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A FUNCTIONAL DESCRIPTION OF AIR TRAFFIC CONTROL

by

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16. Abstract

This document contains a description of air traffic control in terms of generic operational functions. The functions are grouped by flight phase and by major system function (navigation, surveillance, control and communication). More detailed descriptions of these functions, and estimates of related parameters are contained in the appendix. A diagram is shown of the sequence of events for a typical IFR flight through the current ATC system. Also, certain aspects of ATC which cannot be described in terms of operational functions (e.g., legal responsibilities) are discussed.

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CONTENTS

ABBREVIATIONS

ADI	Attitude Director Indicator (also called Flight Director)
A/G (G/A)	Air Ground (Ground Air) Communication
ARTCC	Air Route Traffic Control Center
ASDE	Airport Surface Detection Equipment
Area "S" Radar	Area Surveillance Radar
ATCRBS	Air Traffic Control Radar Beacon System
ATIS	Automatic Terminal Information Service
Beacon	Transponder in Aircraft
CFCF	Central Flow Control Facility
Decca	British Manufactured Hyperbolic Radio Navigation System
DME	Distance Measuring Equipment
Doppler	Airborne Doppler Navigation System (Also Doppler VOR)
FIX	Geographical or NAVAID location that can be identified by the pilot
FSS	Flight Service Station
GCA	Ground Controlled Approach (radar)
HF	High Frequency
IFF	Identification, friend or foe
ILS	Instrument Landing System
Inertial	Airborne Inertial Guidance System
LF	Low Frequency
LGS	Landing Guidance System
LORAN	Long Range Navigation System

NOTAM	Notice to Airmen
OMEGA	Very low frequency long range navigation system
PIREPS	Pilot Reports - usually weather information
QSY	Change to ___________
Sector	A geographical section of an Air Route Traffic Control Center's area of responsibility
Skin Paint	A direct radar return from an aircraft surface
TACAN	Ultra high frequency omni-directional range (tactical air navigation)
TRACON	Terminal radar control. (approach or departure) Also called Radar Approach Control RAPCON for USAF - RATCC for Navy
TSC	Transportation Systems Center
UHF	Ultra high frequency
VHF	Very high frequency
VOR	VHF omni-directional range
VORTAC	Collocated VOR and TACAN equipment

1.0 INTRODUCTION

The primary objective in this document is the description of the generic functions of air traffic control. This description is to be used as a guide for: (a) evaluating the completeness of ATC system concepts under consideration in PPA OS04; (2) evaluating the representation of functional relationships of the ATC simulation being developed under PPA FA06.

A major impetus to the development of this document was the realization that few people are familiar with all aspects of air traffic control. Pilots, controllers or equipment designers, each understand the system from their own point of view and often are not fully aware of important functions in other areas. However, evaluation of future system concepts should be based upon a set of functional requirements which reflect *all* important aspects of air traffic control. This document contains detailed descriptions of all the functions which a total system must satisfy.

In addition to the usual operational functions (e.g., "acquire aircraft position data", "formulate maneuver commands", etc.) certain responsibilities must be accounted for and certain miscellaneous services must be provided by the air traffic control system. These are discussed in section 2.0.

In order to understand what general operations are currently performed and how they are sequenced during a routine IFR flight, a parallel flow diagram of the flight activity on the part of the pilot, and of the ground activity among the controllers servicing the flight, is shown in section 3.0.

In section 4.0, the generic operational functions are listed. These are organized in a Function Description Matrix, by flight phase and by major system function (navigation, surveillance, tactical control, strategic control, air/ground and ground/ground communication). In the appendix, each function is described in more detail and quantitative estimates of important parameters which bear on each function are provided.

In section 5.0 an attempt is made to diagram the flow of primary information or data between the elements of the ATC system. The resulting flow diagrams were useful in determining the assignment of communications functions to each flight phase in the Function Description Matrix.

This document was prepared under Project Planning Agreement FA06 for the FAA. Mr. L.O. Higgins, of the Systems Analysis Division,

was the TSC task manager and provided overall guidance for the effort. Dr. Walter Hollister of M.I.T. made many valuable contributions in a consulting role.

Revisions and suggestions for improvement should be forwarded to the Systems Analysis Division (SA) at TSC, Cambridge, Massachusetts.

2.0 SYSTEM RESPONSIBILITIES

The current air traffic control system provides several very important services which cannot be neatly categorized like the operational functions. In addition, the system is structured so that the legal responsibility for maintaining aircraft separation is unambiguously defined at all times. Certain derivative responsibilities such as rule making, system maintenance and training are also accounted for by the present system.

Although such considerations are not explicit in an operational function description they, more than any other, determine the nature of the system and must be accounted for when devising or implementing new ATC systems.

These responsibilities and special services are considered to be of overriding importance and are therefore presented first. Past functional analyses of ATC have tended to ignore these "hidden" aspects of air traffic control.

2.1 LEGAL RESPONSIBILITY

Probably the most important factor in the operation of an air traffic control system is the designation of who has the legal responsibility for maintaining the separation of aircraft. At the present time, the air traffic control system is only responsible for maintaining separation between controlled aircraft. It is the legal responsibility of the operator through the pilot in command to maintain separation from uncontrolled aircraft even though his own aircraft is under air traffic control. Only in positive control airspace does the air traffic control system have complete responsibility for the separation of all traffic. Current interest in a Collision Avoidance System on the part of the airlines is driven by *their* legal responsibility in this regard. In order to establish legal responsibility in the case of an accident, there is elaborate recording of information. All voice communications and video displays are put on magnetic tape and maintained for a specified time period. Cockpit recordings are made of the aircraft intercom plus flight instrument readings sufficient to establish aircraft trajectories. Any proposed future systems must have the capability of recording sufficient data to establish legal responsibility. In the case of distributed management systems the legal responsibility must be carefully delineated. An individual will not accept legal responsibility for a function over which he has no control.

2.2 RULE MAKING

It is the responsibility of the air traffic control system to establish rules for the orderly flow of air traffic. The collision thread could be drastically reduced immediately, simply by introducing regulations that completely separate controlled and uncontrolled air traffic. The problem is that this would, at the present time, constitute an unfair restriction on many users of the airspace. Rules which are postulated for a future air traffic control system must be reasonable in that they are in the best interests of the majority of the persons utilizing the airspace. It should also be kept in mind that the establishment of new rules can be a very rapid process in comparison to the development and installation of new equipment. Furthermore, current rules such as the 250 knot speed limit below 10,000 feet may not be necessary with the adoption of other rules such as the segregation of traffic by speed.

2.3 MAINTENANCE

The air traffic control system has to allow for periodic maintenance and checking of its facilities while providing continuous service to air traffic. Breakdowns in individual equipments cannot permit the system to break down. Navigation equipment requires periodic flight checking to verify that the accuracy is within specification. These operations should not interfere with the capacity of the system. Individual components must be designed with maintenance in mind. Maintenance must not be overlooked as a cost component of each equipment. The cost of ownership concept can be applied to air traffic equipment as well as airborne equipment.

2.4 COMPATIBILITY

The introduction of a new system must not interfere with the continuity of air traffic control services. The air traffic control system is a public utility. Aircraft and airborne equipment introduced into service will remain operational over periods from 10 to 20 years. The old and the new systems must be compatible and allow for a gradual transition from one to the other. Furthermore, the United States has a responsibility to the worldwide aviation community, and the system introduced into this country must be compatible with foreign systems. The requirements placed on the small general aviation operator must be considered. He has very little money to invest in aircraft electronics and will insist that for each piece of equipment he purchases he will be given some new service which he would be unable to enjoy without it.

2.5 ENVIRONMENT

The air traffic control system has a responsibility to the people it serves to preserve the desirable features of the environment. One of the most severe problems in this regard is noise. Noise could be the limiting factor on the capacity of an airport. Closely spaced runways may be able to accept more aircraft than the surrounding residents will tolerate because of the noise level it creates. Curved and steep approaches offer some help in noise abatement, but complicate the problem of instrument landings.

2.6 WEATHER SERVICE

The dissemination of weather information is an important responsibility of an air traffic control system. It is also important to use the system to collect weather information. Pilot reports of existing weather are the most pertinent observations of hazardous meteorological conditions at flight levels. The ground tracks of the aircraft offer continuous wind information at several altitudes and over wide geographical areas, many unserviced by ground weather stations. Although the primary function of air traffic control is to prevent collisions with other aircraft, equally tragic consequences can occur when aircraft encounter severe weather such as hail, thunderstorms, cyclones, clear air turbulence, etc. Many of these meteorological phenomena develop and move rapidly. The communications system should be used to promptly alert aircraft of such developments. Aircraft should also have a continuous monitor of their destination weather since meteorological conditions could force them to proceed to an alternate.

2.7 NOTICES TO AIRMEN (NOTAMS)

NOTAMS which contain aeronautical information of a short term duration are currently disseminated by teletype like weather sequences, and are stored and displayed in locations that have an appropriate teletype terminal. Cancellations are processed in the same fashion. Improvements for future NOTAM handling should be considered on the same priority level as the future of weather dissemination and made available to all locations where aircraft are dispatched.

2.8 AIRSPACE SPECIAL USAGE

Rules and priorities are required for special users of the airspace such as the operators of balloons, gliders, towed aircraft, model rockets, etc. The present rules of the road give priority to the less maneuverable aircraft. Areas need to be made available for flight training and aerobatics. The present system generally provides such areas for military flight training. The military also needs restricted and warning areas for weapons training and flight testing.

2.9 JOINT USAGE WITH THE MILITARY

Military aircraft fly regularly in the common en-route and terminal airspace structure in addition to their special military operations. As such, the Air Traffic Control System must be compatible with the military airborne equipment. Historically, the military has been the first to develop and implement the new communication, navigation and surveillance avionics. Most of the air traffic control equipment has been an outgrowth of military development and the selection of a civil system has usually come after the corresponding military system is operational. The civil system then has to accommodate the military system or else provide dual systems. In the present system, for example, the military uses UHF communications frequencies while civil aircraft use VHF and the air traffic control system requires both. The VORTAC navigation aids are the result of a compromise between military TACAN and civil VOR/DME. Civil aircraft use the DME portion of the military-developed TACAN while tuned to the (VHF) VOR for navigation. The present beacon is an outgrowth of military IFF equipment and has been kept compatible in its development for civil use. Future systems must be cognizant of the extensive military development in advanced communications, navigation and surveillance equipment and consider the requirement for joint usage by military aircraft. The military will be reluctant to accept a civil system which requires additional hardware to duplicate an existing military capability.

2.10 TRAINING

The training of controllers does not place a strain on the operational air traffic control system, but it should be considered as a functional requirement. On the job training must be possible without interrupting normal service. The time and money required for training must be included as a system cost. Consideration must also be given to use of the air traffic control system by student pilots. At the present time, they are offered special consideration when they identify themselves to controllers over the radio. It should also be noted that a large portion of the IFR flights by military and general aviation pilots are purely for training and proficiency in the procedures of instrument flying.

2.11 EMERGENCY SITUATIONS

One of the most important requirements of an air traffic control system is to be able to cope with emergencies. The variety and frequency of aircraft emergencies usually comes as a surprise to persons unfamiliar with aviation. The majority of these emergencies never develop so far as to result in major tragedy, just because of emergency systems and emergency procedures developed to cope with such situations. Examples of the type of airborne emergencies which must be accommodated are: fire, structural failure such as a bird strike, engine failure, electrical failure, loss of pressurization, depletion of fuel or oxygen, hydraulic failure, loss of communication, failure of navigation equipment, severe turbulence, icing and hijacking. Examples of ground emergencies which may force aircraft to divert are weather below landing minimums, snow accumulation on runway, excessive cross wind, flooding, a crash, a blown tire, field maintenance, power failure, equipment failure and labor disputes.

The FAA and specifically Air Traffic Services, plays a key role in the National SAR Plan (Search and Rescue). The FAA provides emergency service to aircraft in distress; assures that SAR procedures will be initiated if an aircraft becomes overdue or unreported; attempts to locate overdue or unreported aircraft by INREQ (Inquiry Request) and ALNOT (Alert Notice) communication search; cooperates in the physical search by making all possible facilities available for use by the searching agencies.

It is important to consider the way in which controllers will react to innovation in air traffic control. They are the ones who have had to cope with emergencies in the real world, and they will be very critical of a system which cannot accommodate these emergency situations.

3.0 EVENT SEQUENCE DIAGRAM

The Event Sequence Diagram (figure 3.1) shows the parallel actions that occur during a typical IFR flight through the Air Traffic Control System. Pilot functions are performed in the aircraft as it progresses through the flight toward its destination. The controller functions are those which pertain to the flight of this particular aircraft and are performed at different geographical locations by different individuals as control of the aircraft is passed from one section of the system to another. Minute detail is not included but any section or function can be expanded as necessary with the aid of the detailed functional descriptions which are given later. The individual boxes of the flow diagram do not correlate directly with those of the Function Description matrix because all of the functions which the system performs are not necessarily utilized on a typical flight. This condensed list of the pilot-controller parallel actions is intended to show how the more important system functions interact in operation.

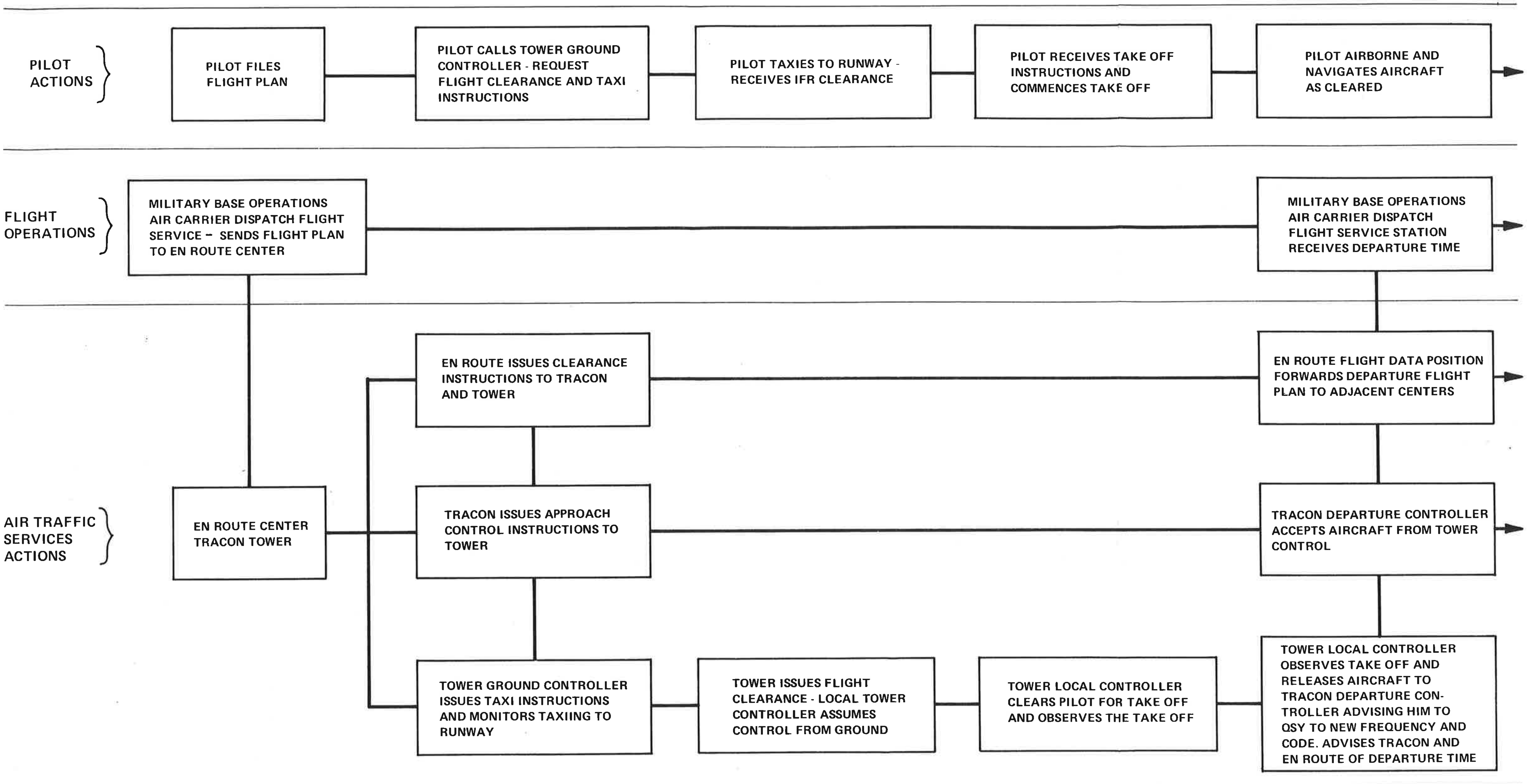

Figure 3.1.- Event sequence diagrams of related pilot - air traffic services (parallel actions during IFR flight) (sheet 1 of 3)

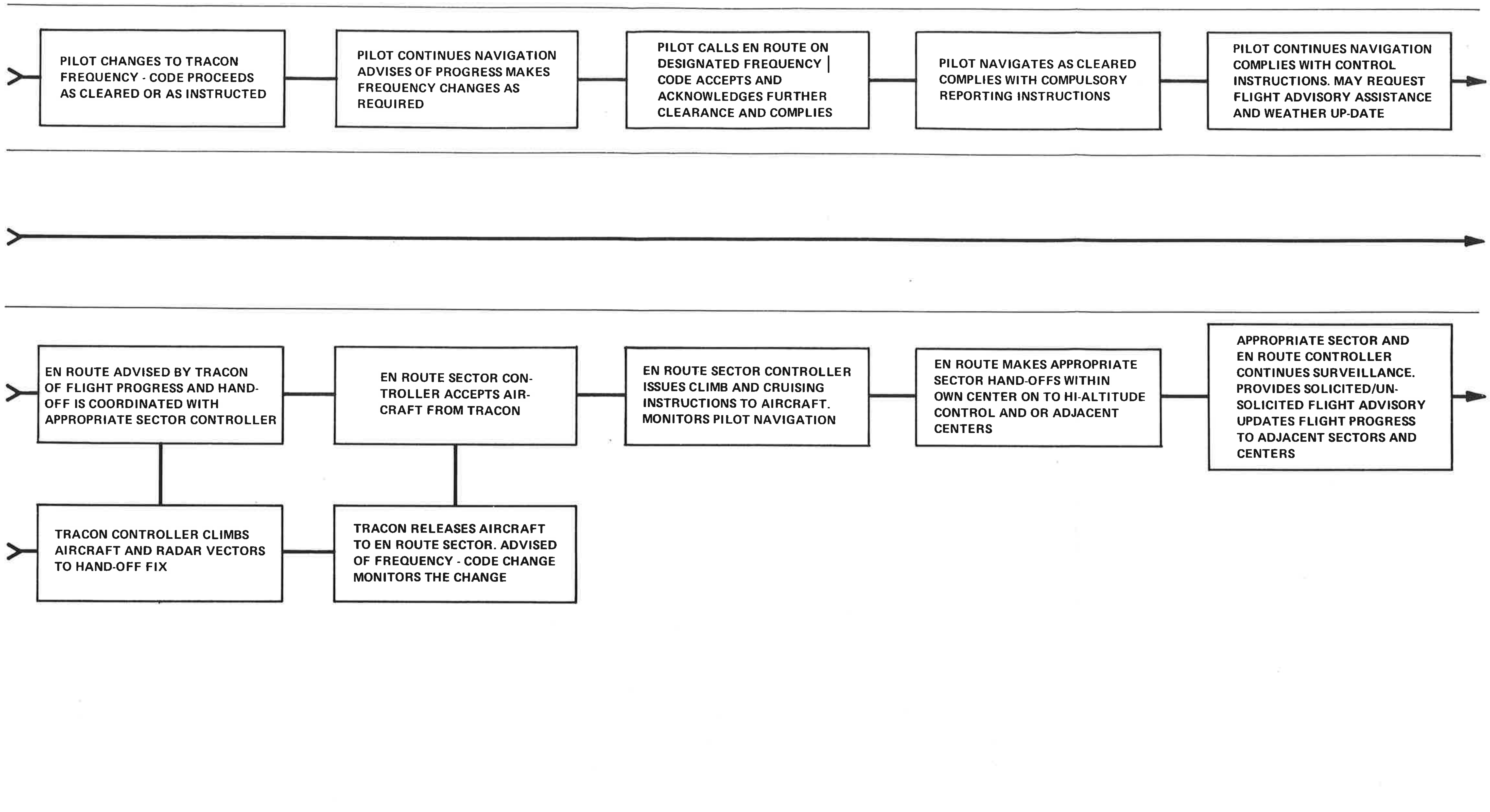

Figure 3.1.- Event sequence diagrams of related pilot - air traffic services (parallel actions during IFR flight) (sheet 2 of 3)

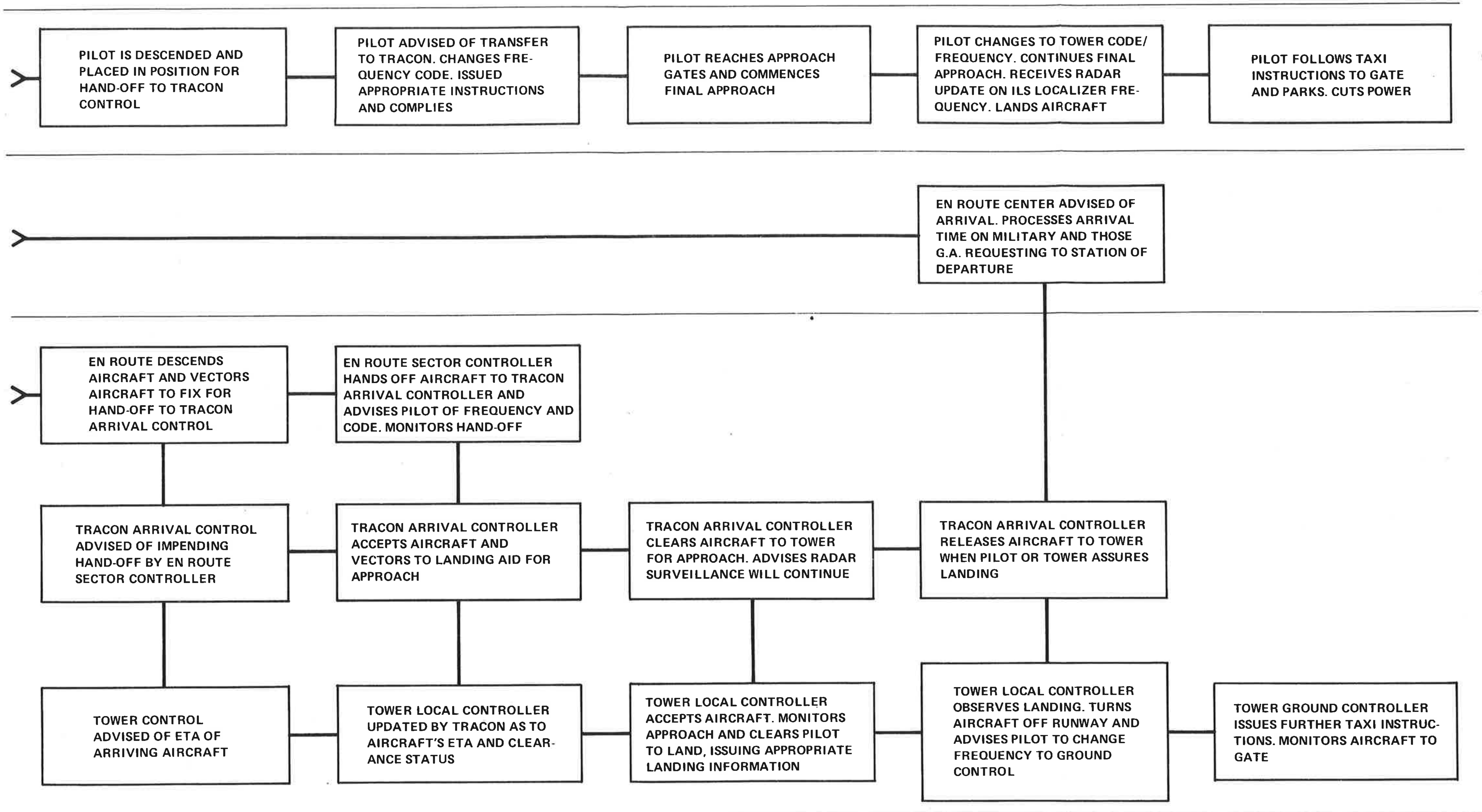

Figure 3.1.- Event sequence diagrams of related pilot - air traffic services (parallel actions during IFR flight) (sheet 3 of 3)

4.0 FUNCTION DESCRIPTION MATRIX

This section contains a chart (figure 4.1) in which the functions of air traffic control are listed by flight phase and by major system function (navigation, surveillance, control, communication). An attempt is made to list functions in generic terms, that is, as functions which would have to be accounted for in any ATC system concept. In some cases current terminology is used, especially with regard to the decision centers responsible for performing particular functions. In addition, the division of the control function into "tactical" and "strategic" and the allocation of functions to each is, to a certain extent, arbitrary. The important point, however, is that the specific entries in the matrix are generic functional activities.

As used here, the term "tactical" applies to control activities which are not routine, such as resolving conflicts which may occur. The term also applies to one-on-one control situations, such as when the tower controller is handling one landing at a time. The term "strategic" applies to routine tasks, relatively long range and preparatory tasks, and to such things as clearing aircraft through standard routes.

	NAVIGATION	SURVEILLANCE	TACTICAL CONTROL	STRATEGIC CONTROL	A/G COMMUNICATIONS	G/G COMMUNICATIONS
GATE ACTIVITY PHASE (PRE-TAXI OR POST-TAXI)	PARKING			RECEIVE PROCESS AND DISTRIBUTE FLIGHT PLAN	WEATHER, NOTAMS AND ATIS IFR CLEARANCE	FLIGHT PLAN DISTRIBUTION IFR CLEARANCE TRANSMISSION
GROUND CONTROL PHASE (DEPARTURE TAXI OR ARRIVAL TAXI)	SURFACE NAVIGATION	SURFACE SURVEILLANCE	TAXI GUIDANCE VEHICULAR CONTROL	IMPLEMENT FLOW CONTROL INSTRUCTIONS RELAY OR INITIATE ADVISORIES (TO PILOT)	TAXI CLEARANCE TAXI INSTRUCTIONS ADVISORIES	VEHICULAR INSTRUCTIONS TOWER/GROUND CONTROLLER COORDINATION
TOWER CONTROL PHASE (TAKE-OFF OR LANDING)	TAKE-OFF NAVIGATION LANDING NAVIGATION	TAKE-OFF SURVEILLANCE FINAL APPROACH SURVEILLANCE	TAKE-OFF SEQUENCING FINAL APPROACH SEQUENCING AND SPACING	RELAY OR INITIATE ADVISORIES (TO PILOT)	TAKE-OFF CLEARANCE LANDING CLEARANCE LANDING ABORT INFORMATION MANEUVER INSTRUCTIONS ADVISORIES AND PILOT REPORTS	HAND-OFF TO DEPARTURE CONTROL LANDING ABORT INFORMATION (TOWER TO TRACON) FLIGHT PLAN AND FLIGHT PROGRESS (TO GROUND FACILITIES)
APPROACH AND DEPARTURE CONTROL PHASE (DEPARTURE OR APPROACH)	DEPARTURE NAVIGATION APPROACH NAVIGATION	CLIMBOUT AND DEPARTURE SURVEILLANCE APPROACH SURVEILLANCE	CONFLICT DETECTION & RESOLUTION APPLY SPECIAL RULES (TO MILITARY, VIP, EMERGENCIES, ETC.)	DEPARTURE SEQUENCING ARRIVAL SEQUENCING IMPLEMENT FLOW CONTROL INSTRUCTIONS RECEIVE, PROCESS AND DISTRIBUTE FLIGHT PROGRESS INFORMATION (FROM PILOT) RELAY OR INITIATE ADVISORIES (TO PILOT)	FINAL APPROACH CLEARANCE LANDING ABORT INFORMATION FLIGHT PROGRESS INFORMATION AIRSPACE CLEARANCES MANEUVER INSTRUCTIONS ADVISORIES AND PILOT REPORTS	HAND-OFF TO/FROM ARTCC LANDING ABORT INFORMATION (TRACON TO TOWER) FLIGHT PLAN AND PROGRESS (TO GROUND FACILITIES)
ENROUTE CONTROL PHASE (TRANSITION)	ROUTE NAVIGATION	FLIGHT SURVEILLANCE	CONFLICT DETECTION & RESOLUTION MONITOR RESTRICTED AREAS FOR INTRUDERS APPLY SPECIAL RULES	ACCEPT AIRCRAFT AND DIRECT TO CRUISE ALTITUDE MONITOR AIRCRAFT AT CRUISE ALTITUDE AND ISSUE STATION KEEPING COMMANDS ISSUE DESCENT INSTRUCTIONS AND HAND-OFF TO APPROACH CONTROL IMPLEMENT FLOW CONTROL INSTRUCTIONS RECEIVE, PROCESS AND DISTRIBUTE FLIGHT PROGRESS INFORMATION (FROM PILOT) RELAY OR INITIATE ADVISORIES (TO PILOT)	FREQUENCY CHANGES FLIGHT PROGRESS INFORMATION AIRSPACE CLEARANCES ADVISORIES AND PILOT REPORTS MANEUVER INSTRUCTIONS	HAND-OFF SECTOR TO SECTOR HAND-OFF ARTCC TO ARTCC HAND-OFF ARTCC/TERMINAL FLIGHT PLAN AND PROGRESS (TO GROUND FACILITIES)
				ANY PHASE(S): FORMULATE AND ISSUE FLOW CONTROL DIRECTIVES (CFCF OR ARTCC) RECEIVE AND PROCESS FLIGHT PROGRESS INFORMATION (TO/FROM GROUND FACILITIES) RECEIVE AND DISTRIBUTE WEATHER AND NOTAMS (TOWER, A/D CONTROL, ARTCC, CFCF) FORECAST EXPECTED ACCEPTANCE RATES (TOWER OR A/D CONTROL)		ANY PHASE(S): NOTAMS AND WEATHER INFORMATION DISTRIBUTION ESTIMATED ACCEPTANCE RATE FORECASTS (TOWER TO ARTCC OR CFCF) FLOW CONTROL DIRECTIVES FLIGHT PLAN & PROGRESS (FROM GROUND FACILITIES) NAVAIDS MONITOR DATA

Figure 4.1.- Function description matrix.

5.0 PRIMARY ATC INFORMATION FLOWS

The flow of data or information between decision centers in the air traffic control system is the life-blood of the system, enabling it to function.

The primary information flowing through the system was analyzed with respect to the decision centers involved and the timing of such flows between the centers. These analyses are summarized in five block diagrams (figures 5.1 to 5.5): (1) real time position information flow; (2) flight plan and flight progress information flow; (3) clearances, maneuver commands, advisories and PIREPS; (4) weather and NOTAMS information; and (5) flow control information. The timing of the flows, in terms of flight phases, is indicated by the code numbers on the diagrams.

The numbers are related to the flight phases as follows:

- 0 - Information flow before taxi
- 1 - During taxi (gate to runway)
- 2 - During take-off
- 3 - During departure transition
- 4 - During en route flight
- 5 - During approach transition
- 6 - During final approach and landing
- 7 - During taxi (runway exit to gate)

The detailed assignment of communications functions to each flight phase in the ATS Function Description Matrix is based upon the flow diagrams.

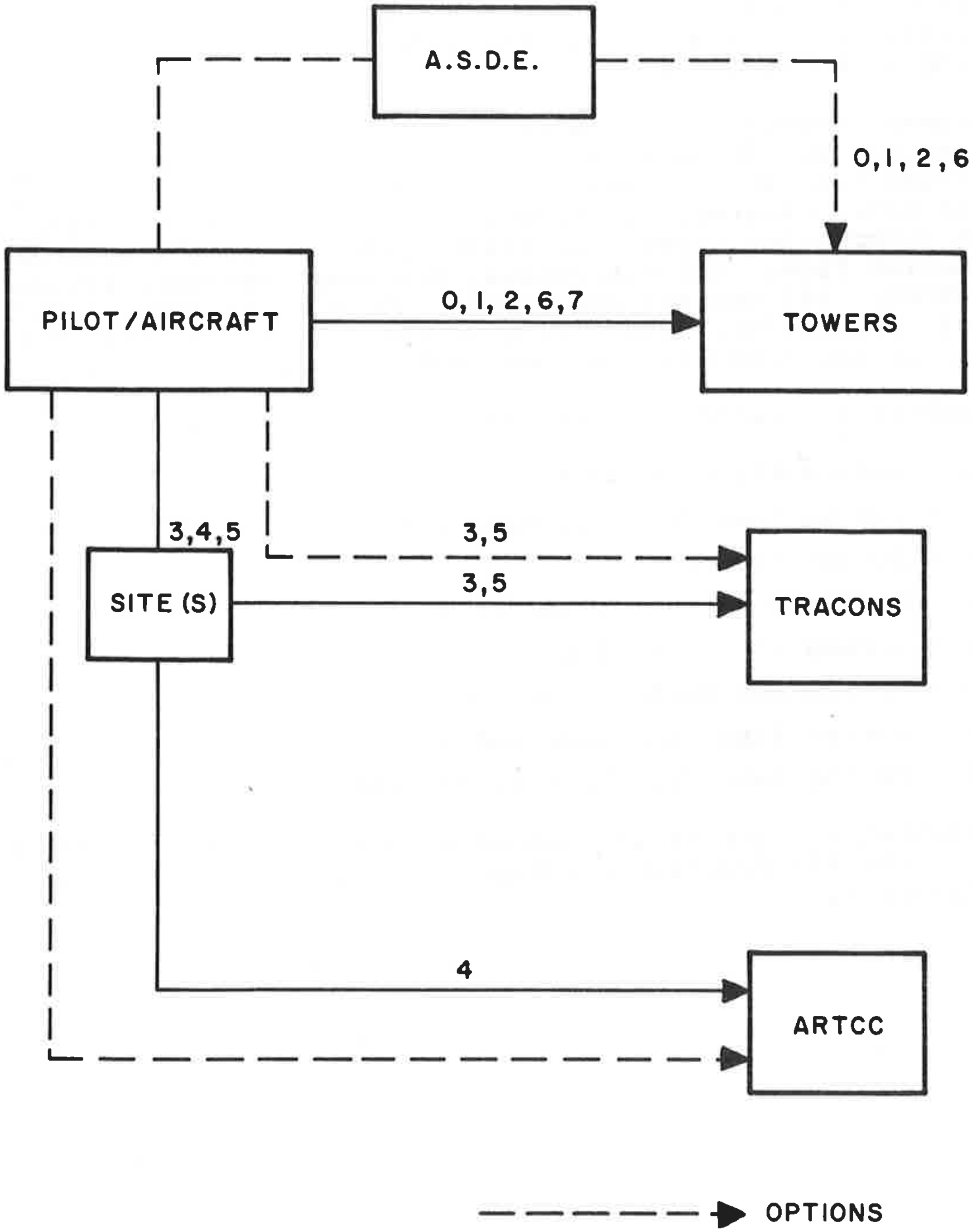

Figure 5.1.- Real time position information flow.

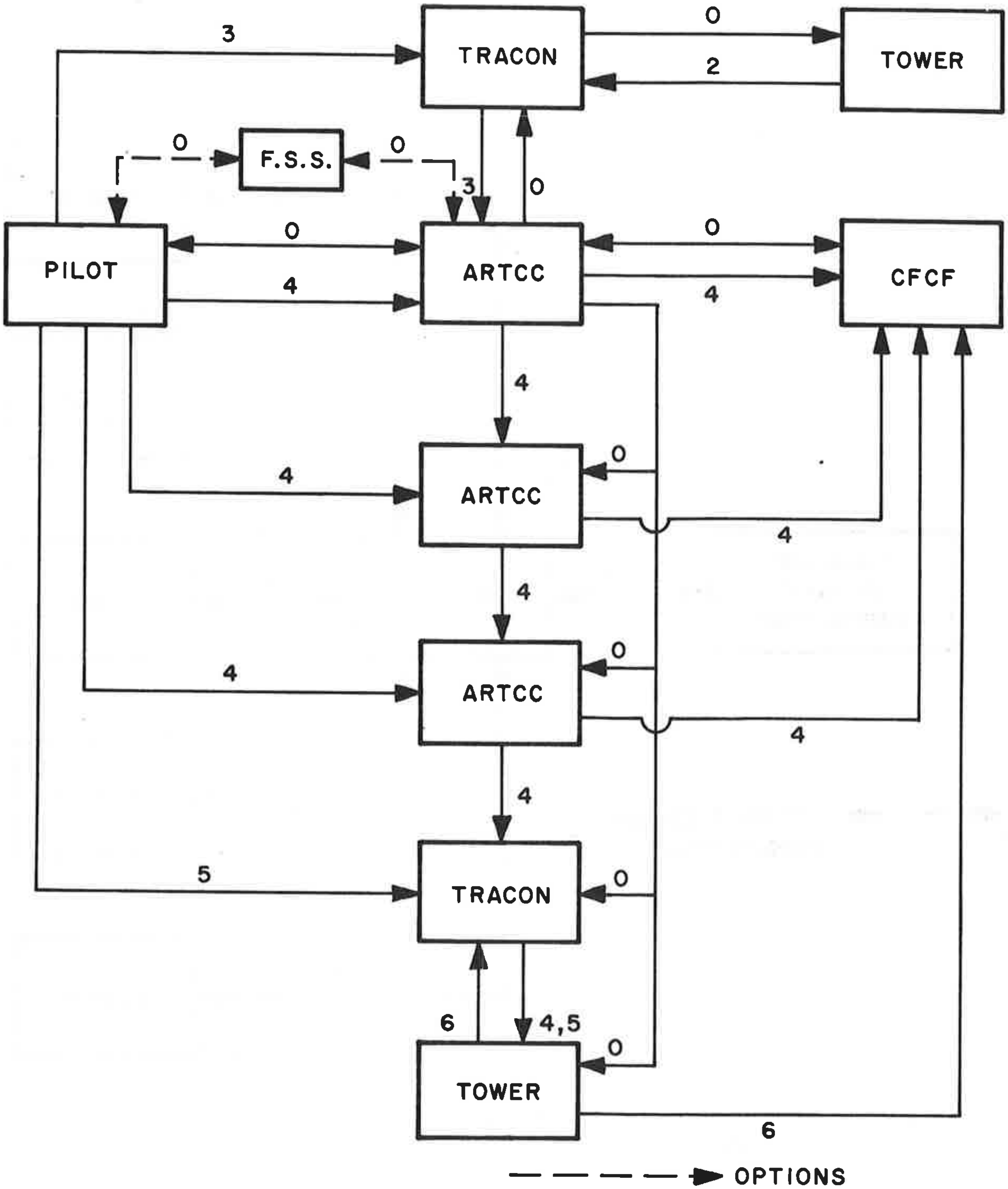

Figure 5.2.- Flight plan information flow*.

*includes pre-flight IFR clearance

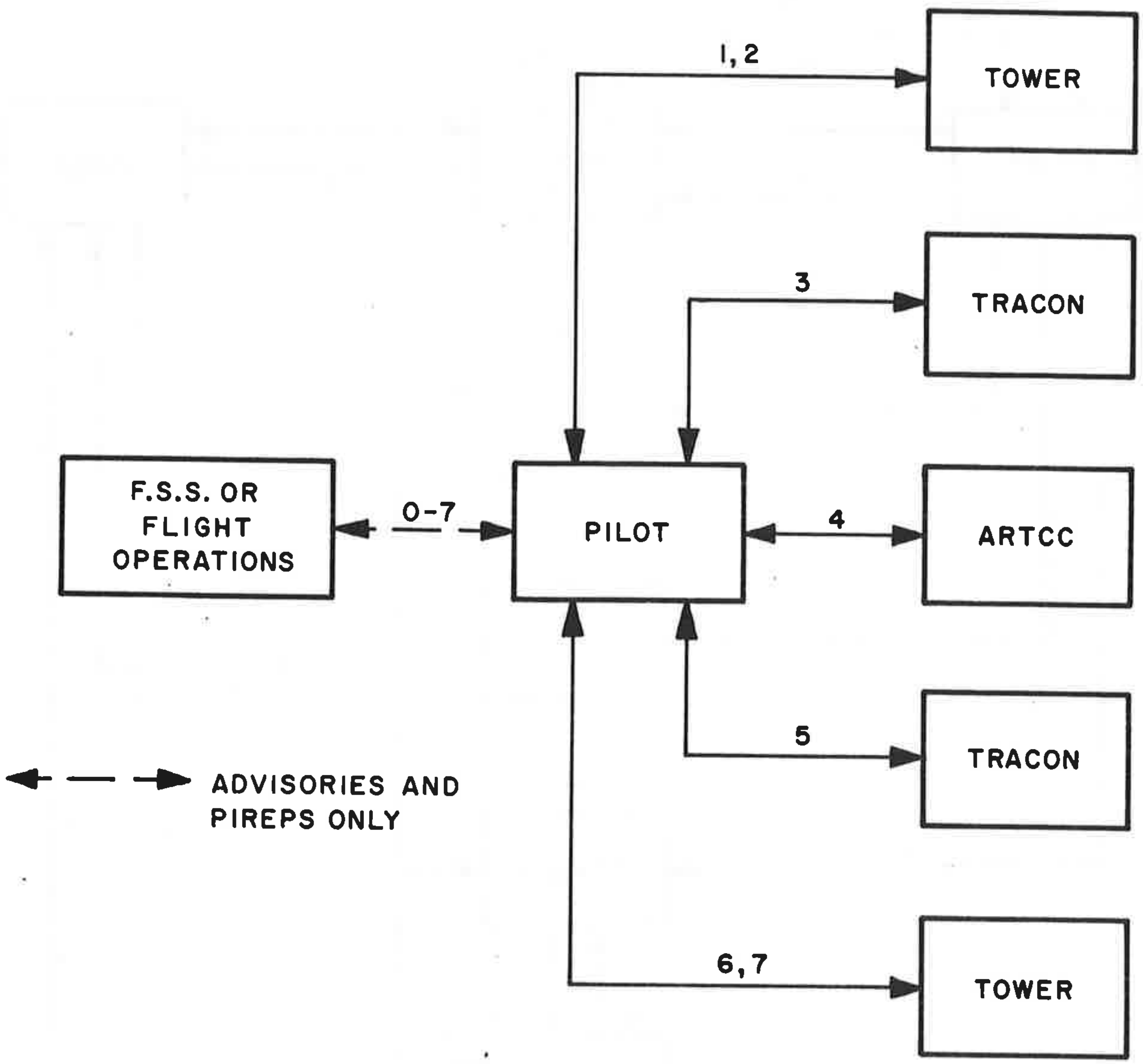

Figure 5.3.- Clearances,* maneuver commands,* advisories and pilot reports.

*including acknowledgment of information

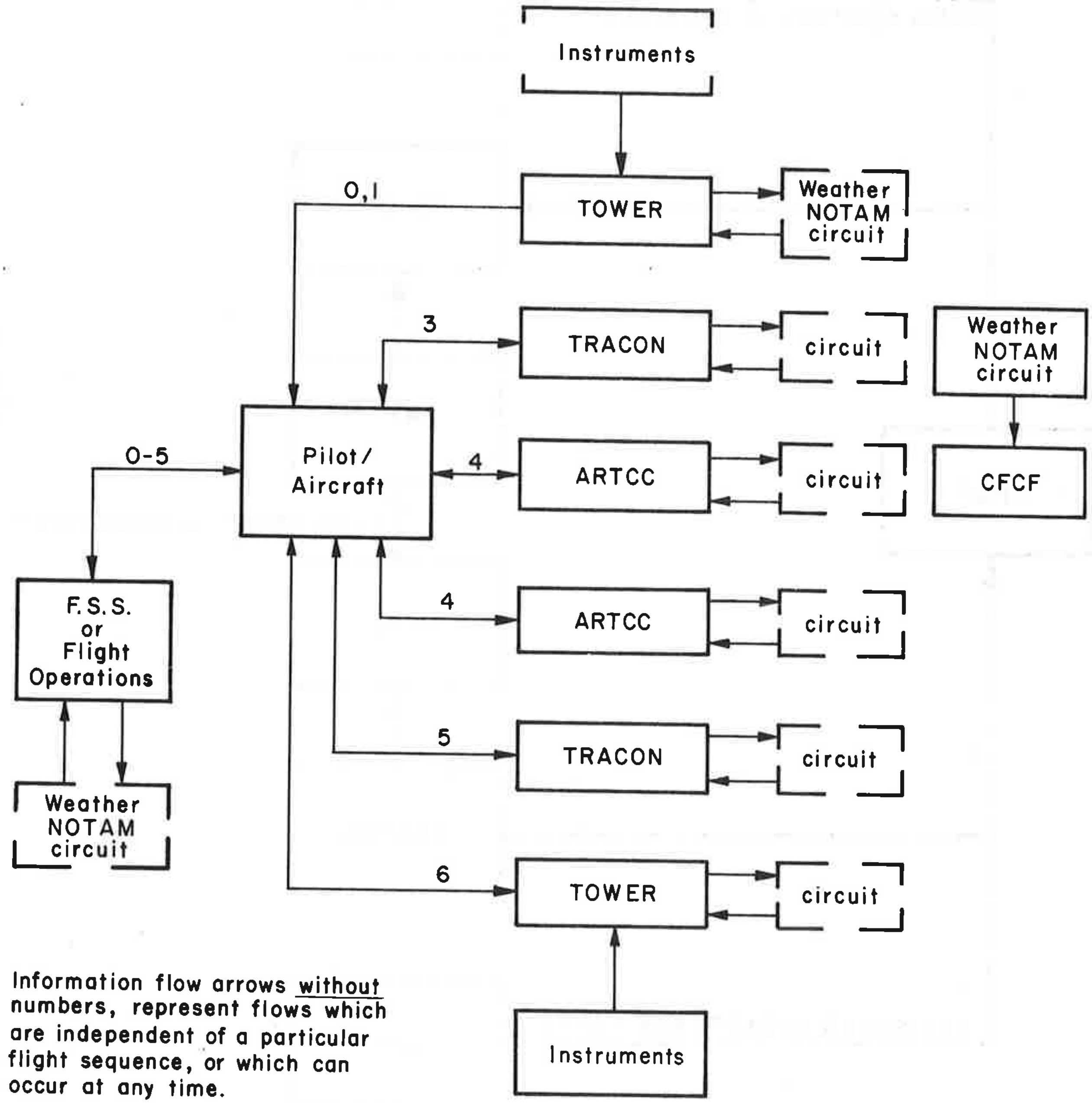

Figure 5.4- Weather and NOTAMS information flow.

Figure 5.5- Flow control information.

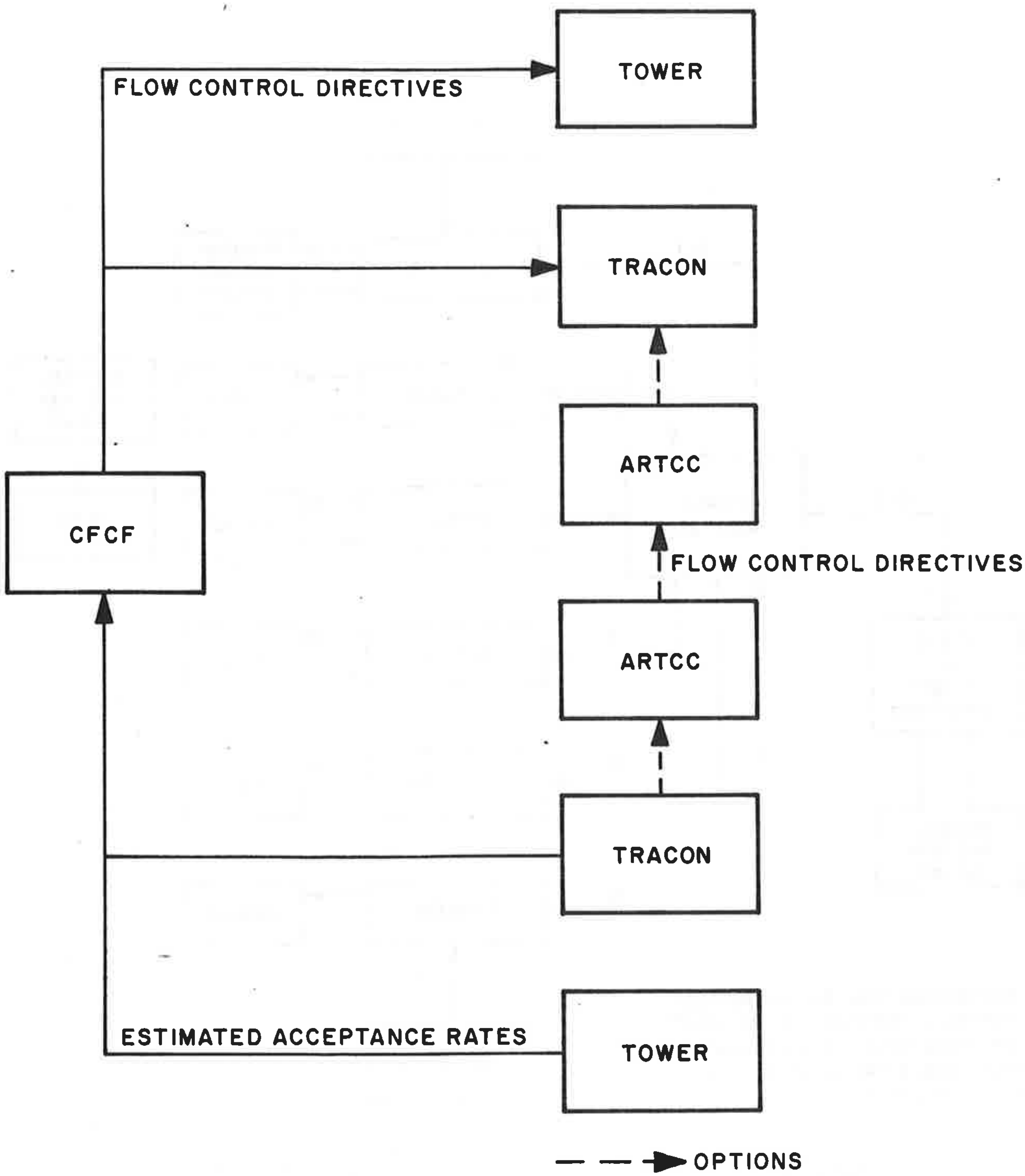

Figure 5.5- Flow control information.

APPENDIX
DETAILED FUNCTION DESCRIPTIONS

In this Appendix the individual functions which were listed in section 4.0 are described in greater detail. The equipment or method which is currently employed is identified. There are estimates of the magnitudes of pertinent functional parameters which are thought to be appropriate for traffic levels of the 1990's. The numbers which are used are best estimates and should be considered as order of magnitude rather than firm specifications. Many of the numbers have to be derived from forecasts of the traffic activity, which contain considerable uncertainty.

The parameters for which quantitative estimates have been made are explained briefly below for certain major functions.

<u>Navigation Functions</u>

Saturation	This is the maximum number of aircraft (peak) which the appropriate navigation aid (ILS, VORTAC, etc.) can be expected to handle in a 1990 traffic environment.
Accuracy	The values listed indicate how accurately the aircraft system must know its position after a measurement is taken. All values shown are approximately 2σ.
Position Fix Interval	This is the time interval between position/velocity measurements.

<u>Surveillance Functions</u>

Coverage	Coverage in 3 dimensions.
Saturation	The maximum number of aircraft (peak) which the appropriate surveillance data acquisition site can be expected to handle in a 1990 traffic environment.
Accuracy	The values listed indicate how accurately a separation control system must know aircraft positions. All values are 2σ.
Sample Interval	The time interval between position/velocity measurements.

Resolution	The separation at which two aircraft can be resolved.

<u>Tactical Control Functions</u>

Coverage	Typical spatial jurisdiction.
Saturation	The maximum number of aircraft (peak) which the appropriate control center can be expected to handle in the traffic environment of the 1990's.
Risk Level	An explicit measure is the allowable probability of a collision while in a particular control jurisdiction. Expected separation standards (implicitly stated risk) for the 1990's are also shown. There is no attempt to make a rigorous correlation between explicit risk level and separation standards.
Response	Typical separation - control response times for necessary calculation and command formulation (not including the time necessary for data acquisition or for perceiving a situation).

<u>Air/Ground Communications Functions</u>

Digital Data Rates	The values shown are the maximum data rates which would be required (bits/second) to transmit surveillance information and maneuver instructions in order to conform to the stated data acquisition sample intervals and aircraft saturation levels.

PHASE Gate Activity FUNCTION Navigation

SUB-FUNCTIONS: Taxi into and out of Parking Area

FUNCTION ABSTRACT

Based on the gate assignment, the aircraft must be parked in the proper space with the proper heading. The outputs pertinent to this function are instructions to the tractor operator and aircraft control movements.

Current Equipment/Methods

Human taxi director, line-up lines, tow tractors, radio, intercom, hand signals.

PARAMETER ESTIMATES

Accuracies: parking ~1 foot
heading $\sim 3^{o}$

PHASE <u>Gate Activity</u> FUNCTION <u>Strategic Control</u>

<u>SUB-FUNCTIONS</u>: Receive, Process and Distribute Flight Plan

FUNCTION ABSTRACT

The flight plan submitted by the pilot or the flight operations group must be processed and distributed by the F.S.S. or ARTCC to all appropriate ground facilities. Confirmation of the flight plan is given by a Central Flow Control Facility. Each appropriate facility generates and posts a flight progress strip (or maintains a file).

<u>Current Equipment/Methods</u>

Telephone, teletype, computer, printers, land lines.

PHASE Gate FUNCTION A/G Communication

SUB-FUNCTIONS: Weather, NOTAMS and ATIS IFR Clearance

FUNCTION ABSTRACT

A channel must be available between the pilot and the terminal in order to receive pre-taxi information on weather, NOTAMS and ATIS (runway in use, altimeter setting, ceiling, visibility, wind velocity).

A channel must also be available for transmitting an IFR clearance from the ARTCC to the pilot.

Current Equipment/Methods

VHF, UHF, recording equipment.

PHASE Gate FUNCTION G/G Communication

SUB-FUNCTIONS: Flight Plan Distribution IFR Clearance Transmission

FUNCTION ABSTRACT

A channel must be provided for the transmission of the flight plan from the originating ARTCC or F.S.S. to appropriate ARTCC's, departure and arrival terminals, and to the CFCF; and for the return transmission of an IFR clearance or a recommended flight plan revision.

Current Equipment/Methods

Telephone, teletype, land lines, recording equipment.

PHASE Ground Control FUNCTION Navigation

SUB-FUNCTIONS: Surface Navigation

FUNCTION ABSTRACT

With the appropriate visual or instrument position cues, the locations of other traffic, and the assigned taxi route, the pilot must navigate the aircraft between the gate and the runway. This consists of the following activities: executing taxi instructions, monitoring taxiway centerline and sidelines, observing separation from other vehicles and obstructions, controlling taxi speed and advising the ground controller of position and intentions.

Current Equipment/Methods

Dead reckoning, taxi and runway centerlines.
Taxiway, runway lights, centerline lights, observation lights.
Signs (lit at night), runway distance to go.
Airport maps.
Inertial navigator (for taxi speed indication).
Radio and light signal instructions.

PARAMETER ESTIMATES

Accuracies: Along track ~5 ft. (2σ)
Across track ~5 ft.
Velocity ~5 knots

Position Fix Interval: 1 second

PHASE <u>Ground Control</u> FUNCTION <u>Surveillance</u>

<u>SUB-FUNCTIONS:</u> Surface Surveillance

FUNCTION ABSTRACT

The controller responsible for delivering aircraft to and from the runway, or anywhere on the taxiways, must have information on target position and velocity, and on the positions and velocities of all other vehicles on the surface.

<u>Current Equipment/Methods</u>

Visual, ASDE.

PARAMETER ESTIMATES

Coverage: 2-4 mile radius

Saturation: ~100 aircraft and vehicles

Accuracies: along track ~5 ft. (2σ)
across track ~5 ft.
velocity ~5 knots

Sample Interval: ~1 second

PHASE Ground Control FUNCTION Tactical Control

SUB-FUNCTIONS: Taxi Guidance, Vehicular Control

FUNCTION ABSTRACT

The ground controller must guide the aircraft, via route designations and stop/go commands, between the gate and the runway, assuring that conflicts at intersections will be resolved. In addition, the ground controller must monitor and control all other vehicles which may interfere with the target aircraft. As inputs, the controller requires knowledge of aircraft and vehicle positions and velocities, the taxiway layout, the active runways, and aircraft performance characteristics.

Current Equipment/Methods

Ground controller, ASDE display, VHF/UHF.

PARAMETER ESTIMATES

Coverage: 2-4 mile radius

Saturation: ~100 aircraft and vehicles

Risk Level: $< 10^{-7}$

Response: (imminent collision)*
~2 seconds
(avoidance of potential conflicts at intersections)
~10 seconds

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* Due to a blunder such as turning onto an active runway or turning wrong way at an intersection.

PHASE Ground Control FUNCTION Strategic Control

SUB-FUNCTIONS: Implement Flow Control Instructions

FUNCTION ABSTRACT

The ground controller receives flow control directives from the CFCF or the ARTCC, and directs ground traffic so as to conform to the directives; usually by delaying gate departure times. Information required by the controller would be: existing departure schedules, and runway operations rates imposed on the terminal.

Current Equipment/Methods

Ground controller, teletype, telephone, VHF/UHF.

PHASE Ground Control FUNCTION Strategic Control

SUB-FUNCTIONS: Relay or Initiate Advisories

FUNCTION ABSTRACT

The ground controller relays important information, such as recent NOTAMS or hazard information, to the pilot (usually on departure); or, will initiate an advisory based on current local airport conditions, such as taxiway, runway obstructions, construction, etc. (usually on arrival).

Current Equipment/Methods

VHF, UHF, human ground controller.

PHASE <u>Ground Control</u> FUNCTION <u>A/G Communication</u>

SUB-FUNCTIONS: Taxi Clearance
Taxi Instructions
Advisories

FUNCTION ABSTRACT

A two-way channel must be provided between the pilot and the ground controller for the transmission (and requesting) of taxi clearance, taxi route instructions, stop/go commands at intersections, and advisories. Acknowledgment of transmission must also occur.

Current Equipment/Methods

VHF, UHF, recording equipment.

PHASE Ground Control FUNCTION G/G Communication

SUB-FUNCTIONS: Vehicular Instructions
Tower/Ground Controller Coordination

FUNCTION ABSTRACT

There must be a 2-way channel between the ground controller and the airport ground vehicles to assure that vehicles can be controlled so as not to interfere with taxiing or runway operations.

In addition, there must be a 2-way, open channel between the ground controller and the tower controller, so that they may be aware of each other's control directions in order to minimize the chance of conflict at runway/taxiway intersections.

Current Equipment/Methods

VHF, HF.

PHASE <u>Tower Control</u> FUNCTION <u>Navigation</u>

<u>SUB-FUNCTIONS:</u> Take-off Navigation
Landing Navigation

FUNCTION ABSTRACT

Based on visual cues, instrument readings, control instructions, wind and weather information, the aircraft must be navigated when taking off or when landing. The specific activities include: lining up the aircraft with the runway and runway exit, verifying clearance of obstacles, monitoring acceleration or deceleration, remaining clear of visual traffic, executing take-off or landing, and maintaining proper altitude.

<u>Current Equipment/Methods</u>

ILS, GCA, Marker Beacon, Dead Reckoning Approach Lights, Runway Markers, Radar Altimeter, Barometric Altimeter, LGS, Automatic Landing Equipment.

PARAMETER ESTIMATES

Saturation: ~6 (landing/runway)

Accuracies: along track ~10 ft. (2σ)
across track ~10 ft.
altitude ~3 ft. (landing), 10 ft. (take-off)
velocity ~2 knots (landing), 5 knots (take-off)

Position Fix Interval: landing ~0.1 second
take-off ~1 second

PHASE Tower Control FUNCTION Surveillance

SUB-FUNCTIONS: Take-off Surveillance
Final Approach Surveillance

FUNCTION ABSTRACT

The tower or local controller requires surveillance of the aircraft take-off and of runway intersections and immediate airspace. He must specifically know target and other vehicle positions, velocities, and headings.

On final approach, surveillance must be provided from the assumption of control at the outer marker to the hand-off of control at the exit taxiway. The tower controller must also be aware of wind conditions.

Current Equipment/Methods

Visual, ASDE, radar (back-up).

PARAMETER ESTIMATES

Coverage: 3000 ft. altitude, 5 nm. radius

Saturation: 24 (taking off and landing on parallel runways)

Accuracies: along track ~10 ft.
across track ~10 ft.
altitude ~10 ft.
velocity ~2 knots (landing), 5 knots (take-off)

Sample Interval: ~0.1 second (landing), 1 second (take-off)

PHASE Tower Control FUNCTION Tactical Control

SUB-FUNCTIONS: Take-off Sequencing
Final Approach Sequencing and Spacing

FUNCTION ABSTRACT

The tower controller must formulate and issue take-off clearance and departure instructions so that aircraft waiting to depart are sequenced onto and off the runway safely and efficiently. The necessary input information for the controller includes a knowledge of the aircraft's request for departure, target and other aircraft position and heading, aircraft performance characteristics, and separation standards.

For final approach and landing, the controller maintains safe and efficient spacing through speed and maneuver commands. In addition the controller issues landing clearance, advises of the taxi exit number and the ground control frequency, and issues appropriate maneuver commands in the case of a wave-off or missed approach.

Current Equipment/Methods

Human controller, ASDE display, flight progress strips, VHF, UHF.

PARAMETER ESTIMATES

Coverage: 0-3000 ft. altitude, 5 nm. radius

Saturation: 24 (taking off and landing on parallel runways)

Risk Level: (explicit) $<10^{-7}$
(implicit, separation standards)
lateral ~2500′ (parallel approaches), 30° divergence for closely spaced departures
longitudinal ~2 nm., single runway occupant

Response: (imminent collision avoidance)
~3 seconds (calculation and formulation)

PHASE Tower Control FUNCTION Strategic Control

SUB-FUNCTIONS: Relay or Initiate Flight Advisories

FUNCTION ABSTRACT

Based on recent NOTAMS, local conditions, pilot reports, or other pertinent information, the tower controller should decide whether or not to initiate or relay advisories to the pilot. He should also decide whether or not to post or distribute such information.

Current Equipment/Methods

Human controller, weather and NOTAM printouts, VHF, UHF.

PHASE Tower Control FUNCTION A/G Communication

SUB-FUNCTIONS: Take-off or Landing Clearance
Landing Abort Information
Maneuver Instructions, Advisories
and Pilot Reports

FUNCTION ABSTRACT

A 2-way channel must be provided between pilot and controller for the requesting and/or issuing of take-off clearances or landing clearances (including ground frequency and taxi exit), advisories and pilot reports.

A channel must also exist for the transmission of maneuver (heading, speed, altitude, fix) instructions, whether for landing abort, routine maneuvering, or collision avoidance; and also a channel for acknowledgments, missed approach decisions and flight progress information from the aircraft to the controller.

Current Equipment/Methods

VHF, UHF, recorders.

PARAMETER ESTIMATES

Digital Data Link

(Down): Identification, altitude, position, velocity, ETA ("flight progress information")
Message length ~72 bits
Maximum Data rate ~1.8×10^4 bits/second*

(UP): Heading, altitude, speed, fix (maneuver, spacing instructions)
Message length ~45 bits
Maximum Data rate ~1×10^4 bits/second

Voice Link

Contact/acknowledge
Departure frequency
Advisories, pilot reports
Take-off and landing clearances

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*For surveillance purposes

PHASE <u>Tower Control</u> FUNCTION <u>G/G Communication</u>

<u>SUB-FUNCTIONS:</u> Hand-off to Departure Control
Landing Abort Information
(to TRACON)

FUNCTION ABSTRACT

A channel must be provided for the tower controller to inform the departure controller of a take-off (flight number and lift-off time).

In addition, if there is a wave-off or a missed approach, the tower communicates such a decision and the given maneuver instructions to the approach and departure controllers so that they may re-sequence the aircraft.

<u>Current Equipment/Methods</u>

Telephone, VHF, UHF.

PHASE <u>Tower Control</u> FUNCTION <u>G/G Communication</u>

<u>SUB-FUNCTIONS</u>: Flight Plan and Progress (to ground facilities)

FUNCTION ABSTRACT

A channel must be provided for transmitting important flight progress or flight plan changes to down-stream control regions. Also, the tower must be able to relay time of departure and time of arrival.

<u>Current Equipment/Methods</u>

Teletype, land lines, telephone.

PHASE <u>A/D Control</u> FUNCTION <u>Navigation</u>

<u>SUB-FUNCTIONS</u>: Departure Navigation
Approach Navigation

FUNCTION ABSTRACT

Based on external visual cues, instrument readings, control instructions and advisories, the pilot must: maintain the aircraft on departure (or arrival) route and altitude assignment; maintain speed as required; accomplish aircraft configuration changes; remain clear of visual traffic; receive advisories; and determine and report position and altitude.

<u>Current Equipment/Methods</u>

VOR, DME, TACAN, ADI, DECCA, LORAN, Vectoring, ILS, LGS, Barometric altimeter, Radar altimeter.

PARAMETER ESTIMATES

Saturation:	~1000 aircraft/NAVAID
Accuracies:	along track ~100 ft. across track ~100 ft. altitude ~50 ft. (departure), 20 ft. (approach) velocity ~5 knots
Position Fix Interval:	~1 second

PHASE A/D Control FUNCTION Surveillance

SUB-FUNCTIONS: Climb Out and Departure Surveillance
Approach Surveillance

FUNCTION ABSTRACT

The departure controller must have a means of acquiring data on the position, heading and speed of target aircraft and of other aircraft in the vicinity; from take-off to hand-off to an ARTCC.

The approach controller requires similar data.

Current Equipment/Methods

Terminal radar, flight progress strips, VHF, UHF.

PARAMETER ESTIMATES

Coverage:	1500 - 18,000 ft., ~40 nm. radius
Saturation:	~1000 aircraft/site
Accuracies:	along track ~100 ft. across track ~100 ft. altitude ~50 ft. velocity ~5 knots
Sample Interval:	1-3 seconds

PHASE <u>A/D Control</u> FUNCTION <u>Tactical Control</u>

SUB-FUNCTIONS: Conflict Detection and Resolution

FUNCTION ABSTRACT

The approach and the departure controllers must monitor their airspace, decide whether conflict hazards exist between uncontrolled and controlled (or between controlled and controlled) aircraft, and issue maneuver instructions or advisories as appropriate. The controller must base his decisions on data such as controlled aircraft positions, headings, altitudes and speeds, primary position returns from uncontrolled aircraft, and a knowledge of separation criteria.

Current Equipment/Methods

VHF, UHF, primary radar, ATCRBS, video display.

PARAMETER ESTIMATES

Coverage: 1500-18,000 ft. altitude, 40 nm. radius

Saturation: ~1000 aircraft/TRACON

Risk Level: (explicit) $<10^{-7}$
(implicit, separation standards)
lateral ~1-2 nm.
longitudinal ~2-5 nm.
altitude ~1000 ft.

Response: (imminent collision avoidance)*
3-5 seconds (calculation and formulation)
(potential conflict or congestion avoidance)
20 seconds

*Situations which arise from blunders or from VFR aircraft appearing unexpectedly.

PHASE A/D Control FUNCTION Tactical Control

SUB-FUNCTIONS: Apply Special Rules

FUNCTION ABSTRACT

To assure the safety of special VIP flights, emergency craft, military aircraft and training flights, the controller should be able to amend the rules and regulations and issue special flight instructions when necessary. In order to carry out this function, the controller must be aware of the special flight mission, and must also have previous agreements with those responsible for the flight (this does not apply for emergencies).

Current Equipment/Methods

Human controller, radar display, VHF, UHF, recorder, ATCRBS.

PHASE A/D Control FUNCTION Strategic Control

SUB-FUNCTIONS: Departure Sequencing and Monitoring
Arrival Sequencing and Monitoring

FUNCTION ABSTRACT

Based on flight plan information, aircraft position, heading, speed and altitude information, the departure controller assures that departing aircraft are properly spaced and routed to en-route transfer points via standard way points.

The approach controller accepts control from the en-route center; clears aircraft for altitude changes, and guides and sequences aircraft for delivery to final approach. The controller also re-sequences aircraft which have executed missed approach procedures.

The guidance and sequencing are accomplished by issuing appropriate altitude, heading and speed instructions or clearances, and fixes.

Current Equipment/Methods

Human controllers, radar, flight strips, VHF, UHF.

PHASE A/D Control FUNCTION Strategic Control

SUB-FUNCTIONS: Implement Flow Control Instructions

FUNCTION ABSTRACT

The approach controller, upon receiving flow restrictions from the tower, must direct aircraft into holding patterns (altitude, fix, period), releasing them at a specified rate.

The departure controller must likewise put aircraft into holding patterns if the en-route control is not ready to accept hand-off.

Current Equipment/Methods

VHF, UHF, Radar, flight progress strips, telephone.

PHASE <u>A/D Control</u> FUNCTION <u>Strategic Control</u>

<u>SUB-FUNCTIONS:</u> Receive, Process, Distribute Flight Progress Information (from pilot)

Relay Initiate Advisories (to pilot), Receive PIREPS

FUNCTION ABSTRACT

The approach or departure controller must receive flight progress information from the aircraft, prepare and post up-dated strips. If necessary he must distribute the information to the tower or to the en-route center.

The approach or departure controller will also receive and relay recent NOTAMS and weather data, or will initiate advisories based on current local conditions. The controller will also receive pilot reports.

<u>Current Equipment/Methods</u>

Human controller, VHF, UHF, flight progress strips.

PHASE A/D Control FUNCTION A/G Communication

SUB-FUNCTIONS: Final Approach Clearance
Landing Abort Information
Flight Progress Information
Airspace Clearance
Maneuver Instructions
Advisories and Pilot Reports

FUNCTION ABSTRACT

A channel must be provided for transmitting to the aircraft: final approach clearance, landing abort information (the decision, and maneuver instructions if not a standard procedure), airspace clearances (altitude, route, speed, fix) for descent or for transition to en-route control, maneuver instructions (altitude, heading, speed, fix or hold pattern) for conflict avoidance or for holding, and advisories (weather, NOTAMS).

Also, the pilot/aircraft must be able to transmit to the controller: flight progress information (position, altitude, velocity, ETA), missed approach decision, acknowledgement (by repeating message) of clearances and maneuver instructions, pilot reports, and emergency information.

Current Equipment/Methods

VHF, UHF, recorders.

PARAMETER ESTIMATES

Digital Data Link
(Down): Identification, altitude, position, velocity, ETA ("flight progress information")
Message length ~72 bits
Maximum Data rate ~7.2×10^4 bits/sec.*

(Up): Route, heading, altitude, speed, fix (clearances, maneuver instructions)
Message length ~65 bits
Maximum Data rate ~6×10^4 bits/second

Voice Link
Final approach clearance, landing abort decisions, advisories, pilot reports, emergencies

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*For surveillance purposes

PHASE A/D Control FUNCTION G/G Communication

SUB-FUNCTIONS: Hand-off To/From ARTCC

FUNCTION ABSTRACT

A means must be provided for transferring control (necessary flight information, position reports) between terminal and en-route control regions. There also must be a means for transmitting acceptance or acknowledgement.

Current Equipment/Methods

Telephone, teletype, land lines, video display, recorders.

PHASE A/D Control FUNCTION G/G Communication

SUB-FUNCTIONS: Landing Abort Information
(TRACON to tower)

FUNCTION ABSTRACT

The approach controller must inform the tower controller and the departure controller of a landing abort decision and of maneuver instructions given to the aircraft. There should also be an acknowledgement from the departure or tower controller to the approach controller.

Current Equipment/Methods

Telephone, VHF, recorders.

PHASE <u>A/D Control</u> FUNCTION <u>G/G Communication</u>

<u>SUB-FUNCTIONS:</u> Flight Plan and Progress (to ground facilities)

FUNCTION ABSTRACT

A channel must be provided for transmitting important flight progress or flight plan changes to down-stream control regions.

<u>Current Equipment/Methods</u>

Teletype, land lines, telephone.

PHASE En-Route FUNCTION Navigation

SUB-FUNCTIONS: Route Navigation

FUNCTION ABSTRACT

Based on external visual cues, assigned flight plan, instrument readings and advisories, the pilot must: maintain aircraft on flight plan route and altitude; monitor progress to achieve ETA; check fuel remaining; determine wind; monitor weather; monitor aircraft systems; request changes in flight plan as necessary; execute changes; maintain lookout for other traffic; determine and report position and altitude; and receive traffic advisories.

Current Equipment/Methods

VOR, DME, TACAN, ADF, DECCA, LORAN, Inertial, Doppler, OMEGA, Radar, Dead Reckoning, Vectoring Barometric altimeter.

PARAMETER ESTIMATES

Saturation: ~1000 aircraft/NAVAID

Accuracies: along track ~1000 ft., 5000 ft. (oceanic)
across track ~1000 ft., 5000 ft. (oceanic)
altitude ~100-200 ft.
velocity ~5 knots

Position Fix Interval: 3 seconds, 100 seconds (oceanic)

PHASE En-route FUNCTION Surveillance

SUB-FUNCTIONS: Flight Surveillance

FUNCTION ABSTRACT

The en-route controller must have a means of acquiring and displaying the positions, headings and speeds of aircraft transiting his control region.

Current Equipment/Methods

Area "S" radar, ATCRBS, VHF, UHF.

PARAMETER ESTIMATES

Coverage: 15,000 - 100,000 ft. altitude, CONUS, ocean routes

Saturation: ~2500 aircraft/site

Accuracies: along track ~1000 ft., 5000 (oceanic)
across track ~1000 ft., 5000 (oceanic)
altitude ~100 - 200 ft.
velocity ~5 knots

Sample Interval: 3 seconds, 100 seconds (oceanic)

Resolution: (at display) 2 aircraft separated 1000 ft. laterally
100 ft. altitude

PHASE En-route FUNCTION Tactical Control

SUB-FUNCTIONS: Conflict Detection and Resolution

FUNCTION ABSTRACT

Based on position, altitude, heading and speed information of aircraft in his control region, the controller must detect and assess potential conflict situations and formulate appropriate maneuver instructions to resolve conflicts. The controller should also advise of weather hazards or vector the aircraft around such hazards.

Current Equipment/Methods

Human controller, radar display, VHF, UHF, flight progress strips.

PARAMETER ESTIMATES

Coverage: 15,000 - 100,000 ft. altitude, CONUS, ocean routes

Saturation: ~ 4000 aircraft/en-route center

Risk Level: (explicit) $< 10^{-7}$

(implicit, separation standards)

	domestic	oceanic
lateral	2-3 nm.	15 nm.
longitudinal ...	5 nm	3 minutes
altitude	1000-2000 ft.	1000-2000 ft.

Response: (imminent collision avoidance)*

3-5 seconds (calculation and formulation)

(potential conflict or congestion avoidance)

20-30 seconds

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*Situations which arise from blunders or from VFR aircraft appearing unexpectedly.

PHASE En-route FUNCTION Tactical Control

SUB-FUNCTIONS: Monitor Restricted Areas for Intruders

FUNCTION ABSTRACT

The responsible controller must monitor restricted and danger areas for intruders (military bases, experimental ranges, etc.); and must issue warnings and maneuver instructions to the intruders. To be able to do this the controller must have primary surveillance capability for VFR aircraft, and also must have a knowledge of the restricted areas and altitudes.

Current Equipment/Methods

Radar, VHF, UHF, human controller.

PHASE En-route FUNCTION Tactical Control

SUB-FUNCTIONS: Apply Special Rules

FUNCTION ABSTRACT

To assure the safety of special VIP flights, emergency craft, military aircraft and training flights, the controller should be able to amend the rules and regulations and issue special flight instructions when necessary. In order to carry out this function, the controller must be aware of the special flight mission, and must also have previous agreements with those responsible for the flight (this does not apply for emergencies).

Current Equipment/Methods

Human controller, radar display, VHF, UHF, recorders, ATCRBS.

PHASE En-route FUNCTION Strategic Control

SUB-FUNCTIONS: Accept Aircraft and Direct to Cruise Altitude.

Monitor Aircraft at Cruise Altitude and Issue Station Keeping Commands

FUNCTION ABSTRACT

The en-route controller must accept control of the aircraft from the departure controller at a scheduled time, place and altitude. The controller must then issue clearances or maneuver instructions in order to direct the aircraft to cruise altitude.

When the aircraft is at cruise altitude the controller monitors the aircraft, determines if it is deviating from desired speed, altitude or heading, and if so issues appropriate maneuver instructions (station keeping commands). If the pilot requests clearance to deviate from flight plan, the controller will assess the potential for conflict and will issue or withold clearance as appropriate. Control of the aircraft is passed from sector to sector and on to other control regions.

Current Equipment/Methods

Radar display, VHF, UHF, flight strips, human controller.

PHASE <u>En-route</u> FUNCTION <u>Strategic Control</u>

<u>SUB-FUNCTIONS</u>: Issue Descent Instructions and Hand-off to Approach Control

FUNCTION ABSTRACT

The en-route controller must issue clearances or descent instructions (routes, altitudes, fixes) to the A/C, and must transfer control (and flight data) to the approach controller at a particular position, altitude and time.

<u>Current Equipment/Methods</u>

Human controller, radar display, VHF, UHF, teletype, telephone, flight progress strips.

PHASE En-route FUNCTION Strategic Control

SUB-FUNCTIONS: Implement Flow Control Instructions

FUNCTION ABSTRACT

The en-route controller, upon receiving flow restrictions from a terminal or an adjacent ARTCC, must direct aircraft into holding patterns, releasing them at a specific rate. If the restrictions last for an appreciable length of time, to the point where the number of aircraft being held by the center approaches some criterion, the center will impose its own flow restrictions on the adjacent control regions.

Current Equipment/Methods

Human controller, radar display, VHF, UHF, teletype, telephone, flight progress strips.

PHASE <u>En-route</u> FUNCTION <u>Strategic Control</u>

<u>SUB-FUNCTIONS</u>: Receive, Process, Distribute Flight Progress Information (from pilot)

Relay or Initiate Advisories (to pilot)
Receive PIREPS

FUNCTION ABSTRACT

The en-route controller must receive flight progress information from the aircraft, prepare and post up-dated strips. If necessary he must distribute the information to the tower or to other en-route centers.

The controller will also receive and relay recent NOTAMS and weather data, or will initiate advisories based on current local conditions. The controller will also receive pilot reports.

<u>Current Equipment/Methods</u>

Human controller, VHF, UHF, flight progress strips.

PHASE <u>En-route</u> FUNCTION <u>A/G Communication</u>

SUB-FUNCTIONS: Frequency changes
Flight Progress Information
Airspace Clearances
Maneuver Instructions
Advisories and Pilot Reports

FUNCTION ABSTRACT

A means must be provided for the controller to transmit to the aircraft: the radio frequency and code of the control region (or sector) to which the aircraft will be transferred, airspace clearances (route, altitude, speed, fix); maneuver instructions (altitude, heading, speed, fix or holding pattern) for conflict avoidance or for holding, and advisories (weather, NOTAMS).

Also the pilot/aircraft must be able to transmit to the controller: flight progress information (position, altitude, velocity, ETA), acknowledgment of clearances and maneuver instructions, clearance requests, pilot reports, and emergency information.

<u>Current Equipment/Methods</u>

VHF, UHF, recorders.

PARAMETER ESTIMATES

<u>Digital Data Link</u>

(Down): Identification, altitude, position, velocity, ETA ("flight progress information")

Message length ~ 72 bits

Maximum Data Rate ~ 6×10^4 bits/second*

(Up): Route, heading, altitude, speed, fix (clearances, maneuver instructions)

Message length ~ 65 bits

Maximum Data Rate ~ 5×10^4 bits/second

<u>Voice Link</u>

Frequencies, advisories and pilot reports, emergencies

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*for surveillance purposes

PHASE En-Route FUNCTION G/G Communication

SUB-FUNCTIONS: Hand-off, Sector/Sector
Hand-off, ARTCC/ARTCC
Hand-off, ARTCC/Terminal

FUNCTION ABSTRACT

There must be a means for transferring the necessary information for control (flight plan information, position reports) between sectors within a center, between centers, and between center and terminal. There must also be a means for the return transmission of acknowledgement and acceptance.

Current Equipment/Methods

Telephone, teletype, land lines, video display, recorders.

PHASE En-Route FUNCTION G/G Communication

SUB-FUNCTIONS: Flight Plan and Progress
(to ground facilities)

FUNCTION ABSTRACT

A channel must be provided for the en-route controller to transmit flight plan changes to downstream control regions, or to the CFCF if important.

Current Equipment/Methods

Telephone, teletype, land lines.

PHASE -   FUNCTION Strategic Control

SUB-FUNCTIONS: Formulate and Issue Flow Control Directives (CFCF or ARTCC)

FUNCTION ABSTRACT

For flow control as currently practiced an ARTCC, based on traffic levels, current flight plans and sector workload criteria, will formulate and issue flow restrictions to preceding control regions (or terminals).

A possible advanced flow control system would consist of a CFCF, receiving forecasted terminal acceptance rates, NOTAMS, weather, current and proposed flight plans; and then formulating and issuing departure restrictions to terminals.

Current Equipment/Methods

(No advanced flow control)
VHF, UHF, teletype, flight progress strips.

PHASE ___-___ FUNCTION Strategic Control

SUB-FUNCTIONS: Receive and Process Flight Progress Information (between ground facilities)

FUNCTION ABSTRACT

Based on flight plans and flight plan changes from preceding control regions, each appropriate facility (tower, TRACON, ARTCC) must generate and post or distribute flight progress information.

Current Equipment/Methods

Teletype, land lines, flight strip printer.

PHASE -   FUNCTION Strategic Control

SUB-FUNCTIONS: Receive, Distribute NOTAMS and Weather Data (to/from ground facilities)

FUNCTION ABSTRACT

Each ground facility must either receive and post information coming over the NOTAM/weather circuit, or must initiate and distribute information of this type to other ground facilities (towers, TRACONS, F.S.S., ARTCC, CFCF).

Current Equipment/Methods

Teletype, land lines, telephone.

PHASE -   FUNCTION Strategic Control

SUB-FUNCTIONS: Forecast Expected Acceptance Rates (terminals)

FUNCTION ABSTRACT

For advanced flow control, the terminals periodically estimate their acceptance rate capability for several hours to one day in advance; and, communicate these forecasts to the CFCF. Their estimates are based on flight plans, NOTAMS and weather information, local conditions and controller workload criteria.

Current Equipment/Methods

(No advanced flow control)
Teletypes, land lines, telephone, printers, computers.

PHASE -   FUNCTION G/G Communication

SUB-FUNCTIONS: NOTAMS and Weather Information

FUNCTION ABSTRACT

A common communications circuit is required for all ATS ground facilities (terminals, centers, F.S.S., CFCF) to enable the distribution of NOTAMS and weather information at any time.

Current Equipment/Methods

Teletype, land lines.

PHASE -   FUNCTION G/G Communication

SUB-FUNCTIONS: Estimated Acceptance Rate Forecasts (Tower to ARTCC or CFCF)
Flow Control Directives

FUNCTION ABSTRACT

There must be a means for the terminals to transmit their estimated acceptance rate forecasts to an advanced flow control facility or to an ARTCC.

It is also necessary that the CFCF be able to transmit flow control directives (imposed departure rates) to any terminal; or that the affected ARTCC or terminal be able to transmit directives to preceding control regions.

Current Equipment/Methods

(no CFCF), telephone, teletype, land lines.

PHASE -

FUNCTION G/G Communication

SUB-FUNCTIONS: Flight Plan and Progress (from ground facilities)

FUNCTION ABSTRACT

Each control facility must be able to receive important flight plan changes and flight progress information from other control facilities at any time.

Current Equipment/Methods

Telephone, teletype, land lines.

PHASE -   FUNCTION G/G Communication

SUB-FUNCTIONS: NAVAIDS Monitor Data

FUNCTION ABSTRACT

Channels must be provided from NAVAIDS monitoring equipment to the appropriate control facility displays and to flight service stations. NAVAIDS would include ILS, VORTAC, and VOR/DME.

Current Equipment/Methods

Cables, display panels.