AN OVERVIEW OF

# Airport Surface Traffic Control

PRESENT AND FUTURE

**U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION
SYSTEMS RESEARCH AND DEVELOPMENT SERVICE
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COVER PHOTOGRAPH: Tower cab and controllers at Boston-Logan Airport

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16. Abstract

The Airport Surface Traffic Control System, an integral part of the nation's Air Traffic Control System, is specifically concerned with the safe and efficient control of airport airside surface traffic. The current status of airport surface traffic control in the United States is summarized, and the most important of the planned system improvements are presented.

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# AN OVERVIEW OF Airport Surface Traffic Control PRESENT AND FUTURE

## CONTENTS



*This document has been prepared for use by the FAA Air Traffic, Airway Facilities and Airports Services, local airport authorities and agencies, and others interested in the present Airport Surface Traffic Control (ASTC) System and its planned improvements.*

Aircraft About to Depart From Boston—Logan Airport

# FOREWORD

In recognition of the importance of air transportation, the Federal Aviation Act charges the Federal Aviation Administration (FAA) of the Department of Transportation (DOT) with ensuring the safe and efficient use of the nation's airspace, by military as well as civil aviation, and with fostering civil aeronautics and air commerce.[1]

The nation's Air Traffic Control (ATC) System has been under continuous development, motivated by three general goals: to increase and improve performance, to improve safety, and reduce costs.[2,3] The system had its beginnings in the 1930's as an air navigation network and has evolved through several major phases to the present "third generation" system, which consists of an extensive network of navigation, surveillance, communication, and control facilities.

The FAA's major engineering and development activity is currently aimed at upgrading the present (third generation) ATC System. This activity does not represent a commitment to implementation; rather it is a commitment only to those engineering and development activities necessary to investigate and evaluate such a future system. The Airport Surface Traffic Control (ASTC) System — the subject of this document — is one of the key features of the FAA's "Upgraded Third Generation System" program.

The first goal — to increase and improve performance — is concerned with such matters as higher capacities, fewer and shorter delays, and improved services. The major system capacity and delay problems are in the terminal areas, where all flight paths converge, and on the surface of the airport itself, where the numbers of available runways, taxiways, and passenger terminal gates are limiting factors.

These problems are expected to become more critical in the future. Recent aviation forecasts[4] show that, in spite of the present situation of fuel shortages, rising costs, and a depressed economy, air traffic activity is expected to increase significantly over the long term. For example, *the total annual instrument operations count at all U.S. airports with FAA traffic control service is expected to double between the year 1974 and sometime between 1983 and 1987.*[3] Unfortunately, this increase in demand will occur in the face of *little or no increase in the numbers of airports and runways.* Thus, it will be necessary to make even more efficient use of the already limited terminal area system resources. At major airports, *the operations rates during poor-weather conditions will also increase significantly in the future,* along with the installation of improved landing systems. Based upon an analysis of the traffic situation and trends at major airports, it is clear that *as airport capacity is increased to serve the growing demand, ASTC System capacity must be similarly increased.*

The second and *most important general goal is to improve safety.* An analysis of accidents that occurred for the world-wide jet fleet between years 1959 and 1973 revealed that approximately 60% of these accidents occurred at or near airports — i.e., in the final approach, landing, taxi, or take-off phases, which combined represented only about 6% of the flight time.[5] These data underscore the fact that *to improve significantly the overall level of safety, it will be necessary to reduce the likelihood of hazards during flight operations at or near airports.* Based on analyses of actual airport operations and hazardous incidents, it is clear that *to achieve adequate safety under poor-visibility conditions, even at today's traffic levels, improved surveillance capability for the tower controllers must be provided at the busier airports. This need will become even more critical in the future, due to both the growth in demand and the increase in poor-visibility operations that will accompany the installation of additional Category II/III landing systems.*

The third goal is to reduce costs. To prevent escalation of ATC System manpower and operating costs, as the number of controlled aircraft and the quality of control and safeguards increase, *controller productivity must be improved.* This in turn will be possible only with improved navigation, surveillance, communication and control facilities in the ATC System. Also, reduction of flight delays is needed to achieve savings in passengers' time, as well as reduced energy usage, air and noise pollution, and aircraft operating costs.

This document focuses upon the ASTC System, an integral part of the overall ATC System, which is specifically concerned with the safe and efficient control of airside surface traffic. The current status of airport surface traffic control in the United States is summarized, and the highlights of the planned system improvements are presented.

Since the ASTC problems at major airports are complex and the planned solutions involve advanced techniques, a voluminous treatment would be required to cover the subject in detail. However, it is recognized that the salient facts related to ASTC problems and solutions should be understood by many people in the aviation community who cannot afford the time to study the detailed reports that are available. This document therefore describes in general terms the essential aspects of ASTC to provide the reader with *"An Overview of Airport Surface Traffic Control."*

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# INTRODUCTION

At tower-equipped airports, the controllers in the tower cab are responsible for those aspects of Airport Surface Traffic Control (ASTC) requiring centralized management: issuing clearances to aircraft to land, taxi, or take off; establishing routing patterns for arriving and departing aircraft on the runway/taxiway network so as to minimize delays; sequencing aircraft movements on runways and taxiways and at critical intersections to ensure safety; and controlling the movements of service or emergency vehicles on the airport surface. The tower controllers' surveillance function – determining the position and identity of vehicles of interest – is normally accomplished by visual observation supplemented by position reports obtained by voice radio communication with the pilots. Eleven airports also have Airport Surface Detection Equipment (the ASDE-2) which provides a primary-radar type display of the airport surface traffic situation. Control instructions are sent from the controllers to the pilots via voice radio communication. Each pilot is responsible for the guidance of his own aircraft, within the overall framework set up by the controllers. Lights, signs and markings are installed on runways and taxiways and at intersections to aid the pilot in traversing the runway/taxiway network. The pilot calls the appropriate tower controller via voice radio when he requires a clearance or guidance support.

Because of the expertise of the controllers and pilots, the ASTC System has worked well the vast majority of the time. However, unfortunate incidents such as those at Chicago-O'Hare (20 December 1972) and Boston-Logan (31 July 1973) have revealed *deficiencies in the present ASTC System's surveillance capability under conditions of poor visibility.* To overcome these deficiencies, certain *ASDE-2 improvements* have already been installed and others will be implemented over the next several years. Since the ASDE-2 is no longer produced, *an improved ASDE (the ASDE-3) will be procured* for deployment (1) at airports that need an ASDE but do not presently have an ASDE-2, and (2) as an eventual replacement for the aging ASDE-2s now installed.

A program is also underway to identify and acquire *improved visual guidance aids* for use by the pilots.

While these improvements will satisfy the ASTC System requirements of the 1970's, even greater improvements will be needed to meet the more stringent requirements of the 1980's that will result from:

- Increasing flight operations and/or a larger percentage of wide-body jets.
- Increased airport surface traffic flow rates under poor-visibility conditions, which will be an outgrowth of the forthcoming installation of additional Category II and III landing systems at many airports.
- Increased peak-hour aircraft landing rates at major airports due to the forthcoming installation of wake-vortex detection and avoidance systems and automated metering and spacing techniques.[3]

Therefore, development work is underway on two systems that will help satisfy the ASTC System performance and safety requirements of the 1980's:

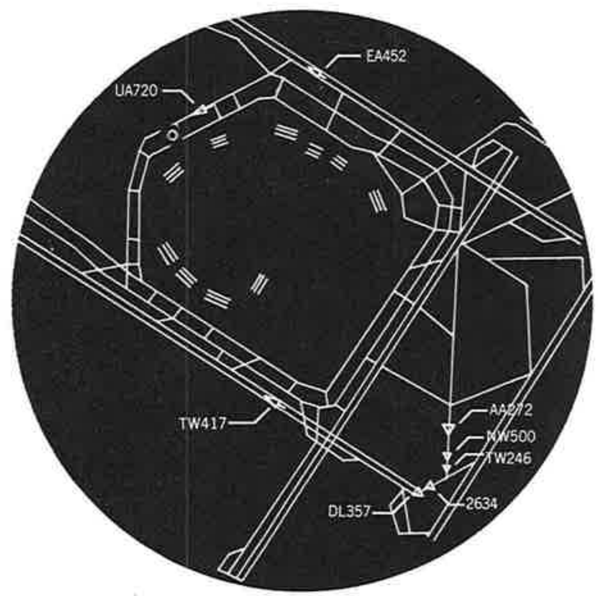
- *The Tower Automated Ground Surveillance (TAGS) System,* which will for the first time provide for the tower controllers (1) an *integrated display* of aircraft of interest in the landing, taxiing, and takeoff phases of flight, and (2) *identity tags* for aircraft, when desired.
- *Automatic Intersection Control,* for use at critical intersections at major airports to aid in limiting controller and pilot workload to acceptable levels.

Figures 1A through 1D show the views obtained of the *same airport surface traffic and movement areas* using the indicated alternative surveillance methods, which are described in detail later in this document.

A. Visual surveillance through tower cab windows during poor-visibility conditions (airport surface traffic and movement areas not visible)

B. ASDE BRITE display presentation

C. Future ASDE-BRITE display presentation with background suppression and boundary enhancement features




D. Future TAGS display presentation with vehicle identity tags

Figure 1. Alternative ASTC Surveillance Methods

# WHAT IS AIRPORT SURFACE TRAFFIC CONTROL?

## DEFINITION

The Airport Surface Traffic Control (ASTC) System is defined as that system (people, procedures, and equipment) which is concerned with the movement of:

- Arriving aircraft through the phases of final approach, landing, and taxiing to the passenger terminal (or cargo or general aviation area, if applicable).*
- Departing aircraft through the phases of pushback from the passenger terminal*, taxiing to the departure runway, takeoff, and initial climb.
- Aircraft in transit between sites at the airport — e.g., from passenger terminal to cargo or maintenance area.
- Service or emergency vehicles — e.g., snow plows or fire engines — operating on the airport taxiways and/or runways.

## PURPOSE

The ASTC System manages the flow of vehicle movement within its jurisdiction so as to achieve the best balance for:

- Maximizing safety and quality of service.
- Minimizing aircraft delays and fuel usage.
- Minimizing air pollution and noise.
- Minimizing costs incurred by airport operators, users, and participating local, state, and federal Government agencies.

Figure 2 shows a top view of the runway/taxiway network of a typical airport, and the associated aircraft movements that are under the jurisdiction of the ASTC System.

### DEPARTING FLIGHT

(1) At Airline Terminal Departure Gate, Awaiting Departure Clearance

(2) Exiting Ramp Area To Enter Taxiway Network

(3),(4) At Taxiway Intersection; Sequencing Required To Avoid Conflict

(5) Taxiing To Departure Runway

(6) In Queue Leading To Departure Runway

(7) Awaiting Clearance To Position and Hold On Runway For Takeoff

(8) Positioned On Runway, Awaiting Clearance To Roll For Takeoff

(9) In Climbout Phase

### ARRIVING FLIGHT

(10) In Final Approach and Landing Phase

(11) Has Landed And Exited Runway, And Is Taxiing To General Aviation Area

(12) Arrival At General Aviation Area

*The ASTC System participates in an advisory basis only concerning control of aircraft in the ramp areas.

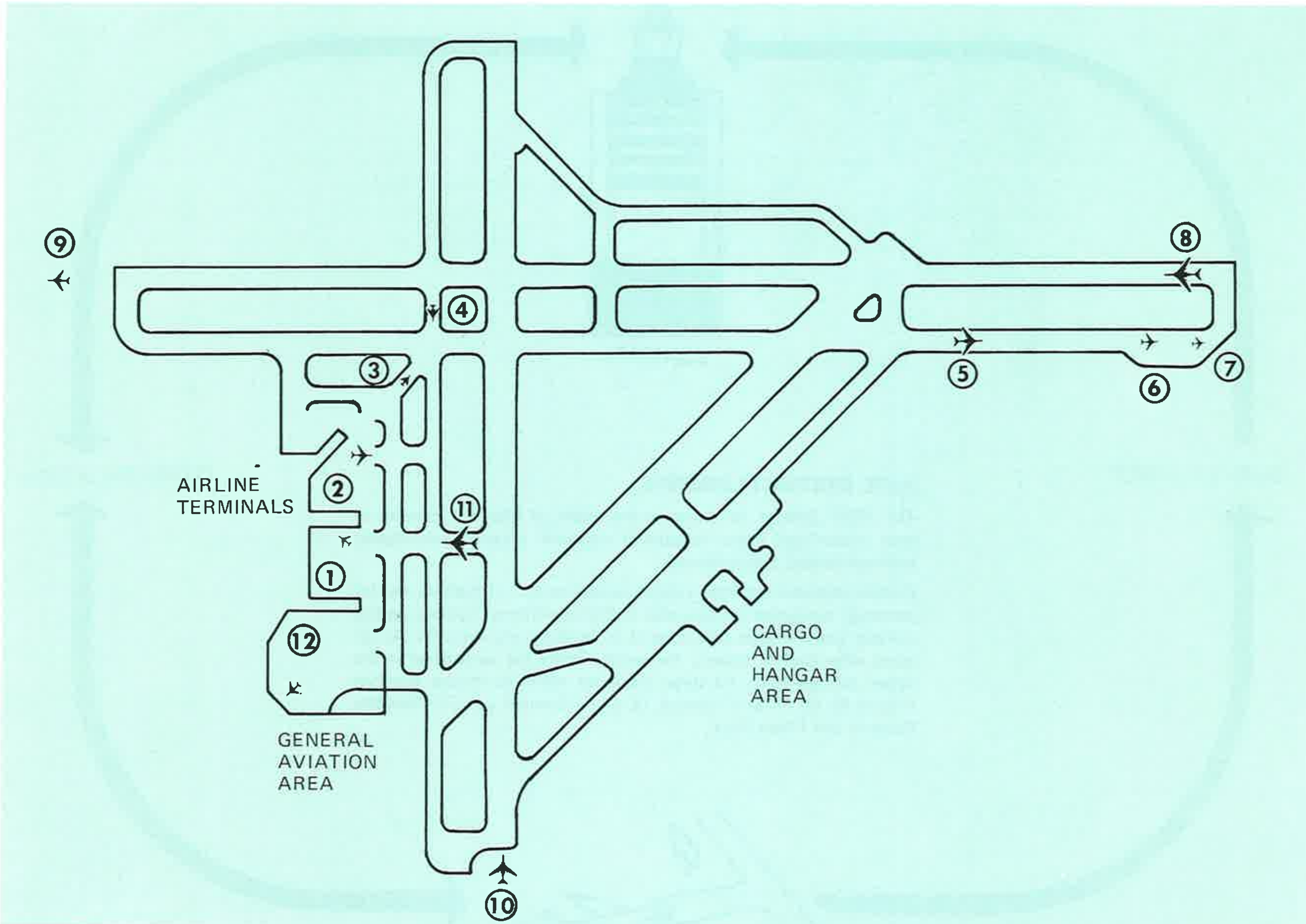



Figure 2. Typical aircraft movements under the jurisdiction of the ASTC System

## ASTC SYSTEM ELEMENTS

The ASTC System, as shown in the model of Figure 3, consists of four interrelated major functional elements: control, surveillance, communication, and guidance.

*Control* element activities include determination of taxiway routing patterns, resolution of potential traffic conflicts at taxiway and/or runway intersections, and control of landings and takeoffs. At airports with control towers, the control tasks are performed in the tower cab, generally by three major air traffic controller activities (Figure 4): (1) Ground Control, (2) Local Control, and (3) Clearance Delivery and Flight Data.

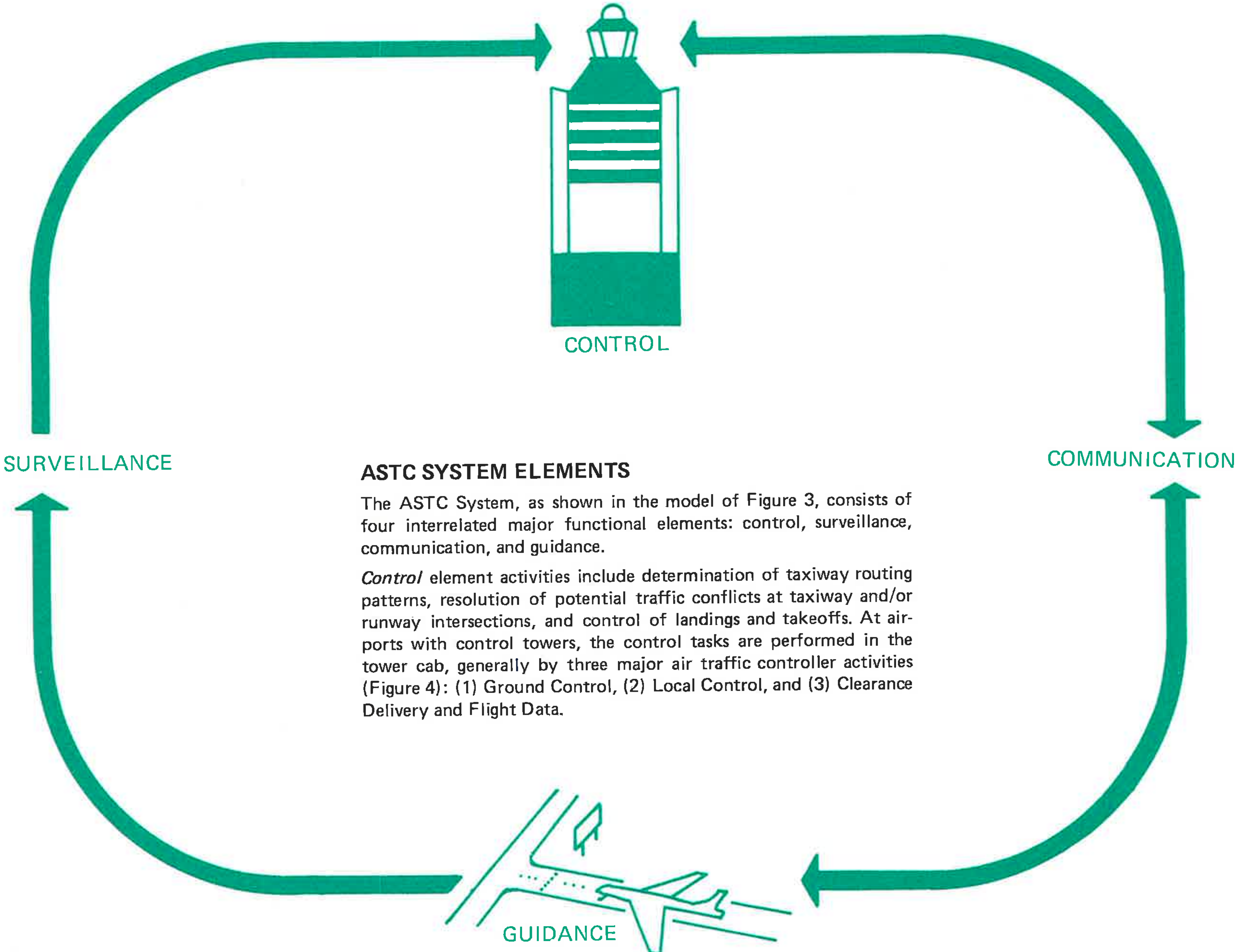



Figure 3. Functional elements of ASTC System

Ground and Local Control each may have several positions (i.e., voice communication links to aircraft and other surface vehicles), with each position manned by a primary controller (and an assistant controller if required). Generally, Local Control is responsible for traffic using runways, Ground Control for traffic using taxiways and occasionally the ramps (on an advisory basis only), and Clearance Delivery provides (or confirms) the clearance instructions for departing aircraft and thus provides an interface with the Air Traffic Control en route flight-scheduling and control system. At certain airports a separate Flight Data position is staffed to assist Clearance Delivery in such tasks as retrieving and posting flight strips (for departing flights) received from the Air Route Traffic Control Center (ARTCC) via the Flight Data Entry Printer.

*Surveillance* is the process whereby Ground and Local Control acquire information on the position and identity of vehicles under their jurisdiction. The Ground Controller uses visual observation, through the windows of the tower cab, as his primary means of surveillance. The Local Controller uses visual observation and the Airport Surveillance Radar (ASR) as his primary surveillance media. The ASR, which provides a radar-derived display of the positions and associated identities of airborne aircraft in the vicinity of the airport, is used to monitor aircraft on final approach or initial climb. Also, Airport Surface Detection Equipment (ASDE-2), a high resolution, ground-mapping radar is available at 11 airports. The ASDE-2 provides a display of airport surface traffic activity for use by the Ground and Local Controllers during conditions of reduced visibility due to weather or darkness. (A typical ASDE-2 display presentation is shown in Figure 1B).

*Guidance* of an individual aircraft is exercised by its pilot who carries out the tasks of aircraft velocity, headway and turning control, wingtip collision avoidance, and route centerline following. Runway and taxiway lights, signs and markings are installed to aid the pilot.

The *communication* element provides the means for two-way controller-to-pilot messages in support of the surveillance, control, and guidance functions.

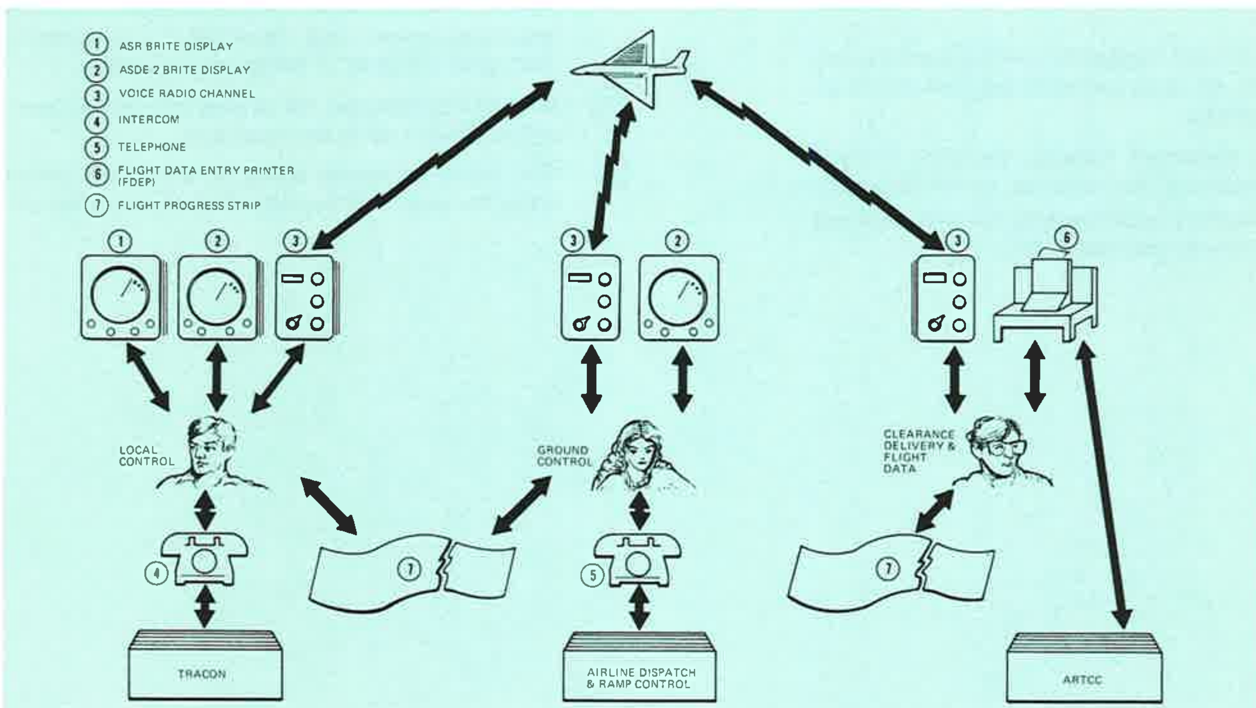



Figure 4. Major controller categories and supporting facilities

## SEQUENCE OF OPERATION

Figure 5 illustrates the way in which the ASTC System typically operates and interfaces with the rest of the Air Traffic Control System. The numbered steps described below correspond to the numbered sequential actions indicated in Figure 5.

(1) A flight to be made using Instrument Flight Rules (IFR) begins with the filing of an IFR flight plan with the Air Route Traffic Control Center (ARTCC).

(2) Just prior to departure, the pilot calls Clearance Delivery in the tower cab to obtain confirmation of his flight plan.

(3) After clearance is received, the airline dispatcher and the pilot clear the aircraft for pushback from the departure gate. The pilot contacts Ground Control to notify him of pushback and receive pushback clearance. However, this clearance is advisory only. Control in the ramp area remains the responsibility of the airline, or in some cases, the airport acting for the airline. The pilot then proceeds through the ramp area and stops short of the taxiway network.

(4) The pilot contacts Ground Control for taxi instructions and, when cleared to do so, taxis as instructed toward the assigned departure runway.

(5) Upon nearing the departure runway, the pilot contacts Local Control concerning his sequence in the departure queue. When so cleared by Local Control, the pilot positions the aircraft on the runway and takes off.

(6) When it is clear of the runway, the aircraft is handed off from the ASTC system to the next Air Traffic Control jurisdictional area — the Terminal Radar Control (TRACON) facility.

(7) Departure Control vectors the aircraft out of the airport terminal area.

(8), (9) When the aircraft clears the terminal area, en route control is performed by an ARTCC until the aircraft enters the terminal area of the destination airport, at which time Approach Control in the TRACON becomes responsible.

(10) Approach Control vectors the aircraft through the terminal area until the aircraft flight path is aligned with the landing runway (i.e., until final approach).

(11) When over the outer marker, the aircraft is handed over from the TRACON to the ASTC System. The pilot contacts Local Control for landing instructions, and lands when cleared to do so. Local Control manages the runways (e.g., sequences arrivals and departures) and controls the aircraft until it is clear of the last active runway.

(12) Ground Control clears the aircraft into the taxiway network and controls it up to the ramp area.

(13) The airline (or airport acting for the airline) takes responsibility for control of the aircraft until it has docked.

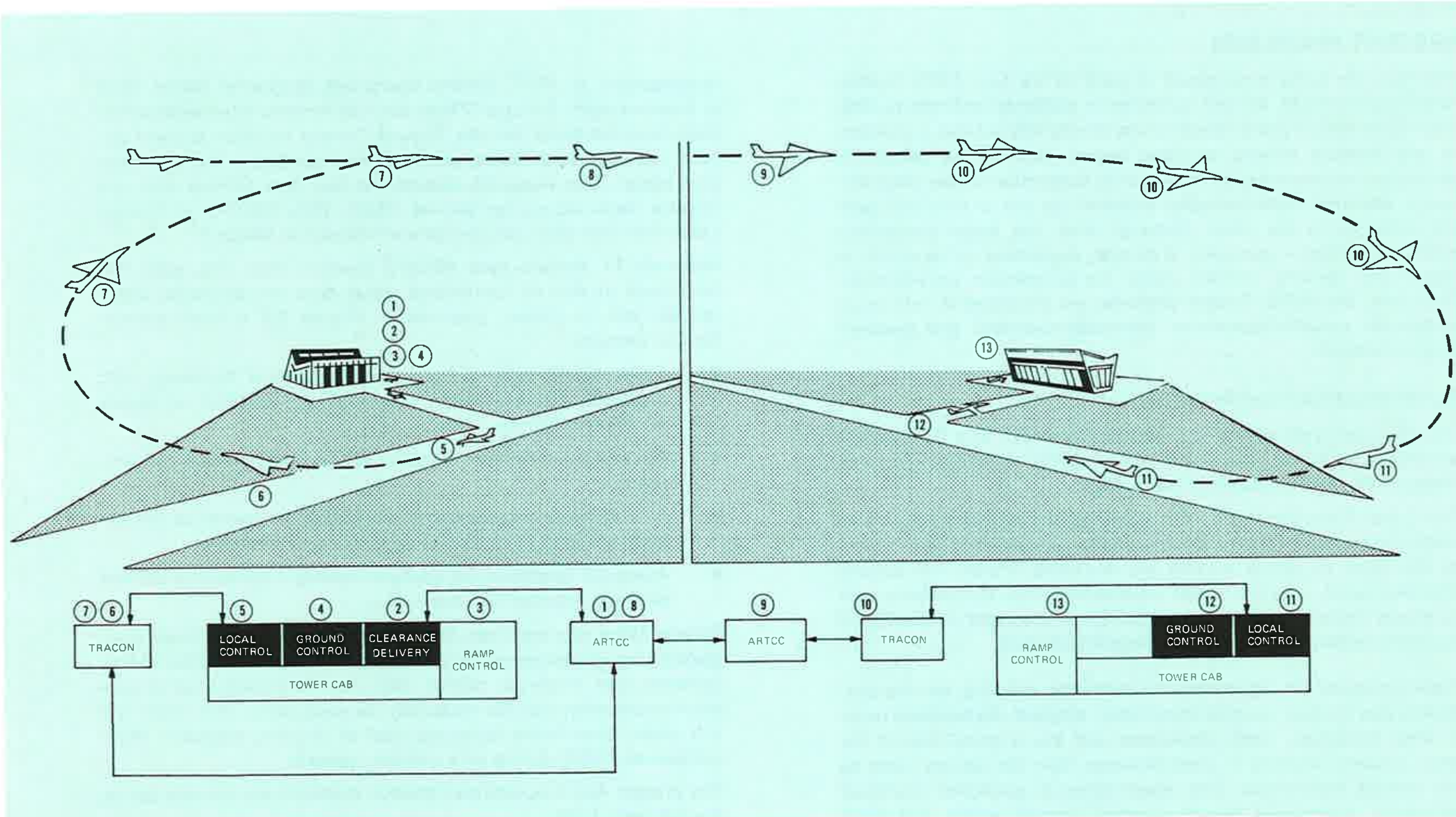



Figure 5. Some sequential flight activities, and relationship of Airport Surface Traffic Control to overall Air Traffic Control System

# WHAT ARE THE MAJOR ASTC SYSTEM PROBLEMS?

## PRESENT PROBLEMS

Problems are being experienced in each of the four ASTC System functional elements: control, surveillance, guidance, and communication. Since these system elements are closely interrelated, a problem in any element affects, to some degree, each of the others. In particular, communication is primarily supportive to the other elements, and most communication problems are due to (and indicative of) problems in the other elements. Also, the tower controller's primary function — control — is strongly dependent on his ability to locate and identify vehicles under his jurisdiction (surveillance). Therefore, the ASTC System problems are presented in two major categories: surveillance/control (controller-oriented) and guidance (pilot-oriented).

### Surveillance/Control Problems

The principal problems for the Ground Controller at a busy airport are related to surveillance and a limited ability to maintain a mental image of the dynamic taxiway traffic flow.

The Local Controller's job of maximizing the *safe* level of runway usage is complicated by the existence of uncertainties in such factors as the times at which arriving and departing aircraft will occupy interdependent runways. These uncertainties lead to problems such as missed departure-release opportunities or *increased possibility of interference between arriving and departing aircraft.*

These problems are aggravated by restricted visibility for the controllers due to poor weather conditions, physical obstructions (such as large buildings), night operations, and the physical size of the larger airports resulting in great distances from the control tower to the airfield extremities. The result often is controller workload saturation, constrained airport capacity, aircraft delays, and worst of all — *unsafe operating conditions.* In the 20 December 1972 accident at Chicago-O'Hare Airport in which a taxiing aircraft and a departing aircraft collided at a runway/taxiway intersection, inadequate surveillance was cited as a major contributor.[12] In the 31 July 1973 accident at Boston-Logan Airport, an arriving aircraft crashed during limited visibility conditions on the airport surface, and for several minutes the tower crew did not know that the accident had occurred and that the wrecked aircraft was at the end of the runway.

Investigations of ASTC System operations conducted during 1972 at Boston-Logan, Chicago-O'Hare and Los Angeles International Airports have indicated that the Ground Control function at these airports was saturated during poor-visibility conditions for the tower controllers. This occurred despite the fact that O'Hare and Los Angeles both had an operational ASDE. (The ASDE-2 at Boston-Logan has since been refurbished and restored to service.)

Although 11 airports have ASDE-2 Systems now, this radar has limitations in that its transmitted signal does not penetrate heavy rainfall, and its display presentation (Figure 1B) is often unsatisfactory, because:

- Radar signal returns from airport terminal buildings, etc. create background clutter that makes it difficult to detect vehicles of interest.
- Aircraft identification symbols (flight numbers) are not provided.
- It is difficult and sometimes impossible to determine the aircraft size class (e.g., medium-size vs. heavy aircraft).
- Adequate brightness for daylight viewing is difficult to achieve with the required high resolution.

Despite these shortcomings, the ASDE-2 does give the tower controllers a better picture of the surface traffic under conditions of fog, darkness, and moderate rainfall than can be obtained using only pilot-to-controller position-reporting via voice radio. This radio link is a major surveillance technique used at airports, especially those without an ASDE, during poor-visibility periods.

The present ASTC surveillance/control problems are summarized in the following table.

PRESENT SURVEILLANCE/CONTROL PROBLEMS

| SURVEILLANCE PROBLEMS | CONTROL PROBLEMS |
|---|---|
| Restricted visibility from tower cab<br>Poor weather<br>Night operations<br>Physical obstructions<br>Distant runways and taxiways<br>Limited surveillance aids<br>ASDE-2 radar limitations<br>Can't "see through" heavy rainfall<br>Reliability low in terms of modern standards<br>Obsolete equipment, difficult to maintain<br>Antenna too heavy for new tower design<br>ASDE-2 display limitations<br>Difficult to distinguish vehicles from background clutter<br>No identity tags for aircraft<br>Difficult to determine aircraft size-class<br>Poor definition of runway/taxiway edges<br>Difficult to achieve adequate display brightness with high resolution<br>Local Controller must divide his attention between two displays: ASDE-2 and ASR BRITE<br>No display of aircraft approximately 0-2 miles before touchdown and after takeoff, at most airports. | Excessive Ground Controller workload under heavy-traffic and poor-visibility conditions<br>Difficult to maintain mental picture of surface traffic<br>Excessive voice radio communication with pilots<br>Misinterpretation of messages<br>Traffic delays and/or *reduced safety*<br>Limited ability of Local Controller to maximize the safe acceptance rate of interdependent runways serving both arriving and departing aircraft<br>Uncertainties regarding runway occupancy times of arrivals and departures<br>Missed departure-release opportunities<br>Traffic delays and/or *reduced safety* |

### Guidance Problems

Pilots can have a difficult time following routing instructions through complex taxiway networks, especially if they are unfamiliar with the airport or if visibility is poor. Many airports with extensive runway/ taxiway networks use visual aids, e.g., guidance signs or lights. However, certain problems can still arise – the visual aids may, for one reason or another, be incomplete, confusing, or out of service (e.g., due to burned-out lights, a power failure, or heavy snow conditions). The Ground Controller must then take an abnormally active role in the guidance function normally performed primarily by the pilot. This results in increased voice-radio communication between pilots and controllers and increased pilot and controller workload, leading to possible system saturation and *unsafe operating conditions.*

The present ASTC guidance problems are summarized in the following table:

PRESENT GUIDANCE PROBLEMS

| |
|---|
| Complex runway/taxiway networks |
| Need for improved, standardized taxiway lights, signs and markings |
| Excessive pilot/crew workload under heavy-traffic and poor-visibility conditions |
| *Hazardous deviations from assigned routes* |
| Excessive voice radio communication with controllers |
| Misinterpretation of messages |

## FUTURE PROBLEMS

At several major airports the ASTC System has already become a limiting factor for airport safety and capacity during poor-visibility conditions. Therefore, ASTC improvements are critically needed to relieve existing problems. In the future, several factors will create an even greater need for ASTC improvements; these factors include:

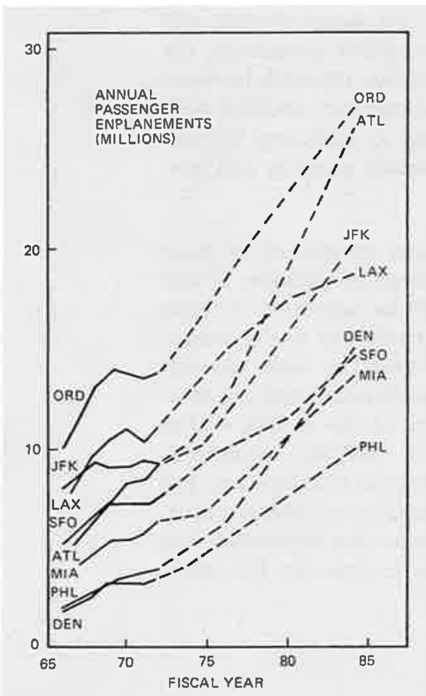
- Increasing passenger counts and cargo tonnage to be transported by air.
- Increasing operations rates under low-visibility conditions.

### Increasing Passenger Counts and Cargo Tonnage

A recent FAA-sponsored study[7] of airport capacity at eight major airports shows that over the next ten years, passenger enplanements may increase by a factor of two or more (Figure 6A) and cargo tonnage by a factor of three or more (Figure 6B). However, if the trend toward use of larger aircraft continues, the aircraft operations rates at some large airports may increase only slightly, if at all, through 1985 (Figures 6C and 6D). While this study concentrated on eight major airports, its results are indicative of what is in store at most major and medium-size airports – in summary:

- Most major airports should experience (1) a greater percentage of larger aircraft and (2) more terminal-to-terminal surface traffic due to the increasing amount of cargo to be transferred from incoming passenger flights to cargo areas.
- Some major and most medium-size airports will experience an increased total annual operations rate.

Although traffic forecasts have a high degree of uncertainty, it is clear that air traffic at most airports will continue to increase. The only question is the *rate* of increase, and thus *when* certain levels will be reached.

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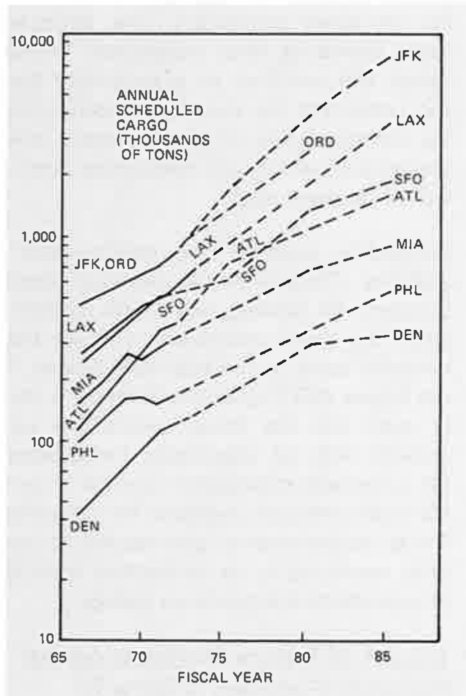


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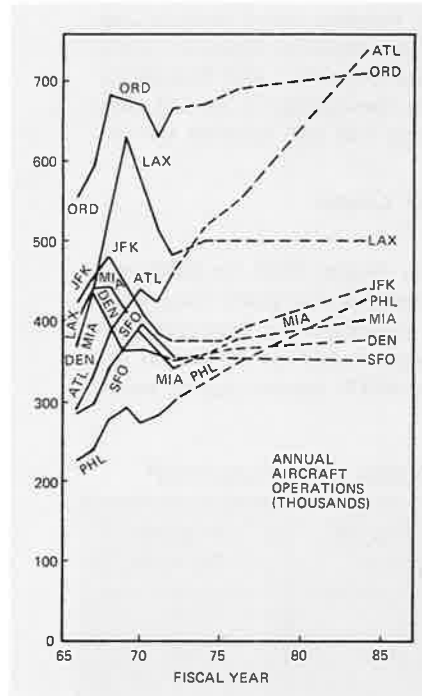


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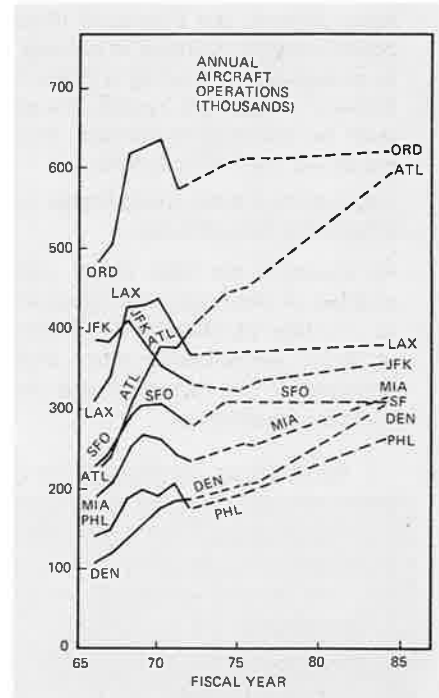


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Figure 6A. Passenger enplanements for eight selected airports

Figure 6B. Scheduled cargo for eight selected airports

Figure 6C. Total operations for eight selected airports

Figure 6D. Air carrier operations for eight selected airports.

The size and weight of the wide-body aircraft contribute to the ASTC problem due to such factors as increased ramp-area congestion, more frequent runway repairs required, and limited availability of runways and taxiways that can accommodate the larger aircraft.

Due to the large trailing wake vortices associated with the wide-body aircraft, the time (and distance) between some landings has been increased, resulting in reduced runway capacity. However, work is underway to develop a Wake Vortex Detection and Avoidance System.[3] After this system is available, the operations rates during peak periods should increase; this factor will also increase the demands on the ASTC System.

## Increasing Operations Rates Under Lower Visibility Conditions

As shown in the table below, over the decade 1975 to 1985, the number of improved landing systems installed at airports is expected to increase significantly.[8] Therefore, corresponding improvements in ASTC surveillance/control and guidance will be needed to accommodate the increased load on the ASTC System during poor-visibility conditions.

POTENTIAL INCREASE OF LANDING AID FACILITIES[8]

| Instrument Landing System | Commissioned 12/31/74 | Planned By 1985 |
|---|---|---|
| Category II ILS | 37 | 72 |
| Category III All-Weather Landing System | 2 | 12 |
| Microwave Landing System | 0 | 380* |

*Tentative estimates; no implementation decisions have been made as yet.

## Impact of Future Problems on the Control/ Surveillance Functions (Figure 7)

To accommodate the increasing passenger counts and cargo tonnage to be transported, terminals will continue to expand out into the ramp areas and up into the tower line-of-sight, causing blind spots for the tower controllers. This, along with the larger aircraft, will cause increasing ramp congestion. To minimize this congestion, the ramps will continue to expand into the taxiway network between the ramps and the runways. However, this expansion, coupled with the increasing mix of heavy aircraft, will lead to increasing taxiway congestion, which will necessitate more efficient planning and control of taxiway usage.

Congestion problems are compounded under conditions of poor visibility. Thus, with the increased deployment of Category II and Category III landing aids, more aircraft will be operating at times when the tower controllers can't see the aircraft and the taxiways/runways using only visual surveillance. Therefore, at major airports the future ASTC system will need (1) improved surveillance capability such that the tower controller's picture of the surface traffic activity will be essentially independent of visibility conditions, (2) automatic intersection control at certain busy intersections, and (3) more efficient methods for controller-to-pilot communications. These improvements are needed to constrain the controller and pilot workload to an acceptable level so as to maintain the safety of operations and minimize delays.

## Impact of Future Problems on the Guidance Function (Figure 7)

To enable the pilot to traverse the airport surface safely and expeditiously under the combined conditions of increasing taxiway congestion and lower visibility, improved visual guidance aids (lights, signs and markings) are needed and are being developed. Without these improvements, excessive pilot-to-controller voice communication would occur, resulting in excessive controller and pilot workload and *increased likelihood of unsafe operating conditions.*

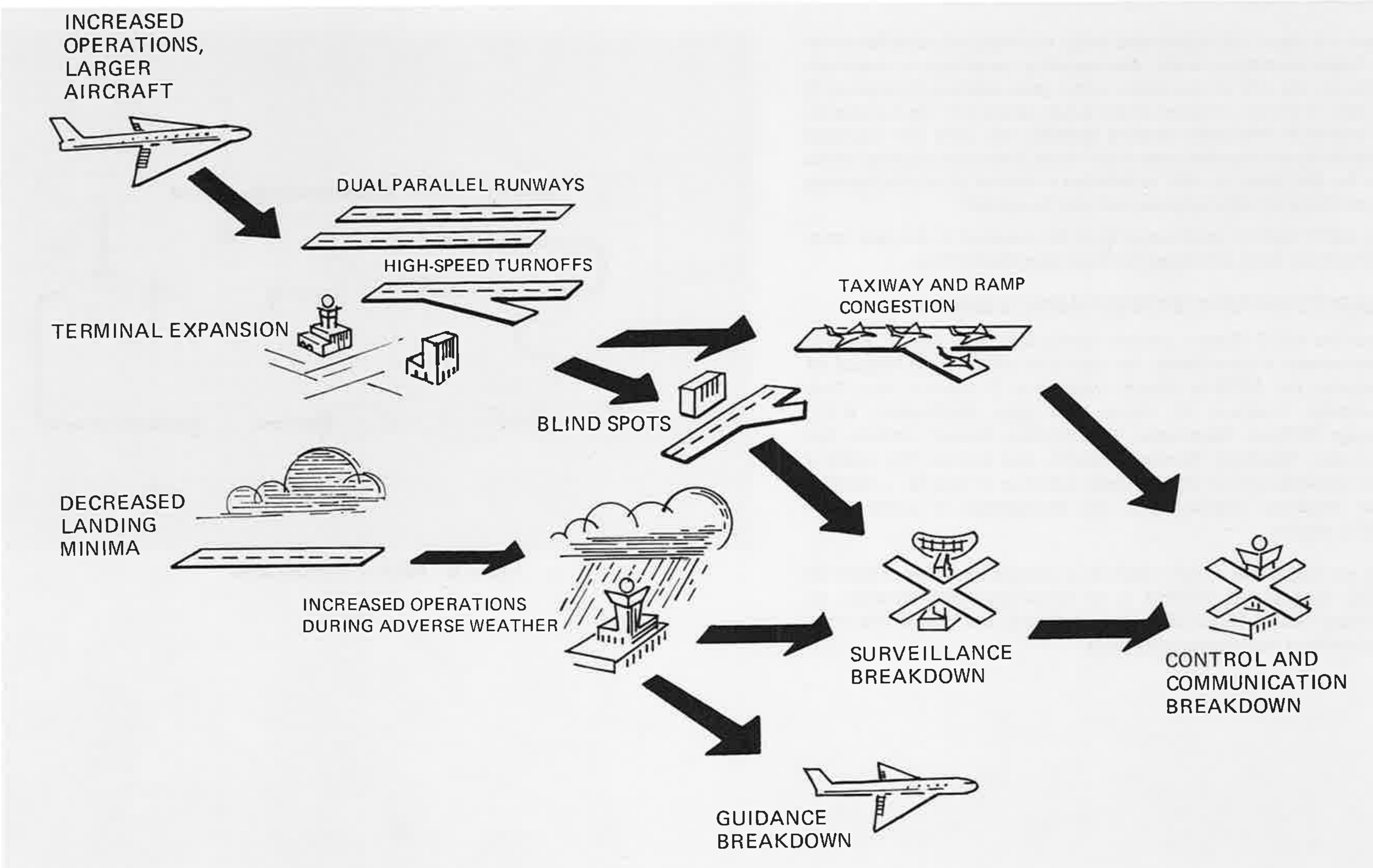



Figure 7. Impact of future problems on the ASTC System

# WHAT ARE THE SOLUTIONS TO THE ASTC SYSTEM PROBLEMS?

There is a clearly identified need *today* for improved surveillance for the tower controllers under poor-visibility conditions at major airports. As the rate of operations under poor-visibility (Categories II and III) conditions increases in the future, along with the installation of improved instrument landing systems, the need for improved surveillance will become even more acute. Improved visual guidance aids for the pilot, as well as automatic control of critical taxiway intersections at major airports, will also be needed.

The ASTC System improvements to be provided in the near term, intermediate term, and longer term are described below.

## NEAR-TERM ASTC SYSTEM IMPROVEMENTS

Since the ASTC System element having the most urgent need for improvement is *surveillance,* the near-term program has focused on improving the ASDE-2s already installed at 11 airports: New York (Kennedy), Andrews Air Force Base (near Washington, D.C.), Chicago (O'Hare), Washington, D.C. (Dulles), Newark, Atlanta, San Francisco, Cleveland, Portland, Seattle, and Boston. The ASDE-2 improvements consist of two major activities (Figure 8) – ASDE-2 radar reliability improvements, and development of a new ASDE BRITE display.

It is not feasible to install ASDE-2s at airports presently without an ASDE, because the ASDE-2 is no longer produced. However, an improved ASDE (ASDE-3) will be procured as a part of the intermediate-term improvement program.

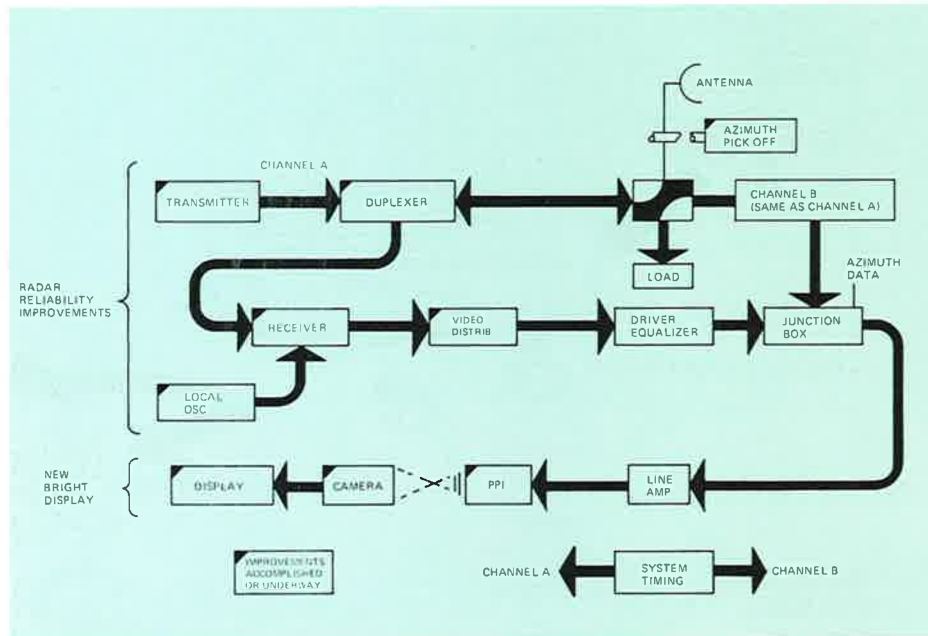



Figure 8. ASDE-2 improvements

## ASDE-2 Radar Reliability Improvements

Modification kits to improve ASDE-2 reliability have already been developed and installed at the 11 airports which have an ASDE-2. By this action, the ASDE-2 reliability has been improved by a factor greater than 10. The new ASDE-3 radar (described later) will provide additional significant reliability improvements.

The results shown in the following table were obtained during equivalent assessment periods before and after installation of the ASDE modifications.

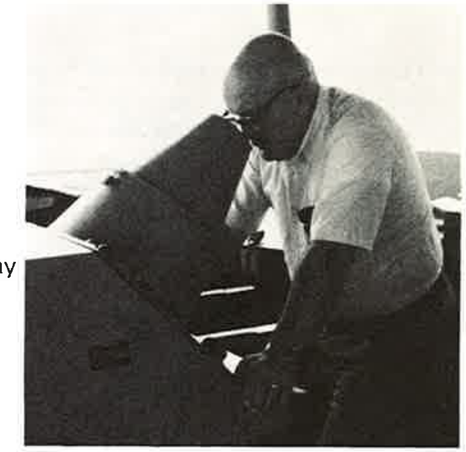


Figure 9. ASDE-2 PPI display with viewing hood

ASDE-2 RELIABILITY ASSESSMENT
(DURING EQUIVALENT PERIODS BEFORE AND AFTER
ASDE-2 MODIFICATIONS INSTALLED)

| | Total Number of ASDE-2 Usage Hours* | Total Number of Unscheduled Maintenance Actions | Mean Time Between Unscheduled Maintenance Actions (Days)** |
|---|---|---|---|
| Before Modifications | 4,827 | 260 | 3.0 |
| After Modifications | 4,827 | 25 | 31.1 |

*The total usage hours for six ASDE-2 sites: Kennedy (New York), Newark, Dulles (Near Washington, D.C.), O'Hare (Chicago), Andrews Air Force Base (Near Washington, D.C.), and Seattle.

**Based on an average ASDE-2 usage time of 6.2 hours per day at each site.

## Improved ASDE BRITE Display

The original ASDE-2 had the plan position indicator (PPI) type of display frequently provided with radars. However, experience proved that the PPI display has insufficient signal brightness and contrast for use in a well-illuminated tower cab without incorporation of a difficult-to-use viewing hood on the display (Figure 9). To overcome this problem, the FAA developed the original ASDE BRITE (Bright Radar Indicator Tower Equipment) Display which, through use of a scan conversion technique employing a TV camera viewing a small PPI display, provides an output on a TV-type display with higher signal brightness and contrast ratio. However, since the installation of the original BRITE display, some of its components have become obsolete, and the state-of-the-art has progressed such that significant improvements in display quality — e.g., sharpness and uniformity of focus, amount and uniformity of contrast, and resolution — can be achieved. These improvements were demonstrated in tests at New York's Kennedy Airport using an engineering model of a new bright display (designated the "ASDE Nu-BRITE" Display) which was developed by the Transportation Systems Center. The Nu-BRITE display is also compatible with the new ASDE-3 radar to be procured.

The Nu-BRITE display experimental model is shown in use in the Kennedy Airport tower cab in Figure 10A, and its presentation is enlarged in Figure 10B. To illustrate the information conveyed to the controller by this presentation, Figure 10B isolates an area of interest on the display. Here, five aircraft are located in a takeoff queue at the right side of the circled area, and one aircraft is located in motion on the runway at the left side of the circled area. To help identify the items of interest within the isolated area of Figure 10B, Figure 10C presents a photographic reproduction of the same airport surface area with simulated aircraft identically located.

Three Nu-BRITE displays are being procured for installation and operational evaluation at Kennedy (New York), O'Hare (Chicago), and San Francisco International Airports during 1976.

Figure 10B. ASDE Nu-BRITE display

Figure 10C. Aerial photograph showing same details as isolated section of Figure 10B

Figure 10A. ASDE-Nu-BRITE display test at New York's Kennedy Airport

## INTERMEDIATE-TERM ASTC SYSTEM IMPROVEMENTS

In the intermediate term (the late 1970's and early 1980's) emphasis will be on further improvements to ASTC surveillance – including deployment of an ASDE Display Enhancement Unit and the ASDE-3 radar – and on installation of improved visual guidance aids.

### ASDE Display Enhancement Unit

The present ASDE-2 display presentation (Figure 11A) is quite cluttered due to the radar signal returns received from airport areas not of interest to the tower controllers (e.g., hangars and terminal buildings). Also, the edges of the runways and taxiways are not always discernible on the existing display presentation; this at times makes it difficult for Controllers using the ASDE-2 to tell whether the vehicles are on or off the taxiways or runways.

A preliminary Display Enhancement Unit model has been tested at Los Angeles (Figure 11B) and Kennedy (New York) International Airports. This has demonstrated the technical feasibility of significantly improving the ASDE display quality by:

- Suppressing the displayed information related to areas of the airport that are not of interest to the controller – e.g., runways or taxiways assigned to another controller, or background clutter around the route of interest. (The controller has the means to eliminate all of the background from the display or to leave in as much as desired by use of a convenient adjustment on the display.)
- Enhancing the boundaries of the areas of interest to the controller (e.g., edges of runways and taxiways), to make them show up more prominently.

It is planned that Display Enhancement Units will be procured for installation (starting in approximately 1977) at each of the 11 airports equipped with an ASDE-2. This improvement will make it considerably easier for the tower controllers to detect and monitor surface traffic on the runways and taxiways of interest.

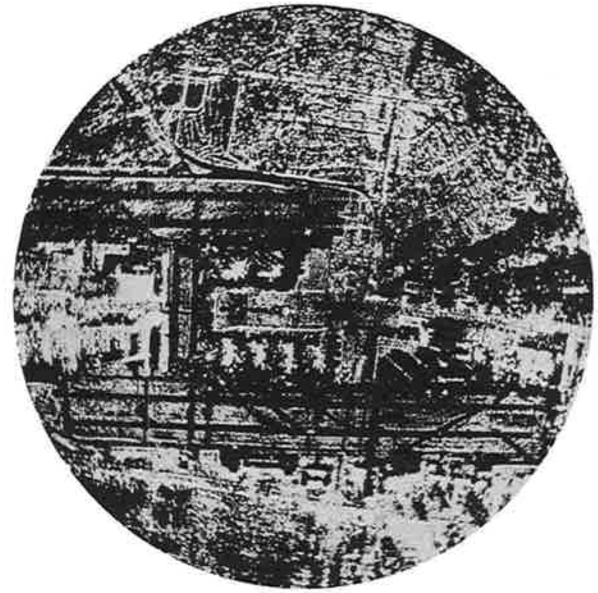


Figure 11A. Present ASDE display

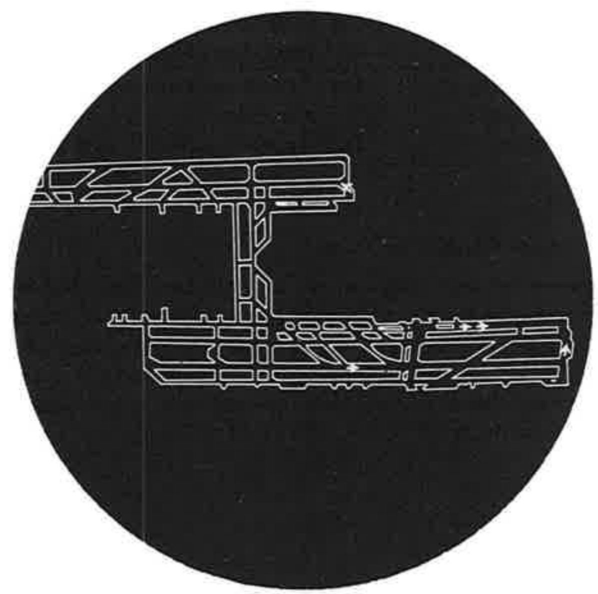


Figure 11B. Display improvement with Display Enhancement Unit

## ASDE-3 Radar

Since the ASDE-2 is reaching the end of its useful lifetime, uses obsolete components, and is no longer produced, it is planned that the ASDE-3 will be procured for installation at airports that need an ASDE but do not now have an ASDE-2, and as an eventual replacement for the ASDE-2s now installed. The ASDE-3 will use solid-state technology to achieve improved performance, reliability and maintainability. The ASDE-3 will be able to "see through" heavier rainfall and will have an improved controller display and a display enhancement unit to provide background suppression and boundary enhancement capability. The ASDE-3 antenna assembly will be substantially lighter in weight than that of the ASDE-2; this will permit simpler and less costly installation and maintenance.

ADVANTAGES OF ASDE-3 OVER ASDE-2

| | |
|---|---|
| Improved, Up-to-date Technology | Improved Rainfall Penetration<br>Improved Controller Display<br>Improved Reliability<br>Improved Maintainability<br>Improved Spare Parts Availability |
| Lighter Weight & Improved Installation Flexibility | Easier to Install Antenna Above Towercab<br>Less Expense to Install and Maintain |

## Improved Visual Guidance Aids

These will consist of improved runway and taxiway signs, lights for identifying runway exits to taxiways, stop/hold signals, and clearance bar lights (Figure 12). A study to identify the specifics of the improvements to be provided is presently underway at DOT's Transportation Systems Center, which will present its recommendations to the FAA during 1975.

## LONGER-TERM ASTC SYSTEM IMPROVEMENTS

As a result of the near-term and intermediate-term improvement projects, considerable gains will be achieved in the areas of ASTC surveillance and guidance. However, with the forthcoming installation of Category II and III landing systems at many airports, greater ASTC System capabilities will be needed to *ensure safety* and minimize delays under the simultaneous conditions of heavy traffic and lower visibility.

Specifically, the longer-term ASTC System program is aimed at achieving:

- A surveillance capability significantly better than that provided by ASDE-2 or ASDE-3 for use at major airports. *Because the surveillance, control, communication and guidance functions in ASTC are rather tightly coupled, improving surveillance (the major bottleneck) will also improve the performance of the other functions.*
- Further reduction in controller and pilot workload by automatic stop/go-signal control of traffic at critical route intersections at major airports.

The developmental projects now underway to achieve these two objectives are, respectively:

- The Tower Automated Ground Surveillance (TAGS) System Project
- The Automatic Intersection Control (AIC) Project

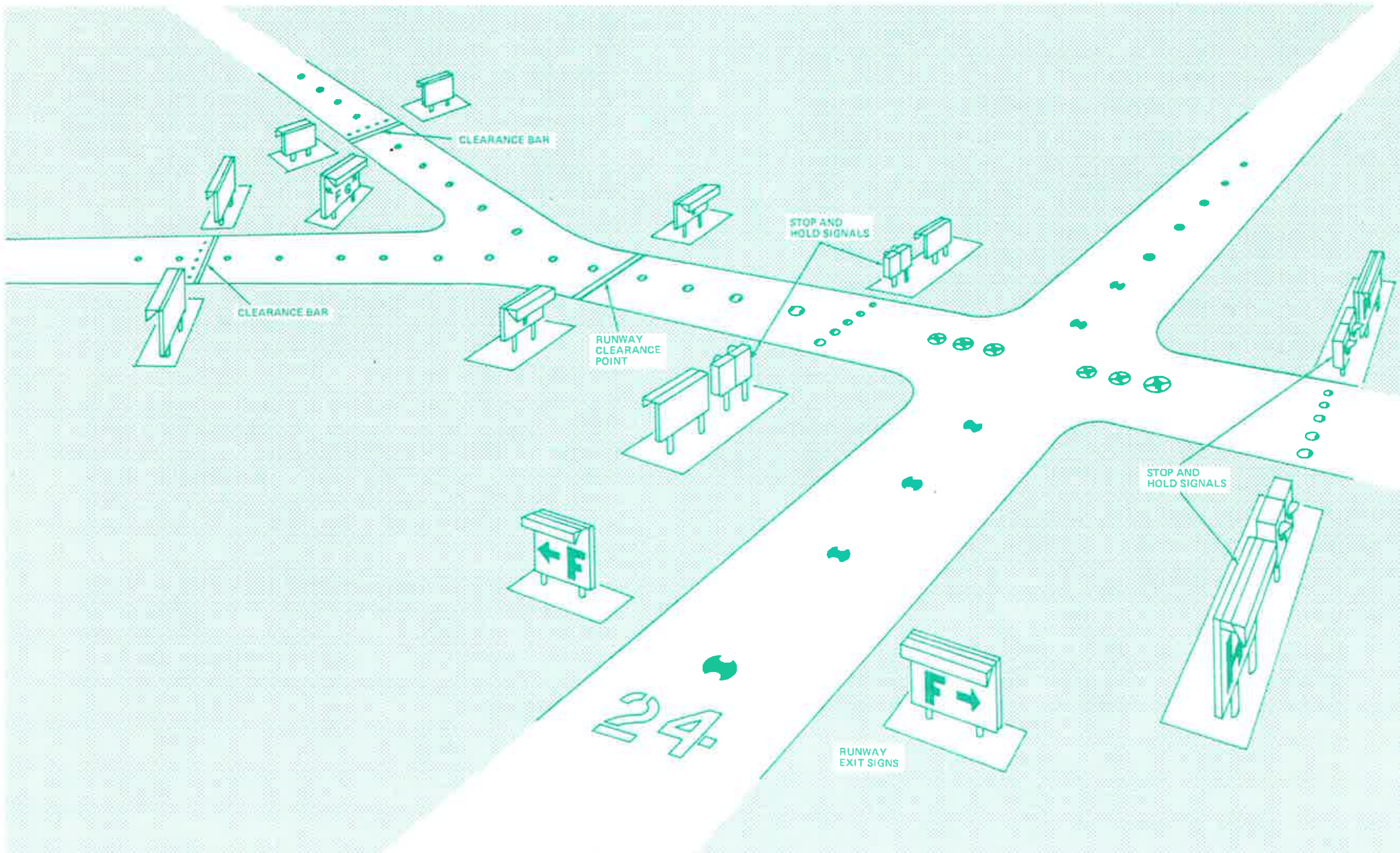



Figure 12. Examples of improved visual guidance aids

## Tower Automated Ground Surveillance (TAGS) System

The present concept for TAGS is that it will not use the primary radar technique. With TAGS, the air traffic control radar beacon already on the aircraft will be interrogated, and its response signal, which contains the aircraft's identity, will be used to position-fix the aircraft by use of the multilateration technique (described later).

Thus, an important advantage of TAGS over ASDE is that TAGS will provide automatic *identity* determination and display of beacon-equipped aircraft and service vehicles. This provides a significant improvement for the tower controllers during poor-visibility conditions — and also a moderate improvement during good-visibility conditions — since specific aircraft identities are presently difficult to determine under heavy traffic conditions, or at night, even if the controllers can see the aircraft. Besides the advantage of automatic identity determination and display, TAGS will provide other significant advantages over ASDE, such as *all-weather capability* and greater flexibility in providing *efficient display presentations* tailored to meet the specific needs of Ground Control and Local Control. This will be accomplished by digital computer processing and correlation of the various surveillance and control inputs to TAGS. Figure 13 shows a candidate display format (subject to change during the TAGS development program) for Ground Control at Chicago-O'Hare Airport. While the symbols and alphanumerics may look small, it should be noted that the display diameter in the figure is less than half the size of that which will be viewed on the actual 16-inch diameter display. The major features of the Ground Control display are as follows:

- Each aircraft assigned to Ground Control has a bright circular symbol indicating its position on the taxiway network (or interfacing areas). The length and direction of the trail line following the symbol are indicative of the aircraft's speed and course, respectively. (Stationary aircraft do not have the trailing line.) A tag indicating the flight call sign (e.g., EA420H for Eastern Airline flight number 420) is also provided for each of these aircraft. The letter "H" after the call sign designates the heavy class of aircraft (i.e., gross weight of at least 300,000 lbs.). The absence of the letter H indicates that the aircraft is not a heavy aircraft. This indication will help Ground Control in the sequencing of departures, as well as in the taxi routing of arrivals and departures at airports where heavy aircraft require special routing.
- Service vehicles which are radio equipped and can be authorized to travel on taxiways (or runways) will be equipped with a special inexpensive beacon. When authorized by radio to travel on a taxiway (or runway), the operator will activate the beacon, and the vehicle will be displayed with a simple code (e.g., "2" for an FAA maintenance vehicle to the left of center on the display).
- The TAGS sensor will be built to detect activation of the "IDENT" button of any beacon by a pilot or service vehicle operator. Beacons so activated will have a bright box drawn around the identity. This feature will permit an action request of the controller by the pilot without voice communication (e.g., DL357 in the holding area is requesting taxi clearance to its gate).

Thus, it is seen that the *advantages of TAGS over ASDE for Ground Control* include having a *much better picture* of the specific surface traffic activity of interest, and *reduced pilot-to-controller voice communication.* These factors will reduce controller and pilot workload, especially during low-visibility conditions, and thus *enhance both safety and capacity.*

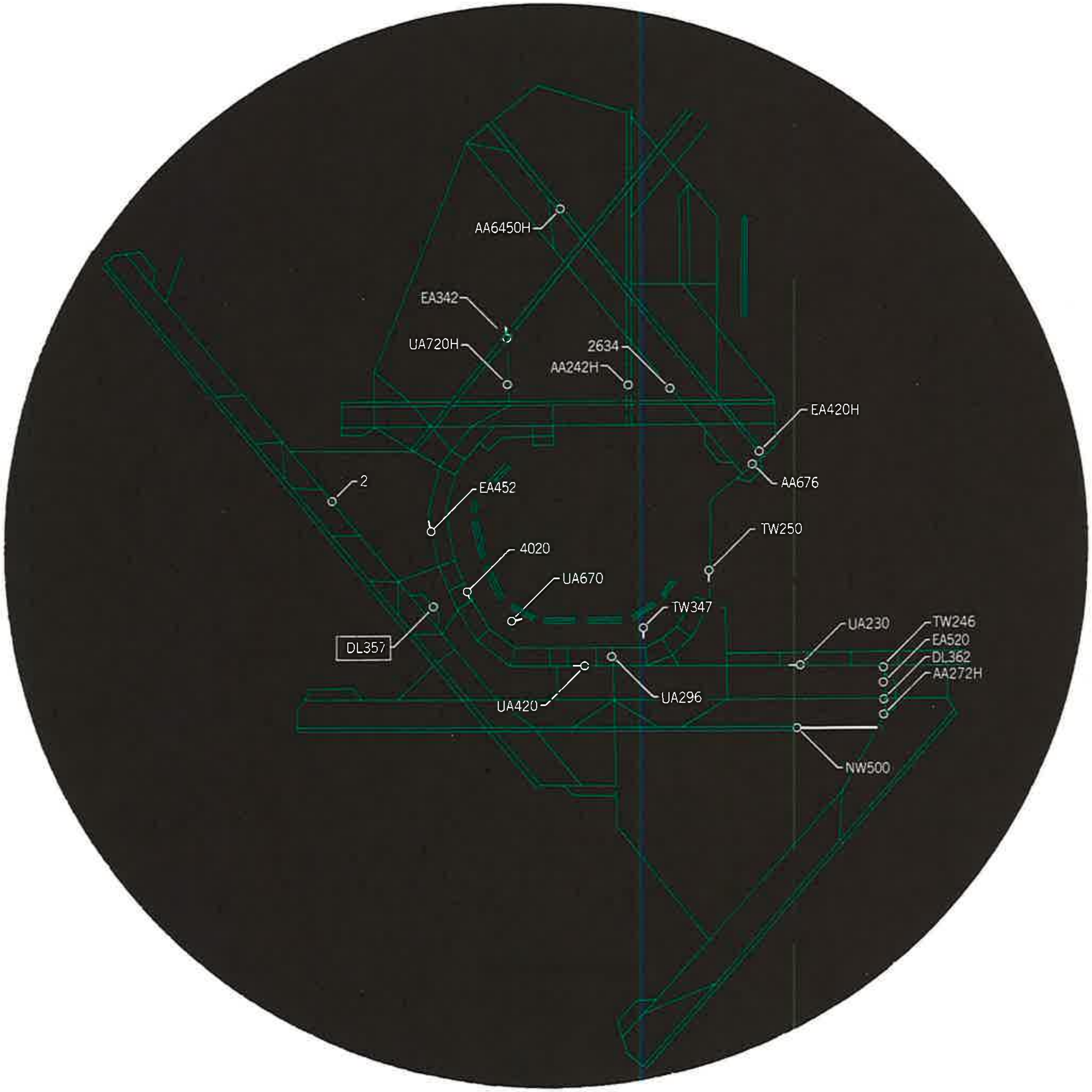



Figure 13. Candidate TAGS display presentation for Ground Control at O'Hare airport.

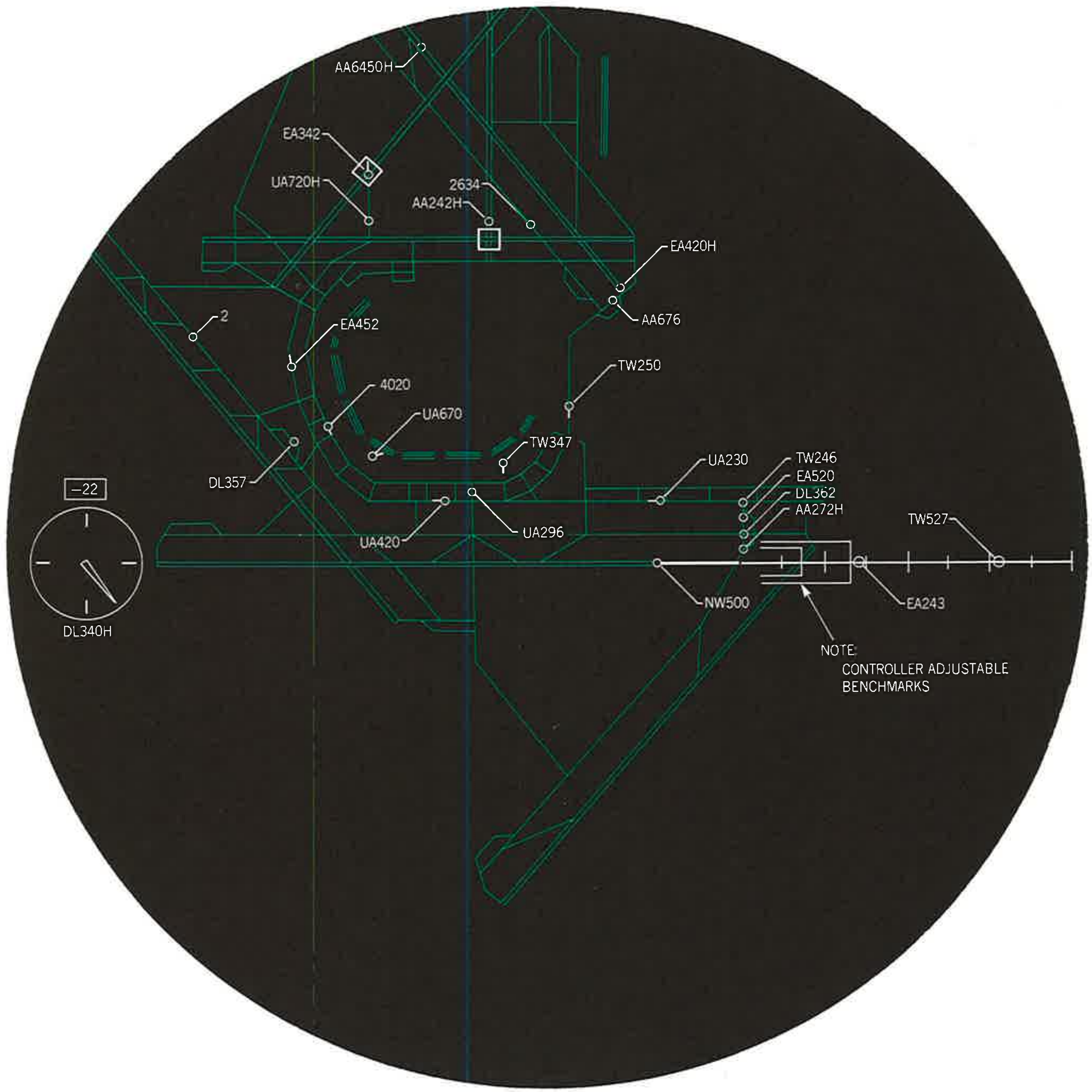



**Figure 14. Candidate TAGS display presentation for South-side Local Control at O'Hare airport**

Figure 14 is a candidate display format (subject to change during the TAGS development program) for south-side Local Control at Chicago-O'Hare Airport. (The Local Control function at O'Hare is divided geographically. A similar but separate display presentation, not shown, will be provided for north-side Local Control). The major features of the south-side Local Control display are as follows:

- For the first time, an *integrated display* will be available for Local Control that covers aircraft that are either landing on a given runway (e.g., TW527 and EA243), already located on a runway (e.g., NW500), awaiting clearance to position-and-hold on a runway (e.g., AA272H), or in the climbout phase (e.g., DL340H). Information concerning the airborne aircraft will be provided to TAGS from ARTS. This is an advantage over the present situation wherein Local Controllers use both an ASDE and an ASR display to cover airborne aircraft of interest in the vicinity of the runways. The TAGS display will not replace the ASR display for coverage of aircraft in the terminal area.
- A "range to threshold" scale is provided to indicate the range (in miles) of a landing aircraft (e.g., TW527) to the threshold of its arrival runway. Each tick mark on the 8-mile scale represents one mile.
- A "time since start of takeoff" clock is provided to indicate the time (in minutes) since the last aircraft in the climbout phase (DL340H in this case) started to roll for takeoff. The box above the clock indicates the aircraft's course with respect to the runway. This box will contain no reading until the aircraft is detected as turning.
- Airborne aircraft, although moving on the display, will be shown without trail lines. Thus, on touch down, acquisition of a long trail will cue the controller that the aircraft is down and braking (e.g., NW500), and on lift-off, loss of a long trail will cue the controller that the aircraft is up and clearing (e.g., AA6450H).
- *Controller adjustable benchmarks* are provided as an aid in assessing departure-release opportunities when departures are dependent on arrivals. In this example, the Local Controller adjusts the outer benchmark such that when an arrival (NW500) touches down and begins braking, if the next arrival (EA243) is outside the benchmark, then the next departure (AA272H) can safely be directed onto the runway (assuming the previous departure is clearing as required). The inner benchmark is set such that if the current arrival (NW500) does not clear the runway permitting the take-off clearance of the next departure (AA272H) before the next arrival (EA243) reaches the inner benchmark, then the next arrival must be directed to execute a missed approach.
- Runway/taxiway intersections that are occupied by an aircraft (or vehicle) will be flagged with a bright box. Thus, positive runway clearance will be established for aircraft (or vehicles) exiting an active runway (e.g., EA342 having just landed is not yet clear of the runway) or holding short of an active runway (e.g., UA720H is holding clear while AA242H has "nosed out" over the runway clearance marker).

Thus, the TAGS Local Control display will significantly help the Local Controller by providing *critically needed information concerning the positions, identities, and separations of aircraft that are landing and taking off.* This will aid appreciably in *improving safety* and increasing peak operations rates (arrivals plus departures per busy hour) at major airports.

## The TAGS Sensor

A new sensor system[9] is being developed for use in acquiring the information concerning aircraft position and identity needed to drive the TAGS displays. This ground-based sensor will operate in conjunction with the Air Traffic Control Radar Beacon System (ATCRBS) transponder, which is required equipment on aircraft operating in the 21 major U.S. Terminal Control Airspace (TCA) airports.

To understand how the TAGS System will work with the ATCRBS transponders on-board the aircraft, one should be aware of two features of these transponders:

- If the transponder receives a properly coded *interrogation* signal, it will reply with another coded signal that represents the aircraft's *identification.*
- If the transponder receives a properly coded *suppression* signal, it will be *inhibited* from replying to interrogations for a period of 35 ±10 microseconds (i.e., it will be suppressed).

Since both the TAGS sensor and the local Airport Surveillance Radar (ASR) will be interrogating these aircraft transponders, the TAGS sensor will be timed to operate only during the inactive time of the ASR, to prevent interference between these two sensors.

With these operational characteristics in mind, refer to Figure 15, which shows a 3-station sensor configuration set up so as to encompass the airport surface. The sequence of operation is as follows (see Figure 15A through 15D):

A. Station 1 radiates (transmits) a suppression-signal pattern which inhibits all transponders located within the pattern from replying for a period of 35 ±10 microseconds.

B. A few microseconds later, Station 2 transmits a second suppression-signal pattern which inhibits for 35 ±10 microseconds all transponders located within this pattern. Note that each of the radiation patterns contains a "notch" wherein no suppression occurs. The intersection of the two notches forms a *unique, suppression-free cell,* which can be positioned in a controlled manner at any point on the airport surface. The cell's area is sized to encompass a single aircraft (i.e., transponder antenna).

C. Eight microseconds after the start of Station 2's *inhibit* transmission, Station 2 transmits an *interrogation* signal along the notch of its suppression-signal pattern. Only the transponder located within the suppression-free area is able to respond. *This feature prevents the interference that would be caused by overlapping replies from many transponders.*

D. The transponder's reply to the interrogation is received at each of the *three* stations, after which (a) the aircraft's position is determined by measuring the *differences* in the arrival times of the reply signal at the three stations, and (b) the aircraft's identity is determined from the identity code contained in the reply signal of its transponder.

This sensor technique is referred to as "ATCRBS trilateration" when three stations are used (or "ATCRBS multilateıation" when more than three stations are used).

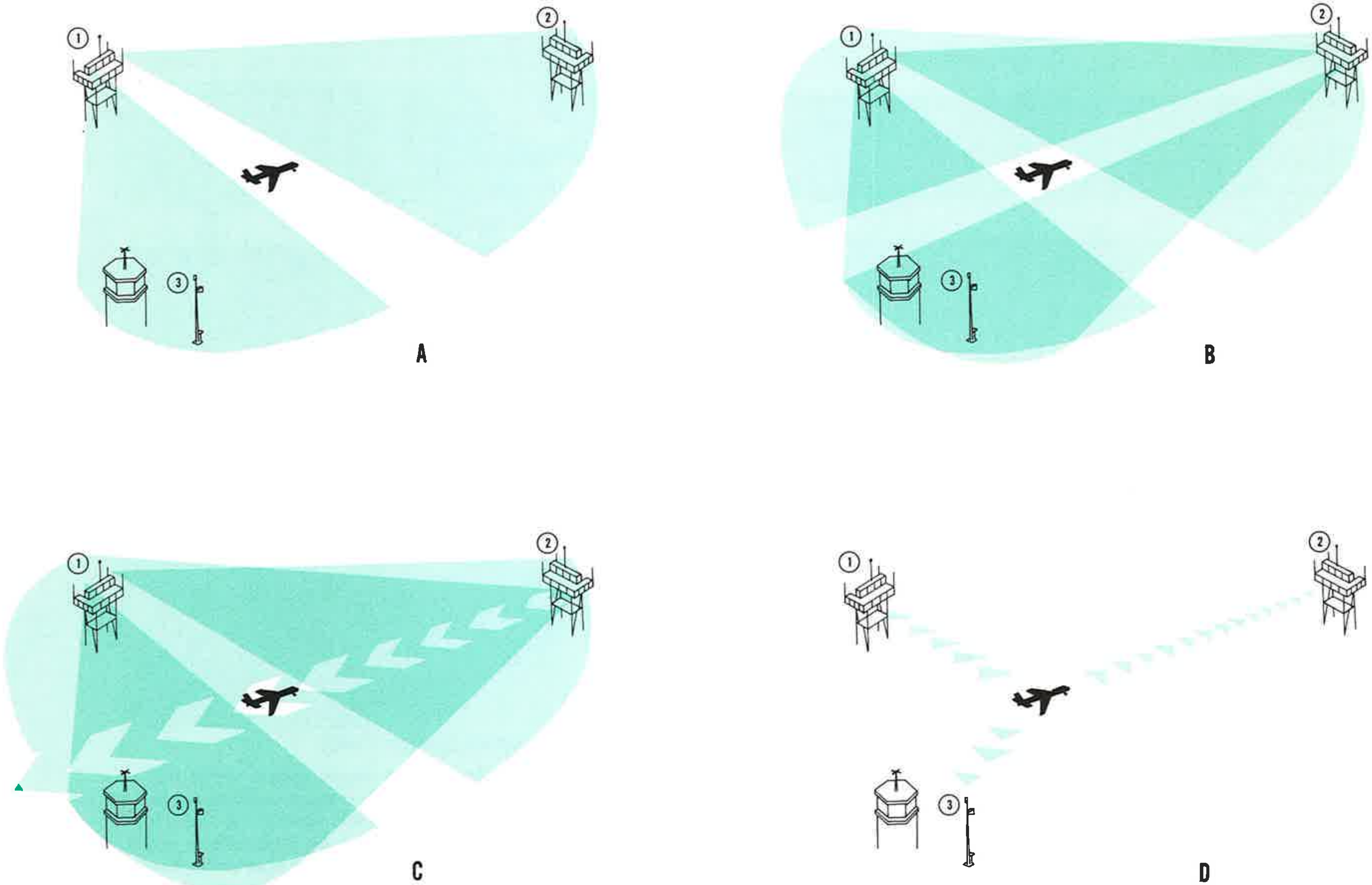
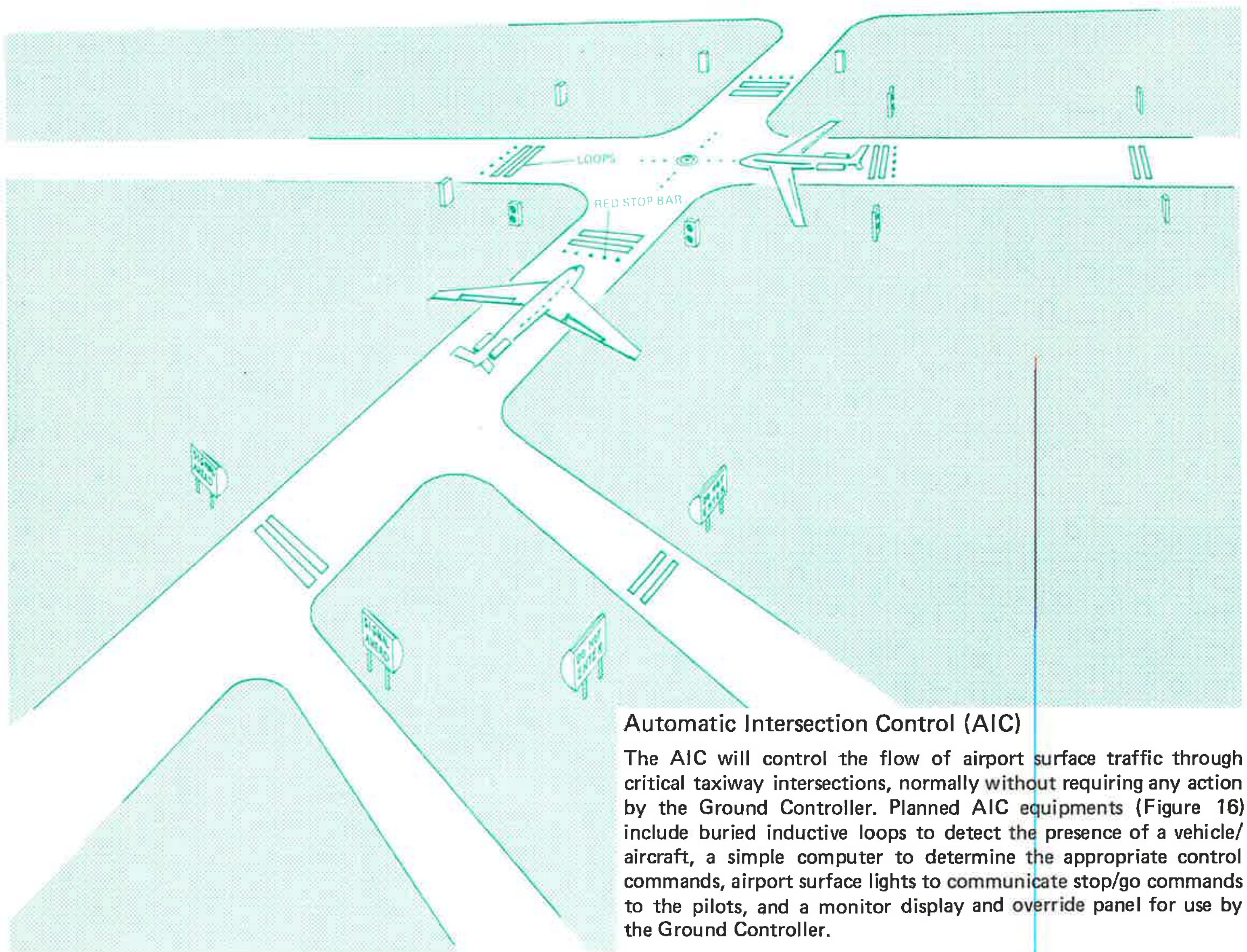



Figure 15. Operational sequence for three-station TAGS sensor




## Automatic Intersection Control (AIC)

The AIC will control the flow of airport surface traffic through critical taxiway intersections, normally without requiring any action by the Ground Controller. Planned AIC equipments (Figure 16) include buried inductive loops to detect the presence of a vehicle/aircraft, a simple computer to determine the appropriate control commands, airport surface lights to communicate stop/go commands to the pilots, and a monitor display and override panel for use by the Ground Controller.

Figure 16. A proposed Automatic Intersection Control System

# WHAT ARE THE BENEFITS OF THE IMPROVED ASTC SYSTEMS?

This discussion considers the benefits to be realized due to deployment of:

- TAGS and additional ASDEs
- Improved visual guidance aids
- Automatic intersection control

## BENEFITS OF TAGS AND ADDITIONAL ASDEs

The benefits to be realized by deployment of ASDEs or TAGS fall into two categories: performance and safety.

### Performance Benefits

A study of airport surface traffic operations[6,10] has established the relationship between Ground Controller communications loading, which is a good measure of Ground Controller workload, and the number of aircraft per hour being handled. This relationship is surprisingly independent of the individual airport. This study established the capacity benefits presented below.

The estimated capacity of the Ground Control position as a function of key variables is indicated in Figure 17. The capacity is expressed in terms of the number of aircraft operations (arrivals plus departures) per hour handled by one controller. The variables are the visibility (good or poor) and the surveillance method used. "Good visibility" means that both the controller and the pilot have the unrestricted visibility experienced on a clear day; "poor visibility" means that the pilots can see well enough to taxi, but the tower controllers can't see the aircraft and movement areas on the airport surface. During good-visibility conditions the surveillance alternatives are visual-only and TAGS (ASDE generally offers no improvement over the visual-only case when visibility is good). During poor-visibility conditions the surveillance alternatives are TAGS, ASDE plus position reports from pilots via radio communication, and position reports only (i.e., neither TAGS nor ASDE available).

In Figure 17, the 100% capacity reference level for Ground Control is taken to be the capacity that is typically achievable today during good visibility — 81 operations per hour per controller. Figure 17 shows that:

- With today's ASTC surveillance methods, Ground Control capacity degrades significantly as the controller's visibility changes from good to poor — to about 57% of the reference level with ASDE, and 43% without ASDE.
- When TAGS becomes available, Ground Control capacity should be 25% higher (or, alternatively, controller workload should be about 25% lower) than the reference level — *during good visibility as well as poor.*

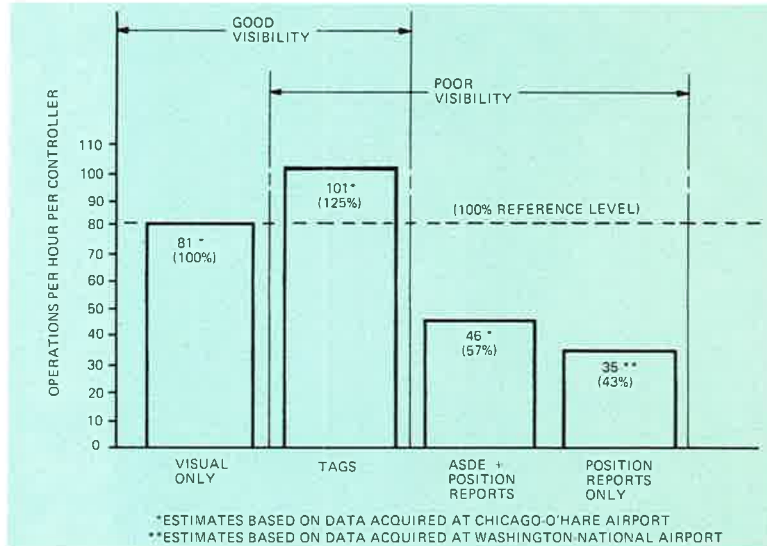



Figure 17. Estimated Ground Control performance

Figure 18 shows estimates of how Local Control performance is affected by visibility conditions and the ASTC surveillance technique used. The example shown pertains to the capacity of a single runway serving a mix of arrivals and departures. "Good" and "poor" visibility have the same meaning given above for the Ground Control case. The capacity of 57 operations per hour, which can be achieved at present during good-visibility conditions, is taken as the 100% capacity reference level. It is seen that:

- Using existing surveillance techniques, Local Control capacity decreases when the visibility conditions for the controller change from good to poor. This degradation is modest — to 95% of the reference level — if an ASDE is available; however, capacity decreases to 75% of the reference level if an ASDE is not available.
- With the future availability of TAGS, Local Control capacity should increase to about 9% above the reference level, *during good visibility as well as poor.*

*Thus, it is seen that use of ASDE or TAGS should significantly increase the tower controllers' aircraft-handling capacity, especially during poor-visibility conditions.*

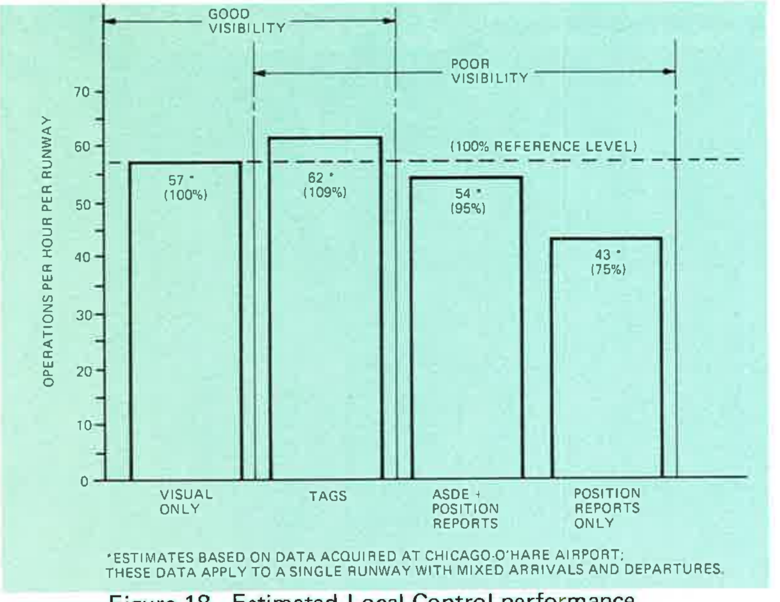



Figure 18. Estimated Local Control performance

## Safety Benefits

When the aircraft operations rate approaches the controllers' capacity, the level of safety begins to deteriorate. Use of either the ASDE or TAGS Systems will result in an *increase in the operations rate at which the level of safety is acceptable.*

A prime hazard factor during poor visibility conditions is the lack of positive surveillance. For example, in the case of the Boston-Logan accident of 31 July 1973, use of either the ASDE or TAGS Systems would have permitted Local Control to make an instant determination that the aircraft had crashed. He could then have dispatched fire and rescue assistance immediately instead of having the delay of several minutes that actually occurred. In addition, operations during the period following the accident would not have been exposed to the potential danger caused by the wreckage.

In the accident at Chicago-O'Hare on 20 December 1972, in which an aircraft taxiing across an active runway collided with a departing aircraft, the accident would have been very unlikely had Ground or Local Control been using the proposed TAGS system. Since TAGS will provide the controllers with a dynamic presentation of aircraft location and identity, Ground Control would not have misunderstood where the taxiing aircraft was, and Local Control would likely have seen the aircraft crossing the runway.

The following table summarizes some of the safety-related benefits provided by ASDE and TAGS.

SAFETY-IMPROVEMENT FEATURES PROVIDED BY ALTERNATIVE ASTC SURVEILLANCE METHODS

| Safety-Improvement Feature | Surveillance Method | | |
|---|---|---|---|
| | Visual | ASDE | TAGS* |
| See through darkness or heavy fog | No | Yes | Yes |
| See through heavy rainfall | No | No | Yes |
| Positive identification of each aircraft | No | No | Yes |
| Predictive ranging/timing information regarding critical events (e.g., aircraft touchdown on runway) | No | No | Yes |

*Aircraft must be equipped with Air Traffic Control Radar Beacon.

## BENEFITS OF IMPROVED VISUAL GUIDANCE AIDS

These include the following advantages — especially under poor-visibility conditions:

- Reduced pilot workload
- Decreased need for the pilot to rely on the tower controllers for guidance support; this reduces controller workload.

The above factors result in reduced aircraft delays, improved safety, and increased ASTC System capacity.

## BENEFITS OF AUTOMATIC INTERSECTION CONTROL

The installation of automatic stop/go intersection control at key intersections of the busiest tower-equipped airports will further contribute to reduction of controller and pilot intercommunication and workload, and thus promote reduced aircraft delays, improved safety, and increased ASTC System capacity.

# HOW MANY IMPROVED ASTC SYSTEMS MIGHT BE DEPLOYED?

It is premature to develop a detailed, specific plan for deployment of the ASDE-3 and TAGS Systems. This will be done at the appropriate time by the FAA Operating Services. However, a preliminary quantitative analysis[11] was performed to aid in determining how many ASDE-3 and TAGS Systems might be deployed *as a minimum.* This information was needed to justify the expenditure of engineering and development funds on the ASDE-3 and TAGS System projects.

This analysis covered the 39 airports that are busiest in terms of annual air carrier operations and instrument operations, which are key indicators of ASTC System workload. Estimates were made, for each airport, of demand vs. capacity and the resultant delay during each year through the year 2000. These delays, and the associated cost penalties to the airlines, were determined for three alternative surveillance mechanizations: visual only, ASDE, and TAGS. The analysis assumed that an ASDE-3 or TAGS System would be deployed when the annual cost savings, due to the delay reduction to be achieved by the equipment deployment, would exceed the pro-rated annual life-cycle cost of the equipment.

The results of this analysis are summarized in the tables at the end of this section, which show the dates at which deployment of ASDE-3 or TAGS, respectively, would be *cost-effective.* Regarding ASDE-3 deployment, the following numbers of airports would qualify, on the basis of cost-effectiveness, at the indicated dates:

| Number (Minimum) | Date |
|---|---|
| 19 | 1979 |
| 25 | 1989 |
| 30 | 2000 |

Similarly, the following numbers of airports would qualify for TAGS Systems:

| Number (Minimum) | Date |
|---|---|
| 7 | 1979 |
| 16 | 1989 |
| 20 | 2000 |

The actual deployment plans will be developed in a way which takes advantage of the existing 11 ASDE-2's now in the field as well as the earlier availability of ASDE-3 as compared to TAGS. The deployment of ASDE-3 will take into account the forthcoming TAGS system so as to avoid having ASDE-3 becoming a "throwaway" item at any airport.

It should be noted that this quantitative analysis did not directly consider deployment on the basis of *safety improvement,* since safety factors are difficult to quantify. Other important factors such as energy conservation and air/noise pollution reduction were also *not* considered directly in this first-cut analysis. Therefore, this preliminary deployment estimate may be conservative.

REPRESENTATIVE DEPLOYMENT OF ASDE SYSTEMS*

| No. | Location (Airport) | Date When Deployment Cost-Effective |
|---|---|---|
| 1 | Atlanta, GA (Hartsfield) | 1973** |
| 2 | Boston, MA (Logan) | 1973** |
| 3 | Chicago, IL (O'Hare) | 1973** |
| 4 | Cleveland, OH (Hopkins) | 1973** |
| 5 | Dallas/Fort Worth, TX (Regional) | 1973 |
| 6 | Detroit, MI (Wayne County) | 1973 |
| 7 | Los Angeles, CA (International) | 1973** |
| 8 | New York, NY (Kennedy) | 1973** |
| 9 | New York, NY (LaGuardia) | 1973 |
| 10 | Philadelphia, PA (International) | 1973 |
| 11 | Pittsburgh, PA (Greater Pitt.) | 1973 |
| 12 | San Francisco, CA (International) | 1973** |
| 13 | Seattle, WA (Seattle-Tacoma) | 1973** |
| 14 | St. Louis, MO (Lambert) | 1973 |
| 15 | Washington, DC (National) | 1973 |
| 16 | Newark, NJ | 1976** |
| 17 | Houston, TX (Intercontinental) | 1978 |
| 18 | Kansas City, MO | 1978 |
| 19 | Denver, CO (Stapleton) | 1979 |
| 20 | Baltimore, MD (Friendship) | 1983 |
| 21 | Milwaukee, WI (Mitchell) | 1985 |
| 22 | New Orleans, LA (Moisant) | 1985 |
| 23 | Indianapolis, IN (Weir Cook) | 1988 |
| 24 | Dayton, OH (Cox-Municipal) | 1989 |
| 25 | Minneapolis, MI (Mpls.-St. Paul) | 1989 |
| 26 | Portland, OR (International) | 1991** |
| 27 | Hartford, CT (Bradley-International) | 1992 |
| 28 | San Diego (Lindberg) | 1992 |
| 29 | Washington, DC (Dulles) | 1992** |
| 30 | Memphis, TN (International) | 1996 |

*Prepared for engineering and development planning purposes only.
**ASDE presently installed.

REPRESENTATIVE DEPLOYMENT OF TAGS SYSTEMS*

| No. | Location (Airport) | Date When Deployment Cost-Effective |
|---|---|---|
| 1 | Chicago, IL (O'Hare) | 1973 |
| 2 | Washington, DC (National) | 1973 |
| 3 | Miami, FL (International) | 1974 |
| 4 | Atlanta, GA (Hartsfield) | 1975 |
| 5 | Los Angeles, CA (International) | 1976 |
| 6 | Pittsburgh, PA (Greater Pitt.) | 1978 |
| 7 | San Francisco, CA (International) | 1978 |
| 8 | Cleveland, OH (Hopkins) | 1980 |
| 9 | Philadelphia, PA (International) | 1981 |
| 10 | Denver, CO (Stapleton) | 1982 |
| 11 | New York, NY (Kennedy) | 1982 |
| 12 | New York, NY (LaGuardia) | 1982 |
| 13 | Seattle, WA (Seattle/Tacoma) | 1983 |
| 14 | St. Louis, MO (Lambert) | 1983 |
| 15 | Boston, MA (Logan) | 1984 |
| 16 | Newark, NJ | 1988 |
| 17 | Baltimore, MD (Friendship) | 1990 |
| 18 | Dallas/Fort Worth, TX (Regional) | 1995 |
| 19 | Detroit, MI (Wayne County) | 1995 |
| 20 | Minneapolis/St. Paul, MN (International) | 1995 |

*Prepared for engineering and development planning purposes only.

## SUMMARY

The present ASTC System works quite well during periods of *good* visibility. However, at the major airports, when visibility conditions degrade to the point where the tower controllers are unable to see the aircraft and the movement areas of the airport, *it is not presently possible to maintain both safety and delay within acceptable limits.* The major need is *improved surveillance.* This need is critical today at major airports and will become correspondingly greater with the forthcoming increases in peak-period operations rates during poor-visibility conditions which will result from the combined factors of growing demand and installation of additional Category II/III landing systems.

While the ASDE-2 is a significant aid at the 11 airports where it is installed, it is nearing the end of its useful lifetime. Recent modifications to this equipment have resulted in better than a 10-to-1 improvement in its reliability, but this still falls far short of the reliability provided by a modern radar. Since the ASDE-2 has been out of production for 15 years, additional ASDEs to satisfy the needs of airports today and in the future will not be available until a new ASDE (ASDE-3) is in production. Finally, the main operational limitation of the ASDE-2 – its poor performance during periods of moderate-to-heavy rainfall – is inherent in its design and will not be eliminated until a new, improved radar is developed. Therefore, immediate procurement and deployment (late 1970s) of the ASDE-3 is urgently needed.

To satisfy, at acceptable cost, the safety and capacity requirements at major airports, accelerated development and deployment (early 1980s) of the Tower Automated Ground Surveillance (TAGS) System is also needed.

### PROBLEMS

Present

- Restricted visibility from tower cab
- ASDE-2 limitations
- Complex runway/taxiway networks
- Excessive controller and pilot workload under heavy traffic and poor - visibility conditions
- Delays and safety hazards

Future

- Larger aircraft, increased operations
- Decreased landing minima
- More operations during bad weather
- Greater delays and safety hazards – unless needed improvements implemented.

### SOLUTIONS

| Planned ASTC System Improvements | Period |
|---|---|
| • ASDE-2 Radar Improvements<br>• Improved ASDE Bright Display | Present |
| • ASDE Display Enhancement Unit<br>• ASDE-3 Radar<br>• Improved Visual Guidance Aids | Late 1970's |
| • Tower Automated Ground Surveillance (TAGS) System<br>• Automatic Intersection Control | 1980's |

### BENEFITS

- Improved safety and service
- ASTC capacity increased in pace with landing system capacity
- Reduced ASTC-related delays – reduced air/noise pollution, energy consumption, and user costs.

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## Glossary

| | | |
|---|---|---|
| ARTCC | — | Air Route Traffic Control Center |
| ASDE | — | Airport Surface Detection Equipment |
| ASR | — | Airport Surveillance Radar |
| ASTC | — | Airport Surface Traffic Control |
| ATC | — | Air Traffic Control |
| ATCRBS | — | Air Traffic Control Radar Beacon System |
| ATL | — | Atlanta, GA (Hartsfield) Airport |
| BRITE | — | Bright Radar Indicator Tower Equipment |
| DEN | — | Denver, CO (Stapleton) Airport |
| DOT | — | Department of Transportation |
| FAA | — | Federal Aviation Administration |
| IFR | — | Instrument Flight Rules |
| JFK | — | New York, N.Y. (Kennedy) Airport |
| LAX | — | Los Angeles, CA (International) Airport |
| MIA | — | Miami, FL (International) Airport |
| Nu-BRITE | — | New Bright Radar Indicator Tower Equipment |
| ORD | — | Chicago, IL (O'Hare) Airport |
| PHL | — | Philadelphia, PA (International) Airport |
| PPI | — | Plan Position Indicator |
| SFO | — | San Francisco, CA (International) Airport |
| TAGS | — | Tower Automated Ground Surveillance |
| TCA | — | Terminal Control Airspace |
| TRACAB | — | Tower Cab |
| TRACON | — | Terminal Radar Control |
| TSC | — | Transportation Systems Center |
| U.S. | — | United States |
| VFR | — | Visual Flight Rules |

Airport Operations Hampered by Fog

Aircraft Departing Boston-Logan Airport


American
American
American
American