Radar, broadband, 40 miles or more, or narrow band, edge of scope	720
10	X		DME arc 35 miles less of NAVAID	283
10		X	DME arc 35 miles or more from NAVAID	283
14		X	FL180-230 course change	281
15		X	RNAV route more than 130 miles	284
17		X	FL230-600 course change	281
20	X		DME/RNAV	271
20		X	DME arc more than 35 miles NAVAID	283
28		X	FL180-230 course change	281
30	X		Only one has DME/RNAV	271
34		X	FL230-600 course change	281

VISUAL SEPARATION

SEPARATION	AIRCRAFT	REMARKS	PARA.
Visual	X	Visual separation & VFR	490
VFR-On-Top	X	IFR-VFR-On-Top	492
VFR	X	Simultaneous departure/ arrival & departure/departure	1103/ 1104

AIRSPACE: not applicable

JACKSONVILLE INTL. AIRPORT, JACKSONVILLE, FLORIDA

THIS GRAPHIC SHOWS AREAS OF CONCENTRATED IFR TRAFFIC FOR THE INFORMATION AND GUIDANCE OF PILOTS OPERATING VFR IN THE JACKSONVILLE TERMINAL AREA. PILOTS INTENDING TO OPERATE VFR WITHIN THE AREA ARE ENCOURAGED TO CONTACT JACKSONVILLE APPROACH CONTROL ON 119.0 335.6 WHILE TRANSITING THIS AIRSPACE

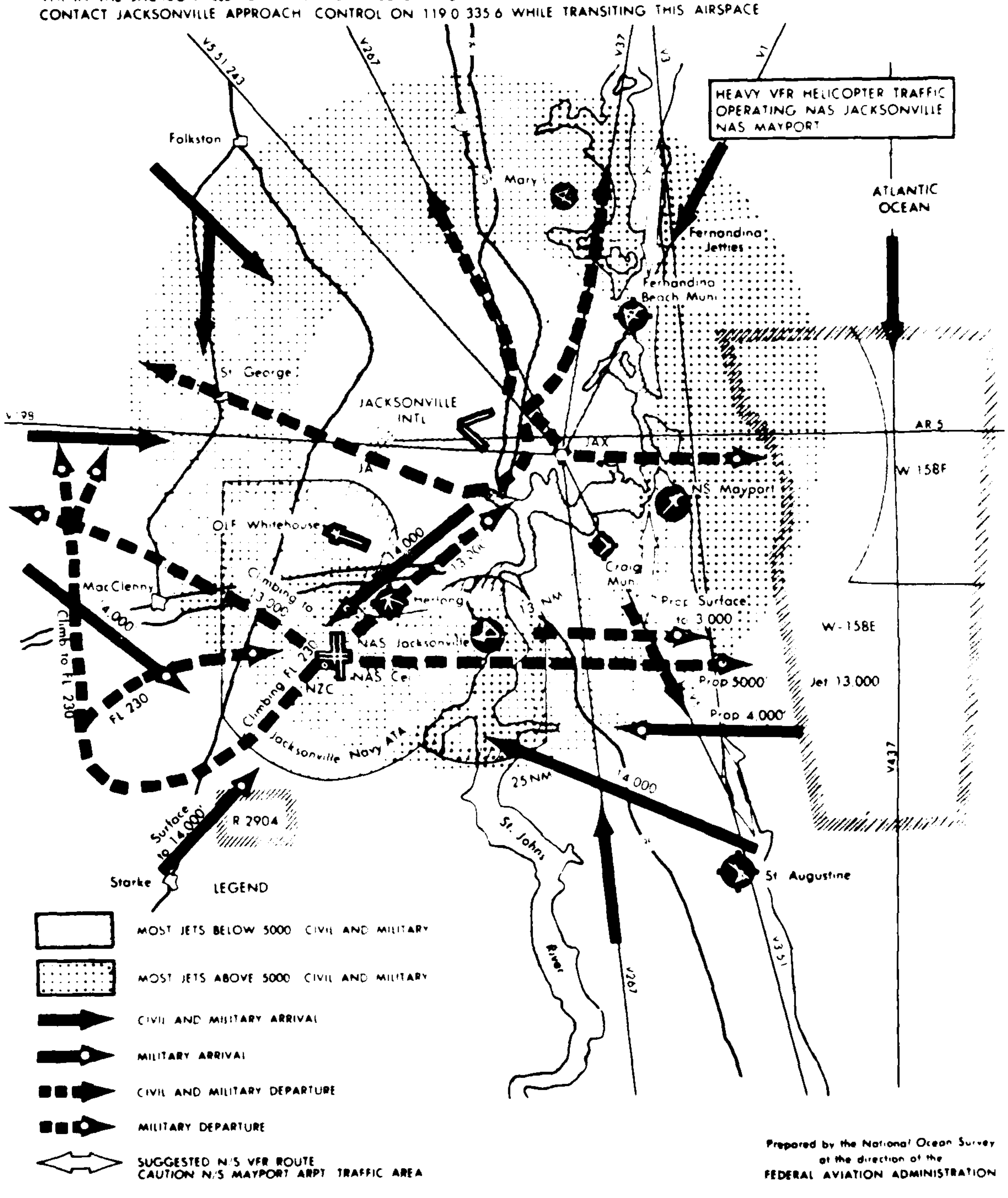


Figure 2-10 Arrival/Departure Routes

AIRCRAFT OPERATING	ON COURSE DEGREES MAGNETIC	ASSIGN
BELOW 3,000 ft ABOVE SURFACE	ANY COURSE	ANY ALTITUDE
BELOW FL 290	0 THROUGH 179	ODD CARDINAL ALTITUDES OF FLIGHT LEVELS AT INTERVALS OF 2,000 ft
	180 THROUGH 359	EVEN CARDINAL ALTITUDES OR FLIGHT LEVELS AT INTERVALS OF 2,000 ft
AT OR ABOVE FL 290	0 THROUGH 179	ODD CARDINAL FLIGHT LEVELS AT INTERVALS OF 4,000 ft BEGINNING WITH FL 290
	180 THROUGH 359	ODD CARDINAL FLIGHT LEVELS AT INTERVALS OF 4,000 ft BEGINNING WITH FL 310

Figure 2-11 ATC Altitude Assignment

able technique, especially appreciated by those concerned about air traffic efficiency. Speed control is frequently used in en route longitudinal separation by reducing the speed of overtaking aircraft. It is common in transition areas and used extensively by feeder and final approach controllers.

The holding of aircraft in a holding pattern is frequently used when extensive delays are required, either due to weather or traffic congestion. In transition areas for landing aircraft the leading aircraft descends to the lowest available altitude and subsequent aircraft are stacked at higher altitudes. En route aircraft are held at various holding points with longitudinal separation between crossing airways or other holding points. Unless landing is imminent, it often is more fuel efficient to hold aircraft at high altitudes, though other reasons may at times suggest the use of another holding technique. In most holding situations a further clearance time is issued to the pilot. If a short delay is necessary, a 360 degree turn may be used.

The most common separation technique used for aircraft climbing/descending and aircraft in transition areas is the radar vector. It is used extensively for aircraft in-trail. It is used until either longitudinal, lateral, or vertical separation exists between aircraft. Radar vectors are frequently used to expedite traffic to/from airways and to assist the pilot in navigation. The use of different radars, radar techniques and presentation, and differing radar separation standards will be a central issue in establishing common facilities, equipment, software, and procedures in the future Area Control Facility.

2.5.3.3 Non-Radar Control Techniques

Greater emphasis is placed upon planning activities to effect separation in non-radar situations. During busy traffic periods, control becomes more rigid, with less emphasis than normal placed on pilot requests and more emphasis placed on maintaining a sequence or established flow of traffic. The use of position reporting, altitude vacating reports, and increased strip marking are tools used by the controller to maintain the "picture" or situation assessment. Calculating and maintaining an awareness of aircraft ground speed becomes more important in en route non-radar situations. The controller will devote more attention to the previous fix and time, current fix and time, and next reporting point as contained in a progress report than in radar situations. During busy periods the use of holding patterns for stacking in-bound aircraft becomes more frequent. In general, pilot/controller communication must, of necessity, increase to a large degree since the pilot must constantly relay position and altitude information.

2.5.4 Advisory Services

Controllers provide additional services such as traffic advisories, radar services, and weather advisories, to the extent possible, depending on higher priority duties.

2.5.4.1 Traffic Advisory

Traffic advisories are normally issued to all IFR, and VFR aircraft on the controller's frequency, when their proximity may diminish to less than separation minima. Aircraft may also be vectored around weather or other phenomenon when requested. These services are not optional on the part of the controller, but rather are required, when the work situation permits.

Stage II and Stage III procedures have been established at many airports with radar approach control. Stage II provides radar sequencing by adjusting the flow of arriving VFR and IFR aircraft into the airport traffic pattern in a safe and orderly manner. It also provides radar traffic information to departing VFR aircraft. Pilot participation is urged but it is not mandatory. Standard radar separation is provided for IFR, but not between VFR aircraft or between VFR and IFR aircraft.

Stage III service provides separation and sequencing between all participating VFR and all IFR aircraft. Pilot participation is urged but is not mandatory. Pilots operating VFR under Stage III must maintain an assigned altitude/heading. If an altitude is not assigned, the pilot should coordinate any altitude change.

2.5.4.2 Other Services

Controllers solicit pilot reports on weather information. This includes reports on strong frontal activity, squall lines, thunderstorms, icing, wind shear, and other pertinent data. These data are disseminated to all other positions, facilities, and aircraft as necessary.

Controllers provide advisory services on other phenomenon such as chaff, gliders, hot air balloons, bird activity, parachutists, etc. To the extent possible, radar vectors are provided around any element which is considered a safety hazard. Controllers also provide radar navigation.

Controllers provide special VFR clearances within most control zones. An ATC clearance must be obtained prior to operating within a control zone when the weather is less than required for VFR flight. A VFR pilot may request and be given a clearance to enter, leave, or operate within most control zones in special VFR conditions, traffic permitting, and provided such flight will not delay IFR operations.

2.5.4.3 Oceanic Services

Air Traffic Control services are provided in accordance with FAA Order 7110.83, Oceanic Air Traffic Control. In addition to air traffic control, controllers provide Flight Information Service and Alerting Service. Flight Information Service consists of weather, change in the status of navigation aids and airports, and information on vessels in the area.

Alerting Service consists of collecting information regarding aircraft emergencies, forwarding that information to an appropriate Rescue Coordination Center, and coordinating with other control facilities.

2.6 AIR TRAFFIC CONTROL EN ROUTE AND TERMINAL OPERATIONS

Historically the control of air traffic has been accomplished by terminal and en route facilities. Although the same operation is involved in both, i.e., air traffic separation, the equipment, procedures, and training are markedly different in each. This is primarily due to the character of aircraft movement in the terminal area versus the en route environment.

This section provides descriptions of en route and terminal radar approach control facilities, equipment, and controller workstations. This section concludes with a discussion of the automation aids that are currently provided to the controller.

2.6.1 Air Route Traffic Control Center (ARTCC) Operations

Commercial airlines and other aircraft flying under instrument flight rules are monitored by Air Route Traffic Control Centers. These centers control an aircraft's route of flight and altitude while it is en route or between airports.

A typical center is responsible for more than 100,000 square miles of airspace and hundreds of miles of airways in the sky, which are like electronic highways to pilots. A center's geographic area is usually divided into 30 or more sectors, with a team of controllers responsible for each sector.

There are 20 air route traffic control centers in the continental United States. There are five offshore centers located at Anchorage, Honolulu, San Juan, Panama, and Guam. By 1985, Panama, Guam, and San Juan will be decommissioned.

Another integral part of the en route system is the Central Flow Control Facility (CFCF) in Washington, D.C. Central flow control serves as a focal point for evaluating and approving traffic flow redistribution, nationwide management of air traffic flow, and providing authority for initiating systemwide flow control. Central flow control relieves congestion at the busiest airports. When associated with the central altitude reservation function (CARF), it supports military operations and provides coordination of other activities requiring airspace protection.

These en route centers control all aircraft in the United States operating under IFR and not under control of military or other facilities. They provide separation services, traffic advisories, and weather advisories. In addition, they track aircraft operating under distress.

2.6.1.1 En Route Sector: Lowest Allocation of ATC Responsibility

Within each center's control room there are specified areas of operation or specialization. An area of operation consists of a group of sectors requiring the service of several teams of specialists or controllers.

The basic unit of airspace in each en route area of operation is the sector. The sector is an airspace volume of defined horizontal and vertical dimensions for which a controller, or group of controllers, has air traffic control responsibility. Sectors are classified as radar, nonradar, or oceanic and can be subclassified by altitude strata; such as high altitude, including ultra high altitude, and low altitude. Both high and low sectors can be further categorized as overflight or transition type sectors although some sectors are in both categories. See Table 2-4 for a description of sector type. Some sectors involve only military operational activities. The basic operating area is called a sector and is equipped with flight progress boards, radar Plan View Displays (PVDs), interphone and radio communication panels, and automation input/output devices and displays. See Figure 2-12 which shows a typical sector controller workstation.

Note the flight strip bays in Figure 2-16. Most flight data, after being processed are currently displayed on paper strips torn from flight strip printers. This is a costly mechanical system requiring manual coordination and input by the air traffic controllers.

The size and configuration of sectors are determined by traffic volume, traffic flow, types of aircraft, location and activity of underlying terminals, special operations/procedures, coordination requirements, radar/radio coverage, equipment limitations, and airway alignments. Accordingly, sectors are aligned to contain the longest possible segments of airways and conform to primary traffic flow.

Center sectors are normally staffed with a "D" sector controller, or manual controller, who is responsible for maintaining the flight strip board, issuing clearances over the interphone, and pre-planning control activities; an "R" radar controller or "DR" radio controller, who are responsible for issuing clearances by air/ground communications: and an "A" developmental controller, sometimes called an assistant controller. The "A" controller may serve two or more sectors. At busy sectors "RH" radar handoff controllers or "C" coordinators may be staffed. During light traffic situations or relief periods the "D" and "R" positions may be combined. See Table 2-5 for position descriptions.

There are many positions within the control room which provide support and supervision of control activities. Each team of controllers has an immediate supervisor, called an Area Supervisor, who normally oversees the activities of many sectors. The entire control room is under the supervision and management on a shift basis of an Area Manager. The Flow Control [illegible] position is responsible for coordinating the overall flow of traffic. Where required for aircraft entering Air Defense Identification Zones, an Aircraft Movement [illegible] Information Service [illegible]

TABLE 2-4 SECTOR TYPE DESCRIPTION

SECTOR	DESCRIPTION
Low Altitude Arrival	Transitions Air Traffic Descending from High Altitude or from Intermediate Altitude into Busy Approach Control Area.
Low Altitude Departure	Transitions Air Traffic from Busy Approach Control into Low or High Altitude En Route Stratum.
Low Altitude En Route	Provides En Route Separation Outside of High Density Airport Areas. May Involve Several Low to Medium Density Airports.
Low Altitude Manual	Same as Low Altitude En Route Except Limited or No Radar Coverage of Majority of Area.
Low Altitude Training	Predominately Involved with Military Training Areas at Low Altitudes Generally with Low Performance Aircraft.
High Altitude En Route	Provides En Route Separation and Transitions Arrival/Departure Traffic into/out of En Route Traffic Flow.
High Altitude Training	Predominately Involved with Military Training Areas at High Altitude, Generally with High Performance Aircraft.
Oceanic	Provides En Route Oceanic Separation and Transitions Air Traffic from/to Domestic to Oceanic Control.
Aircraft Movement and Information Service	Coordinates the Identification Information Service of Aircraft with the Air Force's Air Defense Sites.

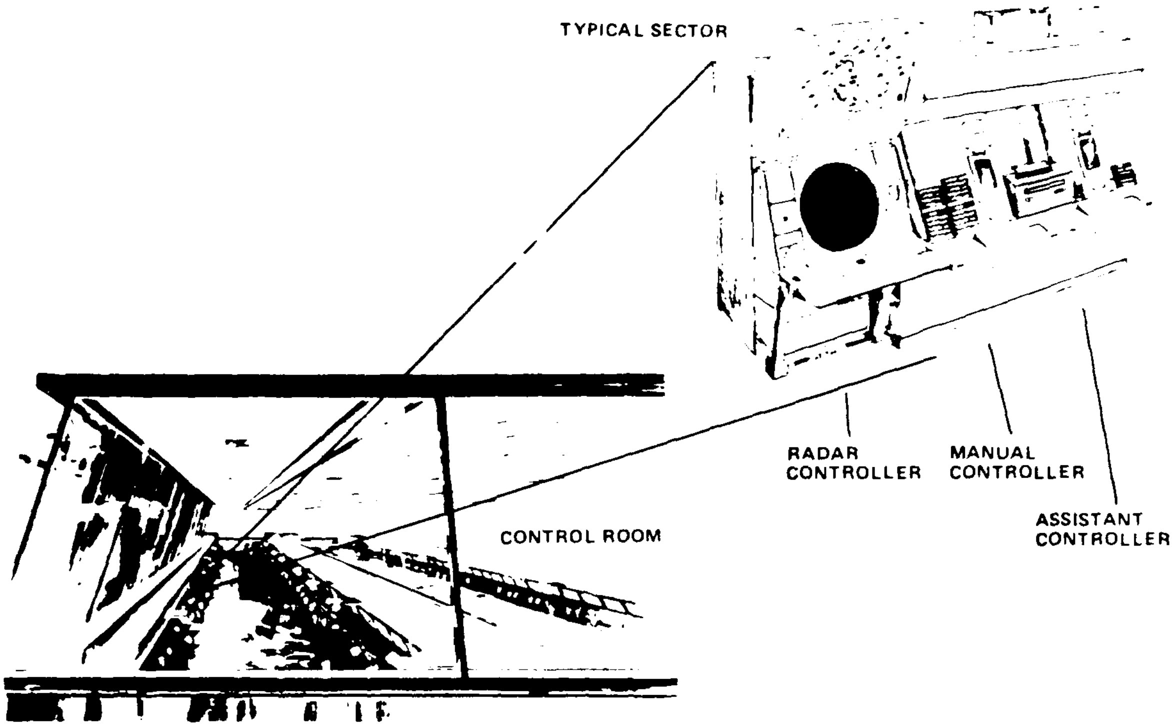


Figure 2-12 En Route Sector Controller Workstation

TABLE 2-5. DESCRIPTION OF CENTER POSITIONS

POSITION	SYMBOL	DESCRIPTION
Radar	R	Provides separation of air traffic by direct air/ground radio frequencies and a radar display.
Radio	DR	Provides separation of air traffic by direct air/ground radio frequencies.
Manual	D	Maintains flight strip board and separation of aircraft through interphone communications.
Radar Handoff	RH	Assists the radar controller in tracking aircraft and provides radar handoffs to adjacent positions/facilities.
Coordinator	C	Coordinates the movement of traffic between sectors. May assist in radar handoffs.
Area Supervisor		Supervises a team of controllers working specified positions.
Area Manager		Responsible for supervision and management of the control room.
Flow Control	FC	Coordinates the flow of traffic by system, within the facility, or with adjacent facilities.
Aircraft Movement and Information Service	AMIS	Coordinates identification of aircraft with the Air Force's air defense sites.
Flight Data Communications Specialist	FDCS	Responsible for receiving and entering Teletype messages. Also responsible for making computer entries and computer corrections on flight plans.

TABLE 2-5. DESCRIPTION OF CENTER POSITIONS (Cont'd)

POSITION	SYMBOL	DESCRIPTION
Supervisory Flight Data Communications Specialist	SDCS	Supervises FDCS.
Weather Coordinator	WC	Insures the collection and dissemination of pertinent weather data and controller briefing.

controller (M), is responsible for coordinating identification of aircraft with the Air Force's NORAD air defense sites. The flight data positions and Teletype positions are staffed by Flight Data Communications Specialists (FDCS). They are supervised by a Supervisory Flight Data Communications Specialist (SDCS). The FDCS is responsible for reentering designated flight plans which have not been accepted by the computer. The errors are generally logic errors in the flight plan route. The FDCS and Teletype positions are also involved in Teletype flight plan messages, as well as weather data transmitted via Teletype. The Weather Coordinator (WC) insures the collection and dissemination of pertinent weather data and controller briefing. The WC receives this data from the FSS, airlines, military base operations, and National Weather Service.

2.6.1.2 Controller Workstation Features

Figure 2-13 provides a picture of the display equipment which comprises the controller workstation. The components of the en route controller workstation include the PVD, Flight Strip Printer, flight strip progress boards, computer readout displays (CRD), and other interaction (input/output) devices such as a trackball, quick action keys, and keyboard.

The PVD is a digital presentation of tracked and untracked targets, background maps, tabular and status lists, and weather display. Figure 2-14 provides a sample PVD situation display and a detailed legend describing the contents of this display picture.

The flight progress board used by the "D" or manual controller also contains a CRD. In addition to displaying entered data, the CRD will display messages composed by the computer, such as amended data to a flight progress strip, after the controller depresses the proper function key.

The "R" and "D" controllers also have keyboards and standard data entry formats for message composition and entry. In addition, the "R" controller has a trackball which is used for aircraft identification or geographic reference points to the computer.

The controller's radar console consists of a PVD, six control panels, a track ball, and a keyboard (see Figure 2-13). The field select control panel allows the controller to vary the range of the display up to 400 miles. The target history can be adjusted from zero to five histories or trails. The vector length can be set to forecast the target's position up to 8 minutes in the future. The leader length varies the length from the target to the data block.

The display adjustment control panel provides for the contrast, brightness, focus, alarm volume, dimmer, and power on the PVD.

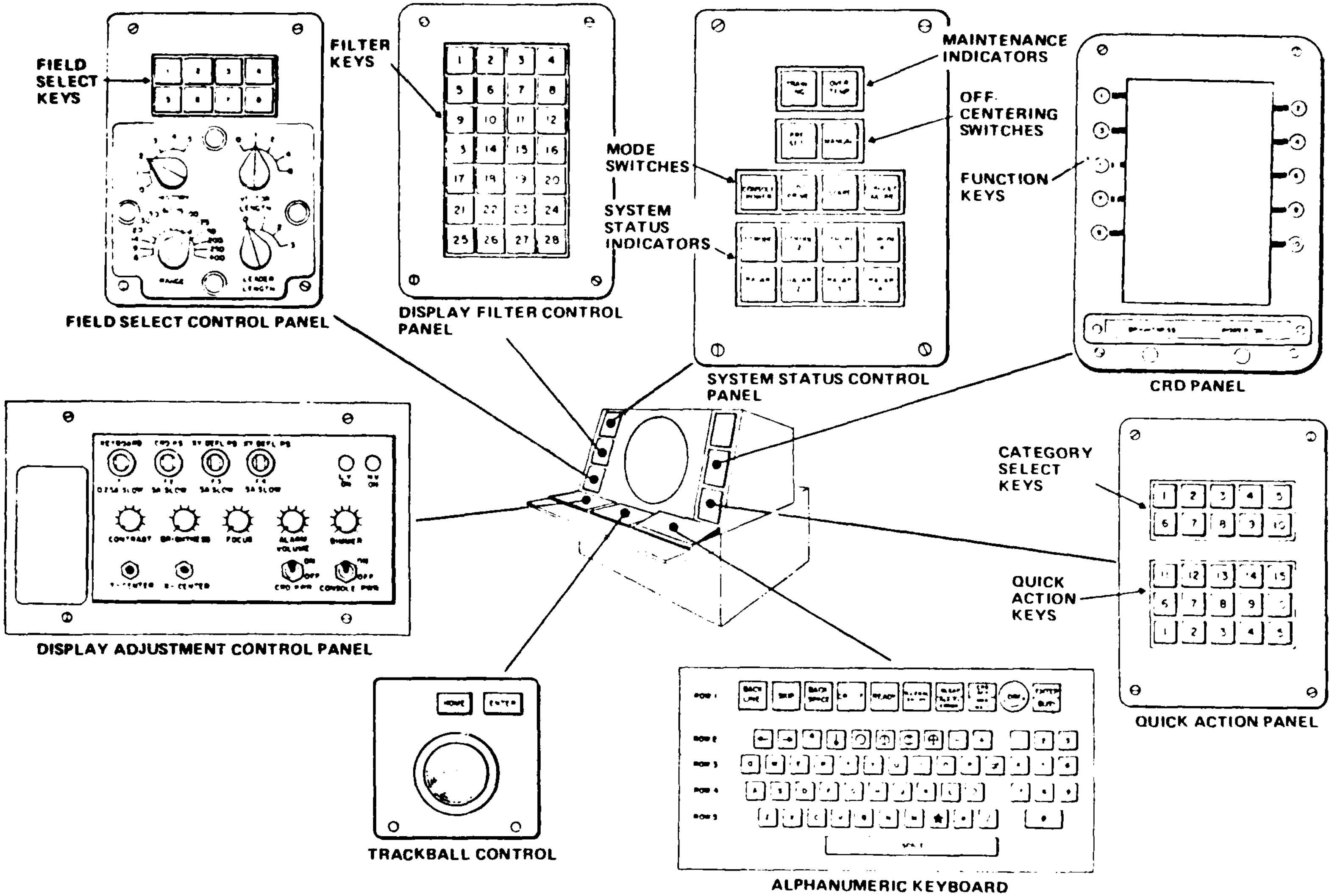
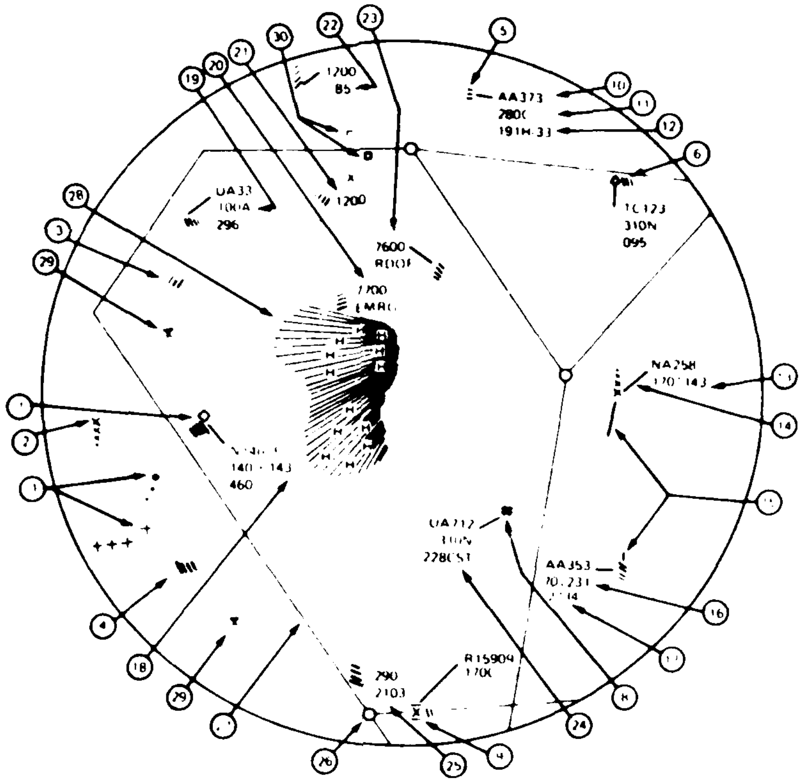


Figure 2-13 Radar Console Operator Panels



Target Symbols

1 Uncorrelated primary radar target + ●
2 *Correlated primary radar target X
3 Uncorrelated beacon target /
4 Correlated beacon target \
5 Identing beacon target ≡
(*Correlated means the association of radar data with the computer projected track of an identified aircraft)

Position Symbols

6 Free track (No flight plan tracking) △
7 Flat track (flight plan tracking) ◇
8 Coast (Beacon target lost) #
9 Present Position Hold ⧗

Data Block Information

10 *Aircraft Identification
11 *Assigned Altitude FL280, mode C altitude same or within ±200' of asgnd altitude
12 *Computer ID #191, Handoff is to Sector 33 (0-33 would mean handoff accepted) (*Nr's 10, 11, 12 constitute a "full data block")
13 Assigned altitude 17,000', aircraft is climbing, mode C readout was 14,300 when last beacon interrogation was received
14 Leader line connecting target symbol and data block
15 Track velocity and direction vector line (Projected ahead of target)
16 Assigned altitude 7000, aircraft is descending, last mode C readout (or last reported altitude was 100' above FL230
17 Transponder code shows in full data block only when different than assigned code
18 Aircraft is 300' above assigned altitude
19 Reported altitude (No mode C readout) same as assigned. An "N" would indicate no reported altitude)
20 Transponder set on emergency code 7700 (EMRG flashes to attract attention)
21 Transponder code 1200 (VFR) with no mode C
22 Code 1200 (VFR) with mode C and last altitude readout
23 Transponder set on Radio Failure code 7600, (RDOF flashes)
24 Computer ID #228, CST indicates target is in Coast status
25 Assigned altitude FL290, transponder code (These two items constitute a "limited data block")

Other symbols

26 Navigational Aid
27 Airway or jet route
28 Outline of weather returns based on primary radar (See Chapter 4, ARTCC Radar Weather Display. H's represent areas of high density precipitation which might be thunderstorms. Radial lines indicate lower density precipitation)
29 Obstruction
30 Airports Major □ Small ⌜

Figure 2-14 Plan View Display of Air Traffic Situation

The quick action panel provides the quick action keys and the category select keys for rapid computer entries by the controller.

The CRD panel provides for function keys and a device for the display of computer messages. It also contains a preview of keyboard entries.

The system status control panel provides for maintenance indicators, off-centering switches, console power mode switches, and radar system status indicators.

The display filter control panel provides for filter keys for altitude discrimination and filtering of targets.

The keyboard is used to input messages composed by the controller (displayed on the CRD) into the computer. The controller can use the trackball to identify aircraft position, aircraft identification, or define position location to the computer.

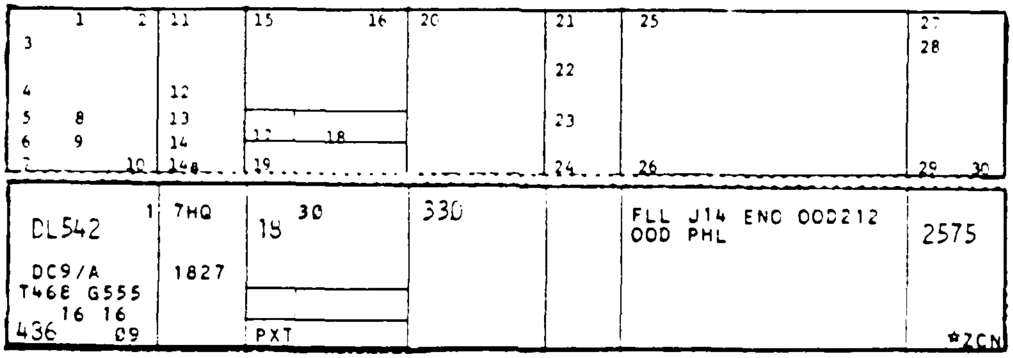
The sector or manual (D) controller portion of the work station consists of four flight progress strip bays, a CRD, an alphanumeric keyboard, and an associated flight strip printer. The computer prints flight progress strips on the printer. The strips are separated, individually inserted into flight progress strip holders, and placed in appropriate bays. The controller can amend the data on the strips by writing new information on the strips, then revising the computer data base (associated with the strips) by using the function keys and keyboard. The computer can display amended strip data by displaying the data on the CRD, which the controller can copy onto the strip printer.

To support the D-controller, the en route 9020 system computer calculates the time over each fix for a flight and produces a strip for each FPA. The strip is printed on the flight strip printer at the "A" position in the center. The "A" controller, if available, will insert the strip into a strip holder and pass it to the "D" controller for posting. Figure 2-15 shows a sample en route flight strip.

The center "D" controller will place the strip under the proper fix identifier bay. The controllers will assess the current strip against other flights to determine if adequate separation will exist between aircraft. If non-radar separation does not exist, the "D" controller will normally alert the "R" controller by marking the strip. The "D" controller will constantly scan the flight strip bays on his board for any change which affects separation or coordination. See Figure 2-16 and also refer to FAA ATC Procedures 7110.65, Appendix 1. See also Appendix C for description of controller flight strip marking abbreviations and symbols.

2.6.1.3 Controller-Pilot and Interphone Communications

The controller/pilot communications are via air/ground Very High or Ultra High Frequencies. In the centers and some of the large towers remote frequencies are con-



(1) VERIFICATION SYMBOL, IF REQUIRED.
(2) REVISION NUMBER.
(3) AIRCRAFT IDENTIFICATION.
(4) NUMBER OF AIRCRAFT (IF MORE THAN ONE), HEAVY AIRCRAFT INDICATOR "H/" (IF APPROPRIATE), TYPE OF AIRCRAFT AND SPECIAL EQUIPMENT INDICATORS.
(5) FILED TRUE AIRSPEED.
(6) SECTOR NUMBER.
(7) COMPUTER IDENTIFICATION NUMBER, IF REQUIRED.
(8) ESTIMATED GROUNDSPEED.
(9) REVISED GROUNDSPEED OR STRIP REQUEST (SR) ORIGINATOR.
(10) STRIP NUMBER.
(11) PREVIOUS FIX.
(12) ESTIMATED TIME OVER PREVIOUS FIX.
(13) REVISED ESTIMATED TIME OVER PREVIOUS FIX.
(14) ACTUAL TIME OVER PREVIOUS FIX OR ACTUAL DEPARTURE TIME ENTERED ON FIRST FIX POSTING AFTER DEPARTURE.
(14a) PLUS TIME EXPRESSED IN MINUTES FROM THE PREVIOUS FIX TO THE POSTED FIX.
(15) CENTER-ESTIMATED TIME OVER FIX (IN HOURS AND MINUTES) OR CLEARANCE INFORMATION FOR DEPARTING AIRCRAFT.
(16) ARROWS TO INDICATE IF AIRCRAFT IS DEPARTING ↑ OR ARRIVING ↓
(17) PILOT-ESTIMATED TIME OVER FIX.
(18) ACTUAL TIME OVER FIX, TIME LEAVING HOLDING FIX, ARRIVAL TIME AT NONAPPROACH CONTROL AIRPORT, OR SYMBOL INDICATING CANCELLATION OF IFR FLIGHT PLAN FOR ARRIVING AIRCRAFT OR DEPARTURE TIME (ACTUAL OR ASSUMED).
(19) FIX. FOR DEPARTING AIRCRAFT, ADD PROPOSED DEPARTURE TIME.
(20) ALTITUDE (IN HUNDREDS OF FEET) INFORMATION.
(21) NEXT POSTED FIX OR COORDINATION FIX.
(22) PILOT'S ESTIMATED TIME OVER NEXT FIX.
(23) ARROWS TO INDICATE NORTH ↑ , SOUTH ↓ , EAST → , OR WEST ← DIRECTION OF FLIGHT, IF REQUIRED.
(24) REQUESTED ALTITUDE.
(25) POINT OF ORIGIN, ROUTE AS REQUIRED FOR CONTROL AND DATA RELAY, AND DESTINATION.
(26) PERTINENT REMARKS, POINT OUT/RADAR VECTOR/SPEED ADJUSTMENT INFORMATION OR SECTOR/POSITION NUMBER. FACILITY CHIEFS MAY AUTHORIZE THE OPTIONAL USE OF SPACES 13, 14, 14a, 22, 23, 24, OR 28 FOR POINT OUT/RADAR VECTOR OR SPEED ADJUSTMENT INFORMATION.
(27) MODE 3/A BEACON CODE (IF APPLICABLE).
(28) MISCELLANEOUS CONTROL DATA (EXPECTED FURTHER CLEARANCE TIME, TIME CLEARED FOR APPROACH, ETC).
(29–30) TRANSFER OF CONTROL DATA AND COORDINATION INDICATORS.

Figure 2-15 NAS Stage A En Route Strip

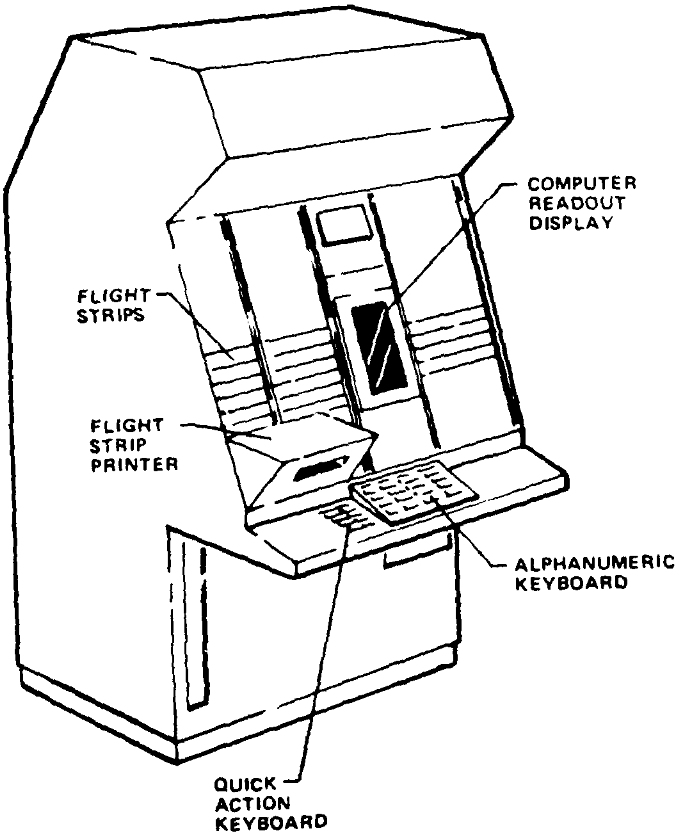


Figure 2-16 Flight Strip Printer and Flight Strip Bays for Manual (D) Position

nected to the facility by either microwave or telephone lines. All pilot/controller communications are recorded by multi-channel voice recorders in each facility. If an incident or accident occurs, a transcript can be made of all pertinent communications. The transcript will be used during the review of the incident or accident. Recordings are also used for search and rescue activities, as well as controller training and evaluation. In the center and terminal facilities controller communications are initiated when the controller depresses a button on the wire to his headset. At some terminals a foot pedal is also used.

Each control position has direct interphone access to immediately adjacent control positions and satellite airfield facilities. Other positions or facilities are accessible via indirect access interphone. All controller conversation over the interphone is recorded on voice recorders. Direct person to person communication is generally not recorded.

2.6.1.4 <u>NAS Stage A Data Processing</u>

In the NAS Stage A centers radar returns are digitized at the radar site by a Common Digitizer (CD) and transmitted in digital (narrowband) form to the center. Broadband radar has been retained and eventually will be replaced by Direct Access Radar Channel (DARC).

The NAS Stage A centers are equipped with either the IBM 9020A Central Computer Complex (CCC) and Raytheon Computer Display Channel (CDC), or the IBM 9020D CCC/CDC or IBM 9020E display channel hardware. Digitized radar is associated with flight plan data by the CCC, and presented on a controller's PVD by the CDC or 9020E. The data or data block on the PVD contains the flight call sign or identification; interim assigned altitude; and, if the flight has a Mode C transponder, the actual altitude; computer identification number; position of track symbology; track velocity and direction vector line; and other data such as handoff codes and beacon codes if appropriate. Other information on the PVD includes weather data presentation, navigational aids, routes, airports, and obstructions. Please refer to Figure 2-14.

The NAS Stage A Flight Data Processing (FDP) and Radar Data Processing (RDP) computer programs provide automated tools for the center controller. In a manual mode a flight plan must be hand written onto flight progress strips for all fixes that are posted on the flight progress boards. As the flight progresses through the center's area, or when amendments are made to the flight data, each affected controller must verbally pass the data to the next controller. All radar handoffs must be verbally given to the receiving controller. The last sector, where the aircraft will exit the center's area, must verbally pass the flight plan data to the next facility. With automation the flight plans are forwarded to the center's computer and strips are automatically generated for each required fix. The computer calculates and updates all fix times based upon radar track speed. Once a revision is manually entered, all subsequent sectors and facilities automatically receive the revision. Radar handoffs are automatically generated for all sectors and facilities.

Each center sector has one or more uniquely associated fix posting areas (FPA). (An FPA is a volume of airspace, bounded by a series of connected line segments with altitudes, which is assigned to a sector.) The fix may be an airport, navigational aid, or airway intersection. The area surrounding the fix and abutting the next area is called an FPA. Terminal areas may be defined as one or more FPAs.

2.6.1.5 EARTS

The En Route Automated Radar Tracking System (EARTS) is an automated radar and radar beacon tracking system used at San Juan, Honolulu, and Anchorage. Its functional capabilities and design are essentially the same as the ARTS IIIA system.

2.6.2 Tower/Terminal Radar Approach Control Operations

Underlying the centers are Airport Traffic Control Towers (ATCT) and terminal ATC Approach Control facilities that use radar and non-radar procedures to provide services to arriving, departing, or flights transitioning the controlled airspace.

A Terminal Radar Approach Control (TRACON) facility may be operated by the FAA, U.S. Army, U.S. Air Force, U.S. Navy or U.S. Marine Corp, or jointly by the FAA and a military service. Specific nomenclatures are used for administrative purposes in identifying radar approach controls. They are:

a. Army Radar Approach Control (ARAC), Army.

b. Radar Air Traffic Control Facility (RATCF), Navy/FAA.

c. Radar Approach Control (RAPCON), Air Force/FAA.

d. Terminal Radar Approach Control (TRACON), FAA.

e. Terminal Radar Approach Tower Cab (TRACAB), FAA.

Approach control facilities that are not radar equipped are referred to as non-radar approach control facilities.

The basic equipment for terminals consist of control desks or consoles, communications panels, weather instruments and displays, radar displays, flight progress strip boards, and auto- mation input/output devices. Whereas, in the center the equipment configuration is basically standardized, in the terminal there are many different configurations according to the type of facility and equipment in use. See Table 2-6 for different configurations.

The ATCTs are located at airports that meet specific tower establishment traffic

TABLE 2-6 DIFFERENT APPROACH CONTROL CONFIGURATIONS

EQUIPMENT	ENHANCED CAPABILITIES	REMARKS
NON-RADAR	None	May Have FDEP.
TPX-42	RADAR, Numeric Readout of Beacon Code and Mode C Altitude	May Have FDEP. No Interfacility Computer Capability.
ARTS II	RADAR, Alphanumeric Call Sign, Mode C Altitude and Special Indicators. (No Tracking)	Most Have FDEP. Some Facilities have Computer Interface.
ARTS III	RADAR, Alphanumeric Call Sign, Mode C Altitude, Ground Speed (Beacon Tracking) and Special Indicators	Most ARTS III Facilities have FDEP. All Facilities are Interfaced.
ARTS IIIA	RADAR, Alphanumeric Call Sign, Mode C Altitude, Ground Speed (Tracking) and Special Indicators. (Will be improved to full digital mode in the future.)	Same as ARTS III.

volume criteria. The airport movement area and airspace in the immediate vicinity of the airport are controlled by the towers. Where a tower and an approach control are colocated or in close proximity they are generally under the same air traffic manager.

Normally, there are no areas of specialization within the terminal facility, except at the largest facilities, such as the New York TRACON. Occasionally, the tower may be operationally split from the TRACON, although they are at the same location. Generally, terminal controllers will rotate through all operational control positions at colocated facilities, though not necessarily on the same watch.

The airport runway and taxiway configuration, prevailing winds, and noise abatement procedures are significant factors in the terminal flow of traffic. A modern airport with dual runways and high speed turnoffs onto taxiways, such as the Dallas/Fort Worth Airport, can handle much more traffic than an airport with one major runway.

There may be one or more Area Supervisors in support of the controller activities located in the approach control and tower. The shift is usually under the administrative control of an Area Manager or Area Supervisor. Technicians and Data Systems personnel are staffed on most shifts or are "on-call".

2.6.2.1 Terminal [illegible] Tower ATC [illegible] ATC Resp[illegible]

Terminal controller [illegible] tions of responsibilit[illegible] associated with the [illegible] defined for each position [illegible] facility directive. [illegible] provides a descrip[illegible] of the possible operati[illegible] sitions in a terminal [illegible]ity.

The radar positions [illegible] further identified as east west or north south. [illegible] tions working traffic [illegible]ily at secondary or satellite airports may have various names associated with the geographic area, or may have a generic name such as satellite controller. Other names used in the terminal include feeder controller, final controller, or other designations to accommodate local conditions. Traffic volume and airport configuration may directly influence tower controller staffing. At large towers one local and one ground controller may be staffed for each hemisphere of activity associated with dual runways.

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UNCLASSIFIED DTFA01-83-Y-10554 F/G 17/7 NL

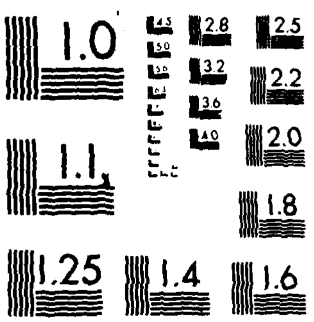
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

TABLE 2-7. DESCRIPTION OF TERMINAL POSITIONS

POSITION	SYMBOL	DESCRIPTION
Local Control (Tower)	LC	Provides separation of air traffic on active runways and in the immediate airport area.
Ground Control (Tower)	GC	Provides separation of air traffic on airport surface area excluding active runways and gate areas.
Clearance Delivery (Tower)	CD	Issues ATC clearances with appropriate terminal restriccions to pilots prior to departure.
Flight Data (Tower)	FD	Responsible for receiving, distributing, and entering computer messages on flight plans.
*Approach Control	AP	Responsible for providing separation to arrival aircraft in the terminal area using air/ground radio and flight progress strips.
*Arrival Control (Radar)	AR	Responsible for providing separation to arrival aircraft in the terminal area using air/ground radio, radar display, and flight progress strips.
Arrival Data (Radar)	AD	Responsible for receiving, distributing, and entering computer messages on arrival flight plans.
*Departure Control	DC	Responsible for providing separation to departing aircraft in the terminal area using air/ground radio and flight progress strips.
*Departure Control (Radar)	DR	Responsible for providing separation to departing aircraft in the terminal area using air/ground radio, radar display, and flight progress strips.
Departure Data (Radar)	DD	Responsible for receiving, distributing, and entering computer messages on departing flight plans.

* Traffic overflying the terminal area will be separated by the positions specified in the facility directives.

TABLE 2-7. DESCRIPTION OF TERMINAL POSITIONS (Cont'd)

POSITION	SYMBOL	DESCRIPTION
Gate Hold	GH	Responsible for issuing taxi times or engine start times to departing air craft to effect flow control when necessary.
Coordinator (Tower)	CC	Coordinates the movement of traffic between positions. May assist in radar handoffs.
Coordinator (Radar)	CI	Coordinates the movement of traffic between positions. May assist in radar handoffs.
Area Supervisor	AS	Supervises a team of controllers work ing specified positions.
Area Manager	AM	Responsible for supervision and man agement of control room/tower cab.

NOTE 1: Tower positions included here for convenient reference.

NOTE 2: Facility air traffic managers may use position designators other than those listed to accommodate local situations. As an example, handoff position (HO), similar to arrival/departure data positions, but adds handoff and coordination responsibilities.

2.6.2.2 Terminal Position Workstation Features

The ARTS Data Entry and Display Equipment (Figure 2-17) consists of a radar console and associated controls, an alphanumeric keyboard, a slew ball in the ARTS III, and a Peripheral Entry Module (PEM) or joy stick in the ARTS II, and five quick look buttons or switches.

The display is a radar display with alphanumeric data written on top of broadband radar. By using the appropriate control switches and settings the controller can present radar targets (broadband), weather (broadband), video mapping, and digitized data blocks containing aircraft identity, altitude, speed, and control symbology. See Figure 2-18. The radar scope can be off-centered and has a maximum range of 60 miles.

The controller communicates with the ARTS computer through the use of the keyboard, which contains function keys as well as alphanumeric data. Keyboard-entered data and status messages are displayed in preview and status areas on the radar display. These areas are relocatible and are dynamically selected by the individual controller.

The controller can quick look, or present up to five other positions on his display, through the selection of the predetermined quick look buttons or switches.

Except for the smaller terminals, most approach controls and towers are equipped with FDEP equipment. FDEP consists of one or more keyboards and flight strip printers. This equipment is interfaced directly to the center's computer through a Data Communication Control Unit (DCCU). FDEP provides for flight progess strips and control messages such as departure times and flight amendment messages. The flight data controller will deliver the strip to the appropriate position. An example of these strips is given in Figure 2-19.

2.6.2.3 Terminal Controller-Pilot and Interphone Communication

All terminal air traffic control facilities are equipped with radio communications to aircraft, telephone communications to ARTCCs and FSSs, and have a variety of equipment for observing, detecting, receiving, and displaying weather information.

Radios and telephones are major tools of the terminal controller.

Terminal ground-to-air communications are conducted with VHF or UHF transmitters and receivers. See Section 2.6.1.3 for additional details.

2.6.2.4 ARTS Data Processing

The ARTS II/III also provide automated tools for the terminal controller. The center's computer will forward a condensed flight plan to the ARTS. It will store the data and present a tabular listing of the call sign at the appropriate position. If the

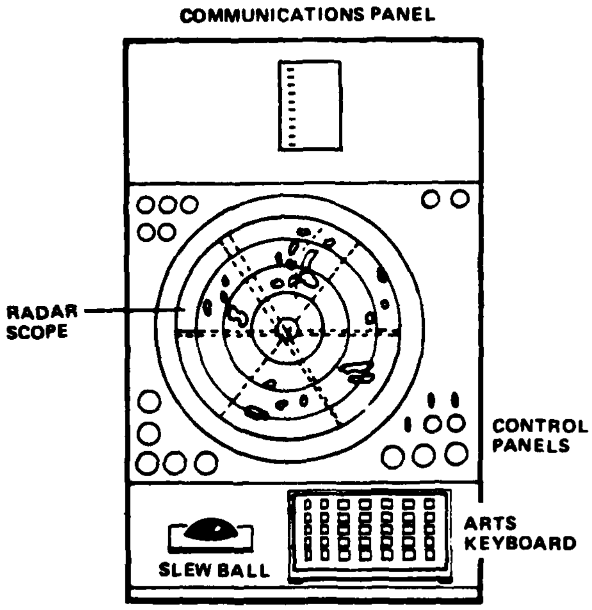

Figure 2-17 TRACON ARTS Position Console

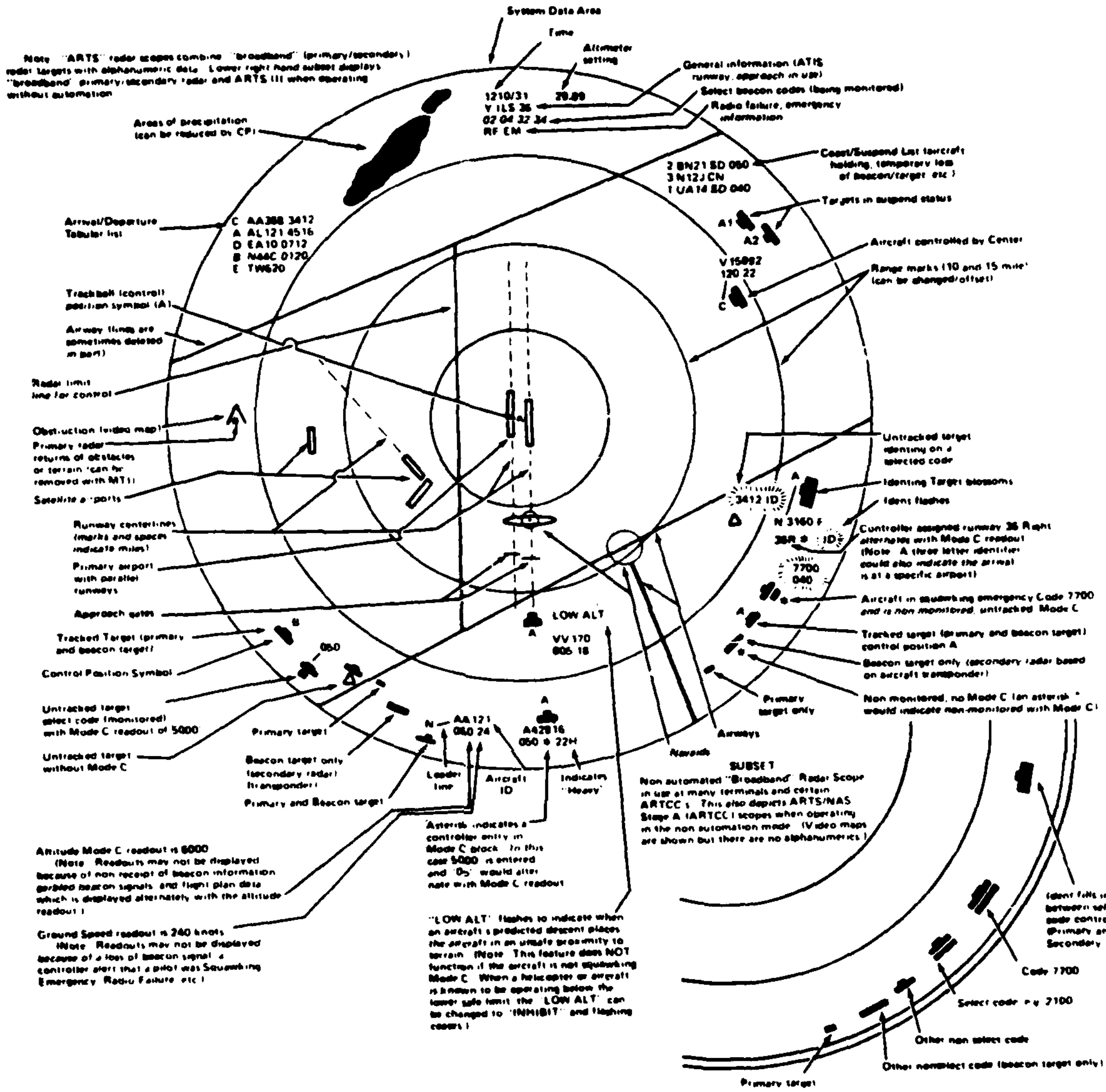

Figure 2-18 ARTS Situation Display

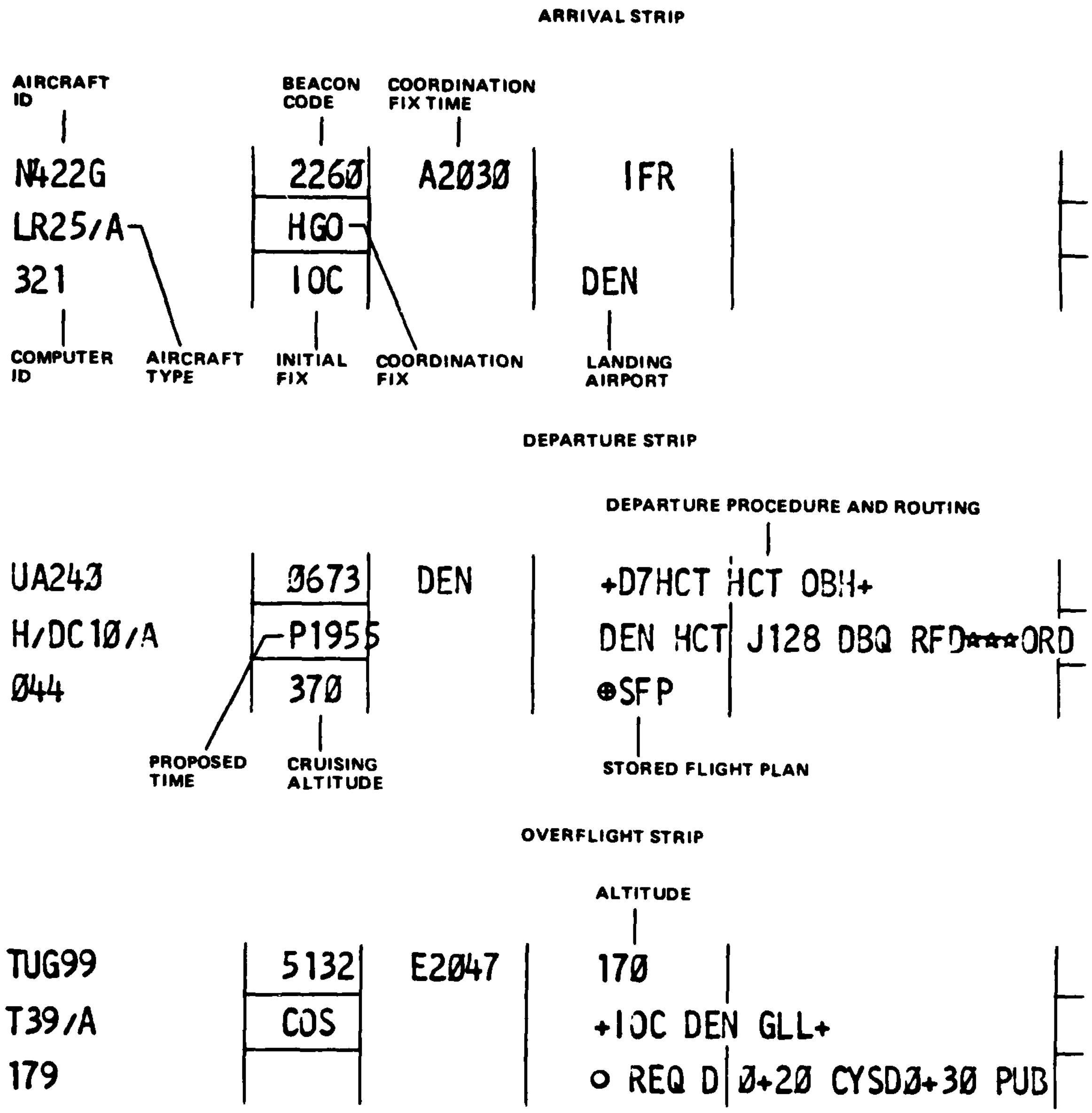

Figure 2-19 FDEP Strips

flight is a departure, ARTS will automatically forward a departure message to the center's computer when the flight is airborne. If the flight is an arrival, ARTS will forward a 'terminate' message to the center's computer when the flight has landed. The ARTS does not have automatic handoff generation, except as a local modification to the ARTS computer program.

Most terminals are equipped with the FDEP equipment, which is directly on-line to the center's computer. There is no physical association between the ARTS and FDEP except at the center. Handwritten strips must be produced for local terminal operations. Figure 2-20 provides a flow diagram of the ARTS data facility.

The ARTS III is presently being upgraded to the ARTS IIIA. This eventually will provide a digital radar display presentation. The current and interim systems associate a data block with a broadband radar target. The data block includes the controller position symbol, leader line, aircraft identification, heavy jet indicator, ground speed, and Mode C altitude data if available. The controller can also insert assigned altitude, aircraft type, and other data in a "scratch pad" area if desired. The ARTS display also contains arrival/departure lists, coast /suspend lists, and systems data area. Obstructions, airports, navigational aids, etc., are presented via a video map and not as a digital picture segment by the ARTS III system.

The ARTS II is very similar to the ARTS III with one major exception-tracking. The ARTS III predicts the movement of the target and is considered a tracking system. The ARTS II does not track but displays the last reported position of the target. The ARTS II is being upgraded to the ARTS IIA and will be the functional equivalent to the ARTS III system.

The FAA and Air Force are currently using a beacon code and Mode C altitude readout device on the radar called TPX-42. The agency will replace this numeric device with the ARTS IIA. The Air Force and Navy are implementing the PIDP to replace the TPX-42 and other radar systems. The Army uses the ARTS II/III.

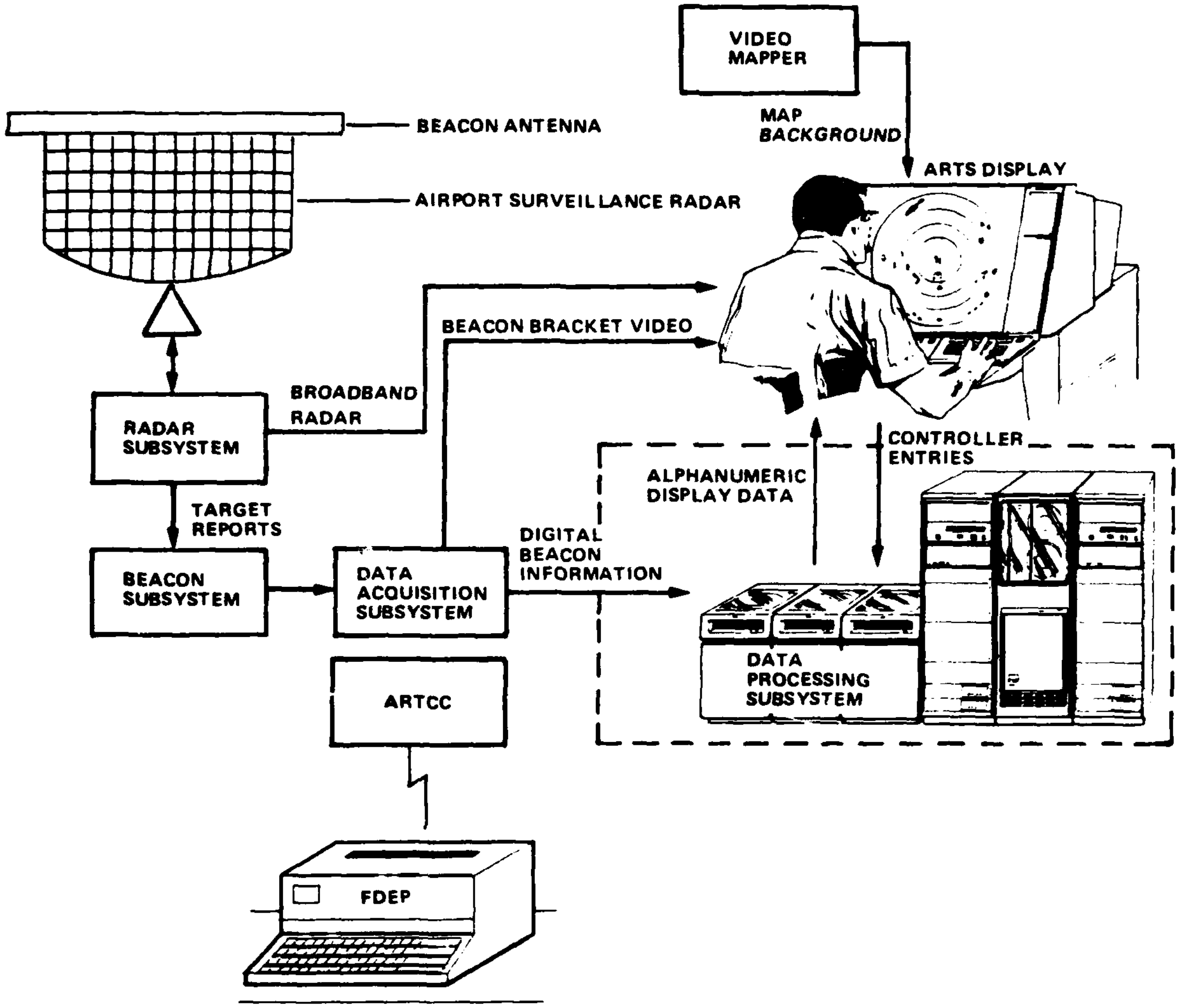

Figure 2-20 ARTS Display Data Path

2.6.3 Contrast In Center/Terminal Operations

A control position in a terminal is usually a single position backed up by a coordinator position. Whereas, in a center, a sector is normally a two or three, and in some cases, a four man operation. Relief is given by combining the D & R positions at a sector or by another controller. In the terminal the position will be combined with another position, thereby giving the controller relief. Alternate staffing occasionally permits relief without combining. On the midnight shift the center will be reconfigured into as few sectors as possible. In many terminals, responsibility for performing the approach control function is shifted to the towercab on the midnight shift, where they are operationally combined.

The delegation of responsibility from the center for air traffic control services (i.e., approach control service, control boundary jurisdiction, etc.) is identified in a letter of agreement between the center and one or more terminals. Normally, the airspace delegated to the terminal facility, holding patterns, provisions for emergency services, and arrival/departure routes, including transfer of control points, are identified in the agreement. If the terminal is a part-time facility, either fewer than 24 hours per day or 7 days per week operation, the airspace and associated control responsibility reverts back to the respective center.

2.6.4 Flight Service Stations (FSSs)

FSSs are air traffic facilities which provide pilot briefings, en route communications, VFR search and rescue services, assist lost aircraft and aircraft in emergency situations, relay ATC clearances, originate Notices to Airmen (NOTAM), broadcast aviation weather, receive and forward IFR flight plans to the center's computer, and monitor navigation aids. In addition, at selected locations, FSSs provide en route flight advisory service (flight watch), take weather observations, issue airport advisories, and advise customs and immigration of transborder flights.

There are currently over 300 FSSs in the U.S. When they are fully automated this number will be reduced to 61. Most of the data associated with the above services will be contained in a data base and presented to the FSS specialist through computer driven displays. The final phase of automation will permit the pilot, through his entry and display device, to receive briefing material direct without the need for an FSS specialist.

2.6.5 Interfacility Communications Systems

Interfacility systems provide communications between facilities, including major manned facilities, such as air route traffic control centers (ARTCC), airport traffic control towers, and smaller remote facilities like radar sites and ground-to-air transmitter sites.

Although most interfacility services used for both voice and data transmission are leased, some are FAA owned. Most FAA-owned transmission are radar microwave link (RML) equipment. About 16,000 miles of RML are used to send en route radar information to the appropriate air route traffic control center. These links also are used for backup emergency communications (BUEC), ground-to-air receivers and transmitters, and limited other applications.

The FAA also owns television microwave links (TML) which are used to remote radar information and other data. For example, a TML could be used to transmit radar data from one radar to two different airports. It also could remote a radar across an airport where it would be too expensive to lay cable, as would otherwise be necessary.

All other transmission media are leased, generally from the local utility company. Low-speed teletype networks emanate from the Kansas City, Missouri, NATCOM. These are multiple networks for appropriate national and international distribution. Networks are typically oriented toward specific functions, such as the distribution of flight plan information (Service B), weather information (Service A and C), and international messages (aeronautical fixed telecommunications network (AFTN). Often, multiple terminals are colocated in the same facility. Network interconnections also are provided with other countries, the National Weather Service, and other users, such as airlines.

Most data circuits are low-speed (150 bits-per-second or below) subvoice grade lines. Little interoperability exists on these circuits. Medium-speed lines (2400 bits-per-second) are used to connect newer equipment, such as computers. Very few highspeed circuits exist.

2.6.6. Special Controller Aids

Although the use of the airborne transponder provided a significant improvement to the original primary radar return, it became the key ingredient in providing automatic identification, track initiation, and altitude reporting data to the controller. The use of the discrete beacon code was essential for accurate tracking. The display of Mode C altitude became an indispensable tool for the controller and it reduced the pilot/controller communication by a considerable amount. It also paved the way for two new safety features which have been added to the ARTS III and NAS Stage A software programs. These safety routines are called the Conflict Alert Program and the Minimum Safe Altitude Warning (MSAW) Program. Although the programs have different software parameters which affect the alert warning time and display, both are alert techniques which are important tools to the controller.

2.6.6.1 Conflict Alert

Conflict alert is a capability within ARTS and NAS Stage A3d2 software to signal the controller that two aircraft are or will come within minimum specified distance or altitude of one another. The significant difference between the terminal and en route conflict alert is the availability of the assigned or interim altitude in the en route system. By using the assigned altitude the computer program can determine whether a conflict will exist when aircraft are climbing-descending to the assigned altitude. The ARTS III, not having an assigned altitude available, assumes that aircraft will continue the climb/descend pattern and not stop at an unknown assigned altitude.

2.6.6.2 Minimum Safe Altitude

The ARTS III has had a MSAW function for several years. The NAS Stage A also has this program. The main differences are in the adaption of the boxes containing high terrain or obstacles. The NAS STAGE A divides its area into irregular shaped boxes of varying dimensions. Whereas, the ARTS program adapts the highest terrain or obstacle for each 2 mile square bin. The ARTS III also provides for special adaptation of airport areas to reduce false alerts involving aircraft in the approach to the runways.

2.6.6.3 Range Bearing/Vector Line

The NAS Stage A computer program includes a function which will read out the range/bearing/time from an aircraft to a fix or geographical point. This controller aid is not available in the terminal programs except as a local modification, but has become a frequently used tool in the terminals where it is available. The vector line is another frequently used center controller tool. The vector line is used to forecast the flight of one or more aircraft by drawing the projected route on the display. There is no terminal system equivalent.

2.6.6.4 Metering

The en route system has recently added a metering program designed to reduce terminal congestion. The program will calculate arrival [illegible] times, determine the delay factor from inserted airport/runway acceptance rates, and display a delay factor on the metering positions. The metering position must coordinate metering times with the affected controller(s). Thus, the controller can reduce the speed of aircraft prior to the inbound fix so that little or no holding time is required in close to the terminal or airport area.

2.6.6.5 ARTS III Scratch Pad

Although the terminals have reduced the need for flight progress strips, there remains the need for flight plan data. Many terminals display fix, altitude, type aircraft, and/or other data in the special areas of the full data block. The area containing inserted data is frequently referred to as "scratch pad". Another terminal tool is the use of a partial data block. This condenses the data of another controller's full data block, thereby reducing the clutter on a display.

2.7 REFERENCES

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Chapter 3.0

Air Traffic Control Operational Events

3.0 AIR TRAFFIC CONTROL OPERATIONAL EVENTS

This chapter identifies the events which directly influence controller actions on the job. To proceed from the Chapter 2 description of the Air Traffic Control system, this chapter begins the systematic analysis of controller work in that system.

As stated in Section 1.4, the methodology for the analysis of the controller's tasks is based upon the assumption that these activities may be characterized as event responsive. Although all of the controller's complex thought processes and not individual judgment may not be directly observed by the analyst, it is a useful analysis tool to identify the types of events which occur within a controller's environment, and to which he must be responsive.

As defined in Chapter 1, and portrayed in Figures 1-3 and 1-4, an event may be characterized as a product of the interactions among aircraft, airspace, facilities, surveillance capabilities, and ATC operations (which include controller/controller, pilot/controller, controller/staff, and controller/machine interactions). That is, an event is a distinct occurrence which the controller perceives and responds to in some manner. To identify the tasks the controller performs in response to these events, the controller may be modeled as an information processor. The advantage of using this model as an analysis tool is that, if a comprehensive list of events which the controller observes is documented, as well as a similarly extensive list of tasks, a great deal of accuracy may be had in describing the controller's work. The disadvantage in modeling the controller as an information processor, whose response to events is to perform tasks, is the dynamic operational complexity of the controller's job necessitates a highly interactive analysis model, the application of which is inherently complex. One event may trigger another event before an appropriate controller response occurs. In addition, it may not be appropriate for the controller to outwardly respond immediately. A mental response is difficult to document until the response evolves into an overt one. Therefore, in viewing the controller as an individual who processes information in response to events, we do not have an exact reproduction of the controller as in a photograph, but we do have an accurate and extremely useful model <u>which can be applied</u>.

The purpose of Chapter 3 is to capture the events and groups of events which influence what the controller does on his job. Actual observations of controllers on the job, as well as documentation listed as References [1], [2], and [3] at the end of this chapter, were used to identify and describe events. These were synthesized into a comprehensive and structured list. Direct observations of controllers at work were made at both terminal and en route facilities, of varying size and traffic volume/complexity. Categories of events are portrayed in Figure 3-1 as being

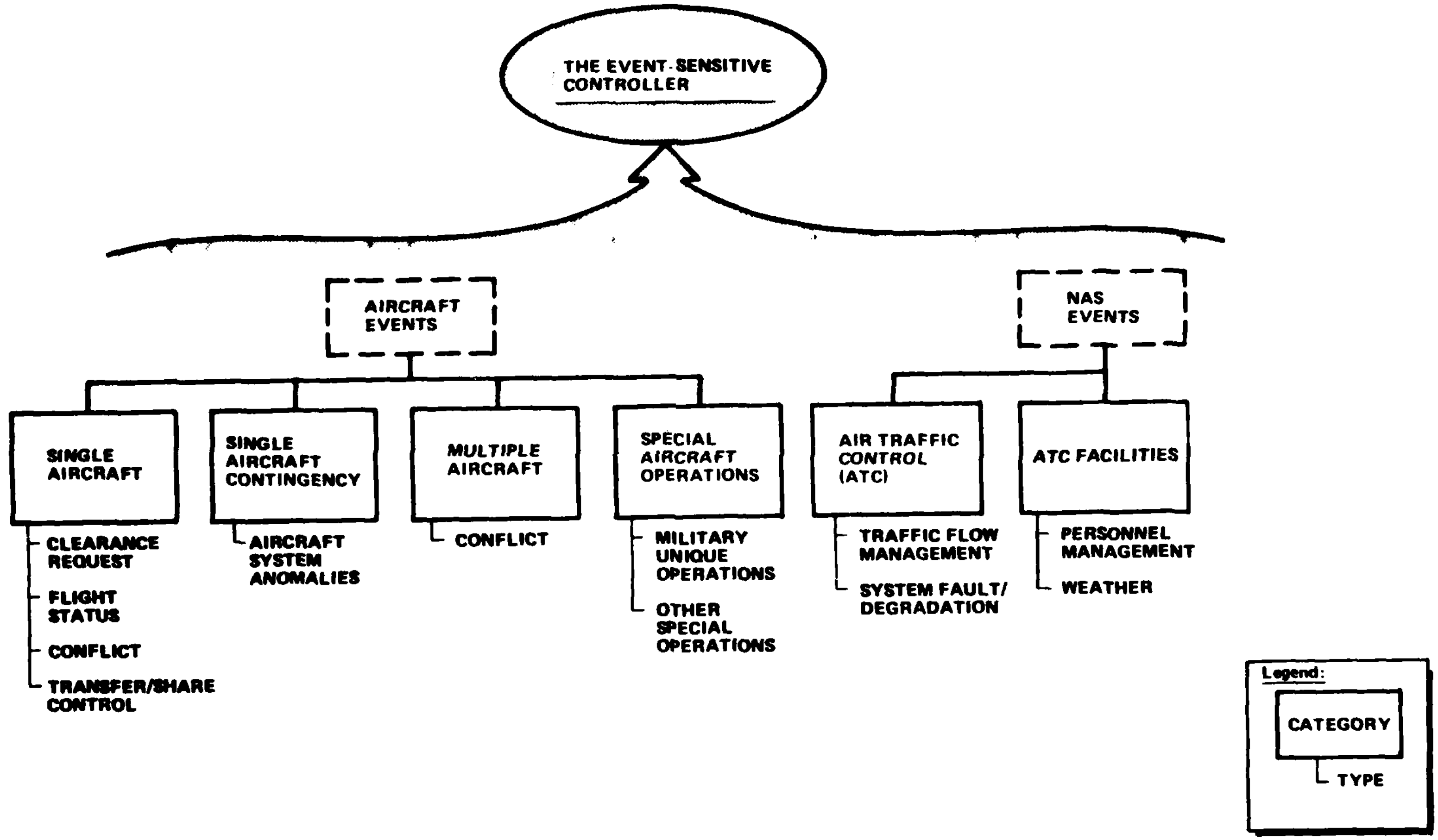


Figure 3-1 Event Categories

either aircraft related events or NAS related events. Within the Aircraft related events are the Single Aircraft, Single Aircraft Contingency, and Multiple Aircraft Categories. Within the NAS related events are the Air Traffic Control and ATC Facilities Categories. Each category is then broken down into Types.

See Table 3-1 for the list of events identified with respect to these types. Table 3-1 is the events list in its entirety. For the purposes of discussion and ease in reference, these events are grouped roughly according to the functional genesis as a specified group of events. For example, the single aircraft category will progress through several clearance request types of events. This grouping of events is intended primarily to provide an organization which may be readily reviewed for completeness.

Figures 3-2 through 3-18 follow this grouping description in portraying a synopsis of these events and providing event descriptions. In addition, this simplified representation of the ATC event scenario illustrates the character of events derived in each category of Figure 3-1, as they occur within the flow of the ATC operational environment.

The event [illegible] suggests what t[illegible]oller might say in re[illegible]o an event occurrence [illegible]stances where this may illuminate the event description. However, the controllers' quotes on the graph are not transcribed in exact controller-ese, rather in prose form to enhance understanding of the concept for the non-controller. Similarly, a possible portrayal of either the STAGE A or ARTS display is shown, when appropriate.

Following the synthesis of events in Chapter 3, Chapter 4 draws a relationship between these events and the controllers' corresponding activities. These activities are then broken down into sub-activities, so that each event corresponds to at least one sub-activity. Thus, is preserved a direct linkage from events, through controller activities, to statements of component sub-activities.

TABLE 3-1. EVENTS/TYPES/CATEGORIES

EVENT	TYPE	CATEGORY
	Clearance Request	Single Aircraft
Clearance Delivery		
Taxi Clearance		
Takeoff Clearance		
Amended Altitude/Route/ Destination		
Flight Following		
VFR TCA/TRSA		
Approach Clearance		
Landing Clearance		
	Flight Status	Single Aircraft
Initial Contact		
Filed Flight Plan		
PIREP		
Missed Approach		
TAS, Altitude, Route Deviation		
Entering/Leaving Hold		
FAF Inbound		
Overdue Aircraft		
	Conflict	Single Aircraft
Minimum Safe Altitude Warning		
Display of Severe Weather		
Impending Airspace Conflict		

TABLE 3-1. EVENTS/TYPES/CATEGORIES (Cont'd)

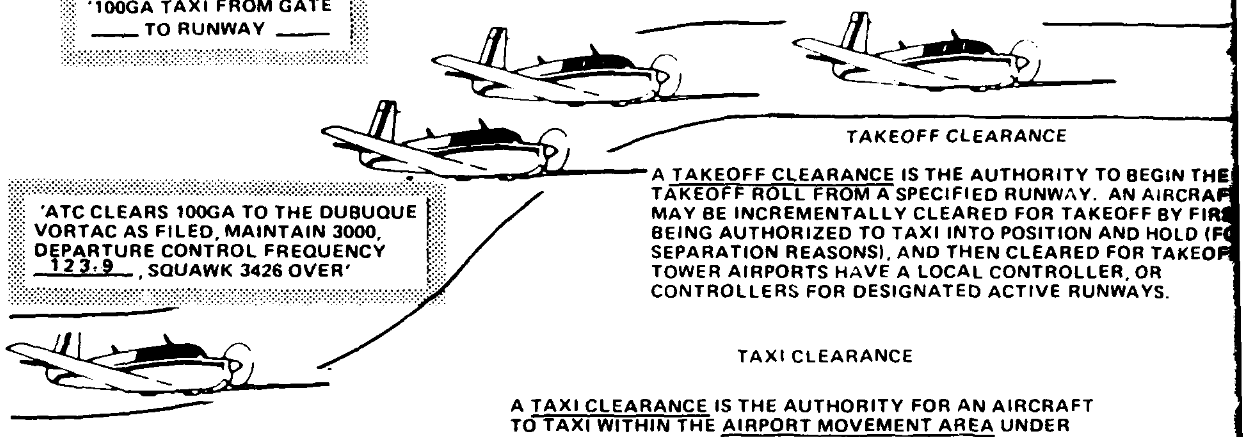
EVENT	TYPE	CATEGORY
	Transfer/Share Control	Single Aircraft
Handoff Receipt		
Aircraft to Edge of Sector		
Pointout Receipt		
Airspace Release		
	Conflict	Multiple Aircraft
Aircraft-Aircraft Conflict		
Traffic Advisory		
Refueling, Exercises, Air Shows		
	Aircraft System Anomalies	Single Aircraft Contingencies
No Radio		
Beacon Failure		
Aircraft Emergency		
Medical		
	Military Unique Operations	Special Aircraft Operations
Interceptor Flights		
Military Training Routes		
Above FL 600		

TABLE 3-1. EVENTS/TYPES/CATEGORIES (Cont'd)

EVENT	TYPE	CATEGORY
	Other Special Operations	Special Aircraft Operations
Balloons, Gliders		
Experimental Flights		
Fuel Dumping, Jettison		
Law Enforcement		
D.O.E. Flights (e.g. Hazardous Cargo)		
Lifeguard Missions		
Hijack		
Bomb Threat		
Restricted, Warning, "Hot" MOA		
	Traffic/Flow Management	Air Traffic Control
Flow Management Required		
ALTRV, Airspace Reservation		
Change Flow Pattern		
Runway Configuration Change		
Facility Closure/ Capacity Change		

TABLE 3-1. EVENTS/TYPES/CATEGORIES (Cont'd)

EVENT	TYPE	CATEGORY
	Systems Fault Degradation	Air Traffic Control
Communications Failure		
RDP Failure		
FDP Failure		
NAVAID Status		
Duplicate Beacon Code		
Failure to Receive Handoff		
	Personnel Management	ATC Facilities
Controller on Duty		
Controller Overload		
	Weather	ATC Facilities
SIGMET/AIRMET Advisories		
Wind Shear Report		
Ceiling Height Report		
Visibility Report		
Pressure Display/Report		



TAKEOFF CLEARANCE

A TAKEOFF CLEARANCE IS THE AUTHORITY TO BEGIN THE TAKEOFF ROLL FROM A SPECIFIED RUNWAY. AN AIRCRAF MAY BE INCREMENTALLY CLEARED FOR TAKEOFF BY FIR BEING AUTHORIZED TO TAXI INTO POSITION AND HOLD (F SEPARATION REASONS), AND THEN CLEARED FOR TAKEOF TOWER AIRPORTS HAVE A LOCAL CONTROLLER, OR CONTROLLERS FOR DESIGNATED ACTIVE RUNWAYS.

TAXI CLEARANCE

A TAXI CLEARANCE IS THE AUTHORITY FOR AN AIRCRAFT TO TAXI WITHIN THE AIRPORT MOVEMENT AREA UNDER SPECIFIED CONDITIONS. TOWER AIRPORTS HAVE CONTROLLED AIRPORT MOVEMENT AREAS. THE GROUND CONTROLLER HAS THE RESPONSIBILITY OF MANAGING THE FLOW OF AIRCRAFT MOVEMENTS ON THE GROUND CLEAR OF ALL RUNWAYS. AT VERY SMALL FACILITIES, OR DURING VERY LIGHT PERIODS OF AIRCRAFT ACTIVITY, THE LOCAL CONTROLLER MAY HANDLE THE GROUND CONTROL DUTIES.

CLEARANCE DELIVERY

CLEARANCE DELIVERY IS THE TRANSMITTAL OF AN INITIAL CLEARANCE, BASED UPON A FILED FLIGHT PLAN TO THE AIRCRAFT BY ATC. IT SIGNIFIES THE ACCEPTANCE OF THE FLIGHT PLAN AND INCLUDES ANY MODIFICATIONS INTERJECTED BY ATC. NON-FLIGHT PLAN ITEMS INCLUDED IN THE CLEARANCE DELIVERY ARE THE ASSIGNED BEACON CODE, THE FREQUENCY FOR THE ATC FACILITY HANDLING, THE DEPARTURE AFTER TAKEOFF, AND ANY RESTRICTIONS OR ADVISORIES. AT TOWER AIRPORTS CLEARANCE DELIVERY IS HANDLED BY THE GROUND CONTROL POSITION OR, IN THE LARGER FACILITIES, BY A DEDICATED CLEARANCE DELIVERY POSITION. AT UNCONTROLLED AIRPORTS, OR WHEN A TOWER IS CLOSED, A FLIGHT SERVICE STATION (FSS) MAY DO THE CLEARANCE DELIVERY, EITHER OVER RADIO OR BY PHONE. WHEN THIS IS IMPRACTICAL, OR WHEN A VFR DEPARTURE IS MADE, THE CONTROLLING ARTCC SECTOR MAY DELIVER THE CLEARANCE DIRECTLY BY RADIO.
FOR AIRFILED FLIGHT PLANS, THE FSS OR ARTCC MAY DELIVER THE CLEARANCE, AND FOR POP-UP CLEARANCE REQUESTS, THE ARTCC OR TRACON DOES THE DELIVERY.

A CHANGE OF ALTITUDE MAY BE REQUESTE FOR BETTER EFFICIENCY DUE TO FAVORAB AVOID TURBULENCE OR OTHER WEATHER, A CLIMB OR DESCENT. THIS INCLUDES REQU MODIFICATION OF A RESTRICTION WHEN IT WITH THE PILOT/CREW JUDGEMENT. CERTA SPECIAL OPERATIONS MAY REQUEST A BLO ASSIGNMENT. THIS ASSIGNS AIRSPACE WITH LOWER BOUNDARIES. A CRUISE CLEARANC ATC IS SIMILAR, ASSIGNING AIRSPACE FROM ALTITUDE DOWN TO THE MINIMUM IFR ALTI CRUISE CLEARANCE ALSO INCLUDES THE A PROCEED AND MAKE AN APPROACH AT THE AIRPORT.

AN AMEN REASON, ROUTING AIRWAY, OR COOR ROUTES DUE TO P

Figure 3-2 Clearance Request Events (Single Aircraft)

IGHT LEVEL 290,
OOD RATE OF CLIMB
, REPORT READY TO
370'.

PPROVE YOUR
CENTER HAS
SPACE IN YOUR
U MIGHT TRY
N."

'100GA, SAY PRESENT POSITION, DESTINATION AND ALTITUDE.'

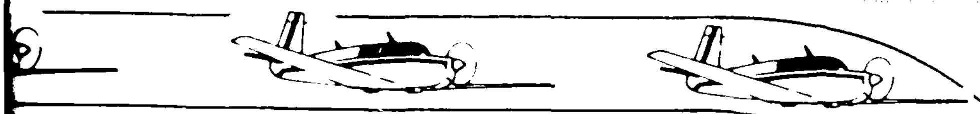
'100GA, SQUAWK CODE 5333 AND IDENT, WHAT TYPE AIRCRAFT ARE YOU?'

'100GA RADAR CONTACT, ONE-EIGHT MILES SOUTH OF PUEBLO, PUEBLO ALTIMETER ____

'100GA WHAT IS YOUR PRESENT POSITION, DESTINATION AND ALTITUDE?'

'100GA SQUAWK CODE 4066 AND IDENT, AND BRIEFLY FOLLOWING, '100GA, RADAR CONTACT, TRAFFIC IS 12 O'CLOCK AND 4 MILES SOUTH-WEST BOUND,

'100GA, TRAFFIC NO LONGER A FACTOR.'



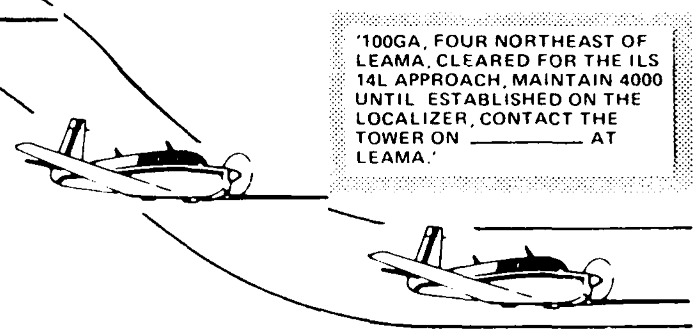
ANCE

IORITY TO BEGIN THE
UNWAY. AN AIRCRAFT
FOR TAKEOFF BY FIRST
OSITION AND HOLD (FOR
LEARED FOR TAKEOFF.
NTROLLER, OR
TIVE RUNWAYS.

VFR TCA/TRSA

A PILOT/CREW MAY REQUEST CLEARANCE THROUGH A TERMINAL CONTROL AREA(TCA) OR ELECT TO PARTICIPATE IN THE STAGE II (SEQUENCING) OR STAGE III (SEQUENCING AND SEPARATION) PROGRAM OF A TERMINAL RADAR SERVICE AREA (TRSA).

'100GA, FOUR NORTHEAST OF LEAMA, CLEARED FOR THE ILS 14L APPROACH, MAINTAIN 4000 UNTIL ESTABLISHED ON THE LOCALIZER, CONTACT THE TOWER ON ________ AT LEAMA.'



FLIGHT FOLLOWING

RCRAFT
NDER
ONTROLLED
OLLER HAS
AIRCRAFT
AYS. AT
PERIODS OF
Y HANDLE

A VFR AIRCRAFT MAY REQUEST AND BE GRANTED/DENIED FLIGHT FOLLOWING SERVICE FROM AN ATC FACILITY ON A WORKLOAD-PERMITTING BASIS. THE FACILITY MUST HAVE RADAR TO PROVIDE FLIGHT FOLLOWING.

'100GA, CLEARED TO LAND RUNWAY ONE-FOUR LEFT, CAUTION WAKE TURBULENCE FROM A BOEING 747 AHEAD OF YOU ON THE APPROACH, WIND CALM.'

APPROACH CLEARANCE

AN APPROACH CLEARANCE IS THE AUTHORITY TO EXECUTE A SPECIFIC PUBLISHED APPROACH TO AN AIRPORT. THE APPROACHES MAY BE INSTRUMENT LANDING SYSTEM (ILS), INCLUDING BACK COURSE (BC), LOCALIZER (LOC), PRECISION APPROACH RADAR (PAR), VOR, LOCALIZER TYPE DIRECTIONAL AID (LDA), SIMPLIFIED DIRECTIONAL FACILITY (SDF), NON-DIRECTIONAL BEACON (NDB), TACTICAL AIR NAVIGATION (TACAN), AIRPORT SURVEILLANCE RADAR (ASR), MICROWAVE LANDING SYSTEM (MLS), AND VISUAL AND CONTACT APPROACHES. FOR TRAINING OR EQUIPMENT LIMITATION REASONS THE PILOT/CREW MAY REQUEST AN APPROACH PROCEDURE OTHER THAN THE PREFERRED ONE IN USE BY ATC. APPROACH CLEARANCES ARE ISSUED TO AIRCRAFT ARRIVING AT IFR AIRPORTS BY TERMINAL FACILITIES OR THE ARTCC SECTOR HAVING CONTROL OF THE APPROACH AIRSPACE.

E MAY BE REQUESTED BY AN AIRCRAFT
Y DUE TO FAVORABLE WINDS, TO
R OTHER WEATHER, OR TO OPTIMIZE
THIS INCLUDES REQUESTING THE
STRICTION WHEN IT INTERFERES
JUDGEMENT. CERTAIN MILITARY AND
AY REQUEST A BLOCK ALTITUDE
IGNS AIRSPACE WITH UPPER AND
A CRUISE CLEARANCE ISSUED BY
ING AIRSPACE FROM THE SPECIFIED
E MINIMUM IFR ALTITUDE. THE
SO INCLUDES THE APPROVAL TO
N APPROACH AT THE DESTINATION

LANDING CLEARANCE

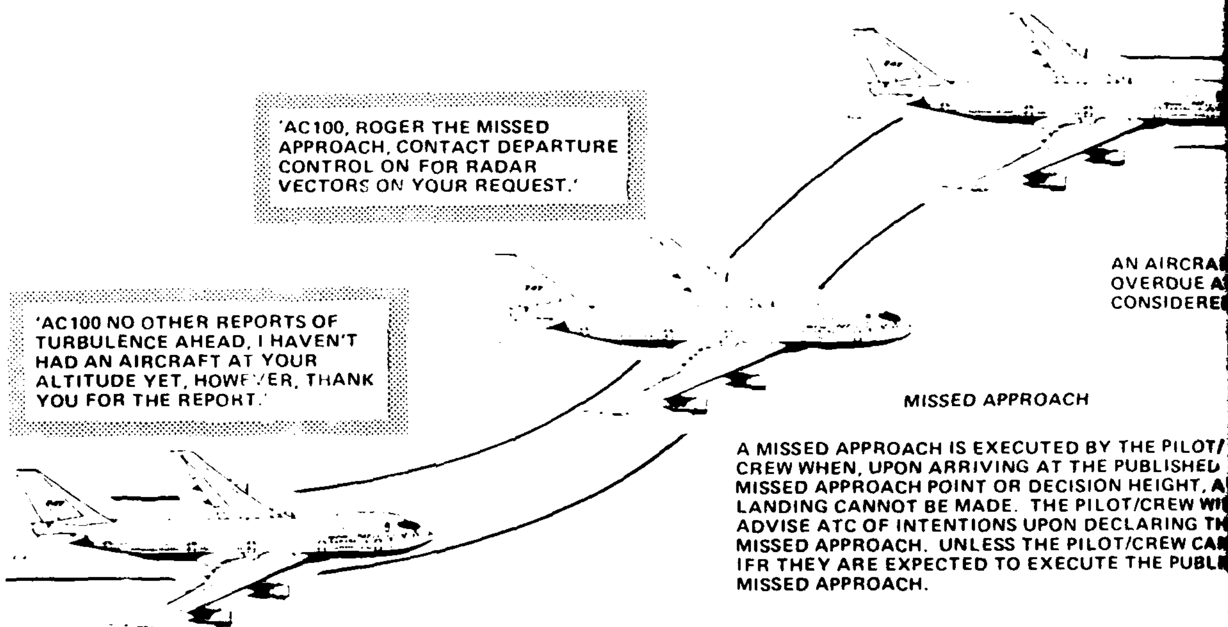
A LANDING CLEARANCE IS THE AUTHORITY FOR AN AIRCRAFT TO LAND ON A SPECIFIC RUNWAY. THE PILOT/CREW MAY REQUEST A LOW APPROACH, TOUCH AND GO, OR STOP AND GO LANDING INSTEAD OF A NORMAL FULL STOP. A CLEARANCE FOR AN OPTION APPROACH ALLOWS THE PILOT/CREW TO DO ANY OF THE ABOVE. TOWER CONTROLLED AIRPORTS REQUIRE A LANDING CLEARANCE WHENEVER THE AIRPORT TRAFFIC AREA IS ACTIVE (TOWER IN OPERATION). VFR AIRCRAFT CONTACT THE TOWER OUTSIDE THE AIRPORT TRAFFIC AREA FOR THEIR LANDING CLEARANCES.

AMENDED ALTITUDE/ROUTE

AN AMENDED ROUTE MAY BE REQUESTED FOR ANY REASON, BUT IS GENERALLY USED TO OBTAIN MORE DIRECT ROUTING OR TO AVOID WEATHER. THE NEW ROUTE MAY BE AIRWAY, NAVAID DIRECT-NAVAID, RNAV, RADAR VECTORS OR COORDINATES (LAT/LONG) TO COORDINATES. AMENDED ROUTES MAY ALSO ARISE FROM A CHANGE IN DESTINATION DUE TO PILOT REQUEST OR CONTINGENCIES.

TAS, ALTITUDE, ROUTE DEVIATION

AN AIRCRAFT IS REQUIRED TO REPORT ANY CHAN
IN TAS OF + 10 KNOTS OR + 5% (WHICH EVER IS GRE
FROM THE FILED FLIGHT PLAN VALUE. WHEN ATC
A SPEED RESTRICTION, THE PILOT/CREW IS EXPECT
TO REMAIN WITHIN THE ABOVE LIMITS.



AN AIRCRA
OVERDUE A
CONSIDERE

MISSED APPROACH

A MISSED APPROACH IS EXECUTED BY THE PILOT/
CREW WHEN, UPON ARRIVING AT THE PUBLISHED
MISSED APPROACH POINT OR DECISION HEIGHT, A
LANDING CANNOT BE MADE. THE PILOT/CREW WI
ADVISE ATC OF INTENTIONS UPON DECLARING TH
MISSED APPROACH. UNLESS THE PILOT/CREW CA
IFR THEY ARE EXPECTED TO EXECUTE THE PUBL
MISSED APPROACH.

PIREP

PIREP'S ARE PILOT REPORTS OF ACTUAL WEATHER OR ATMOSPHERIC CONDITIONS. THE PIREP MAY DEAL WITH WINDS ALOFT, TURBULENCE, ICING, THUNDERSTORM, CLOUD COVER OR OTHER WEATHER ENCOUNTERS VALUABLE TO THE CONTROLLER AND OTHER TRAFFIC IN THE AREA OF INFLUENCE.

INITIAL CONTACT

AFTER THE TRANSFER OF CONTROL FROM ONE POSITION/SECTOR/FACILITY TO ANOTHER THE PILOT WILL INITIATE A CALL ON THE ASSIGNED AIR/GROUND FREQUENCY. THE CONTROLLER WILL ACKNOWLEDGE THE TRANSMISSION AND, IF APPROPRIATE, ADVISE THE PILOT THAT THE AIRCRAFT IS IN RADAR CONTACT AND VERIFIES THE REPORTED ALTITUDE

FIL

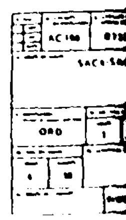


Figure 3-3 Flight Status Events (Single Aircraft)

'AC100, I SHOW YOU FIFTEEN MILES SOUTH OF CENTERLINE, TURN LEFT 30° TO INTERCEPT THE AIRWAY.

DEVIATION

PORT ANY CHANGE
ICH EVER IS GREATER)
LUE. WHEN ATC ASSIGNS
CREW IS EXPECTED
MITS

'AC100, IF YOU ARE ON FREQUENCY PLEASE ANSWER MINNEAPOLIS CENTER.'

OVERDUE AIRCRAFT

AN AIRCRAFT THAT IS MORE THAN THIRTY MINUTES OVERDUE AT A REPORTING POINT OR DESTINATION IS CONSIDERED OVERDUE.

'AC100, HOLD WEST OF DUBUQUE ON THE 272° RADIAL, LEFT TURNS.'

ACH

ED BY THE PILOT/
T THE PUBLISHED
CISION HEIGHT, A
IE *PILOT/CREW* WILL
ON DECLARING THE
E *PILOT/CREW* CANCELS
ECUTE THE PUBLISHED

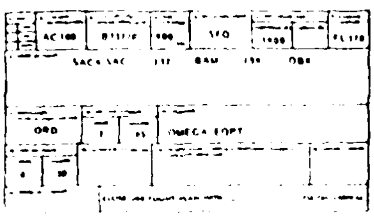
ENTERING/LEAVING HOLD

AN AIRCRAFT IS REQUIRED TO REPORT TIME AND ALTITUDE ENTERING A HOLD OR REACHING A CLEARANCE LIMIT. ANOTHER REPORT IS REQUIRED LEAVING THE HOLDING FIX OR POINT. THE HOLDING PATTERN MAY BE BASED ON *TIMED LEGS* OR SOME LEG LENGTH. THE PATTERN MAY BE PUBLISHED OR NOT, AND MAY USE RIGHT TURNS (STANDARD) OR LEFT TURNS.

FAF INBOUND

AN AIRCRAFT IS REQUIRED TO REPORT LEAVING THE FINAL APPROACH FIX INBOUND TO THE AIRPORT IN A NON-RADAR ENVIRONMENT.

FILED FLIGHT PLAN



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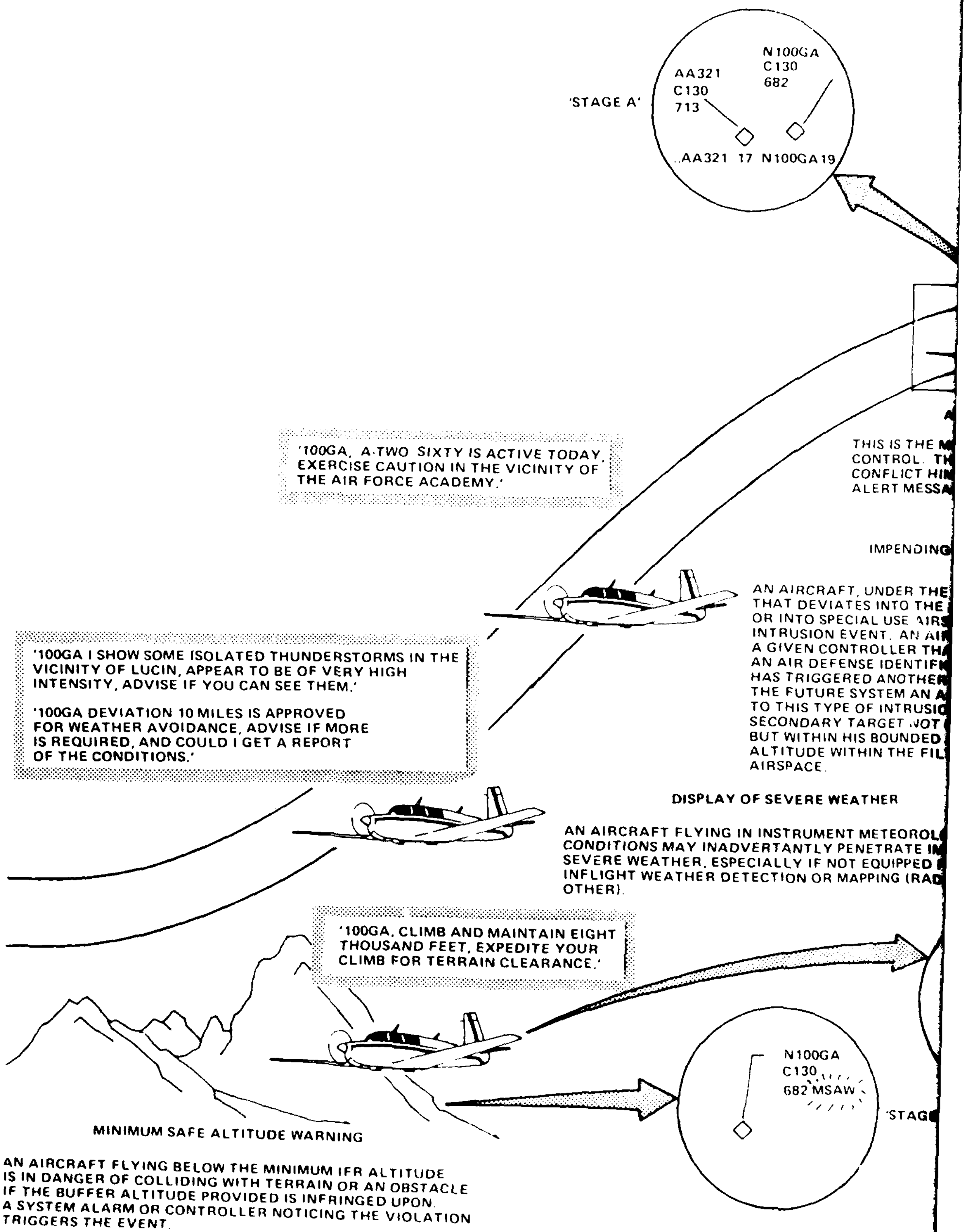
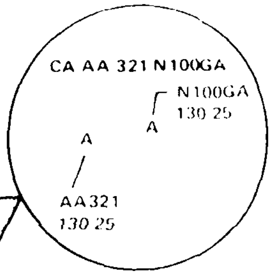
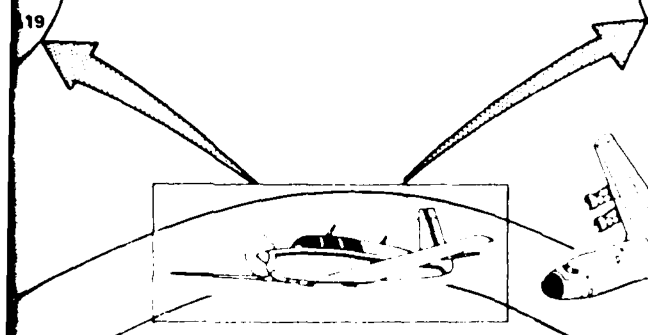
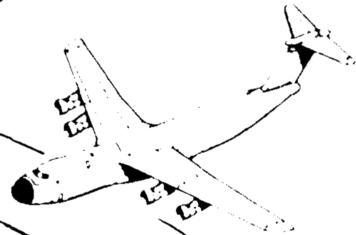


Figure 3-4 Conflict Events (Single/Multiple Aircraft)



'ARTS III'

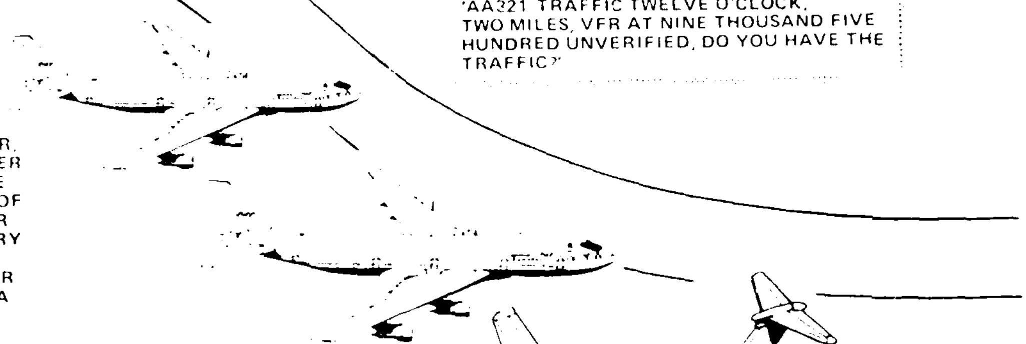




AIRCRAFT AIRCRAFT CONFLICT

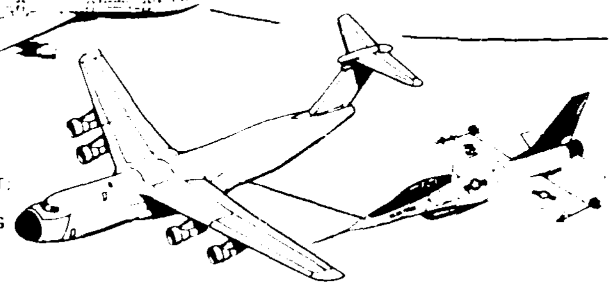
THIS IS THE MOST CRITICAL EVENT IN AIR TRAFFIC CONTROL. THE CONTROLLER MAY DETECT THE POSSIBLE CONFLICT HIMSELF OR MAY GET A SYSTEM CONFLICT ALERT MESSAGE.

'AA321 TRAFFIC TWELVE O'CLOCK, TWO MILES, VFR AT NINE THOUSAND FIVE HUNDRED UNVERIFIED, DO YOU HAVE THE TRAFFIC?'



IMPENDING AIRSPACE CONFLICT

CRAFT, UNDER THE CONTROL OF A GIVEN CONTROLLER, DEVIATES INTO THE AIRSPACE OF ANOTHER CONTROLLER D SPECIAL USE AIRSPACE HAS TRIGGERED AN AIRSPACE SION EVENT. AN AIRCRAFT NOT UNDER THE CONTROL OF N CONTROLLER THAT INTRUDES INTO HIS AIRSPACE, OR DEFENSE IDENTIFICATION ZONE OR SIMILAR BOUNDARY IGGERED ANOTHER KIND OF AIRSPACE INTRUSION. IN TURE SYSTEM AN ALARM MAY ALERT THE CONTROLLER S TYPE OF INTRUSION. A MODE C INTRUDER ALARM IS A DARY TARGET NOT CONTROLLED BY THE CONTROLLER THIN HIS BOUNDED AIRSPACE AND REPORTING AN UDE WITHIN THE FILTER LIMITS SET FOR THAT BOUNDED CE.

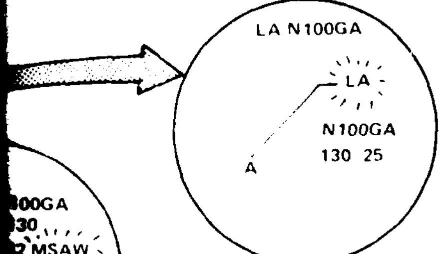


TRAFFIC ADVISORY

TRAFFIC ADVISORIES WILL BE ISSUED WHEN IN THE CONTROLLER'S JUDGEMENT: A POTENTIAL HAZARD WILL EXIST; AN AIRCRAFT MAY ENCOUNTER PHENOMENA SUCH AS PARACHUTISTS, GLIDERS, ETC.; OR THE AIRCRAFT IS DEVIATING FROM HIS COURSE.

RE WEATHER

UMENT METEOROLOGICAL TLY PENETRATE IMBEDDED IF NOT EQUIPPED FOR N OR MAPPING (RADAR OR



'ARTS III'

'STAGE A'

REFUELING, EXERCISES, AIR SHOWS

REFUELING IS PERFORMED BY MILITARY UNITS FOR TRAINING AND OPERATIONALLY TO EXTEND THE RANGE OF AIRCRAFT ON CERTAIN MISSIONS. THE REFUELING TAKES PLACE ON A PUBLISHED REFUELING TRACK, IN AIRSPACE SO RESERVED BY THE MILITARY THROUGH THE CENTRAL ALTITUDE RESERVATION FACILITY (CARF) OR ON A DIRECTLY REQUESTED BASIS.

EXERCISES ARE PERIODICALLY PERFORMED BY USAF STRATEGIC AIR COMMAND (SAC) AND TACTICAL AIR COMMAND (TAC) UNITS. THE EXERCISES ARE PART OF READINESS TRAINING AND MAY INVOLVE LARGE NUMBERS OF AIRCRAFT OF VARYING INTENTIONS AND PERFORMANCE, AND USER ACTIVATION OF SPECIAL USE AIRSPACE.

2

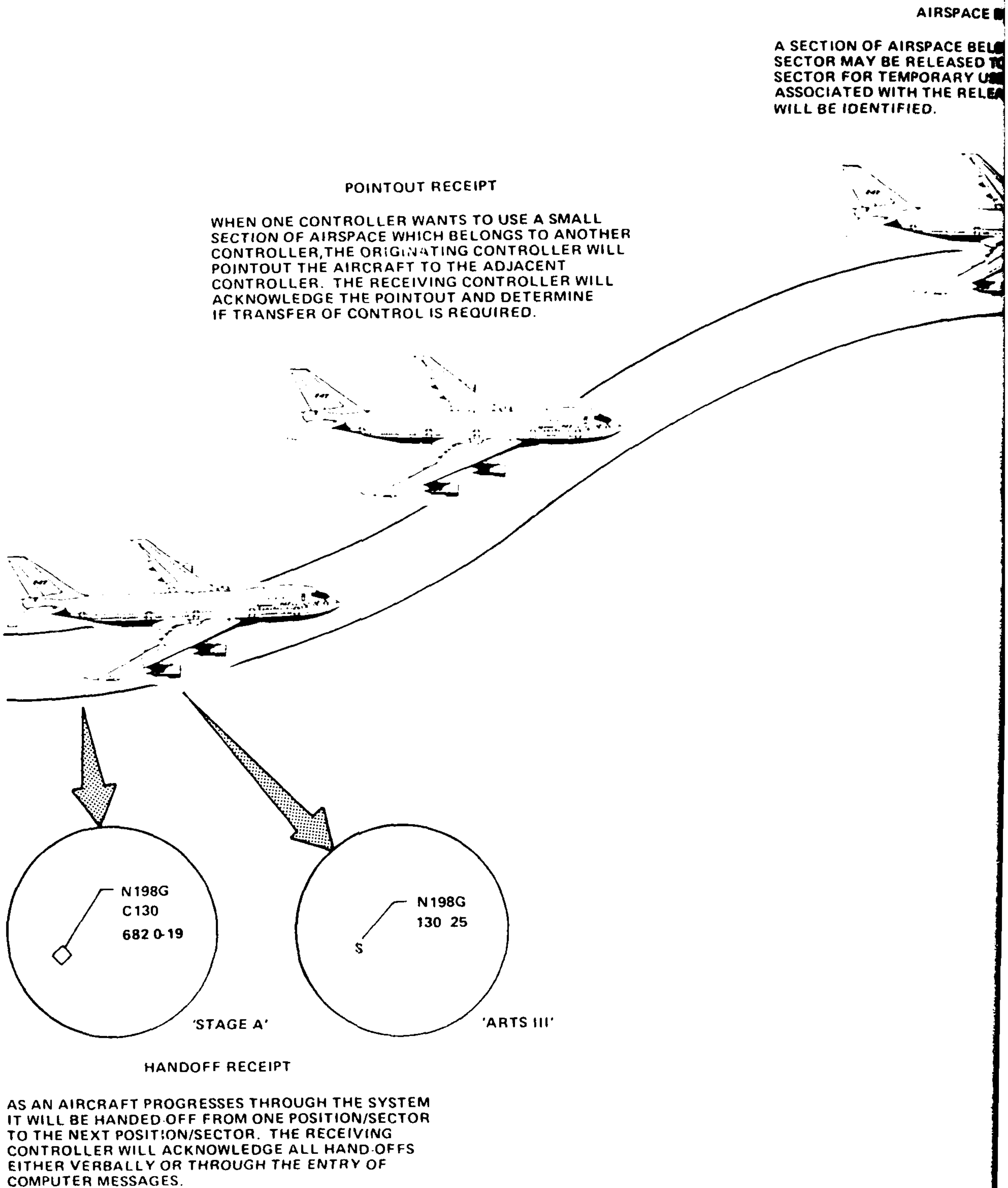
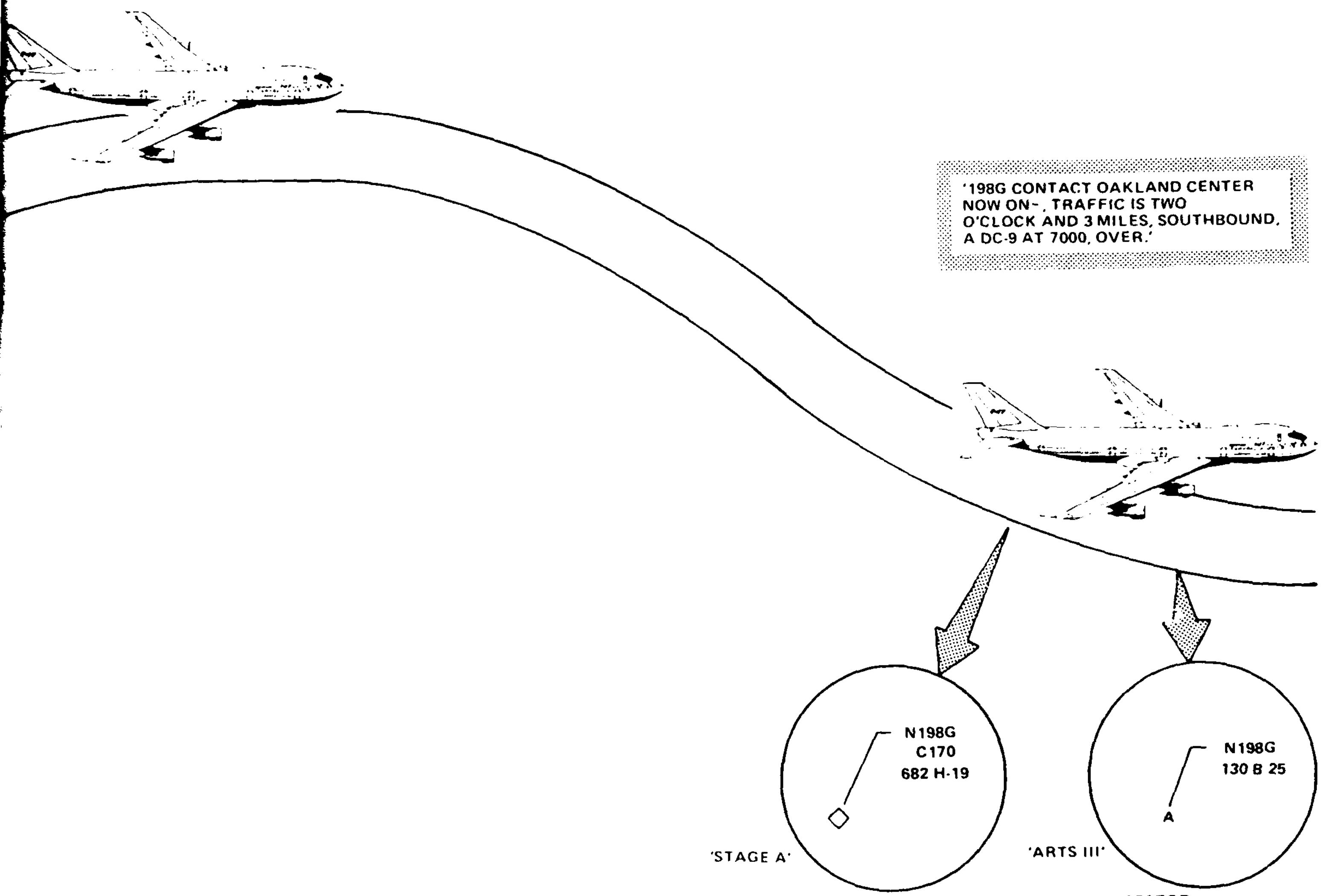


Figure 3-5 Transfer/Share Control Events (Single Aircraft)

AIRSPACE RELEASE

OF AIRSPACE BELONGING TO ONE POSITION/
Y BE RELEASED TO AN ADJACENT POSITION/
R TEMPORARY USE. THE CONDITIONS
D WITH THE RELEASE, SUCH AS DURATION,
ENTIFIED.



AIRCRAFT TO EDGE OF SECTOR

A HANDOFF IS TRIGGERED WHEN AN AIRCRAFT APPROACHES A CONTROLLERS AIRSPACE BOUNDARY. THE CONTROLLER POSITION-TO-POSITION HANDOFF IS ACCOMPLISHED FIRST AND THEN THE AIRCRAFT IS ASSIGNED A FREQUENCY CHANGE TO THE GAINING CONTROLLER. THE POSITION-TO-POSITION HANDOFF IS PERFORMED WITH VARYING LEVELS OF AUTOMATION DEPENDING UPON THE TWO SYSTEMS INVOLVED IN THE HANDOFF. HANDOFF TO CONTROLLERS WITH NO AUTOMATION IS ACCOMPLISHED BY USE OF INTERPHONE.

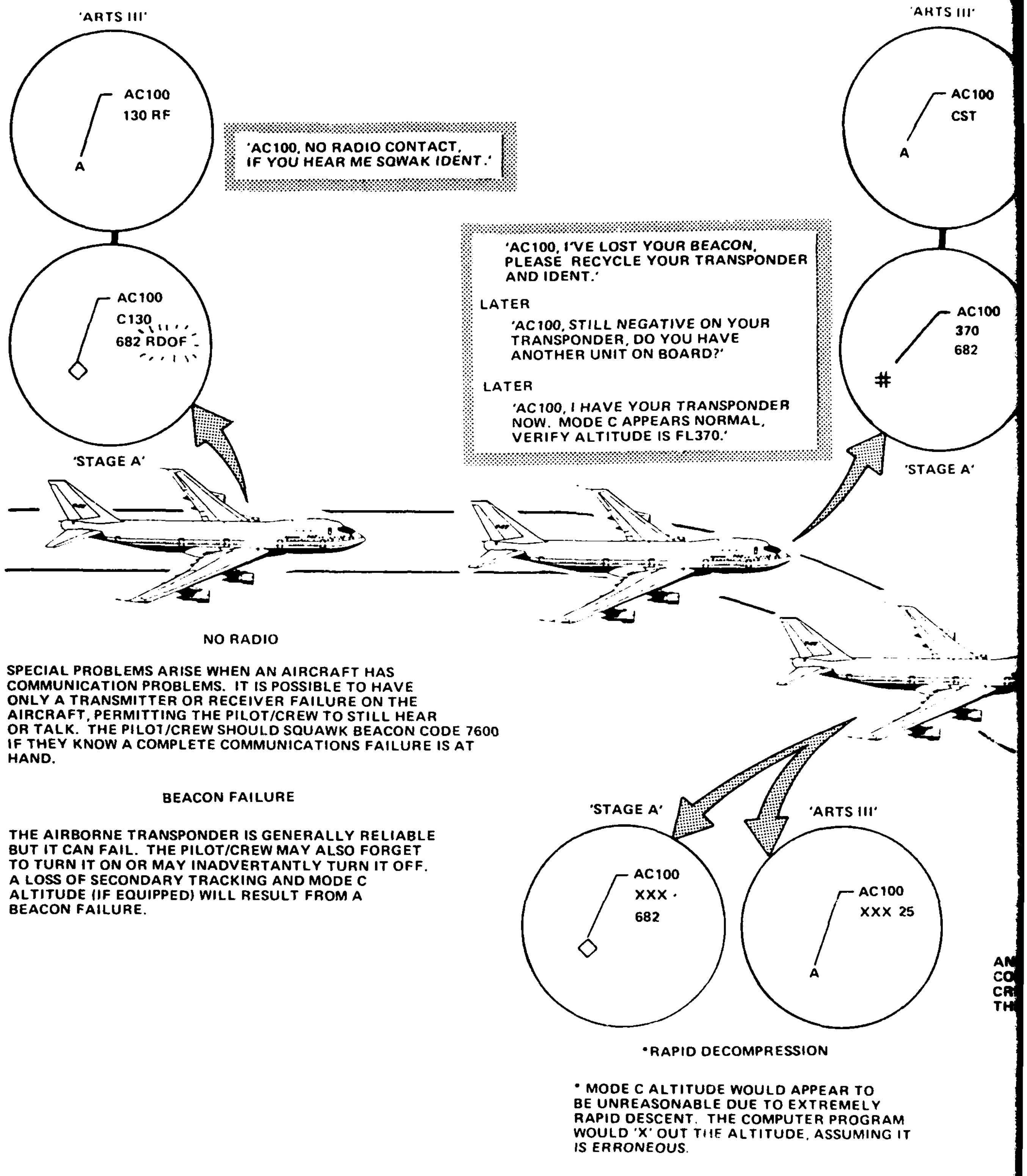
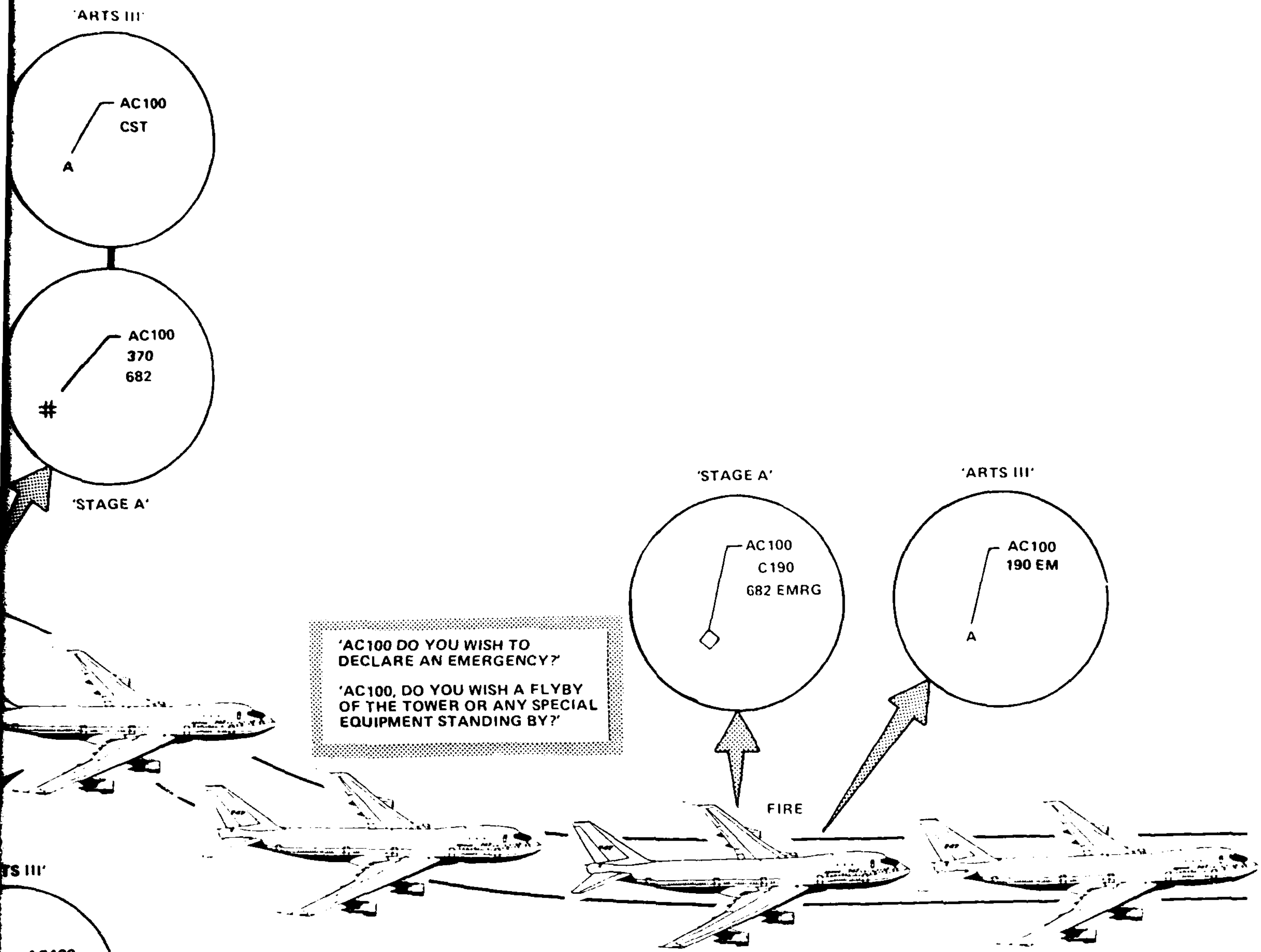


Figure 3-6 Aircraft System Anomalies Events (Single Aircraft Contingencies)



CRITICAL FAILURE

AN AIRCRAFT WILL REPORT AN EMERGENCY UNDER CONDITIONS OF INFLIGHT FIRE, RAPID DECOMPRESSION, CRITICAL SYSTEM FAILURE OR OTHER PROBLEMS THAT THE PILOT/CREW DEEMS AN EMERGENCY.

MEDICAL

AN AIRCRAFT MAY BE IN DISTRESS WITH A MEDICAL EMERGENCY. THE PILOT/CREW MAY DECLARE AN EMERGENCY FOR REASONS OF INCAPACITATION, DISORIENTATION, OR OTHER FACTORS AFFECTING ABILITIES TO PERFORM THEIR DUTIES.

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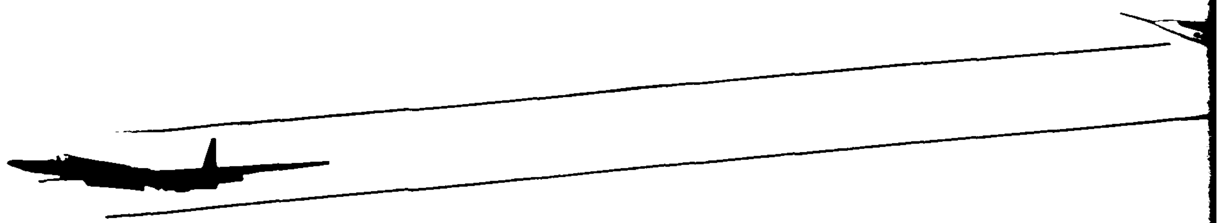


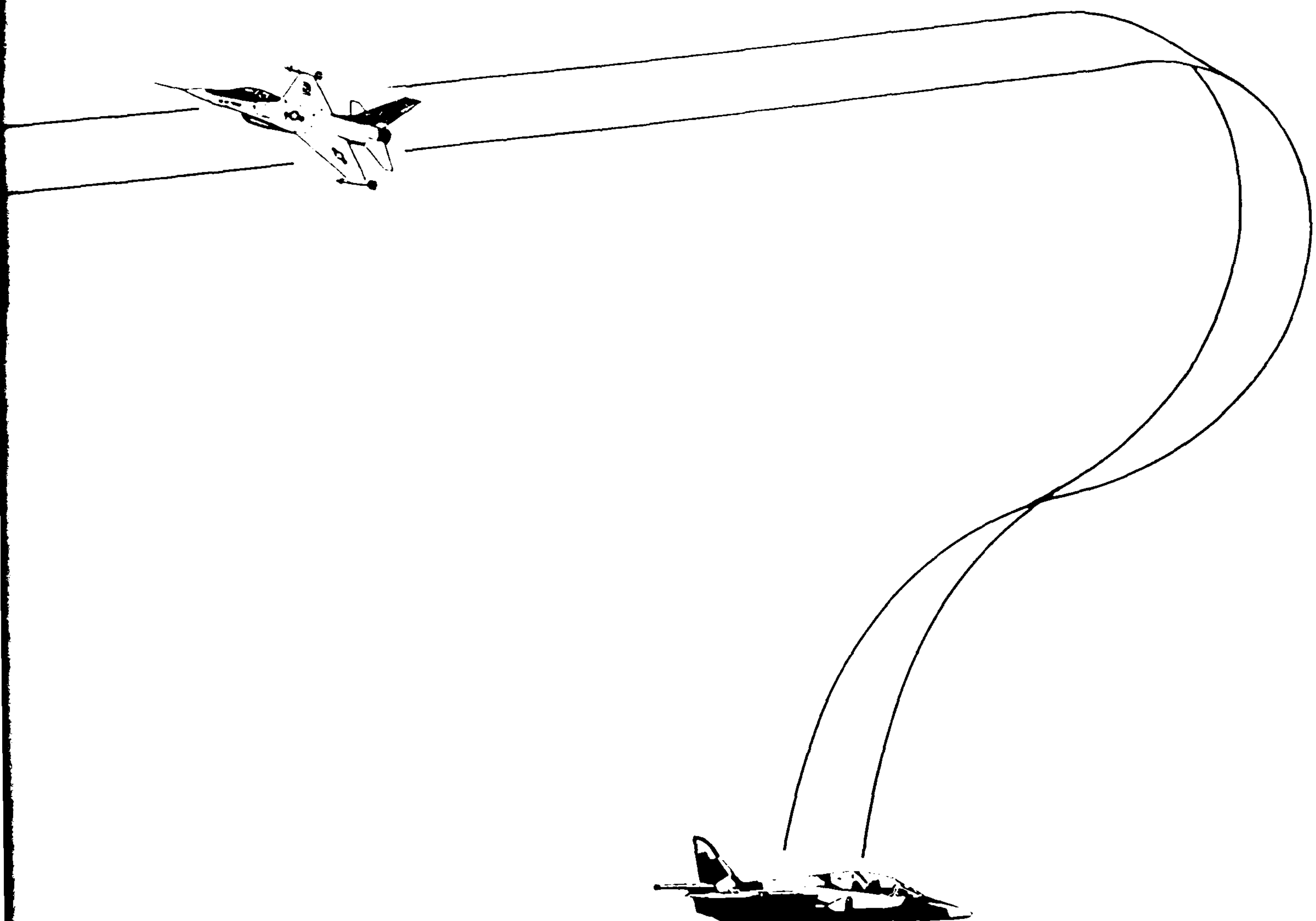
ABOVE FL 600

THE MILITARY MAY OPERATE AIRCRAFT ABOVE THE POSITIVE CONTROL AREA (PCA). THESE OPERATIONS ABOVE FLIGHT LEVEL 600 (60,000 FEET PRESSURE ALTITUDE) ONLY INVOLVE CERTAIN AIRCRAFT, AND REQUIRE CLASSIFIED (SECURITY) PROCEDURES.

Figure 3-7 Military Unique Operations Events (Special Aircraft Operations)

INTERCEPTOR FLIGHTS

THE MILITARY MAY DESIRE TO INTERCEPT AIRCRAFT FOR INTRUDING INTO PROHIBITED AREAS, FLIGHT IDENTIFICATION REGIONS (FIR), AIR DEFENSE IDENTIFICATION ZONES (ADIZ) OR OTHER AIRSPACE.



MILITARY TRAINING ROUTES

MILITARY TRAINING ROUTES (MTR), ARE DESIGNATED ROUTES FOR TRAINING IN NAVIGATION AND WEAPONS DELIVERY. BOTH VFR AND IFR ROUTES EXIST, AND ARE PUBLISHED IN DOD FLIGHT INFORMATION PUBLICATIONS (FLIP). THE ROUTES ENCOMPASS MANY ALTITUDES AND INVOLVE HIGH PERFORMANCE FLIGHT PROFILES.

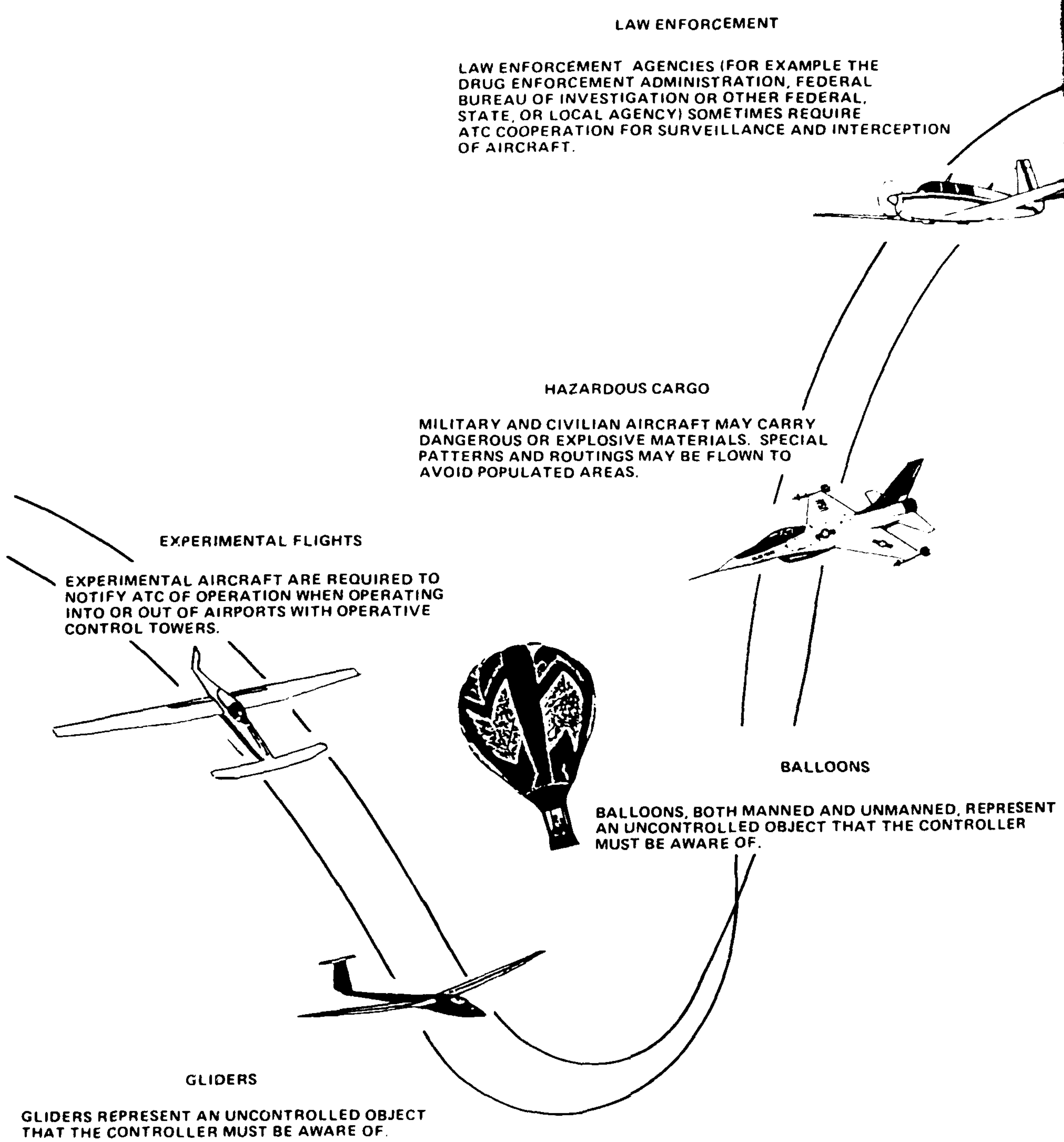


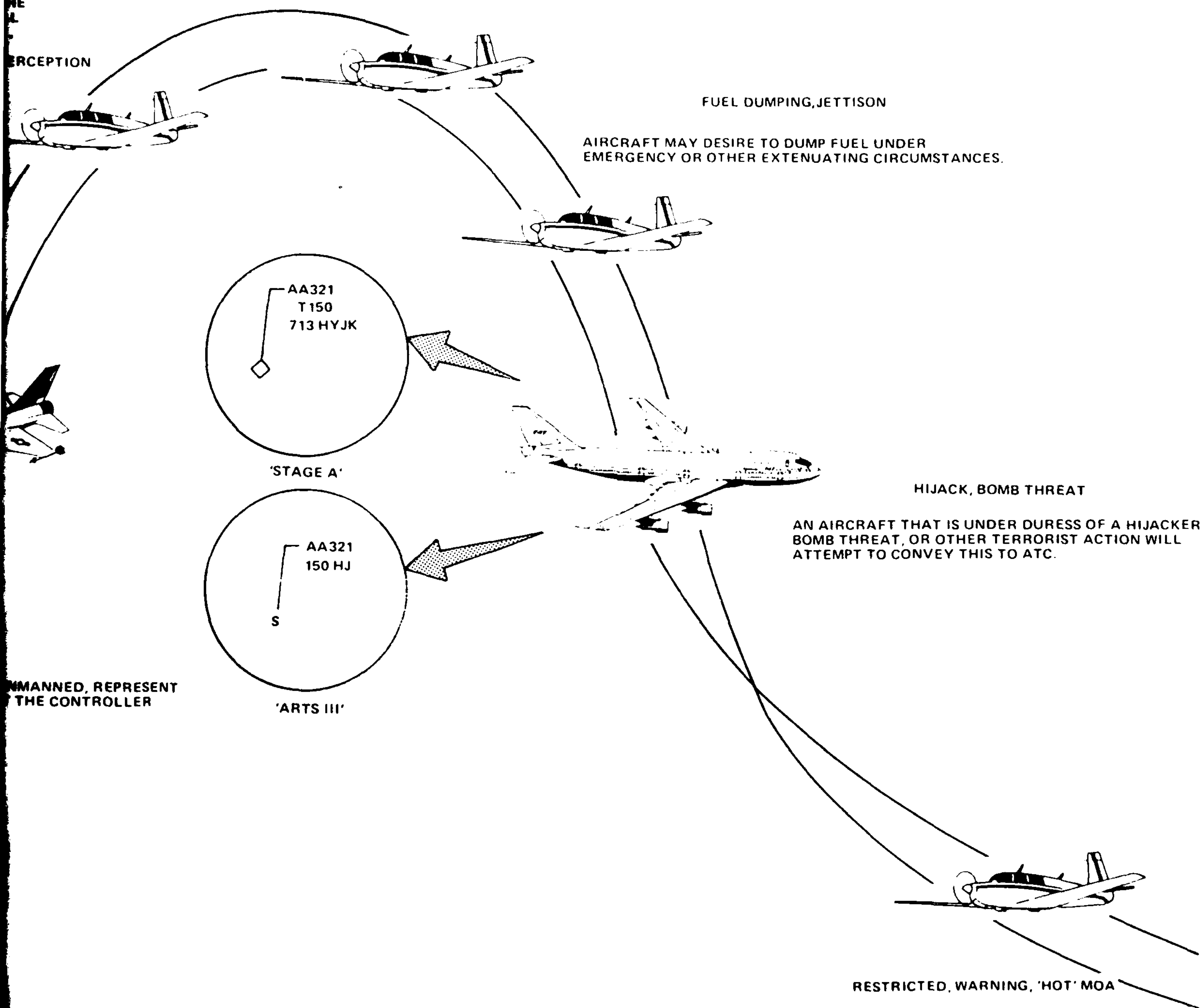
Figure 3-8 Other Special Operations Events (Special Aircraft Operations)

LIFEGUARD MISSIONS

MILITARY AND CIVILIAN FLIGHTS INVOLVING MEDICAL EVACUATION AND SUPPORT ARE TERMED 'LIFEGUARD' BY ATC. THESE FLIGHTS ARE HANDLED AS EXPEDITIOUSLY AS POSSIBLE.

FUEL DUMPING,JETTISON

AIRCRAFT MAY DESIRE TO DUMP FUEL UNDER EMERGENCY OR OTHER EXTENUATING CIRCUMSTANCES.



HIJACK, BOMB THREAT

AN AIRCRAFT THAT IS UNDER DURESS OF A HIJACKER, BOMB THREAT, OR OTHER TERRORIST ACTION WILL ATTEMPT TO CONVEY THIS TO ATC.

RESTRICTED, WARNING, 'HOT' MOA

CONTROLLED AIRCRAFT WILL BE ROUTED SO AS TO AVOID RESTRICTED, WARNING, OR MILITARY OPERATING AREAS THAT ARE IN USE

2

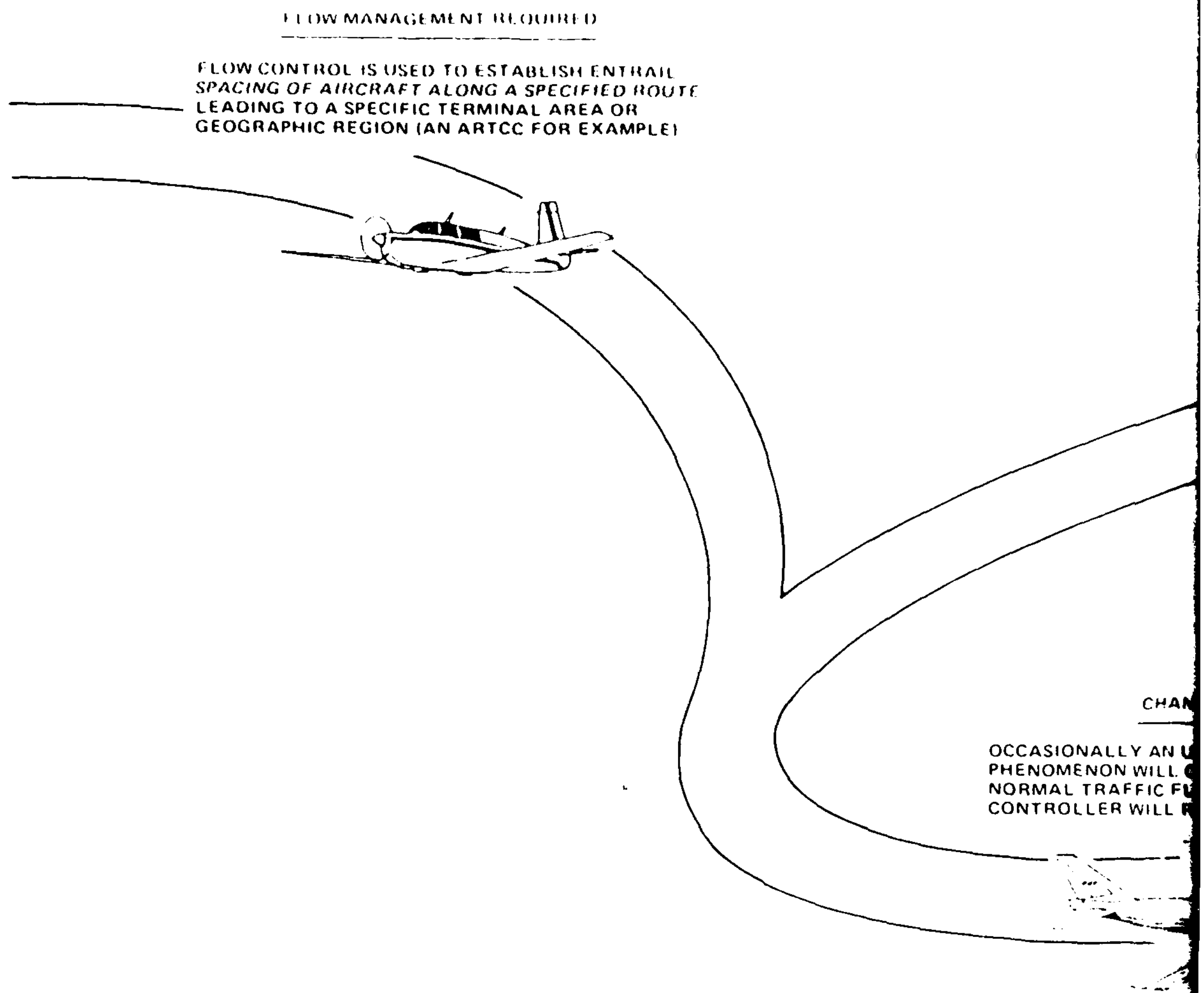
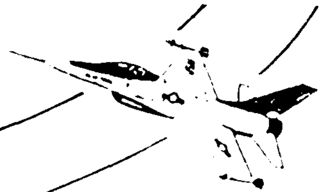


Figure 3-9 Traffic Flow Management Events (Air Traffic Control)

ALTRV, AIRSPACE RESERVATION

MILITARY MISSIONS MAY REQUIRE THE ADVANCE RESERVATION OF ALTITUDES REQUIRED FOR THE MISSION. ALTITUDE RESERVATIONS ARE FILED WITH THE CENTRAL ALTITUDE RESERVATION FACILITY (CARF) AND FORWARDED TO APPROPRIATE FACILITIES.



CHANGE FLOW PATTERN

OCCASIONALLY AN UNEXPECTED EVENT OR WEATHER PHENOMENON WILL OCCUR WHICH WILL DISRUPT THE NORMAL TRAFFIC FLOW. WHEN THIS OCCURS THE CONTROLLER WILL REINITIALIZE A NEW TRAFFIC FLOW.

FACILITY CLOSURE/CAPACITY CHANGE

SMALL AND MEDIUM TOWERS MAY BE CLOSED WHEN THERE IS LITTLE OR NO TRAFFIC ACTIVITY SUCH AS ON A MIDNIGHT SHIFT. AIRSPACE, WHICH HAD BEEN DELEGATED TO THE TERMINAL, REVERTS TO THE AIR ROUTE TRAFFIC CONTROL CENTER UNTIL THE TOWER IS REOPENED. THE CONTROL OF ANY AIRCRAFT IN THE AREA WILL BE COORDINATED BETWEEN THE FACILITIES DURING THE TRANSITION PERIOD.

RUNWAY CONFIGURATION CHANGE

NOISE ABATEMENT PROCEDURES, RUNWAY MAINTENANCE, AND WEATHER CONDITIONS, PRIMARILY WIND VELOCITY AND DIRECTION, DETERMINE RUNWAY UTILIZATION. RUNWAY CHANGES ARE ACCOMPLISHED TO ACCOMODATE CHANGES IN THE AIRPORT ENVIRONMENT AS NECESSARY.

2

COMMUNICATIONS FAILURE

A FAILURE IN INTERPHONE OR AIR - TO - GROUND COMMUNICATION ISOLATES THE CONTROLLER FROM RESOURCES, OTHER CONTROLLERS, AND THE TRAFFIC HE IS CONTROLLING. ISOLATED OR TOTAL FAILURES ARE POSSIBLE.

NAVAID STATUS

A FAILURE IN THE ILS CAN BE IN THE LOCALIZER, GLIDE SLOPE, MARKER BEACON, DME (IF INSTALLED) OR APPROACH LIGHT SYSTEM COMPONENTS. A COMBINATION OF FAILURES IS POSSIBLE AS WELL. LANDING MINIMA ARE DIRECTLY RELATED TO THE PROPER FUNCTIONING OF THE ILS COMPONENTS.

A VHF OMNI RANGE (VOR), TACTICAL AIR NAVIGATION (TACAN) OR NON-DIRECTIONAL BEACON (NDB) FAULT/FAILURE AFFECTS ALL TRAFFIC USING THAT STATION. BAD COURSE OR BEARING INFORMATION, OR NONE, REQUIRE THE CONTROLLER TO ROUTE TRAFFIC IN SOME OTHER MANNER.

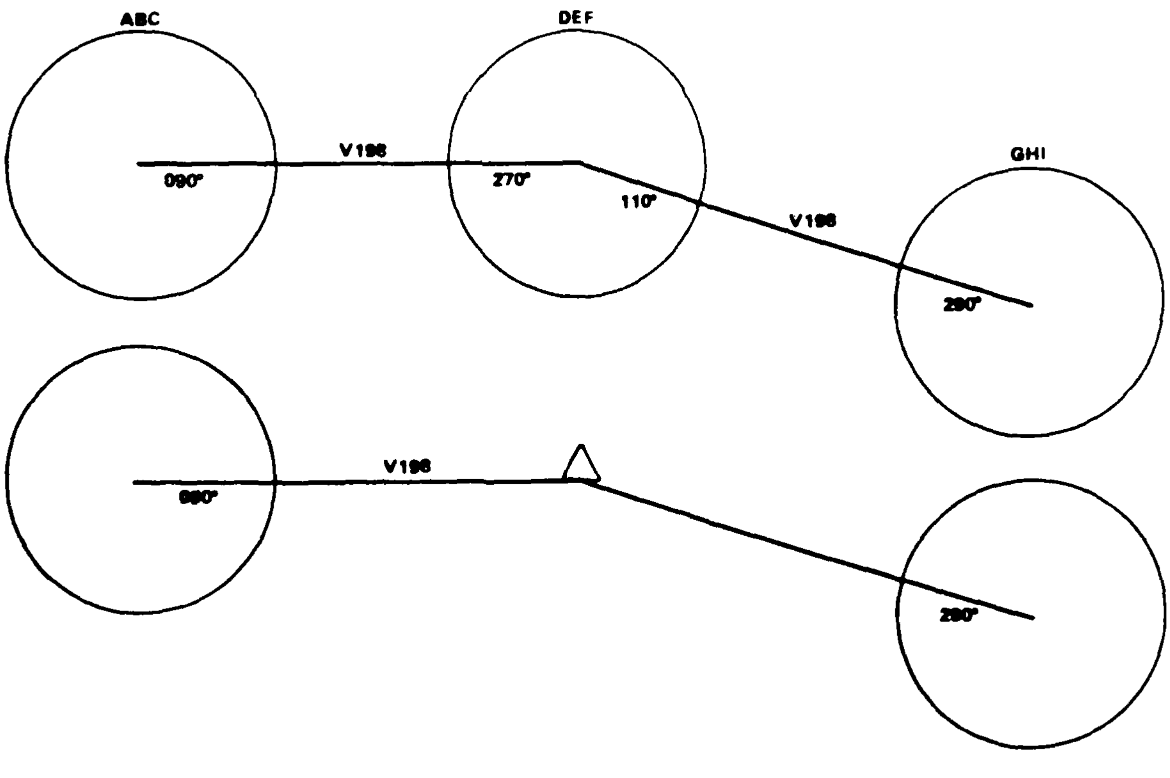
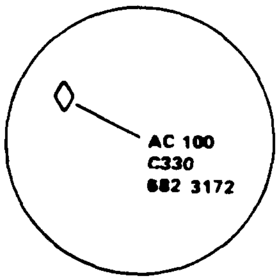


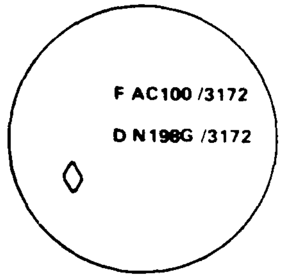
Figure 3-10 Communications Failure and NAVAID Status Events (Systems Fault Degradation)

DUPLICATE BEACON CODE

OCCASIONALLY A TRANSIENT AIRCRAFT WILL BE HANDED OFF TO A FACILITY WITH A BEACON CODE DUPLICATING ONE ALREADY ASSIGNED IN THE FACILITY. THE NATIONAL BEACON CODE ALLOCATION PLAN IS DESIGNED TO ALLOCATE BEACON CODES TO AIRSPACE TO MINIMIZE THE OCCURRENCE

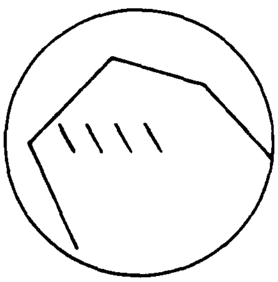


STAGE A



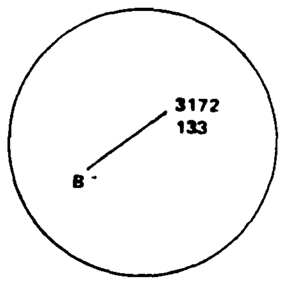
ARTS III

FAILURE TO RECEIVE HANDOFF



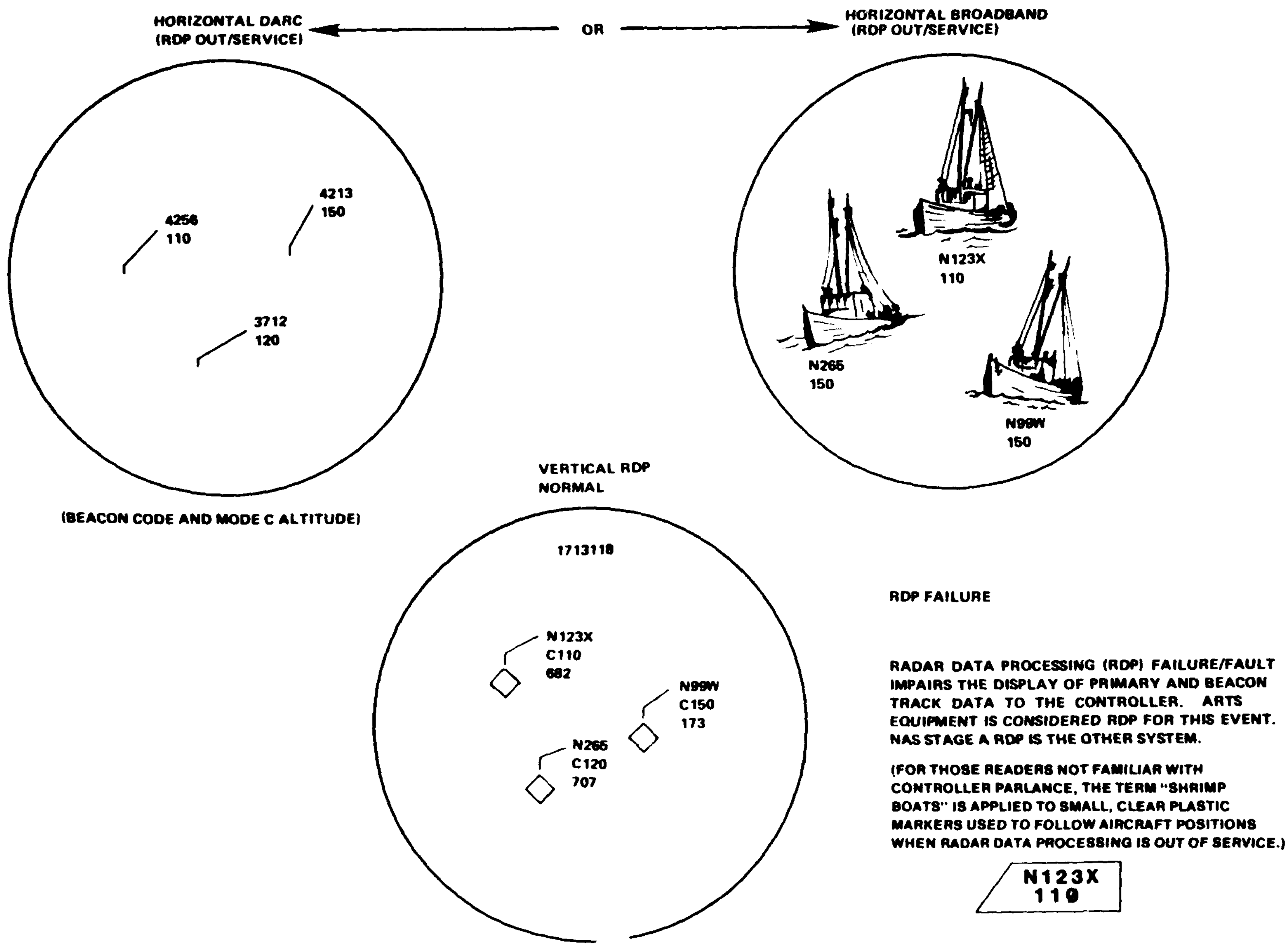
STAGE A

OCCASIONALLY AN AIRCRAFT WILL ENTER THE AIRSPACE OF A CONTROLLER WITHOUT A RADAR HANDOFF DUE TO AN OVERSIGHT OR OMISSION BY THE PREVIOUS CONTROLLER OR BY A SYSTEM MALFUNCTION



ARTS III

Figure 3-11 Duplicate Beacon Code and Failure to Receive Handoff Events (Systems Fault Degradation)



F.. e 3-12 *RDP Failure Events (Systems Fault Degradation)*

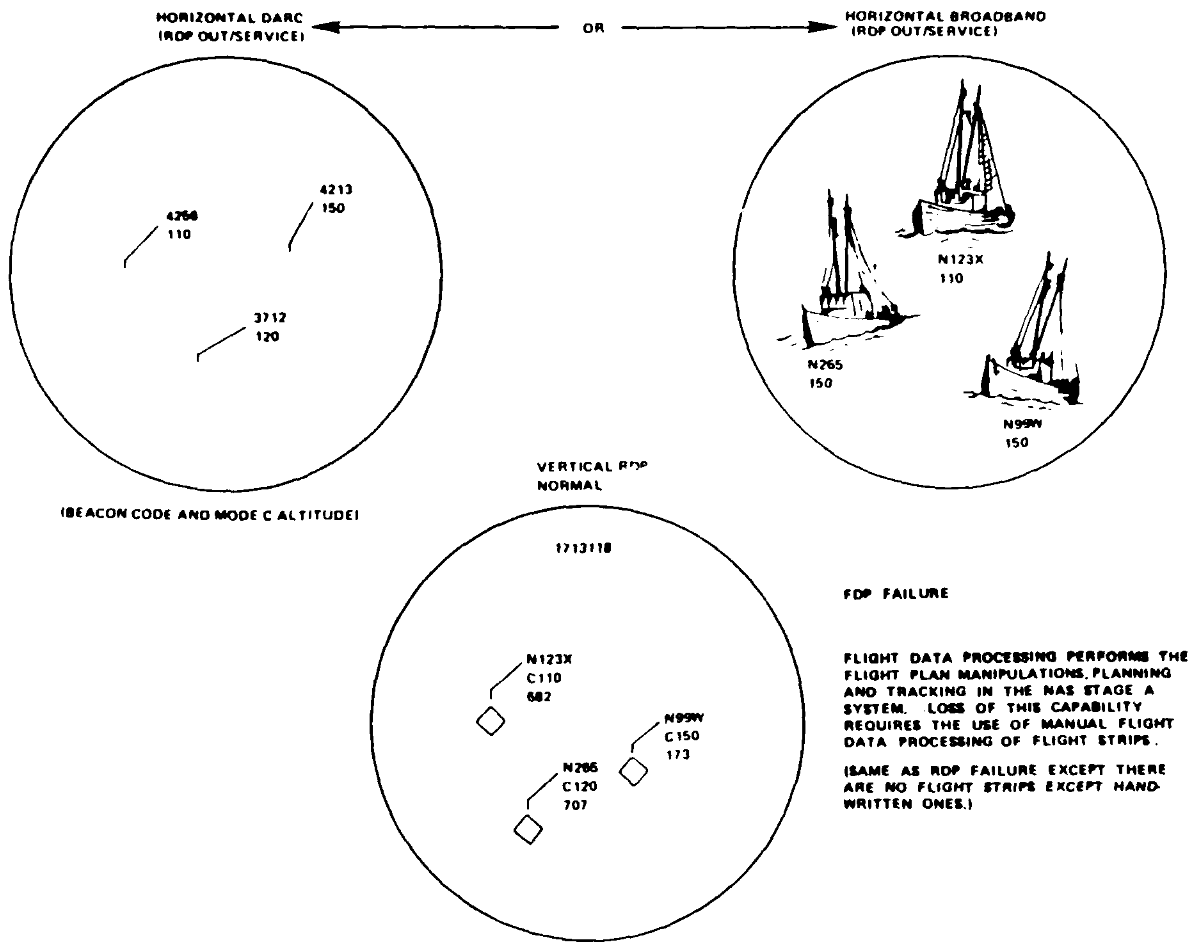


Figure 3-13 FDP Failure Event (Systems Fault Degradation)

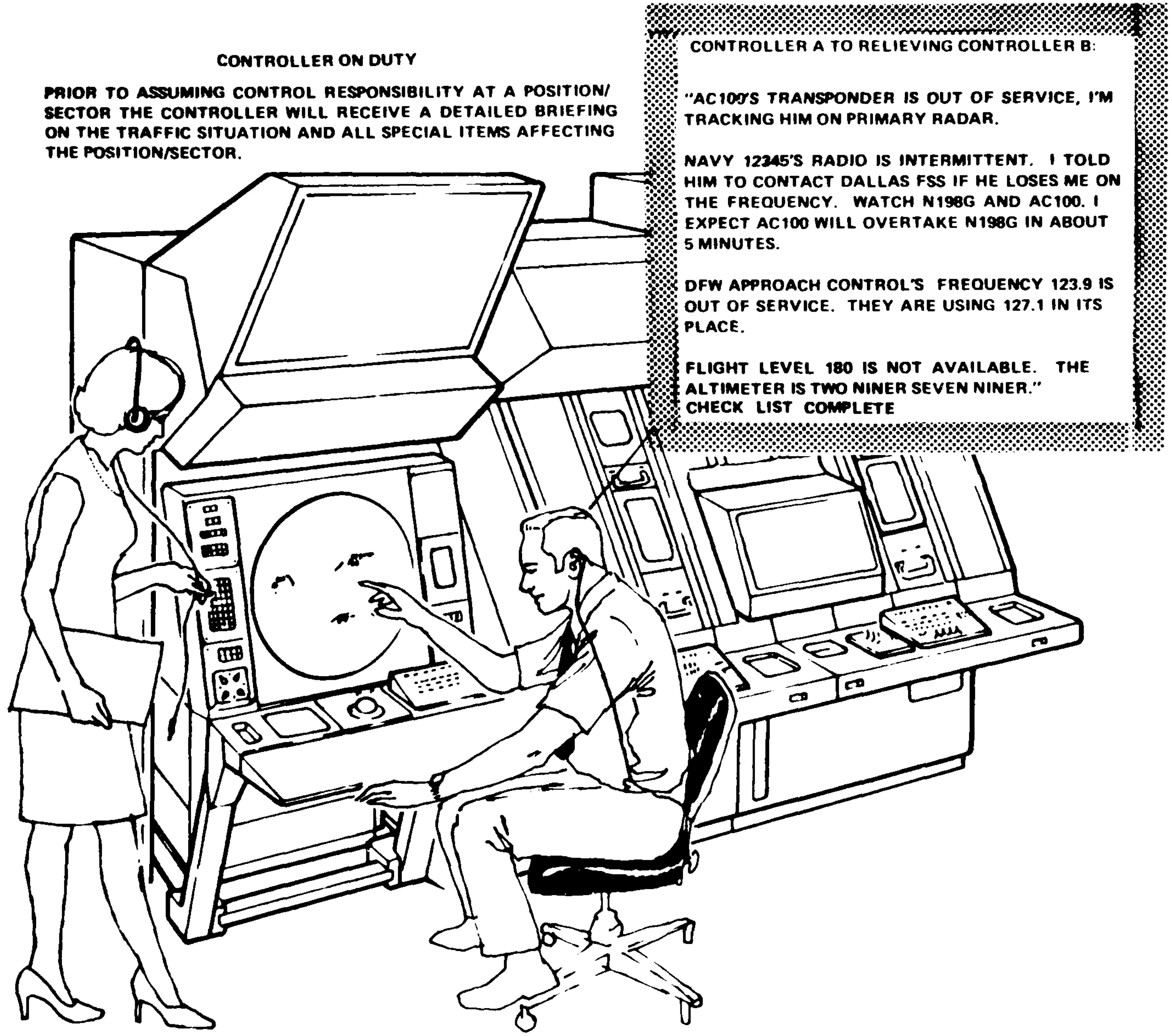


Figure 3-14 Controller on Duty Event (Personnel Management)

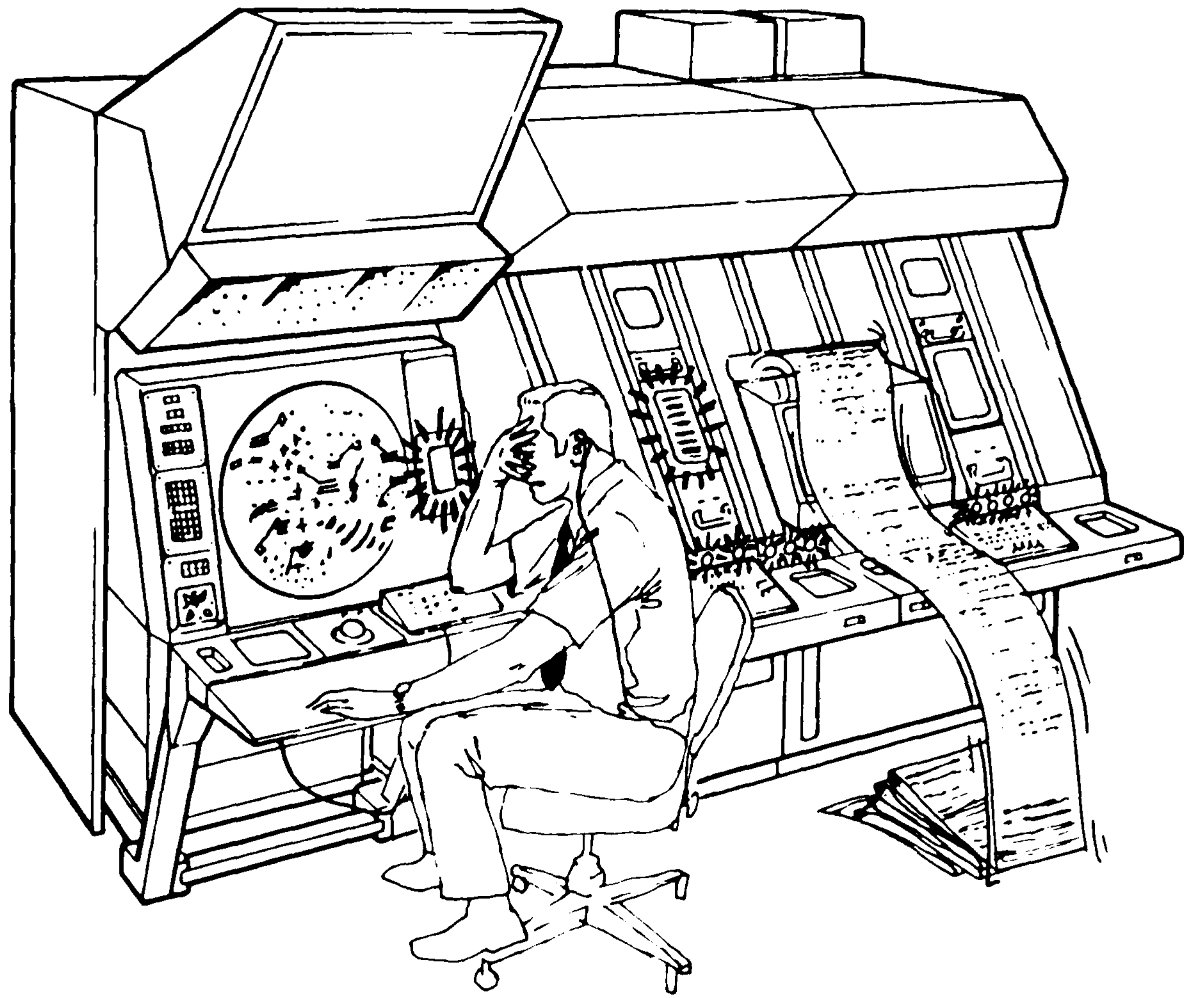


Figure 3-15 Controller Overload Event (Personnel Management)

SIGMET/AIRMET ADVISORIES

SIGNIFICANT METEOROLOGICAL (SIGMET) OR AIRMAN'S METEOROLOGICAL INFORMATION (AIRMET) CONCERNS WEATHER SIGNIFICANT TO AIRCRAFT. AIRMET IS GENERALLY OF LESS SEVERITY THAN SIGMET, AND IS MORE PERTINENT TO LIGHT AIRCRAFT BECAUSE OF LACK OF EQUIPMENT, INSTRUMENTATION, OR PILOT QUALIFICATION.

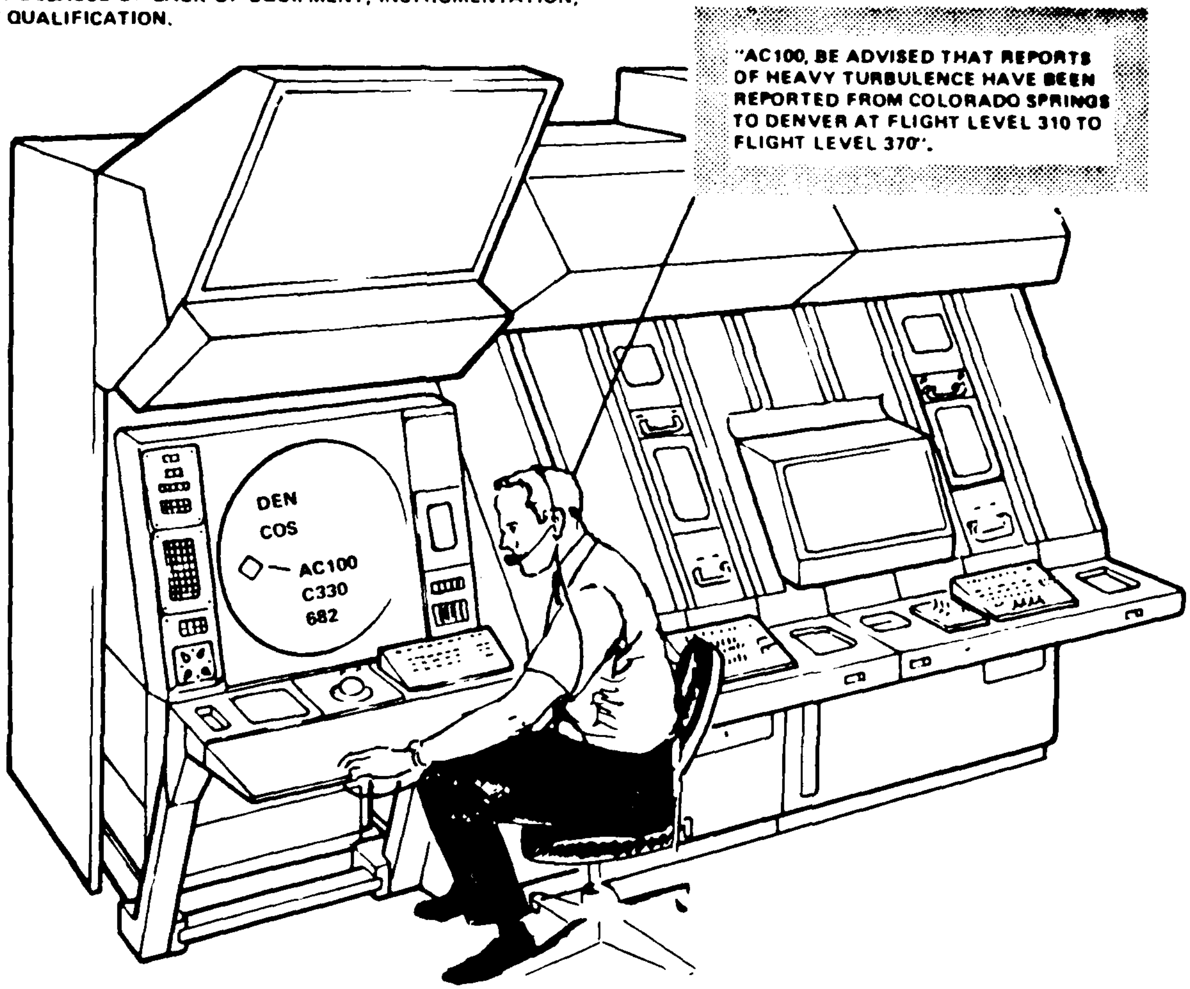
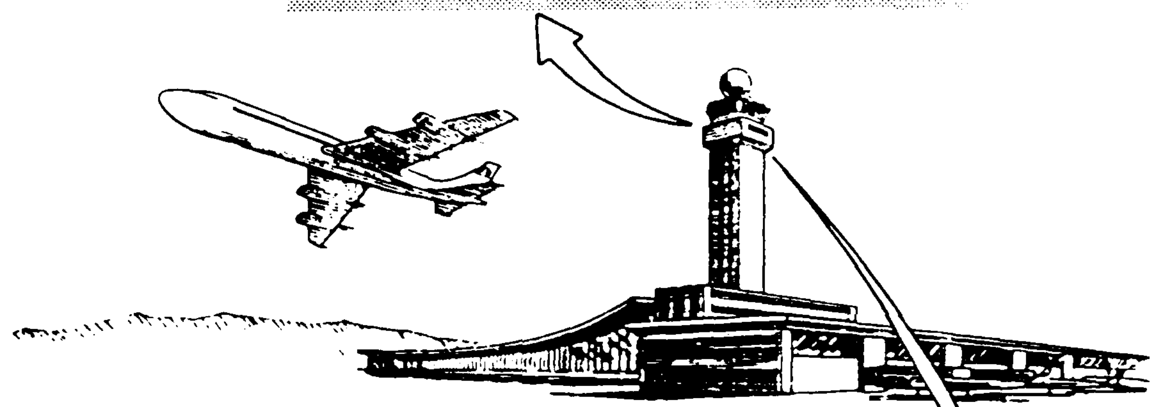


Figure 3-16 SIGMET/AIRMET Advisories Event (Weather)

WIND SHEAR REPORT

AT MAJOR AIRPORTS INSTRUMENTS TO MEASURE WIND SHEAR HAVE BEEN INSTALLED ON THE RUNWAYS. DATA FROM THESE SENSORS ARE DISPLAYED IN THE TOWER FOR USE BY CONTROLLERS AND ARE RELAYED TO THE PILOT.

"WIND SHEAR ALERTS ALL QUADRANTS, CENTERFIELD WIND, TWO ONE ZERO AT ONE FOUR, WEST BOUNDARY WIND, ONE FOUR ZERO AT TWO TWO."



CEILING HEIGHT/VISIBILITY REPORT

A REPORT IS TAKEN BY EITHER NATIONAL WEATHER SERVICE PERSONNEL OR BY CERTIFIED TOWER PERSONNEL TO DETERMINE THE HEIGHT OF THE CEILING OR FORWARD VISIBILITY. THE CEILING AND VISIBILITY REPORTS DETERMINE WHETHER VFR OR IFR CONDITIONS EXIST.

"N198G CLEARED TO EXIT FINDLAY CONTROL ZONE, 5 MILES WEST OF FINDLAY AIRPORT. FINDLAY AIRPORT HAS 300 FOOT OVERCAST WITH ONE & ONE HALF MILE VISIBILITY WITH BLOWING SNOW."

Figure 3-17 Wind Shear, Ceiling Height, and Visibility Report Events (Weather)

PRESSURE DISPLAY/REPORT

THE ALTIMETER REPORT, BASED UPON BAROMETRIC PRESSURE, IS CONTINUOUSLY TAKEN AND DISPLAYED. THIS REPORT IS RELAYED TO THE PILOTS TO INSURE THEY HAVE THE CORRECT ALTIMETER SETTING.

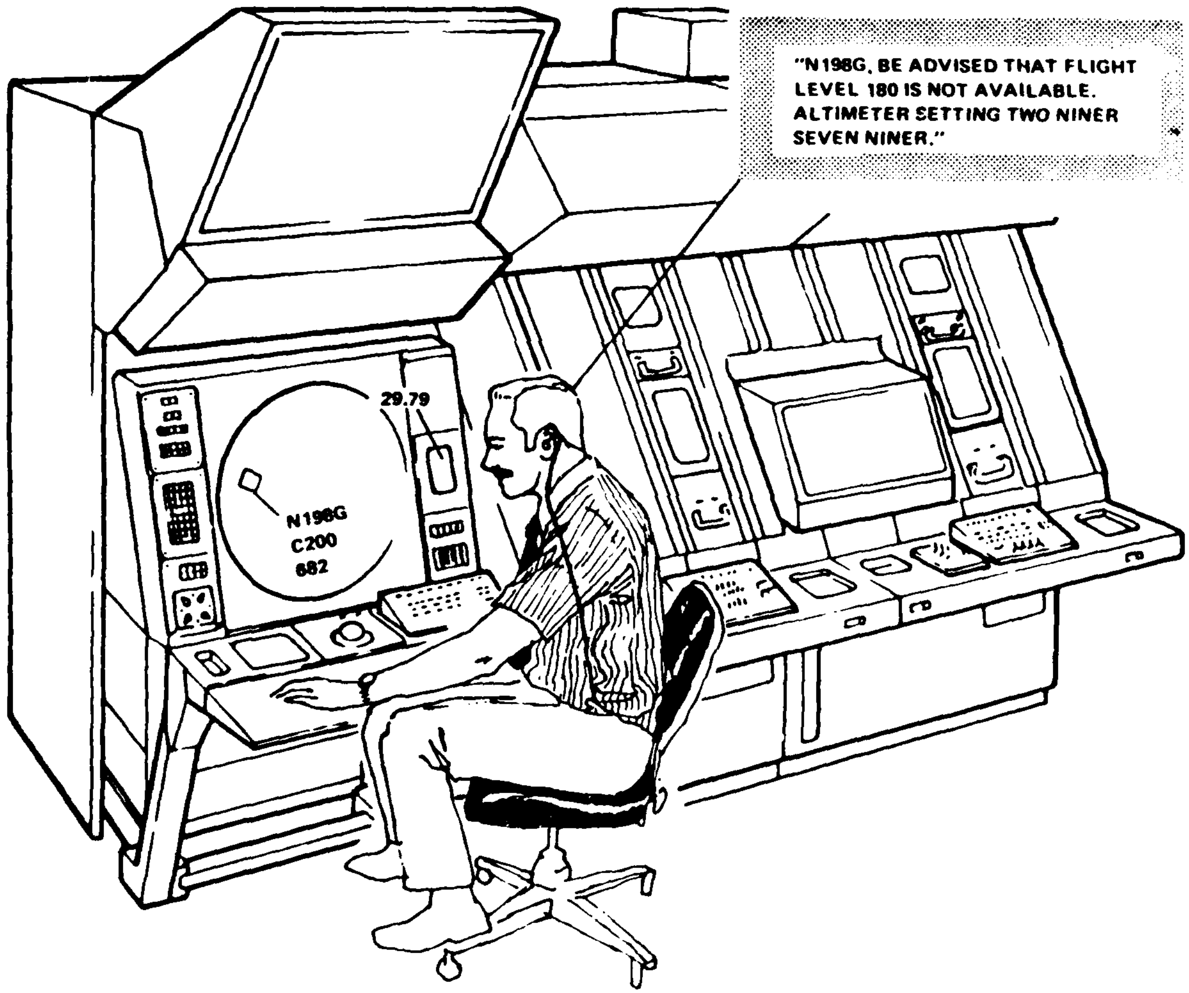


Figure 3-18 Pressure Display/Report Event (Weather)

Chapter 4.0

NAS ATC En Route and Terminal Operations Activities

4.0 NAS ATC EN ROUTE AND TERMINAL OPERATIONS ACTIVITIES

The purpose of this chapter is to first show the correlation between events and operational activities and secondly define the composition of activities and sub-activities. This analysis is directed toward the engineer/designer of the man-machine interface for the Advanced Automation System. This chapter gives a top-level picture of the controller job. Readers who are already familiar with control events and operations may wish to proceed directly to Chapter 5, which identifies terminal and en route information processing tasks. However, this section should prove illuminating to the reader who is interested in the motivation for analyzing the controller as an event-sensitive information processor, and describing his activities in terms of responses to air traffic control events.

In Chapter 3.0, the Air Traffic Control Operational Scenario Events provides a synthesis and definition of events. Chapter 4.0 views the controller as an event-responsive information processor who responds to an event stimulus by performing an action. That is, events are translated into man-machine activities which are performed by the controller. Specifically, activities are defined as top-level sequences of man-machine interactions (i.e., man-machine pairs) which respond to a group of closely related events (i.e., clusters of events).

Section 4.1, first addresses the NAS ATC environment as a system. The major components of this system are described for both TRACON and ARTCC operations. It is assumed during this discussion that there exist activities which are common, and activities which are unique, to TRACON and ARTCC (also designated en route) operations. This assumption is in keeping with the overall objective of this document, to emphasize the similarities between en route and TRACON controller activities which exist at a top-level, as well as to emphasize the differences which appear when the activities are sub-divided into individual tasks and analyzed with respect to position/sector types.

Section 4.2 then discusses the controller as an event-sensitive information processor. A correlation between events and activities is first described.

Section 4.3 presents the controller's activities and their associated events in composition graph form. That is, the activity categories are further subdivided into "sub-activities" where each sub-activity is correlated with specific class events.

Finally, in Section 4.4, the NAS messages, or other forms of controller communications, are tabulated in conjunction with their associated events. Also, a distinction is made as to whether the messages may be associated with an ARTS facility (and, therefore, in most cases to a terminal operations task) or to an en route center task. This is the first step in identifying the controller's information processing tasks. It leads into the topic of Chapter 5.0, "NAS En Route and Terminal Controller Information Handling and Processing Tasks."

4.1 COMPOSITION OF NAS ATC EN ROUTE AND TERMINAL OPERATIONS

The decision was made to use composition graphs in this document as a way to address the multi-dimensional aspects of ATC En Route and Terminal Operations. This tool presents, in a concise fashion, the activity sequences, decisions, iterative actions, and concurrent actions which are descriptive of the multi-tasking nature of the controller's job. Section 1.5 (Figure 1-4) provides a refresher tutorial for understanding the notation and properties of a composition graph.

Figure 4-1 depicts, in composition graph form, the top-level operational elements of the NAS ATC System. By first viewing the entire system, the analyst may be assured of having a comprehensive grasp of the big picture, without running the risk of omitting pertinent concepts. The major components of the ATC System include the ATCTs, TRACONs, and En Route Centers, and an ongoing coordination function which takes the form of either digital communications between centers or voice communication between controllers at various facilities. These elements will be defined briefly and then TRACON and en route operations will be the focus of following sub-sections.

In Figure 4-1 the long dashed lines indicate the division of responsibility between the major organizational and functional elements of the ATC System. These elements coordinate their efforts as shown on the solid double-headed arrows between the boxes. Arrowed lines show how the planning and control responsibility for a specific aircraft moves through the system.

The concurrency notation (&) superimposed on this block diagram shows that each of the indicated functional elements operates in parallel with the others. The appropriate elements of the entire system respond to events and produce the necessary control actions.

The Flight Data Entry and Printout device at the ATCT or the colocated TRACON prints a copy of the flight plan. Upon request from the aircraft, the Clearance Delivery controller (large facility) or Ground Controller (small facility) reads the clearance to the aircraft well before taxi clearance. He may confer with the pilot to resolve differences between the requested and approved flight plan, and to determine how the pilot will handle any delays which have been imposed due to other traffic or conditions within the system. Depending on the amount of traffic, this interaction may take place on a "ground control" frequency or on a separate "clearance delivery" frequency. Following clearance delivery, communication with the aircraft continues on the ground control frequency.

The Ground Controller issues clearances per his (mentally maintained) maneuver plan to position the aircraft for takeoff. At all towers he observes the aircraft location. Ground surveillance

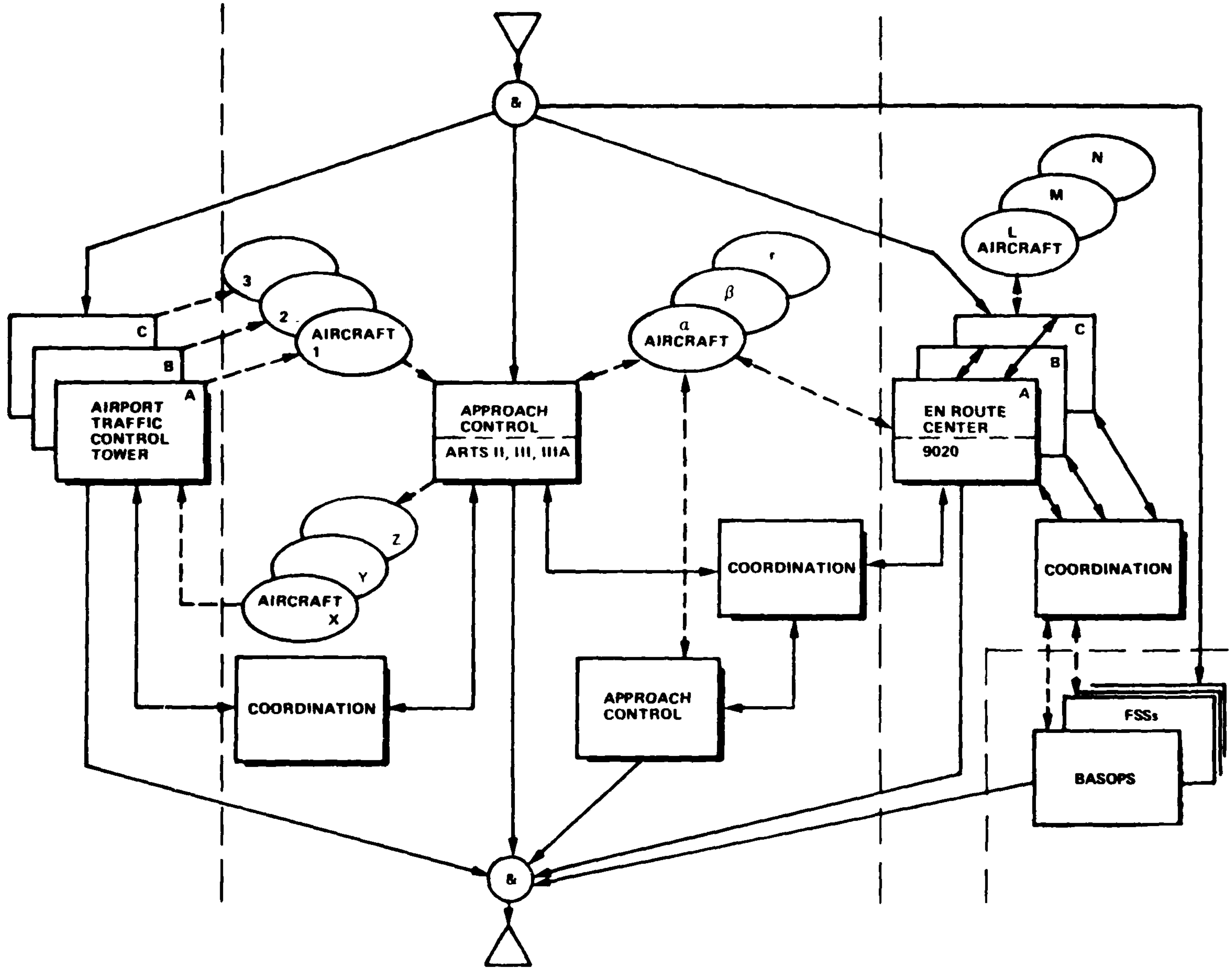


Figure 4-1 Top Level Diagram of the Current ATC System

radar supplements controller vision at a few facilities. The primary aid to the ground controller, and to the local controller who handles the actual takeoff, is the flight strip used for clearance delivery. He relates aircraft characteristics and destination to the current weather, runway configuration, and standard departure routings in preparing his plan of action. He transfers control responsibility to the Local Controller when the aircraft is ready to take the active runway.

The Local Controller clears aircraft for takeoff after considering such issues as wake turbulence, same runway usage, and operations on parallel and intersecting runways in his separation of aircraft. He also maintains a constant visual scan of the airspace and movement areas to avoid conflict with unauthorized or unexpected aircraft, including aircraft executing a missed approach. Coordination of many sorts is accomplished with the departure controller. When he has established the aircraft on the desired route, the controller instructs the pilot to contact the Departure Controller at the TRACON.

In a TRACON colocated with a tower, the Local Controller may actually drop the flight strip (via drop tube) for a departing aircraft to inform the departure controller the aircraft is airborne. At separated facilities, however, the Departure Controller currently works from paper flight strips and/or a proposed departure list presented on his Situation Display.

The ARTS augments the Departure Controller's radar display by indicating which aircraft he currently controls, adding aircraft call sign, speed, altitude, and control status to the basic radar return.

In addition to these passive perceptual aids, the ARTS systems provide warning of impending conflict between controlled aircraft, or between controlled aircraft and stationary obstacles. The display normally abbreviates the presentation of any aircraft outside the controller's responsibility to avoid overloading him with irrelevant information. He may, however, display the full flight data block on any aircraft, either on a temporary or permanent basis. This is normally done to better understand the way the situation is developing.

If the departing aircraft will be operating under VFR and has no need for VFR Flight Following Service, the Departure Controller will instruct the computer to discontinue actively following the aircraft ("drop track") when it leaves the area of mandatory control. Otherwise, he will issue additional clearances to establish the aircraft on its course, or at least on the climb to its desired altitude and route. When traffic conditions permit, he will climb the aircraft to its interim altitude as rapidly as possible. Often, however, he will advise the aircraft to expect several more miles, or minutes, of delay before traffic will allow it to resume its climb. From the flight strip the controller may identify a particular "fix" and issue crossing restrictions.

Before a controlled aircraft leaves his airspace, the Departure Controller will transfer control to the next sector or position along its route. Several facilities have local modifications to the ARTS III programs which automatically initiate the handoff to the adjacent center at the appropriate point along the aircraft's planned trajectory. The computer marks the Full Data Block (FDB) for that aircraft to indicate the beginning of a handoff and sends a message to the center requesting that the center accept control (a "cross-tell" TI message). When the center replies with an acceptance of control, the ARTS changes the FDB to indicate that the handoff has been accepted, and soon abbreviates the display for that aircraft. The Departure Controller then directs the aircraft to contact the appropriate center sector.

At TRACONs without the automatic handoff modification, and for aircraft which are being handed off between TRACON positions at the same TRACON, the controller must designate the aircraft for handoff before the computer can take the actions described above. The implied functional concept offers great convenience under a number of circumstances. When a handoff is required, the ARTS interprets the position symbol and aircraft's position (indicated by the controller use of the trackball) as a handoff command. When the commands must be given quickly, as during a busy period at a large terminal, a separate controller is often assigned just to issue the handoff commands. Under these circumstances, the handoff person will often designate the aircraft and the desired action from his keyboard rather than use the trackball.

The ARTCC computer validates the flight plan, making changes as necessary to reflect local adaptation for preferred routings. Arrival times are computed using flight plan information and any available information about winds aloft. The center distributes the approved flight plan to a Tower or FSS for delivery to the aircraft, and to the affected TRACON and en route facilities for presentation to the controllers in time for them to plan their handling of the aircraft.

4.1.1 <u>TRACON Operational Flow</u>

Terminal Radar Approach Control Operations for both large and small facilities are depicted in Figure 4-2. Note in the figure that the position types at TRACON facilities differ slightly from the smaller TRACON or non-radar approach control facilities. For a review of TRACON positions, please consult Table 2-6.

The approach arrival phase of traffic flow may be operationally divided into segments. A feeder position will accept handoffs on traffic from the center and establish an initial sequence or flow of traffic. Subsequently, the feeder positions hand off each aircraft in the sequence to the final controller, who

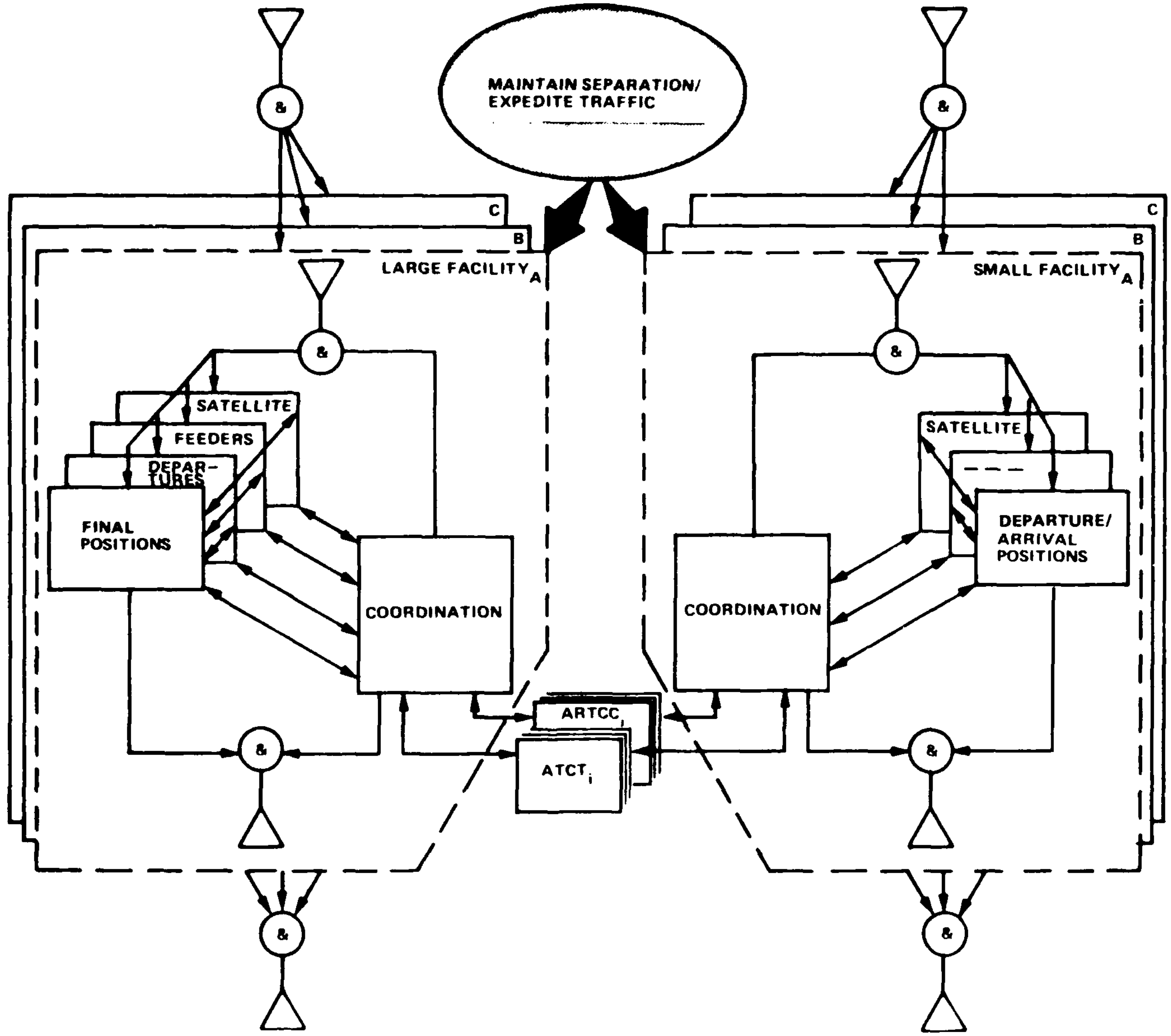


Figure 4-2 ·ent Concept of TRACON Operations provides the separation and spacing for the final arrival sequence to the runway. Two or more feeder fixes or positions may serve one or more final controllers, depending on traffic volume and runway configuration.

The departure controllers generally work all departing traffic from the primary airport and hand off the traffic directly to center sectors. There may be more than one departure controller, depending on traffic volume.

Satellite positions are normally staffed when dictated by traffic volume and complexity. Satellite positions generally work both arrival and departure traffic at secondary or satellite airports.

At large facilities there may be several airports where volume requires feeder, final, and departure positions for each airport. At small facilities the feeder, final, and satellite operations may be combined.

4.1.2 En Route (ARTCC) Operational Flow

En Route Operations are depicted in composition graph form in Figure 4-3. The major components of ARTCC Operations are discussed briefly in the following subsection, but emphasis is given to how en route center sector types interact together to maintain separation and expedite traffic flow.

As contrasted to individual TRACON positions, centers are universally split into high altitude and various types of low altitude sectors (such as feeder and transition sectors which control traffic in and out of major airports). The most common staffing arrangement is a sector (D or Manual) controller, who is reponsible for preplanning activities and separation through, the use of flight progress strips and interphone communication; and a radar (R) controller, who is responsible for radar separation, using a PVD and air/ground communication.

High altitude sectors generally handle considerable over flight traffic, with a mixture of arrival/departure traffic over airport areas.

Low altitude sectors normally have a mixture of aircraft types which fly at lower altitudes. These sectors have a mixture of over flight and arrival/departure slower speed traffic, and higher performance aircraft which are transitioning between the high altitude sectors and the TRACONs.

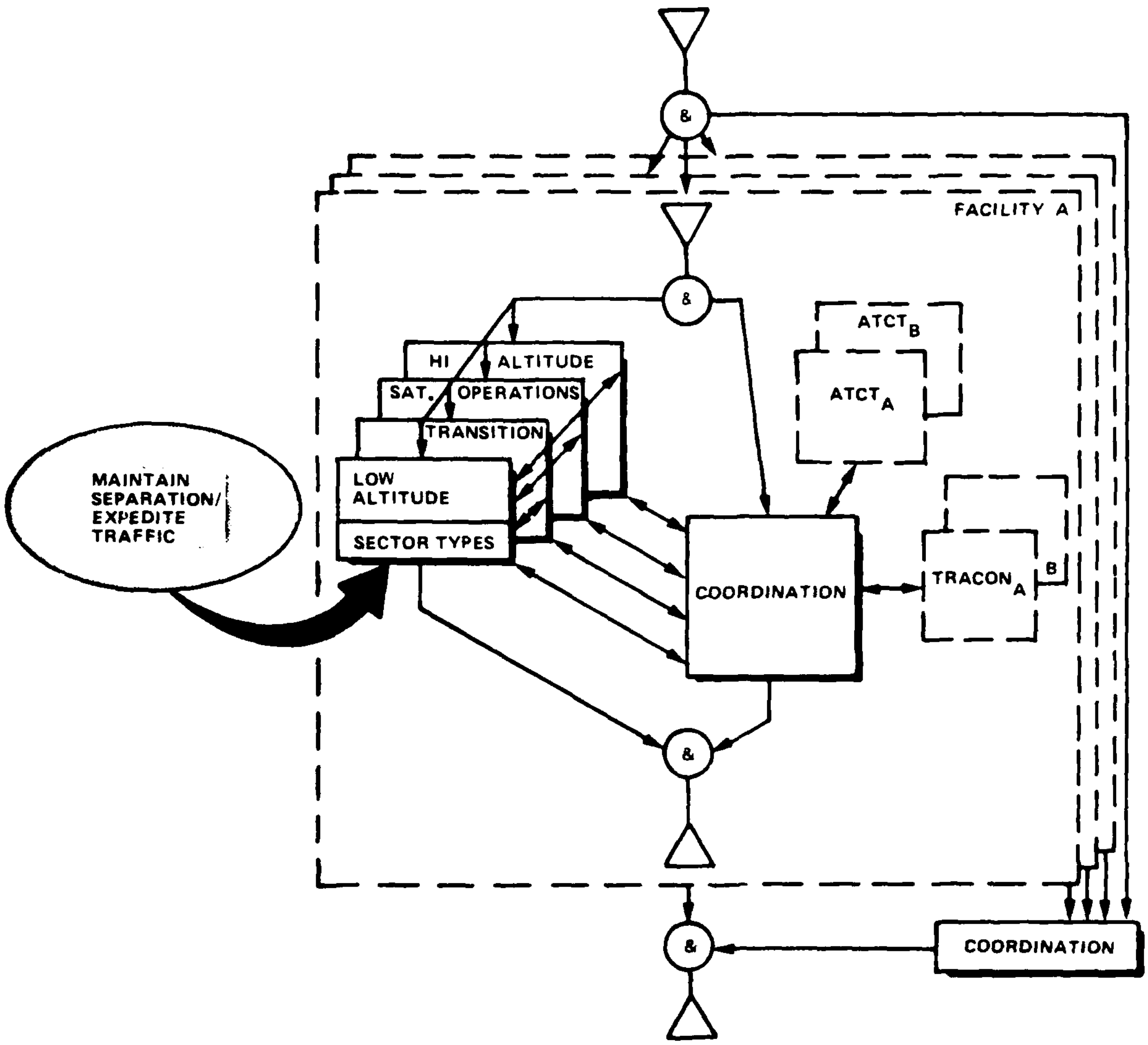


Figure 4-3 Current Concept of En Route Operations

4.2 THE CONTROLLER AS AN EVENT-SENSITIVE INFORMATION PROCESSOR

Air traffic controllers, if called upon to describe their work activity, might well group their efforts into the five categories of:

a. Main Functions (to include separation, clearance, conflict resolution, sequence).

b. Support Actions for Main Functions (to include communication, coordination, housekeeping).

c. Unusual, Non-Routine, and Special Operations.

d. Weather-Related.

e. Resource Management.

Such a grouping serves to characterize the operations view of the job, but does not preserve an information-processing view of the controllers' interaction with the machine/system and traffic environment. The information-processing view of the controller job requires consideration and linkage from the environmental and situational inputs to the control process. These inputs are the types of events identified in Chapter 3. To lead into the identification and grouping of controller tasks, a natural clustering of events was developed. This provided a structure for that task identification and organization, permitting a linkage to be maintained from inputs through controller response actions.

4.2.1 Rationale for Classifying Events

As discussed in Chapters 1 and 3, and illustrated in Figures 1-3 and 1-4, ATC events are considered to be functions of four elements of the ATC environment:

Aircraft
Airspace
Facilities
Surveillance Capabilities

Each type of event was associated with one or more of these four elements, where it was judged to be related in some meaningful way. Quite obviously, the greatest association was with a combination of Aircraft and Airspace elements. To further divide those numerous events into more manageable groupings, the Aircraft-Airspace combination was further split into three groupings:

1. Aircraft-Airspace only.
2. Aircraft-Airspace-Facilities, with emphasis on Aircraft and Facilities.
3. Aircraft-Airspace-Facilities, with emphasis on Airspace and Facilities.

Examining the events grouping into these combinations of elements, it appeared the resultant controller responses would tend to involve the following control matters:

a. Airspace conflicts (involving Aircraft-Airspace elements only).
b. Airspace control, including flow and sequences (Aircraft and Facility emphasis).
c. Flight considerations, including clearances,

flight plans, emergencies, and special operations (Airspace and Facility emphasis).

Two other combinations of ATC environmental elements also emerged, but not heavily involving the Aircraft and Airspace elements together:

4. Airspace - Surveillance Capabilities.
5. Facilities - Surveillance Capabilities.

These appeared to involve the following control matters, respectively:

d. Weather (Airspace and Surveillance Capabilities).
e. Strains on ATC equipment and personnel (Facilities and Surveillance Capabilities).

For each of the five identified clusters of events we stated an overall activity *statement*, reflecting the general nature of controller efforts in relation to that cluster. Additionally, one overall umbrella activity appeared necessary to accommodate monitoring, ongoing sorts of efforts of controllers. These tend to involve all types of events.

These six activities have been labeled as follows:

Activity 1: Perform Situation Monitoring
Activity 2: Resolve Aircraft Conflicts
Activity 3: Manage Air Traffic Sequences
Activity 4: Route or Plan Flights
Activity 5: Assess Weather Impact
Activity 6: Manage Sector/Position Resources.

Table 4-1 lists the events under each of these six activity groupings. Also noted in Table 4-1 are the elements of the ATC environment judged to be most related to each event. It can be noticed, from the nature of the event and its relation to environmental elements, how a natural grouping of related sub-activities and tasks of the controller job should evolve.

Activity 1 implies consideration of all environmental elements.

Activity 2 considers the Aircraft and Airspace element combination only.

Activity 3 tends to be concerned with Aircraft, Airspace, and Facilities, with emphasis on the Aircraft-Facility combination.

Activity 4 concentrates on both Aircraft-Airspace and Aircraft-Facilities combinations, in effect emphasizing Airspace and Facilities.

Activity 5 considers the Airspace-Surveillance Capabilities combination.

Activity 6 concentrates on the Facilities-Surveillance Capabilities combination.

TABLE 4-1. EVENTS VS. ELEMENTS OF ATC ENVIRONMENT

Events	Aircraft	Airspace	Facilities	Surveillance Capabilities
ACTIVITY 1: PERFORM SITUATION MONITORING				
All events, including not elsewhere categorized:	X	X	X	X
Initial Contact	X			X
Flight Following	X			X
ACTIVITY 2: RESOLVE AIRCRAFT CONFLICTS				
Aircraft-Aircraft Conflict	X	X		
Minimum Safe Altitude Warning	X	X		
Traffic Advisory	X	X		
Impending Airspace Conflict	X	X		
Refueling, Exercises, Air Shows	X	X		
ACTIVITY 3: MANAGE AIR TRAFFIC SEQUENCES				
Approach Clearance	X	X		
FAF Inbound	X	X		
Fuel Dumping, Jettison	X	X		
ALTRV, Airspace Reservation	X	X		
Restricted, Warning, "HOT" MOA	X	X		
Taxi Clearance	X		X	
Takeoff Clearance	X		X	

TABLE 4-1. EVENTS VS. ELEMENTS OF ATC ENVIRONMENT (Cont'd)

Events	Aircraft	Airspace	Facilities	Surveillance Capabilities
Handoff Receipt	X	X	X	X
Pointout Receipt	X	X	X	X
Entering/Leaving Hold	X	X	X	
Landing Clearance	X		X	
Missed Approach	X	X	X	
TAS, Altitude, Route Deviation	X	X	X	
Balloons, Gliders	X	X	X	
Runway Configuration Change	X		X	
Aircraft to Edge of Sector	X		X	
Flow Management Required	X	X	X	
Change Flow Pattern	X	X	X	
ACTIVITY 4: ROUTE OR PLAN FLIGHTS				
Overdue Aircraft	X	X		X
Medical	X	X		
Aircraft Emergency	X	X		
Bomb Threat	X	X		
Interceptor Flights	X	X		
Military Training Routes	X	X		
DOE Flights (e.g., haza[illegible]ous cargo)	X	X		
Above FL 600	X	X		

TABLE 4-1. EVENTS VS. ELEMENTS OF ATC ENVIRONMENT (Cont'd)

Events	Aircraft	Airspace	Facilities	Surveillance Capabilities
Lifeguard Missions	X	X		
Experimental Flights	X	X		
Law Enforcement	X	X		
Amended Altitude/ Route/Destination	X	X	X	
Filed Flight Plan	X	X	X	
Clearance Delivery	X		X	
No Radio	X		X	X
Beacon Failure	X		X	X
Hijack	X		X	X
VFR TCA/TRSA	X	X	X	
ACTIVITY 5: ASSESS WEATHER IMPACT				
Display of Severe Weather		X		X
SIGMET/AIRMET Advisories		X		X
Wind Shear Report		X		X
Ceiling Height Report		X		X
Visibility Report		X		X
Pressure Display/ Report		X		X
PIREP	X	X		X

TABLE 4-1. EVENTS VS. ELEMENTS OF ATC ENVIRONMENT (Cont'd)

Events	Aircraft	Airspace	Facilities	Surveillance Capabilities
ACTIVITY 6: MANAGE SECTOR/POSITION RESOURCES				
Controller on Duty			X	X
Controller Overload	X		X	
Airspace Release		X	X	X
Communications Failure	X		X	X
RDP Failure			X	X
FDP Failure			X	X
NAVAID Status			X	X
Duplicate Beacon Code	X		X	X
Facility Closure/ Capacity Change		X	X	X
Failure to Receive Handoff	X	X	X	X

4.2.2 Event Frequency of Occurrence

Table 4-2 draws a coarse distinction between events by indicating whether an event generally occurs with high, medium, or low frequency, from a controller's perspective. It is apparent from the table that no contrast appears at this level. A finer distinction will appear, however, when the activities are broken down to subtask level in Chapter 5. The generalization may be stated that most activities are concerned with planned flights and the separation of aircraft within airspace and facilities.

4.2.3 Activities Involved in Maintaining Separation and Expediting Traffic

Regardless of the type of Air Traffic Control facility or the manner in which operations are implemented, the overall goal of the controller is to maintain appropriate separation among aircraft in a timely and expeditious manner. Figure 4-4 illustrates pictorially that the top-level activities of the controller are the same whether carried out in a TRACON or ARTCC.

TABLE 4-2. EVENTS VS. FREQUENCY OF OCCURRENCE

Activity	Event	Frequency of Occurrence H = High M = Medium L = Low
2.0 Maintain Aircraft Separation	Aircraft-Aircraft Conflict	H
	Minimum Safe Altitude Warning	L
	Traffic Advisory	H
	Impending Airspace Conflict	M
	Refueling, Exercises, Air Shows	L
3.0 Manage Air Traffic Sequences		
	Taxi Clearance	H
	Takeoff Clearance	H
	Handoff Receipt	H
	Failure to Receive Handoff	L
	Pointout Receipt	H
	Approach Clearance	H
	Entering/Leaving Hold	L
	Landing Clearance	H
	Missed Approach	L
	FAF Inbound	L radar H non-radar

TABLE 4-2. EVENTS VS. FREQUENCY OF OCCURRENCE (Cont'd)

Activity	Event	Frequency of Occurrence (H,M,L)
3.0 Manage Air Traffic Sequences (Cont'd)		
	TAS, Altitude, Route Deviation	L
	Balloons, Gliders	L
	Fuel Dumping, Jettison	L
	Runway Configuration Change	L
	Aircraft To Edge Of Sector	H
	Flow Management Required	M
	ALTRV, Airspace Reservation	L
	Change Flow Pattern	L
	Restricted, Warning, "HOT" MOA	M

TABLE 4-2. EVENTS VS. FREQUENCY OF OCCURRENCE (Cont'd)

Activity	Event	Frequency of Occurrence (H,M,L)
4.0 Route or Plan Flights		
	Clearance Delivery	H
	Amended Altitude/ Route/Destination	M
	Filed Flight Plan	H
	No Radio	L
	Beacon Failure	L
	Overdue Aircraft	L
	Aircraft Emergency	L
	Medical	L
	Hijack	L
	Bomb Threat	L
	Interceptor Flights	L
	Military Training Routes	M
	DOE Flights (e.g., hazardous cargo)	L
	Above FL 600	L
	Lifeguard Missions	L
	Experimental Flights	L
	Law Enforcement	L
	VFR TCA/TRSA	H

TABLE 4-2. EVENTS VS. FREQUENCY OF OCCURRENCE (Cont'd)

Activity	Event	Frequency of Occurrence (H,M,L)
5.0 Assess Weather Impact		
	PIREP	M
	Display of Severe Weather	M
	SIGMET/AIRMET Advisories	L
	Wind Shear Report	L
	Ceiling Height Report	H
	Visibility Report	H
	Pressure Display/ Report	H
6.0 Manage Sector/ Position Resources		
	Controller on Duty	H
	Airspace Release	L
	Communications Failure	L
	RDP Failure	L
	FDP Failure	L
	NAVAID Status	L
	Duplicate Beacon Code	L
	Facility Closure/ Capacity Change	L
	Failure To Receive Handoff	L
	Controller Overload	L

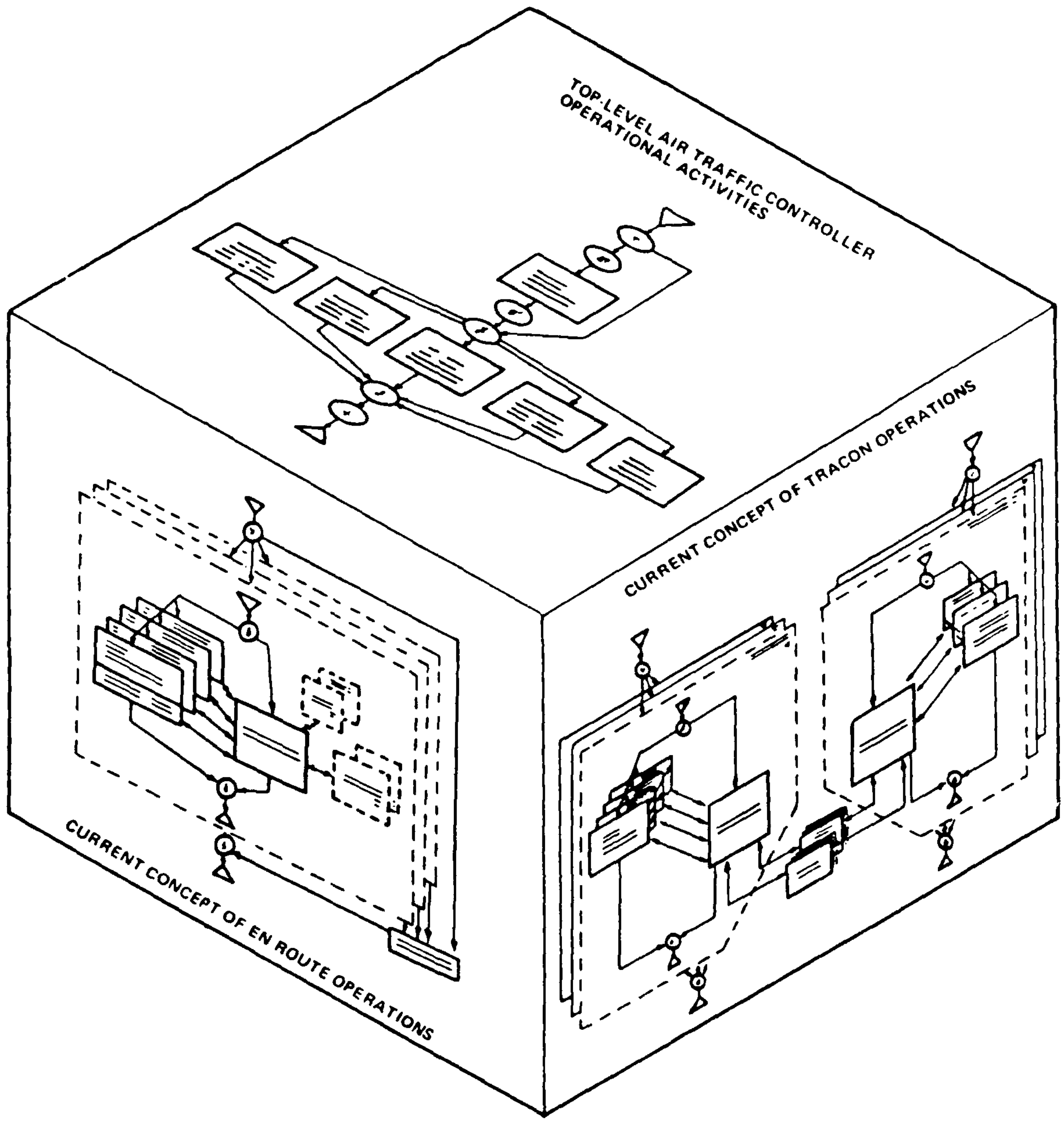


Figure 4-4 Top-Level Activity Similarities for En Route and TRACON Operations

4.3 COMPOSITION OF AIR TRAFFIC CONTROLLER ACTIVITIES

Figure 4-5 graphs the composition of top-level controller activities. The activity of Perform Situation Monitoring is a derived activity which supports all the rest of the activities and is iterative in nature. The others are all shown in parallel to demonstrate the fact that they may all be going on at once, whereas situation monitoring is an umbrella-like activity, indicative of the necessity for the controller to constantly scan and update the "big picture". All six top-level activities are discussed in the following subsections (4.3.1 - 4.3.6) in terms of their related sub-activities. To gain further continuity between Chapters 3.0 and 4.0, refer to Table 4-3 which lists events versus each sub-activity.

4.3.1 Perform Situation Monitoring

The situation monitoring activity may be triggered by any event and comprises six major sub-activities. See Figure 4-6. The first activity involves continuous checking and evaluation of aircraft separation. If there is a potential violation, the controller will execute the approximate sequence of sub-activities described in Section 4.3.2.

The processing of flight plans (in Section 4.3.4) causes the controller to begin pre-planning and analyzing requests for clearances. At this point the controller will opt to route and plan the flight (See Section 4.3.4) or wait to process departure time information and conduct initial aircraft contact. Time permitting, the controller will process requests for flight following, assign a beacon code, and start track of VFR aircraft.

The controller is constantly barraged with information from pilots, other controllers, and computer input and output requirements. The information must be assessed and updated while coordination is maintained among all sources of information. The housekeeping sub-activity refers to all the daily chores which must be performed to support any other activity. For example, mundane tasks such as setting the clock, or the ongoing review of the inactive or proposed flight plan bay for deadwood, must be carried out in order for the controller to be able to perform his primary activities. In addition, information which has not been solicited by the controller must be received by the controller and fit into the overall scheme.

4.3.2 Resolve Aircraft Conflicts

The resolve aircraft conflicts activity comprises the sub-activities of performing conflict alert, MSAW, and airspace conflict processing, as well as issuing traffic advisories. See Figure 4-7. In most cases, the activity of resolving aircraft conflicts takes place without aircraft separation falling below

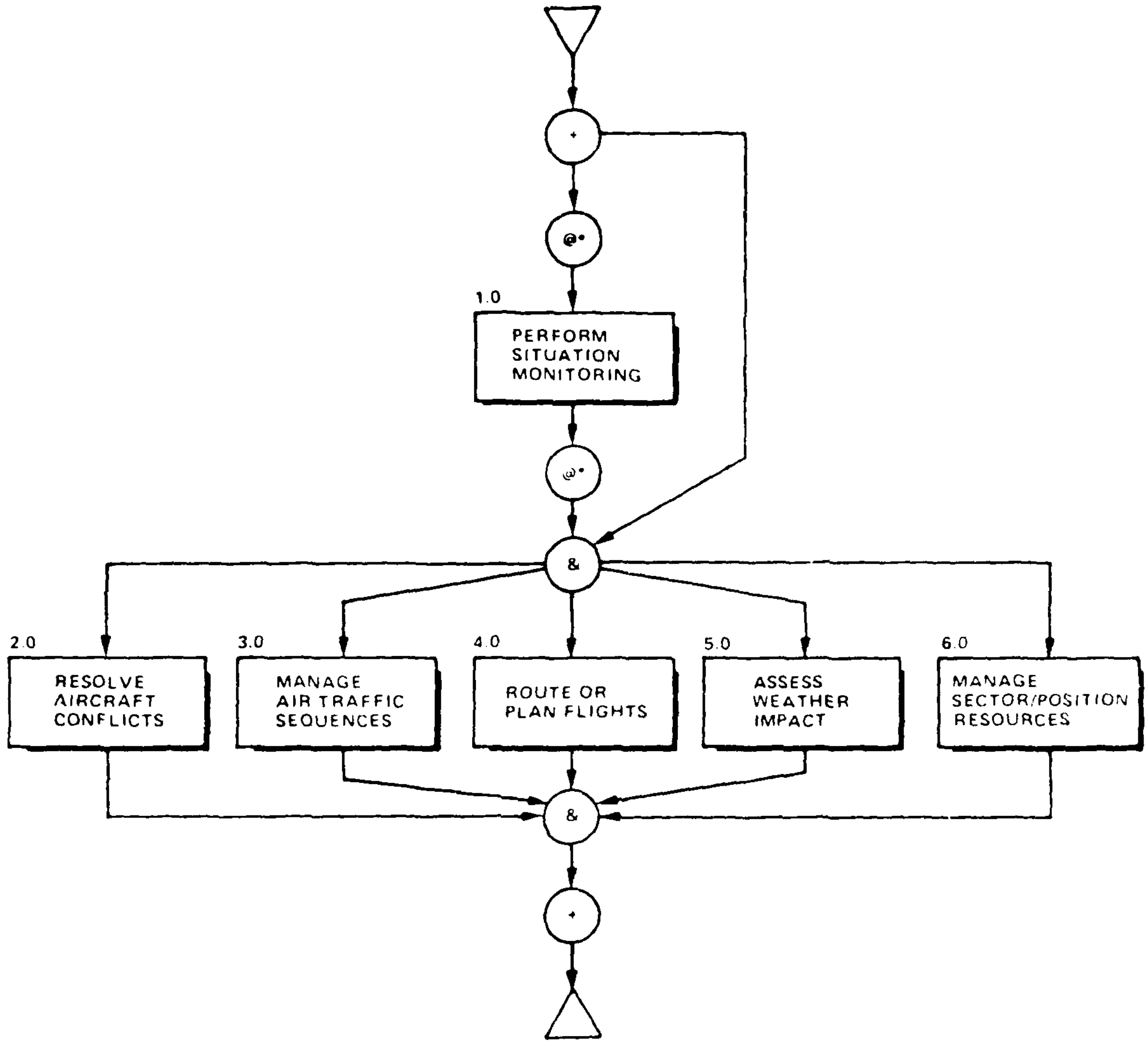


Figure 4-5 Top Level Air Traffic Controller Operational Activities

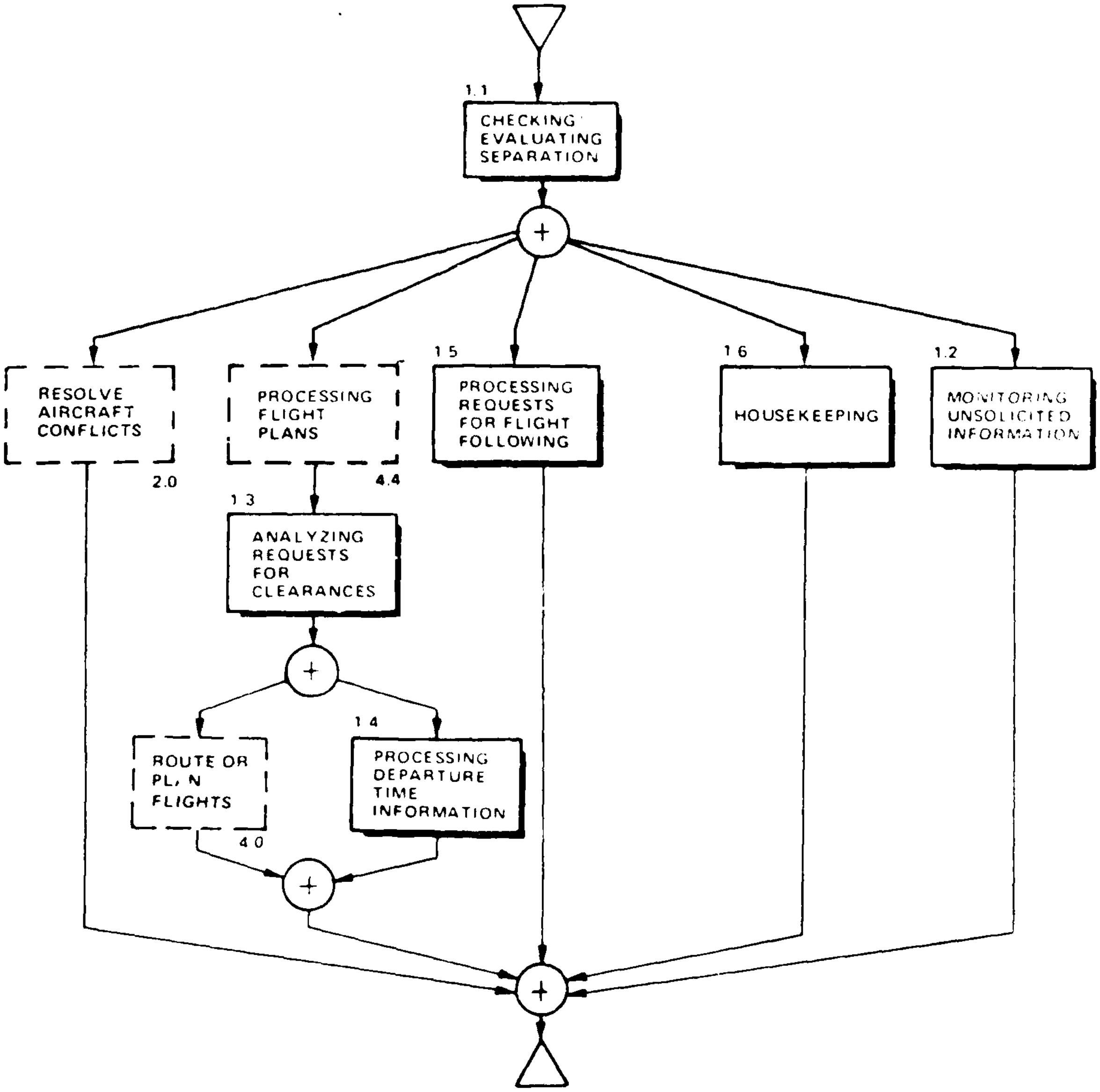


Figure 4-6 Activity 1 Perform Situation Monitoring

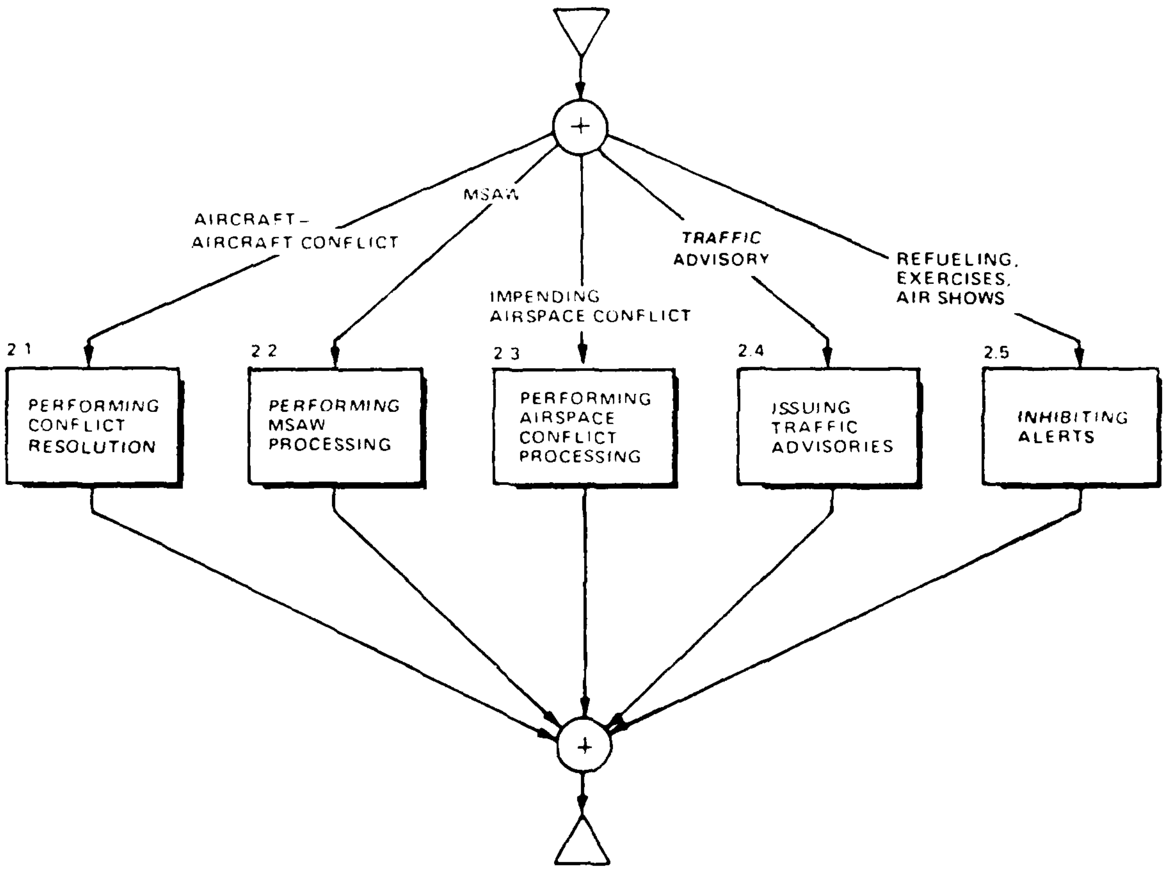


Figure 4-7 Activity 2. Resolve Aircraft Conflicts

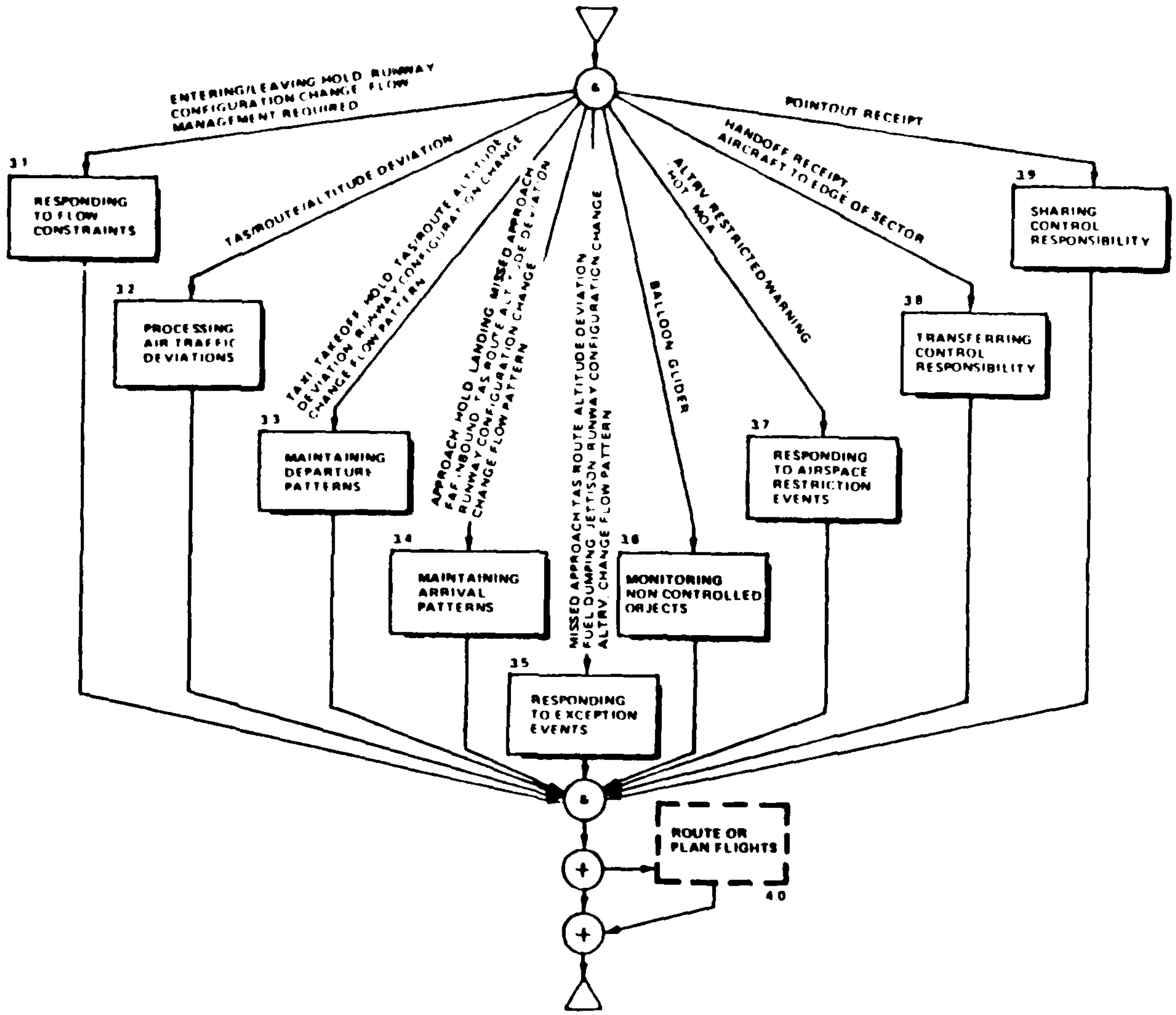


Figure 4-8 Activity 3: Manage Air Traffic Sequences

standards. If a controller predicts that an aircraft's flight path will take it below standards for separation with other aircraft, an obstacle, or restricted airspace, then a clearance or an advisory is issued to the aircraft long before an actual conflict alert or MSAW alarm sounds. As a matter of course, aircraft are separated in order to avoid a conflict, and the controller monitors the solution until it is resolved. In the case of an actual alarm sounding, the validity of the alarm is quickly checked and a clearance or advisory is issued if required.

4.3.3 Manage Air Traffic Sequences

As is apparent from Figure 4-8, managing air traffic sequences is a complex activity. The nine sub-activities are graphed in parallel to demonstrate that they may all be going on at the same time. Some of the sub-activities may be triggered by seldom occurring events, but nevertheless, not one may be given handling priority over another. The controller must respond to flow constraints, exception events, and airspace restriction events while maintaining departure and arrival patterns and coordinating flow control. All of the sub-activities must be maintained even if an air traffic deviation event or a non-controlled object event arises. Sub-activities which also occur with great frequency in support of managing air traffic sequences are the transfer or sharing of responsibility. Also, new information or updated information is input to the controller, necessitating his check, evaluation, and re-evaluating aircraft separation.

Managing air traffic sequences is clearly related to route or plan flights, which is indicated by the dashed box in the composition graph.

4.3.4 Route or Plan Flights

Figure 4-9 illustrates the many events which trigger the five route/plan flights sub-activities. The sub-activity of coordinating and issuing clearances is the ongoing sub-activity, whereas responding to contingencies or special operations happens less frequently. However, they are depicted on the composition graph as parallel to illustrate the possibility of sub-activities such as responding to contingencies, processing proposed flight plans, processing flight plan amendments, and responding to special operations going on at the same time.

4.3.5 Assess Weather Impact

To assess the impact of weather on other controller activities, the overall situation must be analyzed to determine the severity of the weather as well as the extent to which any given weather situation intersects the controller's sector or position. One way to assess the weather situation is to receive PIREPs, either solicited or unsolicited, from pilots in the area under scrutiny. The radar display also presents weather information. Other weather advisories may also be received and must be processed to determine the impact upon

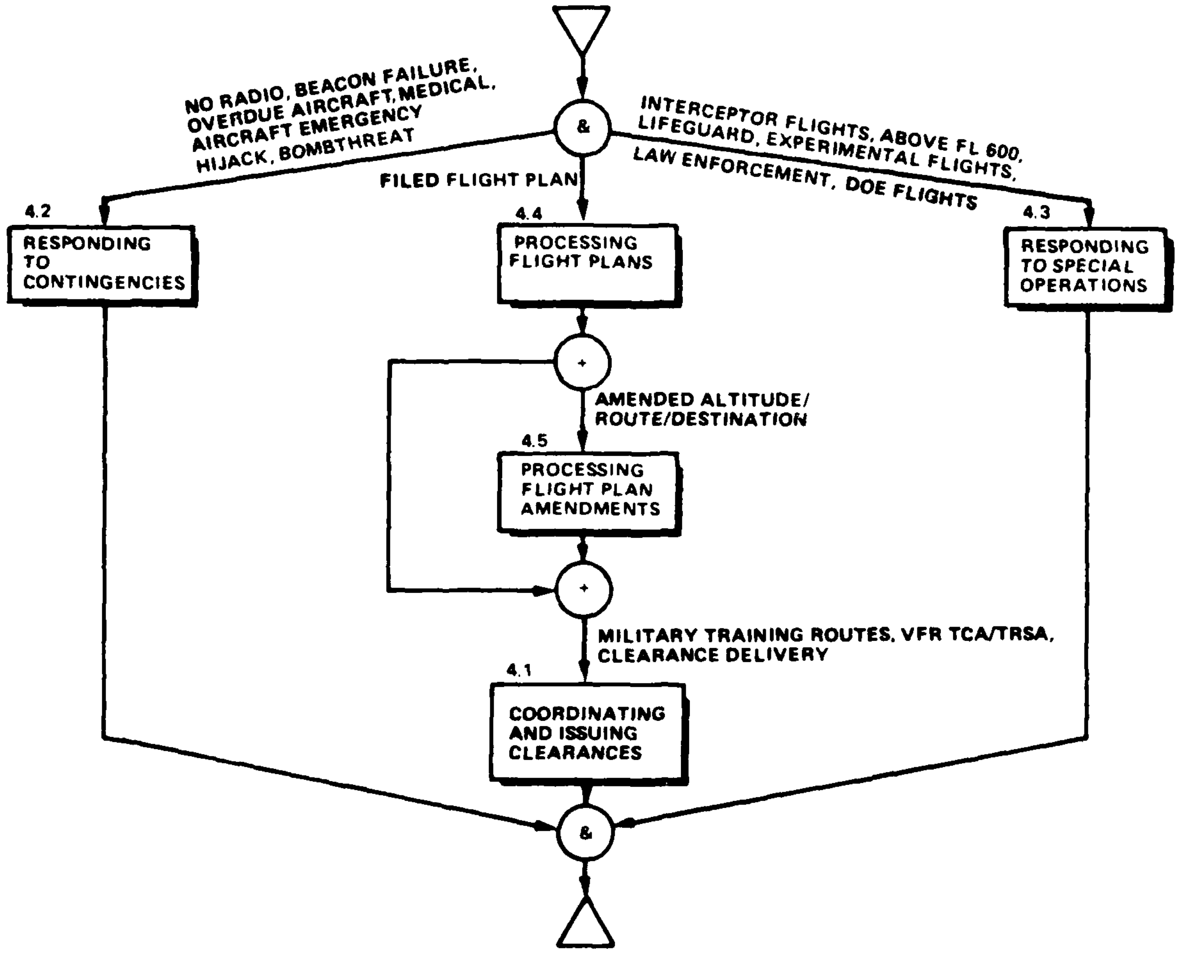


Figure 4-9 Activity 4: Route or Plan Flights

routing the traffic. Figure 4-10 illustrates the four sub-activities related to assessing weather impact and indicates the interface with the manage air traffic sequences activity.

4.3.6 <u>Manage Sector/Position Resources</u>

Refer to Figure 4-11 to see the complicated interplay among the sub-activities related to the management of sector/position resources. These resources include the management of controlled airspace and personnel resources, as well as the actual set-up of the controller's workstation. Also implied in the management of personnel resources and the workstation set-up is the ability to respond to transient fault events. The types of fault events which may occur are FDP failure, NAVAID or communication failure which may occur in parallel, and RDP faults which may appear independently of NAVAID or communication faults, but also appear as a direct consequence of FDP faults. These relationships are shown in composition graph form (Figure 4-11).

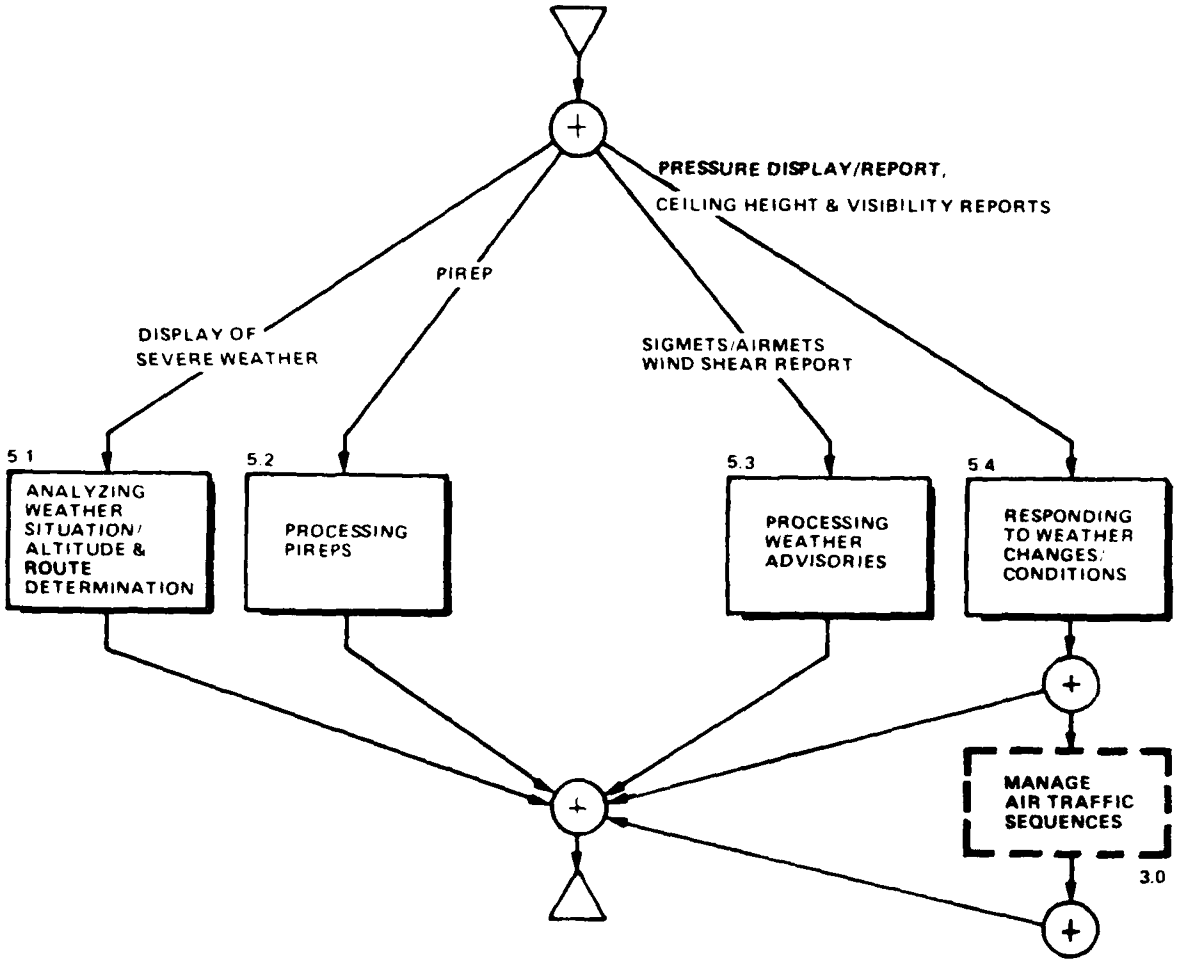


Figure 4-10 Activity 5: Assess Weather Impact

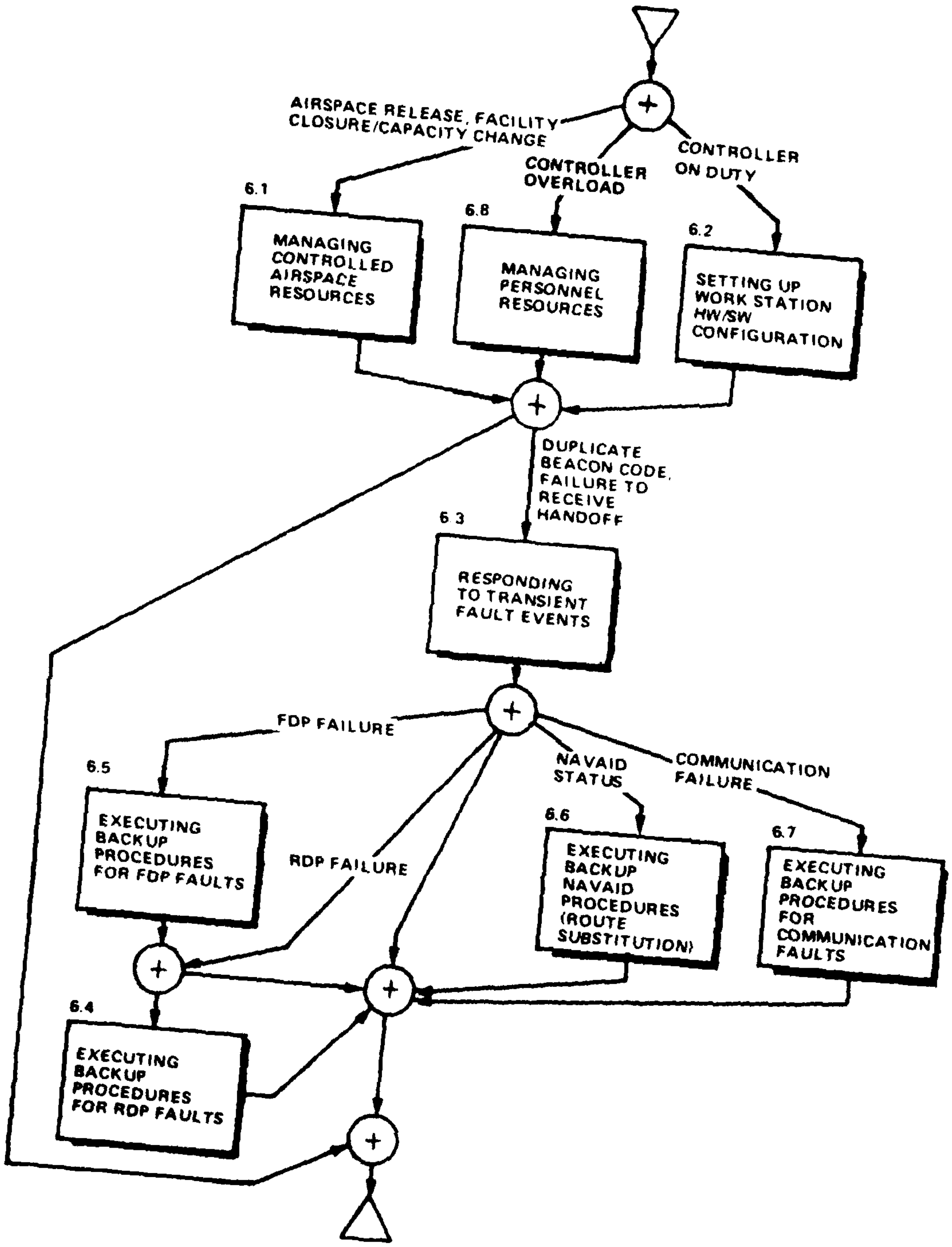


Figure 4-11 Activity 6: Manage Sector/Position Resources

4.4 IDENTIFICATION OF CONTROLLER INFORMATION PROCESSING TASKS

Section 4.3 illustrated the interrelationships among controller activities as decomposed into sub-activities and event stimuli in composition graph form. Table 4-3, which follows, lists the events and their corresponding sub-activities in tabular form. The next step in the analysis of these sub-activities is to break them down into tasks, which is the topic of Chapter 5.0 . Before proceeding to the task breakdown, however, we will first correlate the events with NAS messages, where appropriate, in an effort to detect an indication of task differentiation.

4.4.1 Correlation of NAS Messages and Information to Events

Table 4-4 lists the events, grouped according to activity category. Corresponding to each event is a NAS message, where one appropriately applies. The messages listed are strictly from the controllers' point of view. That is, maintenance and supervisory messages are not listed. Most of the messages are the same regardless of position or sector location, but in the instances where they are unique, indication is made in the table.

4.4.2 Terminal (ARTS) and En Route Task Differentiation

Table 4-4 designates which messages apply to ARTS tasks and which apply to en route tasks. In some cases the messages are identical at both facilities and in some cases they are only different in format, but not content. Of significance are the messages which are unique to one facility or the other. Chapter 5.0 will pursue this distinction further in the breakdown to the subtask level of the controller's job.

TABLE 4-3 SUB-ACTIVITIES VS. EVENTS

ACTIVITY	EVENTS	SUB-ACTIVITIES
1.0 Perform Situation Monitoring	ALL	Checking/Evaluating Separation
		Monitoring Unsolicited Communications
		Analyzing Requests for Clearances
	Initial Contact	Processing Departure Time Information
	Flight Following	Processing Requests for Flight Following
		Housekeeping
2.0 Resolve Aircraft Conflicts	Aircraft-Aircraft Conflict	Performing Conflict Resolution
	Minimum Safe Altitude Warning	Performing MSAW Processing
	Traffic Advisory	Issuing Traffic Advisories
	Impending Airspace Conflict	Performing Airspace Conflict Processing
	Refueling, Exercises, Air Shows	Inhibiting Alerts
3.0 Manage Air Traffic Sequences	Handoff Receipt	Transferring Control Responsibility
	Taxi Clearance	Maintaining Departure Pattern
	Pointout Receipt	Sharing Control Responsibility
	Takeoff Clearance	Maintaining Departure Pattern

TABLE 4-3 SUB-ACTIVITIES VS. EVENTS (Cont'd)

ACTIVITY	EVENTS	SUB-ACTIVITIES
3.0 Manage Air Traffic Sequences (Cont'd)	Approach Clearance	Maintaining Arrival Pattern
	Entering/ Leaving Hold	Responding to Flow Constraints, Maintaining Departure/Arrival Pattern
	Landing Clearance	Maintaining Arrival Pattern
	Missed Approach	Maintaining Arrival Pattern, Responding to Exception Events
	FAF Inbound	Maintaining Arrival Pattern
	TAS, Altitude, Route Deviation	Maintaining Arrival/Departure Patterns, Responding to Exception Events, Processing Air Traffic Deviations
	Balloons, Gliders	Monitoring Non-Controlled Objects
	Fuel Dumping, Jettison	Responding to Exception Events
	Runway Configuration Change	Maintaining Departure/ Arrival Patterns, Responding to Flow Constraints, Responding to Exception Events
	Aircraft to Edge of Sector	Transferring Control Responsibility
	Flow Management Required	Responding to Flow Constraints
	ALTRV, Airspace Reservation	Responding to Exception Events, Responding to Airspace Restriction Events

TABLE 4-3 SUB-ACTIVITIES VS. EVENTS (Cont'd)

ACTIVITY	EVENTS	SUB-ACTIVITIES
3.0 Manage Air Traffic Sequences (Cont'd)	Change Flow Pattern	Maintaining Arrival/Departure Patterns, Responding to Exception Events
	Restricted, Warning "HOT" MOA	Responding to Airspace Restriction Events
4.0 Route or Plan Flights	Clearance Delivery	Coordinating and Issuing Clearances
	Amended Altitude, Route, Destination	Processing Flight Plan Amendments
	Filed Flight Plan	Processing Flight Plans
	No Radio	Responding to Contingencies
	Beacon Failure	Responding to Contingencies
	Overdue Aircraft	Responding to Contingencies
	Aircraft Emergency	Responding to Contingencies
	Medical	Responding to Contingencies
	Hijack	Responding to Contingencies
	Bomb Threat	Responding to Contingencies

TABLE 4-3 SUB-ACTIVITIES VS. EVENTS (Cont'd)

ACTIVITY	EVENTS	SUB-ACTIVITIES
4.0 Route or Plan Flights (Cont'd)	Interceptor Flights	Responding to Special Operations
	Military Training Routes	Coordinating and Issuing Clearances
	DOE Flights (e.g., hazardous cargo)	Responding to Special Operations
	Above FL 600	Responding to Special Operations
	Lifeguard Missions	Responding to Special Operations
	Experimental Flights	Responding to Special Operations
	Law Enforcement	Responding to Special Operations
	VFR TCA/TRSA	Coordinating and Issuing Clearances
5.0 Assess Weather Impact	PIREP	Processing PIREPs
	Display of Severe Weather	Analyzing Weather Situation/Altitude/Route Determination
	SIGMET/AIRMET Advisories	Processing Weather Advisories
	Wind Shear Report	Processing Weather Advisories
	Ceiling Height Report	Responding to Weather Changes/Conditions

TABLE 4-3 SUB-ACTIVITIES VS. EVENTS (Cont'd)

ACTIVITY	EVENTS	SUB-ACTIVITIES
5.0 Assess Weather Impact (Cont'd)	Visibility Report	Responding to Weather Changes/Conditions
	Pressure Display/Report	Responding to Weather Changes/Conditions
6.0 Manage Sector/ Position Resources	Controller on Duty	Setting Up Workstation HW/SW Configuration
	Airspace Release	Managing Controlled Air-space Resources
	Communications Failure	Executing Backup Procedures for Communications Faults
	RDP Failure	Executing Backup Procedures for RDP Faults
	FDP Failure	Executing Backup Procedures for FDP Faults
	NAVAID Status	Executing Backup NAVAID Procedures
	Facility Closure/ Capacity Change	Managing Controlled Air-space Resources, Managing Personnel Resources
	Duplicate Beacon Code	Responding to Transient Fault Events
	Failure to Receive Handoff	Responding to Transient Fault Events
	Controller Overload	Managing Personnel Resources

TABLE 4-4 NAS MESSAGES AND INFORMATION VS. EVENTS

Activity	Events	NAS/ARTS Messages and Information	Unique to Location	Task Identification (ARTS, En Route)
2. Maintain Aircraft Separation				
	Aircraft-Aircraft Conflict	Conflict Alert (on-off)		A,E
		Conflict Alert Status Request		E
		Suppress/Request Conflict Alert Pair		A,E
		Group Suppression		E
	Minimum Safe Altitude Warning	E-MSAW Control		E
		E-MSAW Indefinite Alert Suppress/Restore	Low Altitude Sector	E
		MSAW Specific Alert Suppress/Restore	TRACON	A
		E-MSAW Status Request		E
		E-MSAW VFR Processing		E
	Traffic Advisory	*Filters*		A,E
	Impending Airspace Conflict	Initiate Handoff		A,E
		Pointout		E
		Modify		A
	Refueling, Exercises, Air Shows	Conflict Alert (On-Off)		A,E
		Suppress/Request Conflict Alert Pair		E
		E-MSAW Indefinite Alert Suppress/Restore		E
3. Manage Air Traffic Sequence	Taxi Clearance	None	TRACON	A
	Takeoff Clearance	TRACK Start		A,E
	Handoff Receipt	Handoff		A
	Aircraft to Edge of Sector	Accept Handoff (2)		E
	Pointout Receipt	Pointout		E
		Force Data Block		A,E
	Approach Clearance	None		

TABLE 4-4 NAS MESSAGES AND INFORMATION VS. EVENTS (Cont'd)

Activity	Events	NAS/ARTS Messages and Information	Unique to Location	Task Identification (ARTS, En Route)
3. Manage Air Traffic Sequences (Continued)				
	Hold (Entering, Leaving)	Hold (2) Track Suspend Supress/Request Data Block		E A E
	Landing Clearance	Track Drop Drop Track		A E
	Cancel IFR	ARTS, NAS Cancellation (Drop Flight Plan)		A,E
	Missed Approach	Track Start		A
	FAF Inbound	None		
	TAS, Route, Altitude Deviation	Amendment Route Display Route Readout		E E E
	Balloons, Gliders	Coast Track		E
	Fuel Dumping, Jettison	None		
	Runway Configuration Change	Configuration	TRACON	A
	Flow Management Required	Flow Control, Departure Delay Flight Plan Cancellation Departure Information		E E E
	ALTRV, Airspace Reservation	None	Usually En Route High/Low	
	Change Flow Pattern	Track Reroute Assigned Altitude (2) Interim Altitude		E E E
	Restricted, Warning "HOT" MOA	None		

TABLE 4-4 NAS MESSAGES AND INFORMATION VS. EVENTS (Cont'd)

Activity	Events	NAS/ARTS Messages and Information	Unique to Location	Task Identification (ARTS, En Route)
4. Route or Plan Flights	Clearance Delivery	Departure		E
		Advance Flow Control		E
		FAD Flow		E
		Flight Plan Readout		E
		Strip Request		E
	Amended Altitude, *Route, Destination*	Amendment (AM)		E
	Filed Flight Plan	Flight Plan (FP)		E
	Beacon Failure	Track Suspend		A
	No Radio	RDOF, RF		A,E
	Overdue Aircraft	None		
	Aircraft Emergency	EMER, EM		A,E
	Medical	*None*		
	Hijack	Modify (Beacon)		A
		Code Modification		E
	Bomb Threat	None		
	Interceptor Flights	None		
	Military Training Routes	None		
	DOE Flights (e.g. hazardous cargo)	None		
	Above FL 600	None	En Route	
	Lifeguard Missions	None		
	Experimental Flights	'None		

TABLE 4-4 NAS MESSAGES AND INFORMATION VS. EVENTS (Cont'd)

Activity	Events	NAS/ARTS Messages and Information	Unique to Location	Task Identification (ARTS, En Route)
4. Route or Plan Flights (Continued)				
	Law Enforcement	(Locally Variable)		
	VFR TCA/TRSA	Track Start	TRACON	A
		Flight Data		A
5. Assess Weather Impact				
	PIREP	Weather Requests		E
		General Information		E
	Display of Severe Weather	Weather		E
	SIGMET/AIRMET Advisories	General Information		E
	Wind Shear Report	*None*		
	Ceiling Height Report	Systems		A
	Visibility Report	Weather		E
		Weather Requests		E
	Pressure Display/Report	Altimeter Setting		A
		Systems (2)		A
		Altimeter Requests (2)		E
		Altimeter Setting		E

TABLE 4-4 NAS MESSAGES AND INFORMATION VS. EVENTS (Cont'd)

Activity	Events	NAS/ARTS Messages and Information	Unique to Location	Task Identification (ARTS, En Route)
6. Manage Sector/ Position Resources	Controller on Duty	Beacon Code Selection		A
		Check Configuration		A
		Readout Filter Limits		A
		Re-initialize Display		A
		Modify Leader Direction		A
		Automatic Offset		A
		Relocate Preview Area		A
		Relocate Systems Data		A
		Relocate Tabular List		A
		Relocate Suspend List		A
		Data Block Offset (2)		E
		Modify Altitude Limits		E
		Reposition List		E
		Select Automatic Handoff		E
		Code Insert/Delete		
		Display Code Request		E
	Airspace Release	None		
	Communications Failure	None		
	RDP Failure	Inhibit ARTCC		A
		Inhibit Transmission	Supervisor	E
		Restore ARTS data base		E
		Request ARTS transfer		E
	FDP Failure	Inhibit ARTCC		A
		Select/Inhibit Mag Tape,		A
		Display DM		A
	NAVAID Status	None		
	Duplicate Beacon Code	Track Drop, Modify		A
		Drop Track		E
		Amendment		E
		Code Modification		E
		Remove Strip (2)		A/E
	Facility Closure/ Capacity Change	Flow Control		E
		Control Flow Information		E
		Departure Delay		E
		Change Parameter		E
		Resector		E
		Terminate Flow Control (2)		E
		Restore ARTS Data Base		A,E
	Failure to Receive Handoff			
	Controller Overload	None		

Chapter 5.0

NAS ATC En Route/Terminal Controller Information Handling and Processing Tasks

5.0 NAS ATC EN ROUTE/TERMINAL CONTROLLER INFORMATION HANDLING AND PROCESSING TASKS

This chapter is structured to provide the reader with a comprehensive description of the controller's information handling and processing tasks. It begins with a definition of terms and summarizes the approach employed for analyzing controller tasks (see Section 5.1). In Section 5.2, a summary is provided which characterizes the job of an air traffic controller. It also attempts to provide a "feel" for the dynamic attributes of a controller's job.

In Section 5.3 each task is described as a sub-element of a controller's sub-activity (identified in Chapter 4.0). Please refer to Appendix B, "Composition of Controller Activities, Sub-Activities, and Information Processing Tasks," for a quick look reference. Section 5.4 provides a characterization of the controller tasks in terms of their cognitive, perceptual, and motor attributes. This analysis sets the stage for the discussion on ATC position operations and workload assessment in Chapter 6.0.

The authors recognize the difficulty in accurately describing what it is that controllers do. The composition or breakdown of tasks has proved to be, in some cases, very subjective. Every attempt has been made to preserve the traceability to ATC events which cause the controller to anticipate a course of action, preplan action sequences, follow procedures, or react to unforeseen conditions.

To give the reader a sense of comparison to previous work on this subject, please refer to the 1974 TRW study [12] on automation applications for an Advance Air Traffic Management System (AATMS). This was performed for the Department of Transportation (DOT)/Transportation System Center under contract number DOT-TSC-512. In Volume II, TRW analyzed and described air traffic control in terms of a proposed new system. Air Traffic Control activities were described in 3 levels of detail, i.e., functions, sub-functions, and tasks.

A total of 256 ATC tasks were identified and described by TRW, and the flow of information inputs and outputs among the tasks was specified. These 256 tasks were "generic" and for this analysis were candidates for ATC automation. Of 256 tasks it was concluded that 77 were manual and 179 were candidates for machine automation.

Our emphasis is different. This document focuses on current en route/terminal operations and analyzes to the subtask level the job of first-line duty controllers. In all, 236 tasks have been identified and described. Most previous studies have focused on the en route portion of air traffic control. Little material exists which describes to the same level of detail the operations/tasks of a terminal controller. We did, however, review and consider the information available in several earlier studies of the controller job [2,6,9,10].

5.1 DEFINITIONS AND APPROACH TO TASK COMPOSITION

In this section controller tasks represent the decomposition or breakdown of sub-activities into tasks. In Chapter 4.0, the analysis showed that sub-activites are a function of an ATC event. Thus, in this chapter, the mapping is preserved between events and tasks (i.e., tasks sequenced to show what the controller may do in response to an event).

Please refer to Section 1.5 for a review of the methods and logic employed in describing controller tasks, specifically Figures 1-5 and 1-6.

Human Information Processing Tasks are defined as a meaningful units of work which have the properties of task closure, specific human performance indices or goals, single event stimulus, and multiple response possibilities. Refer to Figure 1-2. Information processing tasks are decompositions of activities. Examples of tasks include: project future position/altitude of an aircraft, generate clearance, evaluate traffic sequencing alternatives.

Controller tasks may be characterized as perceptual (visual), cognitive (mental) or motor (voice, tactile) processes which can be qualitatively and quantitatively assessed. The controller performs multiple cognitive, perceptual, and motor tasks simultaneously. In addition, he is able to handle different priority levels on an interruptible basis.

Therefore, one can expand the characterization of a controller to that of: "an event sensitive, interruptible information processor with the capability of handling multiple priority levels."

5.2 THE CONTROLLER AS AN EVENT-SENSITIVE HUMAN INFORMATION PROCESSOR

The job of a controller is very complex mentally. He is constantly using short-term memory, recognition memory or recall, experiences, and mentally pre-stored procedures to respond to the changing air traffic situation. Figure 5-1 provides an illustration of the number of complex information processing tasks which must be performed in response to a runway change scenario. Note, in Figure 5-1 and the following discussion, the concurrent cognitive and perceptual processes involved in this air traffic scenario which takes place in less than 5 minutes. Also note, in Figure 5-1, the before and after situation display.

Scenario - Tim buk too Facility (TBT)

Time:	1212 Greenwich Mean Time or Zulu Time
Traffic Conditions:	Moderate, landing to the south (South Flow)
Affected Position:	Feeder Position, West

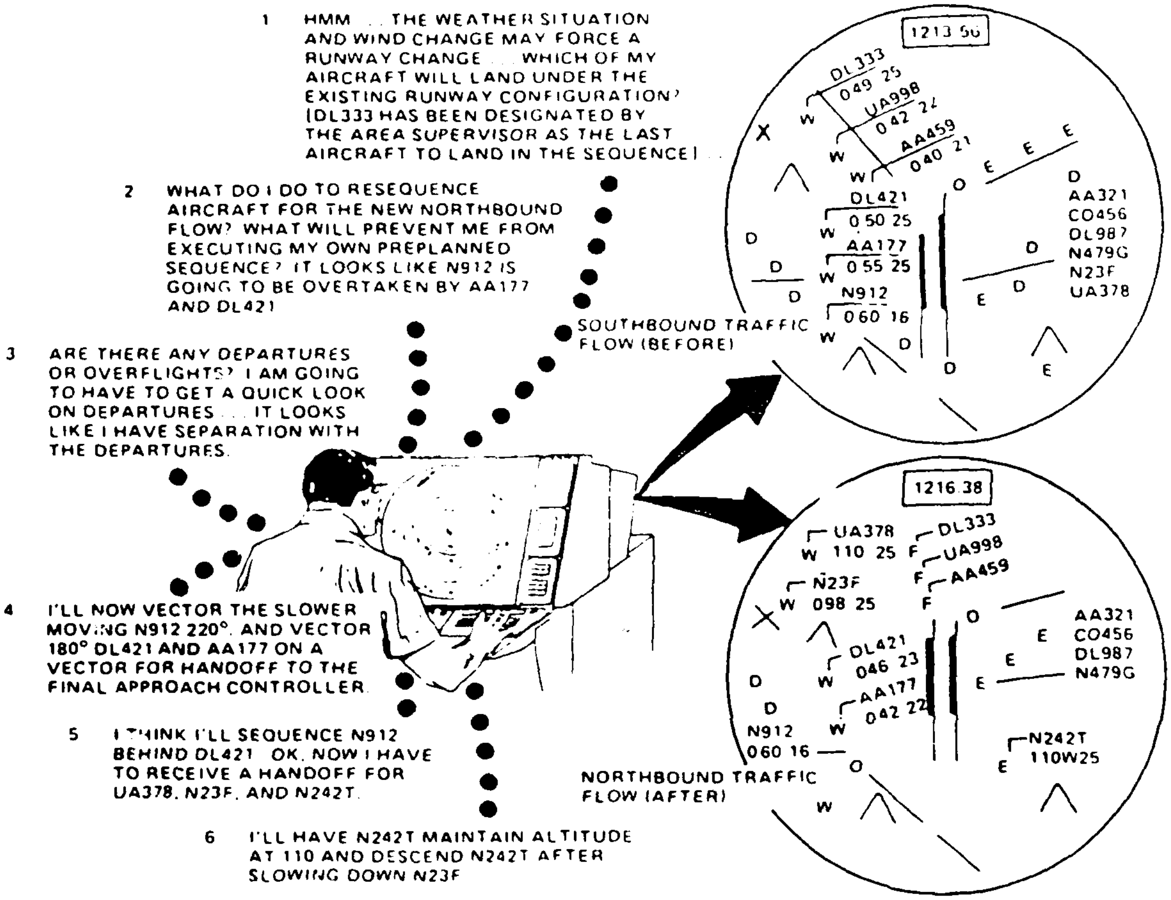


Figure 5-1. ATC Scenario Which Depicts Multi Tasking Properties of the Controller

Event: Wind change, Area Manager decides to change to a north traffic flow.

West feeder position (W) has already handed off 3 aircraft to the final controller (F). West feeder has 3 aircraft coming in from the northwest and 3 aircraft coming in from the southwest. The area supervisor, after reviewing the east final and the east feeder, departure, and west feeder and final positions, advises the west feeder that a runway change is in effect. Traffic that was landing to the south on runways 17L & 17R, will be landing to the north or runway 35L & 35R. The area supervisor tells the west feeder that several departures will be taking off on the east runway but none on the west runway. The runway change will be affected after DL333 lands. The supervisor tells the west feeder to resequence N912, AA177, DL421, and direct any other flights to use runway 35L.

The west feeder must determine how he will resequence the 3 flights, separate them from the departing aircraft that have already departed on the west runway (17R), accept two new aircraft, N23F and UA 378, that have been transferred from the center, sequence N23F and UA378, and be alert to the overflight of N242T which is arriving from the east and landing at a satellite airport just to the west of TBT's TRACON area. N242T will be descending and must be separated from N23F and UA378 who are also descending.

West feeder decides he must first establish a new sequence for N912, AA177, and DL421. Since N912 is much slower than the other two aircraft, the west feeder determines that he will give N912 a wider left turn and bring AA177 and DL421 in before N912. The west feeder must also quick look at the departure (D) position to determine the speed of several of the departures. He already knows the altitude of the departures from the partial data block he has displayed. He determines that he will continue the descent of AA177 while clearing N912 and DL421 to maintain 6,000 and 5,000 feet respectively.

By 1216 Zulu Time, the west feeder has determined that the departure will be clear of N912 and AA177. Also N912 is making a wide turn and he now can safely bring AA177 and DL421 inside of N912. With that part of the sequence established, the west feeder turns his attention to determining a clearance for N242T.

The west feeder determines that he will be able to descend N242T and bring him in between N23F and UA378. He may have to hold up UA378's altitude in case there is not enough room to vector the aircraft. Also, UA378 may overtake N23F. He does not want to delay UA378 since the west feeder anticipates several other inbounds directly behind UA378. AA177, followed by DL421 and N912, are transferred to the final controller. The runway change has been safely accomplished with minimum delay.

5.3 CONTROLLER INFORMATION HANDLING AND PROCESSING TASK DESCRIPTIONS AND ANALYSIS

This section provides a detailed description of each sub-activity identified in Chapter 4.0. Here each sub-activity is decomposed into flows of controller tasks which are illustrated in a composition graph (or linkage type of flow chart). Each task is then described in table form in terms of the interactions between the controller and his workstation, manual interactions between controllers, or interactions with printed media, such as flight strips. These descriptions represent the subtask level of decomposition or breakdown of the controller's job to the lowest level of detail.

These tables also show, by task, the way a controller does his job in the TRACON or En Route Center. It is at this level that one can see similarities and differences between the terminal and en route controller.

Verbal coordination between controllers on controller actions (such as revised clearances) and controller environment (such as airspace, weather) is required. This requirement may be deleted if the receiving controller will receive the information from another source, such as computer generated messages, in sufficient time to take appropriate action. The time requirement varies and is dependent on the specific situation. Therefore, coordination between controllers may be inferred on almost any task that is time critical.

Coordination efforts, though consuming large amounts of controller time, are treated for the most part in this study as "subtasks". That is, they are component actions that are parts of many controller tasks, and are most meaningful within the context of performing those tasks. Since coordination is not generally performed for its own sake, independent of a job task, then such action is not here considered as being a task itself. They remain, however, as important elements for the full understanding of the controller job and its workload. Passive involvement in coordination (as a recipient) is reflected in Sub-Activity 1.2 (Figure 5-3).

In NAS Stage A Operational Computer Programs, a tracked aircraft can be identified to the computer by entering:

a. The call sign of an aircraft;

b. The discrete beacon code; or

c. A 3-digit computer (assigned) number.

A trackball can also be used to identify an aircraft or a location on the display.

In ARTS, an aircraft can be identified by entering:

a. The call sign of an aircraft;

b. The discrete beacon code; or

c. A tabular line (single character) identifier.

A trackball in ARTS III TRACONs, or a peripheral entry module (PEM) in ARTS III towers and all ARTS II sites can also be used to identify an aircraft or a location on the display. In the ARTS the use of the trackball and subsequent enter button depression is called "slew".

When describing controller entered messages, it is normal to infer:

a. The message type, which is either a keyboard or quick action function key, real or implied by the computer;

b. Data as entered in an associated keyboard; and/or

c. The identity of an aircraft, the method of which is left to the controller. In the center, it is most common to use the 3-digi computer number; whe as, in the ARTS the slew is most frequently used.

5.3.1 Activity 1: Perform Situation Monitoring

5.3.1.1 Sub-Activity 1.1: Checking and Evaluating Separation

Maintaining separation between aircraft that are flying in the same direction, opposite directions, or on crossing flight paths is as necessary for the maintenance of safety under manual control conditions as it is under radar control.

Radar coverage is being extended throughout the ATC System. Eventually, most traffic will be controlled by radar procedures. However, presently there are areas in which no radar coverage is available. Further, in areas that are covered by radar, there is always the possibility that radar may be lost due to equipment malfunctions, which will result in the necessity to apply manual procedures.

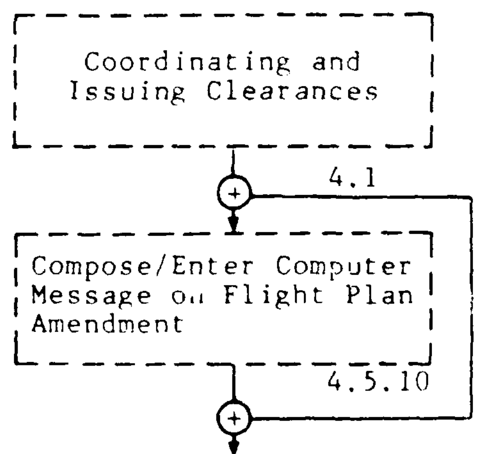
The most significant difference between manual and radar procedures is that the required separation for the manual mode of operation is greatly increased on the longitudinal and lateral planes. Without a radar presentation, the controller keeps the control picture in mind through the use of radio reports and flight strip information, and maintains separation standards in terms of separation by time, distance, and altitude, as well as by miles. Since manual separation standards are greater than radar standards, it is readily apparent that the amount of traffic that can be safely and efficiently controlled is less when manual procedures are applied.

One of the most important functions that a manual "D" controller performs in ensuring the safe flow of traffic through his sector is that of making sure that the proposed traffic will not conflict with present traffic. He must also ensure that traffic being controlled, and proposed traffic, will not come into conflict if the proposed routings are followed. The manual "D" controller prevents these potential conflicts from arising by maintaining a continuous awareness of the control actions being performed by the R-controller, carefully observing the PVD, and reviewing the flight strips in the bay. By pulling together all this information and ascertaining possible future conflict points, the manual controller can take those steps necessary to prevent system errors from occurring. By performing this function the manual controller prevents future problems from arising that require extra effort and time of the R-controller. He coordinates via computer entry, strip marking, and interphone. For example, he may request the previous controller clear aircraft via routes, altitudes, vectors, speeds, etc. to eliminate problems. This could result in the elimination of one of the critical factors that might cause the R-controller and the sector to be overloaded.

Regardless of the type of controller, he must assess the traffic situation for potential violation of separation standards by using both the radar display (Task 1.1.1) and flight progress strips (Task 1.1.6). He may chose to supplement this by either mentally projecting aircraft position, altitude, and path (Task 1.1.2); reading out range, bearing, and time for an aircraft to a fix or geographic point (Task 1.1.3); or forcing a data block to examine track information (Task 1.1.4). In the case of mentally projecting the aircraft's path, the controller will determine whether the aircraft is out-of-tolerence for its flight path or altitude (Task 3.2.1), or determine whether adequate separation will exist between an aircraft pair or an aircraft and an obstacle (Task 1.1.5).

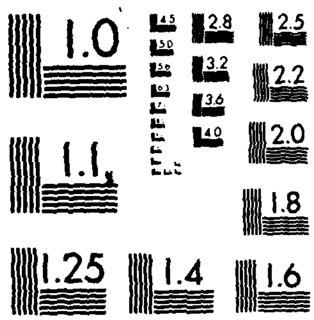
In any of these cases, if the controller perceives or recognizes that an aircraft will be separated by less than the prescribed minima, he will either issue a clearance to IFR aircraft (Sub-Activity 4.1), or a traffic advisory to VFR aircraft (Task 2.4.3).

Here in Sub-Activity 1.1, as in a number of other subactivities throughout the controller job, task efforts often conclude with the development and issuance of a clearance and the subsequent updating of the flight plan data base. These closure tasks are represented in each of the relevant composition graphs as follows:



The box labeled 4.1 is used to infer performance of several related tasks, as appropriate to the situation. These tasks may include any or many of the following:

AD-A138 991 EN ROUTE/TERMINAL ATC (AIR TRAFFIC CONTROL) OPERATIONS 3/5
CONCEPT(U) KAISER ELECTRONICS SAN JOSE CA
H AMMERMAN ET AL. 28 OCT 83 FAA-AP-83-16
UNCLASSIFIED DTFA01-83-Y-10554 F/G 17/7 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

4.1.2 Coordinate a planned clearance with adjacent controller.

4.1.7 Formulate a clearance with appropriate restrictions.

4.1.8 Evaluate a planned course of action, solution, impact.

4.1.9 Deny clearance request.

4.1.10 Issue clearance and instructions to pilot.

4.1.11 Issue clearance and instructions to terminal facility, FSS, BASOPS, or airline office for relay to pilot.

4.1.12 Verify aircraft compliance with clearance.

Not all clearance action may require data base updating (Task 4.5.10), hence the bypass possibility of that dashed box.

The issuing of traffic advisories often occurs as part of the normal watch routine of radar controllers and is an important flight safety factor. For VFR and IFR aircraft the passing of traffic advisories is on a time-permitting or workload basis.

When controlling IFR traffic, controllers will use vectoring or other separation procedures to maintain aircraft separation from other unidentified (VFR) traffic, if the pilot requests this service. If the IFR pilot does not desire this service, controllers will only pass traffic information in clock direction, altitude (if known), range, and traffic direction. If separation may be lost between two aircraft that are both on IFR flight plans, controllers will not wait for pilot request for separation, but initiate the appropriate actions to ensure that separation is maintained. Controllers inform the pilots after they are clear of the traffic and, if a change of flight had been initiated, the controller assists the pilot in navigating back to the original flight routing. When a VFR aircraft contacts a center controller for traffic advisory service, and the controller is able to perform this service, he determines the position and type of aircraft, identifies the aircraft on his radar display, and obtains the aircraft's proposed route and destination. If a VFR pilot requests service, this service will also be provided, workload permitting, as well as passing of the traffic information.

Note in Figure 5-2 the interface with Activity 2.0, Resolve Aircraft Conflicts. See Table 5-1 for a comparative subtask description of terminal and en route controller tasks.

Symbols employed throughout Figures 5-2 thru 5-39 consist of the following:

+	PATH SELECTION
&	PARALLEL PATH OR TASKS
@*	TASK REPETITION OR ITERATION

▽ ENTER

△ EXIT

REFERENCE TO SUB-ACTIVITIES OR TASKS LOCATED PRIMARILY IN ANOTHER GRAPH. THESE MAY HAVE RELATIONSHIPS TO OTHER CONTROLLER EFFORTS THAT INTERACT WITH ITEMS ON THE PRESENT GRAPH.

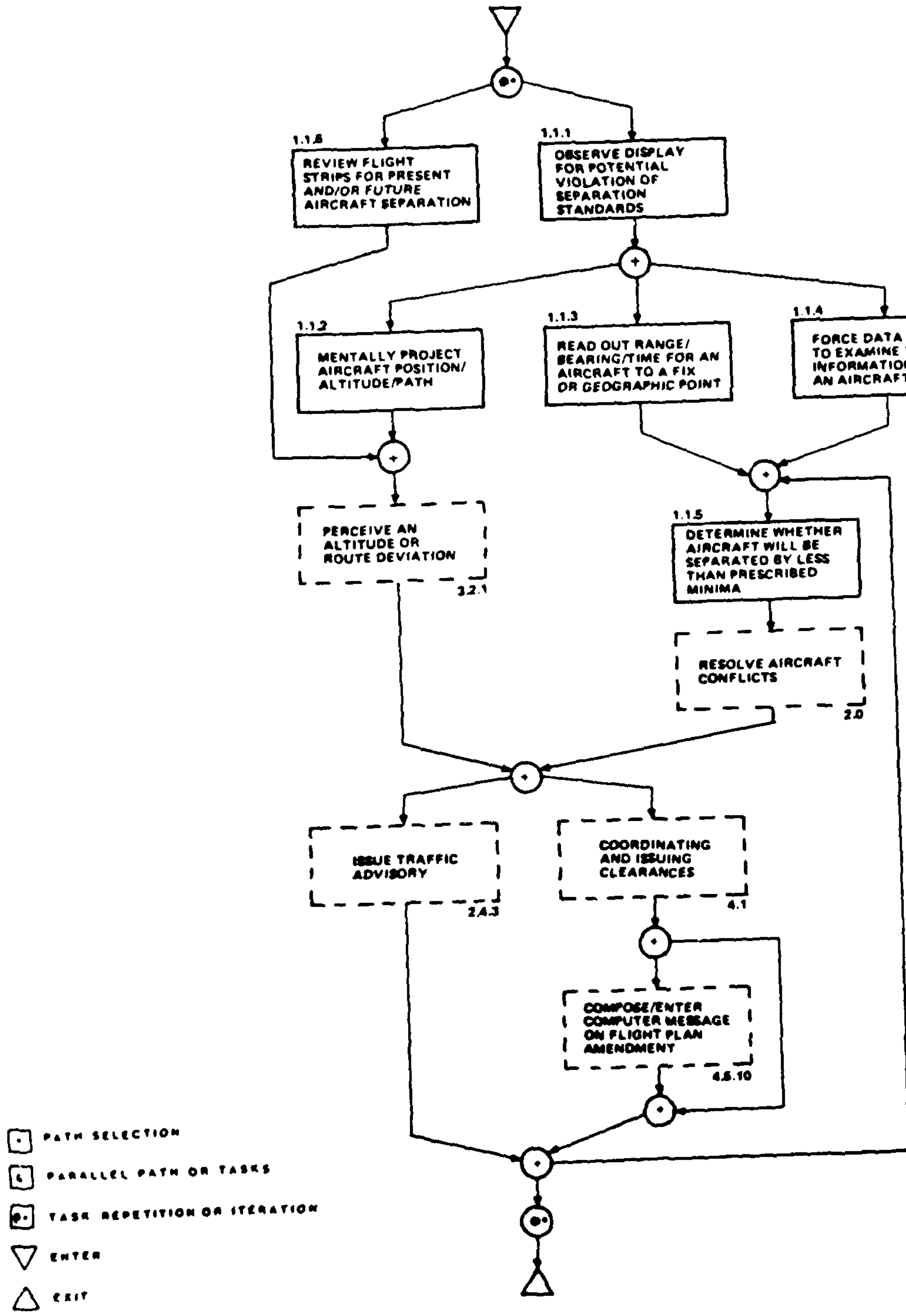


Figure 5.2 Sub-Activity 1.1: Checking and Evaluating Separation

TABLE 5-1. CHECKING AND EVALUATING SEPARATION

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.1.1 Observe display for potential violation of separation standards.	The controller visually observes the existing longitudinal, lateral, and vertical separation between aircraft.	The controller visually observes the existing longitudinal, lateral, and vertical separation between aircraft.
1.1.2 Mentally project aircraft position/altitude/path.	The controller mentally projects the aircraft's position, including altitude and route.	The controller mentally projects the aircraft's position, including altitude and route.
1.1.3 Read out range/bearing/time for an aircraft to a fix or geographic point.	N/A	The controller enters a range bearing message to determine the bearing, range, or time that an aircraft will be at a specified point. This may be done on several aircraft to determine separation between the aircraft.
1.1.4 Force data block to examine track information on an aircraft.	The controller may quick look a position to determine the track data. Data blocks will remain until the action is repeated.	The controller may force a data block in order to determine track data.

TABLE 5-1. CHECKING AND EVALUATING SEPARATION (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.1.5 Determine whether aircraft will be separated by less than prescribed minima.	Using the above tools and mental projections, the controller determines if separation will exist.	Using the above tools and mental projections, the controller determines if separation will exist. In addition, the manual controller may indicate less than standard separation exists by entering a note on the flight strip.
1.1.6 Review flight strips for present and/or future aircraft separation.	The controller will visually observe the flight progress strips for longitudinal, lateral, and vertical separation between aircraft.	The controller will visually observe the flight progress strips for longitudinal, lateral, and vertical separation between aircraft.

5.3.1.2 Sub-Activity 1.2: Monitoring Unsolicited Communications

The controller must constantly monitor a barrage of "unsolicited" information, and integrate it into his overall situation assessment. This includes reports of equipment status (Task 1.2.1), operations status (Task 1.2.2), traffic and flow information (Task 1.2.3), and briefings on weather events (Task 1.2.4).

Figure 5-3 is a composition graph depicting this sub-activity. Table 5-2 provides a comparative subtask description for terminal and en route controller tasks. These descriptions specify a wide variety of information inputs.

5.3.1.3 Sub-Activity 1.3: Analyzing Requests for Clearances

A clearance request is received from either the terminal facility, flight service station, or a pilot (Task 4.1.1). The inactive strip bay is then searched for a strip on the clearance request (Task 1.3.1) and, if the strip is not found, a strip request is put in for the flight (Task 1.3.2). If a controller fails to find a filed flight plan, he will usually obtain data from the pilot (Task 4.4.5) or from the tower or FSS (Task 4.4.6) to complete and enter a flight plan into the system. The "D" controller plays a key role in accomplishing this. A request may also be made for a flight plan readout if more than one strip is necessary (Task 1.3.3).

Within this sub-activity the controller may also receive a Fuel Advisory Departure (FAD) notice (Task 3.1.1). In the case of receiving a FAD notice, the controller will confer with the pilot on the desire for FAD intentions (Task 3.1.3), and then issue clearance and instructions to the pilot (Sub-Activity 4.1.) and update the data base (Task 4.4.10).

See Table 5-3 for a comparative subtask description of terminal and en route controller tasks.

5.3.1.4 Sub-Activity 1.4: Processing Departure Time Information

Sub-Activity 1.4 (see Figure 5-5) includes the tasks for setting the departure time for the flight and thus activating the flight plan. In Task 1.4.1 the controller either observes or receives the departure time. A departure message is then entered into the computer manually (Task 1.4.2). Processing of departure message will generate fix-time calculation, route conversion, and calculation of estimated time of arrival and will cause printing of flight progress strips. At this point the controller is contacted by the aircraft (Task 1.4.3), and the altitude is verified (Task 1.4.4).

The requirement to establish and maintain identification exists for all aircraft that operate under the Air Traffic Control System. The need for a controller to establish this identity arises whenever an aircraft is going

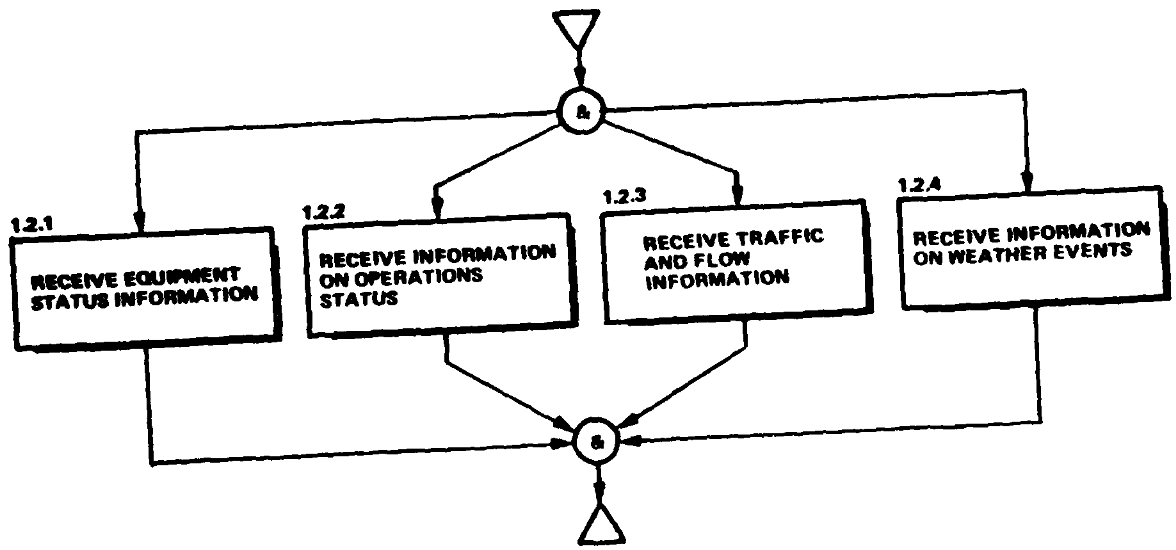


Figure 5-3 Sub-Activity 1.2: Monitoring Unsolicited Communications

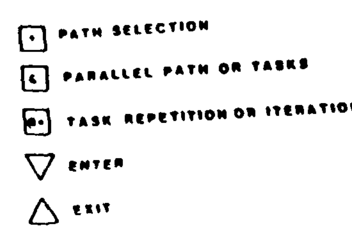


TABLE 5-2. MONITORING UNSOLICITED COMMUNICATIONS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.2.1 Receive equipment status information.	The controller will be informed by his supervisor as to the system status; informed as to a change in a sector/position frequency assignment; and informed by the supervisor as to NAVAID status.	The controller will be informed by his supervisor or by general information strip as to the system status; informed as to a change in a sector/position frequency assignment; and informed by the supervisor as to NAVAID status.
1.2.2 Receive information on operations status.	The controller will be informed by his supervisor on routes; airspace, sector, or position configurations; and route substitutions. The controller must also be aware of other controller workloads and activities (i.e., emergencies, etc.).	The controller will be informed by his supervisor on routes; airspace, sector, or position configurations; and route substitutions. The controller must also be aware of other controller workloads and activities (i.e., emergencies, etc.).
1.2.3 Receive traffic and flow information.	The controller will receive sector flow, flow sequencing, metering, flow constraints, and metering and terminal traffic condition from his supervisor.	The controller will receive information from his supervisor or flow controller on: sector flow; flow sequencing; flow constraints; metering, and terminal traffic conditions.
1.2.4 Receive information on weather events.	The controller will be briefed on weather forecasts, unusual weather, and potential diversion of traffic due to weather.	The controller will be briefed on weather forecasts, unusual weather, and potential diversion of traffic due to weather.

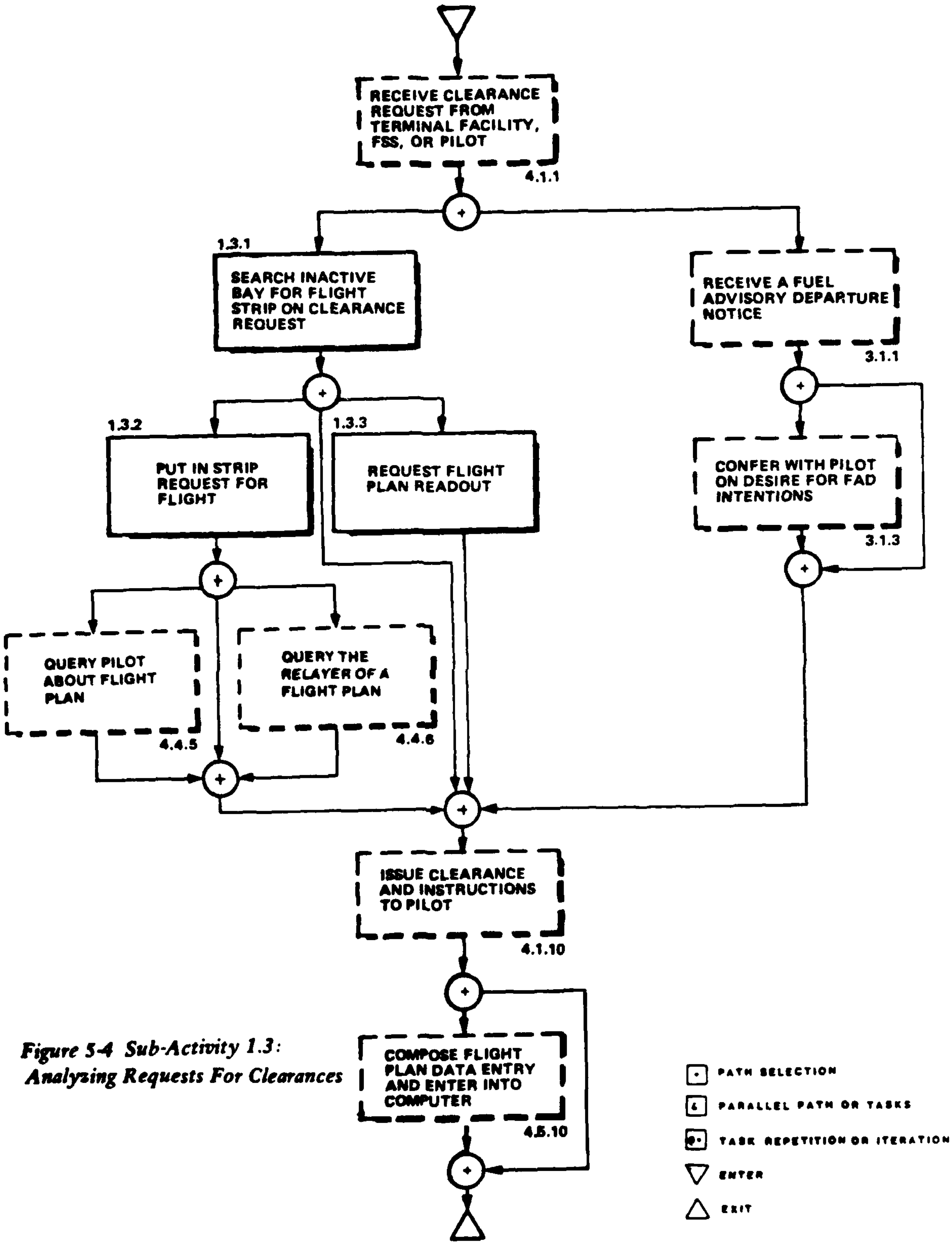


Figure 5-4 Sub-Activity 1.3: Analyzing Requests For Clearances

TABLE 5-3. ANALYZING REQUESTS FOR CLEARANCES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.3.1 Search inactive bay for flight strip on clearance request.	The controller will locate the proposed strip.	The controller will locate the proposed strip by visually searching the inactive bay.
1.3.2 Put in strip request for flight.	If the controller does not find the flight plan strip, he will enter a strip request.	If the controller does not find the flight plan strip, he will enter a strip request.
1.3.3 Request flight plan readout.	If the route portion of the flight plan is not complete and if a full route clearance needs to be issued, the controller will request a full route readout.	If the route portion of the flight plan is not complete and if a full route clearance needs to be issued, the controller will request a full route readout.

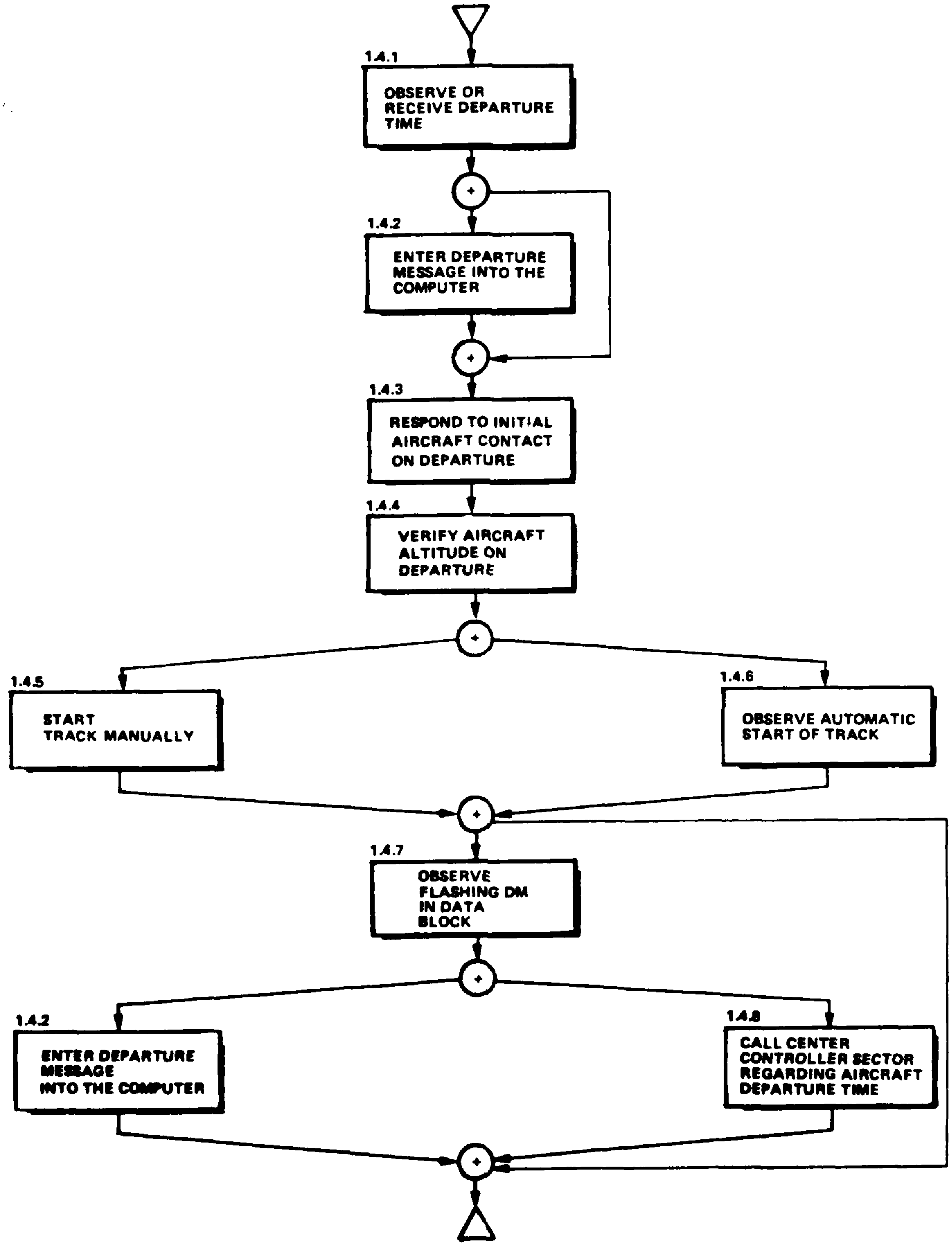


Figure 5-5 Sub-Activity 1.4: Processing Departure Time Information

TABLE 5-4. PROCESSING DEPARTURE TIME INFORMATION

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.4.1 Observe or receive aircraft departure time.	The controller will observe or verbally receive a departure time. He will write the departure time on the strip if it is received verbally.	The controller will observe or verbally receive a departure time. He will write the departure time on the strip if it is received verbally.
1.4.2 Enter Departure Message (DM) into computer.	When there is no ARTS, the controller will enter a DM message into the computer via FDEP. With ARTS, the controller will either enter or request the flight data controller to enter a departure message if the ARTS was not able to forward it.	The controller will enter a DM message at his keyboard.
1.4.3 Respond to initial aircraft contact on departure.	The controller shall respond to the call from a departing aircraft. The controller will note on the strip when he has radar contact.	The controller shall respond to the call from a departing aircraft. The controller will note on the strip when he has radar contact.
1.4.4 Verify aircraft altitude on departure.	The controller receives a continuous Mode C readout from the aircraft or the airport which is observed to be valid when compared to field evaluation. Otherwise, he will verify the altitude with the pilot.	The controller will verbally verify the altitude with the pilot on the initial contact. He will note the aircraft reports reaching or level at the assigned altitude.

TABLE 5-4. PROCESSING DEPARTURE TIME INFORMATION (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.4.5 Start track manually.	The controller will manually start a track on any aircraft that does not automatically start tracking.	The controller will manually start a track on any aircraft that does not automatically start tracking.
1.4.6 Observe automatic start of track.	The controller will visually observe the automatic acquisition of tracks.	The controller will visually observe the automatic acquisition of tracks.
1.4.7 Observe flashing DM in data block.	The controller will observe in the data block if the ARTS was not able to forward the departure message.	N/A
1.4.8 Call center controller sector regarding aircraft departure time.	The controller will verbally forward departure message to center sector on any DM not passed by ARTS or FDEP, and note the action on the flight strip.	The controller will write the departure time on the strip and enter the departure message into the computer at his keyboard.

to be under his control jurisdiction, whether as a handoff from an adjacent controller/facility or a pickup of an *airfile aircraft*. The identification process is repeated for every aircraft under control and has a direct bearing on flight safety and the orderly flow of traffic. If the aircraft has no transponder, or it is non-operational, the controller then requires the aircraft pilot to assist in the identification process by reporting his position over a fix (geographic positioning) or his DME reading from a particular NAVAID. The controller may also elect to identify the aircraft by requesting heading changes of 30 degrees or more while monitoring the primary return. If the target on the scope changes direction in accordance with the issued heading changes, the controller is assured of the target's identity. Under Radar Data Processing the manual controller helps ensure the data block data remain in correlation with the appropriate target by seeing that the correct Mode 3/A codes are inserted in the computer to assist the automatic program functions.

Altitude tracks for Mode C-equipped aircraft are initiated and maintained using validated altitude reports after they have been pressure-corrected. The altitude accompanying the correlated beacon report is used to smooth the altitude position and rate, and to calculate its predicted altitude position.

For aircraft not equipped with Mode C, an altitude profile is based upon flight plan or controller assigned altitude, pilot-reported altitude, and climb and descent rates determined by aircraft characteristics.

The current altitude and altitude rate are computed each tracking cycle and are necessary inputs to both the Conflict Alert and En Route Minimum Safe Altitude Warning (E-MSAW) functions.

Without benefit of discrete, or 4,096, *beacon code* data, the initiation of tracks and their identification (Task 1.4.5) must be accomplished by the controller. Once initiated, a track may be maintained through a radar/track correlation process, or the controller may observe the automatic start of track (Task 1.4.6). If, however, a flashing "DM" appears, the *message was not* sent to the center (Task 1.4.7). Then the controller will enter the departure message using FDEP (Task 1.4.2), or call the center controller sector (Task 1.4.8), who will enter the departure message directly.

Beacon codes are automatically assigned by the Center Central Computer Complex. The assignment of beacon codes is made in accordance with a beacon code allocation plan as provided in the FAA Order 7110.66, National Beacon Code Allocation Plan.

A capability will be provided to automatically assign discrete beacon codes to all appropriately equipped (Mode 3/A transponder) aircraft that do not already have an assigned code in the flight plan data. If the available pool of discrete codes for the flight's category is exhausted, the non-discrete codes basic to the subset will be assigned. *However, subsequent* amendment events to the flight plan will cause a check of available discrete codes for potential reassignment of a discrete code. Discrete codes will be returned to the available code pool, and thus be eligible for reassignment, when certain predefined flight plan events occur, e.g., dropping of the flight plan.

Air carriers, military aircraft, and other civil aircraft flying IFR within the ATC System are routinely required to squawk specific Mode 3/A codes in accordance with prescribed FAA procedures. Table 5-4 provides a comparative subtask description of terminal and en route controller tasks.

5.3.1.5 Sub-Activity 1.5: Processing Requests for Flight Following

See Figure 5-6. When a request for flight following is received (Task 1.5.1), the controller will assign a beacon code to the VFR pilot (Task 1.5.2), if flight following service is to be granted. Then, a track is started (Tasks 1.4.5 or 1.4.6). The controller may enter the data into the computer (Task 4.4.7). The controller will deny a request for flight following due to workload or if the radar is out of service (*Task* 1.5.3). See Table 5-5 for a comparative subtask description of terminal and en route operations tasks.

5.3.1.6 Sub-Activity 1.6: Housekeeping

See Figure 5-7. Two major *housekeeping tasks are to* check TAB List against flight strips for completeness/receipt of flight strips (Task 1.6.2), and to review TAB List/data block for old data to drop (Task 1.6.5). After checking the TAB List the controller may either request that flight strips be produced from the data base (Task 1.6.3), or request an ARTS message be forwarded on the TAB List (Task 1.6.4). The result of reviewing the TAB List/data block for old data may be either to reposition a data block (Task 1.6.1), drop the data block for *an active track* (Task 1.6.6), or drop an inactive track from the TAB List (Task 1.6.7). The controller must also review the flight strips to ensure that all data are passed to the next controller when appropriate (Task 1.6.8), update the date base (Task 4.5.10) which may include removing non-pertinent data from flight strips, review inactive or proposed flight plan bay for deadwood (that is, strips no longer active for the sector/position) (Task 1.6.9), and review active flight plan bays for flights which are past transfer or control points (Task 1.6.12). As a result of these review tasks the controller will cancel flight data in the data base (Task 1.6.10), then remove flight strips from the *holders (Task* 1.6.11).

The remaining tasks the controller does as a matter of course to remain prepared. He will check the clock setting for accuracy (Task 1.6.13),

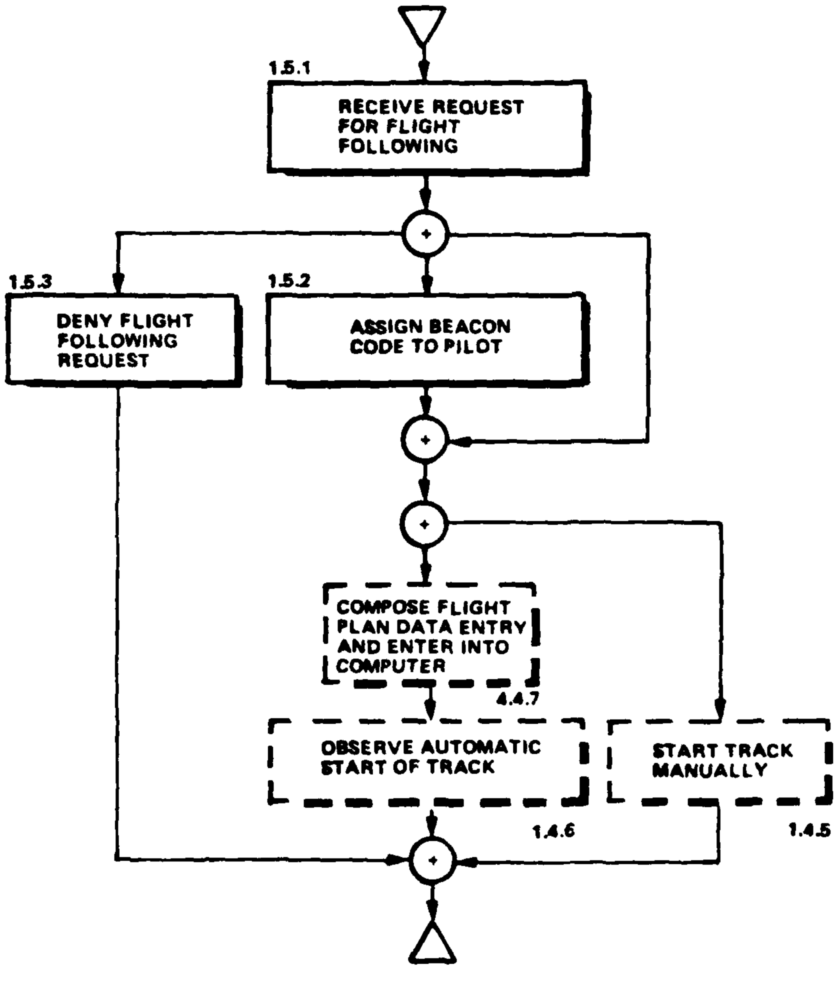


Figure 5-6 Sub-Activity 1.5: Processing Requests For Flight Following

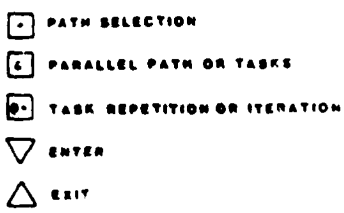


TABLE 5-5. PROCESSING REQUESTS FOR FLIGHT FOLLOWING

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.5.1 Receive request for flight following.	The controller will verbally receive a request for flight following from a pilot or previous controller/facility.	The controller will verbally receive a request for flight following from a pilot or previous controller/facility.
1.5.2 Assign beacon code to pilot.	The controller will enter a beacon code request message and issue the code to the pilot, when necessary, implying acceptance of the pilot's request.	The controller will enter a beacon code request message and issue the code to the pilot.
1.5.3 Deny flight following request.	The controller will deny flight following service due to workload or radar out of service.	The controller will deny flight following service due to workload or radar out of service.

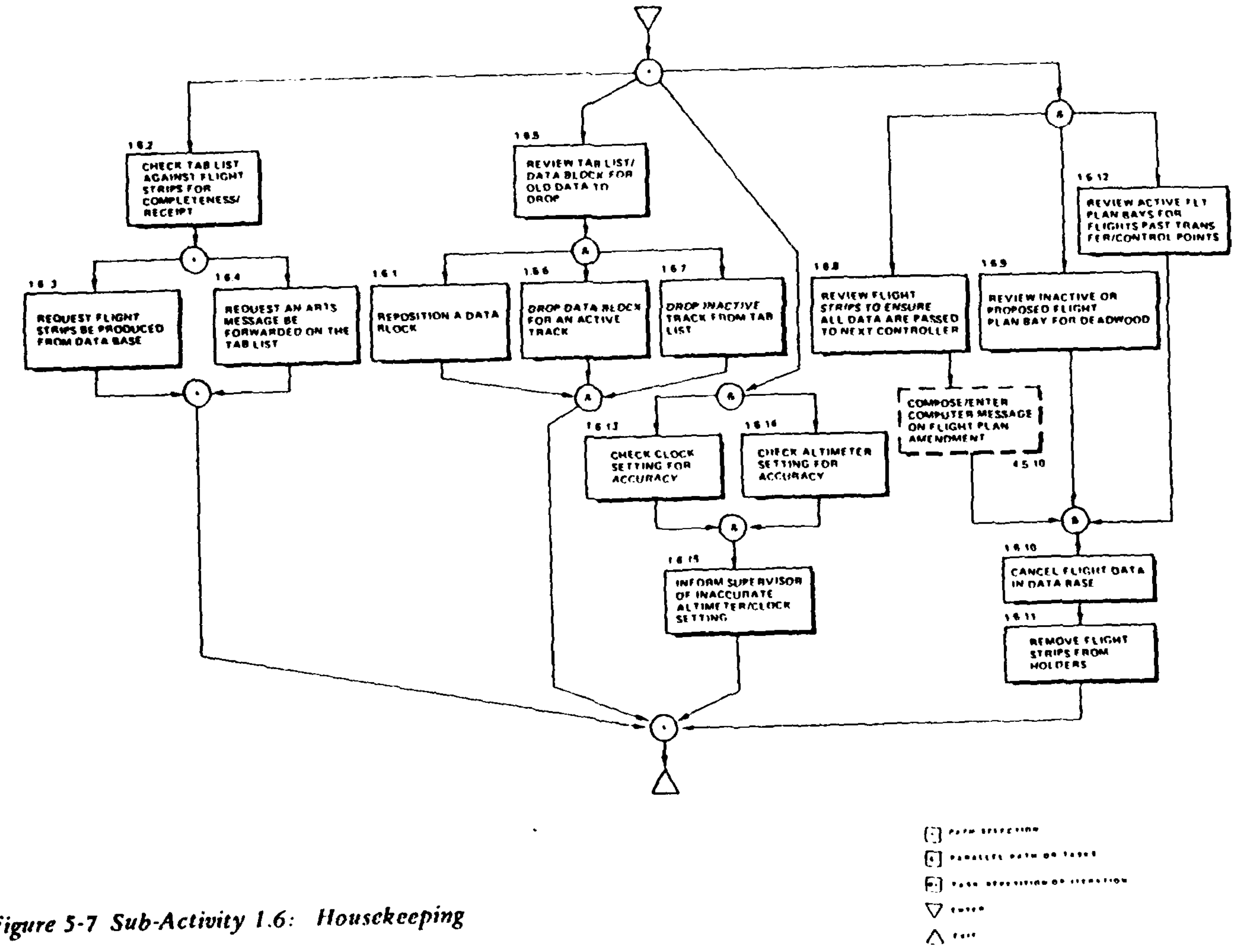


Figure 5-7 Sub-Activity 1.6: Housekeeping

TABLE 5-6. HOUSEKEEPING

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.6.1 Reposition a data block.	The controller repositions any data blocks not associated with the appropriate target by entering the reposition message, slewing to the old position, and slewing to the new position.	The controller repositions any data block not associated with the appropriate target by a track message identifying the aircraft, and moving the trackball to the current target position.
1.6.2 Check tabular list against flight strip for completeness/receipt of flight strips.	The controller visually compares the tabular list against the flight progress strip to determine if all data are available. The controller will enter a display message to determine the time and fix for the aircraft.	The controller visually compares the tabular list against the flight progress strip to determine if all data are available.
1.6.3 Request flight strips be produced from data base.	The controller enters a strip request for a flight entering his area without a strip.	The controller enters a strip request for a flight when the computer has not produced the strip.
1.6.4 Request an ARTS message be forwarded on the TAB List.	The controller enters a "Force to ARTS" message from information contained on the flight progress strip.	The controller enters a "Force to ARTS" message from information contained on the flight progress strip.

TABLE 5-6. HOUSEKEEPING (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.6.5 Review TAB List/data block for old data to drop.	The controller periodically reviews the tabular list and enters a track drop message on any old flight data.	N/A
1.6.6 Drop data block for an active track.	The controller enters a track drop message on aircraft that are no longer a factor. This includes tracks in the coast/suspend list.	The controller enters a track drop message on aircraft that are no longer a factor.
1.6.7 Drop inactive track from TAB List.	The controller enters a drop track message to delete flight plans from the tabular list.	N/A
1.6.8 Review flight strips to insure all data are passed to next controller.	The controller periodically reviews flight progress strips and strip marking to insure all amended data have been passed to the next controller/facility. He insures all data are properly noted.	The controller periodically reviews flight progress strips and strip marking to insure all amended data have been forwarded to the next controller/facility. He insures all forwarded data are properly noted.
1.6.9 Review inactive or proposed flight plan bay for deadwood.	The controller visually compares the proposed time against the current time.	The controller visually compares the proposed time against the current time.

TABLE 5-6. HOUSEKEEPING (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
1.6.10 Cancel flight data in data base.	The controller inputs a remove strip message.	The controller inputs a remove strip message.
1.6.11 Remove flight strips from holders.	The controller removes old flight strips from the holder.	The controller removes old flight strips from the holder.
1.6.12 Review active flight plan bays for flights past transfer control points.	The controller will visually compare active flight fix time or transfer of control time to determine if he is through with the flight, or perhaps the flight is overdue at a fix.	The controller will visually compare active flight fix time or transfer of control time to determine if he is through with the flight, or perhaps the flight is overdue at a fix.
1.6.13 Check clock setting for accuracy.	After normal startup of the computer the controller will insure the time is correct.	After normal startup of the computer the controller will insure the time is correct.
1.6.14 Check altimeter setting for accuracy.	The controller periodically checks the altimeter setting for accuracy. If inaccurate, the controller enters a system message with the correct altimeter setting.	The controller periodically checks the altimeter setting for accuracy. If inaccurate, the controller enters a system message with the correct altimeter setting.
1.6.15 Inform supervisor of inaccurate altimeter or clock setting.	The controller will notify the supervisor of inaccurate altimeter or clock settings.	The controller will notify the supervisor of inaccurate altimeter or clock settings.

check the altimeter setting for accuracy (Task 1.6.14), and inform the supervisor if there is an inaccurate altimeter or clock setting (Task 1.6.15). See Table 5-6 for a comparative subtask description of terminal and en route controller tasks.

5.3.2 Activity 2: Resolve Aircraft Conflicts

5.3.2.1 Sub-Activity 2.1 Performing Conflict Resolution

See Figure 5-8. A controller may either receive a conflict alert notice from an adjacent controller (Task 2.1.1), detect a conflict alert indicator (Task 2.1.2), or determine himself whether adequate separation will exist (Task 1.1.5).

During each tracking computation cycle all pairs of tracks in the system are examined to determine if the aircraft will violate separation requirements represented by internally stored parameters. When a pair of aircraft are determined to be in conflict, the full data blocks associated with the tracks are blinked and the pair is identified in a tabular list, and you get an aural alarm in the terminal environment. Display of alerts for aircraft below adapted sector floors is inhibited. The en route controller can specifiy a group of aircraft so as to inhibit display of conflicts which may occur among them.

Regardless of how a conflict alert is detected, the controller will attempt to determine the validity of the notice or indicator before proceeding (Task 2.1.3).

If appropriate, he will inform the adjacent controller of a conflict alert in his sector/position (Task 2.1.4). If the indicator or notice was valid and the conflict occurs in his own sector, he will formulate a clearance with appropriate restrictions (Task 4.1.7) and possibly request the temporary release of special use airspace or area (Task 3.7.5). He will then issue a clearance and instructions to the pilot (Task 4.1.10), which may be an interim altitude, and update the data base (Task 4.5.10). If coordination is necessary, the controller will then inform the adjacent controller of the course of action (Task 2.1.5) or detect the maneuver, to monitor the resolution of the situation (Task 2.1.6). See Table 5-7 for a comparative subtask description of terminal and en route controller tasks.

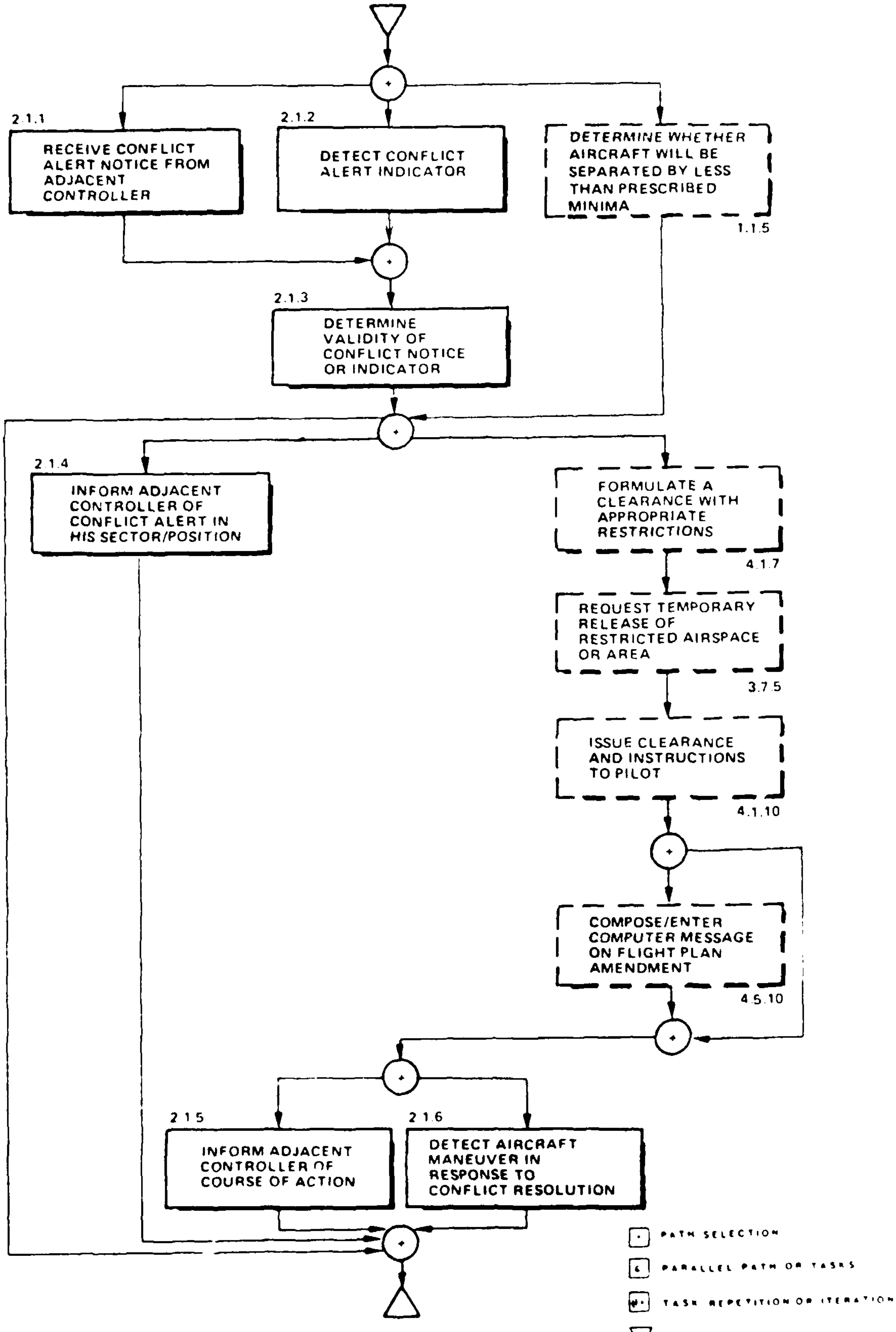


Figure 5-8 Sub-Activity 2.1 Performing Conflict Resolution

TABLE 5-7. PERFORMING CONFLICT RESOLUTION

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.1.1 Receive conflict alert notice from adjacent controller.	The controller acknowledges the message.	The controller acknowledges the message.
2.1.2 Detect conflict alert indicator.	The controller hears an aural alarm and observes the display to determine which aircraft are in conflict.	The controller observes the display to determine which aircraft are in conflict.
2.1.3 Determine validity of conflict notice or indicator.	The controller determines if less than prescribed separation exists.	The controller determines if less than prescribed separation exists.
2.1.4 Inform adjacent controller of conflict alert in his sector/position.	The controller informs the adjacent controller of an alert which is detected at the originator's sector/position.	The controller informs the adjacent controller of an alert which is detected at the originator's sector/position.
2.1.5 Inform adjacent controller of course of action.	If the clearance issued will immediately impact the adjacent controller, he advises the controller of the course or altitude change.	If the clearance issued will immediately impact the adjacent controller, he advises the controller of the course or altitude change.
2.1.6 Detect aircraft maneuver in response to conflict resolution.	The controller observes the display or listens for a pilot report concerning the position of an aircraft.	The controller observes the display or listens for a pilot report concerning the position of an aircraft.

5.3.2.2 Sub-Activity 2.2: Performing MSAW Processing

See Figure 5-9. The controller may either receive an MSAW notice from an adjacent controller or facility (Task 2.2.1), detect an MSAW indicator (Task 2.2.2), or determine himself that separation will exist (Task 1.1.5).

The three-dimensional position of each eligible track is computed to determine if an aircraft will penetrate a volume of airspace defined by a minimum sector altitude.

At the en route sector, a graphic display is generated identifying the point of violation and the altitude violated. If an aircraft violates the minimum altitude of a volume of airspace to which its destination airport is adapted, no alert is displayed.

Regardless of how the situation is perceived or detected, the controller will attempt to determine the validity of the message (Task 2.2.3). If it is ascertained that the situation is valid, the controller will formulate a clearance with appropriate restrictions (Task 4.1.7). He will then either determine whether the aircraft in the vicinity will permit a climb or turn (Task 2.2.4), or request the temporary release of an adjacent airspace or area (Task 3.7.5), if necessary. The controller will inform the adjacent controller or facility of a change which might necessitate a delay or changes in route (Task 4.1.6). After issuing a clearance and instructions to the pilot (Task 4.1.10) and update the data base (Task 4.5.10), the controller will then notify the supervisor of a valid MSAW alert or flight assist, if appropriate (Task 2.2.5), or detect the maneuver to monitor the resolution of the situation (Task 2.2.6). See Table 5-8 for a comparative subtask description of terminal and en route controller tasks.

5.3.2.3 Sub-Activity 2.3: Performing Airspace Conflict Processing

See Figure 5-10. The controller may perceive or recognize on his display that an aircraft is approaching the limits of its airspace (Task 2.3.1). He will then calculate the aircraft's path with respect to the special use airspace (Task 2.3.2). He may then either request the temporary use of the airspace (Task 3.7.5), or formulate a clearance with appropriate restrictions (Task 4.1.7), or simply issue an advisory regarding the airspace (Sub-Activity 2.4) See Table 5-9 for a comparative subtask description of terminal and en route controller tasks.

5.3.2.4 Sub-Activity 2.4: Issuing Traffic Advisories (Cautionary Separation)

See Figure 5-11. During the checking and evaluating of separation (Sub-Activity 1.1), the controller may observe that aircraft separation is not likely to meet required standards (Task 2.4.1). He will then issue a clearance or traffic advisory to the aircraft in regard to the air traffic deviations (Task

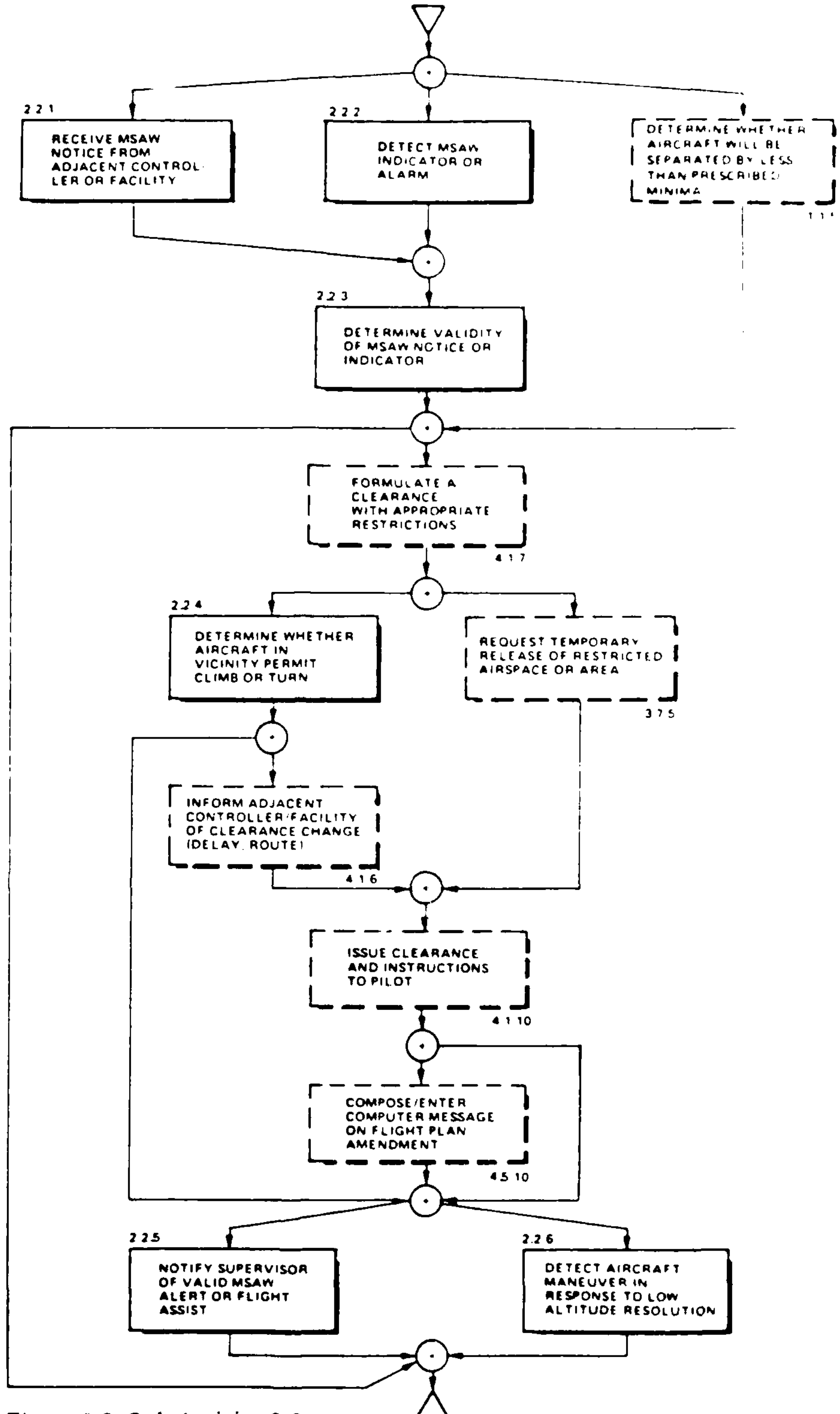


Figure 5-9 Sub-Activity 2.2: Performing MSAW Processing

TABLE 5-8. PERFORMING MSAW PROCESSING

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.2.1 Receive MSAW notice from adjacent controller or facility.	The controller receives a notice of a low altitude alert from an adjacent controller or facility. The controller will observe the display to detect which aircraft is causing the alarm.	The controller receives a notice of a low altitude alert from an adjacent controller or facility. The controller then observes the display to detect which aircraft is causing the alarm.
2.2.2 Detect MSAW indicator or alarm.	The controller will hear an aural alarm and see a visual alarm on the display. The controller will observe the display to detect which aircraft is causing the alarm.	The controller will observe the display to determine which aircraft is too low.
2.2.3 Determine validity of MSAW notice or indicator.	After comparing the altitude as described above, the controller will determine if the alert is valid.	After comparing the altitude as described above, the controller will determine if the alert is valid.
2.2.4 Determine whether aircraft in vicinity permit climb or turn.	Before issuing the clearance, the controller will insure that another aircraft is not in conflict with this aircraft.	Before issuing the clearance, the controller will insure that another aircraft is not in conflict with this aircraft.
2.2.5 Notify supervisor of valid MSAW alert or flight assist.	The controller will notify the area supervisor of a flight assist, if appropriate.	The controller will notify the area supervisor of a flight assist, if appropriate.

TABLE 5-8. PERFORMING MSAW PROCESSING (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.2.6 Detect aircraft maneuver in response to low altitude resolution.	After a clearance is issued the controller will observe the aircraft to insure clearing the terrain or obstacle.	After a clearance is issued the controller will observe the aircraft to insure clearing the terrain or obstacle.

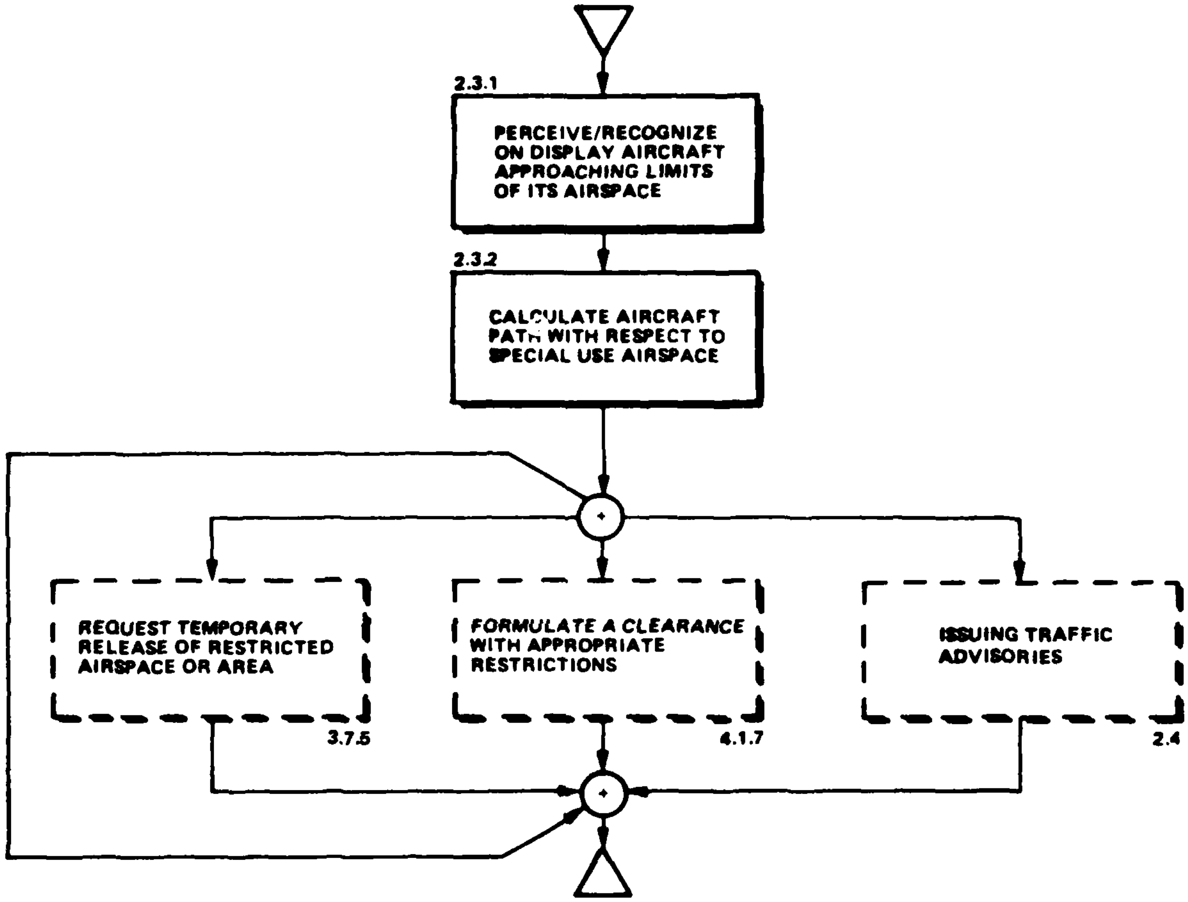


Figure 5-10 Sub-Activity 2.3: Performing Airspace Conflict Resolution

- PATH SELECTION
- PARALLEL PATH OR TASKS
- TASK REPETITION OR ITERATION
- ENTER
- EXIT

TABLE 5-9. PERFORMING AIRSPACE CONFLICT PROCESSING

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.3.1 Perceive/recognize on display aircraft approaching limits of its airspace.	The controller observes the target and its relationship to a boundary line on the display or an imaginary line from memory.	The controller observes the target and its relationship to a boundary line on the display or an imaginary line from memory.
2.3.2 Calculate aircraft's path with respect to special use airspace.	The controller projects the aircraft's course to determine if the aircraft will penetrate the airspace.	The controller projects the aircraft's course to determine if the aircraft will penetrate the airspace. In addition, the controller may extend the vector line on the PVD between the target and the airspace to see if the vector line intercepts the airspace.

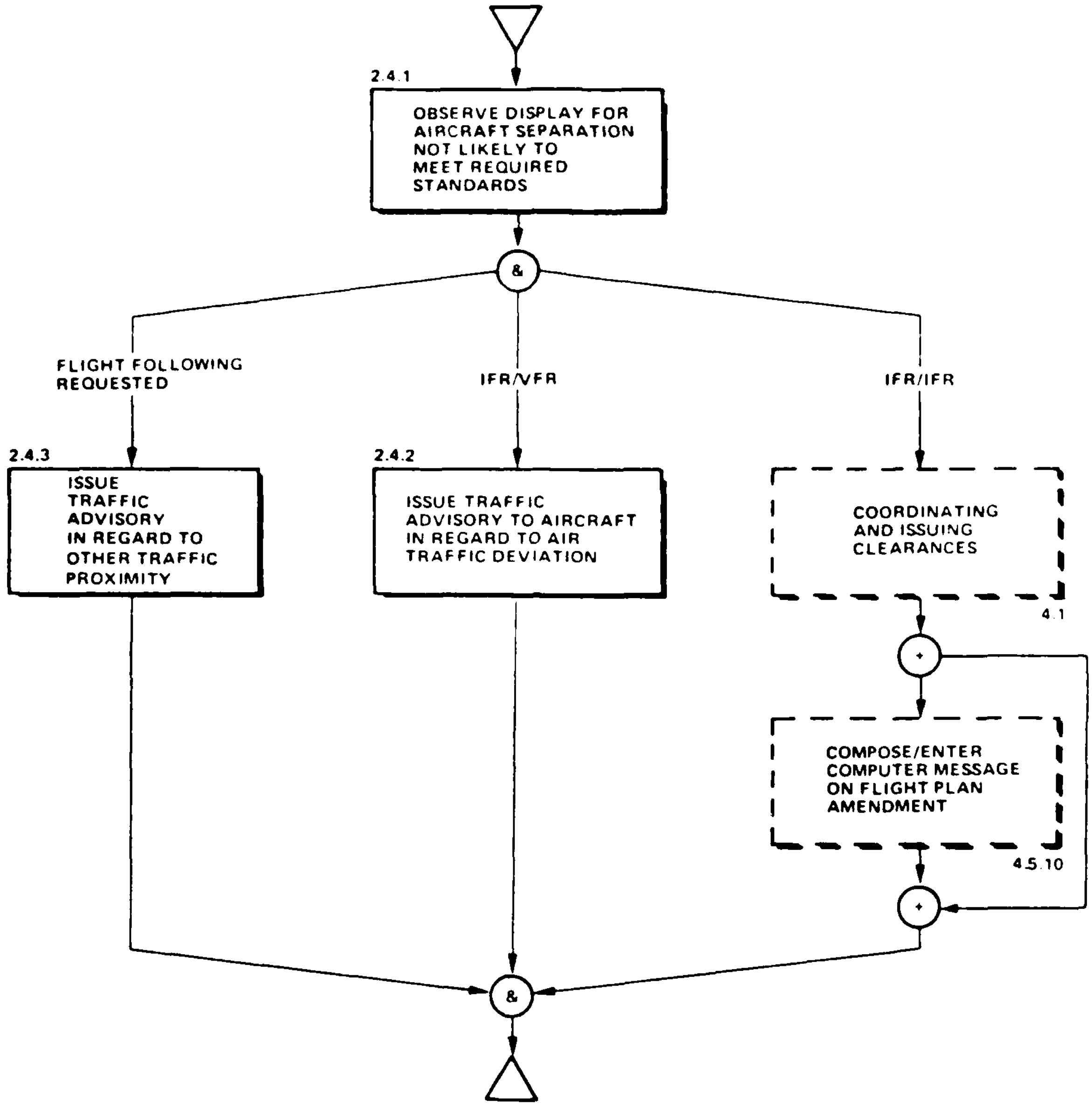


Figure 5-11 Sub-Activity 2.4: Issuing Traffic Advisories (Cautionary Separation)

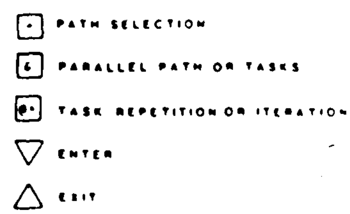


TABLE 5-10. ISSUING TRAFFIC ADVISORIES (CAUTIONARY SEPARATION)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.4.1 Observe display for aircraft separation not likely to meet required standards.	The controller monitors display to determine if an aircraft will be a potential conflict to another aircraft or if an aircraft is deviating from route or altitude assignment.	The controller monitors display to determine if an aircraft will be a potential conflict to another aircraft or if an aircraft is deviating from route or altitude assignment.
2.4.2 Issue traffic advisory to aircraft in regard to air traffic deviation.	The controller issues a cautionary advisory to the pilot and tells the pilot where he is in relation to where he should be.	The controller issues a cautionary advisory to the pilot and tells the pilot where he is in relation to where he should be.
2.4.3 Issue traffic advisory in regard to other traffic proximity.	If flight following has been requested, the controller issues traffic to the pilot by clock position, distance, direction, relative speed, and altitude if known. If Mode C altitude has not been verified on the traffic, the controller specifies unverified altitude. The controller issues a VFR traffic advisory to aircraft which will be in close proximity. In addition, the controller will issue traffic advisory messages to IFR aircraft, unless they are separated by more than the minimum vertical separation.	If flight following has been requested, the controller issues traffic to the pilot by clock position, distance, direction, relative speed, and altitude if known. If Mode C altitude has not been verified on the traffic, the controller will specify unverified altitude. The controller issues a VFR traffic advisory to aircraft which will be in close proximity. In addition, the controller will issue traffic advisory messages to IFR aircraft, unless they are separated by more than the minimum vertical separation.

2.4.2), or in the case of a flight following, issue traffic advisories (Task 2.4.3). Again, the process is closed with clearance tasks (Sub-Activity 4.1) and updating of the data base (Task 4.5.10). See Table 5-10 for a comparative subtask description of terminal and en route controller tasks.

5.3.2.5 Sub-Activity Inhibiting Alerts

See Figure 5-12. There may be instances when the controller will wish to inhibit the conflict alert indicator. He may, for example, inhibit it for paired or group suppression (Task 2.5.1), for refueling operations (Task 2.5.2), or for an air show (Task 2.5.2). The MSAW alert may be inhibited (Task 2.5.4) to preclude an invalid alert. See Table 5-11 for a comparative subtask description of terminal and en route controller tasks.

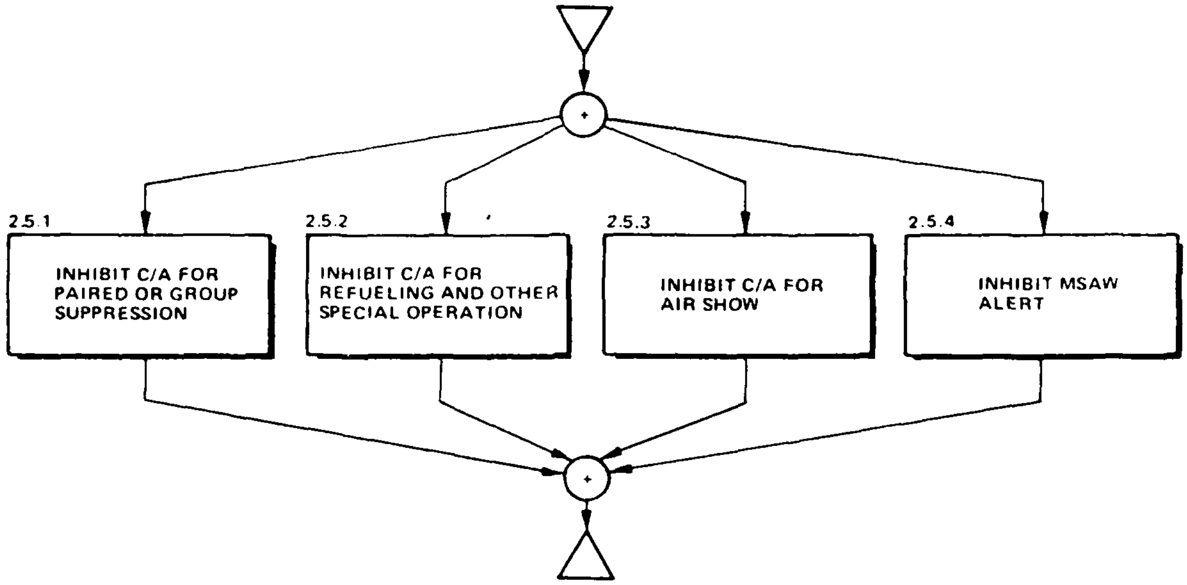


Figure 5-12 Sub-Activity 2.5: Inhibiting Alerts

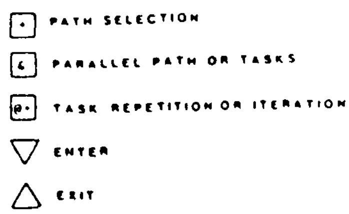


TABLE 5-11. INHIBITING ALERTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
2.5.1 Inhibit conflict alert for paired or group suppression.	Controller enters pair suppression message when he observes a situation that would cause an alert notice, but knows that the situation is OK (as when 2 aircraft are climbing, but to different altitudes).	Controller enters pair/group suppression message. System provides acceptance and inhibits conflict alert on aircraft type specified in message entry.
2.5.2 Inhibit conflict alert for refueling and other special operations.	Controller enters inhibit track pair and track identification. The system provides acceptance and inhibits conflict alert on specified pair.	Controller enters suppress conflict alert pair message. The system provides acceptance and inhibits conflict alert on specified pair.
2.5.3 Inhibit conflict alert for air show.	Controller inhibits conflict alert processing by depressing a function key, and entering track identification on the keyboard. The system provides acceptance and turns Conflict Alert off.	N/A
2.5.4 Inhibit MSAW alert.	The controller may inhibit the MSAW alarm by depressing the appropriate function key and track identification.	The controller may inhibit the MSAW alarm by depressing the appropriate function key and track identification.

5.3.3 Activity 3: Manage Air Traffic Sequences

5.3.3.1 Sub-Activity 3.1: Responding to Flow Constraints

See Figure 5-13. Situations occasionally occur within a sector that cannot be resolved through application of normal control procedures, by sector manning changes, or by temporary help from the Coordinator. When this occurs the Coordinator may elect to apply flow control procedures to slow down the rate and numbers of aircraft flowing into and through the sector under consideration. Although this procedure may reduce traffic flow, Coordinators apply flow control procedures because in their judgment this is preferable to the other available alternatives.

For example, a controller may receive a Fuel Advisory Departure (FAD) notice (Task 3.1.1), or receive a flow restriction (Task 3.1.2). If he does receive a FAD, he will then confer with the pilot concerning his FAD intentions (i.e., Task 3.1.3) before proceeding.

In selecting a new sequence, the controller will evaluate its effect upon the flow (Task 3.1.8).

Flow control is a function which uses the system's flight plan data base, enhanced by long-lead-time flight plans received at the Central Flow Control Facility.

The Flow Control position has the capability to retrieve selected information contained in the flight plan data base and the capability to sort the information according to key terms such as sectors, fixes and terminal areas.

The function provides the capability of supplying advance and current flow-control flight-plan data to the local flow control position and to Central Flow Control Facility.

That is, the controller will either choose the desired sequence (Task 3.1.4), or select a new flow or sequence (Task 3.1.5). Then he will determine the technique he will use for the delay (Task 3.1.6), perhaps employing preplanned constraints available in letters of agreement that include altitudes, crossing restrictions, or automatic releases. When he does determine the technique he will use, he also negotiates the speed reduction or hold with the pilot (Task 3.1.7).

The Local Flow Controller coordinates and implements flow control services whenever it best serves the ATC System and its users, and disseminates pertinent weather information to all ATC personnel. The Local Flow Controller analyzes the general flow of traffic in his center, weather data, and available system status information. He recommends changes in traffic patterns to reduce traffic congestion to the Area Manager. After approval, he issues restrictions and route changes to implement his recommendations. He also remains informed of all events that cause restrictions or changes in the normal flow of traffic and issues communiques to the appropriate users and other ATC personnel.

Appropriate clearances and instructions are issued to the pilot (Sub-Activity 4.1) followed by updating the data base (Task 4.5.10). See Table 5-12 for a comparative description of terminal and en route controller tasks.

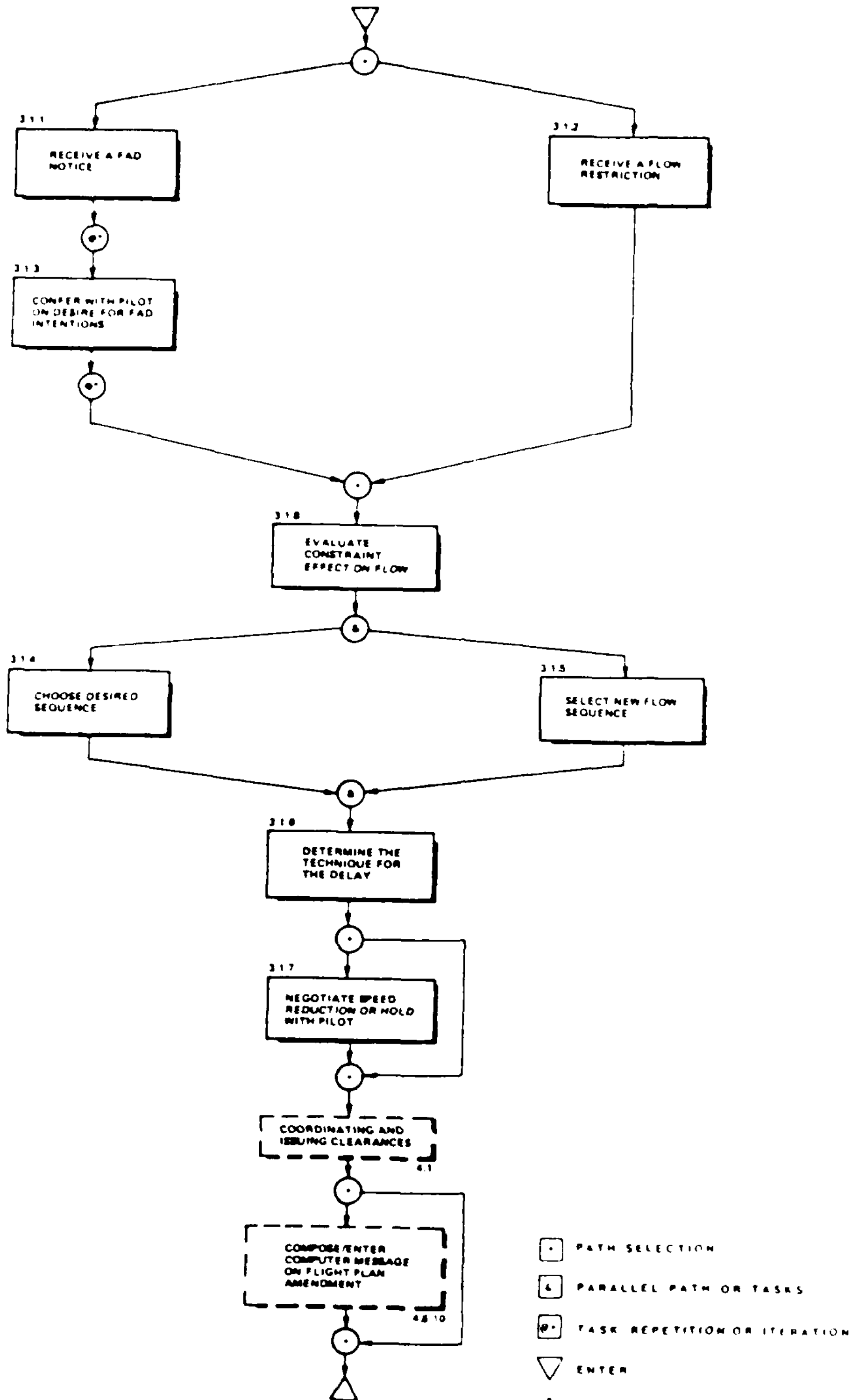


Figure 5-13 Sub-Activity 3.1: Responding To Flow Constraints

TABLE 5-12. RESPONDING TO FLOW CONSTRAINTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.1.1 Receive a Fuel Advisory Departure (FAD) notice.	The controller receives notification from his supervisor on FAD.	The controller receives notification from his supervisor on FAD.
3.1.2 Receive a flow restriction.	The controller receives notification from an adjacent controller/facility, supervisor, or coordinator.	The controller receives notification from an adjacent controller/facility, supervisor, or flow controller.
3.1.3 Confer with pilot on desire for FAD intentions.	The controller confers with the pilot as to ground or airborne delay.	The controller confers with the pilot or the tower controller as to ground or airborne delay.
3.1.4 Choose desired sequence.	The controller mentally determines the desired sequence of aircraft, considering aircraft characteristics, weather, etc.	The controller mentally determines the desired sequence of aircraft, considering aircraft characteristics, weather, etc.
3.1.5 Select new flow/sequence.	If aircraft deviations or a failure to establish the desired sequence is not successful, the controller mentally establishs a new sequence.	If aircraft deviations or a failure to establish the desired sequence is not successful, the controller mentally establishs a new sequence.

TABLE 5-12. RESPONDING TO FLOW CONSTRAINTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.1.6 Determine the technique for accomplishing a delay.	The controller mentally determines whether to hold an aircraft, reduce its speed, or vector the aircraft to effect the delay.	The controller mentally determines whether to hold an aircraft, reduce its speed, or vector the aircraft to effect the delay.
3.1.7 Negotiate speed reduction or hold with pilot.	The controller may confer with the pilot to obtain the delay by either speed reduction or holding.	The controller may confer with the pilot to obtain the delay by either speed reduction or holding.
3.1.8 Evaluate constraint effect on flow.	The controller maintains a constant evaluation on the current flow to insure it meets the flow restrictions.	The controller maintains a constant evaluation on the current flow to insure it meets the flow restrictions.

5.3.3.2 <u>Sub-Activity 3.2: Processing Air Traffic Deviations (Observed or Requested)</u>

See Figure 5-14. A controller may either perceive a deviation (Task 3.2.1) or determine whether adequate separation will exist between aircraft pair/obstacle. Otherwise, he may receive a deviation notice (Task 3.2.2) or a deviation request from a pilot (Task 3.2.3). In any case, the controller will then identify the transition from the old to the new sequence (Task 3.2.4) and then determine the maneuver needed (Task 3.2.5). This would be followed by tasks to issue a clearance (Sub-Activity 4.1) and update the data base (Task 4.5.10). See Table 5-13 for a comparative subtask description of terminal and en route controller tasks.

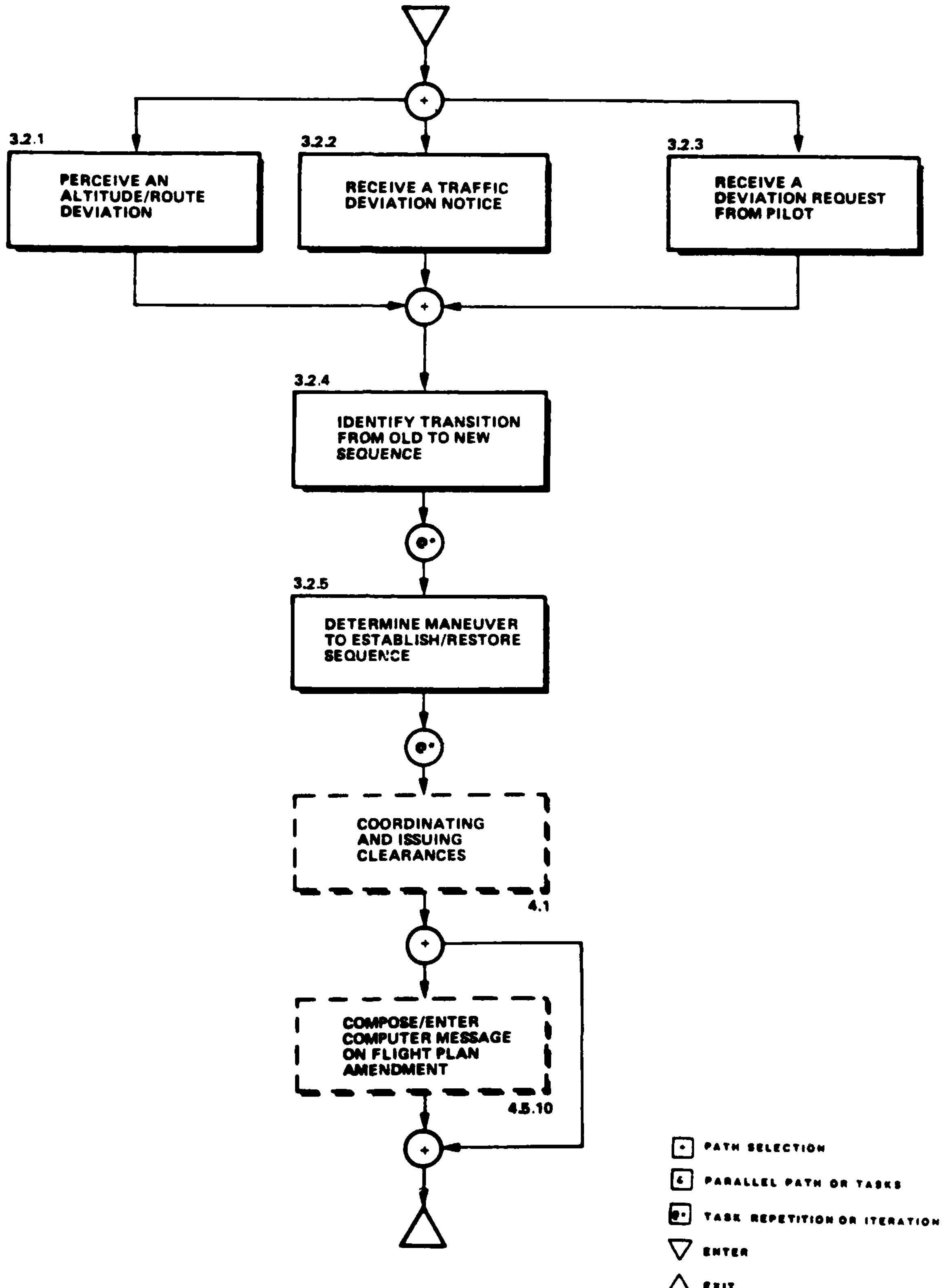


Figure 5-14 Sub-Activity 3.2: Processing Air Traffic Deviations

TABLE 5-13. PROCESSING AIR TRAFFIC DEVIATIONS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.2.1 Perceive an altitude or route deviation.	The controller observes that the flight path of an aircraft will take the aircraft into severe weather or a safety hazard. The controller observes on the display that an aircraft is not on the intended course, or that the altitude is not in conformance with the assigned altitude, or that the altitude field of the data block contains "X".	The controller observes that the flight path of an aircraft will take the aircraft into severe weather or a safety hazard. The controller observes on the display that an aircraft is not on the intended course, or that the altitude is not in conformance with the assigned altitude, or that the altitude field of the data block contains "X". In addition, the data block will indicate free tracking symbology in lieu of flat tracking. If the altitude is not in conformance, the symbol "C" will not be displayed in the data block.
3.2.2 Receive a traffic deviation notice.	The controller verbally receives deviation notice from previous controller, and writes the deviation on the flight progress strip.	The controller verbally receives deviation notice from previous controller and writes the deviation on the flight progress strip. "D" controller will verbally alert "R" controller (or vice versa) if necessary.
3.2.3 Receive a deviation request from pilot.	The controller receives the request from the pilot or previous controller.	The controller receives the request from the pilot or previous controller.

TABLE 5-13. PROCESSING AIR TRAFFIC DEVIATIONS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.2.4 Identify transition from old to new sequence.	If the deviation has taken the aircraft out of a planned sequence, the controller mentally identifies a new position in the sequence for the aircraft.	If the deviation has taken the aircraft out of a planned sequence, the controller mentally identifies a new position in the sequence for the aircraft.
3.2.5 Determine maneuver to establish/restore sequence.	The controller, after contacting the pilot to determine the reason for the deviation, determines whether to clear the aircraft to a new route or altitude or to the old route/altitude.	The controller, after contacting the pilot to determine the reason for the deviation, determines whether to clear the aircraft to a new route or altitude or to the old route/altitude.

5.3.3 3 Sub-Activity 3.3: Maintaining Departure Pattern

See Figure 5-15. In maintaining the departure pattern, the controller will simultaneously project the aircraft's position in a departure sequence(Task 3.3.1), and plan his control actions to permit departing aircraft to climb to a specific altitude safely (Task 3.3.2). Then, the controller will issue a clearance and instructions to the pilot (Sub-Activity 4.1) to establish the aircraft on the flight plan route. The data base would then be updated (Task 4.5.10). See Table 5-14 for a comparative subtask description of terminal and en route controller tasks.

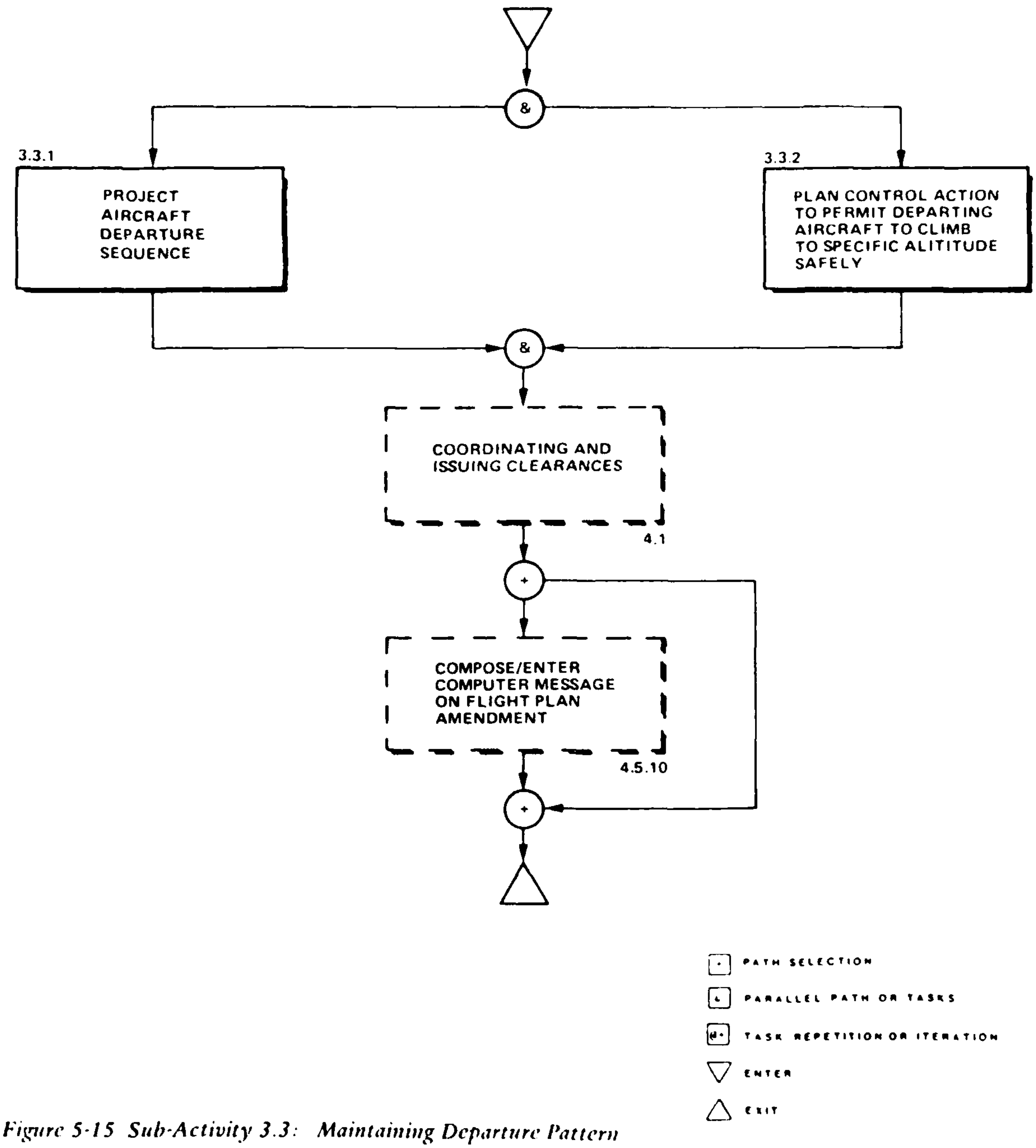


Figure 5-15 Sub-Activity 3.3: Maintaining Departure Pattern

TABLE 5-14. MAINTAINING DEPARTURE PATTERN

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.3.1 Project aircraft departure sequence.	The ground controller establishs a departure sequence in taxiing aircraft to the active runway. The local controller clears departing aircraft for takeoff, insuring that subsequent departures are initially separated. The departure controller is notified of the departing aircraft. He also insures the ARTS forwards a departure message automatically by the absence of a flashing "DM".	Upon receipt of the departure time, the controller mentally prepares a departure sequence for the aircraft, considering planned climb/rate. Based upon the type aircraft, route, etc., the controller will determine if coordination with other sectors is required for the anticipated climb. If the controller receives a verbal DM, he enters the DM into the system. Otherwise, the controller receives the DM on his CRD.
3.3.2 Plan control action to permit departing aircraft to climb to a specific altitude safely.	The controller observes the attitude of the departing aircraft to determine if predictions on climb/turn rate are accurate.	The controller observe the attitude of the departing aircraft to determine if predictions on climb/turn rate are accurate.

5.3.3.4 Sub-Activity 3.4: Maintaining Arrival Pattern

See Figure 5-16. The controller will advise the supervisor of factors affecting the need for a change in the arrival rate (Task 3.4.1). Upon being notified of a change in arrival rate, he will then either project the traffic sequence (Task 3.4.2) by including other traffic and weather into his analysis, or determine the descent time or point for the aircraft (Task 3.4.3), possibly by conferring with the pilot. The controller will then issue a clearance and instructions to the pilot (Sub-Activity 4.1) followed by updating of the data base (Task 4.5.10). See Table 5-15 for a comparative subtask description of terminal and en route controller tasks.

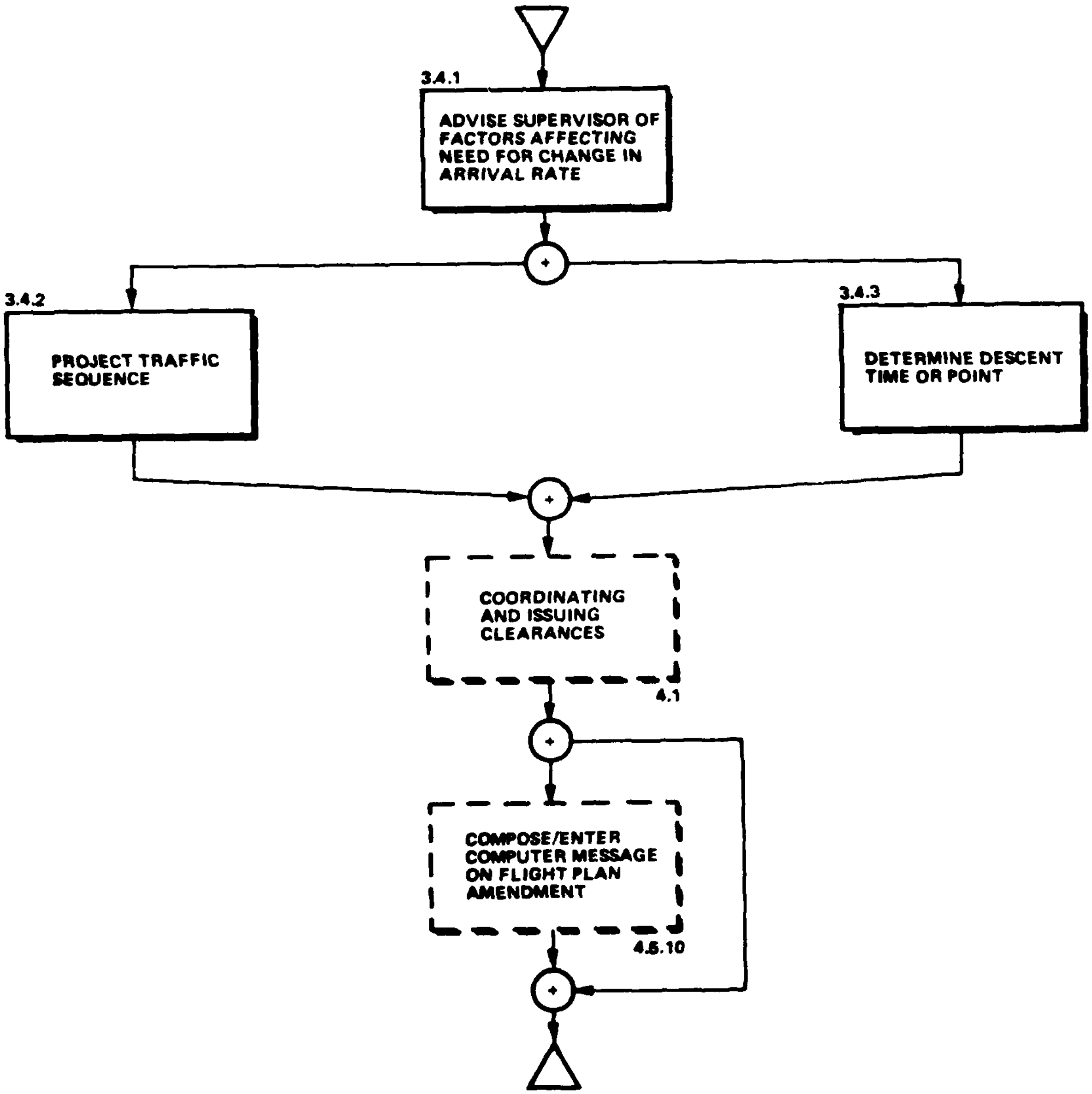


Figure 5-16 Sub-Activity 3.4: Maintaining Arrival Pattern

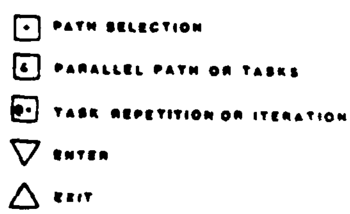


TABLE 5-15. MAINTAINING ARRIVAL PATTERN

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.4.1 Advise supervisor of factors affecting need for change in arrival rate.	The controller advises the supervisor when the aircraft currently in the arrival sequence are approaching saturation. The supervisor examines the weather, number of aircraft, runway configurations, etc., and determines the acceptance rate.	N/A
3.4.2 Project traffic sequence.	The feeder controller projects the traffic flow for his area of responsibility. He establishs the sequence as coordinated with other feeder positions. The final controller merges the aircraft in the final sequence.	The controller projects the traffic sequence, considering aircraft characteristics, and establishes an inbound flow for his sector. The controller keeps aware of airport configurations and weather.
3.4.3 Determine descent time or point.	The controller mentally projects the time or location to descend an aircraft, considering aircraft characteristics.	The controller mentally calculates, or uses range bearing message, to determine the time or location to start the aircraft's descent.

5.3.3.5 Sub-Activity 3.5: Responding to Exception Events

See Figure 5-17. In responding to exception events, such as flameouts or missed approaches, the controller will either receive notice of an exception event from a pilot, a supervisor, or an adjacent controller (Task 3.5.1), or perceive the event independently of any notice or alert (Task 3.5.2). In either case, he must maintain all of his normal activities while he is formulating a judgment about the exception event. In some cases, all aircraft may need to be cleared or vectored away from the area/aircraft/emergency. See Table 5-16 for a comparative subtask description of terminal and en route controller tasks.

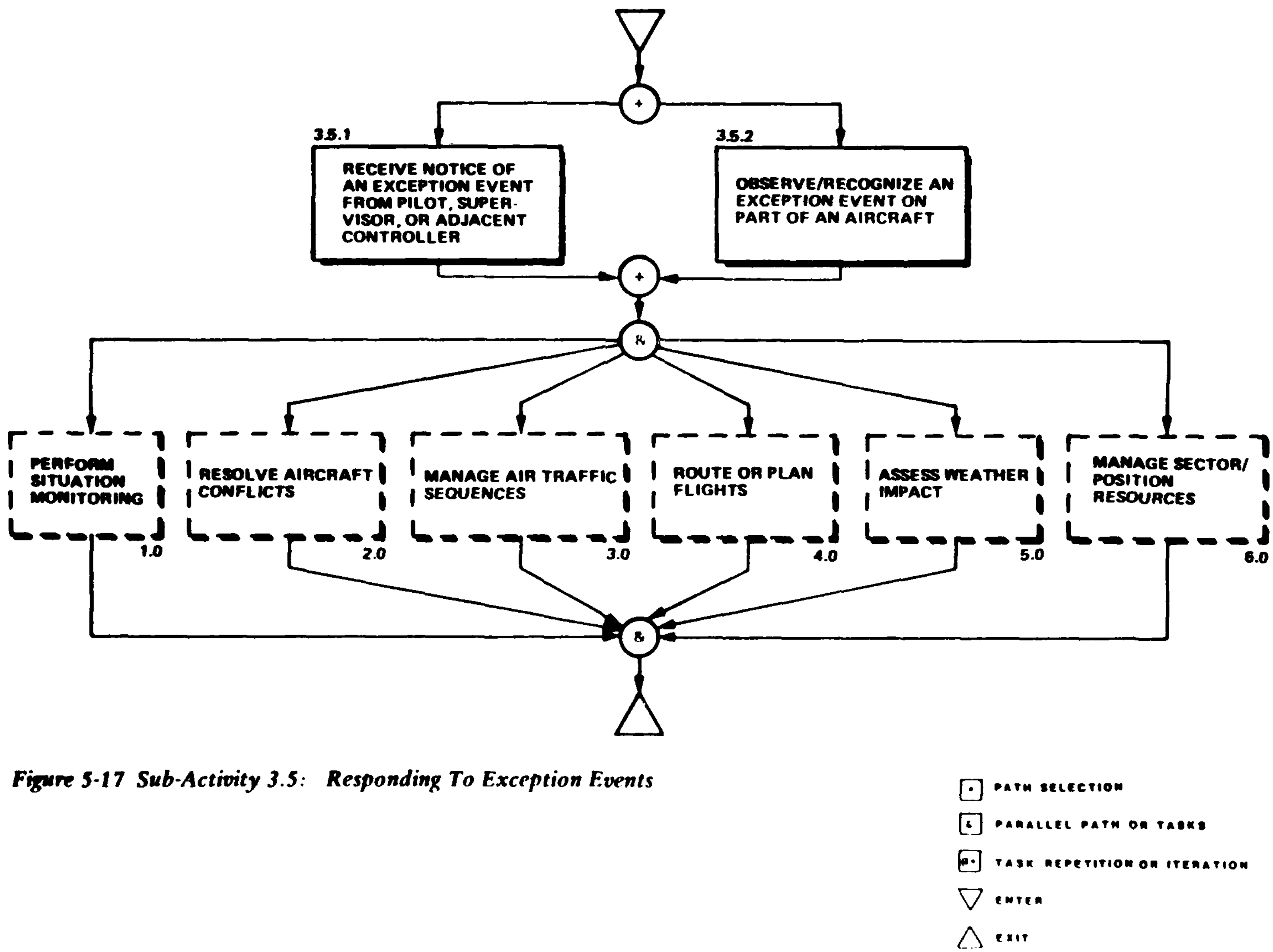


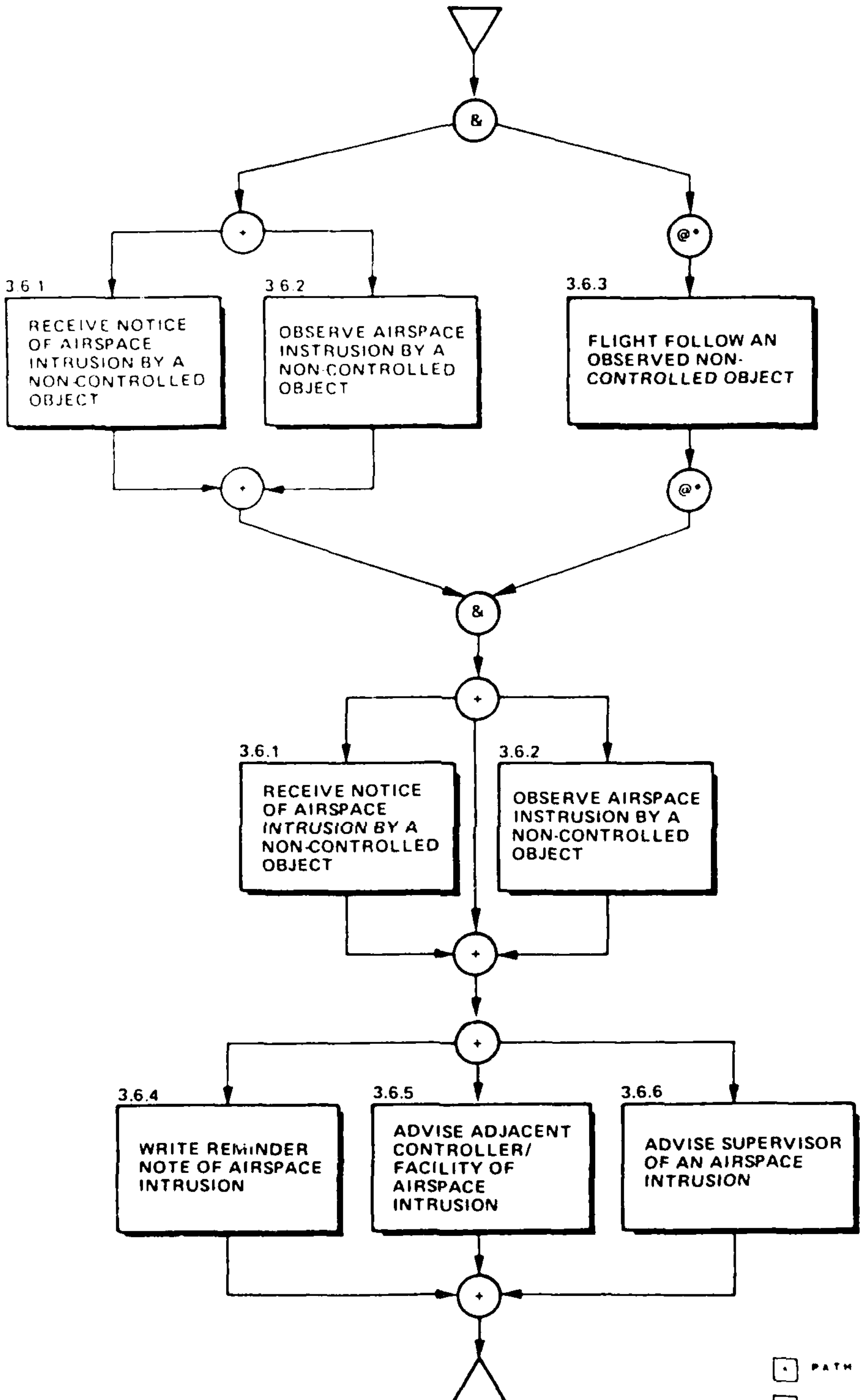
Figure 5-17 Sub-Activity 3.5: Responding To Exception Events

TABLE 5-16. RESPONDING TO EXCEPTION EVENTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.5.1 Receive notice of an exception event from a pilot, supervisor, or adjacent controller.	The controller is notified either by the pilot, supervisor, or an adjacent controller of an exception event. The controller gathers as many facts as he possibly can and determines the course of action on the basis of the facts.	The controller is notified either by the pilot, supervisor, or an adjacent controller of an exception event. The controller gathers as many facts as he possibly can and determines the course of action on the basis of the facts.
3.5.2 Observe/recognize an exception event on part of an aircraft.	The controller, through his proficiency and experience, is alerted to exception events.	The controller, through his proficiency and experience, is alerted to exception events.

5.3.3.6 Sub-Activity 3.6: Monitoring Non-Controlled Objects

See Figure 5-18. A controller may receive notice of an airspace intrusion (Task 3.6.1), or observe an airspace intrusion by a non-controlled object (Task 3.6.2). He may flight follow an observed non-controlled object (Task 3.6.3). He may either write a reminder note about the intrusion (Task 3.6.4), advise the adjacent controller or facility of an airspace intrusion (Task 3.6.5), or advise his supervisor of the intrusion (Task 3.6.6). See Table 5-17 for a comparative subtask description of terminal and en route controller tasks.



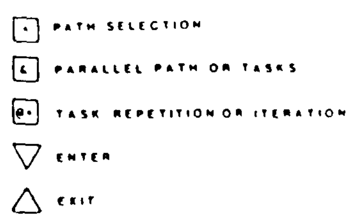


Figure 5-18 Sub-Activity 3.6: Monitoring Non-Controlled Objects

TABLE 5-17. MONITORING NON-CONTROLLED OBJECTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.6.1 Receive notice of airspace intrusion by a non-controlled object.	The controller is notified of non-controlled objects by his supervisor, pilot, or adjacent controller.	The controller is notified of non-controlled objects by his supervisor, pilot, or adjacent controller.
3.6.2 Observe airspace intrusion by a non-controlled object.	The controller observes a non-controlled object on the display. Normally, the flight characteristics, speed, size, etc. will provide clues as to the type of object.	The controller observes a non-controlled object on the display. Normally, the flight characteristics, speed, size, etc. will provide clues as to the type of object. An exception is that on digital mode the size of the object may not be discernible.
3.6.3 Flight follow an observed non-controlled object.	The controller may start a pseudo track by initiating a track start message. If the object does not have a transponder, the controller immediately (before coast drop) hands-off the aircraft to a non-controlled position.	The controller may start a pseudo track by initiating a track initiate message.
3.6.4 Write reminder note of airspace intrusion.	The controller may write a note on the back of a flight progress strip and either place it in the flight strip bay or on the shelf.	The controller may write a note on the back of a flight progress strip and place it in the appropriate flight progress bay.

TABLE 5-17. MONITORING NON-CONTROLLED OBJECTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.6.5 Advise adjacent controller/facility of airspace intrusion.	The controller points out or hands off any observed airspace intrusion. The pointout is made verbally, the handoff is by a handoff message.	The controller points out or hands off any observed airspace intrusion. The pointout is made by a pointout message, the handoff is by a handoff message.
3.6.6 Advise supervisor of an airspace intrusion.	The controller notifies the supervisor of any significant airspace intrusions.	The controller notifies the supervisor of any significant airspace intrusions.

5.3.3.7 Sub-Activity 3.7: Responding to Airspace Restriction Events

See Figure 5-19. When a controller receives notice that an airspace restriction has been imposed (Task 3.7.1), he must first determine whether the restricted area is under ATC control (Task 3.7.2). He may then designate an area in use (Task 3.7.3), such as by starting a pseudo track and then restrict aircraft activity in the area (Task 3.7.4), or request the temporary release of the restricted airspace or area (Task 3.7.5). If the temporary release of special use airspace is requested, he will have to follow through with appropriate clearances (Sub-Activity 4.1), and update of the data base (Task 4.5.10). See Table 5-18 for a comparative subtask description of terminal and en route controller tasks.

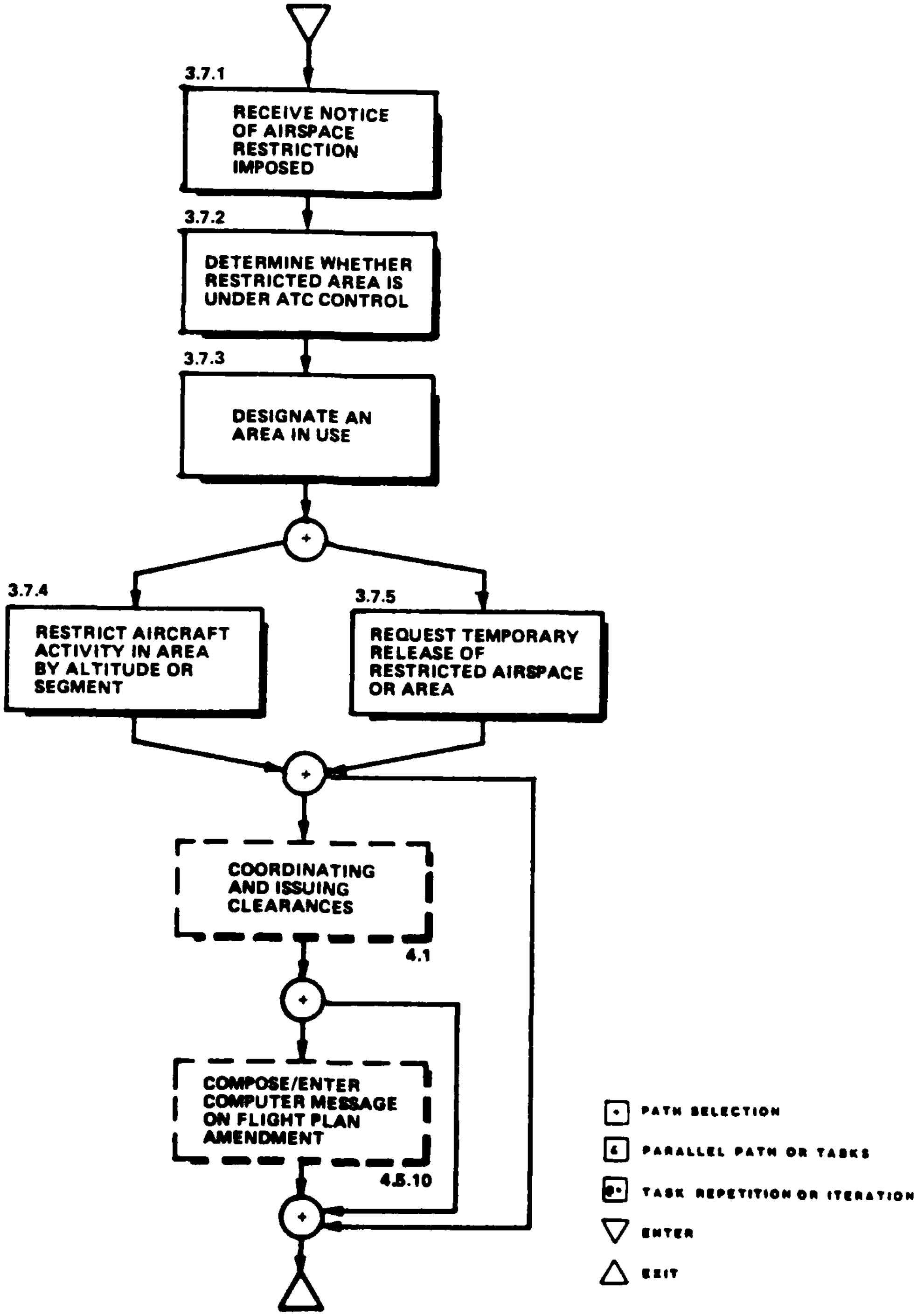


Figure 5-19 Sub-Activity 3.7: Responding To Airspace Restriction Events

TABLE 5-18. RESPONDING TO AIRSPACE RESTRICTION EVENTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.7.1 Receive notice of airspace restriction imposed.	The controller is informed by another controller or a supervisor of airspace restrictions.	The controller is informed by another controller or a supervisor of airspace restrictions. In addition, the flow controller may advise the controller of airspace actions.
3.7.2 Determine whether restricted area is under ATC control.	The controller determines who has control of the airspace; e.g., ATC or military.	The controller determines who has control of the airspace; e.g., ATC or military.
3.7.3 Designate an area in use.	The controller may start a pseudo track with a descriptive call sign using a track start message and hands the target off to an unused position using the handoff message to freeze the data block in place.	The controller may start a track with a descriptive call sign using a track message.
3.7.4 Restrict aircraft activity in area by altitude or segment.	The controller may restrict aircraft in controlled airspace by altitude or segment to allow another aircraft to transit the area.	The controller may restrict aircraft in controlled airspace by altitude or segment to allow another aircraft to transit the area.

TABLE 5-18. RESPONDING TO AIRSPACE RESTRICTION EVENTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.7.5 Request temporary release of restricted airspace or area.	The controller requests the user for temporary release of the airspace. The length of time of the release may be specified or the controller may call back after the airspace use is completed.	The controller requests the user for temporary release of the airspace. The length of time of the release may be specified or the controller may call back after the airspace use is completed.

5.3.3.8 Sub-Activity 3.8: Transferring Control Responsibility

See Figure 5-20. Handoff is automatically initiated for en route tracks in association with a flight plan at a predetermined time before the boundary crossing time calculated for an adjacent sector/facility. (Task 3.8.1).

The process of handing off aircraft from one controller to another is frequently performed. Almost every aircraft that is under the jurisdiction of a controller during a watch is required to be handed off to another sector within the facility, or to an external facility such as another center or terminal. The smooth transition of aircraft from controller to controller as they fly through the ATC System is vital to the maintenance of safe traffic flow.

One of the jobs requiring the greatest use of the controller's skills is the sequencing of aircraft that are approaching a handoff fix or position. The aircraft approach from different sectors and must be sequenced, with the appropriate separation, at the proper altitude and on the correct heading prior to reaching the handoff fix. This task requires that the controller make use of all the control procedures available.

The "merging" of aircraft from different parts of the scope into an orderly handoff pattern is begun many miles prior to the aircraft arriving at the handoff fix for transfer to terminal control. The "first-come-first-served" rule is normally applied; however, if this approach is applied on an absolute basis, there could be a loss of efficiency. An example is the situation where two aircraft are being controlled to an in-line trail and one aircraft is significantly faster than the other. In this case, the controller would endeavor to position the faster aircraft in front of the slower. When the approaching aircraft are at high altitudes, the vectoring process is primarily used, as speed control is less effective the higher the aircraft altitude. Speed control is also limited by aircraft capabilities and by such factors as company policy, pilot preference, and fuel consumption.

Either the receiving controller will observe the handoff acceptance (Task 3.8.2), or the receiving controller will be called if there is no response (Task 3.8.3).

After the receiving controller has radar contact, the transferring Radar Controller tells the aircraft to contact the facility (by call sign), and transmits the appropriate frequency and any restrictions or code change requested by the receiving controller. When the aircraft has changed frequency (Task 3.8.5.), the flight strip is marked to indicate the transfer and the strip is removed from the bay.

There is the possibility that, after the handoff is initiated, for some reason it will then be retracted (Task 3.8.4).

The task of receiving control of aircraft is performed on a continuing basis by controllers. Accomplishment of handoffs requires close coordination between controllers, and the smooth transition of control from sector to sector or facility to facility is important to the maintenance of the smooth and safe flow of traffic.

If the aircraft's transponder is inoperative, but primary radar is available, the controller will verify the aircraft's position by relation to a NAVAID or fix. If neither primary nor secondary radar is available, manual procedures are applied.

A handoff may also be received automatically (Task 3.8.8), but must still be accepted by the receiving controller (Task 3.8.9).

The receiving controller will receive non-automated handoffs (Task 3.8.6), and acknowledge the handoff and start the track (Task 3.8.7).

After control of an aircraft has been transferred and the originating controller has issued a clearance to change the aircraft's frequency, the receiving controller will either contact or respond to the pilot's contact (Task 3.8.10). The controller will verify the altitude of the aircraft with the pilot (Task 3.8.11). If a radar handoff cannot be accomplished, the pilot will be advised that radar service is terminated (Task 3.8.12).

In a manual (non-automated) mode the receiving controller answers the interphone call by stating his sector number/position and any requirements for restrictions or heading and altitude changes to ensure separation. See Table 5-19 for a comparative subtask description of terminal and en route controller tasks.

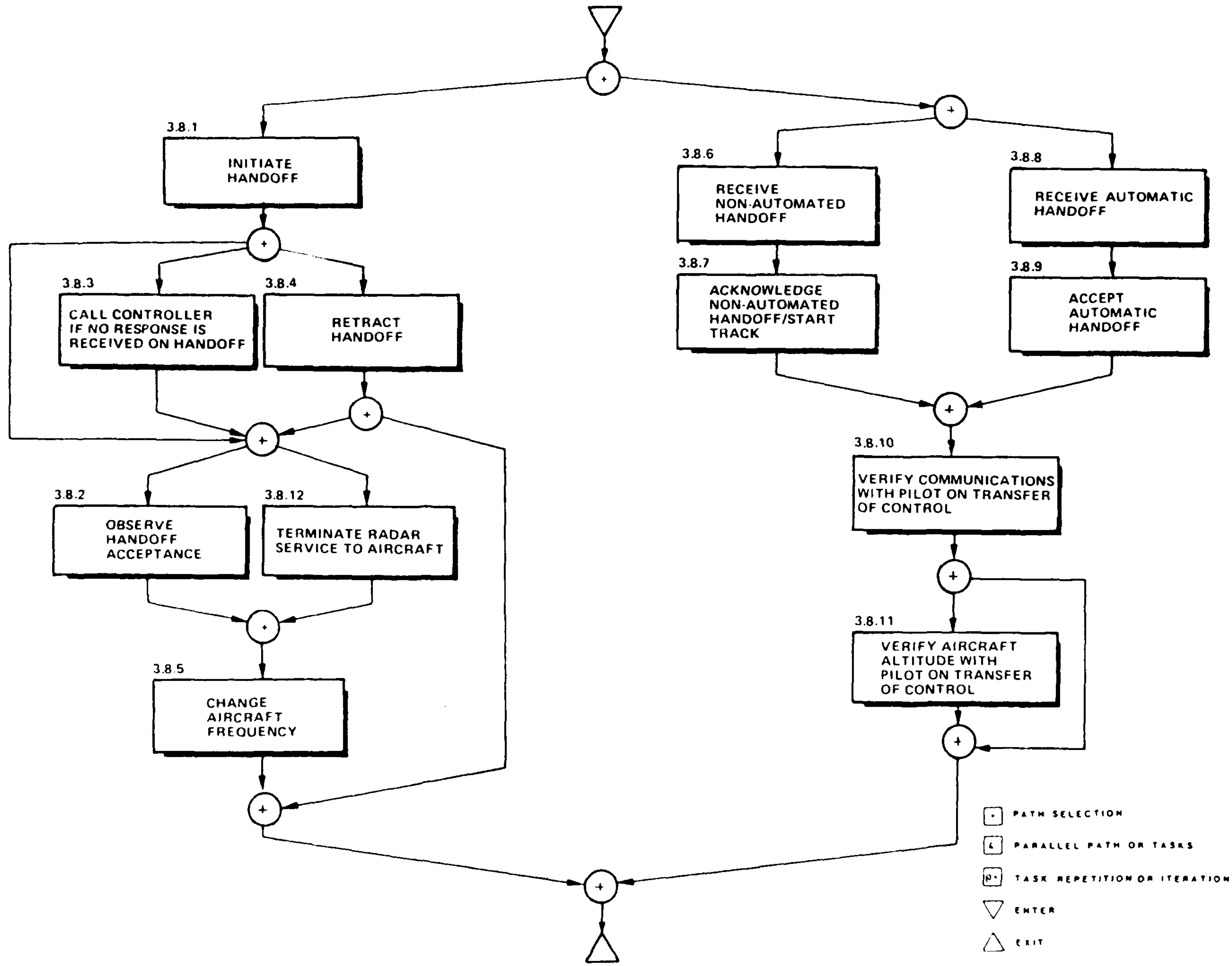


Figure 5-20 Sub-Activity 3.8: Transferring Control Responsibility

TABLE 5-19. TRANSFERRING CONTROL RESPONSIBILITY

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.8.1 Initiate handoff.	The controller initiates a handoff by entering the controller position, or center, or adjacent ARTS facility character identifier. He slews the trackball to the target and initiates the action.	The controller observes the automatic initiation of a handoff, or he manually initiates a handoff message including the sector number or facility identification in a handoff message.
3.8.2 Observe handoff acceptance.	The controller visually observes the handoff accept indicator.	The controller visually observes the handoff accept indicator. In addition, the controller notes on the strip to indicate radar contact.
3.8.3 Call controller if no response is received on handoff.	The controller initiates an interphone call to the receiving controller if no accept message has been received.	The controller initiates an interphone call to the receiving controller if no accept message has been received. The controller notes on the strip if radar service is terminated.

TABLE 5-19. TRANSFERRING CONTROL RESPONSIBILITY (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.8.4 Retract handoff.	If a controller determines control cannot yet be transferred, or the handoff is in error, the controller initiates the handoff again by slew, which retracts the handoff.	If a controller determines control cannot yet be transferred or the handoff is in error, the controller reinitiates the handoff, which retracts the handoff. The controller notes on the strip if radar contact is lost.
3.8.5 Change aircraft frequency.	After receiving and mentally noting the accept message or the verbal accept after an interphone call, the controller clears the aircraft to another frequency.	After receiving and mentally noting the accept message or the verbal accept after an interphone call, the controller clears the aircraft to another frequency. The controller notes on the strip the frequency, if the frequency used is non-standard.
3.8.6 Receive non-automated handoff.	The controller receives a call with a verbal handoff which describes the identification and location of the aircraft.	The controller receives a call with a verbal handoff which describes the identification and location of the aircraft.

TABLE 5-19. TRANSFERRING CONTROL RESPONSIBILITY (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.8.7 Acknowledge non-automated handoff/start track.	After locating the target, the controller verbally acknowledges the handoff and accepts the transfer. The controller initiates a track by the track start function button (key) and slewing to the target.	After locating the target the controller verbally acknowledges the handoff and accepts the transfer after locating the target.
3.8.8 Receive automatic handoff.	The controller observes a flashing data block symbol from the center or another control position symbol. Control is transferred as the aircraft enters the airspace of the receiving controller unless otherwise coordinated.	The controller observes the flashing handoff indicator and the originating controller position number or identification. Control is transferred as the aircraft enters the airspace of the receiving controller unless otherwise coordinated.
3.8.9 Accept automatic handoff.	The controller slews and accepts the handoff if the target is in the proper position with respect to the data block. Control is transferred as the aircraft enters the airspace of the receiving controller unless otherwise coordinated.	The controller accepts a handoff by trackball or computer identification number. The controller notes the action on the strip. Control is transferred as the aircraft enters the airspace of the receiving controller unless otherwise coordinated.

TABLE 5-19 TRANSFERRING CONTROL RESPONSIBILITY (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.8.10 Verify communications with pilot on transfer of control.	The receiving controller will either initiate or respond to communication with the pilot after the transfer of control is accomplished.	The receiving controller will either initiate or respond to communication with the pilot after the transfer of control is accomplished.
3.8.11 Verify aircraft altitude with pilot on transfer of control.	The controller will verify the altitude of the aircraft with the pilot on the initial air/ground radio contact. Verification may be made visually on departing aircraft if the observation is made within specific distance.	The controller will verify the altitude of the aircraft with the pilot on the initial air/ground radio contact.
3.8.12 Terminate radar service to aircraft.	The controller will inform the pilot when radar service is no longer available.	The controller will inform the pilot when radar service is no longer available.

5.3.3.9 Sub-Activity 3.9 Sharing Control Responsibility

See Figure 5-21. The controller may either conduct or issue a pointout for small infringement of another airspace without handing off the aircraft (Task 3.9.1), or respond to one which is issued to him (Task 3.9.2). Whenever the controller no longer finds it necessary to share responsibility of control, he may suppress the flight data block (Task 3.9.3). See Table 5-20 for a comparative subtask description of terminal and en route controller tasks.

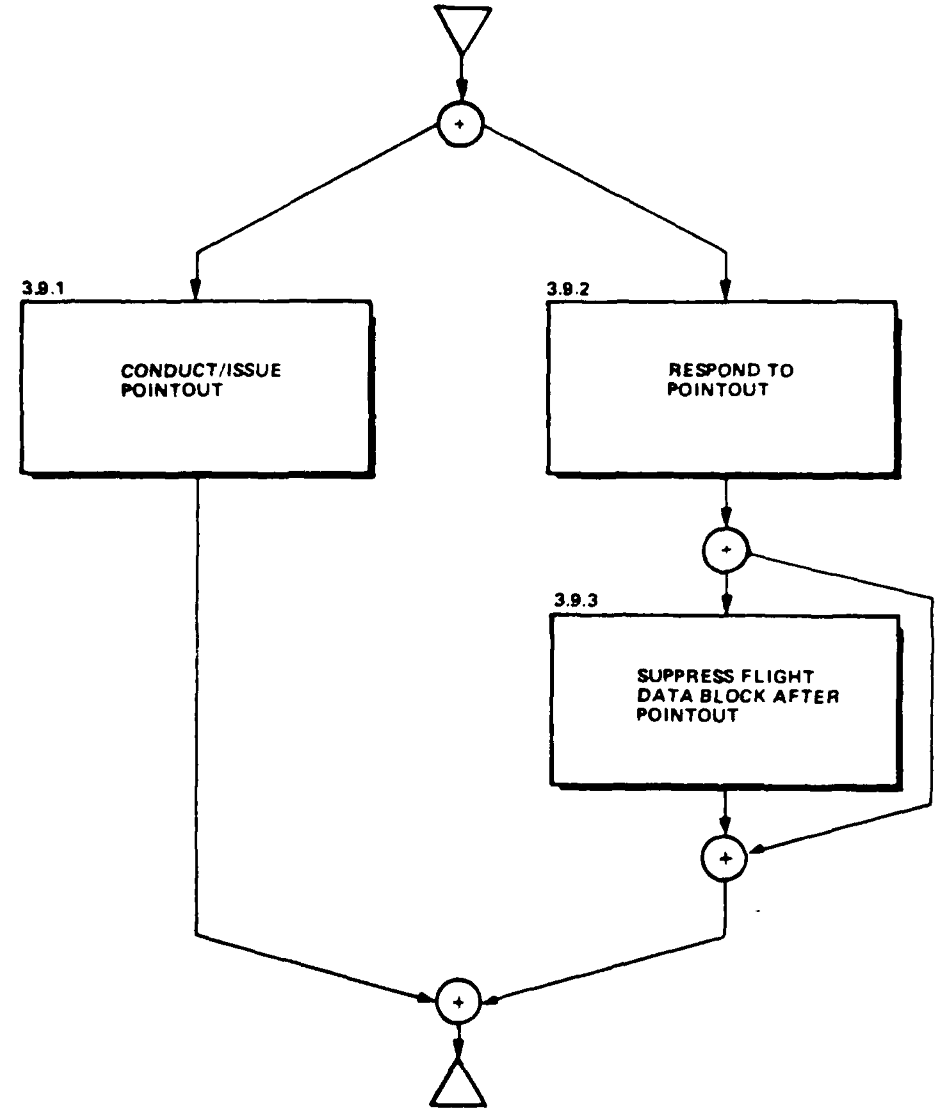


Figure 5-21 Sub-Activity 3.9: Sharing Control Responsibility

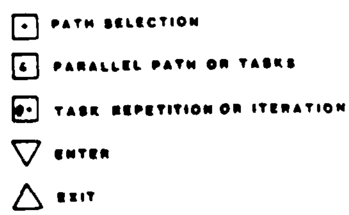


TABLE 5-20. SHARING CONTROL RESPONSIBILITY

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
3.9.1 Conduct/issue pointout.	Upon recognizing that an aircraft will enter another controller's airspace for a temporary period, the controller verbally points out the aircraft to another controller. Coordination is effected as necessary, the controller notes the action on the strip and the facility/sector/position designating who received the pointout.	Upon recognizing that an aircraft will enter another controller's airspace for a temporary period, the controller initiates a pointout message which will cause a display of the data block on the receiving controller display. The controller notes the action on the strip and the facility/sector/position designating who received the pointout. Coordination is effected as necessary.
3.9.2 Respond to pointout.	The receiving controller "quick looks" the target.	The controller observes a data block on his display.
3.9.3 Suppress flight data block after pointout.	The data block, which was "quick looked" will remain on the receiving controller's display until the target is "quick looked" again. The originating controller drops the data by a drop track message or the system drops the data block.	The controller drops the pointout by using the suppress track function to remove the data block.

5.3.4 Activity 4: Route or Plan Flights

5.3.4.1 Sub-Activity 4.1: Coordinating and Issuing Clearances

See Figure 5-22. A controller may receive a clearance request from a terminal facility, FSS, or from a pilot (Task 4.1.1). Or, he may coordinate a planned clearance with an adjacent controller (Task 4.1.2). Also, the controller may receive a clearance and instructions to relay to the pilot (Task 4.1.3). He may observe the display for other aircraft which require separation (Task 4.1.4). In any of the above cases, he may advise another controller of required clearances on aircraft entering or leaving his sector if appropriate (Task 4.1.5) or informs the adjacent controller or facility of a change which might necessitate a delay or changes in routes (Task 4.1.6). He then formulates a clearance with appropriate restrictions (Task 4.1.7) and then evaluates the course of action, solution, and impact (Task 4.1.8). Upon evaluation of the situation and the clearance request, the controller may decide to deny a clearance request (Task 4.1.9).

If he does decide to implement a planned clearance, he either issues the clearance and instruction to the pilot (Task 4.1.10), or issues the clearance and instructions to a terminal facility, FSS, BASOPS, or airline office for relay to the pilot (Task 4.1. 11). Finally, the controller will verify the compliance of the aircraft in all situations (Task 4.1.12). He updates the data base as appropriate (Task 4.5.10). See Table 5-21 for a comparative subtask description of terminal and en route controller tasks.

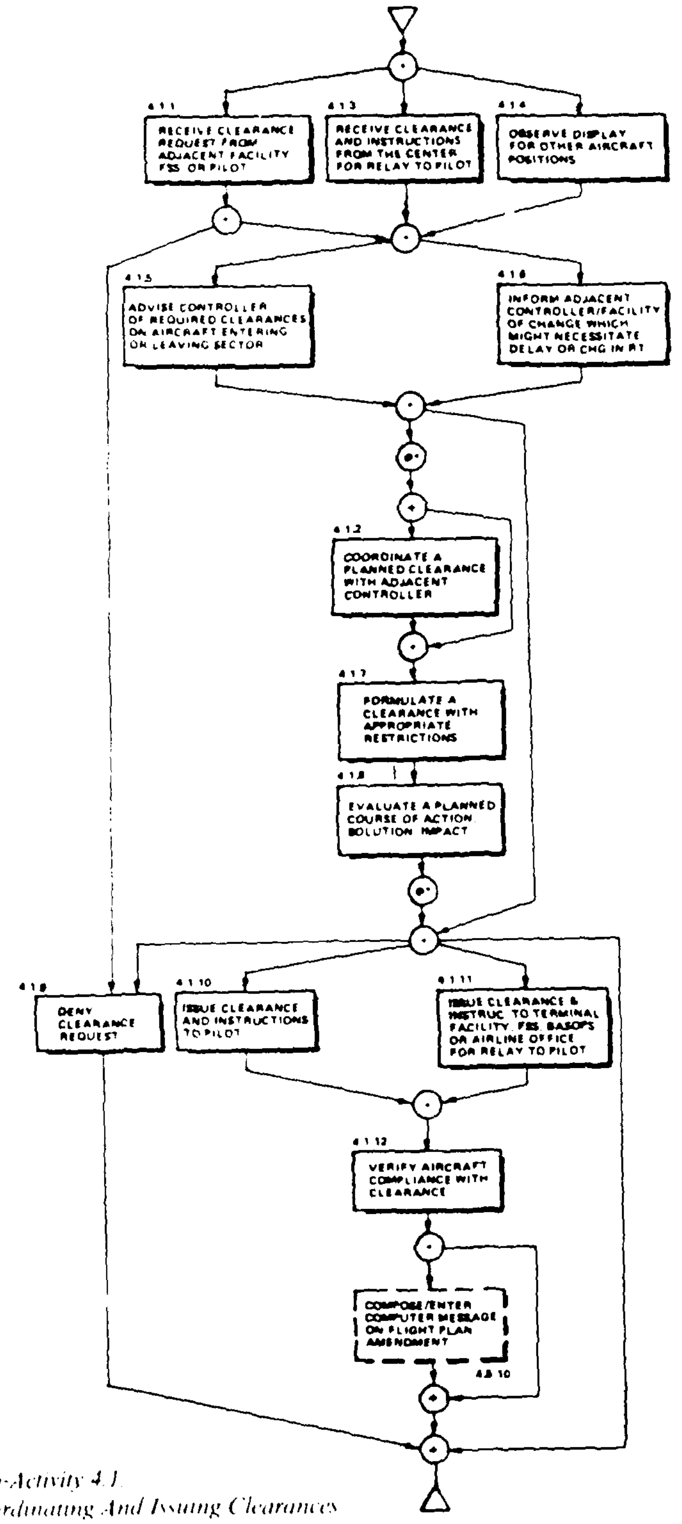


Figure 5-22 Sub-Activity 4.1
Coordinating And Issuing Clearances

TABLE 5-21. COORDINATING AND ISSUING CLEARANCES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.1.1 Receive clearance request from adjacent facility, FSS, or pilot.	The controller verbally receives a clearance request from a facility, FSS, or pilot.	The controller verbally receives a clearance request from a facility, FSS, or pilot.
4.1.2 Coordinate a planned clearance with adjacent controller.	The controller determines if coordination with the next controller/facility is required as when it is time critical. If so, the appropriate restrictions will be incorporated into the clearance after verbal coordination is completed.	The controller determines if coordination with the next controller/facility is required as when it is time critical. If so, the appropriate restrictions will be incorporated into the clearance after verbal coordination is completed.
4.1.3 Receive clearance and instructions from the center for relay to pilot.	The controller receives a clearance from the center controller.	The controller receives a clearance from an adjacent controller for issuance to the pilot, along with any required restrictions.
4.1.4 Observe display for other aircraft positions.	The controller evaluates the separation required from other aircraft with respect to longitudinal, lateral, and vertical separation.	The controller evaluates the separation required from other aircraft in regards to longitudinal, lateral, and vertical separation.
4.1.5 Advise controller of required clearances on aircraft entering or leaving sector/position.	The controller may provide appropriate strip marking or verbally alert another controller of the need for a clearance.	The controller may provide appropriate strip marking to alert the radar controller of required clearances. This may also be done verbally.

TABLE 5-21. COORDINATING AND ISSUING CLEARANCES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.1.6 Inform adjacent controller/facility of clearance change which might necessitate delay or changes in route.	The controller verbally briefs the next controller/facility of changes which impact flights into the next sector/position. The controller marks the strip as appropriate.	The controller verbally briefs the next controller/facility of changes which impact flights into the next sector/position. The controller marks the strip as appropriate.
4.1.7 Formulate a clearance with appropriate restrictions.	The controller formulates a clearance which will provide either longitudinal, lateral, or vertical separation from other aircraft. The clearance contains restrictions as applied by any other sector/position.	The controller formulates a clearance which will provide either longitudinal, lateral, or vertical separation from other aircraft. The clearance contains restrictions as applied by any other sector/position.
4.1.8 Evaluate a planned course of action, solution, and impact.	The controller evaluates the course of action, solution, and impact.	The controller evaluates the course of action, solution, and impact.
4.1.9 Deny clearance request.	The controller will inform the originator of a clearance request when that request is denied. Time permitting, the rationale may also be forwarded.	The controller will inform the originator of a clearance request when that request is denied. Time permitting, the rationale may also be forwarded.

TABLE 5-21. COORDINATING AND ISSUING CLEARANCES (Cont'd)

Information Processing Task		Terminal Subtask Description	En Route Subtask Description
4.1.10	Issue clearance and instructions to pilot.	The controller verbally issues the clearance to the pilot and simultaneously writes the clearance on the strip. Strip marking is accomplished on initial pilot contact, forwarding data to the next controller/facility, or simultaneously with the clearance. Strip marking items not directly related to clearances are: flight plan cancellation; reporting at assigned altitude; pointout; emergency; warning; and radar contact or termination. The controller may issue a clearance in the form of a radar vector to clear a safety hazard, effect separation, or provide navigation. See Appendix C for further details regarding strip marking.	The controller verbally issues the clearance to the pilot and simultaneously writes the clearance on the strip. The controller may issue a clearance in the form of a radar vector to clear a safety hazard, effect separation, or provide navigation. In addition, the radar controller notes the action on the strip and the appropriate heading. When the pilot resumes normal navigation, the controller again notes the status on the strip.
4.1.11	Issue clearance and instructions to terminal facility, FSS, BASOPS, or airline office for relay to pilot.	The controller relays a clearance through a terminal facility, FSS, BASOPS, or airline office and simultaneously writes the clearance on the strip.	The controller relays a clearance through a terminal facility, FSS, BASOPS, or airline office and simultaneously writes the clearance on the strip.

TABLE 5-21. COORDINATING AND ISSUING CLEARANCES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.1.12 Verify aircraft compliance with clearance	The controller shall observe aircraft or receive a progress report for compliance with a clearance.	The controller shall observe aircraft or receive a progress report for compliance with a clearance.

5.3.4.2 Sub-Activity 4.2: Responding to Contingencies

See Figure 5-23. A controller may either receive a report of an overdue aircraft (Task 4.2.1), or detect the problem himself as in the case of hypoxia (Task 4.2.2). If he receives an overdue report, he conducts a radio search (Task 4.2.3), and then contacts facilities along the route of flight to try to secure information on the overdue aircraft (Task 4.2.5). If he detects a problem on his own, he declares it an event and invokes a contingency plan (Task 4.2. 4). He may alert an emergency crew and/or other designated personnel of aircraft having flight difficulties (Task 4.2. 6). The controller reports the event to his supervisor (Task 4.2.7). A variety of contingencies may arise for which no specific set of tasks can be stated, but which call upon all of the controller's background of skill and knowledge (Sub-Activity 3.5). Aircraft events calling for those responses include aircraft emergency, hijack, bombthreat, medical, no radio, and beacon failure. See Table 5-22 for a comparative subtask description of terminal and en route controller tasks.

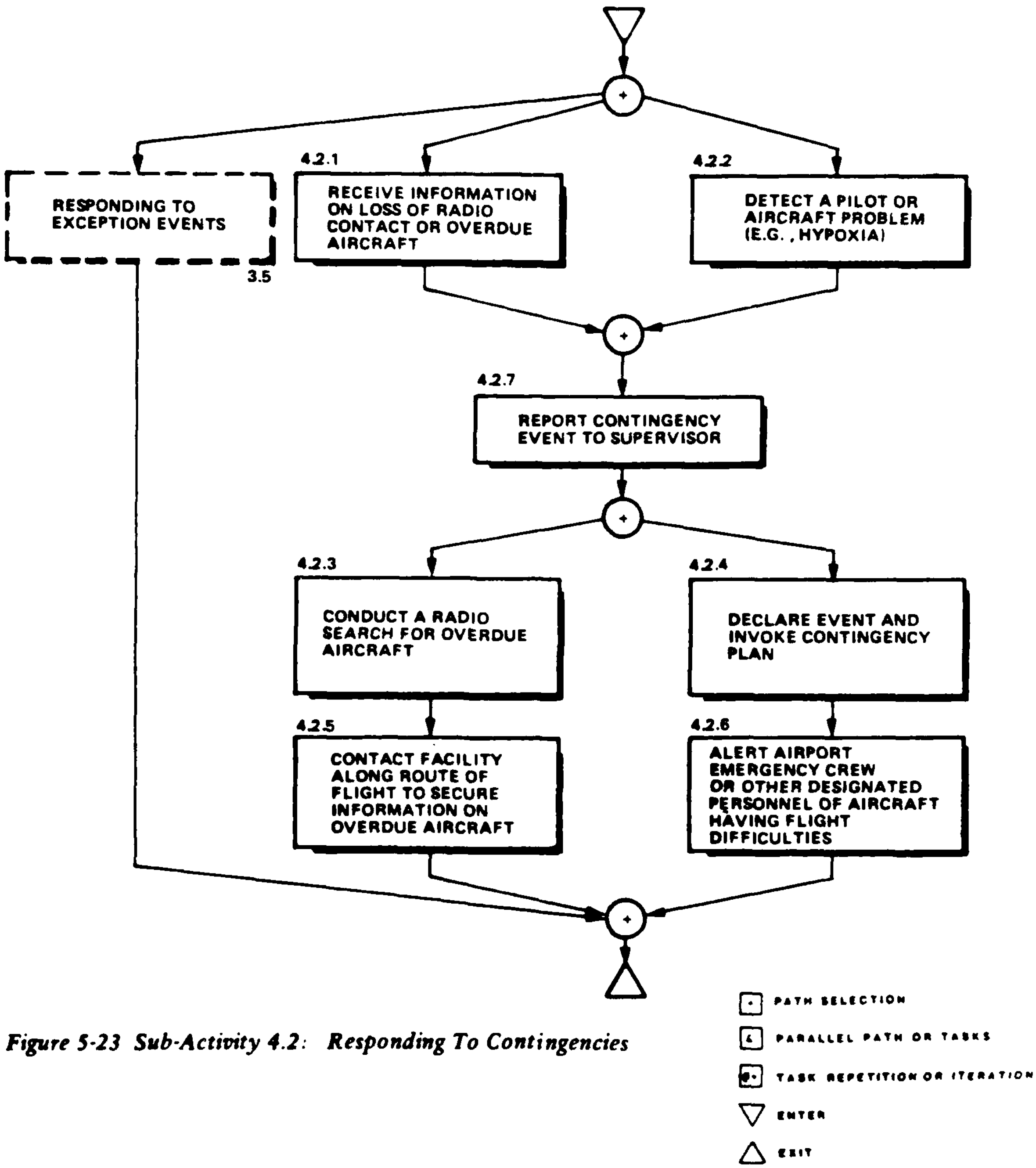


Figure 5-23 Sub-Activity 4.2: Responding To Contingencies

TABLE 5-22. RESPONDING TO CONTINGENCIES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.2.1 Receive information on loss of radio contact or overdue aircraft.	The controller will become aware of the loss of radio contact or an overdue aircraft either from another controller or facility, or by his inability to contact the aircraft.	The controller will become aware of the loss of radio contact or an overdue aircraft either from another controller or facility, or by his inability to contact the aircraft.
4.2.2 Detect a pilot or aircraft problem (e.g., hypoxia).	The controller may be notified by his supervisor or the pilot that a contingency exists, or he may determine it himself.	The controller may be notified by his supervisor or the pilot that a contingency exists, or he may determine it himself.
4.2.3 Conduct a radio search for overdue aircraft.	The controller attempts to establish direct radio contact, requests other aircraft to contact the aircraft, requests the FSS to contact the aircraft including broadcasts on the NAVAID while the controller observes the display for transponder response, or other types of response.	The controller attempts to establish direct radio contact, requests other aircraft to contact the aircraft, requests the FSS to contact the aircraft including broadcasts on the NAVAID while the controller observes the display for transponder response, or other types of response.
4.2.4 Declare event and invoke contingency plan.	The controller declares a contingency exists and initiates a plan for the event.	The controller declares a contingency exists and initiates a plan for the event. In addition, the controller will note on the strip if there is an emergency.

TABLE 5-22. RESPONDING TO CONTINGENCIES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.2.5. Contact facility along route of VFR flight to secure information on overdue aircraft.	The controller may query adjacent facilities on the route of the aircraft to determine if they have contacted the aircraft.	The controller queries other facilities on the route of the aircraft to determine if they have contacted the aircraft.
4.2.6 Alert airport emergency crew or other designated personnel of aircraft having flight difficulties.	The controller, if appropriate, alerts the airport emergency crew of the aircraft and the nature of the problem.	The controller alerts other appropriate controllers/facilities of the aircraft having flight difficulties.
4.2.7 Report contingency event to supervisor.	The controller alerts the supervisor to the event.	The controller alerts the supervisor to the event.

5.3.4.3 Sub-Activity 4.3: Responding to Special Operations.

See Figure 5-24. A controller may either receive a notice of the necessity for special operations (Task 4.3.1), or perceive for himself the necessity for special operations (Task 4.3.2). In either case, he must maintain all of his other activities while he is coping with special operations. See Table 5-23 for a comparative subtask description of terminal and en route controller tasks.

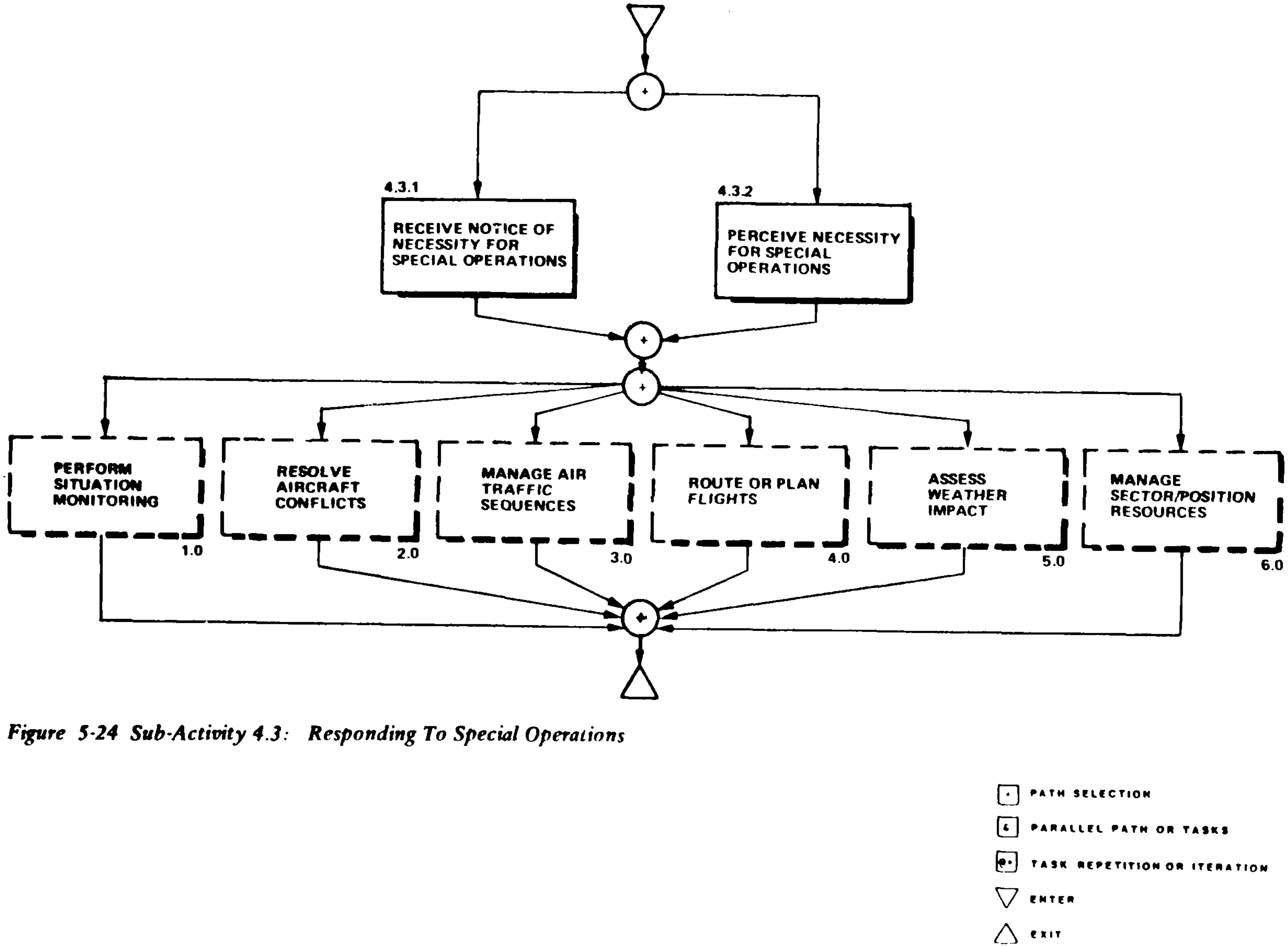


Figure 5-24 Sub-Activity 4.3: Responding To Special Operations

TABLE 5-23. RESPONDING TO SPECIAL OPERATIONS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.3.1 Receive notice of necessity for special operations.	The controller is notified by his supervisor of special operations, reads it, or receives a pilot report.	The controller is notified by his supervisor of special operations, reads it, or receives a pilot report.
4.3.2 Perceive necessity for special operations.	The controller observes the performance of an aircraft and recognizes the need for a special operation.	The controller observes the performance of an aircraft and recognizes the need for a special operation.

5.3.4.4. Sub-Activity 4.4: Processing Flight Plans

See Figure 5-25. Whether a flight plan is received from a pilot, a controller, or flight strip printer (Tasks 4.4.1, 4.4.2, 4.4.3, respectively), its function is the same.

This function establishes a data base for a flight plan. Flight plan data is input from selected local and remote sources and may contain the following information:

- Flight identification
- Aircraft data
- Speed
- Beacon code
- Coordination fix and time
- Departure point and proposed departure time
- Assigned and/or requested altitude
- Route data
- Remarks
- Equipment indicator: communications equipment, navigation and approach aids, and Air Traffic Control Radar Beacon System (ATCRBS) transponder.

Processing of these data may include conversion of airspeed, establishment of a computer identification number, assignment of a beacon code, route conversion, and fix-time calculation, and may cause printing of flight progress strips.

The flight plan is also reviewed for completeness and checked to ensure accuracy and logic, and necessary corrections are made (Task 4.4.4). If any discrepancies are found or any questions arise as to format or content, the controller may then query the pilot (Task 4.4.5) or the previous controller (Task 4.4.6).

The data entry is then composed and entered into the computer (Task 4.4.7). The flight plan is forwarded to the next controller (Task 4.4.8), if necessary.

An important factor in this function is recognizing errors contained in the flight plans and ensuring, through use of manual strip marking and computer updating, that the errors are deleted and correct information only is used for control processes. That is, review flight strip for altitude, direction, beacon code, and route logic.

Flight data is entered into the computer system by the manual controller through the Computer Update Equipment (CUE). The Computer Readout Display (CRD) is used as a preview area prior to message entry and as a means of feedback from the Central Computer Complex. The manual controller has the capability to enter numerous types of messages, each with their own specific fields and formats. The rapid and accurate input of these messages by the manual controller helps to provide more time for the more complicated and esoteric functions of the art of safely and effectively controlling aircraft through the sector.

Each input message is checked for certain format and logic errors. The purpose of format checking is to ensure that the data are entered in one of the formats designated as acceptable and in the proper sequence. The purpose of logic checking is to insure that the different items of data are compatible with each other, with adaptation data and with other filed flight plan data. Additional checks are also made to assure eligibility of source for the type of input message entered and the time the message is entered.

The following data may be entered into the computer to establish, maintain, or request the flight plan data base:

- Initial flight plan data
- Amendment data
- Departure data
- Progress report data
- Hold data
- Cancellation data
- Stereo flight plan data
- Mission flight plan data
- Correction data
- Request for flight plan data

The controller will distribute new flight progress strips to the appropriate controllers (Task 4.4.9). The last task in this sub-activity is then to post the flight strips in the strip bays (Task 4.4.10). See Table 5-24 for a comparative subtask description of terminal and en route controller tasks.

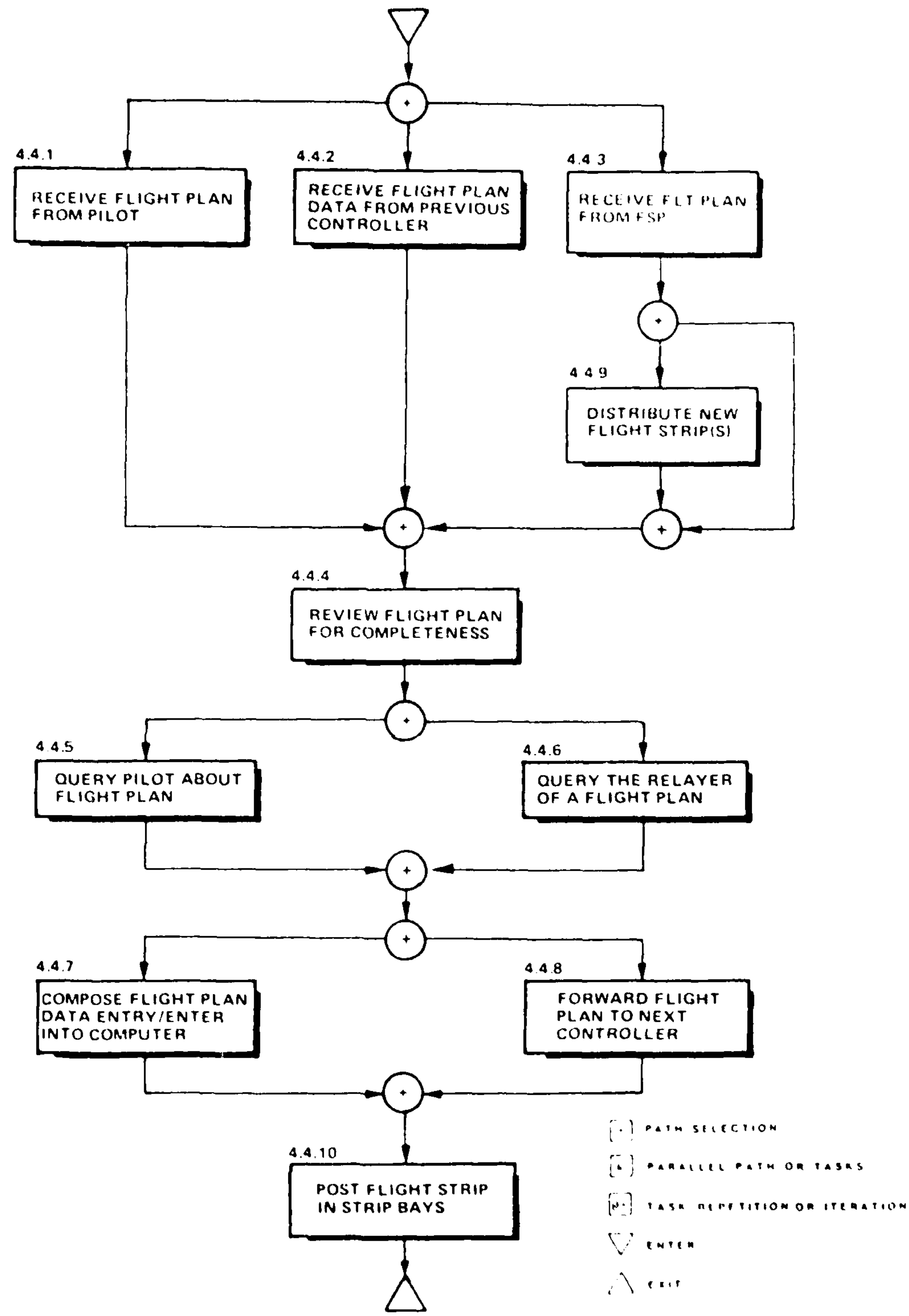


Figure 5-25 Sub-Activity 4.4. Processing Flight Plans

TABLE 5-24. PROCESSING FLIGHT PLANS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.4.1 Receive flight plan from pilot.	The controller receives a flight plan from the pilot on an air/ground frequency and writes the flight plan on a flight progress strip.	The controller receives a flight plan from the pilot on an air/ground frequency and writes the flight plan on a flight progress strip.
4.4.2 Receive flight plan data from previous controller.	The controller receives a flight plan from adjacent controller/facility and writes it on a flight progress strip.	The controller receives a flight plan over the interphone from adjacent controller/facility and writes it on a flight progress strip.
4.4.3 Receive flight plan on flight strip printer (FSP).	The controller receives a proposed flight plan on a FSP from the stored flight plan program, FSS, BASOPS, terminal, air carrier Teletype, or manual input.	The controller receives a proposed flight plan on a FSP from the stored flight plan program, FSS, BASOPS, terminal, air carrier Teletype, or manual input.
4.4.4 Review flight plan for completeness.	The controller reviews the proposed flight plan for completeness and accuracy, especially the proper altitude/direction and route logic. He may write necessary corrections.	The controller reviews the proposed flight plan for completeness and accuracy, especially the proper altitude/direction and route logic. The manual controller marks the necessary corrections on the flight strip.

TABLE 5-24. PROCESSING FLIGHT PLANS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.4.5 Query pilot about flight plan.	If the flight plan is not correct, the controller queries the pilot as to his intentions.	If the flight plan is not correct, the controller queries the pilot as to his intentions.
4.4.6 Query the relayer of a flight plan.	If the flight plan came from another source, the controller queries the relaying source as to the pilot's intentions.	If the flight plan came from another source, the controller queries the relaying source as to the pilot's intentions.
4.4.7 Compose flight plan data entry and enter into computer.	The controller enters the flight plan into the computer if appropriate and may enter "scratch pad" data on data block.	The controller enters the flight plan into the computer if appropriate.
4.4.8 Forward flight plan to next controller.	If the next controller will not receive a pre-departure coordination strip, the controller verbally forwards the information if appropriate.	If the next controller will not receive a pre-departure coordination strip, the controller verbally forwards the information if appropriate. In addition the manual controller notes data that are passed to the next controller.
4.4.9 Distribute new flight strip(s).	The controller will forward to the appropriate position any flight progress strip torn from the flight strip printer.	The controller will forward to the appropriate position any flight progress strip torn from the flight strip printer.

TABLE 5-24. PROCESSING FLIGHT PLANS (Cont'd)

Information Processing Task		Terminal Subtask Description	En Route Subtask Description
4.4.10	Post flight strip in strip bays.	The controller will sequence the strip in the appropriate bay or on the console shelf.	The controller will sequence the strip in the appropriate bay.

5.3.4.5 Sub-Activity 4.5: Processing Flight Plan Amendments

See Figure 5-26. A controller may receive a request for a flight change or amendment from a pilot/controller (Task 4.5.1) or receive a flight plan amendment from a previous controller (Task 4.5.5). Or, a chime may sound indicating that a message is waiting to transmit the amendment at a sector, or a new FDEP strip may be printed (Task 4.5.6). Also, a progress report may be received (Task 4.5.14). This input updates the status of an active flight plan or releases a flight from a prior hold action. Progress report data can be entered from selected remote or local sources. If a progress report is received, the speed and time are checked against the existing flight plan (Task 4.5.15). If an amendment is received either from the previous controller or via a computer message, the controller may request a flight progress strip over a given fix (Task 4.5.7).

In FDP, the fix time calculation task calculates and updates, when necessary, arrival times at fixes, delay intervals, climb completion times, and boundary crossing times.

Updated fix times are recomputed for a flight whenever new time data is entered for the flight (e.g., a progress report, hold message). The update mode will adjust the calculated arrival times and delay intervals for all converted fixes and an amendment will be written on the flight strip (Task 4.5.8). In the case of receiving an amendment from a pilot, the request is reviewed before proceeding (Task 4.5.2). This may include coordinating with the next controller regarding any special requirements or routing. Regardless of how the amendment has been received, the flight strip will now be flagged as a reminder to the controller that action is required (Task 4.5.3) and the strips may need to be resequenced because of the changed information (Task 4.5.9). The controller then mentally projects the aircraft's position, altitude, and path (Task 1.1.2) and evaluates the event effect on the current flow pattern (Task 3.1.5).

He will also negotiate the change with the pilot if required (Task 4.5.4), and then coordinate and issue the clearance and instructions to the pilot (Sub-Activity 4.1). If no further coordination is necessary, the controller will enter a computer message describing the amendment (Task 4.5.10), or forward the flight plan to the next controller (Task 4.4.8), or advise the controller of required clearances on aircraft entering or leaving his sector (Task 4.1.5). Depending upon the facility, he will then modify the display or the DEDS scratch pad (Task 4.5.11). Finally, he will flag the strip (Task 4.5.12), and once again review the situation to assure himself that the event has been handled properly (Task 4.5.13). See Table 5-25 for a comparative subtask description of terminal and en route controller tasks.

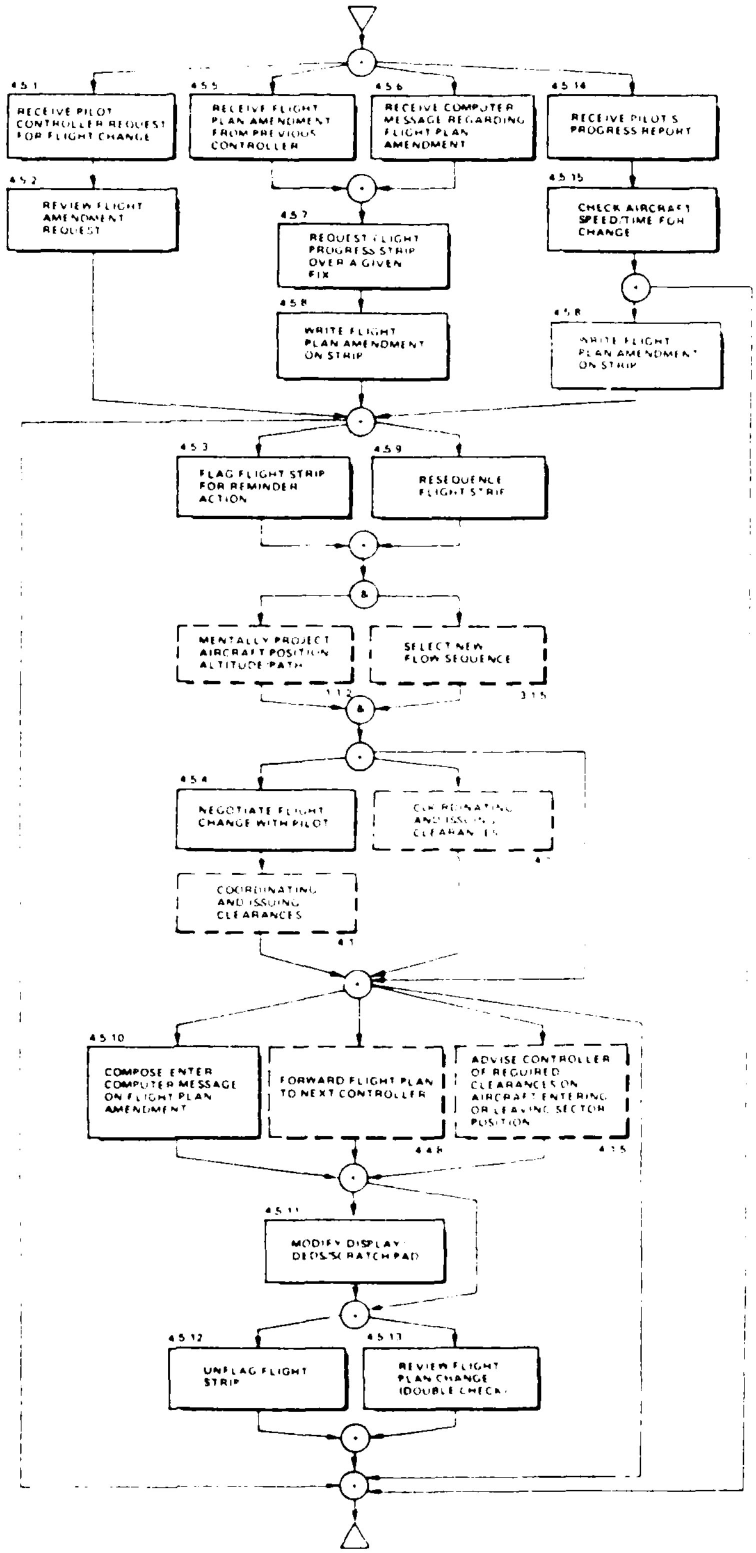


Figure 5-26 Sub-Activity 4.5 Processing Flight Plan Amendments

TABLE 5-25. PROCESSING FLIGHT PLAN AMENDMENTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.5.1 Receive pilot/controller request for flight change.	The controller verbally receives a request for a flight change from the pilot or adjacent controller. If it is a cancellation, the controller marks the strip.	The controller verbally receives a request for a flight change from the pilot or adjacent controller. The request will be written on the strip. If it is a cancellation, the controller marks the strip.
4.5.2 Review flight amendment request.	The controller reviews the request.	The controller reviews the request.
4.5.3 Flag flight strip for reminder action.	The controller may flag the strip to signal further action required.	The controller may flag the strip to signal further action required.
4.5.4 Negotiate flight change with pilot.	The controller may confer with the pilot if the controller is unable to approve the requested change. The controller may be able to approve either part of the change or may be able to approve the change in the future.	The controller may confer with the pilot if the controller is unable to approve the requested change. The controller may be able to approve either part of the change or may be able to approve the change in the future.
4.5.5 Receive flight plan amendment from previous controller.	The controller verbally receives a request for an amendment from the previous controller/facility and writes it on the strip.	The controller verbally receives a request for an amendment from the previous controller/facility and writes it on the strip.

TABLE 5-25. PROCESSING FLIGHT PLAN AMENDMENTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.5.6 Receive computer message regarding flight plan amendment.	The controller receives amended flight progress strips on the FDEP.	The controller will receive a computer message on his computer readout device. The computer will alert the controller to a pending message by a chime.
4.5.7 Request flight progress strip over a given fix.	If the controller cannot locate a strip, he enters a strip request message.	If the controller cannot locate a strip, he enters a strip request message.
4.5.8 Write flight plan amendment on strip.	The controller writes the amended data on the strip. Every change a controller makes is supposed to be documented on the strip, and then passed to the next controller.	The controller writes the amended data on the strip. Every change a controller makes is supposed to be documented on the strip, and then passed to the next controller.
4.5.9 Resequence flight strip.	The controller resequences the strip, if appropriate, based upon the revised data.	The controller resequences the strip, if appropriate, based upon the revised data.
4.5.10 Compose/enter computer message on flight plan amendment.	The controller enters an amendment message reflecting the amended clearance.	The controller enters an amendment message reflecting the amended clearance.
4.5.11 Modify display/DEDS/scratch pad.	The controller enters updated scratch pad data as required.	The controller enters interim altitude message, if appropriate.

TABLE 5-25. PROCESSING FLIGHT PLAN AMENDMENTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
4.5.12 Unflag strip.	The controller unflags the strip after all data have been forwarded and the strip marked appropriately.	The controller unflags the strip after all data have been forwarded and the strip marked appropriately.
4.5.13 Review flight plan change (double check).	The controller reviews the strip to insure that all action has been completed, especially if he has been interrupted.	The controller reviews the strip to insure that all action has been completed, especially if he has been interrupted.
4.5.14 Receive pilot's progress report.	The controller verbally receives a progress report or observes an updated position on the display. He writes the report on the strip in a non-radar environment. The controller writes the report on the strip and enters a progress report into the computer as appropriate.	The controller verbally receives a progress report or observes an updated position on the display. He writes the report on the strip and enters a progress report into the computer, if appropriate.
4.5.15 Check aircraft speed/time for change.	The controller compares the original computed time over the fix and compares it to the current time to determine if a revision is required.	The controller compares the original computed time over the fix and compares it to the current time to determine if a revision is required.

5.3.5 Activity 5: Assess Weather Impact

5.3.5.1 Sub-Activity 5.1: Analyzing Weather Situation/Altitude and Route Determination

See Figure 5-27. The controller not only maintains an awareness of significant weather conditions from PIREPs and weather advisories received, but also attempts to analyze emerging situations to assist in providing aircraft with specific altitude and route changes to avoid danger.

Storm buildups are followed to observe their direction and movement of front lines (Task 5.1.1) and to determine their base and height (Task 5.1.2). This monitoring of the situation helps in determining whether and where holes may exist in the buildup line (Task 5.1.3), enabling the controller to advise pilots of their availability. Navigational assistance around or through known significant weather may be provided. The monitoring further serves to allow the controller to determine if and how the weather is impacting the approach to a terminal or the routes of aircraft in his area of responsibility (Task 5.1.4). Accompanying meteorological/atmospheric conditions serve as a basis for anticipating icing conditions that could impact on some aircraft in his area (Task 5.1.6).

Of a more routine nature, the controller maintains an awareness of the base and height of clouds in the area (Task 5.1.5). This information is for use when advising VFR aircraft wanting to reach and cruise on top of cloud layers or proceed VFR. See Table 5-26 for a comparative subtask description of terminal and en route controller tasks.

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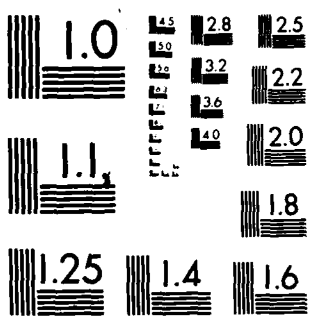

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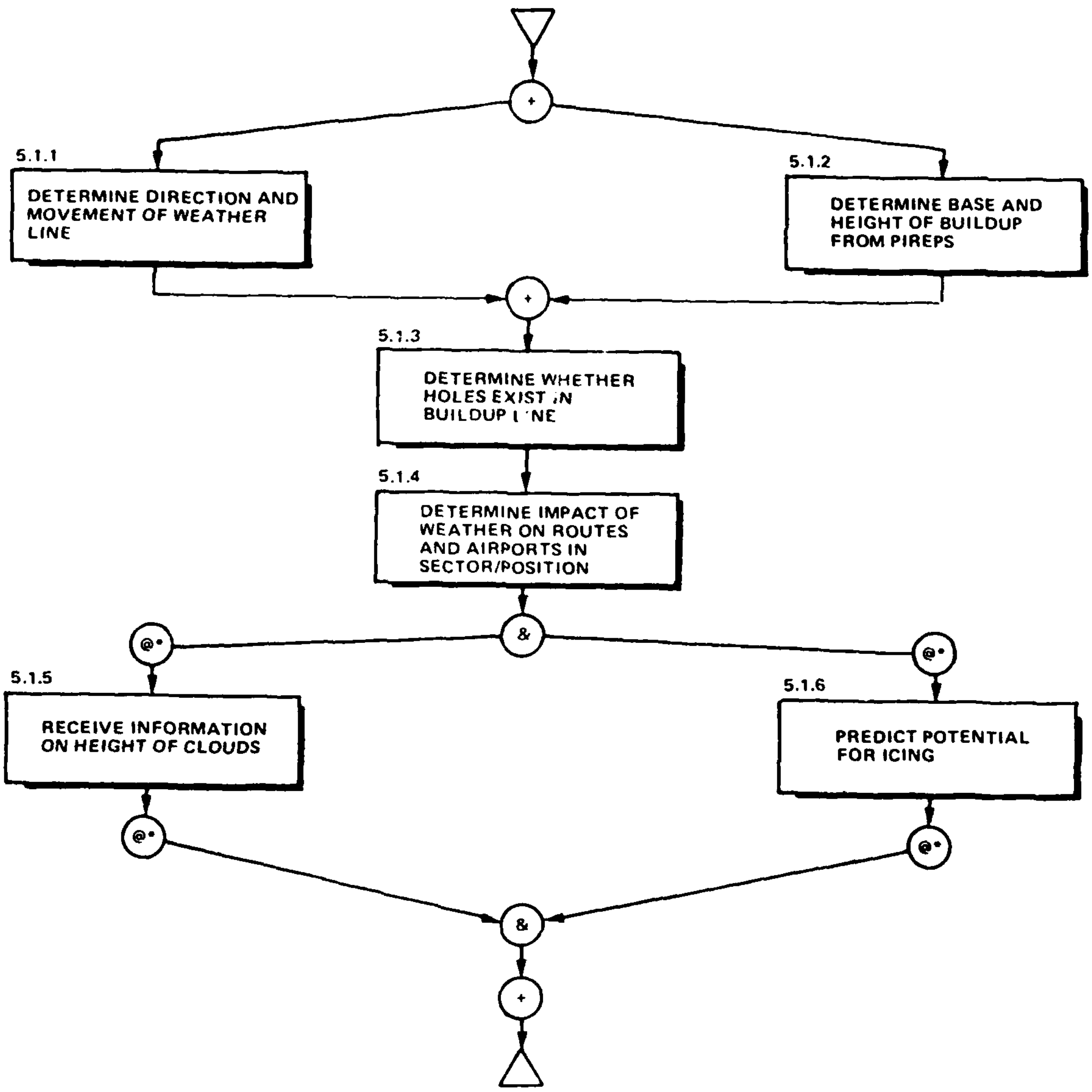


Figure 5-27 Sub-Activity 5.1: Analyzing Weather Situation/Altitude And Route Determination

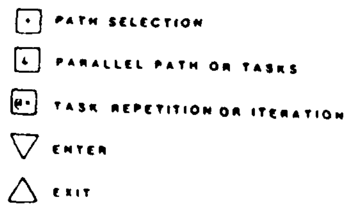


TABLE 5-26. ANALYZING WEATHER SITUATION/ALTITUDE AND ROUTE DETERMINATION

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
5.1.1 Determine direction and movement of weather line.	The controller observes the buildup of cell activity. He determines the speed of the buildup, the direction of the buildup, and the direction of the line of cells.	The controller observes the buildup of cell activity. He determines the speed of the buildup, the direction of the buildup, and the direction of the line of cells.
5.1.2 Determine base and height of buildup from PIREPs.	The controller attempts to obtain from pilot reports the base and height of the buildup.	The controller attempts to obtain from pilot reports the base and height of the buildup.
5.1.3 Determine whether holes exist in buildup line.	The controller observes if any breaks appear in a line of buildup activity. He attempts to verify radar observations through pilot reports.	The controller observes if any breaks appear in a line of buildup activity. He attempts to verify radar observations through pilot reports.
5.1.4 Determine impact of weather on routes and airports in sector/position.	The controller determines if the weather is impacting the route of aircraft or the arrival to an airport.	The controller determines if the weather is impacting the route of aircraft or the arrival to an airport.
5.1.5 Receive information on height of clouds.	Through PIREPs the controller maintains an awareness of the base and height of clouds.	Through PIREPs the controller maintains an awareness of the base and height of clouds.

TABLE 5-26. ANALYZING WEATHER SITUATION/ALTITUDE AND ROUTE DETERMINATION (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
5.1.6 Predict potential for icing.	The controller maintains an awareness of icing conditions, including the possiblity of icing, by PIREPs, cloud formation, and freezing level.	The controller maintains an awareness of icing conditions, including the possibility of icing, by PIREPs, cloud formation, and freezing level.

5.3.5.2 <u>Sub-Activity 5.2: Processing PIREPs</u>

See Figure 5-28. One useful source of weather information is from a pilot presently encountering those conditions. This information expands the controller's specific awareness of significant weather conditions, and provides the controller with timely information to convey to others about evolving weather situations.

Pilot reports (PIREPs) of weather and atmospheric phenomena are requested and/or received (Tasks 5.2.1 and 5.2.2). These are transmitted by air/ground radio. When obtaining the PIREP, the controller determines time, aircraft positioning, altitude, and type of aircraft.

As storms move and build-up, or unforecasted weather occurs, the controller obtains additional information so that other aircraft may be advised of existing conditions before confronting areas of severe weather. By this means the controller learns more about strong frontal activity, squall lines, icing, or turbulence.

Pilot-reported significant weather conditions, whether solicitated or not, are relayed by the controller to other appropriate ATC facilities or aircraft that may be concerned (Tasks 5.2.3 and 5.2.4). Note the interface with Sub-Activity 5.3. See Table 5-27 for a comparative subtask description of terminal and en route controller tasks.

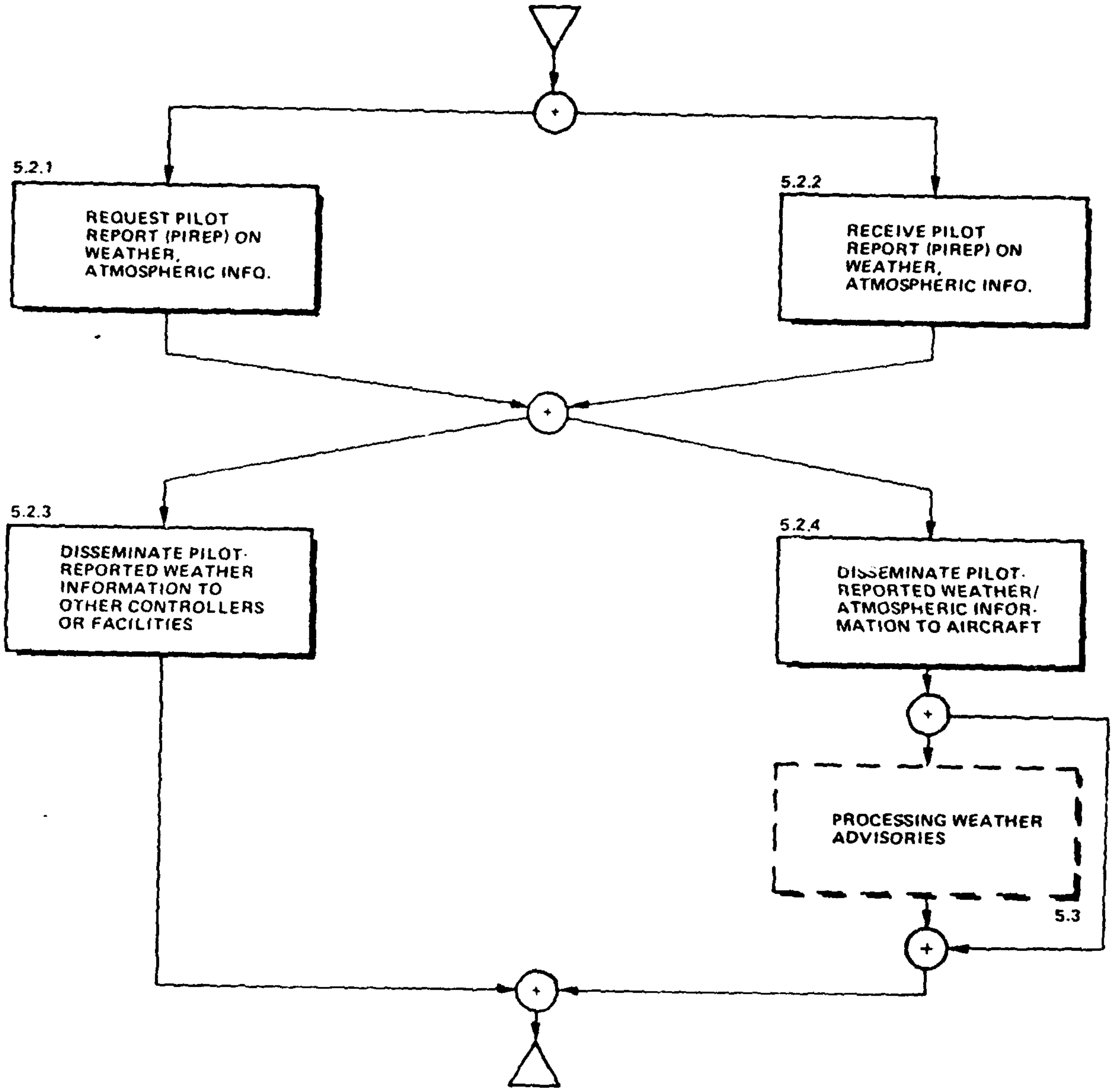


Figure 5-28 Sub-Activity 5.2: Processing PIREPs

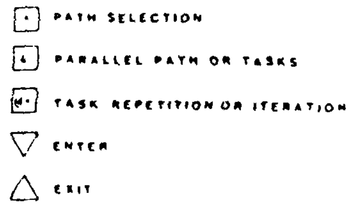


TABLE 5-27. PROCESSING PIREPS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
5.2.1 Request pilot report on weather and atmospheric information.	The controller requests the pilot to describe pertinent weather phenomenom.	The controller requests the pilot to describe pertinent weather phenomenom.
5.2.2 Receive pilot report on weather/atmospheric information.	The pilot either initiates or responds to a request and provides the controller with a description of weather phenomenom that the pilot has or will encounter. The controller writes the data on a strip or on a note pad.	The pilot either initiates or responds to a request and provides the controller with a description of weather phenomenom that the pilot has or will encounter. The controller writes the data on a strip or on a note pad.
5.2.3 Disseminate pilot reported weather information to other controllers or facilities.	After analyzing the data the controller forwards, by interphone, the data to other positions or facilities as appropriate.	After analyzing the data the controller forwards, by interphone, the data to other positions or facilities as appropriate. In addition, the controller forwards the data to the weather coordinator.
5.2.4 Disseminate pilot reported weather/atmospheric information to aircraft.	The controller forwards pertinent weather data to other pilots.	The controller forwards pertinent weather data to other pilots.

5.3.5.3 Sub-Activity 5.3: Processing Weather Advisories

See Figure 5-29. Providing extensive assistance to pilots to plan for severe weather conditions, and their avoidance, is a most important service of controllers (Task 5.3.2). The controllers maintain a check of weather reports and radar indications to determine any significant changes (Task 5.3.3).

Additionally, the Teletype, Computer Readout Device, and voice relay are all further sources of weather-related reports (Task 5.3.1). These reports include SIGMETs (Significant Meteorological Advisories regarding severe or extensive conditions), AIRMETs (Advisories for Light Aircraft regarding less severe matters of concern to some smaller aircraft), Winds and Temperatures Aloft Forecasts, and various more regional route or terminal reports. If a SIGMET alert is received, the controller broadcasts an alert for aircraft to monitor the VOR frequency for this information.

If the aircraft under the controller's jurisdiction are likely to be affected by newly reported weather conditions, the controller will in most cases transmit this information to each pilot (Tasks 5.3.4 and 5.3.5). The controller, from his view of the weather situation, may suggest use of alternative routes/deviations to avoid areas of significant weather (Task 5.3.4). See Table 5-28 for a comparative subtask description of terminal and en route controller tasks.

5.3.5.4 Sub-Activity 5.4: Responding to Weather Changes/Conditions

See Figure 5-30. The controller will constantly be alert to and note any change in the wind direction/velocity and wind shear (Task 5.4.1). The wind direction/ velocity and noise abatement procedures will normally determine the preferred runway in use (Task 5.4.2). The controller will recommend a change in the traffic flow or runway configuration if appropriate (Task 5.4.3).

The controller will also be alert to the lowest usable flight level based upon the current altimeter setting (Task 5.4.4).

The controller will review the control zone weather, ceiling,and visability for VFR or IFR conditions (Task 5.4.5).

See Table 5-29 for a comparative subtask description for terminal and en route controller tasks.

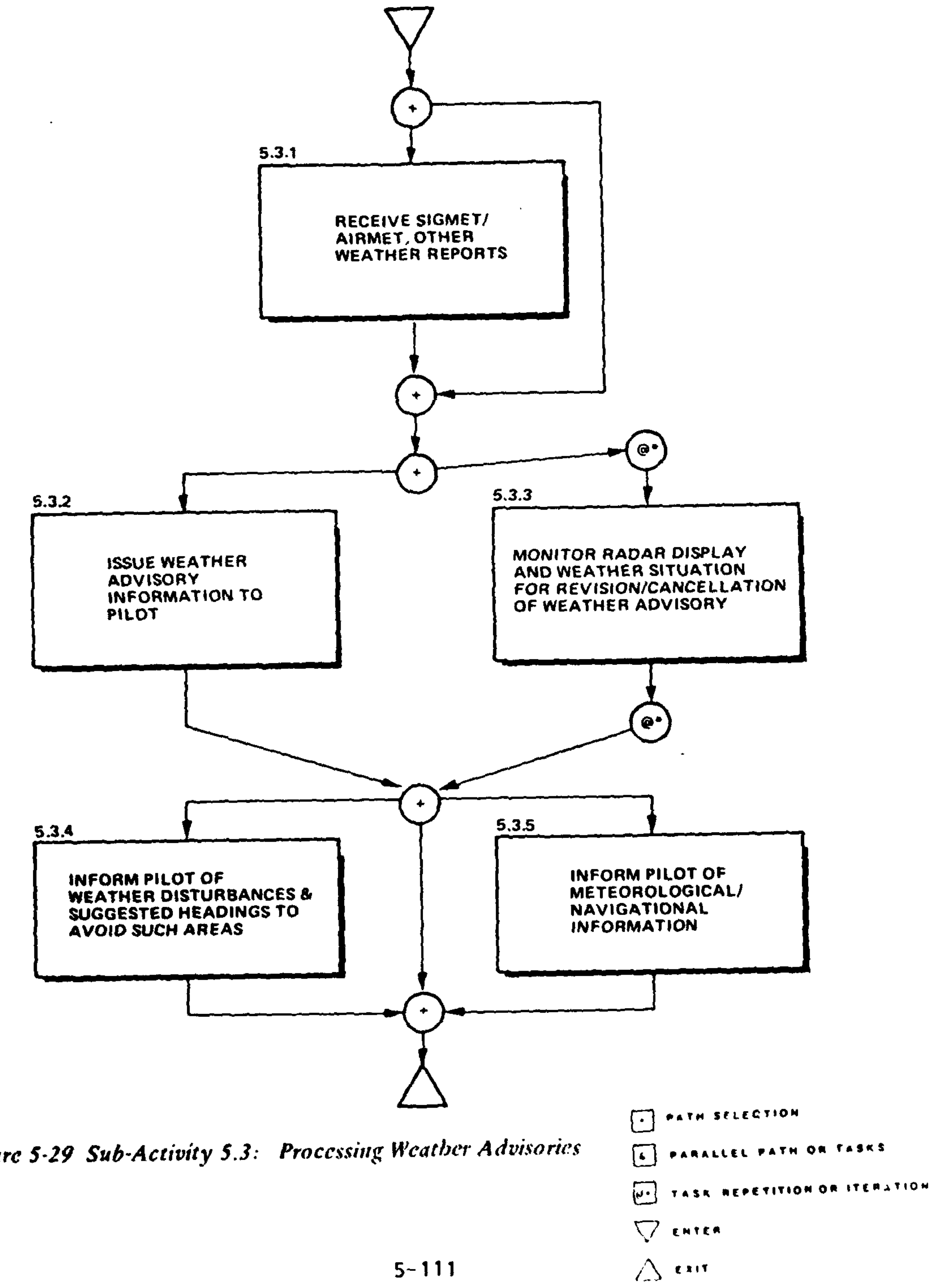
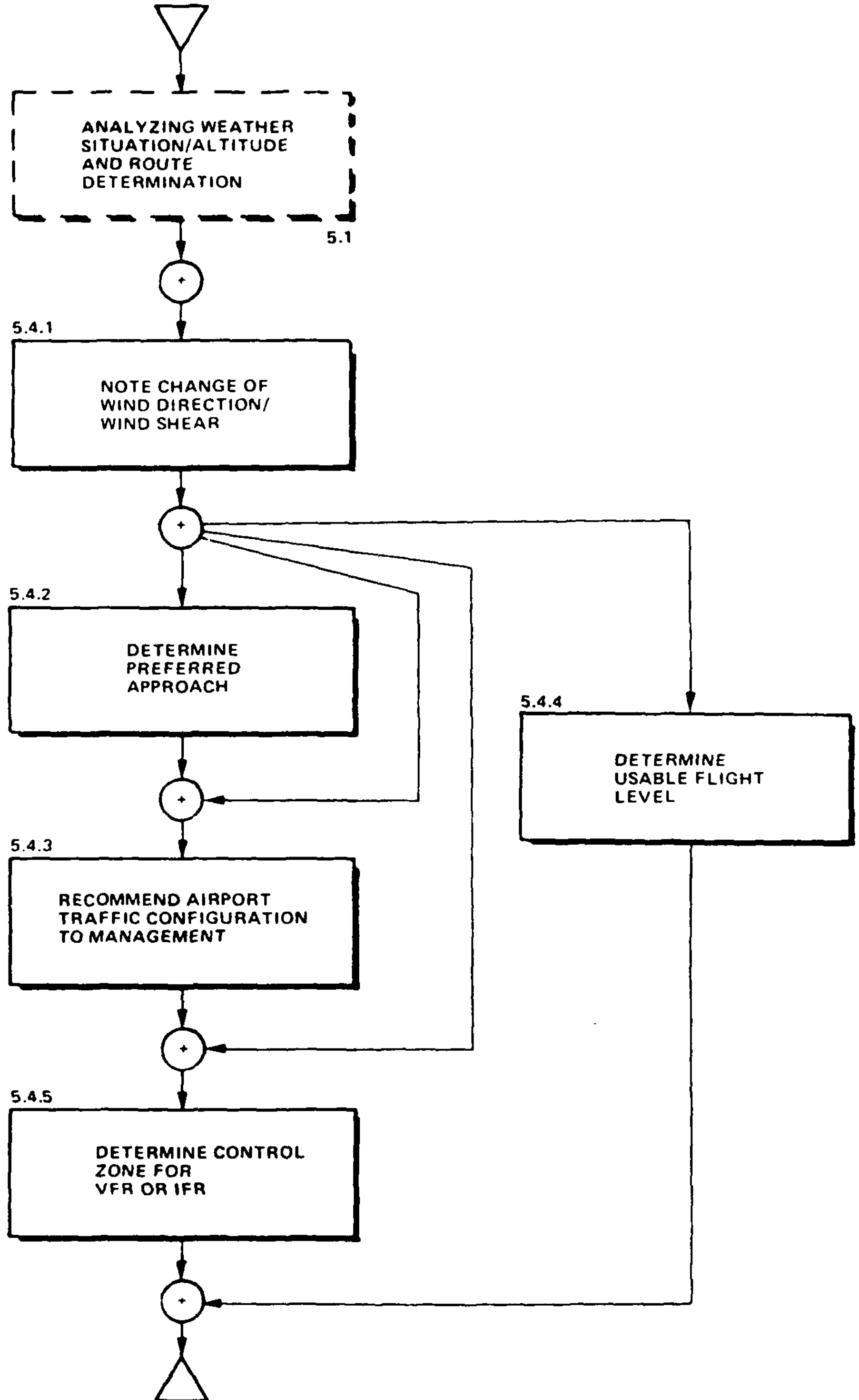


Figure 5-29 Sub-Activity 5.3: Processing Weather Advisories

TABLE 5-28. PROCESSING WEATHER ADVISORIES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
5.3.1 Receive SIGMET/AIRMET, other weather reports.	The controller verbally receives various weather reports. In addition, he receives local weather reports by Telautograph or interphone. The controller also reads wind sheer instruments at airports with wind sheer equipment.	The controller receives general information message or weather briefing from the Weather Coordinator and/or his supervisor. In addition, the computer responds to controller weather request messages and presents weather data.
5.3.2 Issue weather advisory information to pilot.	The controller issues weather advisories to the pilot.	The controller issues weather advisories to the pilot by air/ground radio.
5.3.3 Monitor radar display and weather situation for revision/cancellation of weather advisory.	The controller monitors his display for pertinent changes in the weather, especially the increase/decrease in weather activity.	The controller monitors his display for pertinent changes in the weather, especially the increase/decrease in weather activity.
5.3.4 Inform pilot of weather disturbances and suggested headings for avoiding such areas.	The controller either offers or responds to a pilot request with suggested radar headings to avoid build-up activity.	The controller either offers or responds to a pilot request with suggested radar headings to avoid build-up activity.
5.3.5 Inform pilot of meteorological/navigational information.	The controller informs the pilot of any change in weather or in routing affected by weather.	The controller informs the pilot of any change in weather or in routing affected by weather.



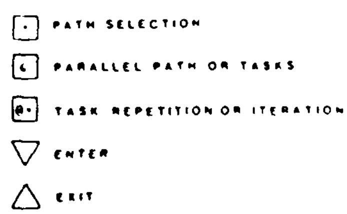


Figure 5-30 Sub-Activity 5.4: Responding To Weather Changes/Conditions

TABLE 5-29. RESPONDING TO WEATHER CHANGES/CONDITIONS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
5.4.1 Note change of wind direction/wind shear.	The controller observes a wind change to determine the significance of the change.	Knowledge of wind direction and velocity are critical for maximum efficiency in vectoring aircraft.
5.4.2 Determine preferred approach.	The controller compares the existing wind direction/velocity with runway criteria.	N/A
5.4.3 Recommend airport traffic configuration to management.	Based upon the above comparison the controller will advise his supervisor of his findings.	N/A
5.4.4 Determine usable flight level.	The controller may observe the current altimeter setting displayed and use appropriate flight levels.	The controller receives information from the supervisor concerning the use of appropriate flight levels.
5.4.5 Determine control zone for VFR/IFR.	The controller reviews current weather information concerning the ceiling and visibility in a control zone and applies this information when receiving requests for special VFR flights.	The controller reviews current weather information concerning the ceiling and visibility in a control zone and applies this information when receiving requests for special VFR flights.

5.3.6 Activity 6: Manage Sector/Position Resources

5.3.6.1 Sub-Activity 6.1: Managing Controlled Airspace Resources

See Figure 5-31. The controller may receive a request for temporary use of his airspace from an adjacent controller or an adjacent facility. In a radar environment this request will be accompanied by a verbal or computer radar pointout (Task 6.1.5). Or, likewise, the controller may make a request for temporary use of airspace (Task 6.1.4). The controller will determine if he has or will have (immediate future) aircraft which will conflict with the release of the requested airspace (Task 6.1.3).

If there isn't any conflict with the release of the airspace, the controller will release the requested airspace and specify the conditions, i.e., duration, etc., on the release (Task 6.1.2).

If the controller is unable, he will so state. If the receiving controller can release part of the airspace, he may try to provide some accommodation for a portion of the airspace if that will help the originating controller (see Task 6.1.2).

After the airspace has been released, a manual controller will write a note that the airspace is released (Task 6.1.8). After the airspace has been released, a radar controller will continue to flight follow the radar pointout, start a track, or start a pseudo track in the airspace that has been released (Task 6.1.9).

The controller will be notified that sector/position reconfiguration will be undertaken (Task 6.1.1). The controller will review his correct current airspace against the airspace associated with reconfiguration. If necessary, the radar controller will handoff and/or transfer communication of aircraft that will leave his control after the reconfiguration is complete. The manual controller will transfer appropriate flight progress strips to the receiving sector/position.

The controller associated with the sector/position which is being combined/decombined will insure that the receiving controller is briefed on the traffic and status items and that all aircraft are transferred, e.g., handed off and frequency changed, if necessary (Task 6.1.6).

The controller will also ensure that proper coordination is maintained in the use or release of shared airspace (Task 6.1.7).

The controller will be notified that an adjacent facility will be closed. The controller will insure that all associated aircraft are in the computer system and displayed at the appropriate sector. The controller may receive a handoff, strip request, or enter a flight plan to insure obtaining all pertinent data (Task 6.1.10).

The controller will be notified that an adjacent facility will be opened. The controller will determine from the receiving controller as to what flight plan and radar data are required. The controller will either strip request, force to ARTS, or request a Data Systems Coordinator restore ARTS data base as appropriate (Task 6.1.11).

See Table 5-30 for a comparative subtask description of terminal and en route controller tasks.

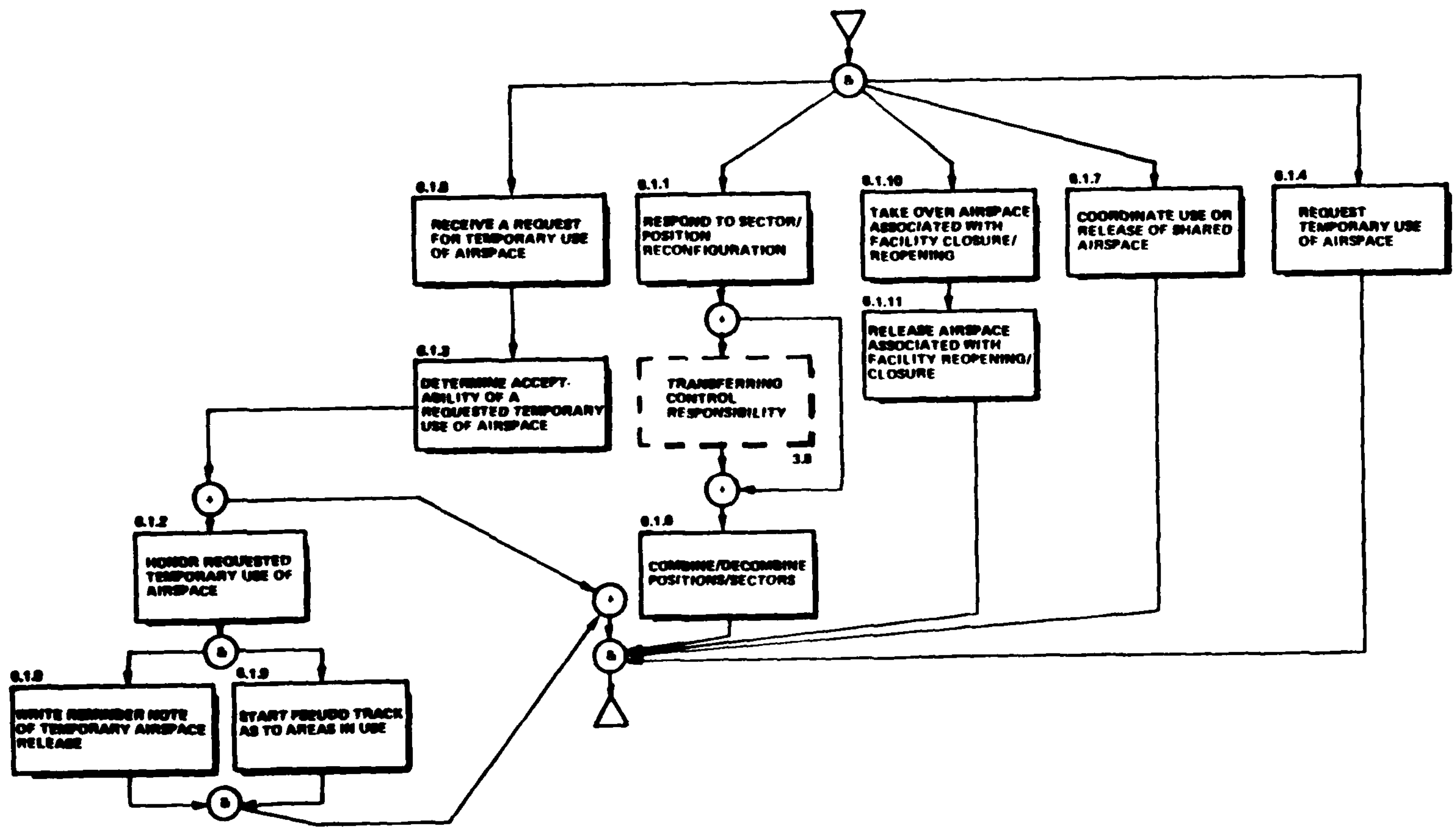


Figure 5-31 Sub-Activity 6.1: Managing Controlled Airspace Resources

TABLE 5-30. MANAGING CONTROLLED AIRSPACE RESOURCES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.1.1 Repond to sector/position reconfiguration.	The controller reviews the airspace associated with the new configuration.	The controller reviews the airspace associated with the new configuration.
6.1.2 Honor a requested temporary use of airspace.	If appropriate, the controller approves the request for airspace.	If appropriate, the controller approves the request for airspace.
6.1.3 Determine acceptability of a requested temporary use of airspace.	The controller determines if any aircraft are or will be in the airspace in the time period for which the airspace will be released.	The controller determines if any aircraft are or will be in the airspace in the time period for which the airspace will be released.
6.1.4 Request temporary use of airspace.	The controller may request temporary use of adjacent airspace. He will coordinate the conditions of its use with the adjacent controller.	The controller may request temporary use of adjacent airspace. He will coordinate the conditions of its use with the adjacent controller.
6.1.5 Receive a request for temporary use of airspace.	The controller receives a verbal request for temporary use of airspace.	The controller receives a verbal request for temporary use of airspace.

TABLE 5-30. MANAGING CONTROLLED AIRSPACE RESOURCES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.1.6 Combine/decombine positions/sectors.	The controller either briefs or receives a briefing on the aircraft in the sector he is releasing or assuming. The controller insures that the aircraft are tracked by the proper position by using the keyboard handoff message if required, and insures that the proper frequency switches are enabled/disabled. He notifies adjacent positions/sectors of airspace realignment.	The controller either briefs or receives a briefing (using the briefing checklist) on the aircraft in the sector he is releasing or assuming. The controller insures that the aircraft are tracked by the proper position by using the keyboard handoff message if required, and insures that the proper frequency switches are enabled/disabled. He notifies adjacent sectors/positions of airspace realignment.
6.1.7 Coordinate use or release of shared airspace.	The controller requests or releases airspace that is shared with another position.	N/A
6.1.8 Write reminder note of temporary airspace release.	The controller writes a note that the airspace is released.	The controller writes a note that the airspace is released.
6.1.9 Start pseudo track as to areas in use.	The controller starts a track with an appropriate call sign and hands off o an unused posi- on to freeze the ·k and to show area in use.	The controller starts a track with an appropriate call sign to show the area in use.

TABLE 5-30. MANAGING CONTROLLED AIRSPACE RESOURCES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.1.10 Take over airspace associated with facility closure/re-opening.	The controller receives notification from the center of any aircraft in the area. The controller initiates communication with the aircraft and starts a track using the track start message.	The controller receives notification from the releasing facility of any aircraft in the area. The controller initiates communication with the aircraft and starts a track using the track start message. He requests a computer entry to change fix posting area from terminal to center control.
6.1.11 Release airspace associated with facility re-opening/closure.	The controller notifies the center sector of the release of airspace and the aircraft that are in the area. He instructs the aircraft to contact the center, if appropriate.	The controller notifies the approach control of any aircraft in the area. He instructs the aircraft to contact the approach control, if appropriate. He requests the supervisor to restore the ARTS Data Base, using the RB message.

5.3.6.2 Sub-Activity 6.2: Setting Up Workstation Hardware/Software Configuration

See Figure 5-32. Upon entering for duty at a sector/position the controller will observe the overall state of traffic flow (e.g., heavy, medium, light), weather activity, and notes pertinent to airspace (Task 6.2.1).

The entering controller will plug-in with the controller to be relieved and receive an in-depth briefing on traffic, weather, and other status items (Task 6.2.2).

The controller will verify that all display and communication switches are in the proper position (Task 6.2.3); adjust the communications volume and display to his personal preference (Task 6.2.4); correlate flight strips and tabular lists and/or data blocks (Task 6.2.5); and insure that the display is presenting critical data, i.e., filter limits, conflict alert, etc. (Task 6.2.6).

The controller will also visually check to ensure that the scope alignment (integrity of radar data, range, off centering, etc.) is proper for the position and that targets are within tolerance (Task 6.2.7).

See Table 5-31 for a comparative subtask description of terminal and en route controller tasks.

5.3.6.3 Sub-Activity 6.3: Responding to Transient Fault Events

See Figure 5-33. The controller will scan the display clock and his frequency lights to occasionally reassure himself that the systems are functioning. This is especially true if he senses something is wrong, e.g., the pilot does not answer the first call (Task 6.3.1)

The controller will attempt to immediately identify any aircraft that has not been handed off that is in or about to be in the controller's sector/position (Task 6.3.10).

The controller will detect unreliable air/ground communication by failure to establish satisfactory communication with aircraft (Task 6.3.5).

The controller will then contact other aircraft to determine if others are in satisfactory communication (Task 6.3.6).

If other aircraft are in satisfactory communication, the controller will attempt to issue alternate instructions to the aircraft who is not communicating. If there is a problem with the controller's communications equipment, the controller will provide for an alternate frequency or use another form of communication, such as a relay through the nearest Flight Service Station (Task 6.3.7).

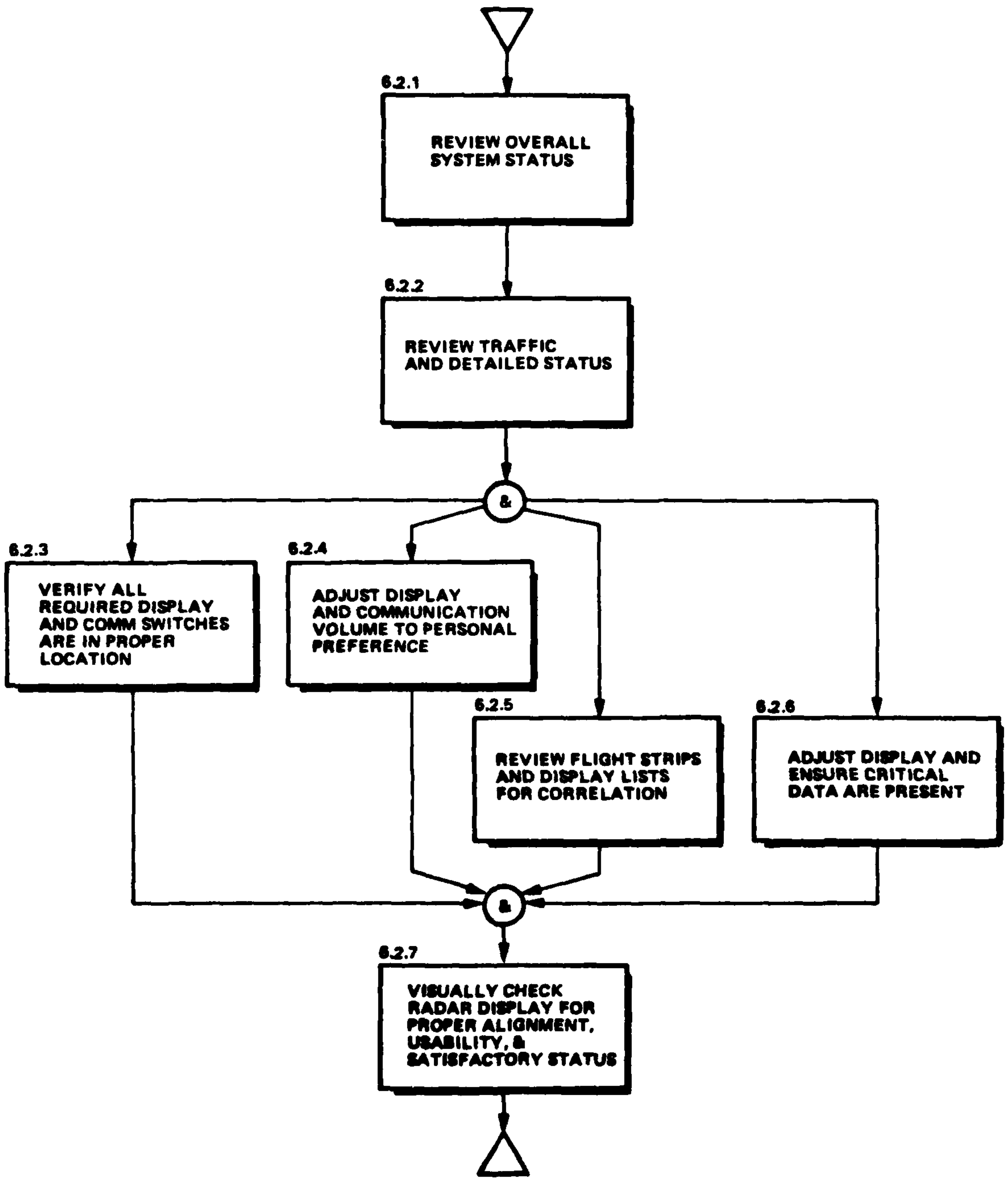


Figure 5-32 Sub-Activity 6.2: Setting Up Workstation HW/SW Configuration

TABLE 5-31. SETTING UP WORKSTATION HW/SW CONFIGURATION

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.2.1 Review overall system status.	The controller reviews the position status, noting such items as traffic flow, special notes concerning airspace, NAVAID, communication, sector configuration, etc.	The controller reviews the position status, noting such items as traffic flow, special notes concerning airspace, NAVAID, communication, sector configuration, etc.
6.2.2 Review traffic and detailed status.	The controller receives a briefing on all traffic situations, status items, and special operations and assumes control of the airspace.	The controller receives a briefing on all traffic situations, status items, and special operations and assumes control of the airspace.
6.2.3 Verify all required display and communication switches are in proper location.	The controller visually checks all display and communication switches to insure they are in the proper position.	The controller visually checks all display and communication switches to insure they are in the proper position.
6.2.4 Adjust display and communication volume to personal preference.	The controller adjusts the focus, brightness, contrast, leader direction (LDR message), preview area (PRE message), offset (OFF message), system area (SYS message), tabular area (TAB message), Beacon Code selections (BCN message), and communication volume to his preference.	The controller adjusts focus, brightness, contrast, leader length, vector line, history, and communications volume to his preference.

TABLE 5-31. SETTING UP WORKSTATION HW/SW CONFIGURATION (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.2.5 Review flight strips and display lists for correlation.	The controller reviews the flight progress strips and display lists. He correlates the aircraft to determine if deadwood exists. If so, he removes either the strip or the item in the display list by the drop track message.	The controller reviews the flight progress strips and display lists. He correlates the aircraft to determine if deadwood exists. If so, he removes either the strip or the item in the display list by the drop track message.
6.2.6 Adjust display and insure critical data are present.	The controller observes that CA/MSAW alert status is proper. He also observes the filter limits and insures they are correctly set.	The controller observes that the CA/MSAW status is proper. He also observes that the filter buttons are correctly set.
6.2.7 Visually check radar display for proper alignment, usability and satisfactory status.	The controller observes the off-centering, range, and target detection for proper display.	The controller observes the off-centering, range, and target detection for proper display.

The controller will be alert to any momentary interruption of data on his display (Task 6.3.2).

The controller will detect non-acceptance of input data to the computer (Task 6.3.3). The controller will forward the unsuccessful transmitted data via interphone (Task 6.3.4) or force a missing message to ARTS (Task 6.3.9), as appropriate.

The controller detects presence of the indicator that a duplicate beacon code has been assigned to an aircraft (Task 6.3.12). Terminal controllers must request a new code from the computer (Task 6.3.13), but center computer automatically displays a new code available for assignment. The data base will be updated by the terminal controller with the new code assignment (Task 4.5.10), and the pilot will be informed (Task 1.5.2) by terminal and center controllers.

The controller will alert the supervisor of all faults that require correction by maintenance or Data Systems personnel (Task 6.3.8).

Routine advisories will be issued by the controller for pertinent equipment outages (Task 6.3.11).

See Table 5-32 for a comparative subtask description of terminal and en route controller tasks.

5.3.6.4 <u>Sub-Activity 6.4: Executing Backup Procedures for RDP Faults</u>

See Figure 5-34. The controller will alert other controllers/facilities of a radar display/computer outage as soon as possible (Task 6.4.1).

The center controller will revert to Direct Access Radar Channel (DARC), and the terminal controller will remain on broadband when ARTS is lost (Task 6.4.2).

The controller will reidentify aircraft if radar contact or identification has been lost (Task 6.4.3).

The controller will clear aircraft to change to code banks if appropriate (Task 6.4.4).

The controller will request position/progress reports if DARC is not available for altitude data or if the radar is out of service (Task 6.4.5).

When transitioning back to a restored computer driven system, controllers will start tracks on any targets that are not automatically restarted (Task 6.4.6) and will restore the ARTS data base through the Data Systems Coordinator or the force to ARTS (RF) message (Task 6.4.7).

The controllers will confirm keyboard entries made during the transition to/from manual to automated mode if appropriate (Task 6.4.8).

See Table 5-33 for a comparative subtask description of terminal and en route controller tasks.

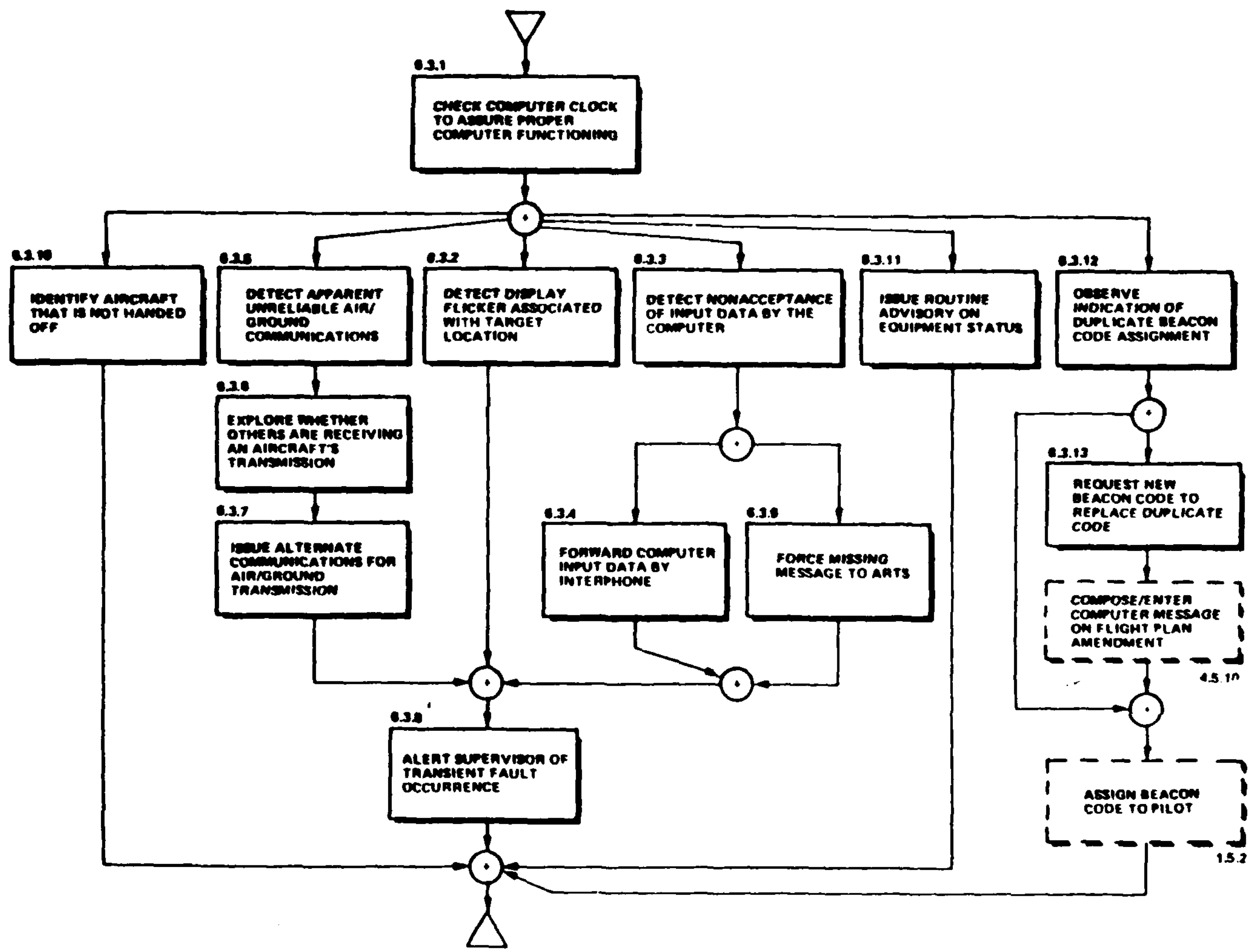


Figure 5-33 Sub-Activity 6.3: Responding To Transient Fault Events

TABLE 5-32. RESPONDING TO TRANSIENT FAULT EVENTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.3.1 Check computer to assure proper computer functioning.	The controller visually checks the clock on a display.	The controller visually checks the clock on a display.
6.3.2 Detect display flicker associated with target location.	The controller visually determines if the display or alphanumeric data is flickering.	The controller visually determines if the display or alphanumeric data is flickering.
6.3.3 Detect nonacceptance of input data by the computer.	The controller detects if the ARTS or FDEP is not accepting input data. He also detects if the data are being accepted but not transmitted on-line to the center's computer.	The controller detects if the manual or radar keyboards are not accepting data. The controller also receives Unsuccessful Transmission Messages (UTMs) on his CRD if an interface problem exists.
6.3.4 Forward computer input data by interphone.	The controller forwards all data that are not accepted or transmitted by the computer. He indicates the data have been passed by marking the strip.	The controller forwards all data that are not accepted or transmitted by the computer. He will indicate the data have been passed by marking the forwarded data on the strip.
6.3.5 Detect apparent unreliable air/ground communications.	The controller determines if an aircraft is not responding to controller's communication.	The controller determines if an aircraft is not responding to controller's communication.

TABLE 5-32. RESPONDING TO TRANSIENT FAULT EVENTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.3.6 Explore whether others are receiving an aircraft's transmissions.	The controller attempts to contact other aircraft on the frequency to see if they are receiving his transmission.	The controller attempts to contact other aircraft on the frequency to see if they are receiving his transmission.
6.3.7 Issue alternate communications for air/ground transmission.	If it is a single aircraft with a transient problem, the controller may elect to communicate through other aircraft or a NAVAID. If it is the controller's equipment, the controller will switch transmitters/receivers. He will request another aircraft to broadcast a frequency change if appropriate.	If it is a single aircraft with a transient problem, the controller may elect to communicate through other aircraft or a NAVAID. If it is the controller's equipment, the controller will switch transmitters/receivers. He will request another aircraft to broadcast a frequency change if appropriate.
6.3.8 Alert supervisor of transient fault occurrence.	The controller advises the supervisor of any series of transient faults, faults that create a special problem, or extended faults.	The controller advises the supervisor of any series of transient faults, faults that create a special problem, or extended faults.

TABLE 5-32. RESPONDING TO TRANSIENT FAULT EVENTS (Cont'd)

Information Processing Tasks	Terminal Subtask Description	En Route Subtask Description
6.3.9 Force missing message to ARTS.	If the center/ARTS interface had a transient fault or if the ARTS had temporarily reached capacity, upon receiving a UTM or a request from the terminal, the controller forces an ARTS message by the RF message on the FDEP.	If the center/ARTS interface had a transient fault or if the ARTS had temporarily reached capacity, upon receiving a UTM or a request from the terminal, the controller forces an ARTS message by the RF message.
6.3.10 Identify aircraft that is not handed off.	The controller visually detects aircraft that are entering area that appear to be IFR (by beacon code, altitude or track symbology) that have not been handed off. Controller may force a data block onto his display.	The controller visually detects aircraft that are entering area that appear to be IFR (by beacon code, altitude or track symbology) that have not been handed off. Controller may force a data block onto his display.
6.3.11 Issue routine advisory on equipment status.	The controller verbally notifies other positions, facilities, and aircraft of pertinent equipment outages.	The controller verbally notifies other positions, facilities, and aircraft of pertinent equipment outages.
6.3.12 Observe indication of duplicate beacon code assignment.	The controller will observe the duplicate beacon code indicator on the tabular list.	The controller will observe the computer readout message that a new beacon code assignment is required for the flight.
6.3.13 Request new beacon code to replace duplicate code.	The controller will request a new code from the computer.	The controller will request a new code from the computer.

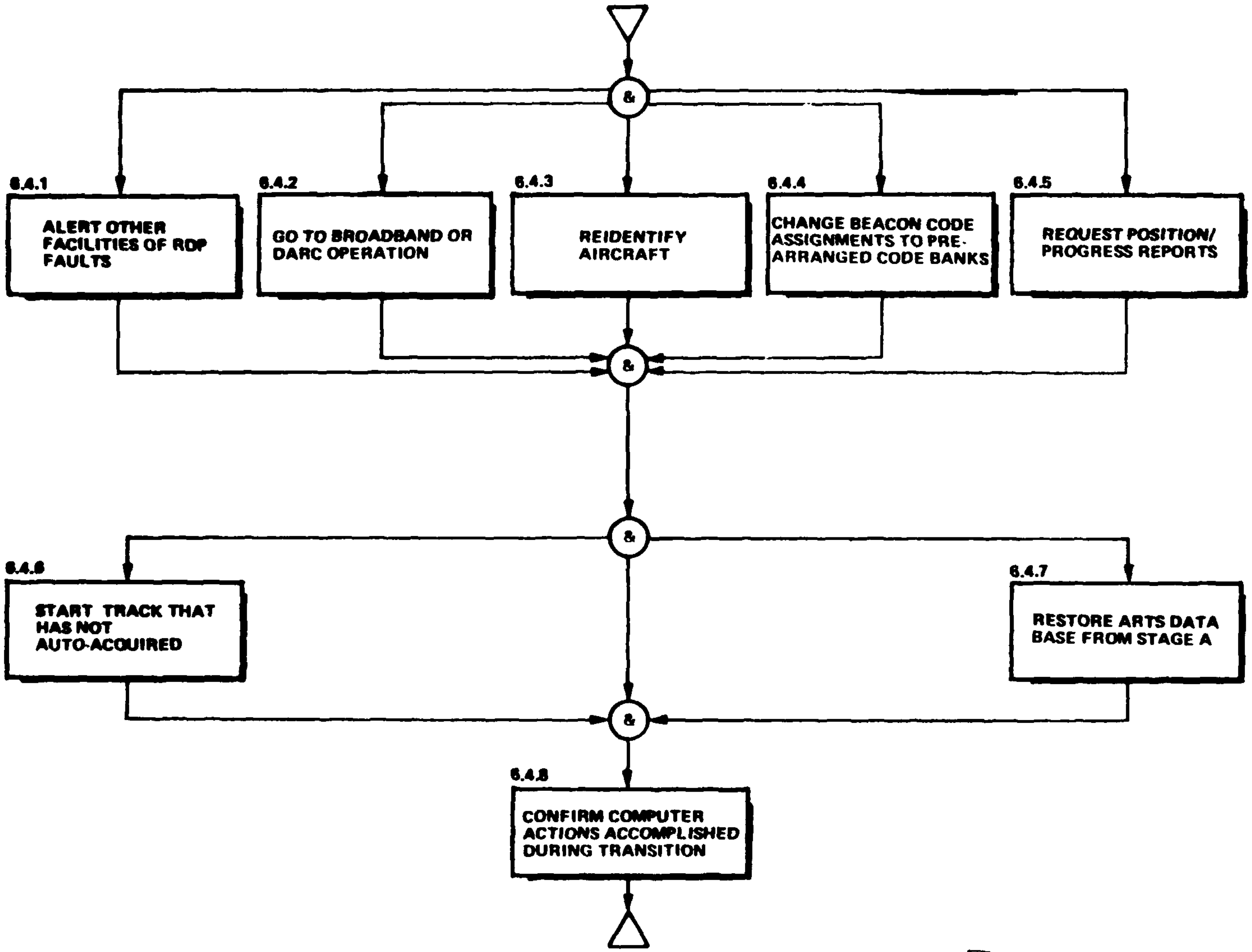


Figure 5-34 Sub-Activity 6.4: Executing Backup Procedures for RDP Faults

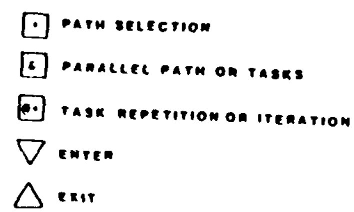


TABLE 5-33. EXECUTING BACKUP PROCEDURES FOR RDP FAULTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.4.1 Alert other facilities of RDP fault.	The controller advises adjacent facilities of any faults involving the ARTS.	controller advises adjacent facilities of any faults involving the RDP.
6.4.2 Go to broadband or DARC operation.	Upon an ARTS fault, the controller reverts to broadband radar.	Facilities have written local procedures which dictate controller actions after an RDP fault. The controller may use DARC with FDP for a specific time and may or may not use shrimp boats with DARC, depending on facility option. The controller may place the display in a horizontal position after reverting to DARC. (Refer to Order 7110.85, Direct Access Radar Channel)
6.4.3 Reidentify aircraft.	The controller reidentifies aircraft if required. This is accomplished by transponder, pilot report, or identifying turns.	The controller reidentifies aircraft if required. This is accomplished by transponder or pilot report. In addition, the controller marks the strips for radar contact.

TABLE 5-33. EXECUTING BACKUP PROCEDURES FOR RDP FAULTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.4.4 Change beacon code assignments to prearranged code banks.	The controller changes aircraft from discrete beacon codes to block code assignments for use with a 10 channel decoder.	Depending on facility procedures, discrete codes assigned by FDP may be used by DARC for a specified time period. After this period non-discrete code banks will be used.
6.4.5 Request position/progress reports.	The controller requests altitude reports as required. If the radar is out, the controller requests progress reports.	N/A (DARC)
6.4.6 Start track that has not auto-acquired.	The controller starts track on any aircraft that has not auto-acquired, by using the start track message.	The controller starts track on any aircraft that has not auto-acquired, by using the track message.
6.4.7 Restore ARTS data base from Stage A.	N/A	The controller requests the supervisor or data system specialist to restore the ARTS data base by using the RB message.
6.4.8 Confirm computer actions accomplished during transition.	The controller verbally confirms computer actions taken just immediately prior to any fault and during the transition back to an automated mode.	The controller will confirm computer actions taken just immediately prior to any fault and during the transition back to an automated mode.

5.3.6.5 Sub-Activity 6.5: Executing Backup Procedures for FDP Faults

See Figure 5-35. The en route manual controller will immediately advise other facilities of an FDP fault. The ARTS controller will notify the center controllers if the FDEP is out of service (Task 6.5.1). An FDP fault automatically creates an RDP fault (Sub-Activity 6.4). The controller will pass any data not previously forwarded by the computer (Task 6.5.2).

The en route manual controller will determine what information had been passed by the computer to the next controller/facility (Task 6.5.3).

The radar controller will assist the manual controller during transition periods by verifying data, especially altitude amendments, when making manual handoffs (Task 6.5.5).

The en route manual controller shall insure that all required data are reentered after the computer system is operational (Task 6.5.4).

See Table 5-34 for a comparative subtask description of terminal and en route controller tasks.

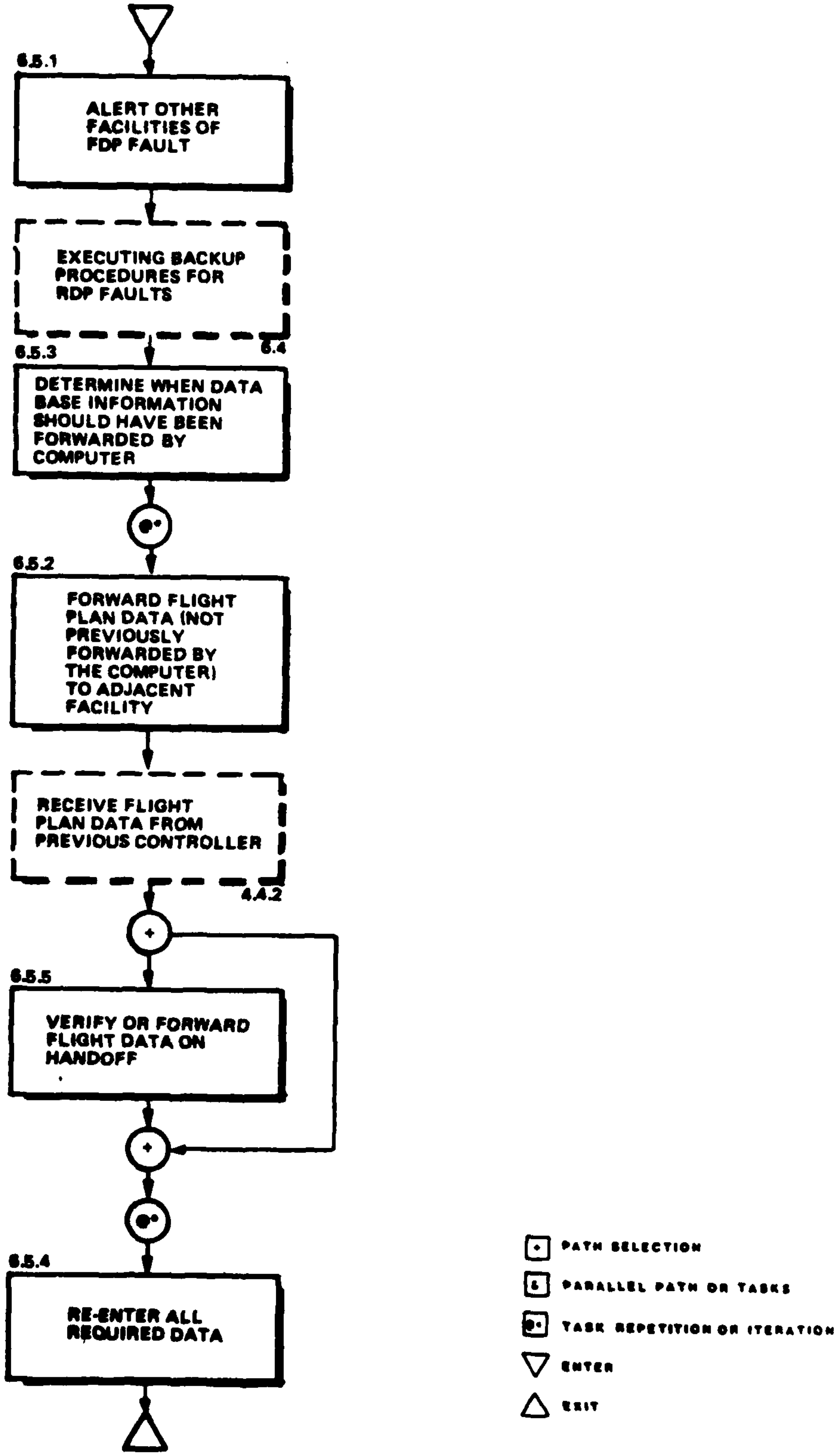


Figure 5-35 Sub-Activity 6.5: Executing Backup Procedures For FDP Faults

TABLE 5-34. EXECUTING BACKUP PROCEDURES FOR FDP FAULTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.5.1 Alert other facilities of FDP fault.	The controller advises the center controller and adjacent facilities if the FDEP is down.	The controller advises adjacent facilities when FDP (RDP) is down.
6.5.2 Forward flight plan data (not previously forwarded by the computer) to adjacent facility.	The controller will verbally forward appropriate flight plan data that were not forwarded by the computer system.	The controller will verbally forward appropriate flight plan data that were not forwarded by the computer system.
6.5.3 Determine when data base information should have been forwarded by computer.	N/A	The controller notes when the fault occurred and when data should have been passed to next position/facility. Any data in question must be confirmed.
6.5.4 Reenter all required data on transition to automated mode.	N/A	The controller enters or reenters all data that have not been recovered (RESCUED) during the outage. The controller verifies all data on any reprinted strip and marks the strips as appropriate.
6.5.5 Verify or forward flight data on handoff.	N/A	The radar controller confirms data, especially altitude data, revised, just prior to fault during the verbal handoff.

5.3.6.6 Sub-Activity 6.6: Executing Backup NAVAID Procedures (Route Substitution)

See Figure 5-36. The controller will obtain substitute routing for routes affected by the outage of a navigation aid (Task 6.6.1).

The controller will copy the substitute routing on a note pad or a flight progress strip (Task 6.6.4).

The controller will plan the reroute of aircraft scheduled to come into the sector/position (Task 6.6.3).

The controller will reroute aircraft, as appropriate, that will be using the NAVAID (Task 6.6.2).

The controller will monitor the status through pilot reports of radio aids for navigation (Task 6.6.5).

The controller will notify pilots of the change in NAVAIDS especially during transition times prior to the issuance of NOTAMS (Task 6.6.6).

See Table 5-35 for a comparative subtask description for terminal and en route controller tasks.

5.3.6.7 Sub-Activity 6.7: Executing Backup Procedures for Communication Faults

See Figure 5-37. The controller will determine a communications failure of either the interphone or air/ground frequency (Task 6.7.1).

The controller will determine what communication systems are impacted and which systems are in operation. From this information he will plan on using the systems available to effect air traffic control (Task 6.7.2).

If the air/ground frequency is out of service the controller will check the availability of another channel, whether he can switch to Backup Emergency Communications (BUEC), or use another frequency which is terminated at the sector/position. In a terminal the controller may check on a battery operated frequency (Task 6.7.3).

The pilot will be advised to change to another frequency, as appropriate (Task 6.7.4). This may be accomplished through another aircraft or by a broadcast by the FSS on the NAVAID.

The controller will advise the supervisor of a communication failure, either interphone or air/ground frequency (Task 6.7.5). The controller will notify the supervisor of any change made in the air/ground frequency or request a frequency if one is not available (Task 6.7.6).

The controller will also notify adjacent controllers/facilities of a change in air/ground frequency (Task 6.7.7).

See Table 5-36 for a comparative subtask description of terminal and en route controller tasks.

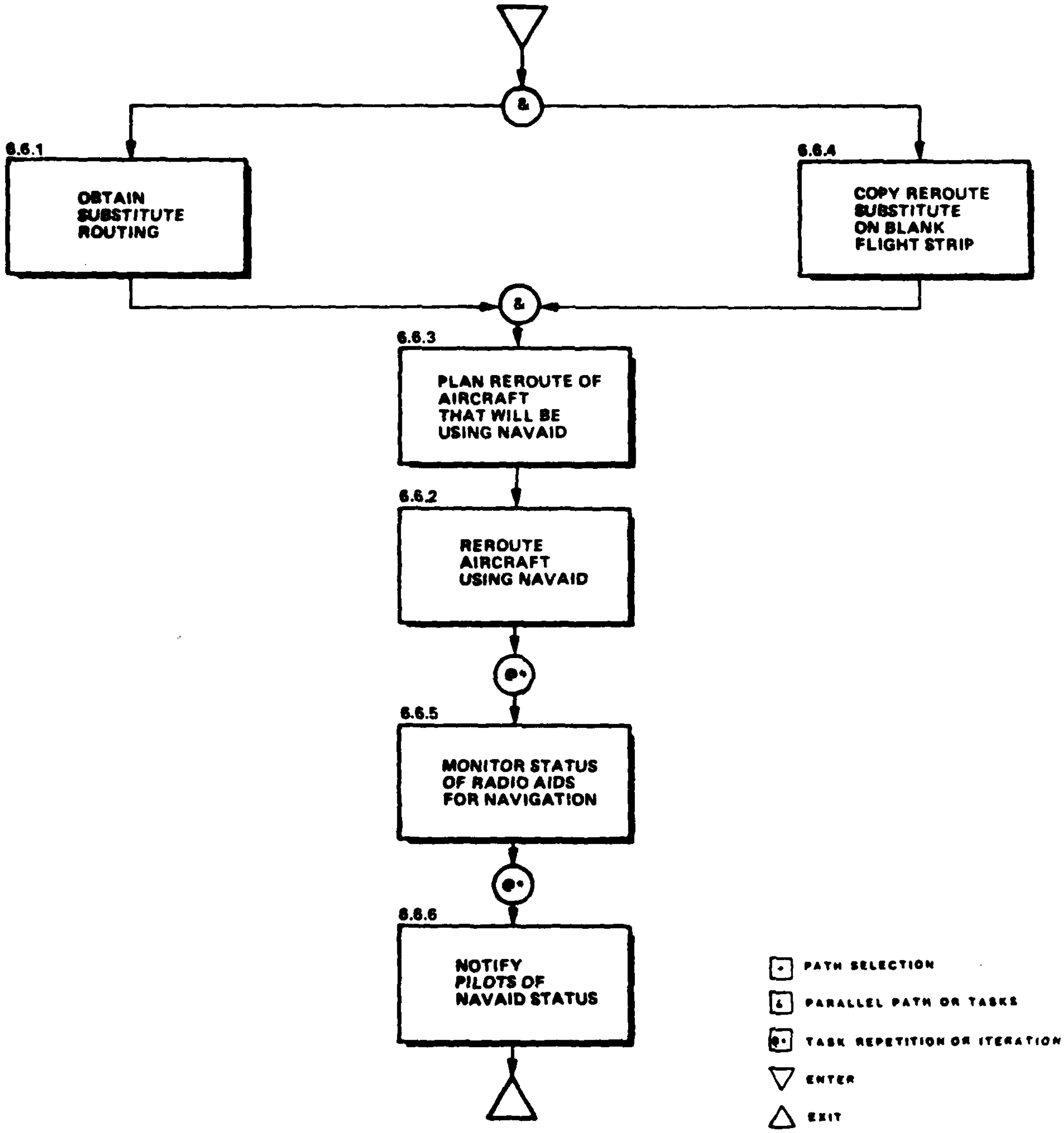


Figure 5-36 Sub-Activity 6.6: Executing Backup NAVAID Procedures (Route Substitution)

TABLE 5-35. EXECUTING BACKUP NAVAID PROCEDURES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.6.1 Obtain substitute routing.	The controller obtains substitute routing from either published procedures or his supervisor during NAVAID failures.	The controller obtains substitute routing from either published procedures or his supervisor during NAVAID failures.
6.6.2 Reroute aircraft using NAVAID.	The controller reclears aircraft via the substitute routing. If the rerouting takes place just inside the controller's area, he requests the previous controller/facility issue the reroute.	The controller reclears aircraft via the substitute routing. If the rerouting takes place just inside the controller's area, he requests the previous controller/facility issue the reroute.
6.6.3 Plan reroute of aircraft that will be using NAVAID.	The controller observes all strips for aircraft that will be using the NAVAID that is not operational. The controller notes substitute routing on the strip.	The controller observes all strips for aircraft that will be using the NAVAID that is not operational. The controller notes substitute routing on the strip.
6.6.4 Copy reroute substitute on blank flight strip.	The controller copies substitute routing on a flight progress strip or note pad.	The controller copies substitute routing on a flight progress strip or note pad.
6.6.5 Monitor status of radio aids for navigation.	The controller queries pilots regarding the receipt of any NAVAID that is in question.	The controller queries pilots regarding the receipt of any NAVAID that is in question.

TABLE 5-35. EXECUTING BACKUP NAVAID PROCEDURES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.6.6 Notify pilots of NAVAID status.	The controller notifies the pilot of the status of any NAVAID when it is out of service or when it is returned to service.	The controller notifies the pilot of the status of any NAVAID when it is out of service or when it is returned to service.

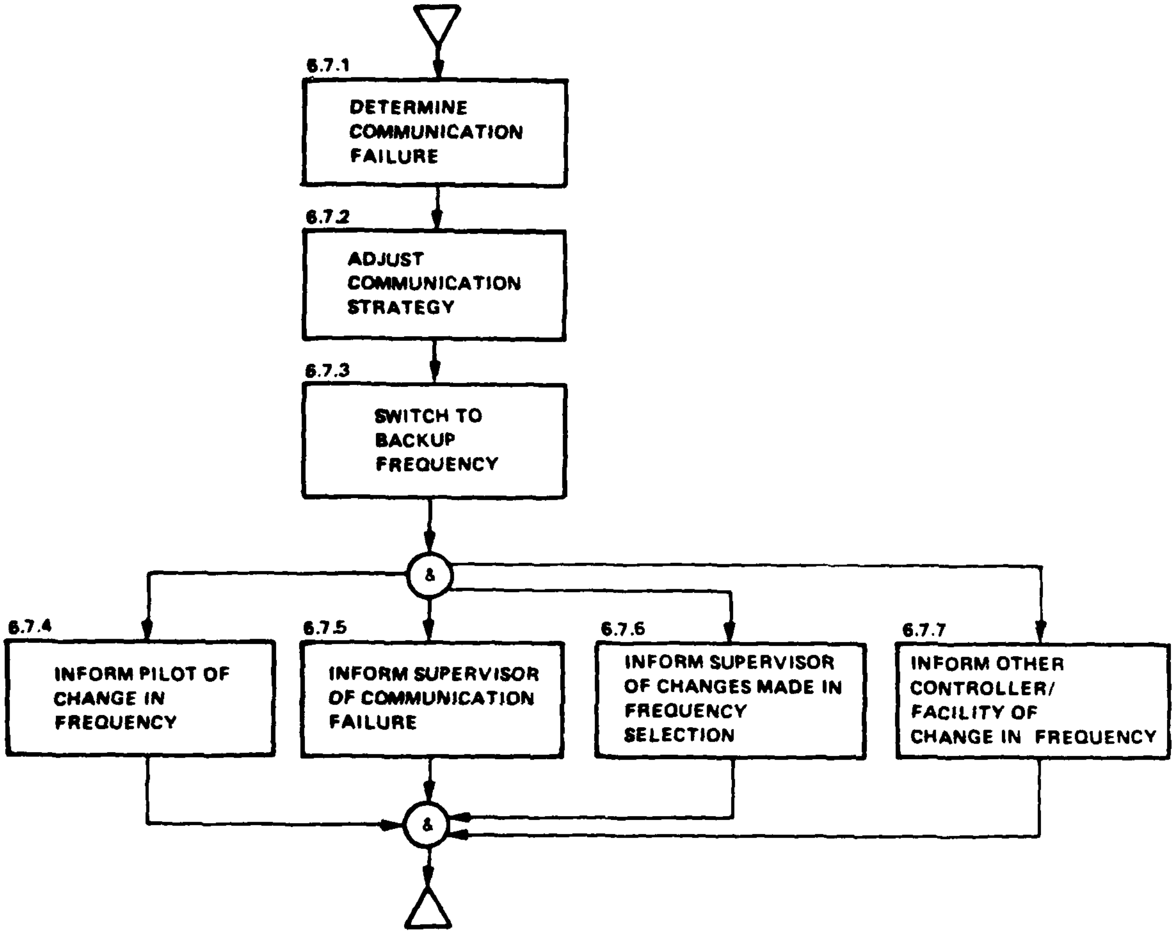


Figure 5-37 Sub-Activity 6.7: Executing Backup Procedures For Communication Faults

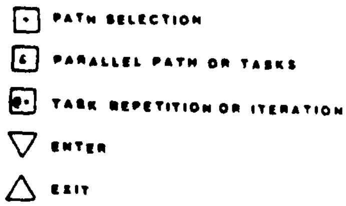


TABLE 5-36. EXECUTING BACKUP PROCEDURES FOR COMMUNICATION FAULTS

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.7.1 Determine communication failure.	The controller determines a failure when he is unable to receive any pilot to respond either through the frequency or the ident feature on the display.	The controller determines a failure when he is unable to receive any pilot to respond either through the frequency or the ident feature on the display.
6.7.2 Adjust communication strategy.	The controller determines if another frequency is available, if the FSS can be used, or other methods for communication exist, i.e., battery operated frequency.	The controller determines if another frequency is available, if the FSS can be used, or other methods for communication exist, i.e., battery operated frequency.
6.7.3 Switch to backup frequency.	The controller switches to a backup frequency.	The controller switches to a backup frequency.
6.7.4 Inform pilot of change in frequency.	The controller broadcasts a frequency change, requests the FSS to broadcast the change on the NAVAID, requests another controller to have one of his aircraft broadcast the frequency change on the old frequency, or all of the above.	The controller broadcasts a frequency change, requests the FSS to broadcast the change on the NAVAID, requests another controller to have one of his aircraft broadcast the frequency change on the old frequency, or all of the above.

TABLE 5-36. EXECUTING BACKUP PROCEDURES FOR COMMUNICATION FAULTS (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.7.5 Inform supervisor of communication failure.	The controller informs the supervisor of intermittent or complete failure of his air/ground frequency.	The controller informs the supervisor of intermittent or complete failure of his air/ground frequency.
6.7.6 Inform supervisor of changes made in frequency selection.	If another frequency was available to the controller, he notifies the supervisor of the frequency change.	If another frequency was available to the controller, he notifies the supervisor of the frequency change.
6.7.7 Inform other controller/facility of change in frequency.	The controller notifies other controllers or adjacent facilities of the change in frequency.	The controller notifies other controllers or adjacent facilities of the change in frequency.

5.3.6.8 Sub-Activity 6.8: Managing Personnel Resources

See Figure 5-38. The controller will determine the amount and complexity of traffic that can safely be handled in the sector/position (Task 6.8.1).

If the controller is experiencing fatigue or traffic loads beyond his skill level or sector capacity, he may be assigned to another less busy position (Task 6.8.2); he may request or be assigned assistance or relief (Task 6.8.3); he may request a handoff controller (en route) or a coordinator (terminal) (Task 6.8.4); he may request rerouting of traffic (Task 6.8.5); he may request that flow restrictions be placed upon traffic coming into the sector/position (Task 6.8.6); or he may request the sector/position be decombined (Task 6.8.7).

See Table 5-37 for a comparative subtask description of terminal and en route controller tasks.

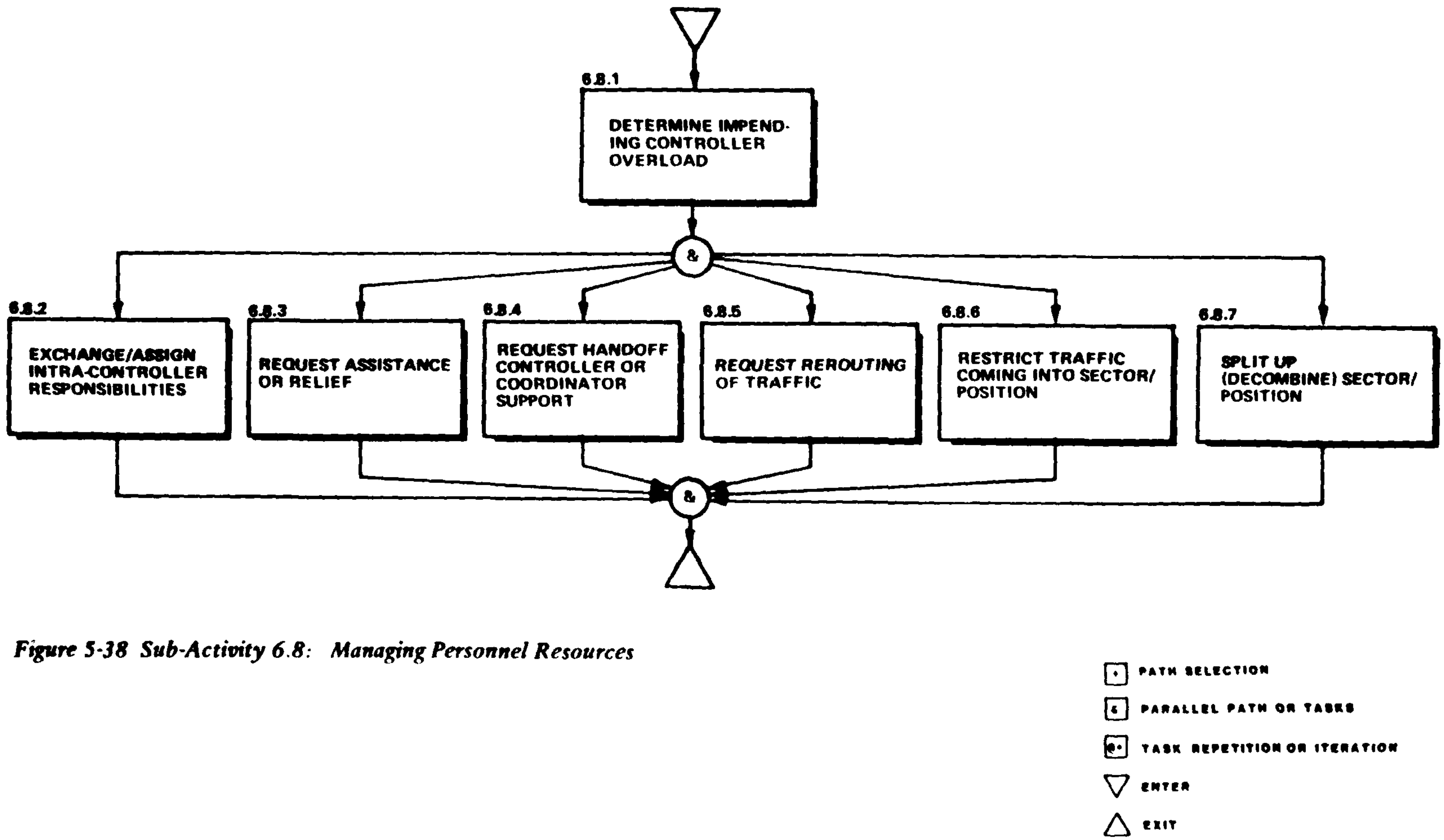


Figure 5-38 Sub-Activity 6.8: Managing Personnel Resources

TABLE 5-37. MANAGING PERSONNEL RESOURCES

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.8.1 Determine impending controller overload.	The controller is alert to his capability to handle the traffic load and determine if the traffic situation is close to being overloaded.	The controller is alert to his capability to handle the traffic load and determine if the traffic situation is close to being overloaded.
6.8.2 Exchange/assign intra-controller responsibilities.	If the more experienced controller is working a less busy position, the controllers may consider swapping.	If the more experienced controller is working a less busy position, the controllers may consider swapping.
6.8.3 Request assistance or relief.	The controller may request assistance or, if he is fatigued, he may request relief.	The controller may request assistance or, if he is fatigued, he may request relief.
6.8.4 Request handoff controller or coordinator support.	The controller may request a coordinator's assistance.	The controller may request a handoff controller.
6.8.5 Request rerouting of traffic.	The controller may request tower en route traffic be rerouted or assigned an altitude above the terminal area.	The controller may request en route traffic be rerouted around his sector.
6.8.6 Restrict traffic coming into sector/position.	The controller may request flow control restrictions or metering restrictions be applied.	The controller may request flow control restrictions.

TABLE 5-37. MANAGING PERSONNEL RESOURCES (Cont'd)

Information Processing Task	Terminal Subtask Description	En Route Subtask Description
6.8.7 Split up (decombine) sector/position.	The controller may request, or the supervisor may determine, to split up or decombine positions.	The controller may request, or the supervisor may determine, to split up or decombine sectors.

5.4 ATTRIBUTE DESCRIPTION OF CONTROLLER TASKS

Introduced in this section are descriptors of human processes (called Task Attributes) which may be involved significantly in the performance of specific controller tasks. Such descriptors supplement the task information developed in the preceding section. Their value and descriptions are cited (Section 5.4.1), along with an outline of how certain ones may serve as component's of the human information processing system.

Acknowledging that there are many issues which surround the proper role of humans in complex automated systems, a general discussion of human and computer contributions is introduced in Section 5.4.2. Attention is then directed to special capabilities of humans in exercising control in an operational setting (see Section 5.4.3), particularly in regard to processing large amounts of information and to performing multiple tasks concurrently.

The Task Attributes (categories of human effort) are then related to individual tasks to illustrate how they provide an additional dimension to the characterization of controller tasks (Section 5.4.4). Serving as descriptive units of controller work behavior, the attributes provide a way to characterize the dimensionality of work performance within a task. Attributes represent ability requirements, particularly for the complex perceptual and cognitive aspects of information-processing tasks. They point out extensive controller involvement in the processing of air traffic and control information. Such explicit descriptors of each task should prove useful in studies of how the job may change as new procedures and equipment become introduced into the ATC system.

5.4.1 Categories of Task Attributes

The key human processes involved in the performance of controller tasks and subtasks can be characterized generally as being (a) perceptual, (b) cognitive, and (c) motor. These general cagetories represent one level of description of the human processes occuring in the Man-Machine Interaction (MMI) of command and control systems such as Air Traffic Control.

However, it seems useful to apply human process categories at a somewhat more specific level of descriptor. A great many attributes (or work-oriented human behaviors) are available at this next level of human process description. Primary reference sources for compiling the attributes and their definitions were Theologus, Romashko, & Fleishman [11], Neeb, Cunningham, & Pass [8], Marquardt & McCormick [4], and McCormick [5]. For the present purposes, only those attributes likely to be most meaningful in characterizing the human processes involved in the execution of information processing tasks of en route and terminal Air Traffic Controllers are considered.

The task attributes can be

associated with specific controller subtasks to characterize the significant human efforts involved in a particular task. Such characterizations serve:

a. To show the nature of human efforts involved in existing controller job positions, and to demonstrate how a position may change its effort requirements as the job changes to accommodate different equipment, machines, or types of facilities and to be able to do this in advance of implementing a change.

b. To provide a basis for estimating controller workload under different traffic conditions or when assistance is provided by other controllers to relieve the workload.

The composite volume and nature of all task attributes involved to a meaningful degree in a particular event scenario should yield a useful measure of relative controller workload. This measure can then be compared with those derived from different event scenarios or changed task allocations between controllers and machine components, or between controller positions at different sizes or types of facilities.

In some instances, it may also be helpful to assign certain attributes to work units larger than subtasks. Thus, to clarify further the controller workload, an attribute could be assigned to a whole task, or even to a particular event scenario. Attributes seemingly most meaningful for such assignment are such ones as Image or Pattern Formation, Sensitivity to Problems, Planning Ability, and Screening/Filtering.

The attribute descriptors of controller work efforts may also serve several additional purposes, having value in later efforts to:

a. Reallocate efforts between man and machine, perhaps off-loading of manual tasks that do not require uniquely human qualities and capabilities (e.g., to speed the system handling of trivial or repetitive tasks or subtasks).

b. Validate the component human performance characteristics to be included in an MMI test bed or simulator (i.e., performance fidelity).

c. Validate the human performance content included in a controller training program.

Tables 5-38, 5-39, and 5-40 describe and illustrate each of the attributes for characterizing specific controller efforts. It should be noted that more than one attribute may be meaningful to the performance of a particular task or to its component subtasks. Similarly, one particular attribute can be significant at several points in the performance of a task.

These attributes are grouped in Tables 5-38, 5-39,

TABLE 5-38. PERCEPTUAL (Sensory) ATTRIBUTES

These involve a relatively high state of consciousness or awareness of one's behavior

Code	Attribute Title(s)	Description	ATC Illustration
P1	Image or Pattern Formation (Closure)	See or foresee in the mind an arrangement or composition that suggests or reveals a design or configuration (that is, a complex of parts that function as a whole picture); *Have a mental picture* of something to be; Perceptually organize a disorganized or ambiguous visual field into a single perception.	Observe scope for quality of radar target-to-clutter display; Conceptualize tactical situation based on time variations presented on scope; form picture of situation by observation of flight progress strips.
P2	Form Perception (Form Matching)	Perceive pertinent detail in objects or in pictorial or graphic material; Make fine visual comparisons and discriminations among such characteristics as shape-shading-width-lengths.	Discriminating between symbols; Differentiating between two closely adjacent aircraft on the display.
P3	Movement Detection	Recognize the physical movement and judge the direction or speed of a visual object.	To help predict delays or conflicts. In observing broadband radar; In confirming radar contact.
P4	Spatial Scanning (Object Detection)	Rapidly identify or detect objects or events displayed in a wide or complicated visual field.	Observing display for new aircraft; Looking for data in a table.
P5	Perceptual Speed	Rapid discriminations of visual detail, including verbal or tabular material.	In estimating separations.
P6	Recognition of Spatial Patterns (Pattern Recognition)	Perceive spatial patterns and relations among static or dynamic visual inputs. May involve orienting one's self to the position or configuration.	In telling pilot which way to turn; In terminal operations observing close-in flight paths.

TABLE 5-38. PERCEPTUAL (Sensory) ATTRIBUTES (Cont'd)

Code	Attribute Title(s)	Description	ATC Illustration
P7	Transformation of Spatial Patterns (Spatial Visualization)	Observing spatial patterns or objects in two or three dimensions, and mentally transforming them into other spatial patterns; Visualize objects in dimensional or geometric form.	In determining the effect of a proposed aircraft maneuver on other aircraft; In comparing intended time-position profiles for intersection in position/altitude/time.
P8	Visual Recognition (Visual Memory, Recognition Memory)	Mental storage and recall of visual forms and patterns, and relate/compare newly perceived visual detail to those forms and patterns.	In applying separation standards to estimated separations.
Secondary Listing			
P9	Depth Perception (Stereoscopic Acuity)	Estimate depth of distances or objects (or judge their physical relationship in actual space).	Observing inflight aircraft from the tower.
P10	Auditory Acuity	Perceive relevant sound cues and discriminate between sounds; Accurately hear difficult speech transmissions against a background of noise, static, or interruption.	
P11	Far Visual Acuity	Perceive detail at distances beyond normal reading distance.	
P12	Near Visual Acuity	Perceive detail at normal reading distance.	
P13	Color Discrimination	Perceive similarities or differences in colors or in shades of the same color (or identify certain colors).	
P14	Tactual Discrimination (Touch Sensitivity)	Perceive relevant cues by touch.	

TABLE 5-39. COGNITIVE (Intellectual) ATTRIBUTES

These involve a relatively high state of consciousness or awareness of one's behavior.

Code	Attribute Title(s)	Description	ATC Illustration
C1	Short-Term Memory	Mental storage and selective recall of relevant information within a brief period of time; Retention and selecting the use of procedure-following information.	To enter aircraft call sign on FDEP.
C2	Technical Grammar	Form and structure of job words and phrases, including codes and abbreviations.	Programming; Formatting a flight plan; Issuing clearance to a pilot.
C3	Expressional Fluency	Rapidly putting ideas into spoken or written words.	In talking to a pilot; Planning clearance instructions.
C4	Ideational Fluency	Rapidly coming up with creative or imaginative ideas or solutions.	In resolving potential air conflicts.
C5	Sensitivity to Problems (Evaluation)	Recognizing existence of a problem, deficiencies in courses of action or plans, or implications of activities; Evaluating goodness or appropriateness of ideas; Judging which problems are significant; Determining cause and effect relationships. Does not necessarily include any of the reasoning necessary for the solution of a problem.	Monitor status; Anticipate problems that could arise; Recognize inconsistencies in the available data.
C6	Deductive Reasoning (Fact Conclusion)	Reach a conclusion that follows logically from the known facts or data; Select from among alternative answers or methods; Following a prescribed rule.	Calculate likely future position of aircraft.

TABLE 5-39. COGNITIVE (Intellectual) ATTRIBUTES (Cont'd)

Code	Attribute Title(s)	Description	ATC Illustration
C7	Inductive Reasoning (Generalization)	Generating an explanation for a set of specific data or instances, giving structure and meaning to the information; Make generalizations or working hypotheses from specific events; Discern basic differences and relationships among symbols, figures, and figure patterns; Generate a new solution to a problem; Make a knowledgeable assumption even though using insufficient data.	Formulate new requirements in order to meet stated objectives; Search for new information on the basis of contingencies that have arisen; Checking the adequacy of a proposed aircraft maneuvering.
C8	Planning Ability (Prioritize/Schedule)	Ordering of events in sequence; Establish priorities.	Determining the urgency of a perceived event; Deferring task action.
C9	Social Intelligence (Interpersonal Communication)	Correctly process behavioral information obtained through personal interaction; Sensitive to personal reactions of others; Teamwork effectiveness.	Negotiation of revised flight plan; Talking a lost or panicked pilot to a landing site or position reference; Training a new controller on the job; Mesh with other controllers upstream/downstream.
C10	Numerical Computation (Number Facility)	Rapid and accurate simple arithmetic operations, but not including more complex or reasoning situations. Includes use of quantitative symbols.	Plotting on numbered coordinates; Computing answer to an equation; Chart trends.
C11	Input Transformation/ Translation (Coding)	Coding.	Convert text to graphics or alphanumerics; Recording a voice message; Transform pattern information into usable data.
C12	Screening or Filtering (Overload Accommodation, Selective Attention)	Select inputs on which to focus attention in presence of distracting stimuli or overload of work.	In deferring action on a task; Selecting aircraft trajectories to examine for conflicts.

TABLE 5-39. COGNITIVE (Intellectual) ATTRIBUTES (Cont'd)

Secondary Listing

Code	Attribute Title(s)	Description	ATC Illustration
C13	Verbal Comprehension	Meaning of words and associated ideas, and able to use them effectively.	In conversing with foreign pilots; Negotiating flight plan changes.
C14	Mathematical Reasoning	Structuring of computational problem prior to solution.	
C15	Probability Estimation	Translate uncertainty into probability, assigning a subjective probability number regarding the likelihood of an event being true; Express opinion or judgments in terms of numbers.	Translate uncertain variables into trends or patterns; Assign a numerical probability to an uncertain stimulus event, representing the controller's opinion about the state of that event.
C16	Probabilistic Calculation (Prediction)	Use probabilities to estimate optimal courses of action. Does not include the final decision of selecting a course of action.	Assess the risk of a maneuver.

TABLE 5-40. MOTOR ATTRIBUTES

These involve bodily movement, usually in coordination with sensory processes.

Code	Attribute Title(s)	Description	ATC Illustration
M1	Simple Reaction Time	Rapid initiation of appropriate physical response to an input stimulus when it appears.	Responding to rejection of a handoff; Resolving a conflict alert.
M2	Speed of Arm Movement	Rapid movement of arm in a gross but discrete move where accuracy is not overly important, such as to reach for an object.	
M3	Arm Extension	Near or full extension of arm to reach an object, particularly when it is just beyond normal arm reach and requires some stretching to reach that point.	Reaching for flight strips during expanded staffing of the position; Changing radio frequency.
M4	Eye-Hand Coordination	Rapid and accurate coordination of hand movements with visual stimuli, or inputs.	Use of the trackball: Tracing lines; Aiming at an object.
M5	Manual Dexterity	Skillful and controlled arm-hand movements of fairly large objects with the hands.	Use of trackball to locate a point on the scope.
M6	Keyboard Dexterity	Skillful and controlled manipulation of keyboard keys (typing format or matrix format) to enter data or commands.	
M7	Control Precision (Fine Control Sensitivity)	Delicate and highly controlled adjustments of a control mechanism through the use of one hand (or foot), usually involving anticipations and adjustments for a moving object.	Rotary pursuit tasks with joystick; Adjusting radar display controls.

TABLE 5-40. MOTOR ATTRIBUTES (Cont'd)

Code	Attribute Title(s)	Description	ATC Illustration
M8	Rate Control	Continuous anticipations and adjustments of timing in tracking a moving target with changing speed and/or path.	Tracking a moving aircraft on scope with use of the track-ball.
Secondary Listing			
M9	Muscular Strength (Static Strength)	Exertion of considerable force on an object briefly to lift or move it.	Lowering PVD display.
M10	Response Orientation	Recognize the direction indicated by a visual signal or input (such as an arrow or symbol) and rapidly respond with a motor action that represents or corresponds to that directional signal.	Depress a particular switch or combination of switches in response to a light appearing in a certain location or grid.
M11	Finger Dexterity	Skillful and controlled finger movement to manipulate small objects rapidly.	
M12	Arm-Hand Steadiness	Precision and steadiness in positioning one or both hands, or holding them in a set position for a time.	
M13	Multilimb Coordination	Using two limbs in a simultaneous control movement.	Using both hands simultaneously.

and 5-40 under the general attribute categories of Perceptual, Cognitive, and Motor processes. Additionally, the attributes are divided into two parts within each grouping: Primary and Secondary.

The primary listing sets apart those categories that appear to be more important and frequently occurring in the controller job. The secondary listing contributes a few more categories that occasionally may be important, preserves the less frequent attributes for possible use in a briefer, easier-to-handle form for later reviewing attribute relevance in subtask job performance.

These selected task attributes can be used to describe the significant controller behaviors in accomplishing each procedural subtask of a controller. Their summation, in turn, serves as the descriptor of human processes in the whole task of which the subtasks are a component.

It can be noted that this listing of selected human attributes does not include a number of attributes that might be useful in other types of jobs. For example:

a. Mechanical Ability
b. Body Equilibrium
c. Aesthetic Judgment
d. Memory for Musical Tones
e. Originality (production of clever or uncommon ideas)

Thus, the selected categories are not fully representative of the entire domain of perceptual - cognitive - motor attributes. Rather, they are intended to focus upon the information handling and processing efforts of controllers. No attempt is made to account for the large number of simpler perceptual and motor actions (e.g., observing indicator lights, depressing switchlights) that also may be involved in the performance of tasks.

5.4.1.1 Information Processing View of Cognitive Attributes

Each of the cognitive (intellectual) attributes can be viewed as components of an information processing system. Such an information processing system is considered to have five general groupings of attribute categories. These groupings pertain to:

1. Action Initiation (given some information or event on which to initiate action).

2. Adaptive Processes (to aid in handling the information to be processed at a particular time).

3. Knowledge Base (to aid in effectively processing the information).

4. Transformation of Input or Data (to convert information to a more usable form).

5. Reasoning (mentally structuring the information in relation to guidance to yield new information).

The following outline (Table 5-41) locates the 16 selected cognitive attributes within these general groupings.

TABLE 5-41. OUTLINE OF INFORMATION PROCESSING ATTRIBUTES

Action Initiation

Sensitivity to Problems (Evaluation)

Planning Ability (Prioritize/Schedule)

Adaptive Processes

Social Intelligence (Interpersonal Communication)

Screening/Filtering (Selective Attention, Overload Accommodation)

Knowledge Base

Short-Term Memory

Technical Grammar

Verbal Comprehension

Transformation of Input or Data

Expressional Fluency

Numerical Computation (Number Facility)

Input Transformation/Translation (Coding)

Probability Estimation

Reasoning

Ideational Fluency

Deductive Reasoning (Fact Conclusion)

Inductive Reasoning (Generalization)

Mathematical Reasoning

Probabilistic Calculation (Prediction)

5.4.2 General Contributions of Man and Machine to System Functioning

Air traffic control, by its very name, implies a command and control of air traffic. Historically, this function was a manual effort, generally aided by the use of a radio or visual signals. Control was primarily of a service nature to aid pilots. As increasing numbers of machines were made available to the controller, there came an increasing dependency on their use. The recent advances occurring in machine capability should provide the controller with vast new resources to use in exercising control over air traffic.

This expansion of machine capability has become so intense that questions become raised as to what properly should be assigned to machine performance, and what properly should be maintained as a manual effort. Clearly, machines have become much more than aids to the controller in their performance of manual control. They almost appear to become threats to the controllers' meaningful control of the system. Yet, conversely, the controller cannot be expected to exercise the traditional nature of human control over a system that is expected to increase in traffic load so dramatically in the next few years and decades.

As with other highly computerized command and control systems, careful consideration must be made of the proper roles to be assigned humans and machines. It's becoming clearer that human capabilities still are highly valued, but there are some functions in which the machine is vastly superior in handling and processing great amounts of system input data.

There have been at least four basic functional concepts proposed in defining the decision roles of man in highly automated command and control systems [1].

1. Facilitate System Functioning - to include manual augmentation, enhancement of system capability, and monitoring of trends and patterns.

2. Override (bypass) System Malfunctions - essentially a maintenance monitoring function and allowing manual bypass of machine-based system malfunctions. This concept implies a manual backup capability to normal machine actions.

3. Control System Degradation - involving man's anticipatory monitoring of system functions to detect and prevent system overloads and subsequent deteriorations, with man instituting programs of preferential treatment to inputs, events, and machine functions.

4. Permit System to Operate - where man decides on the need for the machine portion of the system to operate; either allowing, prohibiting, or forcing the machine to handle particular situations. This concept is sometimes called "control by exception".

Both the controllers and the computers have valuable contributions to make toward overall system success in attaining its primary goals of safe and expeditious air traffic operations. General areas in which each of these system components can provide special capabilities are briefly listed in Tables 5-42 and 5-43. These listings were derived from the early suggestions of Fitts [3] and as expanded upon by Munger [7] and the US Air Force [13].

TABLE 5-42. SPECIAL HUMAN CAPABILITIES IN COMPLEX C^2 SYSTEMS

1. Recognize patterns in complex visual displays (or spoken words, or longhand writing) in spite of transpositions, rotations, translations, and other distortions.

2. Translate uncertainty into probability (with tolerance for ambiguity and uncertainty, use operator as transducer for probabilities, and enter into computer).

3. Detect own mistakes.

4. Work out a plan to correct own mistakes or to remedy their effects.

5. Inductive reasoning (generate an explanation for a set of data, or generate a new solution to a problem).

6. Make inferences from one set of conditions to another.

7. Make decisions in situations not previously encountered.

8. Determine when a decision must be made.

9. Determine what decision options are available.

10. Search memory for information, not knowing its location.

11. Estimate system conditions that are dependent upon subjective or unanticipated factors.

12. Improvise and adapt flexible procedures.

13. Select inputs and perform when overloaded (focus concentration and ignore less important tracks when confronted with a saturated scope).

14. Apply situation - specific knowledge.

15. Obtain global perspectives of the entire traffic situation.

16. Estimate contingency probabilities from an ambiguous data base.

17. Accommodate multiple priority levels.

18. React intelligently to situations which cannot be anticipated at the time the system is designed.

19. Reconstruct a jumbled English message.

TABLE 5-43. SPECIAL COMPUTER CAPABILITIES IN COMPLEX C^2 SYSTEMS

1. Use probabilities and payoffs (that can be quantified) and compute the optimal course of action.

2. Update new probabilistic information as it becomes available.

3. Transmit data at high rate.

4. Appraise values of physical energies quickly and accurately.

5. Vigilance and detection (sensing, extrapolating, and decision making, and reacting continuously to stimuli).

6. Respond quickly to signals.

7. Perform precise, routine, repetitive operations.

8. Compute and handle large amounts of stored information rapidly and accurately.

9. Monitor infrequent events.

10. Reason deductively (identify a specific item as belonging to a large inclusive class, and use preprogrammed logic in processing information).

11. Sense forms of energy in bands beyond man's spectrum (e.g., infrared and radio waves, ultrasonic vibrations).

12. Generate automated aids for man's use.

At the end of the list of special computer capabilities (Table 5-43) is the suggestion of using the machine to generate aids to augment human capabilities in system control. This can provide an alternative approach to the allocation of system efforts among man and machines. It need not be an all or none allocation to one system component or another.

Portions of information handling tasks may be given over to computer processing. For example, the computer can be asked to compute an aircraft's future position. In turn, the computer displays its results back to the controller for manual use in arriving at conclusions, plans, decisions, and control commands.

Thus, the principle of activity decomposition used in this study serves further to allow the pinpointing of specific matters that the computer may be permitted or required to consider in future ATC systems. By such sharing of task performance, it becomes possible to make effective use of machine capacities while retaining significant human involvement.

5.4.3 Concurrent Human Capabilities

Controllers in the ATC system can be faced with large amounts and a variety of information inputs, and with overlapping demands for their time, attention, and task accomplishment. Fortunately, well-trained individuals can exercise a number of capacities to accommodate a complex work situation.

While it may appear to an observer that the controller often is attending to volumes of stimuli simultaneously, the human is capable of (a) rapidly alternating his attention among matters, (b) deferring and later resuming some efforts, (c) sampling among information inputs to obtain a general picture, or even, (d) filtering some inputs to screen out that which does not well serve an immediate need.

By such means the controller can respond to increasing loads on his own task performance during an on-rush of diverse events and stimuli. At the level of attribute behavior, more than one attribute will in fact often be performed simultaneously in doing a particular subtask. A later section of this report will deal with the allocation of selected tasks to other controllers to reduce controller load and work complexity.

5.4.3.1 Multiplexing Among Tasks and Targets

In a complex scenario involving many aircraft, the controller often is faced with conflicting task demands. Priorities may be set of which tasks are to be attended to first, and which can be delayed. Or, the controller may decide to defer further action on one task until a more urgent matter is resolved, after which he may resume completion of the first task. The "action initiation" attributes of Sensitivity to Problems and Planning Ability come into play during these situations.

5.4.3.2 Filtering/Sampling Inputs

Another capability of humans is to "turn off" selected information in order to attend more properly to an urgent matter at hand. In this mode, the controller exercises selective attention to certain chosen information inputs. For example, the controller may observe information pertaining only to one aircraft or air situation until an issue is resolved. Scope controls also allow for increase or reduction of displayed information. The attribute of Screening/Filtering comes into play during such adaptations to complex inputs.

5.4.3.3 Cognitive Activity

The information processing attributes listed in Table 5-41 represent a special capacity for the human in the system to process the same information set in more than one way. In some instances this can occur in such a brief time as to appear for all practical purposes as occuring simultaneously. All significant attributes would be noted.

5.4.3.4 Paired Output Generation

Resulting from a set of subtasks involving a variety of cognitive attributes may be the need for taking more than one action to carry out the result of that intellectual effort. That is, it may be necessary for the controller to perform more than one type of action to exercise control over a situation. These output actions may occur nearly simultaneously, as when depressing a TALK switch and speaking an instruction to a pilot and writing the instruction on a flight progress strip.

5.4.4 Using the Task Attributes to Further Characterize the Human Efforts Involved in Performing Controller Tasks

With the lists of tasks available from the decompositions of Sub-Activities in Section 5.3, this section takes an initial look at which attributes appear to be involved in controller performance of each task. An experienced Air Traffic Controller, familiar with each of the categories of Task Attributes and their definitions, was asked to indicate the attributes that characterize each task (that is, attributes which are significantly involved in the task).

These task characterizations are reported in Table 5-44. Certainly, judgments by more individuals would be necessary to achieve highly reliable and valid associations of attributes with tasks. However, the present effort provides a useful supplement to the descriptions of human performance that are in the previous Section 5.3.

In this particular judging effort, the controller considered the task statement and used his knowledge of the controller efforts involved in performing the task. Increased judgment detail can be obtained by first establishing and listing all the procedural steps and actions (Subtasks) done by controllers in accomplishing a task, and then judging the attributes for each subtask. Adding a measure of the extent an attribute is involved in task performance may also contribute to increased sensitivity.

In Table 5-44, where the task involves only a minor Perceptual or Motor action, a "P" or "M" is entered as the overall attribute character, with no further statement of a specific attribute.

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
		P	C	M	
1.1.1	Observe display for potential violation of separation standards	P	C		Form Perception, Planning Ability, Screening/Filtering
1.1.2	Mentally project aircraft position/altitude/path	P			Image or Pattern Formation
1.1.3	Read out range/bearing/time for an aircraft to a fix or geographic point		C	M	Input Transformation/Translation, Keyboard Dexterity
1.1.4	Force data block to examine track information on aircraft		C	M	Input Transformation/Translation, Eye-Hand Coordination
1.1.5	Determine whether aircraft will be separated by less than prescribed minima		C		Sensitivity to Problems, Inductive Reasoning
1.1.6	Review flight strips for present and/or future aircraft separation	P	C		Transformation of Spatial Patterns, Visual Recognition, Short-term Memory, Sensitivity to Problems
1.2.1	Receive equipment status information	P	C		Short-Term Memory
1.2.2	Receive information on operations status		C		Short-Term Memory, Sensitivity to Problems
1.2.3	Receive traffic and flow information		C		Short-Term Memory, Sensitivity to Problems
1.2.4	Receive information on weather events		C		Short-Term Memory, Sensitivity to Problems
1.3.1	Search inactive bay for flight strip on clearance request	P			-
1.3.2	Put in strip request for flight			M	-
1.3.3	Request flight plan readout			M	-
1.4.1	Observe/receive aircraft departure time	P			-
1.4.2	Enter Departure Message (DM) into the computer			M	-
1.4.3	Respond to initial aircraft contact on departure		C		Short-Term Memory
1.4.4	Verify aircraft altitude on departure		C		Sensitivity to Problems
1.4.5	Start track manually			M	Keyboard Dexterity
1.4.6	Observe automatic start of track		C		Deductive Reasoning
1.4.7	Observe flashing DM in data block			M	-
1.4.8	Call center controller sector regarding aircraft departure time				-
1.5.1	Receive request for flight following		C		Short-Term Memory
1.5.2	Assign beacon code to pilot			M	-
1.5.3	Deny flight following request		C		Deductive Reasoning

LEGEND
P - PERCEPTUAL
C - COGNITIVE
M - MOTOR

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
1.5.1	Reposition a data block			M	Eye-Hand Coordination, Keyboard Dexterity
1.6.2	Check TAB List against flight strips for completeness/receipt of flight strips	P	C		Short-Term Memory
1.6.3	Request flight strips be produced from data base		C	M	Deductive Reasoning, Keyboard Dexterity
1.6.4	Request an ARTS message be forwarded on the TAB List			M	-
1.6.5	Review TAB List/data block for old data to drop	P			-
1.6.6	Drop data block for an active track			M	-
1.6.7	Drop inactive track from TAB List			M	-
1.6.8	Review flight strips to insure all data are passed to next controller	P	C		Short-Term Memory
1.6.9	Review inactive or proposed flight plan bay for deadwood	P			-
1.5.10	Cancel flight data in data base			M	-
1.6.11	Remove flight strips from holders			M	-
1.6.12	Review active flight plan bays for flights past transfer/control points		C		Short-Term Memory
1.6.13	Check clock setting for accuracy	P			-
1.6.14	Check altimeter setting for accuracy	P			-
1.6.15	Inform supervisor of inaccurate altimeter/clock setting				-
2.1.1	Receive conflict alert notice from adjacent controller		C		Short-Term Memory
2.1.2	Detect conflict alert indicator	P			Perceptual Speed
2.1.3	Determine validity of conflict notice or indicator		C		Deductive Reasoning
2.1.4	Inform adjacent controller of conflict alert in his sector/position			M	-
2.1.5	Inform adjacent controller of course of action			M	-
2.1.6	Detect aircraft maneuver in response to conflict resolution	P			Movement Detection
2.2.1	Receive MSAW notice from adjacent controller or facility	P			-
2.2.2	Detect MSAW indicator or alarm	P			-
2.2.3	Determine validity of MSAW notice or indicator		C		Deductive Reasoning
2.2.4	Determine whether aircraft in vicinity permit climb or turn	P	C		Image or Pattern Formation, Sensitivity to Problems
2.2.5	Notify supervisor of valid MSAW alert or flight assist				-
2.2.6	Detect aircraft manuever in response to low altitude resolution	P			Movement Detection
2.3.1	Perceive/recognize on display an aircraft approaching limits of its airspace	P	C		Image or Pattern Formation, Inductive Reasoning
2.3.2	Calculate aircraft's path with respect to a special use airspace	P			Visual Recognition

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (CONT'D)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
2.4.1	Observe display for aircraft separation not likely to meet required standards	P	C		Form Perception, Sensitivity to Problems
2.4.2	Issue traffic advisory to aircraft in regard to air traffic deviation		C		Technical Grammar
2.4.3	Issue traffic advisory in regard to other traffic proximity	P	C		Perceptual Speed, Technical Grammar, Numerical Computation, Transformation of Spatial Patterns
2.5.1	Inhibit conflict alert for paired or group suppression		C		Technical Grammar, Sensitivity to Problems, Long-Term Recall
2.5.2	Inhibit conflict alert for refueling or other special operation		C		Technical Grammar, Sensitivity to Problems, Long-Term Recall
2.5.3	Inhibit conflict alert for air show		C		Technical Grammar, Long-Term Recall
2.5.4	Inhibit MSAW alert		C		Deductive Reasoning , Planning Ability
3.1.1	Receive a Fuel Advisory Departure (FAD) notice			M	-
3.1.2	Receive a flow restriction			M	-
3.1.3	Confer with pilot on desire for FAD intentions		C		Technical Grammar, Social Intelligence
3.1.4	Choose desired sequence	P	C		Image or Pattern Formation, Transformation of Spatial Patterns, Inductive Reasoning
3.1.5	Select new flow/sequence		C		Sensitivity to Problems, Deductive Reasoning
3.1.6	Determine the technique for accomplishing a delay		C		Ideational Fluency
3.1.7	Negotiate speed reduction or hold with pilot		C		Technical Grammar, Social Intelligence
3.1.8	Evaluate constraint effect on flow	P	C		Form Perception, Sensitivity to Problems
3.2.1	Perceive an altitude or route deviation	P			Movement Detection, Spatial Scanning, Visual Recognition
3.2.2	Receive a traffic deviation notice		C		Short-Term Memory
3.2.3	Receive a deviation request from pilot		C		Short-Term Memory
3.2.4	Identify transition from old to new sequence	P			Transformation of Spatial Patterns
3.2.5	Determine maneuver to establish/restore sequence		C		Ideational Fluency
3.3.1	Project aircraft departure sequence	P			Image or Pattern Formation
3.3.2	Plan control action to permit departing aircraft to climb to a specific altitude safely		C		Ideational Fluency, Planning Ability
3.4.1	Advise supervisor of factors affecting need for change in arrival rate		C		Sensitivity to Problems, Numerical Computation
3.4.2	Project traffic sequence	P			Image or Pattern Formation
3.4.3	Determine descent time or point		C		Sensitivity to Problems, Numerical Computation
3.5.1	Receive notice of an exception event from pilot, supervisor, or adjacent controller	P			-
3.5.2	Observe/recognize an exception event on part of an aircraft		C		Sensitivity to Problems, Deductive Reasoning, Probability Estimation

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
3.6.1	Receive notice of airspace intrusion by a non-controlled object	P			-
3.6.2	Observe airspace intrusion by a non-controlled object		C		Deductive Reasoning
3.6.3	Flight follow an observed non-controlled object		C	M	Short-Term Memory, Keyboard Dexterity
3.6.4	Write reminder note of airspace intrusion			M	-
3.6.5	Advise adjacent controller/facility of airspace intrusion		C		Sensitivity to Problems, Social Intelligence
3.6.6	Advise supervisor of an airspace intrusion				-
3.7.1	Receive notice of airspace restriction imposed	P			-
3.7.2	Determine whether restricted area is under ATC control		C		Deductive Reasoning
3.7.3	Designate an area in use			M	Keyboard Dexterity
3.7.4	Restrict aircraft activity in area by altitude or segment		C		Technical Grammar, Sensitivity to Problems
3.7.5	Request temporary release of restricted airspace or area		C		Expressional Fluency
3.8.1	Initiate handoff	P	C	M	Recognition of Spatial Patterns, Technical Grammar, Keyboard Dexterity
3.8.2	Observe handoff acceptance		C		Short-Term Memory
3.8.3	Call controller if no response is received on handoff		C		Sensitivity to Problems, Screening/Filtering
3.8.4	Retract handoff		C		Deductive Reasoning
3.8.5	Change aircraft frequency			M	-
3.8.6	Receive non-automated handoff	P			-
3.8.7	Acknowledge non-automated handoff/start track	P	C	M	Short-Term Memory, Technical Grammar, Keyboard Dexterity
3.8.8	Receive automatic handoff		C		Short-Term Memory
3.8.9	Accept automatic handoff			M	-
3.8.10	Verify communications with pilot on transfer of control		C		Short-Term Memory
3.8.11	Verify aircraft altitude with pilot on transfer of control		C		Short-Term Memory
3.8.12	Terminate radar service to aircraft		C		Deductive Reasoning
3.9.1	Conduct/issue pointout		C	M	Deductive Reasoning, Keyboard Dexterity
3.9.2	Respond to pointout		C		Sensitivity to Problems
3.9.3	Suppress flight data block after pointout			M	-

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK	KEY SPECIFIC ATTRIBUTES INVOLVED
4.1.1	Receive clearance request from adjacent facility, FSS, or pilot	P	-
4.1.2	Coordinate a planned clearance with adjacent controller	P	-
4.1.3	Receive clearance and instructions from the center for relay to pilot	C	Short-Term Memory, Technical Grammer, Input Transformation/Translation
4.1.4	Observe display for other aircraft positions	P	-
4.1.5	Advise controller of required clearances on aircraft entering or leaving sector/position	C	Deductive Reasoning, Input Transformation/Translation
4.1.6	Inform adjacent controller/facility of clearance change which might necessitate delay or changes in route	C	Expressional Fluency, Planning Ability
4.1.7	Formulate a clearance with appropriate restrictions	C	Technical Grammar, Input Transformation/Translation
4.1.8	Evaluate a planned course of action, solution, impact	C	Sensitivity to Problems, Deductive Reasoning
4.1.9	Deny clearance request	C	Sensitivity to Problems, Deductive Reasoning, Planning Ability
4.1.10	Issue clearance and instructions to pilot	C	Expressional Fluency
4.1.11	Issue clearance and instructions to terminal facility, FSS, BASOPS, or airline office for relay to pilot	C	Expressional Fluency
4.1.12	Verify aircraft compliance with clearance	P	Movement Detection
4.2.1	Receive information on loss of radio contact or overdue aircraft	P	-
4.2.2	Detect a pilot or aircraft problem (e.g. hypoxia)	C	Sensitivity to Problems, Deductive Reasoning, Social Intelligence
4.2.3	Conduct a radio search for overdue aircraft	C	Short-Term Memory, Technical Grammar
4.2.4	Declare event and invoke contingency plan	C	Deductive Reasoning
4.2.5	Contact facility along route of flight to secure information on overdue aircraft	C	Expressional Fluency, Input Tranformation/Translation
4.2.6	Alert airport emergency crew or other designated personnel of aircraft having flight difficulties	C	Technical Grammar, Expressional Fluency
4.2.7	Report contingency event to supervisor		-
4.3.1	Receive notice of necessity for special operations	P	-
4.3.2	Perceive necessity for special operations	P C	Recognition of Spatial Patterns, Sensitivity to Problems
4.4.1	Receive flight plan from pilot	C	Input Transformation/Translation
4.4.2	Receive flight plan data from previous controller	C	Input Transformation/Translation
4.4.3	Receive flight plan on flight strip printer (FSP)	M	-
4.4.4	Review flight plan for completeness	C	Short-Term Memory, Sensitivity to Problems, Inductive Reasoning, Planning Ability

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
4.4.5	Query pilot about flight plan		C		Social Intelligence
4.4.6	Query the relayer of a flight plan		C		Social Intelligence
4.4.7	Compose flight plan data entry and enter into computer		C	M	Short-Term Memory, Input Transformation/Translation, Keyboard Dexterity
4.4.8	Forward flight plan to next controller		C		Sensitivity to Problems
4.4.9	Distribute new flight strip(s)			M	-
4.4.10	Post flight strip in strip bays			M	Arm Extension
4.5.1	Receive pilot/controller request for flight change	P	C		Input Transformation/Translation
4.5.2	Review flight amendment request	P	C		Image or Pattern Formation, Perceptual Speed, Transformation of Spatial Patterns, Short-Term Memory, Inductive Reasoning
4.5.3	Flag flight strip for reminder action			M	Arm Extension
4.5.4	Negotiate flight change with pilot		C		Social Intelligence
4.5.5	Receive flight plan amendment from previous controller			M	-
4.5.6	Receive computer message regarding flight plan amendment			M	Keyboard Dexterity
4.5.7	Request flight progress strip over a given fix			M	-
4.5.8	Write flight plan amendment on strip			M	Arm Extension
4.5.9	Resequence flight strip			M	Arm Extension
4.5.10	Compose/enter computer message on flight plan amendment		C	M	Input Transformation/Translation, Keyboard Dexterity
4.5.11	Modify display/DEDS/scratch pad to amend data			M	Keyboard Dexterity
4.5.12	Unflag flight strip			M	Arm Extension
4.5.13	Review flight plan change (double check)		C		Sensitivity to Problems
4.5.14	Receive pilot's progress report		C		Input Transformation/Translation
4.5.15	Check aircraft speed/time for change		C		Numerical Computation
5.1.1	Determine direction and movement of weather line	P			Image or Pattern Formation, Movement Detection
5.1.2	Determine base and height of buildup from PIREPs		C		Short-Term Memory, Deductive Reasoning
5.1.3	Determine whether holes exist in buildup line	P	C		Recognition of Spatial Patterns, Short-Term Memory
5.1.4	Determine impact of weather on routes and airports in sector/position		C		Sensitivity to Problems
5.1.5	Receive information on height of clouds		C		Short-Term Memory
5.1.6	Predict potential for icing		C		Deductive Reasoning, Probabilistic Calculation
5.2.1	Request pilot report (PIREP) on weather/atmospheric information		C		Expressional Fluency
5.2.2	Receive pilot report on weather/atmospheric information	P	C		Short-Term Memory
5.2.3	Disseminate pilot-reported weather information to other controllers/facilities		C		Sensitivity to Problems
5.2.4	Disseminate pilot-reported weather/atmospheric information to aircraft		C		Sensitivity to Problems
5.3.1	Receive SIGMET/AIRMET, other weather reports	P	C		Short-Term Memory
5.3.2	Issue weather advisory information to pilot		C		Sensitivity to Problems
5.3.3	Monitor radar display and weather situation for revision/cancellation of weather advisory	P	C		Form Perception, Deductive Reasoning

TABLE 5-44. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
		P	C	M	
5.3.4	Inform pilot of weather disturbances and suggested headings for avoiding such areas	P	C		Image or Pattern Formation, Expressional Fluency
5.3.5	Inform pilot of meteorological/navigational information		C		Expressional Fluency
5.4.1	Note change of wind direction/wind shear	P			-
5.4.2	Determine preferred approach		C		Sensitivity to Problems
5.4.3	Recommend airport traffic configuration to management				-
5.4.4	Determine usable flight level				-
5.4.5	Determine control zone for VFR or IFR		C		Deductive Reasoning
6.1.1	Respond to sector/position reconfiguration	P	C		Image or Pattern Formation, Sensitivity to Problems
6.1.2	Honor a requested temporary use of airspace		C		Expressional Fluency
6.1.3	Determine acceptability of a requested temporary use of airspace		C		Sensitivity to Problems, Planning Ability
6.1.4	Request temporary use of airspace		C		Expressional Fluency
6.1.5	Receive a request for temporary use of airspace	P			-
6.1.6	Combine/decombine positions/sectors	P	C		Image or Pattern Formation, Sensitivity to Problems
6.1.7	Coordinate use or release of shared airspace		C		Sensitivity to Problems
6.1.8	Write reminder note of temporary airspace release			M	-
6.1.9	Start pseudo track as to areas in use			M	Keyboard Dexterity
6.1.10	Take over airspace associated with facility closure/reopening	P	C		Image or Pattern Formation, Sensitivity to Problems, Planning Ability
6.1.11	Release airspace associated with facility reopening/closure		C		Expressional Fluency, Sensitivity to Problems
6.2.1	Review overall system status	P			Spatial Scanning
6.2.2	Review traffic and detailed status	P	C		Image or Pattern Formation, Short-Term Memory, Sensitivity to Problems, Planning Ability
6.2.3	Verify all required display and communication switches are in proper location	P			-
6.2.4	Adjust display and communication volume to personal preference			M	Control Precision
6.2.5	Review flight strips and display lists for correlation	P			-
6.2.6	Adjust display and ensure critical data are present			M	Control Precision
6.2.7	Visually check radar display for proper alignment, usability, and satisfactory status	P			Visual Recognition
6.3.1	Check computer clock to assure proper computer functioning	P			-
6.3.2	Detect display flicker associated with target location	P			-
6.3.3	Detect nonacceptance of input data by the computer	P			-
6.3.4	Forward computer input data by interphone		C		Technical Grammar
6.3.5	Detect apparent unreliable air/ground communications		C		Sensitivity to Problems

TABLE 5-[illegible]. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK			KEY SPECIFIC ATTRIBUTES INVOLVED
6.3.6	Explore whether others are receiving an aircraft's transmissions		C		Expressional Fluency
6.3.7	Issue alternate communications for air/ground transmission		C		Technical Grammar
6.3.8	Alert supervisor of transient fault occurrence				-
6.3.9	Force missing message to ARTS			M	Keyboard Dexterity
6.3.10	Identify aircraft that is not handed off	P	C		Spatial Scanning, Sensitivity to Problems, Deductive Reasoning
6.3.11	Issue routine advisory on equipment status		C		Technical Grammar
6.3.12	Observe indication of duplicate beacon code assignment	P			-
6.3.13	Request new beacon code to replace duplicate code			M	-
6.4.1	Alert other facilities of RDP fault			M	-
6.4.2	Go to broadband or DARC operation			M	Muscular Strength
6.4.3	Reidentify aircraft	P	C		Movement Detection, Deductive Reasoning
6.4.4	Change beacon code assignments to prearranged code banks			M	-
6.4.5	Request position/progress reports		C	M	Planning Ability
6.4.6	Start track that has not auto-acquired	P		M	Movement Detection, Keyboard Dexterity
6.4.7	Restore ARTS data base from Stage A			M	Keyboard Dexterity
6.4.8	Confirm computer actions accomplished during transition		C		Technical Grammar, Deductive Reasoning
6.5.1	Alert other facilities of FDP fault			M	-
6.5.2	Forward *flight plan data (not previously for-warded by the computer)* to adjacent facility	P	C	M	Visual Recognition, Deductive Reasoning
6.5.3	Determine when data base information should have been forwarded by computer		C		Deductive Reasoning
6.5.4	Reenter all required data on *transition to* automated mode		C	M	Deductive Reasoning, Planning Ability, Screening/Filtering, Keyboard Dexterity
6.5.5	Verify or forward flight data on handoff			M	-
6.6.1	Obtain substitute routing	P			
6.6.2	Reroute aircraft using NAVAID		C	M	Expressional Fluency
6.6.3	Plan reroute of aircraft that will be using NAVAID		C		Planning Ability
6.6.4	Copy reroute substitute on blank flight strip			M	-
6.6.5	Monitor status of radio aids for navigation		C		Sensitivity to Problems
6.6.6	Notify pilots of NAVAID status			M	-
6.7.1	Determine communication failure		C		Deductive Reasoning
6.7.2	Adjust communication strategy		C		Expressional Fluency, Planning Ability
6.7.3	Switch to backup frequency			M	
6.7.4	Inform pilot of change in frequency			M	
6.7.5	Inform supervisor of communication failure				
6.7.6	Inform supervisor of changes made in frequency selection				
6.7.7	Inform other controller/facility of change in frequency			M	

TABLE 5-46. ESTIMATED ATTRIBUTE CHARACTERIZATION OF CONTROLLER TASKS (Cont'd)

TASK NO.	TASK STATEMENTS	GENERAL NATURE OF TASK	KEY SPECIFIC ATTRIBUTES INVOLVED
5.8.1	Determine impending controller overload	C	Sensitivity to Problems, Deductive Reasoning, Screening/Filtering
5.8.2	Exchange/assign intra-controller responsibilities	C	Social Intelligence
5.8.3	Request assistance or relief	C	Ideational Fluency
5.8.4	Request handoff controller or coordinator support	C	Sensitivity to Problems
5.8.5	Request rerouting of traffic	C	Sensitivity to Problems
5.8.6	Restrict traffic coming into sector/position	C	Planning Ability
5.8.7	Split up (decombine) sector/position	C	Sensitivity to Problems

5.4.5 Controller Review of Attribute Categories

A select team of 15 experienced air traffic controllers and chiefs/administrators were asked to review and comment upon the identified attributes. Their suggestions led to the generation of five additional attributes they believed were important to the job. These are described in Table 5-45. In some instances arbitrary titles had to be selected to express the attribute.

Another of their suggestions was for a structure or model into which all the attributes could be fit. Table 5-46 presents our attempt to produce such a structure. Table 5-47 then illustrates the allocation of attributes, both original and newly suggested, to this structural framework.

TABLE 5-45. POTENTIAL ADDITIONAL ATTRIBUTES

Code	Attribute Titles	Description	ATC Illustration
P15	Sensory Multiplexing	Capability of perceiving multiple verbal and visual inputs simultaneously; attuned to a varied situational environment without disturbing the work process.	Listen and acknowledge many different communications, rapidly occurring and overlapping, and hearing the critical information content (e.g., from pilots and other controllers).
C17	Long-Term Memory	Mental storage of knowledge over a period of time and selective recall of what is relevant and proper to a current situation.	Remember proper procedural instructions or letters of agreement that are relevant to a seldom occurring situation, such as for an air show or large flight formation.
C18	Mental Multiplexing	Mental flexibility and adaptability (dexterity) in effectively and confidently dealing with diverse and changing situations.	Handling student and general aviation pilots, translating communications to acquire/assure correct understanding; Change to a different sector or facility; Assume control of different airport.
C19	Recall from Interruption	Ability to recall a deferred or interrupted action when priorities permit, and able to resume the action appropriately.	Discussing separation or traffic sequence with a controller and being interrupted by another controller who is on the interphone override, then after coordination with the second controller is complete, returning to the first controller without pause.

TABLE 5-45 POTENTIAL ADDITIONAL ATTRIBUTES (Cont'd)

Code	Attribute Titles(s)	Description	ATC Illustration
M14	Speaking Speed with Precision	Skillful technical expression in reasonably rapid, precise, and accurate manner to convey instructions, requests, or status information briefly.	Using proper phraseology when issuing clearances, traffic advisories, and alerts.

TABLE 5-46. STRUCTURE OF INFORMATION HANDLING AND PROCESSING ATTRIBUTES

PERCEPTUAL PROCESSES (Sensory Input)

- Visual Mode of Input
  - Detection
  - Discrimination
  - Visual Field Arrangement
  - Spatial Patterns
- Auditory Mode of Input
- Tactual Mode of Input
- Sensory Multiplexing

COGNITIVE PROCESSES (Intellectual Processing)

- Action Initiation (Evaluation and Planning)
- Adaptive Processes (Aids)
- Knowledge Base (Memory Storage and Retrieval)
- Transformation of Input or Data (Encoding)
- Reasoning (Information Structuring)

MOTOR PROCESSES (Physical Output - usually in coordination with Sensory Processes)

- Manual Mode of Output Response
  - Speed of Movement
  - Gross Control
  - Coordination
  - Fine Control
- Vocal Mode of Output Response

TABLE 5-47. ATTRIBUTE ALLOCATION WITHIN STRUCTURE

PERCEPTUAL PROCESSES (Sensory Input)

Visual Mode of Input

Detection
- Movement Detection
- Spatial Scanning (Object Detection)

Discrimination
- Form Perception (Form Matching)
- Perceptual Speed
- Color Discrimination

Visual Field Arrangement
- Image or Pattern Formation (Closure)
- Visual Recognition (Visual Memory, Recognition Memory)
- Far Visual Acuity
- Near Visual Acuity

Spatial Patterns
- Recognition of Spatial Patterns (Pattern Recognition)
- Transformation of Spatial Patterns (Spatial Visualization)
- Depth Perception (Stereoscopic Acuity)

Auditory Mode of Input
- Auditory Acuity

Tactual Mode of Input
- Tactual Discrimination (Touch Sensitivity)

Sensory Multiplexing
- Sensory Multiplexing

COGNITIVE PROCESSES (Intellectual Processing)

Action Initiation (Evaluation and Planning)
- Sensitivity to Problems (Evaluation)
- Planning Ability (Priortize/Schedule)

Adaptive Processes (Aids)
- Social Intelligence (Interpersonal Communication)
- Screening/Filtering (Overload Accommodation, Selective Attention
- Mental Multiplexing

Knowledge Base (Memory Storage and Retrieval)
- Short-Term Memory
- Technical Grammar
- Verbal Comprehension
- Long-Term Memory
- Recall from Interruption

TABLE 5-47 ATTRIBUTE ALLOCATION WITHIN STRUCTURE (Cont'd)

Transformation of Input or Data (Encoding)
- Expressional Fluency
- Numerical Computation (Number Facility)
- Input Transformation/Translation (Coding)
- Probability Estimation

Reasoning (Information Structuring)
- Ideational Fluency
- Deductive Reasoning (Fact Conclusion)
- Inductive Reasoning (Generalization)
- Mathematical Reasoning
- Probabilistic Calculation (Prediction)

MOTOR PROCESSES (Physical Output, usually in coordination with sensory processes

Manual Mode of Output Response

Speed of Movement
- Simple Reaction Time
- Speed of Arm Movement

Gross Control
- Arm Extension
- Muscular Strength (Static Strength)
- Arm-Hand Steadiness

Coordination
- Eye-Hand Coordination
- Response Orientation
- Multilimb Coordination

Fine Control
- Manual Dexterity
- Keyboard Dexterity
- Control Precision (Fine Control Sensitivity)
- Rate Control
- Finger Dexterity

Vocal Mode of Output Response
- Speaking Speed with Precision

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Chapter 6.0

Position Operations and Workload Assessment

6.0 POSITION OPERATIONS AND WORKLOAD ASSESSMENT

This chapter examines in Sections 6.1 and 6.2 the working relationships of crew members at given controller positions. The tasks generally performed by each controller position are noted. This task allocation description is derived from the present controller tasks that were identified in Chapter 5.0.

In Section 6.3 a method for assessing controller workload is described, based on factors in the air traffic situation facing a controller. Assessment of controller workload is illustrated for ten air traffic situations, employing situation complexity measures to qualitatively estimate overall controller workload in relation to air traffic scenarios.

6.1 NORMAL POSITION MANNING AND RESPONSIBILITIES

Earlier, in Section 2.6 of this document, there was a brief description of the several types of ATC controllers that are possible in terminal and center operations. The composition of controller teams in each kind of facility will fluctuate from time to time as the amount and nature of air traffic necessitate assistance in handling the controller workload.

In this section we first take a look at what might be considered "normal" manning of controller positions and their assigned responsibilities. This staffing view may be representative of smaller facilities. It is recognized that there are many important functions performed by other personnel (e.g., supervisors, coordinators, assistant controllers, and technical support specialists), but for purposes of this "normal" picture of controller tactical operations, the role of such assisting personnel is not considered at this time.

In addition to the tasks captured in this study, controllers contend with many local procedures, and changes thereto.

6.1.1 Terminal Operations Manning/Responsibilities

For the TRACON facility, it is assumed there normally is but one category of controller, the Terminal Controller. This simplified view of controller assignment includes feeder, final, and departure control functions for both the main terminal and any satellite operations. The TRACON facility is assumed to be equipped with ARTS and FDEP capability. Support functions of Clearance Delivery and Flight Data are omitted here, as are Tower functions of local and ground control.

The Terminal Controller is a full performance level controller and is responsible for separation of aircraft that are within the position's area of responsibility. This is accomplished primarily through the use of radar separation, communicating directly with the pilot through air/ ground radio. The controller uses flight progress strips which are printed on the FDEP equipment. The strips are placed on a shelf in front of the radar console. At facilities where there is no radar equipment the strips may be inserted into flight progress bays.

6.1.2 <u>ARTCC Operations Manning/Responsibilities</u>

For the ARTCC facility, the "normal" manning is here considered to consist of two controller types, the "R" Radar Controller and the "D" Manual Controller. The R-Controller assignment includes arrival, departure, en route, and handoff control functions. Oceanic control and non-radar sectors are not considered in this general "normal" setting. The coordination function of Flow Controller is also omitted here.

The "R" Radar Controller is a full performance level controller and is responsible for separation of aircraft that are within the sector's boundaries. This is accomplished primarily through the use of radar separation, communicating directly with the pilot through air/ground radio. When radar coverage is limited or not available, standard non-radar separation is applied. This requires greater pre-planning activity.

The "D" Manual Controller is responsible for the management of the flight progress strip bays, including long range pre-planning control activities. He is responsible for separation, primarily through the issuance of clearances and coordination with other facilities and positions by use of interphone communication.

Thus, "normal" staffing of terminal and center facilities contains the following controller types:

<u>TRACON Facility</u>

Terminal Controller

<u>ARTCC Facility</u>

"R" Radar Controller
"D" Manual Controller

6.1.3 <u>Expanded Staffing for En Route and Terminal Positions/Sectors</u>

From this "normal" baseline, a more "realistic" staffing of position assignments can be developed for current operations. This expanded staffing view is particularly relevant to larger facilities, to accommodate task sharing and reduce controller workload. Additional controller personnel can be added to assist "normal" staffing or to divide the responsibilities among several other controllers. In this expanded staffing version, each of the "normal" position types may be considered to consist of the following controller positions (recognizing full well that there could be many other configurations based on local situations or extent of controller workload and situation complexity):

TRACON Facility

Final Controller
Feeder Controller
Departure Controller
Coordinator (Radar)

ARTCC Facility

"R" Radar Controller
Radar Handoff Controller
"D" Manual Controller
"A" Assistant/Developmental Controller

Again, the helping roles of supervisors and coordinators at center facilities are omitted here, but only because the controller tasks they perform are shared heavily within controller positions normally performing those tasks. At a terminal facility, the Coordinator (Radar) position performs allocated tasks in a much more predominant manner. This Coordinator tends to assume a fairly large and continuing role for certain tasks of the controllers, for as long as the Coordinator position is staffed. These tasks may service and assist more than one of the other manned positions in a terminal facility.

Specific controller tasks which generally are performed by each of these additional controller staffings are discussed in Section 6.2.

6.2 TASK ALLOCATION TO VARIOUS CONTROLLER POSITIONS

6.2.1 Task Position Allocation

The current 236 controller tasks identified in the task composition graphs of Chapter 5.0 are listed in Table 6-1. Each task is associated with one or more of these controller types for the "normal" manning configuration.

In Table 6-1, abbreviated column headings are necessary for space considerations. These abbreviations are defined as:

T - Terminal Controller

R - "R" Radar Controller

D - "D" Manual Controller

Auto (A) - Automated Operational Mode (i.e., performed with computer augmentation)

Man (M) - Manual Operational Mode (i.e., performed without aid of computer augmentation

NR - Operational Mode is Not Relevant (i.e., automation is not necessarily involved)

Table 6-1 lists 232 tasks for Terminal Controllers, 201 tasks for "R" Radar Controllers, and 120 tasks for "D" Manual Controllers. R and D together at ARTCC perform a total of 227 tasks. Nearly all

TABLE 6-1. TASKS PERFORMED BY T-TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS

		CONTROLLER			OPERATIONAL MODES		
		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
ACTIVITY 1.0 PERFORM SITUATION MONITORING							
Sub-Activity 1.1 Checking and Evaluating Separation							
TASK NO.	TASK STATEMENTS						
1.1.1	Observe display for potential violation of separation standards	T	R	D	A	M	
1.1.2	Mentally project aircraft position/altitude/path	T	R	D			NR
1.1.3	Read out range/bearing/time for an aircraft to a fix or geographic point		R		A		
1.1.4	Force data block to examine track information on aircraft	T	R		A		
1.1.5	Determine whether aircraft will be separated by less than prescribed minima	T	R	D	A	M	
1.1.6	Review flight strips for present and/or future aircraft separation	T	R	D			NR
Sub-Activity 1.2 Monitoring Unsolicited Communications							
1.2.1	Receive equipment status information	T	R	D	A	M	
1.2.2	Receive information on operations status	T	R	D	A	M	
1.2.3	Receive traffic and flow information	T	R	D	A	M	
1.2.4	Receive information on weather events	T	R	D	A	M	
Sub-Activity 1.3 Analyzing Requests for Clearances							
1.3.1	Search inactive bay for flight strip on clearance request	T	R	D	A	M	
1.3.2	Put in strip request for flight	T	R	D	A		
1.3.3	Request flight plan readout	T	R	D	A		

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R RADAR, AND D MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Sub-Activity 1.4 Processing Departure Time Information							
1.4.1	Observe/receive aircraft departure time	T	R	D	A	M	
1.4.2	Enter Departure Message (DM) into the computer	T	R	D	A		
1.4.3	Respond to initial aircraft contact on departure	T	R		A	M	
1.4.4	Verify aircraft altitude on departure	T	R		A	M	
1.4.5	Start track manually	T	R		A		
1.4.6	Observe automatic start of track	T	R		A		
1.4.7	Observe flashing DM in data block	T			A		
1.4.8	Call center controller sector regarding aircraft departure time	T				M	
Sub-Activity 1.5 Processing Requests for Flight Following							
1.5.1	Receive request for flight following	T	R		A	M	
1.5.2	Assign beacon code to pilot	T	R		A	M	
1.5.3	Deny flight following request	T	R				NR
Sub-Activity 1.6 Housekeeping							
1.6.1	Reposition a data block	T	R		A		
1.6.2	Check TAB List against flight strips for completeness/receipt of flight strips	T		D	A		
1.6.3	Request flight strips be produced from data base	T		D	A		
1.6.4	Request an ARTS message be forwarded on the TAB List	T	R	D	A		
1.6.5	Review TAB List/data block for old data to drop	T			A		
1.6.6	Drop data block for an active track	T	R		A		
1.6.7	Drop inactive track from TAB List	T			A		
1.6.8	Review flight strips to insure all data are passed to next controller	T	R	D	A	M	
1.6.9	Review inactive or proposed flight plan bay for deadwood	T		D	A	M	
1.6.10	Cancel flight data in data base	T	R	D	A		
1.6.11	Remove flight strips from holders	T		D	A	M	

TABLE 6-1. TASKS PERFORMED BY T=TERMINAL, R=RADAR, AND M=MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
1.6.12	Review active flight plan bays for flights past transfer/control [illegible]	T	R	D	A	M	
1.6.13	Check clock setting for accuracy	T	R	D	A	M	
1.6.14	Check altimeter setting for accuracy	T	R	D	A	M	
1.6.15	Inform supervisor of inaccurate altimeter/clock setting	T	R	D	A	M	
Activity 2.0	RESOLVE AIRCRAFT CONFLICTS						
Sub-Activity 2.1	Performing Conflict Resolution						
2.1.1	Receive conflict alert notice from adjacent controller	T	R	D	A		
2.1.2	Detect conflict alert indicator	T	R	D	A		
2.1.3	Determine validity of conflict notice or indicator	T	R		A	M	
2.1.4	Inform adjacent controller of conflict alert in his sector/position	T	R		A		
2.1.5	Inform adjacent controller of course of action	T	R	D	A	M	
2.1.6	Detect aircraft maneuver in response to conflict resolution	T	R		A	M	
Sub-Activity 2.2	Performing Minimum Safe Altitude Warning Processing						
2.2.1	Receive MSAW notice from adjacent controller or facility	T	R		A		
2.2.2	Detect MSAW indicator or alarm	T	R		A		
2.2.3	Determine validity of MSAW notice or indicator	T	R		A		
2.2.4	Determine whether aircraft in vicinity permit climb or turn	T	R		A		
2.2.5	Notify supervisor of valid MSAW alert or flight assist	T	R		A		
2.2.6	Detect aircraft manuever in response to low altitude resolution	T	R		A		
Sub-Activity 2.3	Performing Airspace Conflict Processing						
2.3.1	Perceive/recognize on display an aircraft approaching limits of its airspace	T	R		A	M	
2.3.2	Calculate aircraft's path with respect to special use airspace	T	R		A	M	

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Sub-Activity 2.4	Issuing Traffic Advisories (Cautionary Separation)						
2.4.1	Observe display for aircraft separation not likely to meet required standards	T	R		A	M	
2.4.2	Issue traffic advisory to aircraft in regard to air traffic deviation	T	R		A	M	
2.4.3	Issue traffic advisory in regard to other traffic proximity	T	R		A	M	
Sub-Activity 2.5	Inhibiting Alerts						
2.5.1	Inhibit conflict alert for paired or group suppression	T	R		A		
2.5.2	Inhibit conflict alert for refueling or other special operation	T	R	D	A		
2.5.3	Inhibit conflict alert for air show	T			A		
2.5.4	Inhibit MSAW alert	T	R	D	A		
Activity 3.0	MANAGE AIR TRAFFIC SEQUENCES						
Sub-Activity 3.1	Responding to Flow Constraints						
3.1.1	Receive a Fuel Advisory Departure (FAD) notice	T	R	D			NR
3.1.2	Receive a flow restriction	T	R	D			NR
3.1.3	Confer with pilot on desire for FAD intentions	T	R				NR
3.1.4	Choose desired sequence	T	R				NR
3.1.5	Select new flow/sequence	T	R				NR
3.1.6	Determine the technique for accomplishing a delay	T	R				NR
3.1.7	Negotiate speed reduction or hold with pilot	T	R				NR
3.1.8	Evaluate constraint effect on flow	T	R				NR
Sub-Activity 3.2	Processing Air Traffic Deviations (Observed or Requested)						
3.2.1	Perceive an altitude or route deviation	T	R		A	M	
3.2.2	Receive a traffic deviation notice	T	R				NR
3.2.3	Receive a deviation request from pilot	T	R				NR

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
3.2.4	Identify transition from old to new sequence	T	R				NR
3.2.5	Determine maneuver to establish/restore sequence	T	R				NR
Sub-Activity 3.3	Maintaining Departure Pattern						
3.3.1	Project aircraft departure sequence	T	R		A	M	
3.3.2	Plan control action to permit departing aircraft to climb to a specific altitude safely	T	R				NR
Sub-Activity 3.4	Maintaining Arrival Pattern						
3.4.1	Advise supervisor of factors affecting need for change in arrival rate	T			A	M	
3.4.2	Project traffic sequence	T	R		A	M	
3.4.3	Determine descent time or point	T	R		A	M	
Sub-Activity 3.5	Responding to Exception Events						
3.5.1	Receive notice of an exception event from pilot, supervisor, or adjacent controller	T	R	D			NR
3.5.2	Observe/recognize an exception event on part of an aircraft	T	R	D			NR
Sub-Activity 3.6	Monitoring Non-Controlled Objects						
3.6.1	Receive notice of airspace intrusion by a non-controlled object	T	R	D			NR
3.6.2	Observe airspace intrusion by a non-controlled object	T	R				NR
3.6.3	Flight follow an observed non-controlled object	T	R				NR
3.6.4	Write reminder note of airspace intrusion	T	R				NR
3.6.5	Advise adjacent controller/facility of airspace intrusion	T	R	D			NR
3.6.6	Advise supervisor of an airspace intrusion	T	R	D			NR

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Sub-Activity 3.7	**Responding to Airspace Restriction Events**						
3.7.1	Receive notice of airspace restriction imposed	T	R	D			NR
3.7.2	Determine whether restricted area is under ATC control	T	R	D			NR
3.7.3	Designate an area in use	T	R		A		
3.7.4	Restrict aircraft activity in area by altitude or segment	T	R				NR
3.7.5	Request temporary release of restricted airspace or area	T	R	D			NR
Sub-Activity 3.8	**Transferring Control Responsibility**						
3.8.1	Initiate handoff	T	R		A	M	
3.8.2	Observe handoff acceptance	T	R		A	M	
3.8.3	Call controller if no response is received on handoff	T	R		A		
3.8.4	Retract handoff	T	R		A		
3.8.5	Change aircraft frequency	T	R		A	M	
3.8.6	Receive non-automated handoff	T	R			M	
3.8.7	Acknowledge non-automated handoff/start track	T	R		A		
3.8.8	Receive automatic handoff	T	R		A		
3.8.9	Accept automatic handoff	T	R		A	M	
3.8.10	Verify communications with pilot on transfer of control	T	R				NR
3.8.11	Verify aircraft altitude with pilot on transfer of control	T	R				NR
3.8.12	Terminate radar service to aircraft	T	R		A	M	
Sub-Activity 3.9	**Sharing Control Responsibility**						
3.9.1	Conduct/issue pointout	T	R		A	M	
3.9.2	Respond to pointout	T	R		A	M	
3.9.3	Suppress flight data block after pointout	T	R		A		

TABLE 6-1. TASKS PERFORMED BY T-TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Activity 4.0 ROUTE OR PLAN FLIGHTS							
Sub-Activity 4.1 Coordinating and Issuing Clearances							
4.1.1	Receive clearance request from adjacent facility, FSS, or pilot	T	R	D			NR
4.1.2	Coordinate a planned clearance with adjacent controller	T	R	D			NR
4.1.3	Receive clearance and instructions from the center for relay to pilot	T	R	D			NR
4.1.4	*Observe display for other aircraft positions*	T	R		A	M	
4.1.5	Advise controller of required clearances on aircraft entering or leaving sector/position	T	R	D	A	M	
4.1.6	Inform adjacent controller/facility of clearance change which might necessitate delay or changes in route	T	R	D			NR
4.1.7	Formulate a clearance with appropriate restrictions	T	R	D			NR
4.1.8	Evaluate a planned course of action, solution, impact	T	R	D			NR
4.1.9	Deny clearance request	T	R	D	A	M	
4.1.10	Issue clearance and instructions to pilot	T	R	D	A	M	
4.1.11	Issue clearance and instructions to terminal facility, FSS, BASOPS, or airline office for relay to pilot	T	R	D	A	M	
4.1.12	Verify aircraft compliance with clearance	T	R				NR
Sub-Activity 4.2 Responding to Contingencies							
4.2.1	Receive information on loss of radio contact or overdue aircraft	T	R	D			NR
4.2.2	Detect a pilot or aircraft problem (e.g. hypoxia)	T	R				NR
4.2.3	*Conduct a radio search for overdue aircraft*	T	R	D			NR
4.2.4	Declare event and invoke contingency plan	T	R	D			NR
4.2.5	Contact facility along route of flight to secure information on overdue aircraft	T		D			NR
4.2.6	Alert airport emergency crew or other designated personnel of aircraft having flight difficulties	T	R	D			NR
4.2.7	Report contingency event to supervisor	T	R	D			NR

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Sub-Activity 4.3	**Responding to Special Operations**						
4.3.1	Receive notice of necessity for special operations	T	R	D			NR
4.3.2	Perceive necessity for special operations	T	R		A	M	
Sub-Activity 4.4	**Processing Flight Plans**						
4.4.1	Receive flight plan from pilot	T	R				NR
4.4.2	Receive flight plan data from previous controller	T		D			NR
4.4.3	Receive flight plan on flight strip printer (FSP)	T		D	A		
4.4.4	Review flight plan for completeness	T		D	A	M	
4.4.5	Query pilot about flight plan	T	R				NR
4.4.6	Query the relayer of a flight plan	T		D			NR
4.4.7	Compose flight plan data entry and enter into the computer	T		D	A		
4.4.8	Forward flight plan to next controller	T		D	A	M	
4.4.9	Distribute new flight strip(s)	T		D	A	M	
4.4.10	Post flight strip in strip bays	T		D	A	M	
Sub-Activity 4.5	**Processing Flight Plan Amendments**						
4.5.1	Receive pilot/controller request for flight change	T	R				NR
4.5.2	Review flight amendment request	T	R				NR
4.5.3	Flag flight strip for reminder action	T		D			NR
4.5.4	Negotiate flight change with pilot	T	R				NR
4.5.5	Receive flight plan amendment from previous controller	T		D	A	M	
4.5.6	Receive computer message regarding flight plan amendment			D	A		
4.5.7	Request flight progress strip over a given fix	T	R			M	
4.5.8	Write flight plan amendment on strip	T		D	A	M	
4.5.9	Resequence flight strip	T		D			NR
4.5.10	Compose/enter computer message on flight plan amendment	T		D	A		
4.5.11	Modify display/DEDS/scratch pad to amend data	T	R		A		

TABLE 6-1 TASKS PERFORMED BY TERMINAL, R RADAR, AND D MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
4.5.12	Unflag flight strip	T		D			NR
4.5.13	Review flight plan change (double check)	T		D			NR
4.5.14	Receive pilot's progress report	T	R				NR
4.5.15	Check aircraft speed/time for change	T	R			M	
Activity 5.0 ASSESS WEATHER IMPACT							
Sub-Activity 5.1	Analyzing Weather Situation/Altitude and Route Determination						
5.1.1	Determine direction and movement of weather line	T	R		A	M	
5.1.2	Determine base and height of buildup from PIREPs	T	R	D			NR
5.1.3	Determine whether holes exist in buildup line	T	R				NR
5.1.4	Determine impact of weather on routes and airports in sector/position	T	R	D			NR
5.1.5	Receive information on height of clouds	T	R	D			NR
5.1.6	Predict potential for icing	T	R				NR
Sub-Activity 5.2	Processing PIREPs						
5.2.1	Request pilot report (PIREP) on weather/atmospheric information	T	R	D			NR
5.2.2	Receive pilot report on weather/atmospheric information	T	R	D			NR
5.2.3	Disseminate pilot-reported weather information to other controllers/facilities	T	R	D			NR
5.2.4	Disseminate pilot-reported weather/atmospheric information to aircraft	T	R				NR
Sub-Activity 5.3	Processing Weather Advisories						
5.3.1	Receive SIGMET/AIRMET, other weather reports	T	R	D			NR
5.3.2	Issue weather advisory information to pilot	T	R				NR
5.3.3	Monitor radar display weather situation for revision/cancellation of weather advisory	T	R				NR

TABLE 6-1. TASKS PERFORMED BY TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
5.3.4	Inform pilot of weather disturbances and suggested headings for avoiding such areas	T	R				NR
5.3.5	Inform pilot of meteorological/navigational information	T	R				NR
Sub-Activity 5.4	Responding to Weather Changes/Conditions						
5.4.1	Note change of wind direction/wind shear	T	R				NR
5.4.2	Determine preferred approach	T					NR
5.4.3	Recommend airport traffic configuration to management	T					NR
5.4.4	Determine usable flight level	T	R	D	A	M	
5.4.5	Determine control zone for VFR or IFR	T	R	D			NR
Activity 6.0	MANAGE SECTOR/POSITION RESOURCES						
Sub-Activity 6.1	Managing Controlled Airspace Resources						
6.1.1	Respond to sector/position reconfiguration	T	R	D	A	M	
6.1.2	Honor a requested temporary use of airspace	T	R	D			NR
6.1.3	Determine acceptability of a requested temporary use of airspace	T	R	D			NR
6.1.4	Request temporary use of airspace	T	R	D			NR
6.1.5	Receive a request for temporary use of airspace	T	R	D			NR
6.1.6	Combine/decombine positions/sectors	T	R	D	A	M	
6.1.7	Coordinate use or release of shared airspace	T			A		
6.1.8	Write reminder note of temporary airspace release	T	R	D			NR
6.1.9	Start pseudo track as to areas in use	T	R		A		
6.1.10	Take over airspace associated with facility closure/reopening	T	R	D			NR
6.1.11	Release airspace associated with facility reopening/closure	T	R	D			NR

TABLE 6.1 TASKS PERFORMED BY TERMINAL, R-RADAR, AND D MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
Sub-Activity 6.2	Setting Up Workstation Hardware/Software Configuration						
6.2.1	Review overall system status	T	R	D	A	M	
6.2.2	Review traffic and detailed status	T	R	D	A	M	
6.2.3	Verify all required display and communication switches are in proper location	T	R	D	A	M	
6.2.4	Adjust display and communication volume to personal preference	T	R	D	A	M	
6.2.5	Review flight strips and display lists for correlation	T	R	D	A	M	
6.2.6	Adjust display and ensure critical data are present	T	R	D	A	M	
6.2.7	Visually check radar display for proper alignment, usability, and satisfactory status	T	R		A	M	
Sub-Activity 6.3	Responding to Transient Fault Events						
6.3.1	Check computer clock to assure proper computer functioning	T	R	D	A		
6.3.2	Detect display flicker associated with target location	T	R		A		
6.3.3	Detect nonacceptance of input data by the computer	T	R	D	A		
6.3.4	Forward computer input data by interphone	T	R	D		M	
6.3.5	Detect apparent unreliable air/ground communications	T	R				NR
6.3.6	Explore whether others are receiving an aircraft's transmissions	T	R				NR
6.3.7	Issue alternate communications for air/ground transmission	T	R				NR
6.3.8	Alert supervisor of transient fault occurrence	T	R	D			NR
6.3.9	Force missing message to ARTS	T	R	D	A		
6.3.10	Identify aircraft that is not handed off	T	R		A	M	
6.3.11	Issue routine advisory on equipment status	T	R	D			NR
6.3.12	Observe indication of duplicate beacon code assignment	T	R		A		
6.3.13	Request new beacon code to replace duplicate code	T	R		A		
Sub-Activity 6.4	Executing Backup Procedures for RDP Faults						
6.4.1	Alert other facilities of RDP fault	T	R	D	A		
6.4.2	Go to broadband or DARC operation	T	R		A		

TABLE 6-1. TASKS PERFORMED BY: T TERMINAL, R RADAR, AND D MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
6.4.3	Reidentify aircraft	T	R			M	
6.4.4	Change beacon code assignments to prearranged code banks	T	R	D		M	
6.4.5	Request position/progress reports	T				M	
6.4.6	Start track that has not auto-acquired	T	R		A		
6.4.7	Restore ARTS data base from stage A			D	A		
6.4.8	Confirm computer actions accomplished during transition	T	R	D	A		
Sub-Activity 6.5 Executing Backup Procedures for FDP Faults							
6.5.1	Alert other facilities of FDP fault	T		D	A		
6.5.2	Forward flight plan data (not previously forwarded by the computer) to adjacent facility	T	R	D		M	
6.5.3	Determine when data base information should have been forwarded by computer			D		M	
6.5.4	Reenter all required data on transition to automated mode			D	A		
6.5.5	Verify or forward flight data on handoff		R		A		
Sub-Activity 6.6 Executing Backup NAVAID Procedures (Route Substitution)							
6.6.1	Obtain substitute routing	T	R	D			NR
6.6.2	Reroute aircraft using NAVAID	T	R				NR
6.6.3	Plan reroute of aircraft that will be using NAVAID	T		D			NR
6.6.4	Copy reroute substitute on blank flight strip	T	R	D			NR
6.6.5	Monitor status of radio aids for navigation	T	R				NR
6.6.6	Notify pilots of NAVAID status	T	R				NR
Sub-Activity 6.7 Executing Backup Procedures for Communication Faults							
6.7.1	Determine communication failure	T	R	D			NR
6.7.2	Adjust communication strategy	T	R	D			NR
6.7.3	Switch to backup frequency	T	R				NR
6.7.4	Inform pilot of change in frequency	T	R				NR

TABLE 6.1. TASKS PERFORMED BY T-TERMINAL, R-RADAR, AND D-MANUAL CONTROLLERS (Cont'd)

		TERMINAL	RADAR	MANUAL	AUTO	MAN	NR
6.7.5	Inform supervisor of communication failure	T	R	D			NR
6.7.6	Inform supervisor of changes made in frequency selection	T	R				NR
6.7.7	Inform other controller/facility of change in frequency	T	R	D			NR
Sub-Activity 6.8	Managing Personnel Resources						
6.8.1	Determine impending controller overload	T	R	D			NR
6.8.2	Exchange/assign intra-controller responsibilities	T	R	D			NR
6.8.3	Request assistance or relief	T	R	D			NR
6.8.4	Request handoff controller o. -dinator support	T	R				NR
6.8.5	Request rerouting of traffic	T	R	D			NR
6.8.6	Restrict traffic coming into sector/position	T	R	D			NR
6.8.7	Split up (decombine) sector/position	T	R	D	A	M	

tasks performed by the Terminal Controller are also performed by ARTCC controllers. The obvious exceptions are tasks concerned with final approach and runway configuration. Available equipment also limits performance of a few tasks, such as entry of "scratch pad" information on a data block.

ARTCC controllers also perform a very few tasks which generally are unique to center operations. These mostly pertain to the use of:

1. Velocity vector (vector lines)
2. Range/bearing/time to a fix
3. Flight levels

Typically, the same tasks are performed by both Terminal and "R" Radar Controllers, though not necessarily in the same manner. Some clearance and information forwarding tasks and emergency communicating tasks of the Terminal Controller are performed in the ARTCC, but by the "D" Manual Controller instead of the R-Controller.

Table 6-1 indicates that 78 percent of the "D" Manual Controller tasks are performed also by R-Controllers. Those tasks performed typically only by the "D" Manual Controller tend to pertain mostly to assisting and alerting the R-Controller on matters of aircraft separation and clearances, as well as to assisting with and informing others about various contingency operations and equipment degradations.

6.2.2 Intra-Position Task Allocation

This subsection examines the influence on task allocation when "normal" staffing is expanded. For this purpose, the Terminal Controller position is assumed to be expanded into the positions of:

Final Controller
Feeder Controller
Departure Controller
Coordinator (Radar)

The "R" Radar Controller is expanded by the addition of a Radar Handoff Controller to help with the aircraft handoff tasks and various other tasks to alleviate the workload of the R-Controller. Similarly, the "D" Manual Controller is expanded by the addition of an "A" Assistant/Developmental Controller.

This examination of task allocation, as may typically be hypothesized to occur in an "average" facility, revealed the following points:

1. With the obvious exception of Sub-Activities 3.3 and 3.4 (Maintaining Departure and Arrival Patterns), the three terminal controller positions of Final, Feeding and Departure Controllers perform identical tasks for the most part. They differ only in determining aircraft over which to exercise control, not over which tasks to perform.

2. The Coordinator position in a terminal facility and the Radar Handoff Control-

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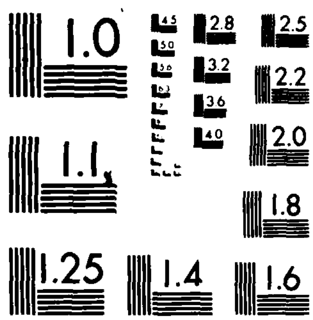

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ler in an ARTCC facility tend to perform the same tasks. They differ primarily in that the Handoff Controller services the aircraft of the responsible R-Controller; whereas, the Coordinator in the terminal services the aircraft of all three of the Final-Feeder-Departure Controllers. This is done on an as needed basis, as judged by the Coordinator or requested by a controller facing task overload.

3. Performance of controller tasks by the Coordinator and by the Handoff Controller does not relieve the other controllers from responsibility for performing the same tasks, though for different aircraft or situations. The tasks are shared, not reallocated. However, when either a Coordinator or Handoff Controller position is staffed, that position most often is the predominant performer of those tasks allocated to that position.

4. Some specific processing and housekeeping of flight progress strips appear to be the primary assignment of "A" Assistant/Developmental Controllers. This responsibility is augmented by work to assist in reentering the data base after FDP faults have been corrected.

Tables 6-2 and 6-3 follow to itemize the tasks commonly shared with Coordinators, Handoff Controllers, and "A" Assistant/Developmental Controllers. All of the tasks in Sub-Activity 3.3, Maintaining Departure Pattern, are exclusively those of the Departure Controller in typical expanded staffing of the Terminal Controller position.

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC)

C or H = Team Support Role

C* or H* = Prime Performance Role

	Coordinator	Handoff Controller
Activity 1.0 PERFORM SITUATION MONITORING		
Sub-Activity 1.1 <u>Checking and Evaluating Separation</u>		
1.1.1 Observe display for potential violation of separation standards	C	H
1.1.2 Mentally project aircraft position/altitude/path	C	H
1.1.3 Read out range/bearing/time for an aircraft to a fix or geographic point		H
1.1.4 Force data block to examine track information on aircraft	C	H
1.1.5 Determine whether aircraft will be separated by less than prescribed minima	C	H
1.1.6 Review flight strips for present and/or future aircraft separation	C	H
Sub-Activity 1.2 <u>Monitoring Unsolicited Communications</u>		
1.2.1 Receive equipment status information	C*	H*
1.2.2 Receive information on operations status	C*	H*
1.2.3 Receive traffic and flow information	C*	H*
1.2.4 Receive information on weather events	C*	H*
Sub-Activity 1.4 <u>Processing Departure Time Information</u>		
1.4.5 Start track manually		H
1.4.6 Observe automatic start of track		H
1.4.7 Observe flashing DM in data block	C	
1.4.8 Call center controller sector regarding aircraft departure time	C	
Sub-Activity 1.6 <u>Housekeeping</u>		
1.6.5 Review TAB List/data block for old data to drop		H
1.6.6 Drop data block for an active track		H
1.6.7 Drop inactive track from TAB List		H
Activity 2.0 RESOLVE AIRCRAFT CONFLICTS		
Sub-Activity 2.1 <u>Performing Conflict Resolution</u>		
2.1.1 Receive conflict alert notice from adjacent controller	C	H
2.1.2 Detect conflict alert indicator	C	H
2.1.3 Determine validity of conflict notice or indicator	C	H
2.1.4 Inform adjacent controller of conflict alert in his sector/position	C*	H*
2.1.5 Inform adjacent controller of course of action	C*	H*

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC) (Cont'd)

		Coordinator	Handoff Controller
Sub-Activity 2.2	Performing Minimum Safe Altitude Warning Processing		
2.2.1	Receive MSAW notice from adjacent controller or facility	C	H
2.2.2	Detect MSAW indicator or alarm	C	H
2.2.3	Determine validity of MSAW notice or indicator	C	H
2.2.5	Notify supervisor of valid MSAW alert or flight assist	C*	H*
Sub-Activity 2.3	Performing Airspace Conflict Processing		
2.3.1	Perceive/recognize on display an aircraft approaching limits of its airspace	C	H
2.3.2	Calculate aircraft's path with respect to a special use airspace	C	H
Sub-Activity 2.4	Issuing Traffic Advisories (Cautionary Separation)		
2.4.1	Observe display for aircraft separation not likely to meet required standards	C	H
Sub-Activity 2.5	Inhibiting Alerts		
2.5.1	Inhibit conflict alert for paired or group suppression	C	H
2.5.2	Inhibit conflict alert for refueling or other special operation	C	H
2.5.3	Inhibit conflict alert for air show	C*	
2.5.4	Inhibit MSAW alert	C	H
Activity 3.0	MANAGE AIR TRAFFIC SEQUENCES		
Sub-Activity 3.1	Responding to Flow Constraints		
3.1.1	Receive a Fuel Advisory Departure (FAD) notice	C*	H*
3.1.2	Receive a flow restriction	C*	H*
3.1.6	Determine the technique for accomplishing a delay	C	H
3.1.8	Evaluate contraint effect on flow	C	H
Sub-Activity 3.2	Processing Air Traffic Deviations (Observed or Requested)		
3.2.1	Perceive an altitude or route deviation	C	H
3.2.2	Receive a traffic deviation notice	C*	H*
3.2.4	Identify transition from old to new sequence	C	H
3.2.5	Determine maneuver to establish/restore sequence	C	H
Sub-Activity 3.3	Maintaining Departure Pattern		
3.3.1	Project aircraft departure sequence	C	H
3.3.2	Plan control action to permit departing aircraft to climb to a specific altitude safely	C	H

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC) (Cont'd)

	Coordinator	Handoff Controller
Sub-Activity 3.4 Maintaining Arrival Pattern		
3.4.1 Advise supervisor of factors affecting need for change in arrival rate	C*	
3.4.2 Project traffic sequence	C	H
3.4.3 Determine descent time or point		H
Sub-Activity 3.5 Responding to Exception Events		
3.5.1 Receive notice of an exception event from pilot, supervisor, or adjacent controller	C*	H*
3.5.2 Observe/recognize an exception event on part of an aircraft	C	H
Sub-Activity 3.6 Monitoring Non-Controlled Objects		
3.6.1 Receive notice of airspace intrusion by a non-controlled object	C*	H*
3.6.2 Observe airspace intrusion by a non-controlled object	C	H
3.6.3 Flight follow an observed non-controlled object	C	H
3.6.4 Write reminder note of airspace intrusion	C	H
3.6.5 Advise adjacent controller/facility of airspace intrusion	C*	H*
3.6.6 Advise supervisor of an airspace intrusion	C*	H*
Sub-Activity 3.7 Responding to Airspace Restriction Events		
3.7.1 Receive notice of airspace restriction imposed	C*	H*
3.7.2 Determine whether restricted area is under ATC control	C	H
3.7.3 Designate an area in use	C	H
3.7.5 Request temporary release of restricted airspace or area	C*	H*
Sub-Activity 3.8 Transferring Control Responsibility		
3.8.1 Initiate handoff	C	H*
3.8.2 Observe handoff acceptance	C	H*
3.8.3 Call controller if no response is received on handoff	C	H*
3.8.4 Retract handoff	C	H*
3.8.6 Receive non-automated handoff	C	H*
3.8.7 Acknowledge non-automated handoff/start track	C	H*
3.8.8 Receive automatic handoff	C	H*
3.8.9 Accept automatic handoff	C	H*
Sub-Activity 3.9 Sharing Control Responsibility		
3.9.1 Conduct/issue pointout	C*	H*
3.9.2 Respond to pointout	C	H
3.9.3 Suppress flight data block after pointout	C	H

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC) (Cont'd)

	Coordinator	Handoff Controller
Activity 4.0 ROUTE OR PLAN FLIGHTS		
Sub-Activity 4.1 <u>Coordinating and Issuing Clearances</u>		
4.1.2 Coordinate a planned clearance with adjacent controller	C*	H
4.1.4 Observe display for other aircraft positions	C	H
4.1.6 Inform adjacent controller/facility of clearance change which might necessitate delay or changes in route	C*	H*
4.1.8 Evaluate a planned course of action, solution, impact	C	H
4.1.9 Deny clearance request	C	H
4.1.12 Verify aircraft compliance with clearance	C	H
Sub-Activity 4.2 <u>Responding to Contingencies</u>		
4.2.1 Receive information on loss of radio contact or overdue aircraft	C*	H*
4.2.2 Detect a pilot or aircraft problem (e.g. hypoxia)	C	H
4.2.4 Declare event and invoke contingency plan	C	H
4.2.6 Alert airport emergency crew or other designated personnel of aircraft having flight difficulties	C*	H*
4.2.7 Report contingency event to supervisor	C*	H*
Sub-Activity 4.3 <u>Responding to Special Operations</u>		
4.3.1 Receive notice of necessity for special operations	C*	H*
4.3.2 Perceive necessity for special operations	C	H
Sub-Activity 4.4 <u>Processing Flight Plans</u>		
4.4.2 Receive flight plan data from previous controller	C*	H
4.4.3 Receive flight plan on flight strip printer (FSP)	C	H
4.4.6 Query the relayer of a flight plan	C	H
4.4.8 Forward flight plan to next controller	C	H
4.4.9 Distribute new flight strip(s)	C	H
4.4.10 Post flight strip in strip bays	C	H
Sub-Activity 4.5 <u>Processing Flight Plan Amendments</u>		
4.5.5 Receive flight plan amendment from previous controller	C*	H
4.5.11 Modify display/DEDS/scratch pad to amend data		H
4.5.15 Check aircraft speed/time for change		H
Activity 5.0 ASSESS WEATHER IMPACT		
Sub-Activity 5.1 <u>Analyzing weather situation/altitude and route determination</u>		
5.1.1 Determine direction and movement of weather line	C	H
5.1.2 Determine base and height of buildup from PIREPs	C	H
5.1.3 Determine impact of weather on routes and airports in sector/position	C*	H*
5.1.5 Receive information on height of clouds	C	H
5.1.6 Predict potential for icing	C	H

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC) (Cont'd)

Task	Coordinator	Handoff Controller
Sub-Activity 5.2 <u>Processing PIREPs</u>		
5.2.3 Disseminate pilot-reported weather information to other controller/facilities	C*	H*
Sub-Activity 5.3 <u>Processing Weather Advisories</u>		
5.3.1 Receive SIGMET/AIRMET, other weather reports	C	H
5.3.3 Monitor radar display and weather situation for revision/cancellation of weather advisory	C	H
Sub-Activity 5.4 <u>Responding to Weather Changes/Conditions</u>		
5.4.1 Note change of wind direction/wind shear	C*	
5.4.2 Determine preferred approach	C*	
5.4.3 Recommend airport traffic configuration to management	C*	
5.4.4 Determine usable flight level		H
5.4.5 Determine control zone for VFR or IFR	C*	H
Activity 6.0 MANAGE SECTOR/POSITION RESOURCES		
Sub-Activity 6.1 <u>Managing Controlled Airspace Resources</u>		
6.1.1 Respond to sector/position reconfiguration	C*	H*
6.1.2 Honor a requested temporary use of airspace	C*	H*
6.1.3 Determine acceptability of a requested temporary use of airspace	C*	H*
6.1.4 Request temporary use of airspace	C*	H*
6.1.5 Receive a request for temporary use of airspace	C*	H*
6.1.6 Combine/decombine positions/sectors	C*	H
6.1.7 Coordinate use or release of shared airspace	C	
6.1.8 Write reminder note of temporary airspace release	C*	H*
6.1.9 Start pseudo track as to areas in use	C	H*
6.1.10 Take over airspace associated with facility closure/reopening		H
6.1.11 Release airspace associated with facility reopening/closure		H
Sub-Activity 6.2 <u>Setting Up Workstation Hardware/Software Configuration</u>		
6.2.1 Review overall system status		H
6.2.2 Review traffic and detailed status	C	H
6.2.3 Verify all required display and communication switches are in proper location		H
6.2.4 Adjust display and communication volume to personal preference		H
6.2.5 Review flight strips and display lists for correlation		H
6.2.6 Adjust display and ensure critical data are present		H
6.2.7 Visually check radar display for proper alignment, usability, and satisfactory status		H

TABLE 6-2. TASKS GENERALLY SHARED WITH COORDINATORS (IN TERMINALS) AND WITH RADAR HANDOFF CONTROLLERS (IN ARTCC) (Cont'd)

		Coordinator	Handoff Controller
Sub-Activity 6.3	Responding to Transient Fault Events		
6.3.1	Check computer clock to assure proper computer functioning	C*	H*
6.3.2	Detect display flicker associated with target location	C	H
6.3.4	Forward computer input data by interphone	C	H
6.3.8	Alert supervisor of transient fault occurrence	C*	H*
Sub-Activity 6.4	Executing Backup Procedures for RDP Faults		
6.4.1	Alert other facilities of RDP fault	C*	H*
6.4.2	Go to broadband or DARC operation		H*
6.4.3	Reindentify aircraft		H
6.4.6	Start track that has not auto-acquired		H*
6.4.7	Restore ARTS data base from Stage A		H
6.4.8	Confirm computer actions accomplished during transition	C	H*
Sub-Activity 6.5	Executing Backup Procedures for FDP Faults		
6.5.1	Alert other facilities of FDP fault	C*	H*
6.5.2	Forward flight plan data (not previously forwarded by the computer) to adjacent facility	C	H*
6.5.5	Verify or forward flight data on handoff	C*	H*
Sub-Activity 6.6	Executing Backup NAVAID Procedures (Route Substitution)		
6.6.1	Obtain substitute routing	C*	H*
6.6.3	Plan reroute of aircraft that will be using NAVAID	C	H
6.6.4	Copy reroute substitute on blank flight strip	C	H
6.6.5	Monitor status of radio aids for navigation	C	H
Sub-Activity 6.7	Executing Backup Procedures for Communication Faults		
6.7.2	Adjust communication strategy	C	H
6.7.5	Inform supervisor of communication failure	C*	H*
6.7.6	Inform supervisor of changes made in frequency selection	C*	H*
6.7.7	Inform other controller/facility changes in frequency	C*	H*
Sub-Activity 6.8	Managing Personnel Resources		
6.8.1	Determine impending controller overload	C*	H*
6.8.6	Restrict traffic coming into sector/position	C*	
6.8.7	Split up (decombine) sector/position	C*	

TABLE 6-3. TASKS GENERALLY SHARED WITH "A" ASSISTANT/ DEVELOPMENTAL CONTROLLERS

TASK NO.	TASK STATEMENTS
1.6.11	Remove flight strips from holders.
4.4.2	Receive flight plan data from previous controller.
4.4.9	Distribute new flight strip(s).
6.5.2	Forward flight plan data (not previously forwarded by the computer) to adjacent facility.
6.5.3	Determine when data base information should have been forwarded by computer.
6.5.4	Reenter all required data on transition to automated mode.

6.3 CONTROLLER PERFORMANCE ASSESSMENTS

6.3.1 Concepts of Controller "Workload"

Controller workload is one of the factors which limits the growth in air traffic that can be supported by the ATC system in the United States. While several initiatives offer the prospect of improved controller productivity, no firm basis for comparing their improvements has been identified.

The concept of controller workload is intended to produce an indication of the relative amount of mental and physical output or effort on the part of the controller. This qualitative indication may be for a given task in *isolation*, or for the conglomerate of all tasks involved in a prescribed event scenario. "Workload" implies a level of complexity of effort and stress upon the controller that is imposed by the nature and rate of work effort required in the situation. Carried to increased amounts of overall workload, this complexity and stress can lead to serious degradation of controller (and, thus, system) performance. The potential for such overloading is one major reason for dividing controller workload among several controllers in actual practice. The non-automated elements of a controller's job are the source of workload indicators for that position.

A Radar Situation Complexity approach will be described for use in examining the workload and complexity of controller jobs.

The Radar Situation Complexity approach reflects CTA's experience, wherein controllers vigorously objected to simplistic measures of their job performance. A common reaction to questioning which related the workload to the number of aircraft being controlled was, "It all depends on the situation." Therefore, CTA has identified the beginnings of a possible tool with which to quantify the complexity of situations in the current system. This measure of Radar Situation Complexity springs directly from the event-responsive view of air traffic control tasks postulated by this report: Events (and, thus, control actions) are a function of airspace, environment, and traffic. Our approach resembles that used for the Cooper-Harper Scale of Aircraft Difficulty of Control, [2] which has been employed for many years in assessing the design of aircraft cockpits.

This "workload" measure is discussed and illustrated in the following section.

6.3.2 Workload Estimation Technique

Radar Situation Complexity assesses the amount of workload impacting on a controller, based on the event scenario with which a controller might be faced. It is postulated that Radar Situation Complexity increases as various situation factors increase. The first postulated set of factors to be considered are:

1. Number of controlled aircraft which should require no controller action in the next 4 minutes (Ctl).

2. Number of uncontrolled aircraft within the controller's area of responsiblity (Unctl).

These aircraft must still be followed because they may force an advisory to controlled aircraft.

3. Number of developing situations which will apparently require controller intervention to prevent a conflict with another aircraft, temporary or permanent obstacle, or adjacent airspace (Dev-Sit).

4. Number of developing situations for which a resolution has already been planned and any necessary clearances issued (Res-Sit).

The adequacy of the clearances and of the aircraft response(s) still must be monitored.

5. Number of aircraft which must be routinely maneuvered as part of a sequence or flow pattern of aircraft (Seq-AC).

For example, several aircraft approaching an arrival gate for handoff from an en route sector to a terminal position, or being set up on final approach for release to the tower.

6. Number of sequences or flow patterns with 2 or more members which the controller is maintaining. The workload comes from the need to add to and remove aircraft from the sequence, as well as from the physical presence of the sequence.

The workload measure is the total of the numbers over all six factors. Different radar control situations may then be compared.

This measure should be expanded to include other situational factors. Reviewing controllers provided the additional factor suggestions cited in Table 6-4.

Further work is needed to develop these factors concepts and, perhaps, a meaningful measure of Cumulative Workload across various time intervals of a dynamic event scenario.

Adapting the existing measure and its factors to non-radar procedures and non-radar sectors/positions also would be quite useful.

Informal validation of this measure has first been done through controller scoring of sample situations. The counter-examples which come up during discussion will provide valuable additional insight and should be considered in a second round of scoring.

Semi-formal validation of the measure (and its variants) could then be conducted on a more structured basis by setting up the samples as ETG/DYSIM scenarios. Selected controllers could be asked to handle the situation while providing a running narrative as to the instantaneous level of difficulty of the scenario.

Given the validated measures of controller workload

TABLE 6-4. ADDITIONAL FACTORS FOR SITUATION COMPLEXITY MEASURE

Aircraft Size (= Performance)
    (speed, maneuverability, standardized performance)
Aircraft Type Mix
Aircraft Frequency (No. of Aircraft)
Special Operations (Flight Handling - e.g., refueling)
Number of Operations that have to be Coordinated
    (No. of Coordinations versus No. of Aircraft Worked)

Random Routing
Aircraft Emergency
NORDO and other Unusual Circumstances
Unconfirmed/Unverified Mode C
Special Airspace (Restricted and Warning Areas)
Special Pilot Request
Student Pilots in IFR Environment
    (pilot proficiency, including language)

Complexity of Local Procedures
Effort Required to Update the Computer
Terminal with Uncontrolled Traffic
Pilots Refusing Clearances

Geographical Size of Sector
Configuration of Airspace
Terrain
Weather (closure of sector size, maneuvering area)
    (No. of clearances that have to be issued based on weather)
Number of Deviations involved (due to wind, weather, NAVAID)
Loss of Radar

Special Controller Request
Controller Training/Competency
Proficiency Level of Adjacent Controller (uncoordinated airspace)
Stuck Microphone

for the current system, experiments could be conducted across as wide a range of scenarios as desired. A control group would handle the scenario using current procedures, while other groups would use proposed new man-machine interaction techniques or proposed machine-aiding techniques. The different measures of controller workload for handling the same scenarios should provide an objective basis for choosing among the multitude of possible enhancements to the productivity of the controller-computer team.

6.3.3 Illustrative Task Workload Assessments

To examine the workload measure, the team of reviewing controllers developed several scenarios of varying complexity. They are presented in comparable format in Table 6-5. These scenarios will also be of service in subsequent studies of the future sector suite workstation.

Factor values were calculated for each new scenario and a measure of situation workload derived. All 15 on the review team provided a separate overall rating of the situation complexity, using a seven-interval rating scale. The results are compared to the factor workload measure in Table 6-6. The product moment correlation between the two is .89, indicating a very high relationship between them.

Adding additional factors suggested by the controller review team (Table 6-4) could generate a powerful and sensitive measure of situation workload, particularly as factor weights could be derived by statistical regression techniques to refine computation of the measure.

TABLE 6-5. RADAR SITUATION SCENARIOS

Scenario 1

The center low altitude manual controller has five aircraft transitioning his sector. The aircraft are on established SID/STAR routes that do not cross. No other traffic is involved and weather is not a factor.

Two of the aircraft will not require action within the next four minutes. There is one developing situation which will require controller intervention in the immediate future. There are no uncontrolled aircraft in the area and no other aircraft require clearances. The complexity of this case is considered low.

Scenario 2

The terminal controller is providing radar vectors to five air carrier aircraft to intercept the localizer course in a landing sequence. There are two uncontrolled aircraft in the area that will conflict with all five controlled aircraft.

All controlled aircraft will require action concerning the two uncontrolled aircraft, which means that there are ten developing situations that require intervention. All five air carrier aircraft are part of one arrival sequence and all need further action. The complexity of this case is considered medium.

Scenario 3

The center high altitude radar controller has 16 en route and four transitioning aircraft. All four aircraft are arrivals and must adhere to STAR routes.

None of the aircraft will require action within the next four minutes. There is only one developing situation which will require intervention. A resolution has been planned and a clearance issued which will resolve that situation. There are two separate sequences involving the 20 aircraft. One sequence involves only the four arrival aircraft. The complexity rating is considered high.

TABLE 6-5. RADAR SITUATION SCENARIOS (Cont'd)

Scenario 4

The center high altitude controller has ten aircraft in one sequence on a one way jet route. No aircraft are transitioning and all are in level flight.

Eight of the aircraft will not require any action. One aircraft has requested an altitude change and only one other aircraft is a factor in complying with the request. The complexity rating is considered low.

Scenario 5

The terminal radar controller is working ten aircraft in two arrival sequences. A runway change has been announced. The controller must coordinate the rearranged sequences with the other arrival controller and the tower. The controller must also advise the center of the change.

There are also ten uncontrolled aircraft in the area. All controlled aircraft will require action in the next four minutes. Four aircraft must be maneuvered around other aircraft. The controller has planned or issued six clearances. Three other situations are still developing which will require intervention. The complexity rating is considered high.

Scenario 6

The terminal controller is working five aircraft in VFR weather with one runway in use. One aircraft is a departure, one is an arrival, one is an overflight, and two aircraft are receiving Stage III services. There are three other VFR aircraft observed in the area.

Two aircraft will require no action in the next four minutes. Of the three VFR aircraft, only one is in the area of the controlled aircraft. One situation is developing which will require further action, and one situation has been resolved by a clearance. There are no aircraft in a sequence. The complexity rating is considered low.

TABLE 6-5. RADAR SITUATION SCENARIOS (Cont'd)

Scenario 7

The terminal controller is working four IFR arrivals, three overflights, and two Stage III arrivals. The weather is marginal VFR and a thunderstorm is approaching the airport. Four VFR aircraft are calling for Stage III services. One of these is a panicky student pilot.

Three of the aircraft will not require action in the next four minutes. There are five uncontrolled aircraft in the area and six situations developing that will require intervention. The controller has planned for or issued ten clearances. All ten arrivals are part of one sequence. The complexity rating is high.

Scenario 8

The center high altitude radar controller is working six aircraft on three converging arrival routes. One aircraft has been issued a speed restriction for flow control and another has been requested to increase its speed for spacing.

None of the aircraft will require action within the next four minutes and there are no uncontrolled aircraft in the area. Two pair of aircraft will not have separation as they converge, and the controller has already issued descent clearances to two aircraft to provide separation. There are three sequences involved. The complexity rating is considered medium.

Scenario 9

The center low altitude radar controller has ten inbound aircraft transitioning his sector. The aircraft are established on the preferred inbound route, which leads to a cornerpost and generates an automatic handoff to the terminal controller. No other traffic is involved and weather is not a factor.

Eight of the aircraft will not require any action in the next four minutes. There are no uncontrolled aircraft in the area and no developing situations which will require intervention. The controller routinely plans and issues descent clearances to the aircraft, who are in one sequence and are traveling at approximately the same speed. The complexity of this case is considered low.

TABLE 6-5. RADAR SITUATION SCENARIOS (Cont'd)

Scenario 10

The center low altitude radar controller has ten aircraft in his sector. Five of the aircraft are inbound to a non-radar approach control, two are crossing the sequence and are converging on one another, and the other three are inbound to a radar approach control, with no conflictions, and an automatic handoff.

Three of the aircraft will require action within the next four minutes. There are no uncontrolled aircraft in the area. There are two developing situations which require intervention: (a) the two converging aircraft and (b) the converging aircraft will be crossing the path of one of the inbound aircraft. The controller has issued four clearances and has already coordinated the arrival sequence and separation for the aircraft inbound to the non-radar approach control. There are two arrival sequences and one en route sequence. The complexity of this case is considered medium.

TABLE 6-6. MEASURES OF SITUATION COMPLEXITY

SITUATION FACTOR	FACTOR VALUES PER SCENARIO SITUATION									
	1	2	3	4	5	6	7	8	9	10
Ctl	1	0	20	8	0	2	3	6	0	3
Unctl	0	2	0	0	10	1	5	0	0	0
Dev-Sit	1	10	1	1	3	1	6	2	0	2
Res-Sit	0	0	1	0	6	1	10	2	0	0
Seq-AC	5	5	4	1	4	1	10	2	10	5
Seq	0	5	2	1	2	0	4	3	1	1
Workload Measure (Factor Total)	8	22	28	11	25	6	38	15	11	11
Average Complexity Rating of Situation	1.6	3.7	5.0	2.3	5.7	2.5	6.8	4.8	2.9	3.8

Key to Factor Abbreviations:

Ctl	Number of controlled aircraft, requiring no controller action
Unctl	Number of uncontrolled aircraft in area
Dev-Sit	Number of developing situations requiring action
Res-Sit	Number of developing situations already resolved
Seq-Ac	Number of aircraft to be maneuvered routinely as part of a sequence/flow
Seq	Number of sequences or flow patterns

6.4 POSITION WORKLOAD CONCLUSIONS

Chapter 6.0 has introduced several concepts which may be worthy of further application and study.

First, there is the demonstration of task allocation to several types of controllers. This is made possible by the development of the extensive list of present controller tasks, both terminal and en route. The availability of the task list now makes it possible to survey controllers in various facility settings to inventory and profile their actual task performance. This survey information would allow the preparation of distinct task profiles of what controllers do under each situation or facility configuration that is sampled.

The proven job analysis technique for doing this is called the Task Inventory Survey. This is the process currently used by the US Air Force and others [1,4,5] for the study of related job positions. It employs the task listing and one or more questions to be answered by job incumbents about each task.

The survey question we would propose to use is the Hemphill [3] Scale of How Much a Part of the Job is the Task. This is a 0 to 7 scale that ranges from "Not Part of My Job" (0) to "A Most Significant Part of My Job" (7). It has some special psychometric characteristics by forcing increased task discrimination at the high end of the scale (preventing the tendency for large numbers of tasks being judged as all highly important) and by causing the respondent to combine the influence of several task factors into a single judgment about how significant the task is to that person's job.

With proper sampling in the survey, it is possible to specifically differentiate what controllers do who have different levels of experience, or who operate with different types of equipment, or who control airspace having differing traffic loads or other characteristics.

The value of both the present description of task allocations and such possible future task surveys is that a baseline of present operations is established. As the ATC system evolves into increased modes of automation, the changes in controller work can be noted. This may prove especially helpful as more of the newer controllers become less experienced in manual or degraded control operations. There would seem to be an emerging need for periodic refresher training in non-automated operations for newer controllers who will not get much opportunity to acquire those backup skills. The present descriptions could help provide a basis for planning such training in future years.

Also introduced in this Chapter 6.0 is the concept of measuring controller workload. The measurement approach that was described should be useful for characterizing any changes in controller activities that may be proposed. The measure, however, warrants further development. Studies need to be made of the reliability of judgments associated with the procedure.

It may also be desirable to explore other measures of controller workload. Simpler measures to apply would be helpful; perhaps something like controller judgments of the "overall perceived task load" of a scenario or whole task. The accuracy of such other processes could be compared with the results obtained by the approach described in this report.

Another approach to workload assessment might be developed to employ the task perceptual and cognitive attributes introduced in Chapter 5. Complex attributes that are significantly involved in task performance may be contributing elements to the perceived workload of controllers. This would be a useful means of estimating workload changes as changes in task procedures are considered.

Effective measures of controller workload are necessary to assess the adequacy of new equipment designs and the job changes that proceed from those new designs. Of particular interest would be predicting the impact on controllers of system changes before they are installed in various types and sizes of facilities.

Preliminary tryouts in an MMI (Man-Machine Interaction) testbed or simulator could measure levels of performance degradation of different controller tasks. Such measures as the number of incomplete tasks that are experienced, the number and points of operations breakdown/slowdown could be recorded. This information yields an excellent means for verifying workload differences as measured by the scenario Radar Situation Complexity indices. In turn, this workload measure may prove most helpful in assessing rapidly several different console or other equipment configurations that may be proposed for development.

These tryouts also could explore how scenarios and task complexity vary as a function of a controller's experiences and ability. It has been proposed in the professional literature that experienced workers can attend to more detail-level data. How they organize and structure the information to achieve this result would be most helpful in designing training or work activities to reduce the time it takes a new controller to reach such an experienced capability.

Computer models of current controller workload have been developed for ARTCC en route controllers. These are the Relative Capacity Estimating Process (RECEP) and the Air Traffic Flow (ATF) model developed by the FAA in conjunction with SRI-International. The RECEP/ATF models have been validated as providing an index of controller workload and as a predictor of controller workload as a function of traffic [6]. These models separately assess routine workload, surveillance workload, and conflict prevention workload in conjunction with set intervals of aircraft traffic flow scenarios.

This comprehensive measure of workload in current operations appears sensitive to differences in sector characteristics. It would be a most powerful adjunct to the other workload measures discussed. However, portions of the RECEP require measures of actual operations, which may not be available in simulation testing of future systems and controller procedures.

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7.0 SIGNIFICANT OBSERVATIONS, ISSUES, AND CONCLUSIONS

This chapter summarizes the results of CTA's analysis and observations, identifies operational issues, and presents conclusions. Documentation of current NAS en route and terminal operations served the purpose of:

- Incorporating, in a single source, the results of earlier studies and data collection efforts.
- Focusing on unique similarities and differences between each type of air traffic control facility, i.e., TRACONs and centers.
- Describing the job of one controller.

CTA's intent is to preserve the "core" of system operations which must be implemented by AAS designers for initial sector suite and final sector suite. Significant observations that are covered in this chapter are the product of actual visits to various TRACONs and en route centers. Issues are raised which concern the transition from current to future AAS operations. Conclusions are the result of our analysis and may be viewed in some cases as assertions or validation of assumptions made in Chapter 1.0 of this document.

7.1 SUMMARY OF SIGNIFICANT OBSERVATIONS

The following is a summary discussion of each CTA observation and how it was treated in this document.

a. Division of Labor. Division of controller work in the TRACON and en route centers is different. In the case of many TRACONs a division of labor exists along specialty lines (e.g., there are positions for the final, arrival, and departure control of aircraft. This means there is an air traffic controller who specializes in handling only departures and clearing traffic to a low-altitude sector in a center. The controller routinely performs this procedure.

In the center the controller division of labor is focused on controlling aircraft within a sector of airspace. Consequently, he may respond to a range of events and perform a variety of procedures such as holding patterns or arrival/departure sequencing.

However, the division of labor philosophy in a TRACON is not always consistent. In the case of the LAX TRACON, controllers are assigned a "sector" of airspace. The controller, as in the case of a center controller, may perform the same range of activities. In the LAX TRACON their situation is more a function of traffic patterns, geography, and the number of airports in the Los Angeles basin which require satellite airfield operations support for radar vectoring and radar separation services.

b. <u>Controller as an Event-Responsive Information Processor.</u> Although the controller responds to a wide range of events (i.e., anything can happen within his area (airspace) of responsibility), many events such as altitude change requests and handoffs, are routine and very procedural in nature. Much of the work that a controller does is carefully preplanned (e.g., in a TRACON, arrival traffic sequences are handled by the preplanned procedure for sequencing inbound traffic into final approach). Many of the highly repetitive operational activities are manual and, thus, may be candidates for some form of automation or machine aiding.

c. <u>Controller Workload.</u> Controller workload appears to be cyclical during his shift. Even at the busiest sectors/positions, there were variations in workload. During the most intense periods controllers used the most efficient and quickest forms of interaction to perform a given unit of work. However, during light periods of activity the controller might use interaction techniques which accomplished the same task, but which were "restful". A restful technique might include slewing the trackball to the track on the PVD and depressing a quick action key vs. entering the computer identification number and depressing a quick action key.

The point is that the controller used alternate forms of man-machine interaction as a means to "relax" from intense periods of activity. Also, he will seek the easiest possible way to perform a given task.

There are also frequent sector/position changes (i.e., once every 1-2 hours) so that the activity during a shift was varied and stressful situations minimized.

d. <u>Coordination.</u> There exists a tremendous amount of inter-position/sector controller coordination via the interphone or direct person-to-person communications. Interphone communications were more extensive in a center than a TRACON due to the physical size of the room and positioning of console workstations. This coordination is essential, but machine aiding might improve inter-position/sector coordination. This is an area which requires further investigation.

e. <u>Workstation Improvements.</u> The controller desires improvements both to his physical workstation and to how he performs his job. Areas that were cited include automated flight planning and flight data display and weather message display.

Improvements to the physical workstation include adequate space for reference materials and a location for coffee/snacks.

Controllers appeared to be eager to participate in any exercise which would contribute toward improving on-the-job performance and improving the capabilities of their workstation.

7.2 SIGNIFICANT ISSUES

The most critical issue is concern that, in the design of the next ATC system, care is taken to insure the system does not result in controller work underload. Studies into the cause of system error (i.e., violation of separation standards resulting from system or controller error) have shown that such occurrences do happen during times when the controller is least stressed.

The controller has evolved tremendously with his job over the last 10 years. Much of his job is mental (i.e., cognitive and perceptual), which introduces an element of job interest and satisfaction. There is a prevalent impression that the controller work should become less intense, and with fewer steps in task performance, yet maintain alertness and controller motivation in the job. To design the next system (AAS) without some understanding of how the job of a controller will change and directions of change is to invite operational problems which could affect overall program success.

Tasks such as clearance delivery, which are candidates for advanced automation, must be carefully studied to determine how the job of a controller will change. For example, if one automates clearance delivery, the question becomes what backup methods does one provide the controller to take care of situations where the "system" for clearance delivery fails, or the aircraft is not equipped with the proper flight management hardware. The recommendation is that care must be given to developing design methods and analytical techniques which help both controller and the designer/engineer understand and assess the impact of change.

7.3 AREAS REQUIRING FURTHER INVESTIGATION AND ANALYSIS

During the analysis, work was focused on the en route and terminal controller. Little effort was spent on the analysis of oceanic controller tasks due to current FAA efforts to develop a near term "Oceanic Display and Probe" capability for the oceanic controller.

However, further investigation is required to document the tasks of an air traffic tower controller and his coordination interfaces with the TRACON and center controllers.

A key area requiring work is in developing a set of techniques and measures for estimating controller workload. Some preliminary techniques have been discussed in Chapter 6.0. However, more work is required to determine the kinds of machine aids which would be both productive and useful to the controller. Some of these aids may take the form of additional display information, scratch pads, formatted message menus, etc.

Another area requiring investigation is a rigorous method for analyzing those tasks which are candidates for advanced automation and clearly showing the analysis in a way such that the FAA air traffic service and the controller can understand the proposed change, determine the impact of the change, and provide feedback to the engineer.

7.4 CONCLUSIONS

The major conclusion of this report is that the controller is an event driven, interruptible, human information processor, capable of handling multiple priority levels.

A second conclusion is that conceptually the differences between a terminal controller and an en route controller are minimal. Both types of controller's at the activity level seek to:

- maintain aircraft separation
- manage traffic sequences
- route or plan flights
- assess weather impact
- monitor airspace situation
- manage resources.

It is at the level of the man-machine interaction (subtask level) where one notices the differences in controller jobs. Those differences which exist are due to the different requirements for flight planning, look ahead times, constraints of terminal airspace versus en route airspace, and different supporting computer systems.

Other conclusions include the point that each ATC facility must uniquely adapt to its airspace, constraints, airway route structure, weather patterns, traffic patterns, and airports. Each center or TRACON then operates in a slightly different manner. There are enough unique ways of "doing business" that these exceptions must be noted and incorporated in any analysis regarding the AAS concept of operatons for the man-machine interface.

Appendix A

Annotated Bibliography

ANNOTATED BIBLIOGRAPHY

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Appendix [illegible]

[illegible] of Controller Activities, [illegible],

and Information Processing Tasks

CONTROLLER ACTIVITIES, SUB-ACTIVITIES, AND TASKS

Activity 1.0 PERFORM SITUATION MONITORING

Sub-Activity 1.1 Checking and Evaluating Separation

1.1.1 Observe display for potential violation of separation standards
1.1.2 Mentally project aircraft position/altitude/path
1.1.3 Read out range/bearing/time for an aircraft to a fix or geographic point
1.1.4 Force data block to examine track information on aircraft
1.1.5 Determine whether aircraft will be separated by less than prescribed minima
1.1.6 Review flight strips for present and/or future aircraft separation

Sub-Activity 1.2 Monitoring Unsolicited Communications

1.2.1. Receive equipment status information
1.2.2 Receive information on operations status
1.2.3 Receive traffic and flow information
1.2.4 Receive information on weather events

Sub-Activity 1.3 Analyzing Requests for Clearances

1.3.1 Search inactive bay for flight strip on clearance request
1.3.2 Put in strip request for flight
1.3.3 Request flight plan readout

Sub-Activity 1.4 Processing Departure Time Information

1.4.1 Observe/receive aircraft departure time
1.4.2 Enter Departure Message (DM) into the computer
1.4.3 Respond to initial aircraft contact on departure
1.4.4 Verify aircraft altitude on departure
1.4.5 Start track manually
1.4.6 Observe automatic start of track
1.4.7 Observe flashing DM in data block
1.4.8 Call center controller sector regarding aircraft departure time

Sub-Activity 1.5 Processing Requests for Flight Following

1.5.1 Receive request for flight following
1.5.2 Assign beacon code to pilot
1.5.3 Deny flight following request

Sub-Activity 1.6 Housekeeping

1.6.1 Reposition a data block
1.6.2 Check TAB List against flight strips for completeness/receipt of flight strips.

1.6.3 Request flight strips be produced from data base
1.6.4 Request an ARTS message be forwarded on the TAB List
1.6.5 Review TAB List/data block for old data to drop
1.6.6 Drop data block for an active track
1.6.7 Drop inactive track from TAB List
1.6.8 Review flight strips to insure all data are passed to next controller
1.6.9 Review inactive or proposed flight plan bay for deadwood
1.6.10 Cancel flight data in data base
1.6.11 Remove flight strips from holders
1.6.12 Review active flight plan bays for flights past transfer/control points
1.6.13 Check clock setting for accuracy
1.6.14 Check altimeter setting for accuracy
1.6.15 Inform supervisor of inaccurate altimeter/clock setting

Activity 2.0 RESOLVE AIRCRAFT CONFLICTS

Sub-Activity 2.1 Performing Conflict Resolution

2.1.1 Receive conflict alert notice from adjacent controller
2.1.2 Detect conflict alert indicator
2.1.3 Determine validity of conflict notice or indicator
2.1.4 Inform adjacent controller of conflict alert in his sector/position
2.1.5 Inform adjacent controller of course of action
2.1.6 Detect aircraft maneuver in response to conflict resolution

Sub-Activity 2.2 Performing Minimum Safe Altitude Warning Processing

2.2.1 Receive MSAW notice from adjacent controller or facility
2.2.2 Detect MSAW indicator or alarm
2.2.3 Determine validity of MSAW notice or indicator
2.2.4 Determine whether aircraft in vicinity permit climb or turn
2.2.5 Notify supervisor of valid MSAW alert or flight assist
2.2.6 Detect aircraft maneuver in response to low altitude resolution

Sub-Activity 2.3 Performing Airspace Conflict Processing

2.3.1 Perceive/recognize on display an aircraft approaching limits of its airspace
2.3.2 Calculate aircraft's path with respect to special use airspace

Sub-Activity 2.4 Issuing Traffic Advisories (Cautionary Separation

2.4.1 Observe display for aircraft separation not likely to meet required standards

2.4.2 Issue traffic advisory to aircraft in regard to air traffic deviation
2.4.3 Issue traffic advisory in regard to other traffic proximity

Sub-Activity 2.5 <u>Inhibiting Alerts</u>

2.5.1 Inhibit conflict alert for paired or group suppression
2.5.2 Inhibit conflict alert for refueling or other special operation
2.5.3 Inhibit conflict alert for air show
2.5.4 Inhibit MSAW alert

Activity 3.0 MANAGE AIR TRAFFIC SEQUENCES

Sub-Activity 3.1 <u>Responding to Flow Constraints</u>

3.1.1 Receive a Fuel Advisory Departure (FAD) notice
3.1.2 Receive a flow restriction
3.1.3 Confer with pilot on desire for FAD intentions
3.1.4 Choose desired sequence
3.1.5 Select new flow/sequence
3.1.6 Determine the technique for accomplishing a delay
3.1.7 Negotiate speed reduction or hold with pilot
3.1.8 Evaluate constraint effect on flow

Sub-Activity 3.2 <u>Processing Air Traffic Deviations (Observed or Requested)</u>

3.2.1 Perceive an altitude or route deviation
3.2.2 Receive a traffic deviation notice
3.2.3 Receive a deviation request from pilot
3.2.4 Identify transition from old to new sequence
3.2.5 Determine maneuver to establish/restore sequence

Sub-Activity 3.3 <u>Maintaining Departure Pattern</u>

3.3.1 Project aircraft departure sequence
3.3.2 Plan control action to permit departing aircraft to climb to a specific altitude safely

Sub-Activity 3.4 <u>Maintaining Arrival Pattern</u>

3.4.1 Advise supervisor of factors affecting need for change in arrival rate
3.4.2 Project traffic sequence
3.4.3 Determine descent time or point

Sub-Activity 3.5 <u>Responding to Exception Events</u>

3.5.1 Receive notice of an exception event from pilot, supervisor, or adjacent controller
3.5.2 Observe/recognize an exception event on part of an aircraft

Sub-Activity 3.6 Monitoring Non-Controlled Objects

3.6.1 Receive notice of airspace intrusion by a non-controlled object
3.6.2 Observe airspace intrusion by a non-controlled object
3.6.3 Flight follow an observed non-controlled object
3.6.4 Write reminder note of airspace intrusion
3.6.5 Advise adjacent controller/facility of airspace intrusion
3.6.6 Advise supervisor of an airspace intrusion

Sub-Activity 3.7 Responding to Airspace Restriction Events

3.7.1 Receive notice of airspace restriction imposed
3.7.2 Determine whether restricted area is under ATC control
3.7.3 Designate an area in use
3.7.4 Restrict aircraft activity in area by altitude or segment
3.7.5 Request temporary release of restricted airspace or area

Sub-Activity 3.8 Transferring Control Responsibility

3.8.1 Initiate handoff
3.8.2 Observe handoff acceptance
3.8.3 Call controller if no response is received on handoff
3.8.4 Retract handoff
3.8.5 Change aircraft frequency
3.8.6 Receive non-automated handoff
3.8.7 Acknowledge non-automated handoff/start track
3.8.8 Receive automatic handoff
3.8.9 Accept automatic handoff
3.8.10 Verify communications with pilot on transfer of control
3.8.11 Verify aircraft altitude with pilot on transfer of control
3.8.12 Terminate radar service to aircraft

Sub-Activity 3.9 Sharing Control Responsibility

3.9.1 Conduct/issue pointout
3.9.2 Respond to pointout
3.9.3 Suppress flight data block after pointout

Activity 4.0 ROUTE OR PLAN FLIGHTS

Sub-Activity 4.1 Coordinating and Issuing Clearances

4.1.1 Receive clearance request from adjacent facility, FSS, or pilot
4.1.2 Coordinate a planned clearance with adjacent controller
4.1.3 Receive clearance and instructions from the center for relay to pilot
4.1.4 Observe display for other aircraft positions
4.1.5 Advise controller of required clearances on aircraft entering or leaving sector/position
4.1.6 Inform adjacent controller/facility of clearance change which might necessitate delay or changes in route

4.1.7 Formulate a clearance with appropriate restrictions
4.1.8 Evaluate a planned course of action, solution, impact
4.1.9 Deny clearance request
4.1.10 Issue clearance and instructions to pilot
4.1.11 Issue clearance and instructions to terminal facility, FSS, BASOPS, or airline office for relay to pilot
4.1.12 Verify aircraft compliance with clearance

Sub-Activity 4.2 <u>Responding to Contingencies</u>

4.2.1 Receive information on loss of radio contact or overdue aircraft
4.2.2 Detect a pilot or aircraft problem (e.g., hypoxia)
4.2.3 Conduct a radio search for overdue aircraft
4.2.4 Declare event and invoke contingency plan
4.2.5 Contact facility along route of flight to secure information on overdue aircraft
4.2.6 Alert airport emergency crew or other designated personnel of aircraft having flight difficulties
4.2.7 Report contingency event to supervisor

Sub-Activity 4.3 <u>Responding to Special Operations</u>

4.3.1 Receive notice of necessity for special operations
4.3.2 Perceive necessity for special operations

Sub-Activity 4.4 <u>Processing Flight Plans</u>

4.4.1 Receive flight plan from pilot
4.4.2 Receive flight plan data from previous controller
4.4.3 Receive flight plan on flight strip printer (FSP)
4.4.4 Review flight plan for completeness
4.4.5 Query pilot about flight plan
4.4.6 Query the relayer of a flight plan
4.4.7 Compose flight plan data entry and enter into computer
4.4.8 Forward flight plan to next controller
4.4.9 Distribute new flight strip(s)
4.4.10 Post flight strip in strip bays

Sub-Activity 4.5 <u>Processing Flight Plan Amendments</u>

4.5.1 Receive pilot/controller request for flight change
4.5.2 Review flight amendment request
4.5.3 Flag flight strip for reminder action
4.5.4 Negotiate flight change with pilot
4.5.5 Receive flight plan amendment from previous controller
4.5.6 Receive computer message regarding flight plan amendment
4.5.7 Request flight progress strip over a given fix
4.5.8 Write flight plan amendment on strip
4.5.9 Resequence flight strip
4.5.10 Compose/enter computer message on flight plan amendment
4.5.11 Modify display/DEDS/scratch pad to amend data
4.5.12 Unflag flight strip
4.5.13 Review flight plan change (double check)

4.5.14 Receive pilot's progress report
4.5.15 Check aircraft speed/time for change

Activity 5.0 ASSESS WEATHER IMPACT

Sub-Activity 5.1 Analyzing Weather Situation/Altitude and Route Determination

5.1.1 Determine direction and movement of weather line
5.1.2 Determine base and height of buildup from PIREPs
5.1.3 Determine whether holes exist in buildup line
5.1.4 Determine impact of weather on routes and airports in sector/position
5.1.5 Receive information on height of clouds
5.1.6 Predict potential for icing

Sub-Activity 5.2 Processing PIREPs

5.2.1 Request pilot report (PIREP) on weather/atmospheric information
5.2.2 Receive pilot report on weather/atmospheric information
5.2.3 Disseminate pilot-reported weather information to other controllers/facilities
5.2.4 Disseminate pilot-reported weather/atmospheric information to aircraft

Sub-Activity 5.3 Processing Weather Advisories

5.3.1 Receive SIGMET/AIRMET, other weather reports
5.3.2 Issue weather advisory information to pilot
5.3.3 Monitor radar display and weather situation for revision/cancellation of weather advisory
5.3.4 Inform pilot of weather disturbances and suggested heading for avoiding such areas
5.3.5 Inform pilot of meteorological/navigational information

Sub-Activity 5.4 Responding to Weather Changes/Conditions

5.4.1 Note change of wind direction/wind shear
5.4.2 Determine preferred approach
5.4.3 Recommend airport traffic configuration to management
5.4.4 Determine usable flight level
5.4.5 Determine control zone for VFR or IFR

Activity 6.0 MANAGE SECTOR/POSITION RESOURCES

Sub-Activity 6.1 Managing Controlled Airspace Resources

6.1.1 Respond to sector/position reconfiguration
6.1.2 Honor a requested temporary use of airspace
6.1.3 Determine acceptability of a requested temporary use of airspace

6.1.4 Request temporary use of airspace
6.1.5 Receive a request for temporary use of airspace
6.1.6 Combine/decombine positions/sectors
6.1.7 Coordinate use or release of shared airspace
6.1.8 Write reminder note of temporary airspace release
6.1.9 Start pseudo track as to areas in use
6.1.10 Take over airspace associated with facility closure/reopening
6.1.11 Release airspace associated with facility reopening/closure

Sub-Activity 6.2 Setting Up Workstation Hardware/Software Configuration

6.2.1 Review overall system status
6.2.2 Review traffic and detailed status
6.2.3 Verify all required display and communication switches are in proper location
6.2.4 Adjust display and communication volume to personal preference
6.2.5 Review flight strips and display lists for correlation
6.2.6 Adjust display and ensure critical data are present
6.2.7 Visually check radar display for proper alignment, usability, and satisfactory status

Sub-Activity 6.3 Responding to Transient Fault Events

6.3.1 Check computer clock to assure proper computer functioning
6.3.2 Detect display flicker associated with target location
6.3.3 Detect nonacceptance of input data by the computer
6.3.4 Forward computer input data by interphone
6.3.5 Detect apparent unreliable air/ground communications
6.3.6 Explore whether others are receiving an aircraft's transmissions
6.3.7 Issue alternate communications for air/ground transmission
6.3.8 Alert supervisor of transient fault occurrence
6.3.9 Force missing message to ARTS
6.3.10 Identify aircraft that is not handed off
6.3.11 Issue routine advisory on equipment status
6.3.12 Observe indication of duplicate beacon code assignment
6.3.13 Request new beacon code to replace duplicate code

Sub-Activity 6.4 Executing Backup Procedures for RDP Faults

6.4.1 Alert other facilities of RDP fault
6.4.2 Go to broadband or DARC operation
6.4.3 Reidentify aircraft
6.4.4 Change beacon code assignments to prearranged code banks
6.4.5 Request position/progress reports
6.4.6 Start track that has not auto-acquired
6.4.7 Restore ARTS data base from Stage A
6.4.8 Confirm computer actions accomplished during transition

Sub-Activity 6.5 Executing Backup Procedures for FDP Faults

6.5.1 Alert other facilities of FDP fault
6.5.2 Forward flight plan data (not previously forwarded by the computer) to adjacent facility
6.5.3 Determine when data base information should have been forwarded by computer
6.5.4 Reenter all required data on transition to automated mode
6.5.5 Verify or forward flight data on handoff

Sub-Activity 6.6 Executing Backup NAVAID Procedures (Route Substitution)

6.6.1 Obtain substitute routing
6.6.2 Reroute aircraft using NAVAID
6.6.3 Plan reroute of aircraft that will be using NAVAID
6.6.4 Copy reroute substitute on blank flight strip
6.6.5 Monitor status of radio aids for navigation
6.6.6 Notify pilots of NAVAID status

Sub-Activity 6.7 Executing Backup Procedures for Communication Faults

6.7.1 Determine communication failure
6.7.2 Adjust communication strategy
6.7.3 Switch to backup frequency
6.7.4 Inform pilot of change in frequency
6.7.5 Inform supervisor of communication failure
6.7.6 Inform supervisor of changes made in frequency selection
6.7.7 Inform other controller/facility of change in frequency

Sub-Activity 6.8 Managing Personnel Resources

6.8.1 Determine impending controller overload
6.8.2 Exchange/assign intra-controller responsibilities
6.8.3 Request assistance or relief
6.8.4 Request handoff controller or coordinator support
6.8.5 Request rerouting of traffic
6.8.6 Restrict traffic coming into sector/position
6.8.7 Split up (decombine) sector/position

Appendix C

Control Abbreviations and Symbols

Appendix C

Control Abbreviations and Symbols

Appendix C CONTROL ABBREVIATIONS AND SYMBOLS

Control Information Symbols

Symbol	Meaning
T→( )	Depart (direction, if specified)
↑	Climb and maintain
↓	Descend and maintain
→	Cruise
@	At
X	Cross
M̶	Maintain
⁊	Join or intercept airway/jet route/track or course
=	While in controlled airspace
△	While in control area
↘△	Enter control area
△↗	Out of control area
NW ↘	Cleared to enter, depart, or cleared through control zone. Indicate direction of flight by arrow and appropriate compass letter. Maintain Special VFR/IFR conditions (altitude, if appropriate), while in control zone.
↗ NE	
⊖→ E	
250K	Aircraft requested to adjust speed to 250 knots.
-20K	Aircraft requested to reduce speed 20 knots.
+30K	Aircraft requested to increase speed 30 knots.
Ⓦ	Local Special VFR operations in the vicinity of (name) airport are authorized until (time). Maintain special VFR conditions (altitude, if appropriate).
>	Before
<	After or Past
ALT (red)	Inappropriate altitude/flight level for direction of flight. (Underline assigned altitude/flight level in red.)
/	Until
( )	Alternate instructions
<u>Restriction</u>	Restriction
T̄	At or Below

Symbol	Meaning
⊥	At or Above
—(Dash)	From—to (route or altitude)
V <	Clearance void if aircraft not off ground by (time)
℄	Pilot cancelled flight plan
✓	*EN ROUTE:* Aircraft has reported at assigned altitude. *Example:* 80✓
✓	*TERMINAL:* Information forwarded (indicated information forwarded as required)
◯ (red)	*EN ROUTE:* Information forwarded (Circle, in red, the time (minutes) and altitude when a flight plan or estimate is forwarded. Also circle, in red, revised information forwarded. Use this method in both inter-center and intra-center coordination)
(50)	Other than assigned altitude reported (circle reported altitude)
10 / 6	DME holding (use with mileages) (Upper figure indicates distance from station to DME fix, lower figure indicates length of holding pattern. In this example, the DME fix is 10 miles out with a 6 mile pattern indicated.)
⌒ (Mi.) (dir.)	DME arc of VORTAC or TACAN
C (Freq.)	Contact (facility) on (freq.), (time, fix, or altitude, if appropriate). Insert frequency only when it is other than standard.
R	Radar contact
R	*EN ROUTE:* Requested altitude (preceding altitude information)
R̸	Radar service terminated
X	Radar contact lost
Ⓡ	Radar handoff (circle symbol when handoff completed)
RV	Radar vector
RX	Pilot resumed own navigation
E (red)	EMERGENCY
W (red)	WARNING
P	Point out initiated. Indicate the appropriate facility, sector, or position. *Example:* PZFW.

NOTE.—The absence of an airway or route number between two fixes in the route of flight indicates "direct"; no symbol or abbreviation is required.

Clearance Abbreviations

Abbreviation	Meaning
A	Cleared to airport (point of intended landing)
B	Center clearance delivered
C	ATC clears (when clearance relayed through non-ATC facility)
CAF	Cleared as filed
D	Cleared to depart from the fix
F	Cleared to the fix
H	Cleared to hold and instructions issued
L	Cleared to land
N	Clearance not delivered
O	Cleared to the outer marker
PD	Cleared to climb/descent at pilot's discretion
Q	Cleared to fly specified sectors of a NAVAID defined in terms of courses, bearings, radials or quadrants within a designated radius.
T	Cleared through (for landing and takeoff through intermediate point)
V	Cleared over the fix
X	Cleared to cross (airway, route, radial) at (point)
Z	Tower jurisdiction

Miscellaneous Abbreviations

Abbreviation	Meaning
BC	Back course approach
CT	Contact approach
I	Initial approach
FA	Final approach
MA	Missed approach
NDB	Nondirectional radio beacon approach
SI	Straight-in approach
TA	TACAN approach
TL	Turn left
TR	Turn right
VA	Visual approach
VR	VOR approach
ILS	ILS approach
OTP	VFR conditions-on-top
PT	Procedure turn
RX	Report crossing
RP	Report immediately upon passing (fix/altitude)
SA	Surveillance approach
PA	Precision approach

STANDARD RECORDING OF HAND PRINTED CHARACTERS

Typed	Hand Printed	Typed	Hand Printed	Typed	Hand Printed	Typed	Hand Printed
A	A	J	J	S	S̲	1	1
B	B	K	K	T	T	2	2
C	C	L	L	U	U	3	3
D	D	M	M	V	V	4	4
E	E	N	N	W	W	5	5
F	F	O	O	X	X	6	6
G	G	P	P	Y	Y	7	7
H	H	Q	Q	Z	Z	8	8
I	I	R	R			9	9
						*0	Ø

* The slant line cross through the numeral zero and the underline of the letter "S" on handwritten portion of the flight progress strips are required only when there is reason to believe the lack of these markings could lead to a misunderstanding. The slant line cross through the numeral zero is required on weather [illegible].

Appendix B

Glossary of Terms

GLOSSARY OF TERMS

ADAPTATION - Unique site-dependent data required by the operational program to provide the flexible capability necessary to allow it to function at individual sites.

ADJACENT FACILITY - A facility whose assigned airspace borders that of the facility being discussed.

ADVISORY - Advice and information provided to assist pilots in the safe conduct of flight and aircraft movement.

AERONAUTICAL FIXED SERVICE (AFS) - Telecommunications service between specified fixed points, provided primarily for the safety of air navigation and for the regular efficient and economical operation of air services.

AERONAUTICAL FIXED TELECOMMUNICATIONS NETWORK (AFTN) - An integrated worldwide system of aeronautical fixed circuits provided, as part of the Aeronautical Fixed Service (AFS), for the exchange of messages between the aeronautical fixed stations within the network.

AIR NAVIGATION FACILITY (NAVAID) - Any facility used in, available for use in, or designated for use in aid of air navigation. Included are landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio direction-finding, or for radio or other electronic communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing or takeoff of aircraft.

AIR ROUTE SURVEILLANCE RADAR - A radar facility remotely connected to an Air Route Traffic Control Center, used to detect and display the azimuth and range of en route aircraft operating between terminal areas, enabling an ATC Controller to provide air traffic control service in the Air Route Traffic Control System.

AIR ROUTE TRAFFIC CONTROL CENTER (ARTCC) - A facility established to provide air traffic control service to aircraft operating on an IFR flight plan within controlled airspace and principally during the en route phase of flight. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft.

AIR TRAFFIC CLEARANCE - An authorization by air traffic control, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified traffic conditions within controlled airspace.

AIR TRAFFIC CONTROL (ATC) - A service that promotes the safe, orderly, and expeditious flow of air traffic, including airport, approach, and en route air traffic control.

AIR TRAFFIC CONTROL COMMAND CENTER (ATCCC) - An air traffic service facility consisting of four operational units.

1. Central Flow Control Function (CFCF) - Responsible for coordination and approval of all major intercenter flow control restrictions on a system basis in order to obtain maximum utilization of the airspace.

2. Central Altitude Reservation Function (CARF) - Responsible for coordinating, planning, and approving special user requirements under the Altitude Reservation (ALTRV) concept.

3. Airport Reservation Office (ARO) - Responsible for approving IFR flights at designated high density traffic airports during specified hours.

4. ATC Contingency Command Post - A facility which enables the FAA to manage the ATC system when significant portions of the system's capabilities have been lost or are threatened.

AIR TRAFFIC CONTROL FACILITY - A facility that provides air traffic control service.

AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (ATCRBS) - See Radar Beacon ATCRBS (Secondary Radar).

AIR TRAFFIC CONTROLLER - A person authorized to provide air traffic service. Refers to en route and terminal control personnel.

AIRCRAFT CLASSES - For the purposes of Wake Turbulence Separation Minima, ATC classifies aircraft as Heavy, Large, and Small.

AIRLINE B TTY - A teletypewriter circuit (network) to which airline operations offices are connected.

AIRMAN'S METEOROLOGICAL INFORMATION (AIRMET) - In-flight weather advisories issued only to amend the area forecast concerning weather phenomena which are of operational interest to all aircraft and potentially hazardous to aircraft having limited capability because of lack of equipment, instrumentation, or pilot qualifications. AIRMETs concern weather of less severity than that covered by SIGMETs or Convective SIGMETs. AIRMETs cover moderate icing, moderate turbulence, sustained winds of 30 knots or more at the surface, widespread areas of ceilings less than 1,000 feet and/or visibility less than 3 miles, and extensive mountain obscurement.

AIRPORT SURVEILLANCE RADAR (ASR) - FAA short-range radar for terminal air traffic control. Radar providing position of aircraft by azimuth and range data without elevation data. Various models are designed for ranges of 30 to 60 miles.

AIRPORT TRAFFIC CONTROL TOWER (ATCT) - A facility providing airport traffic control service. See Tower Cab.

AIRWAY - A control area or portion thereof established in the form of a corridor, the outline of which is defined by radio navigation aids.

ALERT NOTICE (ALNOT) - A message sent by a Flight Service Station (FSS) or Air Route Traffic Control Center (ARTCC) that requests an extensive communication search for overdue, unreported, or missing aircraft.

ALPHA-NUMERIC DISPLAY/DATA BLOCK - Letters and numerals used to show identification, altitude, beacon code, and other information concerning a target on a radar display.

ALTIMETER SETTING - The barometric pressure reading used to adjust a pressure altimeter for variations in existing atmospheric pressure or to the standard altimeter setting (29.92).

ALTITUDE RESERVATION (ALTRV) - Airspace utilization under prescribed conditions normally employed for the mass movement of aircraft or other special user requirements which cannot otherwise be accomplished. ALTRVs are approved by the appropriate FAA facility.

ALTITUDE RESTRICTION - An altitude or altitudes stated in the order flown which are to be maintained until reaching a specific point or time. Altitude restrictions may be issued by ATC due to traffic, terrain, or other airspace considerations.

AREA CONTROL FACILITY (ACF) - The facilities that will result from consolidation of existing ARTCC and TRACON/TRACAB facilities. An ACF may be formed from an existing ARTCC or may be created in a new building. The number, location, and implementation dates of ACFs will be in accordance with the National Airspace System Plan.

ASSIGNED ALTITUDE - The current authorized altitude for an active flight.

AUTOMATED RADAR TERMINAL SYSTEM (ARTS) - Computer-aided radar display subsystems capable of associating alphanumeric data with radar returns. Systems with varying functional capability, determined by the type of automation equipment and software, are denoted by a number/letter suffix following the name abbreviation.

CENTER - Same as Air Route Traffic Control Center (ARTCC).

CENTRAL FLOW CONTROL FACILITY (CFCF) - A facility to adjust the aircraft flow into and from high density airports and along high density routes on a national basis, and to accept reservations and maintain a dynamic list of all IFR aircraft with reservations that operate in these areas.

COMBINING/DECOMBINING - Adapting to traffic loading. At least two, but usually not more than three sectors, are combined when converting from day to night watches or to adjust controller workload.. This is a short-term operational rearrangement of sectors and does not involve any change in wiring to the positions.

CONFLICT ALERT - A function of certain air traffic control automated systems designed to alert radar controllers to existing or pending situations recognized by the program parameters that require his immediate attention/action.

CONTROL SECTOR - An airspace area of defined horizontal and vertical dimensions for which a controller or group of controllers, has air traffic control responsibility, normally within an air route traffic control center. Sectors are established based on predominant traffic flows, altitude strata, and controller workload. Pilot-controller communications during operations within a sector are normally maintained on discrete frequencies assigned to the sector.

CONTROLLED AIRCRAFT - Aircraft that are participating and receiving traffic separation service from the ATC system.

CONTROLLED AIRSPACE - Airspace designated as a Continental Control Area, Control Zone, Terminal Control Area or Transition Area, within which some or all aircraft may be subject to air traffic control.

DIRECT ACCESS RADAR CHANNEL (DARC) - A backup digital radar processing system in the ARTCCs.

DISCRETE BEACON CODE - A unique train of electronic pulses transmitted by an aircraft transponder in reply to a radar beacon interrogator. A four-digit octal code in which one or both of the last two digits is other than zero.

DYNAMIC SIMULATION (DYSIM) - Simulation of air traffic using live or recorded data for training air controllers.

EN ROUTE MINIMUM SAFE ALTITUDE WARNING (E-MSAW) - A function of the NAS Stage A en route computer that aids the controller by alerting him when a tracked aircraft is below or predicted by the computer to go below a predetermined minimum IFR altitude (MIA).

ESTIMATED TIME OF ARRIVAL (ETA) - The estimated time of arrival is the time the pilot expects to arrive at his destination based on the actual time of departure and the estimated time en route (ETE).

FIX - A point on an airway used for aircraft navigation and/or position reporting.

FIX POSTING AREA (FPA) - A volume of air space, bounded by a series of connected line segments with altitudes, which is assigned to a sector.

FLIGHT DATA ENTRY AND PRINTOUT (FDEP) - Equipment for a remote location which contains, as a minimum, a Data Communications Control Unit (DCCU), an alphanumeric keyboard, and a flight strip printer (FSP). Its interface with the Central Computer Complex (CCC) of the existing automation system is by way of FDEP adapters located in the peripheral adapter module (PAM).

FLIGHT LEVEL (FL) - A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Each is stated in three digits that represent hundreds of feet. For example, flight level 250 represents a barometric altimeter indication of 25,000 feet.

FLIGHT PLAN - Specified information relating to an intended flight of an aircraft that is filed either orally or in writing with an air traffic control facility or Flight Service Station (FSS).

FLOW CONTROL - Measures designed to adjust the flow of traffic into a given airspace, along a given route, or bound for a given airport so as to ensure the most effective utilization of the airspace.

FUEL ADVISORY DEPARTURE (FAD) - Procedures to minimize engine running time for aircraft destined for an airport experiencing prolonged arrival delays.

HANDOFF - A controller action taken to transfer the radar identification of an aircraft from one controller to another if the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred.

INSTRUMENT FLIGHT RULES (IFR) - Federal Aviation Regulations (FAR) that govern the procedures for conducting instrument flight (FAR Part 91).

INSTRUMENT METEOROLOGICAL CONDITIONS (IMC) - Weather conditions below the minimum prescribed for flight under Visual Flight Rules.

INTERFACILITY - Between adjacent facilities; for example, between ARTCC and ARTCC or between ARTCC and TRACON, as contrasted with Intrafacility.

INTERIM ALTITUDE - An altitude clearance which is a temporary altitude assignment prior to the issuance of a final altitude clearance. It is used to specify to the computer so that an invalid conflict alert will be precluded. It is used to stop an aircraft's climb or descent in traffic.

INTRAFACILITY - Within a single facility; for example, between two sectors within the same ARTCC, as contrasted with Interfacility.

METERING AND SEQUENCING - Control of aircraft in a manner that provides a stream of properly spaced aircraft arriving at a fix or airport at a rate which can be accepted by adjacent ATC facilities or airports.

MICROWAVE LANDING SYSTEM (MLS) - System which enables equipped aircraft to make curved and closely-spaced approaches to properly instrumented airports.

MINIMUM SAFE ALTITUDE WARNING (MSAW) - A function of the ARTS III computer that aids the controller by alerting him when a tracked Mode C equipped aircraft is below or is predicted by the computer to go below a predetermined minimum safe altitude.

MODE C - An interrogation mode in which a beacon radar transponder automatically reports altitude when interrogated by a ground station.

MODE 3/A - An interrogation mode in which a beacon radar transponder automatically reports identification when interrogated by a ground station. There are 4096 possible identification codes.

NAS STAGE A EN ROUTE SYSTEM - A semi-automated system of en route ATC providing alphanumeric information on flight data and radar data processing.

NATIONAL AIRSPACE SYSTEM (NAS) - The common network of U.S. airspace; air navigation facilities, equipment, and services; airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information, manpower, and material. Included are system components shared jointly with the military.

NON-DISCRETE CODE - A radar beacon Mode 3/A assigned to more than one aircraft within a specific geographic area. Currently a four octal digit code in which the last two digits are zeros.

NOTICE TO AIRMEN (NOTAM) - A notice containing information (not known sufficiently in advance to publicize by other means) concerning the establishment, condition, or change in any component (facility, service, or procedure of, or hazard in the National Airspace System), the timely knowledge of which is essential to personnel concerned with flight operations.

PILOT WEATHER REPORT (PIREP) - A report of meteorological phenomena encountered by aircraft in flight.

PLAN VIEW DISPLAY (PVD) - A cathode ray tube that presents traffic situations using vector lines, digitized video alphanumerics, and special symbols.

PREFERENTIAL ARRIVAL ROUTE (PAR) - An adapted arrival route, program-induced to override, with a route amendment, a filed route from an adapted transition fix or arrival line to one or more adapted airports.

PREFERENTIAL DEPARTURE-ARRIVAL ROUTE (PDAR) - An adapted departure route and arrival route for airport-to-airport processing. In effect, the combination of a PDR and a PAR.

PREFERENTIAL DEPARTURE ROUTE (PDR) - An adapted departure route, program-induced to override, with a route amendment, a filed route from one or more adapted airports to an adapted transition fix or departure line.

PREFERRED ROUTES - Airways designated between major terminals on which IFR flight is preferred for air traffic control reasons. These routes have been developed to increase the efficiency of the air traffic control system.

PRIMARY RADAR - A radar system in which a minute portion of a radio pulse transmitted from a site is reflected by an object and then received back at that site for processing and display at an air traffic control facility.

PROGRESS REPORT - A report over a known location as transmitted by an aircraft to ATC.

QUICK LOOK - A feature which provides the controller the capability to display full data blocks of tracked aircraft from other control positions.

RADAR BEACON - A radar receiver-transmitter aboard an aircraft that transmits a coded signal whenever its receiver is triggered by an interrogating radar. The coded reply can be used to determine position in terms of range and bearing from the beacon. Also called beacon, radar, and radar transponder.

RADAR BEACON ATCRBS (SECONDARY RADAR) - A radar system in which the object to be detected is fitted with cooperative equipment in the form of a radar receiver/transmitter (transponder). Radar pulses transmitted from the searching transmitter/receiver (interrogator) site are received in the cooperative equipment and used to trigger a distinctive transmission from the transponder. This latter transmission, rather than a reflected signal, is then received back at the transmitter/receiver site for processing and display at an air traffic control facility.

RADAR POINT OUT (POINTOUT) - Used between controllers to indicate radar handoff action where the initiating controller plans to retain communications with an aircraft penetrating the other controller's airspace and additional coordination is required.

RADAR SERVICE - A term which encompasses one or more of the following services based on the use of radar which can be provided by a controller to a radar-identified aircraft:

(a) Radar Separation. Radar spacing of aircraft in accordance with established minima.

(b) Radar Navigational Guidance. Vectoring aircraft to provide course guidance.

(c) Radar Monitoring. The radar flight-following of an aircraft whose primary navigation is being performed by its pilot to observe and note deviations from its authorized flight path, airway, or route. This includes noting the aircraft's position relative to approach fixes.

RESECTORIZATION - Splitting or rearrangement of geographic sectors, including sector stratification. This is usually the result of rearrangement of center boundaries, shifting of traffic load geographically, implementation of major system changes, or similar items.

RESTRICTED AREA - Airspace designated under Part 73 of the Federal Aviation Regulations within which the flight of aircraft, while not wholly prohibited, is subject to restrictions.

SEPARATION - In air traffic control, the spacing of aircraft to achieve their safe and orderly movement in flight and while landing and taking off.

SIGNIFICANT METEOROLOGICAL INFORMATION (SIGMET) - A weather advisory issued concerning weather significant to the safety of all aircraft. SIGMET advisories cover severe and extreme turbulence, severe icing, and widespread dust or sandstorms that reduce visibility to less than 3 miles.

SPECIAL VFR CONDITIONS - Weather conditions in a control zone which are less than basic VFR and in which some aircraft are permitted flight under Visual Flight Rules.

SQUAWK (Mode, Code, Function) - Activate specific modes/codes/functions on the aircraft transponder, e.g., "Squawk three/alpha, two one zero five, low."

STANDARD INSTRUMENT DEPARTURE (SID) - A preplanned coded air traffic control IFR departure routing, preprinted for pilot use in graphic and textual form only.

STANDARD TERMINAL ARRIVAL (STAR) - A preplanned coded air traffic control IFR arrival routing, preprinted for pilot use in graphic and textual or textual form only.

START TRACK - A message which requires the computer to track an aircraft and display a full data block.

TACTICAL AIR NAVIGATION (TACAN) - A radio transponder facility in the en route electronic navigation system which provides range information to suitably equipped aircraft.

TARGET - The indication shown as a radar display resulting from a primary radar return or a radar beacon reply.

TERMINAL RADAR SERVICE AREA (TRSA) - Airspace surrounding designated airports wherein ATC provides radar vectoring, sequencing, and separation on a full-time basis for all IFR and participating VFR aircraft. Service provided in a TRSA is called Stage III Service. TRSAs are depicted on VFR aeronautical charts. Pilot participation is urged but is not mandatory.

TOWER CAB - An ATC facility located at an airport. Controllers at these facilities direct ground traffic, take-offs, and landings.

TRACK - A set of predicted points correlated with the radar returns for the flight.

TRACKBALL - Positional identification device available to the controller for identifying an X, Y position on the display. In the terminal this frequently is referred to as the slewball.

TRACKING - A process which uses primary/beacon radar data and paired flight data (if any) to determine the actual position and velocity of a flight. Radar target identification through manual or automatic means; positional agreement of a radar target and the computer predicted position; computation of the difference between the predicted position and the actual position of the radar target.

TRAFFIC -

1. A term used by a controller to transfer radar identification of an aircraft to another controller for the purpose of coordinating separation action. Traffic is normally issued (a) in response to a handoff or point out, (b) in anticipation of a handoff or point out, or (c) in conjunction with a request for control of an aircraft.

2. A term used by ATC to refer to one or more aircraft.

TRAFFIC ADVISORIES - Advisories issued to alert pilots to other known or observed air traffic which may be in such proximity to the position or intended route of flight of their aircraft to warrant attention.

TRANSFER OF CONTROL - The action whereby control responsibility for an aircraft is transferred from one controller to another.

TRANSFERRING CONTROLLER/FACILITY - A controller/facility transferring control of an aircraft to another controller/facility.

TRANSIENT FAULT - An intermittent failure or a temporary interference.

TRANSPONDER - The airborne radar beacon receiver/transmitter portion of the Air Traffic Control Radar Beacon System (ATCRBS) which automatically receives radio signals from interrogators on ground, and selectively replies with a specific reply pulse or pulse group only to those interrogations being received on the mode to which it is set to respond.

UNCONTROLLED AIRCRAFT - Those aircraft not participating in or receiving traffic separation service from the ATC system. This term does not include those flights receiving control service from control towers having only visual surveillance in performing control service.

VECTOR - A heading issued to an aircraft to provide navigational guidance by radar.

VERY HIGH FREQUENCY OMNIRANGE (VOR) - A ground based radio station that propagates an unlimited number of "radials". On board an aircraft, the received signals are converted to visual direction indications expressed as magnetic compass courses to and from the transmitter station.

VFR-ON-TOP - ATC authorization for an IFR aircraft to operate in VFR conditions at any appropriate VFR altitude (as specified in FAR and as restricted by ATC). A pilot receiving this authorization must comply with the VFR visibility, distance from cloud criteria, and the minimum IFR altitudes.

VISUAL FLIGHT RULES (VFR) - Visual flight in which avoidance of collision with other aircraft is dependent upon every pilot seeing other aircraft and avoiding them. To enable pilots to perform the collision avoidance function, the rules take certain weather conditions into account, and specify basic "rules of the air."

VISUAL METEOROLOGICAL CONDITIONS (VMC) - Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specified minima.

WIND SHEAR - A change in wind speed and/or wind direction in a short distance resulting in a tearing or shearing effect. It can exist in a horizontal or vertical direction and occasionally in both.

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