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Investment Criteria for Airport Surveillance Radar (ASR/ATCRBS/ARTS)

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EXECUTIVE SUMMARY

This report develops revised investment criteria for the Airport Surveillance Radar, Air Traffic Control Radar Beacon System, and Automated Radar Terminal System (ASR/ATCRBS/ARTS) for publication in FAA Order 7031.2B, Airway Planning Standard Number One. Airway Planning Standard Number One contains the policy and summarizes the criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of air navigation facilities and air traffic control services. The investment criteria addressed in this report include ASR establishment, ASR discontinuance, improvements, remoted radar bright display scope, establishment of terminal radar approach control in tower cab (TRACAB), establishment of terminal radar approach control (TRACON) and TRACAB to TRACON conversion.

The ASR establishment and discontinuance criteria developed in this report are based on a rigorous computerized benefit/cost analysis. The other supplemental criteria, however, are not readily adaptable to benefit/cost analyses for system-wide application because benefits and costs may vary significantly from case to case. In lieu of detailed benefit/cost analyses for these supplemental criteria, activity levels are identified at which marginal benefits are expected to exceed costs.

The primary benefits of ASR quantified in this report include reduced delays to aircraft operating under instrument flight rule (IFR) conditions made possible by reducing separations below those required by manual procedures and reduced risks of midair and terrain collisions in the terminal area through the application of radar separation services. Other benefits, such as visual flight rule (VFR) radar advisory service, radar flight assists, and convenience have not been adequately quantified and therefore have not been included in the criteria developed in this report. Life-cycle costs are based on investment in and operation and maintenance costs of the ASR-9 in TRACAB and TRACON configurations.

Of particular interest are enhancements introduced into the benefits methodology for the ASR establishment and discontinuance criteria. The revised methodology extends credit for radar services provided to all user classes. The previous criteria focused more on the air carrier user class. Additionally, the revised benefits methodology introduces the "area concept" of providing qualified radar service to multiple airport sites having a common need for radar surveillance. Under this concept, qualified radar service provided to secondary or satellite airports is taken into account in quantifying total benefits. Additionally, the revised benefits methodology is more site-specific. In the previous criteria, benefits were based only on the aviation activity for the first year of the ASR's operation and costs were annualized. Changes in aviation activity growth were not represented in the benefits calculation. The revised benefits methodology uses official aviation activity forecasts by quantifying the benefits independently for each year of an ASR's estimated 15-year economic life and discounting the benefits for each year to their present value. These are summed to represent the present value life-cycle benefits. Capital costs and operations and maintenance costs are approached on a similar present

value life-cycle basis. Lastly, the revised benefits methodology incorporates updated critical value elements, including the value of time of aircraft passengers/occupants, the value of a statistical life, the cost of a statistical serious injury, aircraft replacement and restoration costs and aircraft variable operating costs.

The revised ASR criteria, in relation to the previous ASR criteria, identify more establishment candidates and fewer discontinuance candidates. Based on projections through FY 1987, 19 FAA approach control towers presently without ASR equipment or service will meet the revised establishment criteria, while 13 meet the previous establishment criteria. Two existing ASR installations meet the revised discontinuance criteria, while 5 meet the previous discontinuance criteria. It is impossible to assess the actual budget impact of the revised criteria on agency resources for several reasons. First, meeting candidacy levels does not by itself entail automatic qualification. Benefit/cost screening is but one of several inputs to the FAA decisionmaking process relative to investment in ASR facilities. Investment decisions are made on the basis of all pertinent factors. Second, neighboring airports having a common need for radar surveillance may collectively qualify for an ASR under the "area concept." Qualifying sites in the category will be determined on a case by case basis by the Air Traffic Service. And third, actual costs vary from site to site. Estimated site-specific costs will be applied in actual application of the criteria.

SECTION I - INTRODUCTION

This report develops revised investment criteria for the Airport Surveillance Radar, Air Traffic Control Radar Beacon System, and Automated Radar Terminal System (ASR/ATCRBS/ARTS). These criteria replace the ASR investment criteria that are currently contained in FAA Order 7031.2B, Airway Planning Standard Number One (Reference 1), as developed in FAA Report Number ASP-75-2, *Establishment Criteria for Airport Surveillance Radar (ASR/ATCRBS/BDS)* (Reference 2). Airway Planning Standard Number One contains the policy and summarizes the criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of air navigation facilities and air traffic control services. The investment criteria addressed in this report include ASR establishment, ASR discontinuance, improvements, remoted radar bright display scope, establishment of terminal radar approach control in tower cab (TRACAB), establishment of terminal radar approach control (TRACON) and TRACAB to TRACON conversion.

The ASR, used in conjunction with the ATCRBS and ARTS, upgrades a manual approach control facility to a radar approach control facility. The ASR, itself, is a primary surveillance radar which provides aircraft target information on air traffic controllers' display scopes. The ATCRBS is a cooperative secondary radar system which facilitates the identification of radar targets by interrogating transponder-equipped aircraft. ARTS is a minicomputer-based system that facilitates the display of alphanumeric identification data on controllers' display scopes. For convenience and simplicity, the ASR/ATCRBS/ARTS system will be referred to simply as "ASR" in this report.

The ASR establishment and discontinuance criteria are derived from a rigorous life-cycle benefit/cost analysis. Benefit/cost analysis, as applied to FAA facilities, equipment and services, is a quantitative evaluation in which the life-cycle capital, operating and maintenance costs of a facility or service are compared with the dollar value of the life-cycle benefits that are expected from that facility or service. Intuitively, benefit/cost ratios of one or more are good investments, while those of less than one are poor investments. Since the capital costs of an ASR system are sunk, the only relevant costs for an ASR system being considered for discontinuance are its recurring operations and maintenance costs (ignoring salvage value, relocation costs, etc.). The other supplemental criteria are not readily adaptable to rigorous benefit/cost analyses for system-wide application because benefits and costs may vary significantly from case to case. In lieu of detailed benefit/cost analyses for these supplemental criteria, activity levels are identified at which there is expected to exist reasonable relationships between benefits and costs. Meeting candidacy levels will not mean automatic qualification. Benefit/cost screening will be but one of several inputs to the FAA decisionmaking process relative to investment in ASR facilities. It will in no way affect the responsibilities of the operating services for the validation of candidates.

SECTION II - REVISED ASR INVESTMENT CRITERIA

This section summarizes the ASR investment criteria addressed in this report. The previous ASR investment criteria are reproduced in Appendix A. As discussed in Section I, the ASR establishment and discontinuance criteria are derived from a rigorous benefit/cost analysis, while the supplemental criteria for improvements, remoted radar bright display scope, TRACAB establishment, TRACON establishment, and TRACAB to TRACON conversion are based on activity levels at or above which marginal benefits are expected to exceed marginal costs. The previous criteria for TRACAB establishment, TRACON establishment and TRACAB to TRACON conversion remain unchanged.

Meeting candidacy levels will not mean automatic qualification. Benefit/cost screening will be but one of several inputs to the FAA decisionmaking process relative to investment in ASR facilities. Investment decisions will be made on the basis of all pertinent factors. These criteria will in no way affect the responsibilities of the operating services for the validation of candidates.

A. ASR Establishment

1. Phase I

ASR establishment criteria for FAA approach control towers are two-phased. Phase I is a set of simple generalized criteria designed to initially identify potential candidates. Under Phase I an airport ratio value is computed by summing the relative contributory benefits of ASR. If the airport ratio value obtained is equal to or greater than 1.0, the location satisfies the Phase I criteria for ASR/ATCRBS/ARTS establishment.

If radar coverage will be provided at or below initial approach altitude at secondary or satellite airports, an area ratio value is computed by summing the airport ratio values of the airports making up the radar service area. The Air Traffic Service will determine eligible locations under the area concept on a case-by-case basis. ASR coverage encompassing two or more airports may dictate changes in the operational responsibilities within the radar service area. Prudent management of resources may require that radar service ultimately be provided from that location, regardless of its current facility status, which can best serve the area.

The computation procedure and nomenclature for Phase I establishment criteria are outlined on the following pages.

Contributing Benefit

Ratio Value

Delay Reduction:

$$\frac{\text{ACPRIM}}{3{,}400 - (.0013 \times \text{PRIM})^{*}} = \text{xxxx}$$

$$\frac{\text{ATPRIM}}{26{,}000 - (.0096 \times \text{PRIM})^{*}} = \text{xxxx}$$

$$\frac{\text{GAPRIM}}{53{,}300 - (.0196 \times \text{PRIM})^{*}} = \text{xxxx}$$

$$\frac{\text{MLPRIM}}{8{,}600 - (.0032 \times \text{PRIM})^{*}} = \text{xxxx}$$

Safety:

$$\frac{\text{ACITN}}{107{,}400} = \text{xxxx}$$

$$\frac{\text{ATITN}}{539{,}600} = \text{xxxx}$$

$$\frac{\text{GAITN + GALCL}}{847{,}200} = \text{xxxx}$$

$$\frac{\text{MLITN + MLLCL}}{376{,}200} = \text{xxxx}$$

Sum of Ratio Values

If 1 or greater, locatio
satisfies Phase I criteria

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*If the denominator for <u>any</u> user class results in a value equal to or less than zero, disregard all denominators and use all of the following instead. For the air carrier user class: 9,300 - (.0034 x PRIM); for the air taxi user class: 71,200 - (.0262 x PRIM); for the general aviation user class: 146,000 - (.0538 x PRIM); and for the military user class: 23,400 - (.0086 x PRIM).

ACPRIM, ATPRIM, GAPRIM and MLPRIM, for a primary airport, are the numbers of annual <u>primary</u> instrument operations of the air carrier (FAR 121, 127 and 129), air taxi (FAR 135), general aviation (FAR 91) and military (FAR 91) user classes, respectively. For a qualified secondary airport, these terms are the numbers of annual primary instrument operations of the secondary airport by user class, <u>or</u> the respective numbers of secondary instrument operations by user class of the primary airport associated with or allocable to the secondary airport, <u>whichever are greater</u>.

PRIM, for a primary airport, is the number of total annual primary instrument operations (i.e., the sum of ACPRIM, ATPRIM, GAPRIM and MLPRIM). PRIM, for a qualified secondary airport, is the number of total annual primary instrument operations of the secondary airport, or the number of total annual secondary instrument operations of the primary airport associated with or allocable to the secondary airport, whichever is greater.

ACITN, ATITN, GAITN and MLITN are the numbers of annual itinerant operations of the air carrier, air taxi, general aviation and military user classes, respectively.

GALCL and MLLCL are the numbers of annual local operations of the general aviation and military user classes, respectively.

2. Phase II

Phase II is a site-specific computerized benefit/cost screening process under which candidates identified under Phase I are further evaluated. If an airport benefit/cost ratio or an area benefit/cost ratio of 1.0 or greater is computed, the location satisfies the Phase II criteria for ASR/ATCRBS/ARTS establishment. The ASR subroutine, integrated into the Terminal Area Forecast Data System, requires the following manual input data:

1. System acquisition and installation costs (FAA Form 2500-40, F&E Cost Estimate Summary).

2. Percent of time that IFR weather prevails at the proposed location, if available. For the purpose at hand, IFR weather is defined as weather in which visibility is less than 3 miles and/or the ceiling below 1,500 feet.

3. Fraction of the air carrier user class represented by each of the following aircraft type categories:

   Turbofan, 4-engine, wide body
   Turbojet, 4-engine
   Turbofan, 4-engine, regular body
   Turbofan, 3-engine, wide body
   Turbofan, 3-engine, regular body
   Turbofan, 2-engine, wide body
   Turbofan, 2-engine, regular body
   Turboprop
   Piston

   If this data is not available from local sources, the Official Airline Guide, or the Terminal Area Forecast Data System, national averages will be used as default values in the Phase II screening process.

4. Fraction of secondary instrument operations of each user class (air carrier, air taxi, general aviation, and military) of the primary airport allocable to each secondary or satellite airport. NOTE: This data is required only for those secondary or satellite airports that are provided "qualified" radar coverage by the proposed candidate airport at or below initial approach altitude.

B. <u>ASR Discontinuance</u>

Like ASR establishment criteria, ASR discontinuance criteria are two-phased. To determine whether an ASR facility meets the Phase I discontinuance criteria, a ratio value is calculated by the same sum-of-ratios approach described above for Phase I establishment criteria. If the ratio value so obtained is less than 0.35, the location satisfies Phase I discontinuance criteria. The 0.35 figure is an approximation of the level where the benefits just offset recurring annual operations and maintenance costs, after allowing for salvage value, relocation costs, etc. Initial acquisition and installation costs are irrelevant when an ASR system is being considered for discontinuance since they are sunk costs. Locations satisfying Phase I discontinuance criteria will be further screened under the Phase II benefit/cost screening process. If the benefit/cost ratio so obtained is less than 0.35, the ASR installation may be considered for discontinuance.

C. <u>Improvements</u>

Existing FAA approach control facilities equipped with ASR systems frequently require improvements (e.g., ARTS implementation, relocation of facilities to correct siting problems, component replacement, etc.). Such improvements are normally made when the operational benefits expected to be realized exceed the costs involved.

1. An FAA radar approach control facility recording 25,000 or more annual instrument operations qualifies for those improvements that satisfy an operational requirement and/or facilitate the provision of terminal area radar service. A benefit/cost study may be required for "major" improvements to terminal radar facilities in this category.

2. An FAA radar approach control facility recording between 15,000 and 25,000 annual instrument operations may be a candidate for improvements. It qualifies for those improvements that satisfy an operational requirement and/or facilitate the provision of terminal area radar service. A benefit/cost study may be required for "major" improvements to terminal radar facilities in this category.

3. An FAA radar approach control facility recording less than 15,000 annual instrument operations is not a candidate for improvements. At that activity level, the additional cost per operation resulting from the improvement is not commensurate with the benefit derived. Any improvement to terminal radar facilities in this category will be limited to the correction of a critical situation and shall be justified by an individual staff study.

NOTE: Improvements to FAA-staffed RAPCON's/RATCF's may be considered on an individual basis but the above criteria shall remain a major determinant in considering FAA civil facilities for improvement.

D. Remoted Radar Bright Display Scope

An FAA VFR control tower at an airport, which is a satellite of the primary airport of a radar approach control facility, is a candidate for a remoted radar display scope in the tower cab when:

1. At least 30,000 annual itinerant operations are recorded; and

2. Operationally adequate low altitude coverage is assured at the satellite airport.

E. Terminal Radar Approach Control in Tower Cab (TRACAB) and Terminal Radar Approach Control (TRACON).

1. Establishment. An initial ASR/ATCRBS/ARTS installation shall be a TRACAB facility consisting of appropriate displays placed in the tower cab except when any of the following situations prevail:

   a. If the official agency forecasts indicate an ASR/ATCRBS/ARTS candidate location will exceed 125,000 annual itinerant operations or 60,000 annual instrument operations within 2 years of the year of budget submission for the facility, the initial installation should be planned as a TRACON rather than a TRACAB, subject to an operational determination by the Air Traffic Service. Instrument operations at secondary airports may be included in this forecast provided radar coverage at these locations is expected to exist at or below initial approach altitude.

   b. If an ASR/ATCRBS/ARTS candidate location cannot physically accommodate radar approach control in the tower cab, then individual justification shall be required to go directly to a TRACON facility.

   c. When the complexity of the facility operation warrants, individual justification and consideration shall be given to locating the ASR/ATCRBS/ARTS in a TRACON rather than a TRACAB.

2. Discontinuance. A TRACAB will be discontinued when the ASR system is decommissioned or when the radar approach control function is transferred to a TRACON.

3. Conversion to TRACON. A TRACAB location is a TRACON candidate when the facility has at least 125,000 annual itinerant operations or 60,000 annual instrument operations. Instrument operations at secondary airports that receive radar service at or below initial approach altitude may be included in this count. Also, when the complexity of the facility warrants, individual justification and consideration should be given to relocating from a TRACAB to a TRACON.

SECTION III - ASR COSTS

ASR costs and their life-cycle counterparts are shown in Figure 1 for an ASR installation configured as a TRACAB and in Figure 2 for an ASR installation configured as a TRACON. The total cost of an ASR system consists of facilities and equipment costs plus operations and maintenance costs. Facilities and equipment costs consist of equipment, installation and commissioning flight check costs. Operations and maintenance costs consist of such annual recurring costs as air traffic staffing, support (airway facilities staffing, spares, training, etc.) and utilities. It may be noted that while the average installed system acquisition cost of the solid-state ASR-9 is higher than that of the earlier vacuum-tube ASR models, the operations and maintenance costs are significantly lower. Life-cycle costs are calculated by discounting total operations and maintenance costs over the assumed 15-year economic life of an ASR system to their present value and adding them to facilities and equipment costs, which are assumed to occur at the beginning of the installation year. An ASR's economic life, as opposed to its physical life, provides a more relevant measure of its useful service life. A fifteen year economic life is consistent with published guidelines on transportation-related capital stocks (e.g., Reference 30). Even if a longer life was assumed, the impact would be nominal, because the costs and benefits in the out years are heavily discounted.

The facilities and equipment costs in Figures 1 and 2 include no allowances for remoted radar bright display installations or "leap-frogging" (i.e., the practice of replacing an already existing older generation ASR with a state-of-the-art ASR and relocating the older generation ASR to a newly qualifying site). When either or both of these actions are contemplated, appropriate adjustments should be made to facilities and equipment costs.

Once an ASR is established, the terminal air traffic control facility is organized as either a TRACAB (where the radar control area is located in the air traffic control tower with the usual cab positions) or a TRACON (which entails a separate IFR control room). Early difficulties were experienced with the utilization of the radar display scope in the tower cab due to the high ambient light level and space congestion. With existing improvements in BRITE display performance and tower cab layout, current opinion suggests that the TRACAB concept is feasible at some maximum level of hourly operations. Thus, the impact of adding a separate TRACON or IFR room is simply to relieve any congestion in the tower cab that might exist.

The addition of an IFR control room to a TRACAB increases costs in two ways. First, an extra flight data position (located in the TRACON) is generally required because of the coordination problem created by the physical separation of the controllers. Second, the additional construction and remoting costs of the IFR room must be added. The manpower cost is relatively constant, but the construction and remoting costs of the IFR control room are highly site-dependent. In some cases, existing structures might be used and/or space may be available close to the tower. In others, new construction may be required, possibly at some distance from the tower. Thus, a TRACAB is more economical and preferable if it is operationally feasible. TRACAB/TRACON criteria are outlined in paragraph E of Section II.

The decision to organize as a TRACAB or TRACON rests on current and projected traffic activity, and whether the less costly, but capacity limited, TRACAB configuration is adequate. The criteria developed in this report presume the establishment of the TRACAB configuration unless one or more of the criteria for establishing a TRACON (as outlined in paragraph E of Section II) are satisfied.

The assumed initial staffing level of five controllers per ASR facility is based on the Air Traffic Staffing Standards System (Reference 3). This Standard reflects Air Traffic Service judgment and experience in determining staffing levels necessary to provide safe separation and efficient flow of traffic. It is important to note that the assumption is not that there would be five air traffic control specialists assembled around the radar displays in the tower cab. The Standard provides that a minimum of three controllers is needed to operate the radar over a two-shift operating day. To allow for seven-day staffing and training, a standard factor of 1.6 is applied. Three times 1.6 yields 4.8, showing that five additional controllers must be employed to initially staff the least elaborate terminal radar configuration in the system.

Current FAA policy establishes Expanded Radar Service (ERS) at each new ASR/TRACAB facility within six months after commissioning. When the ERS is established (either Stage II which provides sequencing and advisory services or Stage III which provides sequencing and separation services), the services provided contribute toward the total instrument count at the facility, and therefore, require a concomitant increase in staff. It is current practice to request three additional controllers (in addition to the five necessary to initially establish radar approach control service) for the ERS capability when a new facility is established as a TRACAB, making a total of 8 controllers.

FIGURE 1

Typical Life-Cycle ASR/ATCRBS/ARTS Costs - TRACAB Configuration (ASR-9)

	Cost (1980 $)	10% Discount Factor	15-Year Discounted Costs
Facilities and Equipment:			
System acquisition cost (installed)1/	$6,200,000	1.000	$6,200,000
Operations and Maintenance:			
Air Traffic staffing (8 additional controllers @ $36,0762/)	$ 288,608		
Support (Airway Facilities staffing, spares, training, etc.)	54,600		
Utilities	4,700		
Total O&M	$ 347,908	7.9763/	2,774,914
Total Discounted Life-Cycle Cost			$8,974,914 or $8,970,000

1/Does not include costs for remoted radar bright display installations and leap-frogging (see text).

2/GS-12/5 salary of $27,995 over 9 months and $30,543 over 3 months equates to a weighted 1980 salary of $28,632. Inflating this salary level by a fringe benefits overhead factor of 1.26 (per Reference 4) yields $36,076 per controller in 1980 dollars.

3/Future year costs are discounted to their present values using mid-year rather than end-of-year discount factors ($\sum(1/(1.1)^{y-0.5})$), for y = 1 to 15).

Sources: AAF-356 and Reference 3.

FIGURE 2

Typical Life-Cycle ASR/ATCRBS/ARTS Costs - TRACON Configuration (ASR-9)1/

	Cost (1980 $)	10% Discount Factor	15-Year Discounted Costs
Total Discounted Life-Cycle Cost of TRACAB (from Figure 1)			$8,970,000
Incremental Costs of TRACON:			
Additional flight data positions (2 @ $36,076 2/)	$ 72,152	7.976 4/	575,484
Building of IFR room 3/	$180,000	1.000	180,000
Equipment relocation and cabling	$ 19,000	1.000	19,000
Additional support & utilities	$ 2,000	7.976 4/	15,952
Total Discounted Life-Cycle Cost			$9,760,436 or $9,760,000

1/ As explained in the text, actual costs may vary considerably from site to site. Site-specific costs should be used in actual practice. As with the TRACAB cost estimates in Figure 1, no allowances have been made here for remoted radar bright display installations and leap-frogging (see text).

2/ See Footnote 2 of Figure 1.

3/ New building:

Construction of a minimum 3,000 sq. ft. base building @ $100 per sq. ft.	$300,000	
Site preparation of existing leased space for TRACON	30,000	
Total	$330,000	
x Assumed incidence rate of 50%	x.50	$165,000
Modification of existing facilities: $30,000 x assumed incidence rate of 50%		$ 15,000
Expected cost		$180,000

4/ Future year costs are discounted to their present values using mid-year rather than end-of-year discount factors ($\sum(1/(1.1)^{y-0.5})$), for y = 1 to 15).

SECTION IV - METHODOLOGY FOR ESTIMATING ASR BENEFITS

A. Introduction

An ASR approach control facility, as opposed to a manual approach control facility, can provide benefits through two primary sources: reduced delays to aircraft operating under instrument flight rule (IFR) conditions made possible by reducing separations below those required by manual procedures; and reduced risks of midair and terrain collisions in the terminal area through the application of radar separation services. Secondary benefits provided by an ASR include visual flight rule (VFR) radar advisory service, radar flight assists and convenience. This section details the methodology used to quantify these benefits. Before addressing the benefits in detail, however, the more significant differences in benefit methodology are highlighted between the previous and revised criteria.

First, unlike the previous benefits methodology, the revised Phase I methodology extends credit for radar services provided to all user classes, rather than focusing on the air carrier user class.

Second, in response to many suggestions that ASR establishment criteria be modified to allow credit for radar coverage provided to secondary or satellite airports, this report introduces the "area concept" of providing qualified radar service to multiple airport sites having a common need for radar surveillance. Under this concept, benefits will be ascribed and computed for the secondary airport(s) as well as the primary airport when the airport traffic areas are in a proximity which causes constant overlap of arrival and departure routes. The activity of secondary airports may be included if the siting of the ASR can be expected to provide coverage at or below initial approach altitude at the secondary airport(s). The Air Traffic Service will determine eligible locations in this category.

The methodology employed in determining total benefits of multiple airport sites having a common need for an ASR system is as follows. Because both delay reduction and safety benefits outlined in this report are non-linearly related to activity, each of the airports in the potential radar service area will be addressed independently, i.e., a benefit/cost ratio will be computed for each airport making up the radar service area. An area ratio will be computed by summing the respective airport ratios. ASR coverage encompassing two or more airports may dictate changes in the operational responsibilities within the radar service area. Prudent management of resources may require that radar service ultimately be provided from that location, regardless of its current facility status, which can best serve the area.

Third, the revised benefits methodology is more site-specific. In the previous criteria, benefits were based only on the aviation activity for the first year of the ASR's operation and costs were annualized. Changes in aviation activity growth were not represented in the benefits calculation. The revised benefits methodology uses official aviation activity forecasts by quantifying the benefits independently for each year of an ASR's estimated 15-year economic life and discounting the benefits for each year to their present value. These are summed to represent the present value life-cycle benefits. An ASR's economic life, as opposed to its physical life, provides a more relevant measure of its useful service life. A fifteen year economic life is consistent with published guidelines on transportation-related capital stocks (e.g., Reference 5). Even if, a longer life were assumed, the impact would be nominal, because the benefits and costs in the out years are heavily discounted.

Lastly, the revised benefits methodology incorporates updated economic or critical values, including the value of time of aircraft passengers/occupants, the value of a statistical life, the cost of a statistical serious injury, aircraft replacement and restoration costs and aircraft variable operating costs.

B. <u>IFR Delay Reduction Benefits</u>

The establishment of an ASR at an approach control tower provides controllers with a visual representation of their traffic. It permits the use of reduced separation standards during IFR conditions and provides controllers with the capability of vectoring arrival and departure traffic, thereby increasing the utilization of the terminal area airspace and expediting the flow of traffic.

A National Bureau of Standards report, <u>A Concept for New Establishment Criteria for Airport Surveillance Radar</u> (Reference 6), prepared under an interagency agreement with the FAA, derived radar-preventable delays for various traffic mixes and levels of operation. When used in conjunction with unit delay costs, IFR delay reduction benefits attributable to an ASR can be readily obtained. NBS's DELCAP simulation model was used to obtain estimates of delay with and without ASR available. Since delay reduction benefits of ASR are realized principally under IFR conditions, IFR separation rules were used. It was assumed that ASR would permit minimum spacing (3 nautical miles for the type of airport relevant to this report) to be maintained at high levels of traffic, while without ASR various manual procedures would result in average spacings of 7.5, 10, and 15 nautical miles at the same traffic levels. It was further assumed that the airports in question would be operating in a single runway configuration when IFR conditions prevailed.

Two user classes, whose pertinent flight characteristics are given below, were used in the simulation runs. The flight characteristics of the general aviation user class are also attributed to the air taxi and military user classes in this report.

Flight Characteristics

	Speed (Knots)		Runway Occupancy (Seconds)	
User Class	Landing	Liftoff	Landing	Takeoff
General Aviation (GA)	90	90	35	25
Air Carrier (AC)	125	120	34	32

Four mixes of these user classes were run: 10 percent GA - 90 percent AC; 20 percent GA - 80 percent AC; 40 percent GA - 60 percent AC; and 80 percent GA - 20 percent AC. Five traffic activity levels were simulated: 10, 15, 20, 25, and 30 operations per hour. The distributions of the number of arriving aircraft was assumed to be Poisson. In each case, it was assumed that half of the operations are landings and half are takeoffs.

Delay was calculated for each aircraft, takeoff and landing, as the difference of the flight time actually required from that which would have occurred had no other aircraft been present. The calculations of the delays in landings plus the delays in takeoffs are shown in Figure 3. The values listed in Figure 3 are the average of the results obtained from 20 simulation runs utilizing different strings of random numbers for generating the arrivals. They represent total delay per hour of airport operation of aircraft landing and taking off for each of the 4 mixes of aircraft for airports operating in 4 different approach environments; i.e., 3, 7.5, 10, and 15 nautical mile separation of aircraft.

The ultimate capacities listed in Figure 3 were calculated as shown in the following example. At the 10 nautical mile separation, the average time between the touchdown of one aircraft and the touchdown of a following general aviation aircraft is:

$$\frac{\text{10 nautical miles}}{\text{90 knots}} = 0.11 \text{ hour}$$

and the average time between the touchdown of one aircraft and the touchdown of a following air carrier aircraft is:

$$\frac{\text{10 nautical miles}}{\text{125 knots}} = 0.08 \text{ hour}$$

At the 80 percent AC traffic mix, the probability of the landing aircraft being AC is 0.80, and the probability of the landing aircraft being GA is 0.20.

Therefore, the average time required per landing aircraft is:

$$(.08 \times .80) + (.11 \times .20) = 0.086 \text{ hour}$$

which yields an average rate of 11.6 landing aircraft per hour with no takeoffs. In this example, i.e., 10 nautical mile separation, the separation between landing aircraft is great enough to permit takeoffs without affecting the sequence of landings. Therefore, since half of the operations are landings and half takeoffs, the total potential operations per hour is 23 under the conditions stated. Since these conditions can be considered as "ideal" relative to the actual conditions under which an airport operates, the capacities computed in this manner are considered "ultimate." A slower aircraft landing ahead of a faster aircraft will generate a delay. This factor becomes evident when the plots of the total delay for a 60 percent AC mix are compared with higher and lower percentages of AC aircraft, as illustrated in Figure 4.

FIGURE 3

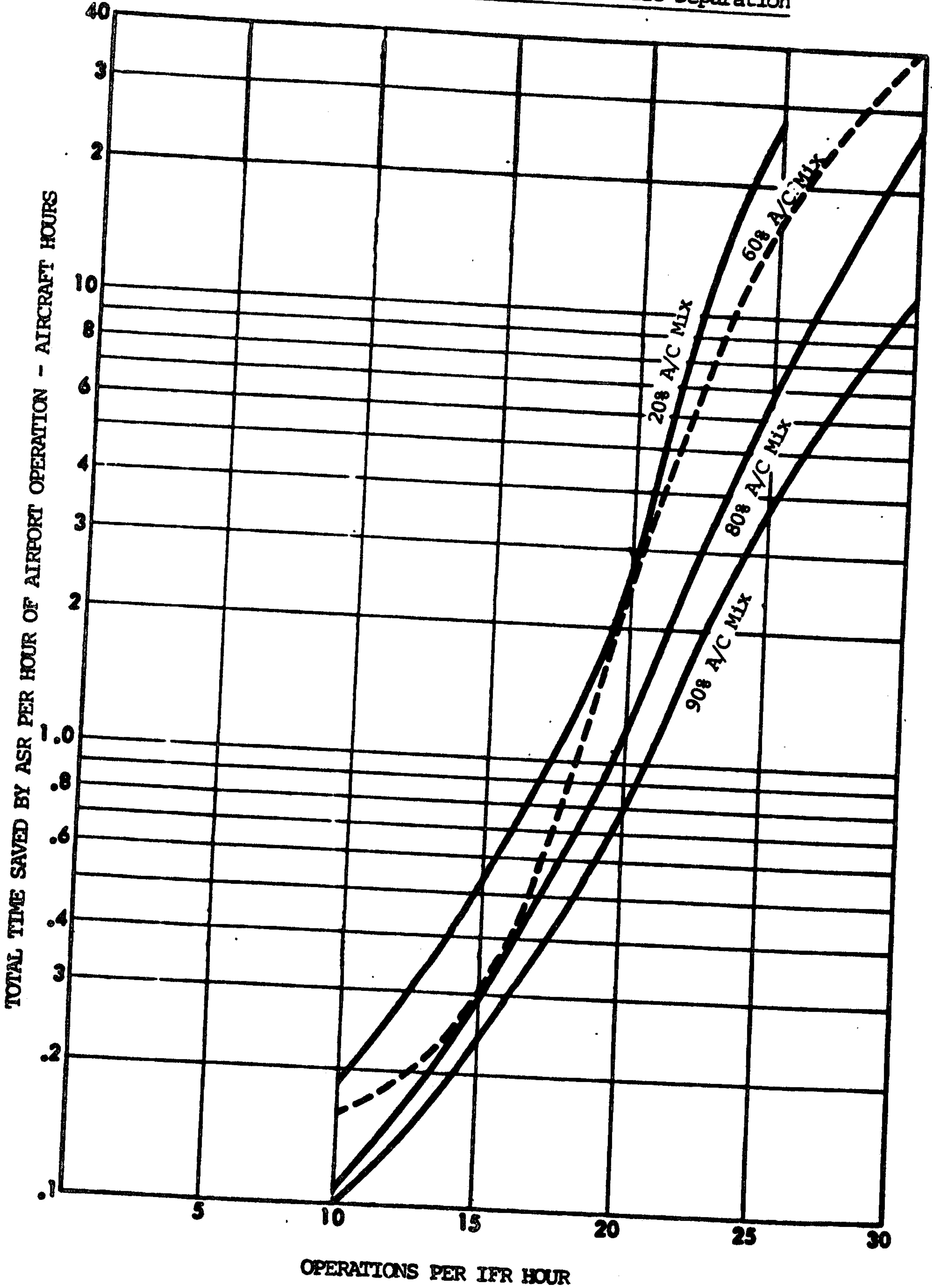
Total Minutes of Aircraft Delay Per Hour of Airport Operation for Varying Numbers of Operations Per Hour

Operations per Hour	90% A/C	80% A/C	60% A/C	20% A/C
3 Nautical Mile Separation				
10	8.7	10.6	11.6	18.8
15	15.7	22.3	31.6	34.1
20	32.5	41.5	52.7	54.4
25	56.7	68.1	79.0	86.2
30	83.8	95.1	102.8	111.8
7.5 Nautical Mile Separation				
10	14.7	16.9	21.2	29.9
15	30.0	39.8	49.1	68.2
20	81.5	106.3	185.3	194.8
25	283.6	472.2	1,061.2	1,701.0
30	744.0	1,549.0	2,620.0	O/C
Ultimate Capacity (opns./hr.)	(32)	(31)	(30)	(26)
10 Nautical Mile Separation				
10	21.9	28.1	33.5	43.2
15	48.6	51.5	82.6	119.9
20	299.1	444.4	889.4	O/C
Ultimate Capacity (opns./hr.)	(24)	(23)	(22)	(19)
15 Nautical Mile Separation				
10	57.0	65.3	79.4	129.5
15	153.8	171.1	O/C	O/C
Ultimate Capacity (opns./hr.)	(16)	(15)	(14)	(12)

O/C = over capacity

FIGURE 4

Time Saved By ASR: 3 Mile vs. 7.5 Mile Separation



In general, at the lower levels of operations per hour, the delay for takeoffs is greater than that for landings since the landing aircraft always have priority. However, as the ultimate capacities are approached, the simulation model permits landing delays to exceed delays in takeoffs to avoid an excessive departure queue.

Additional simulation runs were made at the 3 and 7.5 nautical mile separations increasing the runway occupancy for landing AC aircraft from 34 seconds to 60 seconds. No significant differences in the total delays were apparent for this increase. However, the data suggests that runway occupancy periods of over 60 seconds can become critical when computing delays for a 3 nautical mile separation distance.

For purposes of this report, total delay differentials shown in Figure 3 between the 3 and 7.5 nautical mile separation standards have been converted to average delay savings per aircraft for varying numbers of operations per hour of airport operation, as illustrated in Figure 5. Figure 4 graphically illustrates total aircraft hours saved by ASR per hour of airport operation by lowering the separation standard from 7.5 to 3 nautical miles for the 20%, 60%, 80% and 90% AC mixes.

Given the NBS methodology described above for deriving hourly IFR delay differentials between radar and non-radar environments for various hourly activity levels, the following additional data must be determined in order to compute IFR delay reduction benefits for a specific site:

1. Number of operations during a busy IFR hour;

2. Hourly cost of delay of the aircraft type mix, and

3. Frequency of busy IFR hour

An "IFR hour" is defined as one during which instrument approach weather conditions prevail, usually a ceiling of 1,500 feet or less and/or visibility of 3 miles or less. It is recognized that radar can reduce delays by reducing separation when instrument conditions exist at high altitudes as well. However, data on the frequency of occurrence of "better" IFR weather, e.g., 4000-5, is not available and the 1500-3 observations, which are available (Reference 7), are thought to approximate total IFR conditions closely enough for this purpose. A "busy" IFR hour, as the term connotes, is as an hour during which high instrument operations activity takes place. To estimate the number of operations during a busy IFR hour, a regression analysis between reported busy IFR hour operations and annual instrument operations was performed for 252 towered airports (after omitting outliers). The results of this analysis are presented in Appendix B and summarized in Figures 6 and 7. The data upon which this regression analysis is based were obtained from periodic counts made by tower personnel during periods of known high instrument operations activity (Reference 8). After determining the number of operations during a busy IFR hour and the percent of instrument operations represented by the air carrier user class, the time saved per aircraft per hour of airport operation can be found by referring to Figure 5.

FIGURE 5

Hours Saved per Aircraft for Varying Numbers of Operations Per Hour of Airport Operation
(3 vs. 7.5 nautical mile separation)

Operations/ Busy IFR Hour	Percent Air Carrier Instrument Mix							
	90%	80%	70%	60%	50%	40%	30%	20%
10 or less	.010	.011	.013	.016	.017	.017	.018	.018
11	.011	.012	.014	.016	.017	.017	.019	.021
12	.012	.013	.014	.016	.018	.018	.020	.022
13	.013	.014	.015	.016	.018	.019	.023	.027
14	.014	.016	.017	.018	.020	.021	.026	.030
15	.017	.020	.020	.021	.023	.025	.031	.036
16	.019	.023	.023	.024	.027	.030	.037	.044
17	.022	.028	.029	.029	.033	.036	.045	.053
18	.028	.033	.037	.043	.050	.060	.069	.078
19	.032	.042	.053	.070	.080	.085	.089	.095
20	.040	.055	.075	.110	.113	.115	.118	.120
21	.052	.076	.105	.176	.183	.190	.195	.200
22	.068	.109	.150	.264	.277	.291	.327	.364
23	.087	.152	.217	.374	.404	.435	.500	.565
24	.125	.200	.308	.425	.504	.583	.708	.833
25	.152	.272	.480	.640	.720	.800	.940	1.080
26	.185	.346	.615	.808	.923	1.038	1.212	1.385
27	.222	.444	.667	.963	1.093	1.222	1.426	1.630
28	.271	.536	.786	1.107	1.268	1.429	1.607	1.786
29	.310	.655	.931	1.241	1.414	1.586	1.759	1.931
30 or more	.367	.800	1.033	1.400	1.567	1.733	1.900	2.067

FIGURE 6

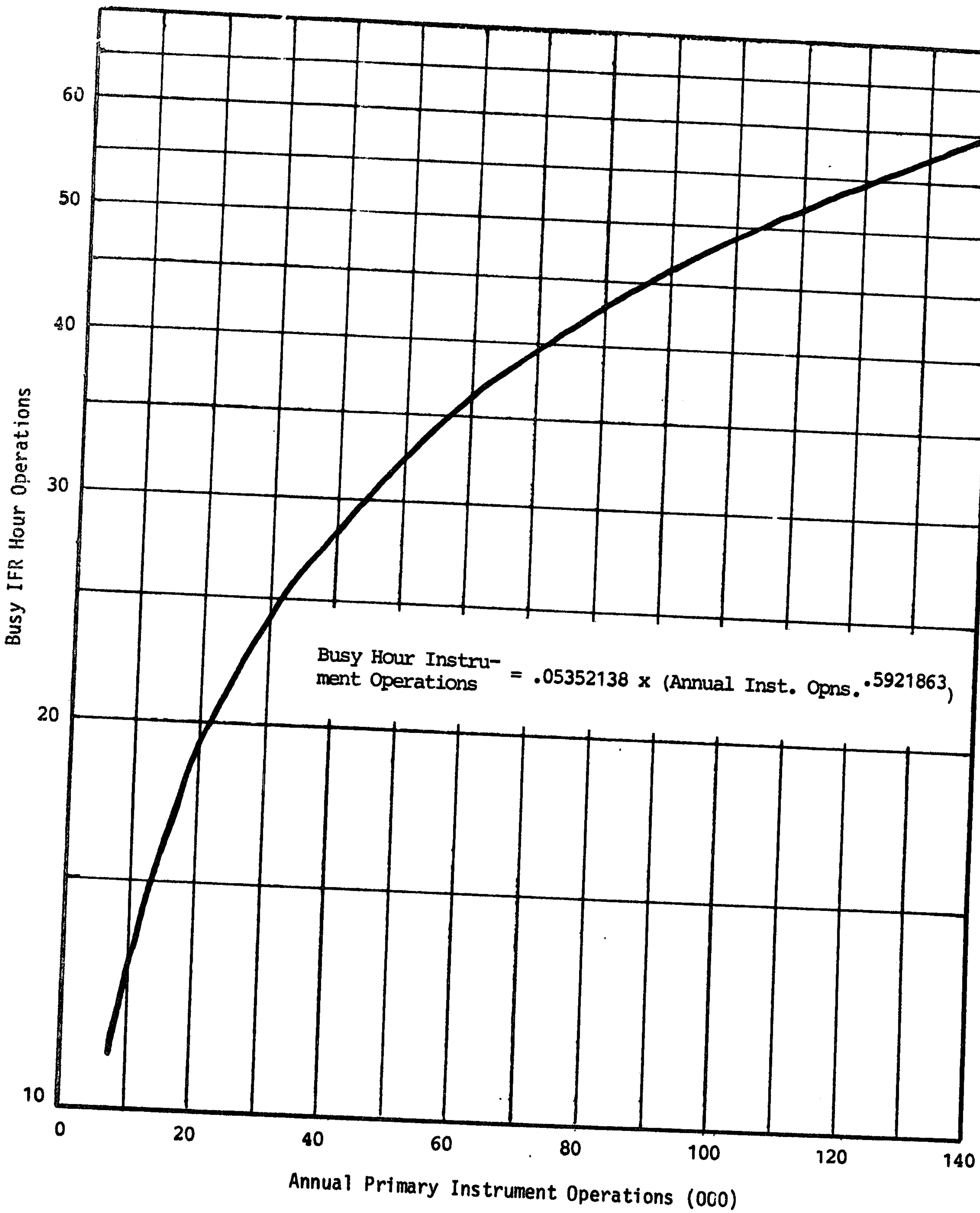
Relationship Between Busy IFR Hour Operations and Annual Instrument Operations Based on Regression Analysis of 252 Towered Airports

IFR BUSY HOUR OPNS	RANGE OF ANNUAL INSTRUMENT OPNS
0	0-43
1	44-277
2	278-658
3	659-1,163
4	1,164-1,778
5	1,779-2,495
6	2,496-3,309
7	3,310-4,214
8	4,215-5,206
9	5,207-6,281
10	6,282-7,438
11	7,439-8,673
12	8,674-9,985
13	9,986-11,371
14	11,372-12,829
15	12,830-14,359
16	14,360-15,958
17	15,959-17,625
18	17,626-19,359
19	19,360-21,159
20	21,160-23,023
21	23,024-24,952
22	24,953-26,943
23	26,944-28,996
24	28,997-31,110
25	31,111-33,284
26	33,285-35,518
27	35,519-37,810
28	37,811-40,161
29	40,162-42,570
30	42,571-45,035
31	45,036-47,556
32	47,557-50,133
33	50,134-52,766
34	52,767-55,453
35	55,454-58,194
36	58,195-60,989
37	60,990-63,838
38	63,839-66,739
39	66,740-69,692
40	69,693-72,697
41	72,698-75,754
42	75,755-78,862
43	78,863-82,021
44	82,022-85,230
45	85,231-88,490
46	88,491-91,799
47	91,800-95,157
48	95,158-98,564
49	98,565-102,020
50	102,021-105,525
51	105,526-109,078
52	109,079-112,678
53	112,679-116,326
54	116,327-120,021
55	120,022-123,764
56	123,765-127,553
57	127,554-131,388
58	131,389-135,270
59	135,271-139,198
60	139,199-143,171
61 and over*	

*Busy hour instrument operations for higher activity levels may be found by solving the formula in Figure 7.

FIGURE 7

Relationship Between Busy IFR Hour Operations and Annual Primary Instrument Operations Based on Regression Analysis of 252 Towered Airports



Basing estimates of annual delay costs on the relatively few hours of the day that are "busy" may appear to understate those costs. However, delays increase exponentially with increases in traffic activity, and the rise is very rapid as the operations rate approaches capacity. Omitting the lower activity hours, therefore, will have little impact on total annual delays, and that impact will be offset on those occasions when higher rates of operation are experienced.

Total hours of aircraft delay per hour of airport operation multipled by average delay costs per hour yields the total cost of delay generated during one hour of airport operation. Delay costs include aircraft variable operating costs and the value of aircraft passengers'/occupants' time. "Aircraft variable operating costs," as used in this report, include the costs of flight crews (for air carrier and air taxi), fuel and oil, and direct maintenance of airframe, avionics and engine. Depreciation, amortization of capital leases, insurance, hangar and tie-down fees, and other costs of a fixed or semi-fixed nature are considered irrelevant for purposes of measuring the cost of delay. The value of time of aircraft passengers/occupants and aircraft variable operating costs used in this report were taken from Reference 9. Hourly delay costs by aircraft type are illustrated in Appendix C and weighted and summarized by user class in Figure 8.

FIGURE 8

Delay Cost Per Hour By User Class
(1980 Dollars)

User Class	Weighted Aircraft Variable Operating Cost/Hour	Weighted Number of Passengers/Occupants1/	Value of Occupants' Time @ $17.50/Hour	Total Delay Cost/Hour
Air Carrier	$1,169	45.7	$800	$1,969
Air Taxi2/	174	4.8	84	258
General Aviation	79	2.7	47	126
Military	709	4.2	74	783

Sources: Appendices C, E-1 and E-2. Data are weighted by the expected mix of aircraft types within each user class at potential establishment candidate airports.

1/Because crew salaries are included in air carrier and air taxi variable operating costs, "passenger" load factors are used. "Occupant" load factors are used for the general aviation and military user classes.
2/Air taxi includes air commuter aircraft.

Reference 10 provides an indication of percentage of traffic activity on an hourly basis for air carrier, general aviation, and military aircraft. Examining the data, heavy airport activity with respect to operations takes place for about 4 hours a day during weekdays and 2 hours a day during weekends, or about 1,252 hours a year. Reference 7 documents the percentage of IFR weather from samplings of hourly airport weather observations segmented on a monthly basis and on an annual basis by 8-hour differentials for 271 airports. The Terminal Area Forecast Data System, maintained by FAA-APO, also contains IFR weather data for many locations. Multiplying 1,252 hours by the average annual IFR occurrence rate gives an estimate of the number of times a year a busy IFR hour occurs.

In order to determine the annual delay reduction benefits of ASR, the delay time avoided per busy IFR hour is multiplied by the frequency that the busy IFR hour occurs in a year. The product yields the total time of preventable delay. This product multiplied by the hourly cost of delay (Figure 8) yields the dollar benefits of annual IFR delay reduction. The life-cycle value of IFR delay reduction benefits is derived by computing and summing this value for each year of an ASR's 15-year economic life and discounting to the present value equivalent, or:

$$\sum_{y=1}^{15} \left\{ \text{DELTOT}_y \times 1/(1+d)^{y-0.5} \right\}$$

where 'y' is each of 15 years of an ASR's economic life, 'DELTOT' is the nondiscounted IFR delay reduction benefits in year 'y', and 'd' is the OMB-prescribed discount rate of ten percent. In cases where qualifying radar service is provided by the airport to secondary airports under the "area concept" outlined in the introduction to this section, delay reduction benefits are computed independently for each of the respective airports.

An application of the above methodology in a manual computation of the benefits of IFR delay reduction is illustrated in Section V. In actual practice, this computation will be performed by a computer program in the Phase II benefit/cost screening process.

C. Safety Benefits

This section examines the measurement of safety provided by an ASR from the standpoint of avertable midair and terrain collisions, VFR radar advisory service and radar flight assists.

1. Collision Analysis

Two kinds of aircraft accident risks can potentially be reduced by ASR systems - midair collision and terrain collision risks. The benefits of the expected reduction of these types of accidents are outlined in this section. Midair collisions, while not the most common form of accident, are a major concern of all facets of the air traffic control process. The air traffic control system maintains specified separation minima between aircraft while trying to expedite the movement of traffic so as to decrease delays to users of the system. The large number of aircraft flying under visual flight rules in the typical ARTS terminal compounds this problem, especially during peak periods. The second kind of accident which can be potentially reduced by ASR systems is terrain collision accidents. ARTS II enhances the ability of the terminal air traffic control system to reduce the incidence of such accidents by its Minimum Safe Altitude Warning (MSAW) and Conflict Alert (CA) features.

a. Midair Collision Analysis

The availability of an ASR/ATCRBS/ARTS system provides a mechanism for reducing the risk and incidence of midair collisions. The basic data used to derive upper bound midair collision avoidance benefits in this report is from the Civil Aviation Midair Collisions Analysis (Reference 11), performed by the MITRE Corporation in 1973, and the 1974 addendum to that report (Reference 12). The data was derived from National Transportation Safety Board accident reports for the nine year period between January 1964 and December 1972. Although the analyses are somewhat aged, their results are generally consistent with those of more contemporary analyses, as indicated in the footnote to Figure 9. The total midair collisions (and associated fatalities) were segregated according to the place of occurrence (airport, enroute, or terminal area), circumstance of collision (runway, midair, nature of ATC control, etc.) and, in the case of airport area collisions, whether the airport was controlled or not.

Figure 9 provides a tabular summary of the results of regression analyses of airport area collisions over an eight year period at uncontrolled, controlled and VFR-towered airports from Reference 11. "Airport area" is defined as the airspace within 5 nautical miles of the airport. The general form assumed was $c = an^b$, where 'c' is the average number of collisions per airport over the period January 1964 - December 1971, 'a' and 'b' are the coefficients which yielded the least error between the actual and estimated numbers of collisions, and 'n' is the average number of aircraft operations per airport in 1971 in units of 100,000. The 1972 collision data provided by Reference 12 did not change the formulae.

FIGURE 9

<u>Summary of Airport Area Collision Regression Analyses*</u>

Airport Category	Best Collision Estimator (c) For January 1964-December 1971
Uncontrolled	$0.13n^{0.92}$
Controlled	$0.048n^{1.54}$
VFR Towers	$0.028n^{2.3}$

*These formulae are applicable only over a relevant range of activity.

When scaled to an annual basis by a scaling factor of 7 to account for activity growth over the eight year period, the airport collision formulae become $.019n^{0.92}$ and $.007n^{1.54}$ for uncontrolled and controlled airports, respectively. The latter is consistent with more contemporary but preliminary work done by Graham and Faison (Reference 13) which yields a formula of $(n/10)^2/2.3902$ for controlled airports, again with n in 10^5 operations. The rationale for the third category, "VFR towers," is that none of the collisions at controlled airports occurred between aircraft which were sequenced on radar by the approach control facility. Rather, the collisions typically occurred at very busy general aviation airports where a busy local controller, without the benefit of a BRITE display, was responsible for procedurally sequencing all aircraft to the runway. Thus, this category represents an attempt to get at the subset of all controlled airports which actually produced the observed collisions, i.e., the "VFR tower" airports. It is this formula upon which the benefits of radar-preventable midair collisions are based in this report.

The data base from which this relationship was derived included 296 midair collisions between January 1964 and December 1972. Thirty-four ASR-preventable midair collisions occurred within five miles of controlled airports: 2 IFR-VFR collisions and 32 VFR-VFR collisions. The airport area is defined as the airspace within 5 nautical miles of the airport. An additional 52 ASR-preventable midair collisions occurred in terminal areas outside the airport area: 1 IFR-IFR collision, 12 IFR-VFR collisions and 39 VFR-VFR collisions. The terminal area is defined at the airspace within 30 nautical miles of the airport. Thus, for a nine year period, there were 86 airport and terminal area midair collisions potentially avertable by today's ASR-9. If terminal area collisions are distributed approximately in proportion to airport collisions, an <u>upper bound</u> for the expected number of <u>annual</u> midair collisions avertable by ASR can be estimated by:

$$\frac{86}{34} \times \frac{0.028n^{2.3}}{7} = .010n^{2.3}$$

where n is the number of annual aircraft operations in units of 100,000 or 10^5. Based on this formula, Figure 10 outlines expected numbers of ASR-preventable midair collisions within the relevant range of activity for new ASR establishment locations.

FIGURE 10

Relationship Between Total Aircraft Operations and Number of Avertable Midair Collisions Expected by ASR

Annual Aircraft Operations (000)	Expected Number of Annual Avertable Midair Collisions*
50	.002
55	.003
60	.003
65	.004
70	.004
75	.005
80	.006
85	.007
90	.008
95	.009
100	.010
105	.011
110	.012
115	.014
120	.015
125	.017
130	.018
135	.020
140	.022
145	.024
150	.025
155	.027
160	.029
165	.032
170	.034
175	.036
180	.039
185	.041
190	.044
195	.046
200	.049

Source: Reference 11

*The expected number of avertable midair collisions may be approximated by solving for $.010n^{2.3}$, where n is the number of annual aircraft operations in units of 100,000.

The equation used to estimate the number of preventable midair collisions as a function of total operations in this report yields significantly fewer collisions than the equation used in the current establishment criteria (Reference 2). Appendix F of Reference 11 contains a complete discussion of the merits of the formula used here versus the one used in Reference 2.

The costs of a midair collision include damage to aircraft, the value of lives lost and the costs of injuries. Collision losses used in the development of the criteria in this report are based on the unit values and costs outlined in Reference 9 and illustrated in Appendix D to this report. Expected midair collision costs per aircraft per involvement are illustrated in Figure 11. The expected number of preventable midair collisions multiplied by the appropriate collision costs for various classes of aircraft yields the estimated midair collision avoidance benefits credited to the establishment of an ASR. The life-cycle value of midair collision avoidance benefits is derived by computing and summing the expected value for each year of an ASR's 15-year economic life and discounting to the present value equivalent, or:

$$\sum_{y=1}^{15} \left\{ \mathrm{MACTOT}_y \times 1/(1+d)^{y-0.5} \right\}$$

where 'y' is each of an ASR's 15-year economic life, 'MACTOT' is the nondiscounted midair collision avoidance benefits in year 'y,' and 'd' is the OMB-prescribed discount rate of ten percent.

The application of the above factors in a manual computation of the safety benefits of ASR is illustrated in Section VII. In actual practice, this computation will be performed by a computer program in the Phase II benefit/cost screening process.

FIGURE 11

Expected Midair Collision Costs per Aircraft per Involvement
(Thousands of 1980 Dollars)

User Class	Costs of Fatalities and Injuries	Cost of Aircraft Damage	Total Costs
Air Carrier	$12,446	$1,871	$14,317
Air Taxi*	1,176	111	1,287
General Aviation	553	66	619
Military	1,038	1,108	2,146

Sources: Appendices D, E-1 and E-3. Data are weighted by the expected mix of aircraft types within each user class at potential establishment candidate airports.

*Air taxi includes air commuter aircraft.

b. Terrain Collision Analysis

The major sources of safety benefits provided by ARTS was found in a report entitled ARTS II Enhancements Costs and Benefits (Reference 14) to be its Mininum Safety Altitude Warning (MSAW) and Conflict Alert (CA) features. Benefits generated from MSAW result from the prevention of terrain collisions while those from CA result from the prevention of midair collisions. Since the preceding section on midair collisions derives the total expected difference in incidence of midair collisions between radar and non-radar environments, no further benefits are ascribed to CA because to do otherwise would potentially result in double counting. The benefits attributable to preventable terrain collisions outlined below are from the above referenced report, updated to reflect the value of a statistical life and aircraft replacement values (from Reference 9). The analysis of aircraft accidents used a series of National Transportation Safety Board files for accidents occurring near ARTS II candidate airports between 1967 and 1972 (during and at which 41,540,000 aircraft operations took place). There were 104 fatal accidents at or near the ARTS II sites during this period. Nineteen of these were collisions with the terrain or obstructions and were considered potentially preventable by MSAW. In this group were 44 fatalities and 19 general aviation aircraft destroyed. No air carrier aircraft were involved in any of these preventable accidents.

The benefits associated with MSAW can be calculated using the annual cost of preventable terrain collision accidents. The total value of the lives and aircraft lost in the 19 fatal accidents over the six year period was $24,384,000 or $0.587 per operation, calculated as follows:

44 fatalities x $530,000 =	$23,320,000
19 GA aircraft x $56,000 =	1,064,000
Total	$24,384,000
Operations	41,540,000
Loss per operation	$ 0.587

Since all of the fatal terrain collision accidents involved general aviation aircraft, MSAW would only be effective if the aircraft were equipped with altitude encoders. The preventable loss must be adjusted since MSAW works only with altitude data. Figure 12 outlines percentages of all aircraft (including air carrier, air taxi, general aviation and military) which are estimated to be equipped with altitude encoding avionics over the next several years at a group of ARTS-II sites, as developed in Reference 14.

FIGURE 12

Forecasts of Mode C Usage (Total Aircraft Population)

Year	Mode C Factor (%)
1982	48
1983	52
1984	56
1985	60
1986	64
1987	68
1988	72
1989	76
1990	80
1991	84
1992	88
1993	92
1994	94
1995	95 (extrapolated)
1996	96 (extrapolated)
1997	97 (extrapolated)
1998	98 (extrapolated)
1999	99 (extrapolated)
2000	100 (extrapolated)

Thus, the present value benefits of MSAW over a 15 year life-cycle at a 10 percent discount rate can be defined as:

$$\sum_{y=1}^{15} \$.587 \times OPS \times MODECF \times (1/(1+d)^{y-0.5})$$

where 'y' is each of the 15 years of an ASR's economic life, 'OPS' is the total aircraft operations in year 'y,' 'MODECF' is the Mode C factor in year 'y,' and 'd' is the OMB-prescribed discount rate of ten percent.

2. VFR Radar Advisory Service. VFR radar advisory service is provided on a work-permitting basis at towers which have terminal radar. It is a service provided primarily to general aviation aircraft. The service consists of radar traffic information, separation between an aircraft receiving radar traffic information and observed traffic, safety advisory to radar-identified aircraft when a situation appears to affect the safety of the aircraft, altitude conflict separation, weather and chart information and radar navigation assistance to avoid those areas, bird activity information, holding pattern surveillance and navigation guidance. All of these activities contribute to an absolute improvement of the level of safety in a radar environment compared with a terminal

environment without radar, but none are easily quantified. Towers record the number of times the service is given, but the significance of each event is not recorded and would obviously be very difficult to ascertain. Accordingly, no attempt has been made in this report to quantify and value these services. The significance of this omission is rather immaterial since the pilot can still resort to other FAA-provided means of assistance such as VHF Direction Finder and emergency services offered through flight service stations (FSS), air route traffic control centers (ARTCC) and tower facilities. ASR can be classified as only an alternative and limited means of offering navigation assistance to pilots in the immediate area of the airport.

3. Radar Flight Assists. Primary reasons for flight assists include the pilot being lost, low on fuel, caught on top and equipment malfunction. Flight assists can and are performed without the aid of radar, but the user of flight assistance during an emergency enjoys a definite advantage when he is helped by a radar-equipped tower. The user, predominately a general aviation itinerant pilot, is in a relatively safer position from the time radar contact is established until the time he is in a safe position on the ground. This relative safety is due to the fact that the user is an identified target on the radar scope. He can be followed, guided and landed at the nearest suitable airport, or sent on his way. As in the case of VFR radar advisory service, radar flight assists afford an absolute improvement on the level of safety over that of a terminal environment which has no radar, but their value is not easily quantified. Again, these intangible services are not taken into account in the benefits developed in this report because of the difficulty of their measurement and valuation. Again this omission is not significant, since ASR should be viewed as only an alternative and limited means of offering navigation assistance to pilots in the immediate area of the airport. The pilot can still resort to other FAA-provided means of assistance such as VHF Direction Finder and emergency services offered through FSS, ARTCC and tower facilities.

D. Convenience

A third major benefit of ASR, both to the controller and the user, is that of convenience. The user benefits from the feeling of having added protection with radar. Convenience to the user arising from reduced flying time is addressed in an earlier part of this section dealing with IFR delay reduction. For the controller, convenience is realized from the reduction in the difficulty of retaining a mental image of the activity he is controlling, or more simply, a reduction in the mental strain of moving traffic. Because there is insufficient data upon which to attach a monetary value to these aspects of radar, they have not been quantified in the benefits developed in this report.

SECTION V - DEVELOPMENT OF PHASE I ASR ESTABLISHMENT AND DISCONTINUANCE CRITERIA

This section explains how the Phase I ASR establishment and discontinuance criteria were derived. Phase I criteria, published in Airway Planning Standard Number One (Reference 1), are a set of generalized criteria designed to initially identify potential candidates. Phase I criteria are easily applied with available data without the aid of a computer. Phase II is a site-specific computerized benefit/cost screening process under which candidates identified by Phase I are further evaluated. Figure 14 of Section VI provides Phase I and II results for all principal FAA approach control towers (other than CIFRR's, CERAP's, RAPCON's and RATCF's) based on extrapolated Terminal Area Forecasts over the 15 year period Fiscal Years 1982 through 1996.

At any given site, the respective contributions of IFR delay reduction and safety benefits to the Phase II benefit/cost ratio can be expressed as:

$$\text{Delay Reduction Component of Benefit/Cost Ratio} = \frac{TSAVE_1 \times PRIM_1 \times BHIO_1 \times VOC_1 \times (PIFR/100) \times BHPY \times NDF}{DISCST}$$

$$\text{Accident Reduction Component of Benefit/Cost Ratio} = \frac{(MACBEN_1 + TRCBEN_1) \times OPS_1 \times NDF}{DISCST}$$

where for the first year of operation:

BC is the Phase II benefit/cost ratio,

TSAVE is the number of delay hours saved per aircraft per hour of airport operation (a function of airport capacity busy hour operations and user class mix),

PRIM is the number of primary instrument operations,

BHIO is the number of operations during a busy IFR hour,

VOC is the hourly variable operating cost of the aircraft mix,

PIFR is the percent of time that IFR weather prevails,

BHPY is the number of busy hours per year,

NDF is a factor by which first year benefits can be inflated to their life-cycle equilavent, taking into account discounting and activity growth,

DISCST is the life-cycle cost,

MACBEN is the expected benefit per operation of averted midair collisions,

TRCBEN is the expected benefit per operation of averted terrain collisions, and

OPS is the number of total aircraft operations.

The objective in developing Phase I criteria is to derive a simple relationship that when applied to first year activity data will produce a reasonable approximation of the Phase II benefit/cost ratio. This relationship should be sensitive to activity by user class composition because the value of ASR benefits differs by user class. Note in the above formulae that the activity measures used to determine the benefits of IFR delay reduction and collision avoidance benefits are primary instrument operations (PRIM) and total aircraft operations (OPS), repsectively.

For each FAA towered airport, values of $PRIM_1$ and OPS_1 for each user class required to achieve a life-cycle benefit/cost ratio of unity (i.e., where benefits just break-even or offset costs) were calculated using the computer program described in Appendix F. The range of values derived for OPS was narrow, with medians of 107,400 for air carrier, 539,600 for air taxi, 847,200 for general aviation and 376,200 for military. Unfortunately the results obtained for PRIM were disparate because site specific weather (PIFR) and PRIM are unrelated and there is an exponential relationship between TSAVE and BHIO on the one hand and PRIM on the other. This poor correlation result could be overcome by making PIFR a separate part of the Phase I computation and by using exponents in the Phase I criteria or constructing a table look-up for the relationship between TSAVE, BHIO and PRIM. Unfortunately, this enhancement conflicts with the ideal of keeping the Phase I criteria as simple as possible and met with resistance during coordination of preliminary draft versions of this report. The Phase I criteria finally adopted, the computation procedure and nomenclature for which are outlined below in Figure 13, correlate very well with the Phase II criteria results in the area of safety but not as well in the area of delay reduction.

FIGURE 13

Phase I Criteria

Contributing Benefit		Ratio Value
Delay Reduction:		
$\dfrac{\text{ACPRIM}}{3{,}400 - (.0013 \times \text{PRIM})^*}$	=	xxxx
$\dfrac{\text{ATPRIM}}{26{,}000 - (.0096 \times \text{PRIM})^*}$	=	xxxx
$\dfrac{\text{GAPRIM}}{53{,}300 - (.0196 \times \text{PRIM})^*}$	=	xxxx
$\dfrac{\text{MLPRIM}}{8{,}600 - (.0032 \times \text{PRIM})^*}$	=	xxxx

FIGURE 13 (Continued)

Safety:

$\frac{ACITN}{107,400}$ = xxxx

$\frac{ATITN}{539,600}$ = xxxx

$\frac{GAITN + GALCL}{847,200}$ = xxxx

$\frac{MLITN + MLLCL}{376,200}$ = xxxx

Sum of Ratio Values

If 1 or greater, location satisfies Phase I establishment criteria

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*If the denominator for any user class results in a value equal to or less than zero, disregard all denominators and use all of the following instead. For the air carrier user class: 9,300 - (.0034 x PRIM); for the air taxi user class: 71,200 - (.0262 x PRIM); for the general aviation user class: 146,000 - (.0538 x PRIM); and for the military user class: 23,400 - (.0086 x PRIM).

ACPRIM, ATPRIM, GAPRIM and MLPRIM, for a primary airport, are the numbers of annual primary instrument operations of the air carrier (FAR 121, 127 and 129), air taxi these terms (FAR 135), general aviation (FAR 91) and military (FAR 91) user classes, respectively. For a qualified secondary airport, these terms are the numbers of annual primary instrument operations of the secondary airport by user class, or the respective numbers of secondary instrument operations by user class of the primary airport associated with or allocable to the secondary airport, whichever are greater.

PRIM, for a primary airport, is the number of total annual primary instrument operations (i.e., the sum of ACRIM, ATPRIM, GAPRIM and MLPRIM). PRIM, for a qualified secondary airport, is the number of total annual primary instrument operations of the secondary airport, or the number of total annual secondary instrument operations of the primary airport associated with or allocable to the secondary airport, whichever is greater.

ACITN, ATITN, GAITN and MLITN are the numbers of annual itinerant operations of the air carrier, air taxi, general aviation and military user classes, respectively.

GALCL and MILCL are the numbers of annual local operations of the general aviation and military user classes, respectively.

When an ASR facility is being considered for discontinuance, initial acquisition and installation costs are irrelevant since they are sunk costs. The only relevant costs are recurring operations and maintenance costs, ignoring salvage value, relocation costs, etc. To determine whether an ASR facility meets Phase I discontinuance criteria, a ratio value is calculated by the same sum-of-ratios approach described above for Phase I establishment criteria. If the ratio value so obtained is less than 0.35, the location satisfies Phase I discontinuance criteria. The 0.35 figure is an approximation of the level where the life-cycle benefits just offset recurring life-cycle operations and maintenance costs.

Ideally, there should be a close relationship between candidates identified in Phase I (simple criteria) and candidates meeting a benefit/cost ratio of 1 or more in Phase II (computerized benefit/cost analysis). If not, one or both of two undesirable situations can occur. First, locations may show up as candidates under Phase I but fail to reflect an acceptable benefit/cost ratio under Phase II, a situation which is termed "false alarm." Secondly, and more critically, locations may not show up as candidates under Phase I but attain a benefit/cost ratio of 1 or more under Phase II screening, a situation termed "non-identification." In the development of the Phase I establishment criteria, the emphasis was primarily to keep the Phase I criteria as simple as possible and secondarily to maintain a reasonable relationship between the benefit/cost ratios derived from both phases. As a result of this approach, Figure 14 shows 24 instances of false alarm but no instances of non-identification of over 200 FAA approach control towers.

SECTION VI - RESULTS OF APPLYING PREVIOUS AND REVISED ASR CRITERIA TO ALL FAA APPROACH CONTROL TOWERS AND IMPACT ANALYSIS OF REVISED ASR CRITERIA

The computer program described in Appendix F, based on the benefit/cost methodology described in Sections III, IV and V, was used to compute Phase I and Phase II benefit/cost ratios for all FAA-operated approach control towers (excluding CIFRR's, CERAP's, RAPCON's and RATCF's) in the Terminal Area Forecasts (TAF) (Reference 25) over the 15 year period Fiscal Years 1982 through 1996. The results are outlined in Figure 14. Figure 14A outlines the results by descending Phase II benefit/cost ratio, Figure 14B in LOCID sequence, and Figure 14C in state sequence. Also included are the Phase II benefit/cost ratios derived from applying the previous ASR criteria. The benefit/cost ratios outlined in Figure 14 are based only on activity at the primary airport and do not reflect any benefits that might be attributable to radar coverage provided to qualified secondary airports, if any, under the "area concept" outlined in Section IV. The Air Traffic Service will determine eligible locations in this category.

Order 1320.1 requires an assessment of the impact of the revised criteria on agency resources. It is impossible, however, to "precisely" assess the impact for several reasons. First, meeting candidacy levels does not by itself entail automatic qualification. Benefit/cost screening is but one of several inputs to the FAA decisionmaking process relative to investment in ASR facilities. Investment decisions are made on the basis of all pertinent factors. Second, neighboring airports having a common need for radar surveillance may collectively qualify for an ASR under the "area concept" introduced in Section IV of this report. Qualifying sites in this category will be determined on a case by case basis by the Air Traffic Service. And third, actual costs vary from site to site. Estimated site-specific costs will be applied in actual application of the criteria.

Aside from these qualifications, the relative impact of the revised ASR establishment and discontinuance criteria may be assessed by comparing the number of FAA approach control towers which qualify under the benefit/cost provisions of the revised criteria with the number that qualify under the previous criteria. Figure 14D summarizes Figure 14A by ranges of Phase II benefit/cost ratios of FAA approach control towers (other than CIFRR's, CERAP's, RAPCON's and RATCF's) under the revised and previous ASR criteria. The revised criteria result in 13 new establishment candidates and 2 discontinuance candidates, while the previous criteria result in 9 new establishment candidates and 5 discontinuance candidates. Projections through FY 1987 suggest an additional 6 new establishment candidates under the revised criteria and 4 under the previous criteria. Again, potential establishment candidates that may qualify under the "area concept" are not reflected in these impact assessments. A sensitivity analysis is provided in Section IX.

FIGURE 14A: RESULTS OF APPLYING ASR CRITERIA TO ALL FAA APPROACH CONTROL TOWERS - B/C RATIO SEQUENCE

LOCID	CITY	ST	RADAR EQUIP & SERV*	PIFR**	DELAY BEN	SAFETY BEN	LC COST	OLD PH II	NEW PH I	NEW PH II
ATL	ATLANTA	GA	ASR-7 B C D G	14.60	51875072.	329240064.	9760000.	85.78	86.95	39.05
DFW	DALLAS-FORT WORTH	TX	ASR-7 B C D G	8.69	54623504.	160226592.	9760000.	74.79	53.59	22.01
IAH	HOUSTON	TX	ASR-8 B C D H	17.10	120442688.	72932976.	9760000.	113.28	70.55	19.81
PIT	PITTSBURGH	PA	ASR-8 B C D H	17.09	122570352.	61214368.	9760000.	127.85	80.20	18.83
DEN	DENVER	CO	ASR-8 B C D H	6.50	41804128.	130659632.	9760000.	60.66	48.87	17.67
BOS	BOSTON	MA	ASR-7 B C D G	16.19	92041824.	62417488.	9760000.	70.34	73.68	15.83
SEA	SEATTLE	WA	ASR-8 B C D H	16.31	117237808.	26465696.	9760000.	76.70	52.11	14.72
PHL	PHILADELPHIA	PA	ASR-7 B C D H	15.70	95685424.	42735040.	9760000.	105.77	55.82	14.18
DLH	DULUTH	MN	ASR-6 A F	20.30	124632048.	1079355.	8970000.	16.26	5.79	14.01
STL	ST LOUIS	MO	ASR-8 B C D H	11.80	84937440.	50579216.	9760000.	85.12	78.19	13.88
DCA	WASHINGTON	DC	ASR-7 B C D G	11.40	79591504.	52279008.	9760000.	83.81	77.29	13.51
CLE	CLEVELAND	OH	ASR-8 B C D H	15.10	106458640.	25337616.	9760000.	76.09	48.59	13.50
DTW	DETROIT	MI	ASR-8 B C D H	14.29	92509584.	36950672.	9760000.	73.55	67.51	13.26
MRY	MONTEREY	CA	ASR-8 E	24.50	111519616.	2376024.	8970000.	29.66	7.82	12.70
SAT	SAN ANTONIO	TX	ASR-8 B C D F	17.50	109842432.	12262231.	9760000.	43.90	19.89	12.51
CVG	COVINGTON/CINCINNA	KY	ASR-8 B C D F	14.60	104210640.	5872153.	8970000.	35.48	20.81	12.27
MSP	MINNEAPOLIS	MN	ASR-8 B C D H	11.50	82447152.	36297248.	9760000.	67.33	61.04	12.17
MEM	MEMPHIS	TN	ASR-8 B C D F	9.39	59375104.	51902944.	9760000.	59.60	57.66	11.40
BDL	WINDSOR LOCKS	CT	ASR-8 B C D F	16.40	102981152.	7215830.	9760000.	50.08	22.39	11.29
MKE	MILWAUKEE	WI	ASR-8 B C D F	14.60	90934352.	19069760.	9760000.	57.07	33.11	11.27
GEG	SPOKANE	WA	ASR-6 A F	14.30	94503280.	5156017.	8970000.	26.70	14.07	11.11
BUF	BUFFALO	NY	ASR-8 B C D F	14.10	97721376.	8975986.	9760000.	42.05	24.30	10.93
BUR	BURBANK	CA	ASR-6 B C D F	16.89	98382816.	5977728.	9760000.	28.40	11.66	10.69
AUS	AUSTIN	TX	A F	15.21	92585008.	7385534.	9760000.	28.70	13.30	10.24
AZO	KALAMAZOO	MI	ASR-6 A F	24.99	89044832.	1342836.	8970000.	16.29	3.94	10.08
IND	INDIANAPOLIS	IN	ASR-8 B C D F	14.80	83821472.	11408724.	9760000.	52.03	25.75	9.76
MSY	NEW ORLEANS	LA	ASR-8 B C D H	10.89	76716080.	16719970.	9760000.	47.30	37.92	9.57
DAY	DAYTON	OH	ASR-8 B C D F	16.10	87958464.	5421579.	9760000.	38.73	16.23	9.57
CLT	CHARLOTTE	NC	ASR-4 B C D F	13.40	74273072.	18754320.	9760000.	54.93	30.61	9.53
MCI	KANSAS CITY	MO	ASR-8 B C D H	10.00	72233920.	20337584.	9760000.	47.31	44.28	9.48
BWI	BALTIMORE	MD	ASR-8 B C D F	13.00	73677056.	18110640.	9760000.	52.51	29.22	9.40
MIA	MIAMI	FL	ASR-8 B C D G	2.41	14001842.	77360784.	9760000.	25.55	39.77	9.36
AVL	ASHEVILLE	NC	ASR-7 F	17.50	80391120.	922692.	8970000.	14.31	4.90	9.07
BGR	BANGOR	ME	ASR-6 A F	19.60	79226416.	1167901.	8970000.	17.84	5.29	8.96
MOB	MOBILE	AL	ASR-7 A F	14.00	74499200.	2681898.	8970000.	19.46	9.45	8.60
GRB	GREEN BAY	WI	ASR-7 F	14.00	74582480.	2414352.	8970000.	18.01	9.10	8.58
GRR	GRAND RAPIDS	MI	ASR-4 F	15.50	71168448.	5074148.	8970000.	25.21	10.97	8.50
ORF	NORFOLK	VA	ASR-6 B C D F	13.70	73699264.	8914189.	9760000.	42.62	22.58	8.46
PDX	PORTLAND	OR	ASR-8 B C D F	10.99	67808048.	14082728.	9760000.	44.47	30.92	8.39
ROC	ROCHESTER	NY	ASR-4 B C D F	11.40	70338416.	10547773.	9760000.	23.61	14.81	8.29
FSD	SIOUX FALLS	SD	ASR-7 F	12.50	72070064.	2014363.	8970000.	15.23	8.55	8.26
CRW	CHARLESTON	WV	ASR-8 F	22.20	71503296.	2305638.	8970000.	23.81	7.08	8.23
CMH	COLUMBUS	OH	ASR-8 B C D F	13.40	67378592.	12874864.	9760000.	39.91	20.94	8.22
IAD	WASHINGTON	DC	ASR-4 B C D F	12.40	70284272.	9131194.	9760000.	32.15	18.42	8.14
FWA	FORT WAYNE	IN	ASR-4 A F	14.70	68404512.	2906030.	8970000.	21.68	9.60	7.95
SDF	LOUISVILLE	KY	ASR-8 B C D F	10.90	71533440.	5694093.	9760000.	31.14	19.98	7.91
SHV	SHREVEPORT	LA	F	11.50	68925440.	1744482.	8970000.	14.38	8.43	7.88
TPA	TAMPA	FL	ASR-8 B C F	6.80	48619920.	28233712.	9760000.	39.83	51.15	7.87
JAX	JACKSONVILLE	FL	ASR-8 B C D F	10.41	64567360.	4504198.	8970000.	22.35	14.97	7.70
TOL	TOLEDO	OH	ASR-4 A F	14.00	66972608.	1749169.	8970000.	16.17	7.49	7.66

RIC	RICHMOND	VA	ASR-4	A					F		13.30	68296432.	6171992.	9760000.	30.81	15.03	7.63
FAY	FAYETTEVILLE	NC	ASR-4	A					F		14.01	67274576.	1071535.	8970000.	11.13	4.73	7.62
JAN	JACKSON	MS	ASR-8	A					F		11.39	65740432.	2241591.	8970000.	15.86	9.29	7.58
GSO	GREENSBORO	NC	ASR-4	A					F		13.69	67090448.	6559222.	9760000.	29.84	14.60	7.55
CID	CEDAR RAPIDS	IA	ASR-7						F		16.30	65179184.	2534673.	8970000.	15.77	5.52	7.55
BHM	BIRMINGHAM	AL	ASR-6		B	C	D		F		12.20	64498144.	8717718.	9760000.	29.33	16.80	7.50
EUG	EUGENE	OR	ASR-5	A				E			12.10	63850864.	2519438.	8970000.	11.86	5.23	7.40
OKC	OKLAHOMA CITY	OK							F		10.40	64493072.	7707210.	9760000.	22.97	14.49	7.40
MBS	SAGINAW	MI	ASR-6						F		14.29	64827376.	1101871.	8970000.	13.17	5.59	7.35
TUL	TULSA	OK	ASR-4		B	C	D		F		9.01	62944160.	8742465.	9760000.	14.51	13.40	7.34
RDU	RALEIGH-DURHAM	NC	ASR-7		B	C	D		F		12.80	60428000.	10390519.	9760000.	33.82	17.36	7.26
MSN	MADISON	WI	ASR-4						F		14.09	59285680.	5683324.	8970000.	21.32	10.12	7.24
BTR	BATON ROUGE	LA	ASR-7						F		1[illegible].2[illegible]	61526064.	3050392.	8970000.	13.01	5.49	7.20
SBN	SOUTH BEND	IN	ASR-7	A					F		[illegible]	62419520.	1606329.	8970000.	16.47	5.50	7.14
LAN	LANSING	MI	ASR-7						F		16.[illegible]	60334128.	3031680.	8970000.	18.87	7.28	7.06
GSP	GREER	SC	ASR-4	A					F		1[illegible].[illegible]1	62071520.	803079.	8970000.	10.46	5.02	7.01
ALB	ALBANY	NY	ASR-4		B	C	D		F		[illegible]1.79	57653040.	3772796.	8970000.	23.22	11.82	6.85
BNA	NASHVILLE	TN	ASR-8		B	C	D		F		[illegible]	52464192.	13985926.	9760000.	35.12	24.34	6.81
SGF	SPRINGFIELD	MO	ASR-7	A				E			11.90	57474384.	2242409.	8970000.	5.70	3.74	6.66
FAR	FARGO	ND	ASR-7						F		11.90	56746448.	1984326.	8970000.	11.03	5.86	6.55
DSM	DES MOINES	IA	ASR-4		B	C	D		F		12.20	55578464.	8033483.	9760000.	24.44	12.71	6.52
ACY	ATLANTIC CITY	NJ	ASR-4	A				E			17.40	56458192.	1991378.	8970000.	13.13	4.37	6.52
BGM	BINGHAMTON	NY	ASR-4						F		21.60	56480976.	590384.	8970000.	12.59	2.27	6.36
CRP	CORPUS CHRISTI	TX	ASR-5	A					F		12.70	54742608.	2261461.	8970000.	14.05	6.90	6.35
ANC	ANCHORAGE	AK	ASR-8	A					F		8.31	50601584.	10773929.	9760000.	22.84	20.81	6.29
HTS	HUNTINGTON	WV	ASR-4						F		15.40	55257712.	905829.	8970000.	9.88	3.70	6.26
SYR	SYRACUSE	NY	ASR-8		B	C	D		F		10.80	54880000.	5445114.	9760000.	24.58	14.22	6.18
GPT	GULFPORT	MS	ASR-4	A					F		14.00	54470672.	728598.	8970000.	8.38	3.64	6.15
PIA	PEORIA	IL	ASR-7						F		14.09	52729200.	2227310.	8970000.	16.18	6.83	6.13
ABE	ALLENTOWN	PA	ASR-7	A					F		16.41	52811264.	1689818.	8970000.	14.28	4.93	6.08
FAT	FRESNO	CA	ASR-4	A				E			9.10	51060240.	7328267.	9760000.	13.89	8.96	5.98
SLC	SALT LAKE CITY	UT	ASR-8		B	C	D		F		5.51	31499040.	26282864.	9760000.	26.79	34.32	5.92
LAS	LAS VEGAS	NV	ASR-8		B	C	D			H	0.20	1237425.	56279760.	9760000.	8.22	55.98	5.89
LBB	LUBBOCK	TX	ASR-5	A					F		8.09	49636768.	3083912.	8970000.	10.12	7.46	5.88
CMI	CHAMPAIGN/URBANA/	IL	ASR-6	A					F		18.50	49005280.	3433191.	8970000.	11.89	3.64	5.85
AMA	AMARILLO	TX	ASR-4						F		8.11	50452592.	1907006.	8970000.	8.51	6.78	5.84
ICT	WICHITA	KS	ASR-5	A					F		10.50	46068816.	10725435.	9760000.	24.34	15.49	5.82
ROA	ROANOKE	VA	ASR-8	A					F		8.59	47950992.	4218192.	8970000.	15.47	11.61	5.82
YNG	YOUNGSTOWN	OH	ASR-8						F		20.90	50398560.	1360590.	8970000.	13.46	3.70	5.77
SUX	SIOUX CITY	IA	ASR-7					E			11.00	49940352.	1411681.	8970000.	5.32	4.64	5.72
TLH	TALLAHASSEE	FL	ASR-4	A					F		12.30	48937184.	2038094.	8970000.	13.68	6.94	5.68
LEX	LEXINGTON	KY	ASR-7						F		13.10	48045440.	2718237.	8970000.	16.01	7.36	5.66
FAI	FAIRBANKS	AK	ASR-8	A				E			10.00	45901265.	9047535.	9760000.	20.40	5.50	5.63
MCO	ORLANDO	FL			B	C	D		F		6.60	39071824.	15199318.	9760000.	28.52	40.73	5.56
CAE	COLUMBIA	SC	ASR-7	A					F		11.60	46209440.	3631410.	8970000.	16.56	8.61	5.56
RST	ROCHESTER	MN	ASR-7						F		13.90	48412736.	1386801.	8970000.	11.16	5.14	5.55
TRI	BRISTOL/JOHNSON	TN	ASR-8	A					F		10.80	47550192.	1969674.	8970000.	12.49	7.12	5.52
MKG	MUSKEGON	MI	ASR-6	A					F		16.70	48256864.	927047.	8970000.	6.47	2.56	5.48
SBA	SANTA BARBARA	CA	ASR-4	A							16.50	45203360.	3546163.	8970000.	9.22	2.48	5.43
ISP	ISLIP	NY	ASR-8					E			19.80	48288192.	4674562.	9760000.	10.54	2.71	5.43
HSV	HUNTSVILLE	AL	ASR-7	A					F		9.20	46783888.	1535572.	8970000.	9.09	6.34	5.39
CAK	AKRON	OH	ASR-4	A					F		17.71	46172176.	1992156.	8970000.	15.43	5.38	5.37
HNL	HONOLULU	HI	ASR-8		B	C	D		F	H	0.50	3231754.	47805360.	9760000.	9.67	55.19	5.23
ILM	WILMINGTON	NC	ASR-6	A					F		11.10	43137344.	1300504.	8970000.	8.31	4.63	4.95
PWM	PORTLAND	ME	ASR-4	A							18.30	42764768.	1658679.	8970000.	17.87	5.86	4.95
MLI	MOLINE	IL	ASR-7						F		12.51	42340736.	1903401.	8970000.	14.82	6.43	4.93
LNK	LINCOLN	NE	ASR-7						F		9.60	42602144.	5379334.	9760000.	12.28	8.10	4.92
PNS	PENSACOLA	FL	ASR-8	A					F		10.80	42480112.	1567156.	8970000.	8.95	5.44	4.91

AGS	AUGUSTA	GA	ASR-6					F	11.60	42971216.	959272.	8970000.	7.88	4.02	4.90
SAV	SAVANNAH	GA	ASR-8	A				F	11.50	41302896.	2475761.	8970000.	11.38	6.32	4.88
MAF	MIDLAND	TX	ASR-7					F	7.00	40092880.	3706526.	8970000.	8.78	7.13	4.88
TYS	KNOXVILLE	TN	ASR-6	A				F	9.51	39545568.	3668694.	8970000.	14.38	9.17	4.82
FNT	FLINT	MI	ASR-7					F	15.50	39281312.	3620212.	8970000.	12.16	5.07	4.78
AVP	WILKES-BARRE/SCRAN	PA	ASR-8	A				F	12.60	40579856.	1160177.	8970000.	4.74	3.20	4.65
SPI	SPRINGFIELD	IL	ASR-7	A				F	12.90	37862768.	1678672.	8970000.	11.84	5.45	4.41
MGM	MONTGOMERY	AL		A				F	10.00	37280016.	1704100.	8970000.	10.10	6.67	4.35
BTV	BURLINGTON	VT	ASR-7	A					8.50	34906016.	1718090.	8970000.	9.07	6.28	4.08
HPN	WHITE PLAINS	NY	ASR-3	A			E		20.20	36626592.	2983667.	9760000.	12.74	3.33	4.06
LIT	LITTLE ROCK	AR	ASR-4	A				F	9.70	34631584.	4384395.	9760000.	16.04	9.24	4.00
ERI	ERIE	PA	ASR-7					F	14.20	34455248.	828037.	8970000.	7.58	3.04	3.93
LFT	LAFAYETTE	LA	ASR-6	A				F	14.11	32280560.	4895293.	9760000.	11.91	4.00	3.81
ALO	WATERLOO	IA	ASR-6	A			E		13.50	31987968.	1272058.	8970000.	2.40	2.85	3.71
YKM	YAKIMA	WA							7.71	31244144.	1829608.	8970000.	1.83	4.28	3.69
COS	COLORADO SPRINGS	CO	ASR-5	A				F	6.21	28547680.	3894731.	8970000.	9.54	9.39	3.62
FSM	FORT SMITH	AR	ASR-6					F	6.70	30491344.	1134107.	8970000.	4.60	3.86	3.53
CHA	CHATTANOOGA	TN	ASR-8	A				F	9.50	29519456.	2049864.	8970000.	9.53	5.80	3.52
MHT	MANCHESTER	NH							20.40	29622960.	1746333.	8970000.	3.36	1.53	3.50
CSG	COLUMBUS	GA	ASR-8					F	12.21	30288752.	903182.	8970000.	6.15	2.75	3.48
PSC	PASCO	WA							6.80	28988800.	2014368.	8970000.	1.62	4.50	3.46
BFL	BAKERSFIELD	CA							6.31	26621024.	2997295.	8970000.	6.28	4.16	3.30
FMY	FT MYERS	FL	ASR-8						4.20	25691328.	3541255.	8970000.	4.81	6.44	3.26
LYH	LYNCHBURG	VA							12.80	27100256.	996132.	8970000.	1.64	3.17	3.13
RFD	ROCKFORD	IL	ASR-6	A				F	13.30	25832272.	2225738.	8970000.	8.73	4.18	3.13
DAB	DAYTONA BEACH	FL	ASR-5	A					6.70	20568400.	9917632.	9760000.	8.27	7.31	3.12
EVV	EVANSVILLE	IN	ASR-6	A				F	10.10	26728240.	1181015.	8970000.	7.49	4.20	3.11
SCK	STOCKTON	CA							8.80	25012592.	1892896.	8970000.	2.85	2.70	3.00
MCN	MACON	GA						F	11.69	26347152.	486448.	8970000.	4.16	1.94	2.99
BIL	BILLINGS	MT	ASR-7					F	5.70	23192848.	3323883.	8970000.	8.69	8.19	2.96
BOI	BOISE	ID	ASR-7					F	4.69	19869296.	7734532.	9760000.	10.87	12.67	2.83
MLU	MONROE	LA	ASR-5	A				F	11.20	22364784.	1198369.	8970000.	1.39	3.10	2.63
BIS	BISMARCK	ND							10.60	21830704.	1458466.	8970000.	2.30	6.00	2.60
PBI	WEST PALM BEACH	FL	ASR-8	A				F	2.70	11609050.	13652344.	9760000.	10.96	21.75	2.59
LAF	LAFAYETTE	IN							14.60	20248992.	1737066.	8970000.	0.68	2.93	2.45
CPR	CASPER	WY	ASR-6	A			E		6.70	19289872.	1285149.	8970000.	4.23	3.31	2.29
LCH	LAKE CHARLES	LA	ASR-6	A				F	13.20	18523968.	572417.	8970000.	4.96	1.53	2.13
CXY	HARRISBURG	PA	ASR-4	A				F	13.30	17851904.	718117.	8970000.	8.40	2.78	2.07
MFR	MEDFORD	OR							11.99	16596910.	1784790.	8970000.	1.39	1.93	2.05
HUF	TERRE HAUTE	IN							13.40	15880670.	1025815.	8970000.	1.38	1.25	1.88
PUB	PUEBLO	CO	ASR-6	A			E		5.40	13995688.	1534634.	8970000.	1.38	2.60	1.73
DEC	DECATUR	IL							18.50	14339153.	868393.	8970000.	0.66	2.02	1.70
ABQ	ALBUQUERQUE	NM	ASR-8		B	C	D	F	1.21	6240726.	10330862.	9760000.	7.88	21.22	1.70
BPT	BEAUMONT/PORT ART	TX	ASR-7	A				F	14.30	14596324.	406929.	8970000.	2.05	1.00	1.67
RNO	RENO	NV	ASR-8	A				F	1.71	7360069.	7930161.	9760000.	9.10	19.39	1.57
MWH	MOSES LAKE	WA							8.60	11343368.	2100228.	8970000.	0.32	1.54	1.50
ELP	EL PASO	TX	ASR-5		B	C	D	F	1.11	5853736.	8458299.	9760000.	5.90	15.99	1.47
ABI	ABILENE	TX					E		7.01	11610204.	1095663.	8970000.	1.15	1.97	1.42
ELM	ELMIRA	NY	ASR-4				E		12.99	11642229.	734184.	8970000.	0.59	2.16	1.38
OGG	KAHULUI	HI	ASR-7					F	1.10	7850099.	3821988.	8970000.	6.00	15.21	1.30
LSE	LA CROSSE	WI							20.30	9997087.	878588.	8970000.	0.70	2.38	1.21
HUT	HUTCHINSON	KS							10.00	6933689.	874221.	8970000.	0.42	1.55	0.87
FYV	FAYETTEVILLE	AR							6.70	7270513.	544019.	8970000.	0.59	2.55	0.87
CYS	CHEYENNE	WY							9.20	6960473.	868846.	8970000.	0.48	2.60	0.87
GNV	GAINESVILLE	FL							6.60	4820726.	1514533.	8970000.	0.54	2.46	0.71
PKB	PARKERSBURG	WV							16.09	5649189.	720677.	8970000.	0.36	0.90	0.71
SJT	SAN ANGELO	TX							7.19	5132306.	930979.	8970000.	0.41	1.60	0.68
ABY	ALBANY	GA							11.01	3705733.	1350669.	8970000.	0.38	2.19	0.56

ITO	HILO	HI	ASR-8	A		3.40	3440382.	643690.	8970000.	0.91	5.43	0.46
IPT	WILLIAMSPORT	PA				13.00	3340351.	695832.	8970000.	0.27	0.73	0.45
RDG	READING	PA	ASR-5	A	E	14.50	2559577.	1438574.	8970000.	0.42	0.74	0.45
MFD	MANSFIELD	OH				17.99	3035652.	590776.	8970000.	0.25	0.86	0.40
ROW	ROSWELL	NM				3.89	2474138.	864802.	8970000.	0.31	2.69	0.37
COU	COLUMBIA	MO				11.80	2581244.	757397.	8970000.	0.32	1.85	0.37
BRO	BROWNSVILLE	TX				11.61	2168286.	951015.	8970000.	0.38	1.84	0.35
GGG	LONGVIEW	TX	ASR-4	A	F	10.90	2377384.	806960.	8970000.	0.19	0.75	0.35
JXN	JACKSON	MI				17.10	1886963.	714753.	8970000	0.26	1.35	0.29
MFE	MC ALLEN	TX				11.61	1553074.	1001624.	8970000.	0.34	1.97	0.28
CKB	CLARKSBURG	WV	ASR	A		27.09	1870000.	544178.	8970000.	0.28	0.71	0.27
SLN	SALINA	KS				7.80	1418543.	754649.	8970000.	0.22	1.40	0.24
KOA	KAILUA-KONA	HI				3.00	837391.	1019706.	8970000.	0.54	5.10	0.21
PSP	PALM SPRINGS	CA	ASR-5	A	F	0.20	600754.	1209852.	8970000.	1.00	4.22	0.20
CLL	COLLEGE STATION	TX				15.21	1104261.	715202.	8970000.	0.16	0.64	0.20
TYR	TYLER	TX				13.30	935003.	615780.	8970000.	0.18	0.58	0.17
GJT	GRAND JUNCTION	CO				1.70	206602.	1271570.	8970000.	0.38	2.23	0.16
MIE	MUNCIE	IN				16.10	772903.	585856.	8970000.	0.15	0.55	0.15
PAH	PADUCAH	KY				10.10	1091030.	290480.	8970000.	0.25	0.84	0.15
ORH	WORCESTER	MA				20.40	624230.	647644.	8970000.	0.20	0.51	0.14
FLO	FLORENCE	SC				12.21	737253.	436053.	8970000.	0.17	0.67	0.13
GLH	GREENVILLE	MS				11.39	633505.	445901.	8970000.	0.22	1.53	0.12
JLN	JOPLIN	MO				11.90	488387.	589073.	8970000.	0.32	1.87	0.12
FMN	FARMINGTON	NM				2.20	118150.	865549.	8970000.	0.23	2.00	0.11
MSO	MISSOULA	MT				8.17	433737.	583426.	8970000.	0.26	2.07	0.11
ACT	WACO	TX	ASR	A		11.00	409850.	431555.	8970000.	0.16	0.58	0.09
TXK	TEXARKANA	AR				11.20	417488.	413440.	8970000.	0.15	0.55	0.09
TWF	TWIN FALLS	ID				6.80	217886.	585914.	8970000.	0.19	1.32	0.09
CGI	CAPE GIRARDEAU	MO				11.80	269252.	454927.	8970000.	0.15	0.69	0.08
MWA	MARION	IL				11.80	195193.	506769.	8970000.	0.12	0.63	0.08
HOT	HOT SPRINGS	AR				9.70	335694.	415425.	8970000.	0.14	0.52	0.08
HLN	HELENA	MT				0.50	26502.	720857.	8970000.	0.22	1.97	0.08
STJ	ST JOSEPH	MO				10.30	146769.	452161.	8970000.	0.08	0.56	0.07
CSM	CLINTON	OK				10.40	378705.	273811.	8970000.	0.11	1.08	0.07
PDT	PENDLETON	OR				6.80	139991.	373103.	8970000.	0.14	0.72	0.06
PBF	PINE BLUFF	AR				9.70	37514.	281504.	8970000.	0.08	0.19	0.04
TUT	PAGO PAGO	SP				2.00	67646.	69197.	8970000.	0.91	1.57	0.02
TNT	MIAMI	FL				2.41	15002.	143749.	8970000.	0.05	0.24	0.02

* RADAR EQUIPMENT AND RADAR SERVICE AS OF SEPTEMBER 30, 1981 (SOURCE: REFERENCE 26).
RADAR SERVICE CROSS REFERENCE CODES:

A = ARTS II
B = ARTS III
C = CONFLICT ALERT
D = MINIMUN SAFE ALTITUDE WARNING
E = STAGE II EXPANDED RADAR SERVICE
F = STAGE III EXPANDED RADAR SERVICE
G = TCA GROUP 1
H = TCA GROUP 2

** IFR WEATHER PREVAILANCE PERCENTAGES WERE TAKEN FROM REFERENCES 7 AND 29.

FIGURE 14B: RESULTS OF APPLYING ASR CRITERIA TO ALL FAA APPROACH CONTROL TOWERS - LOCID SEQUENCE

LOCID	CITY	ST	RADAR EQUIP & SERV*	PIFR**	DELAY BEN	SAFETY BEN	LC COST	OLD PH II	NEW PH I	NEW PH II
ABE	ALLENTOWN	PA	ASR-7 A F	16.41	52811264.	1689818.	8970000.	14.28	4.93	6.08
ABI	ABILENE	TX	E	7.01	11610204.	1095663.	8970000.	1.15	1.97	1.42
ABQ	ALBUQUERQUE	NM	ASR-8 B C D F	1.21	6240726.	10330862.	9760000.	7.88	21.22	1.70
ABY	ALBANY	GA		11.01	3705733.	1350669.	8970000.	0.38	2.19	0.56
ACT	WACO	TX	ASR A	11.00	409850.	431555.	8970000.	0.16	0.58	0.09
ACY	ATLANTIC CITY	NJ	ASR-4 A E	17.40	56458192.	1991378.	8970000.	13.13	4.37	6.52
AGS	AUGUSTA	GA	ASR-6 F	11.60	42971216.	959272.	8970000.	7.88	4.02	4.90
ALB	ALBANY	NY	ASR-4 B C D F	11.79	57653040.	3772796.	8970000.	23.22	11.82	6.85
ALO	WATERLOO	IA	ASR-6 A E	13.50	31987968.	1272058.	8970000.	2.40	2.85	3.71
AMA	AMARILLO	TX	ASR-4 F	8.11	50452592.	1907006.	8970000.	8.51	6.78	5.84
ANC	ANCHORAGE	AK	ASR-8 A F	8.31	50601584.	10773929.	9760000.	22.84	20.81	6.29
ATL	ATLANTA	GA	ASR-7 B C D G	14.60	51875072.	329240064.	9760000.	85.78	86.95	39.05
AUS	AUSTIN	TX	A F	15.21	92585008.	7385534.	9760000.	28.70	13.30	10.24
AVL	ASHEVILLE	NC	ASR-7 F	17.50	80391120.	922692.	8970000.	14.31	4.90	9.07
AVP	WILKES-BARRE/SCRAN	PA	ASR-8 A F	12.60	40579856.	1160177.	8970000.	4.74	3.20	4.65
AZO	KALAMAZOO	MI	ASR-6 A F	24.99	89044832.	1342836.	8970000.	16.29	3.94	10.08
BDL	WINDSOR LOCKS	CT	ASR-8 B C D F	16.40	102981152.	7215830.	9760000.	50.08	22.39	11.29
BFL	BAKERSFIELD	CA		6.31	26621024.	2997295.	8970000.	6.28	4.16	3.30
BGM	BINGHAMTON	NY	ASR-4 F	21.60	56480976.	590384.	8970000.	12.59	2.27	6.36
BGR	BANGOR	ME	ASR-6 A F	19.60	79226416.	1167901.	8970000.	17.84	5.29	8.96
BHM	BIRMINGHAM	AL	ASR-6 B C D F	12.20	64498144.	8717718.	9760000.	29.33	16.80	7.50
BIL	BILLINGS	MT	ASR-7 F	5.70	23192848.	3323883.	8970000.	8.69	8.19	2.96
BIS	BISMARCK	ND		10.60	21830704.	1458466.	8970000.	2.30	6.00	2.60
BNA	NASHVILLE	TN	ASR-8 B C D F	10.20	52464192.	13985926.	9760000.	35.12	24.34	6.81
BOI	BOISE	ID	ASR-7 F	4.69	19869296.	7734532.	9760000.	10.87	12.67	2.83
BOS	BOSTON	MA	ASR-7 B C D G	16.19	92041824.	62417488.	9760000.	70.34	73.68	15.83
BPT	BEAUMONT/PORT ART	TX	ASR-7 A F	14.30	14596324.	406929.	8970000.	2.05	1.00	1.67
BRO	BROWNSVILLE	TX		11.61	2168286.	951015.	8970000.	0.38	1.84	0.35
BTR	BATON ROUGE	LA	ASR-7 F	13.20	61526064.	3050392.	8970000.	13.01	5.49	7.20
BTV	BURLINGTON	VT	ASR-7 A	8.50	34906016.	1718090.	8970000.	9.07	6.28	4.08
BUF	BUFFALO	NY	ASR-8 B C D F	14.10	97721376.	8975986.	9760000.	42.05	24.30	10.93
BUR	BURBANK	CA	ASR-6 B C D F	16.89	98382816.	5977728.	9760000.	28.40	11.66	10.69
BWI	BALTIMORE	MD	ASR-8 B C D F	13.00	73677056.	18110640.	9760000.	52.51	29.22	9.40
CAE	COLUMBIA	SC	ASR-7 A F	11.60	46209440.	3631410.	8970000.	16.56	8.61	5.56
CAK	AKRON	OH	ASR-4 A F	17.71	46172176.	1992156.	8970000.	15.43	5.38	5.37
CGI	CAPE GIRARDEAU	MO		11.80	269252.	454927.	8970000.	0.15	0.69	0.08
CHA	CHATTANOOGA	TN	ASR-8 A F	9.50	29519456.	2049864.	8970000.	9.53	5.80	3.52
CID	CEDAR RAPIDS	IA	ASR-7 F	16.30	65179184.	2534673.	8970000.	15.77	5.52	7.55
CKB	CLARKSBURG	WV	ASR A	27.09	1870000.	544178.	8970000.	0.28	0.71	0.27
CLE	CLEVELAND	OH	ASR-8 B C D H	15.10	106458640.	25337616.	9760000.	76.09	48.59	13.50
CLL	COLLEGE STATION	TX		15.21	1104261.	715202.	8970000.	0.16	0.64	0.20
CLT	CHARLOTTE	NC	ASR-4 B C D F	13.40	74273072.	18754320.	9760000.	54.93	30.61	9.53
CMH	COLUMBUS	OH	ASR-8 B C D F	13.40	67378592.	12874864.	9760000.	39.91	20.94	8.22
CMI	CHAMPAIGN/URBANA/	IL	ASR-6 A F	18.50	49005280.	3433191.	8970000.	11.89	3.64	5.85
COS	COLORADO SPRINGS	CO	ASR-5 A F	6.21	28547680.	3894731.	8970000.	9.54	9.39	3.62
COU	COLUMBIA	MO		11.80	2581244.	757397.	8970000.	0.32	1.85	0.37
CPR	CASPER	WY	ASR-6 A E	6.70	19289872.	1285149.	8970000.	4.23	3.31	2.29
CRP	CORPUS CHRISTI	TX	ASR-5 A F	12.70	54742608.	2261461.	8970000.	14.05	6.90	6.35
CRW	CHARLESTON	WV	ASR-8 F	22.20	71503296.	2305638.	8970000.	23.81	7.08	8.23
CSG	COLUMBUS	GA	ASR-8 F	12.21	30288752.	903182.	8970000.	6.15	2.75	3.48

CSM	CLINTON	OK										10.40	378705.	273811.	8970000.	0.11	1.08	0.07
CVG	COVINGTON/CINCINNA	KY	ASR-8		B	C	D		F			14.60	104210640.	5872153.	8970000.	35.48	20.81	12.27
CXY	HARRISBURG	PA	ASR-4	A					F			13.30	17851904.	718117.	8970000.	8.40	2.78	2.07
CYS	CHEYENNE	WY										9.20	6960473.	868846.	8970000.	0.48	2.60	0.87
DAB	DAYTONA BEACH	FL	ASR-5	A								6.70	20568400.	9917632.	9760000.	8.27	7.31	3.12
DAY	DAYTON	OH	ASR-8		B	C	D		F			16.10	87958464.	5421579.	9760000.	38.73	16.23	9.57
DCA	WASHINGTON	DC	ASR-7		B	C	D			G		11.40	79591504.	52279008.	9760000.	83.81	77.29	13.51
DEC	DECATUR	IL										18.50	14339153.	868393.	8970000.	0.66	2.02	1.70
DEN	DENVER	CO	ASR-8		B	C	D				H	6.50	41804128.	130659632.	9760000.	60.66	48.87	17.67
DFW	DALLAS-FORT WORTH	TX	ASR-7		B	C	D			G		8.69	54623504.	160226592.	9760000.	74.79	53.59	22.01
DLH	DULUTH	MN	ASR-6	A					F			20.30	124632048.	1079355.	8970000.	16.26	5.79	14.01
DSM	DES MOINES	IA	ASR-4		B	C	D		F			12.20	55578464.	8033483.	9760000.	24.44	12.71	6.52
DTW	DETROIT	MI	ASR-8		B	C	D				H	14.29	92509584.	36950672.	9760000.	73.55	67.51	13.26
ELM	ELMIRA	NY	ASR-4					E				12.99	11642229.	734184.	8970000.	0.59	2.16	1.38
ELP	EL PASO	TX	ASR-5		B	C	D		F			1.11	5853736.	8458299.	9760000.	5.90	15.99	1.47
ERI	ERIE	PA	ASR-7						F			14.20	34455248.	828037.	8970000.	7.58	3.04	3.93
EUG	EUGENE	OR	ASR-5	A				E				12.10	63850864.	2519438.	8970000.	11.86	5.23	7.40
EVV	EVANSVILLE	IN	ASR-6	A					F			10.10	26728240.	1181015.	8970000.	7.49	4.20	3.11
FAI	FAIRBANKS	AK	ASR-8	A				E				10.00	45901265.	9047535.	9760000.	20.40	5.50	5.63
FAR	FARGO	ND	ASR-7						F			11.90	56746448.	1984326.	8970000.	11.03	5.86	6.55
FAT	FRESNO	CA	ASR-4	A				E				9.10	51060240.	7328267.	9760000.	13.89	8.96	5.98
FAY	FAYETTEVILLE	NC	ASR-4	A					F			14.01	67274576.	1071535.	8970000.	11.13	4.73	7.62
FLO	FLORENCE	SC										12.21	737253.	436053.	8970000.	0.17	0.67	0.13
FMN	FARMINGTON	NM										2.20	118150.	865549.	8970000.	0.23	2.00	0.11
FMY	FT MYERS	FL	ASR-8									4.20	25691328.	3541255.	8970000.	4.81	6.44	3.26
FNT	FLINT	MI	ASR-7						F			15.50	39281312.	3620212.	8970000.	12.16	5.07	4.78
FSD	SIOUX FALLS	SD	ASR-7						F			12.50	72070064.	2014363.	8970000.	15.23	8.55	8.26
FSM	FORT SMITH	AR	ASR-6						F			6.70	30491344.	1134107.	8970000.	4.60	3.86	3.53
FWA	FORT WAYNE	IN	ASR-4	A					F			14.70	68404512.	2906030.	8970000.	21.68	9.60	7.95
FYV	FAYETTEVILLE	AR										6.70	7270513.	544019.	8970000.	0.59	2.55	0.87
GEG	SPOKANE	WA	ASR-6	A					F			14.30	94503280.	5156017.	8970000.	26.70	14.07	11.11
GGG	LONGVIEW	TX	ASR-4	A					F			10.90	2377384.	806960.	8970000.	0.19	0.75	0.35
GJT	GRAND JUNCTION	CO										1.70	206602.	1271570.	8970000.	0.38	2.23	0.16
GLH	GREENVILLE	MS										11.39	633505.	445901.	8970000.	0.22	1.53	0.12
GNV	GAINESVILLE	FL										6.60	4820726.	1514533.	8970000.	0.54	2.46	0.71
GPT	GULFPORT	MS	ASR-4	A					F			14.00	54470672.	728598.	8970000.	8.38	3.64	6.15
GRB	GREEN BAY	WI	ASR-7						F			14.00	74582480.	2414352.	8970000.	18.01	9.10	8.58
GRR	GRAND RAPIDS	MI	ASR-4						F			15.50	71168448.	5074148.	8970000.	25.21	10.97	8.50
GSO	GREENSBORO	NC	ASR-4	A					F			13.69	67090448.	6559222.	9760000.	29.84	14.60	7.55
GSP	GREER	SC	ASR-4	A					F			12.51	62071520.	803079.	8970000.	10.46	5.02	7.01
HLN	HELENA	MT										0.50	26502.	720857.	8970000.	0.22	1.97	0.08
HNL	HONOLULU	HI	ASR-8		B	C	D		F		H	0.50	3231754.	47805360.	9760000.	9.67	55.19	5.23
HOT	HOT SPRINGS	AR										9.70	335694.	415425.	8970000.	0.14	0.52	0.08
HPN	WHITE PLAINS	NY	ASR-3	A				E				20.20	36626592.	2983667.	9760000.	12.74	3.33	4.06
HSV	HUNTSVILLE	AL	ASR-7	A					F			9.20	46783888.	1535572.	8970000.	9.09	6.34	5.39
HTS	HUNTINGTON	WV	ASR-4						F			15.40	55257712.	905829.	8970000.	9.88	3.70	6.26
HUF	TERRE HAUTE	IN										13.40	15880670.	1025815.	8970000.	1.38	1.25	1.88
HUT	HUTCHINSON	KS										10.00	6933689.	874221.	8970000.	0.42	1.55	0.87
IAD	WASHINGTON	DC	ASR-4		B	C	D		F			12.40	70284272.	9131194.	9760000.	32.15	18.42	8.14
IAH	HOUSTON	TX	ASR-8		B	C	D				H	17.10	120442688.	72932976.	9760000.	113.28	70.55	19.81
ICT	WICHITA	KS	ASR-5	A					F			10.50	46068816.	10725435.	9760000.	24.34	15.49	5.82
ILM	WILMINGTON	NC	ASR-6	A					F			11.10	43137344.	1300504.	8970000.	8.31	4.63	4.95
IND	INDIANAPOLIS	IN	ASR-8		B	C	D		F			14.80	83821472.	11408724.	9760000.	52.03	25.75	9.76
IPT	WILLIAMSPORT	PA										13.00	3340351.	695832.	8970000.	0.27	0.73	0.45
ISP	ISLIP	NY	ASR-8					E				19.80	48288192.	4674562.	9760000.	10.54	2.71	5.43
ITO	HILO	HI	ASR-8	A								3.40	3440382.	643690.	8970000.	0.91	5.43	0.46
JAN	JACKSON	MS	ASR-8	A					F			11.39	65740432.	2241591.	8970000.	15.86	9.29	7.58
JAX	JACKSONVILLE	FL	ASR-8		B	C	D		F			10.41	64567360.	4504198.	8970000.	22.35	14.97	7.70

JLN	JOPLIN	MO										11.90	488387.	589073.	8970000.	0.32	1.87	0.12
JXN	JACKSON	MI										17.10	1886963.	714753.	8970000.	0.26	1.35	0.29
KOA	KAILUA-KONA	HI										3.00	837391.	1019706.	8970000.	0.54	5.10	0.21
LAF	LAFAYETTE	IN										14.60	20248992.	1737066.	8970000.	0.68	2.93	2.45
LAN	LANSING	MI	ASR-7						F			16.40	60334128.	3031680.	8970000.	18.87	7.28	7.06
LAS	LAS VEGAS	NV	ASR-8		B	C	D				H	0.20	1237425.	56279760.	9760000.	8.22	55.98	5.89
LBB	LUBBOCK	TX	ASR-5	A					F			8.09	49636768.	3083912.	8970000.	10.12	7.46	5.88
LCH	LAKE CHARLES	LA	ASR-6	A					F			13.20	18523968.	572417.	8970000.	4.96	1.53	2.13
LEX	LEXINGTON	KY	ASR-7						F			13.10	48045440.	2718237.	8970000.	16.01	7.36	5.66
LFT	LAFAYETTE	LA	ASR-6	A					F			14.11	32280560.	4895293.	9760000.	11.91	4.00	3.81
LIT	LITTLE ROCK	AR	ASR-4	A					F			9.70	34631584.	4384395.	9760000.	16.04	9.24	4.00
LNK	LINCOLN	NE	ASR-7						F			9.60	42602144.	5379334.	9760000.	12.28	8.10	4.92
LSE	LA CROSSE	WI										20.30	9997087.	878588.	8970000.	0.70	2.38	1.21
LYH	LYNCHBURG	VA										12.80	27100256.	996132.	8970000.	1.64	3.17	3.13
MAF	MIDLAND	TX	ASR-7						F			7.00	40092880.	3706526.	8970000.	8.78	7.13	4.88
MBS	SAGINAW	MI	ASR-6						F			14.29	64827376.	1101871.	8970000.	13.17	5.59	7.35
MCI	KANSAS CITY	MO	ASR-8		B	C	D				H	10.00	72233920.	20337584.	9760000.	47.31	44.28	9.48
MCN	MACON	GA							F			11.69	26347152.	486448.	8970000.	4.16	1.94	2.99
MCO	ORLANDO	FL			B	C	D		F			6.60	39071824.	15199318.	9760000.	28.52	40.73	5.56
MEM	MEMPHIS	TN	ASR-8		B	C	D		F			9.39	59375104.	51902944.	9760000.	59.60	57.66	11.40
MFD	MANSFIELD	OH										17.99	3035652.	590776.	8970000.	0.25	0.86	0.40
MFE	MC ALLEN	TX										11.61	1553074.	1001624.	8970000.	0.34	1.97	0.28
MFR	MEDFORD	OR										11.99	16596910.	1784790.	8970000.	1.39	1.93	2.05
MGM	MONTGOMERY	AL		A					F			10.00	37280016.	1704100.	8970000.	10.10	6.67	4.35
MHT	MANCHESTER	NH										20.40	29622960.	1746333.	8970000.	3.36	1.53	3.50
MIA	MIAMI	FL	ASR-8		B	C	D			G		2.41	14001842.	77360784.	976000.	25.55	39.77	9.36
MIE	MUNCIE	IN										16.10	772903.	585856.	8970000.	0.15	0.55	0.15
MKE	MILWAUKEE	WI	ASR-8		B	C	D		F			14.60	90934352.	19069760.	9760000.	57.07	33.11	11.27
MKG	MUSKEGON	MI	ASR-6	A					F			16.70	48256864.	927047.	8970000.	6.47	2.56	5.48
MLI	MOLINE	IL	ASR-7						F			12.51	42340736.	1903401.	8970000.	14.82	6.43	4.93
MLU	MONROE	LA	ASR-5	A					F			11.20	22364784.	1198369.	8970000.	1.39	3.10	2.63
MOB	MOBILE	AL	ASR-7	A					F			14.00	74499200.	2681898.	8970000.	19.46	9.45	8.60
MRY	MONTEREY	CA	ASR-8					E				24.50	111519616.	2376024.	8970000.	29.66	7.82	12.70
MSN	MADISON	WI	ASR-4						F			14.09	59285680.	5683324.	8970000.	21.32	10.12	7.24
MSO	MISSOULA	MT										8.17	433737.	583426.	8970000.	0.26	2.07	0.11
MSP	MINNEAPOLIS	MN	ASR-8		B	C	D				H	11.50	82447152.	36297248.	9760000.	67.33	61.04	12.17
MSY	NEW ORLEANS	LA	ASR-8		B	C	D				H	10.89	76716080.	16719970.	9760000.	47.30	37.92	9.57
MWA	MARION	IL										11.80	195193.	506769.	8970000.	0.12	0.63	0.08
MWH	MOSES LAKE	WA										8.60	11343368.	2100228.	8970000.	0.32	1.54	1.50
OGG	KAHULUI	HI	ASR-7						F			1.10	7850099.	3821988.	8970000.	6.00	15.21	1.30
OKC	OKLAHOMA CITY	OK							F			10.40	64493072.	7707210.	9760000.	22.97	14.49	7.40
ORF	NORFOLK	VA	ASR-6		B	C	D		F			13.70	73699264.	8914189.	9760000.	42.62	22.58	8.46
ORH	WORCESTER	MA										20.40	624230.	647644.	8970000.	0.20	0.51	0.14
PAH	PADUCAH	KY										10.10	1091030.	290480.	8970000.	0.25	0.84	0.15
PBF	PINE BLUFF	AR										9.70	37514.	281504.	8970000.	0.08	0.19	0.04
PBI	WEST PALM BEACH	FL	ASR-8	A					F			2.70	11609050.	13652344.	9760000.	10.96	21.75	2.59
PDT	PENDLETON	OR										6.80	139991.	373103.	8970000.	0.14	0.72	0.06
PDX	PORTLAND	OR	ASR-8		B	C	D		F			10.99	67808048.	14082728.	9760000.	44.47	30.92	8.39
PHL	PHILADELPHIA	PA	ASR-7		B	C	D				H	15.70	95685424.	42735040.	9760000.	105.77	55.82	14.18
PIA	PEORIA	IL	ASR-7						F			14.09	52729200.	2227310.	8970000.	16.18	6.83	6.13
PIT	PITTSBURGH	PA	ASR-8		B	C	D				H	17.09	122570352.	61214368.	9760000.	127.85	80.20	18.83
PKB	PARKERSBURG	WV										16.09	5649189.	720677.	8970000.	0.36	0.90	0.71
PNS	PENSACOLA	FL	ASR-8	A					F			10.80	42480112.	1567156.	8970000.	8.95	5.44	4.91
PSC	PASCO	WA										6.80	28988800.	2014368.	8970000.	1.62	4.50	3.46
PSP	PALM SPRINGS	CA	ASR-5	A					F			0.20	600754.	1209852.	8970000.	1.00	4.22	0.20
PUB	PUEBLO	CO	ASR-6	A				E				5.40	13995688.	1534634.	8970000.	1.38	2.60	1.73
PWM	PORTLAND	ME	ASR-4	A								18.30	42764768.	1658679.	8970000.	17.87	5.86	4.95
RDG	READING	PA	ASR-5	A				E				14.30	2559577.	1438574.	8970000.	0.42	0.74	0.45

RDU	RALEIGH-DURHAM	NC	ASR-7		B	C	D		F		12.80	60428000.	10390519.	9760000.	33.82	17.36	7.26
RFD	ROCKFORD	IL	ASR-6	A					F		13.30	25832272.	2225738.	8970000.	8.73	4.18	3.13
RIC	RICHMOND	VA	ASR-4	A					F		13.30	68296432.	6171992.	9760000.	30.81	15.03	7.63
RNO	RENO	NV	ASR-8	A					F		1.71	7360069.	7930161.	9760000.	9.10	19.39	1.57
ROA	ROANOKE	VA	ASR-8	A					F		8.59	47950992.	4218192.	8970000.	15.47	11.61	5.82
ROC	ROCHESTER	NY	ASR-4		B	C	D		F		11.40	70338416.	10547773.	9760000.	23.61	14.81	8.29
ROW	ROSWELL	NM									3.89	2474138.	864802.	8970000.	0.31	2.69	0.37
RST	ROCHESTER	MN	ASR-7						F		13.90	48412736.	1386801.	8970000.	11.16	5.14	5.55
SAT	SAN ANTONIO	TX	ASR-8		B	C	D		F		17.50	109842432.	12262231.	9760000.	43.90	19.89	12.51
SAV	SAVANNAH	GA	ASR-8	A					F		11.50	41302896.	2475761.	8970000.	11.38	6.32	4.88
SBA	SANTA BARBARA	CA	ASR-4	A							16.50	45203360.	3546163.	8970000.	9.22	2.48	5.43
SBN	SOUTH BEND	IN	ASR-7	A					F		17.30	62419520.	1606329.	8970000.	16.47	5.50	7.14
SCK	STOCKTON	CA									8.80	25012592.	1892896.	8970000.	2.85	2.70	3.00
SDF	LOUISVILLE	KY	ASR-8		B	C	D		F		10.90	71533440.	5694093.	9760000.	31.14	19.98	7.91
SEA	SEATTLE	WA	ASR-8		B	C	D			H	16.31	117237808.	26465696.	9760000.	76.70	52.11	14.72
SGF	SPRINGFIELD	MO	ASR-7	A				E			11.90	57474384.	2242409.	8970000.	5.70	3.74	6.66
SHV	SHREVEPORT	LA							F		11.50	68925440.	1744482.	8970000.	14.38	8.43	7.88
SJT	SAN ANGELO	TX									7.19	5132306.	930979.	8970000.	0.41	1.60	0.68
SLC	SALT LAKE CITY	UT	ASR-8		B	C	D		F		5.51	31499040.	26282864.	9760000.	26.79	34.32	5.92
SLN	SALINA	KS									7.80	1418543.	754649.	8970000.	0.22	1.40	0.24
SPI	SPRINGFIELD	IL	ASR-7	A					F		12.90	37862768.	1678672.	8970000.	11.84	5.45	4.41
STJ	ST JOSEPH	MO									10.30	146769.	452161.	8970000.	0.08	0.56	0.07
STL	ST LOUIS	MO	ASR-8		B	C	D			H	11.80	84937440.	50579216.	9760000.	85.12	78.19	13.88
SUX	SIOUX CITY	IA	ASR-7					E			11.00	49940352.	1411681.	8970000.	5.32	4.64	5.72
SYR	SYRACUSE	NY	ASR-8		B	C	D		F		10.80	54880000.	5445114.	9760000.	24.58	14.22	6.18
TLH	TALLAHASSEE	FL	ASR-4	A					F		12.30	48937184.	2038094.	8970000.	13.68	6.94	5.68
TNT	MIAMI	FL									2.41	15002.	143749.	8970000.	0.05	0.24	0.02
TOL	TOLEDO	OH	ASR-4	A					F		14.00	66972608.	1749169.	8970000.	16.17	7.49	7.66
TPA	TAMPA	FL	ASR-8		B	C			F		6.80	48619920.	28233712.	9760000.	39.83	51.15	7.87
TRI	BRISTOL/JOHNSON	TN	ASR-8	A					F		10.80	47550192.	1969674.	8970000.	12.49	7.12	5.52
TUL	TULSA	OK	ASR-4		B	C	D		F		9.01	62944160.	8742465.	9760000.	14.51	13.40	7.34
TUT	PAGO PAGO	SP									2.00	67646.	69197.	8970000.	0.91	1.57	0.02
TWF	TWIN FALLS	ID									6.80	217886.	585914.	8970000.	0.19	1.32	0.09
TXK	TEXARKANA	AR									11.20	417488.	413440.	8970000.	0.15	0.55	0.09
TYR	TYLER	TX									13.30	935003.	615780.	8970000.	0.18	0.58	0.17
TYS	KNOXVILLE	TN	ASR-6	A					F		9.51	39545568.	3668694.	8970000.	14.38	9.17	4.82
YKM	YAKIMA	WA									7.71	31244144.	1829608.	8970000.	1.83	4.28	3.69
YNG	YOUNGSTOWN	OH	ASR-8						F		20.90	50398560.	1360590.	8970000.	13.46	3.70	5.77

* RADAR EQUIPMENT AND SERVICE AS OF SEPTEMBER 30, 1981 (SOURCE: REFERENCE 26)-.
RADAR SERVICE CROSS REFERENCE CODES:

- A = ARTS II
- B = ARTS III
- C = CONFLICT ALERT
- D = MINIMUM SAFE ALTITUDE WARNING
- E = STAGE II EXPANDED RADAR SERVICE
- F = STAGE III EXPANDED RADAR SERVICE
- G = TCA GROUP 1
- H = TCA GROUP 2

** IFR WEATHER PREVAILANCE PERCENTAGES WERE TAKEN FROM REFERENCES 7 AND 29.

FIGURE 14C: RESULTS OF APPLYING ASR CRITERIA TO ALL FAA APPROACH CONTROL TOWERS - STATE/CITY SEQUENCE

LOCID	CITY	ST	RADAR EQUIP & SERV*	PIFR**	DELAY BEN	SAFETY BEN	LC COST	OLD PH II	NEW PH I	NEW PH II
ANC	ANCHORAGE	AK	ASR-8 A F	8.31	50601584.	10773929.	9760000.	22.84	20.81	6.29
FAI	FAIRBANKS	AK	ASR-8 A E	10.00	45901265.	9047535.	9760000.	20.40	5.50	5.63
BHM	BIRMINGHAM	AL	ASR-6 B C D F	12.20	64498144.	8717718.	9760000.	29.33	16.80	7.50
HSV	HUNTSVILLE	AL	ASR-7 A F	9.20	46783888.	1535572.	8970000.	9.09	6.34	5.39
MOB	MOBILE	AL	ASR-7 A F	14.00	74499200.	2681898.	8970000.	19.46	9.45	8.60
MGM	MONTGOMERY	AL	A F	10.00	37280016.	1704100.	8970000.	10.10	6.67	4.35
FYV	FAYETTEVILLE	AR		6.70	7270513.	544019.	8970000.	0.59	2.55	0.87
FSM	FORT SMITH	AR	ASR-6 F	6.70	30491344.	1134107.	8970000.	4.60	3.86	3.53
HOT	HOT SPRINGS	AR		9.70	335694.	415425.	8970000.	0.14	0.52	0.08
LIT	LITTLE ROCK	AR	ASR-4 A F	9.70	34631584.	4384395.	9760000.	16.04	9.24	4.00
PBF	PINE BLUFF	AR		9.70	37514.	281504.	8970000.	0.08	0.19	0.04
TXK	TEXARKANA	AR		11.20	417488.	413440.	8970000.	0.15	0.55	0.09
BFL	BAKERSFIELD	CA		6.31	26621024.	2997295.	8970000.	6.28	4.16	3.30
BUR	BURBANK	CA	ASR-6 B C D F	16.89	98382816.	5977728.	9760000.	28.40	11.66	10.69
FAT	FRESNO	CA	ASR-4 A E	9.10	51060240.	7328267.	9760000.	13.89	8.96	5.98
MRY	MONTEREY	CA	ASR-8 E	24.50	111519616.	2376024.	8970000.	29.66	7.82	12.70
PSP	PALM SPRINGS	CA	ASR-5 A F	0.20	600754.	1209852.	8970000.	1.00	4.22	0.20
SBA	SANTA BARBARA	CA	ASR-4 A	16.50	45203360.	3546163.	8970000.	9.22	2.48	5.43
SCK	STOCKTON	CA		8.80	25012592.	1892896.	8970000.	2.85	2.70	3.00
COS	COLORADO SPRINGS	CO	ASR-5 A F	6.21	28547680.	3894731.	8970000.	9.54	9.39	3.62
DEN	DENVER	CO	ASR-8 B C D H	6.50	41804128.	130659632.	9760000.	60.66	48.87	17.67
GJT	GRAND JUNCTION	CO		1.70	206602.	1271570.	8970000.	0.38	2.23	0.16
PUB	PUEBLO	CO	ASR-6 A E	5.40	13995688.	1534634.	8970000.	1.38	2.60	1.73
BDL	WINDSOR LOCKS	CT	ASR-8 B C D F	16.40	102981152.	7215830.	9760000.	50.08	22.39	11.29
DCA	WASHINGTON	DC	ASR-7 B C D G	11.40	79591504.	52279008.	9760000.	83.81	77.29	13.51
IAD	WASHINGTON	DC	ASR-4 B C D F	12.40	70284272.	9131194.	9760000.	32.15	18.42	8.14
DAB	DAYTONA BEACH	FL	ASR-5 A	6.70	20568400.	9917632.	9760000.	8.27	7.31	3.12
FMY	FT MYERS	FL	ASR-8	4.20	25691328.	3541255.	8970000.	4.81	6.44	3.26
GNV	GAINESVILLE	FL		6.60	4820726.	1514533.	8970000.	0.54	2.46	0.71
JAX	JACKSONVILLE	FL	ASR-8 B C D F	10.41	64567360.	4504198.	8970000.	22.35	14.97	7.70
MIA	MIAMI	FL	ASR-8 B C D G	2.41	14001842.	77360784.	9760000.	25.55	39.77	9.36
TNT	MIAMI	FL		2.41	15002.	143749.	8970000.	0.05	0.24	0.02
MCO	ORLANDO	FL	B C D F	6.60	39071824.	15199318.	9760000.	28.52	40.73	5.56
PNS	PENSACOLA	FL	ASR-8 A F	10.80	42480112.	1567156.	8970000.	8.95	5.44	4.91
TLH	TALLAHASSEE	FL	ASR-4 A F	12.30	48937184.	2038094.	8970000.	13.68	6.94	5.68
TPA	TAMPA	FL	ASR-8 B C F	6.80	48619920.	28233712.	9760000.	39.83	51.15	7.87
PBI	WEST PALM BEACH	FL	ASR-8 A F	2.70	11609050.	13652344.	9760000.	10.96	21.75	2.59
ABY	ALBANY	GA		11.01	3705733.	1350669.	8970000.	0.38	2.19	0.56
ATL	ATLANTA	GA	ASR-7 B C D G	14.60	51875072.	329240064.	9760000.	85.78	86.95	39.05
AGS	AUGUSTA	GA	ASR-6 F	11.60	42971216.	959272.	8970000.	7.88	4.02	4.90
CSG	COLUMBUS	GA	ASR-8 F	12.21	30288752.	903182.	8970000.	6.15	2.75	3.48
MCN	MACON	GA	F	11.69	26347152.	486448.	8970000.	4.16	1.94	2.99
SAV	SAVANNAH	GA	ASR-8 A F	11.50	41302896.	2475761.	8970000.	11.38	6.32	4.88
ITO	HILO	HI	ASR-8 A	3.40	3440382.	643690.	8970000.	0.91	5.43	0.46
HNL	HONOLULU	HI	ASR-8 B C D F H	0.50	3231754.	47805360.	9760000.	9.67	55.19	5.23
OGG	KAHULUI	HI	ASR-7 F	1.10	7850099.	3821988.	8970000.	6.00	15.21	1.30
KOA	KAILUA-KONA	HI		3.00	837391.	1019706.	8970000.	0.54	5.10	0.21
CID	CEDAR RAPIDS	IA	ASR-7 F	16.30	65179184.	2534673.	8970000.	15.77	5.52	7.55
DSM	DES MOINES	IA	ASR-4 B C D F	12.20	55578464.	8033483.	9760000.	24.44	12.71	6.52
SUX	SIOUX CITY	IA	ASR-7 E	11.00	49940352.	1411681.	8970000.	5.32	4.64	5.72

ALO	WATERLOO	IA	ASR-6 A		E	13.50	31987968.	1272058.	8970000.	2.40	2.85	3.71
BOI	BOISE	ID	ASR-7		F	4.69	19869296.	7734532.	9760000.	10.87	12.67	2.83
TWF	TWIN FALLS	ID				6.80	217886.	585914.	8970000.	0.19	1.32	0.09
CMI	CHAMPAIGN/URBANA/	IL	ASR-6 A		F	18.50	49005280.	3433191.	8970000.	11.89	3.64	5.85
DEC	DECATUR	IL				18.50	14339153.	868393.	8970000.	0.66	2.02	1.70
MWA	MARION	IL				11.80	195193.	506769.	8970000.	0.12	0.63	0.08
MLI	MOLINE	IL	ASR-7		F	12.51	42340736.	1903401.	8970000.	14.82	6.43	4.93
PIA	PEORIA	IL	ASR-7		F	14.09	52729200.	2227310.	8970000.	16.18	6.83	6.13
RFD	ROCKFORD	IL	ASR-6 A		F	13.30	25832272.	2225738.	8970000.	8.73	4.18	3.13
SPI	SPRINGFIELD	IL	ASR-7 A		F	12.90	37862768.	1678672.	8970000.	11.84	5.45	4.41
EVV	EVANSVILLE	IN	ASR-6 A		F	10.10	26728240.	1181015.	8970000.	7.49	4.20	3.11
FWA	FORT WAYNE	IN	ASR-4 A		F	14.70	68404512.	2906030.	8970000.	21.68	9.60	7.95
IND	INDIANAPOLIS	IN	ASR-8	B C D	F	14.80	83821472.	11408724.	9760000.	52.03	25.75	9.76
LAF	LAFAYETTE	IN				14.60	20248992.	1737066.	8970000.	0.68	2.93	2.45
MIE	MUNCIE	IN				16.10	772903.	585856.	8970000.	0.15	0.55	0.15
SBN	SOUTH BEND	IN	ASR-7 A		F	17.30	62419520.	1606329.	8970000.	16.47	5.50	7.14
HUF	TERRE HAUTE	IN				13.40	15880670.	1025815.	8970000.	1.38	1.25	1.88
HUT	HUTCHINSON	KS				10.00	6933689.	874221.	8970000.	0.42	1.55	0.87
SLN	SALINA	KS				7.80	1418543.	754649.	8970000.	0.22	1.40	0.24
ICT	WICHITA	KS	ASR-5 A		F	10.50	46068816.	10725435.	9760000.	24.34	15.49	5.82
CVG	COVINGTON/CINCINNA	KY	ASR-8	B C D	F	14.60	104210640.	5872153.	8970000.	35.48	20.81	12.27
LEX	LEXINGTON	KY	ASR-7		F	13.10	48045440.	2718237.	8970000.	16.01	7.36	5.66
SDF	LOUISVILLE	KY	ASR-8	B C D	F	10.90	71533440.	5694093.	9760000.	31.14	19.98	7.91
PAH	PADUCAH	KY				10.10	1091030.	290480.	8970000.	0.25	0.84	0.15
BTR	BATON ROUGE	LA	ASR-7		F	13.20	61526064.	3050392.	8970000.	13.01	5.49	7.20
LFT	LAFAYETTE	LA	ASR-6 A		F	14.11	32280560.	4895293.	9760000.	11.91	4.00	3.81
LCH	LAKE CHARLES	LA	ASR-6 A		F	13.20	18523968.	572417.	8970000.	4.96	1.53	2.13
MLU	MONROE	LA	ASR-5 A		F	11.20	22364784.	1198369.	8970000.	1.39	3.10	2.63
MSY	NEW ORLEANS	LA	ASR-8	B C D	H	10.89	76716080.	16719970.	9760000.	47.30	37.92	9.57
SHV	SHREVEPORT	LA			F	11.50	68925440.	1744482.	8970000.	14.38	8.43	7.88
BOS	BOSTON	MA	ASR-7	B C D	G	16.19	92041824.	62417488.	9760000.	70.34	73.68	15.83
ORH	WORCESTER	MA				20.40	624230.	647644.	8970000.	0.20	0.51	0.14
BWI	BALTIMORE	MD	ASR-8	B C D	F	13.00	73677056.	18110640.	9760000.	52.51	29.22	9.40
BGR	BANGOR	ME	ASR-6 A		F	19.60	79226416.	1167901.	8970000.	17.84	5.29	8.96
PWM	PORTLAND	ME	ASR-4 A			18.30	42764768.	1658679.	8970000.	17.87	5.86	4.95
DTW	DETROIT	MI	ASR-8	B C D	H	14.29	92509584.	36950672.	9760000.	73.55	67.51	13.26
FNT	FLINT	MI	ASR-7		F	15.50	39281312.	3620212.	8970000.	12.16	5.07	4.78
GRR	GRAND RAPIDS	MI	ASR-4		F	15.50	71168448.	5074148.	8970000.	25.21	10.97	8.50
JXN	JACKSON	MI				17.10	1886963.	714753.	8970000.	0.26	1.35	0.29
AZO	KALAMAZOO	MI	ASR-6 A		F	24.99	89044832.	1342836.	8970000.	16.29	3.94	10.08
LAN	LANSING	MI	ASR-7		F	16.40	60334128.	3031680.	8970000.	18.87	7.28	7.06
MKG	MUSKEGON	MI	ASR-6 A		F	16.70	48256864.	927047.	8970000.	6.47	2.56	5.48
MBS	SAGINAW	MI	ASR-6		F	14.29	64827376.	1101871.	8970000.	13.17	5.59	7.35
DLH	DULUTH	MN	ASR-6 A		F	20.30	124632048.	1079355.	8970000.	16.26	5.79	14.01
MSP	MINNEAPOLIS	MN	ASR-8	B C D	H	11.50	82447152.	36297248.	9760000.	67.33	61.04	12.17
RST	ROCHESTER	MN	ASR-7		F	13.90	48412736.	1386801.	8970000.	11.16	5.14	5.55
CGI	CAPE GIRARDEAU	MO				11.80	269252.	454927.	8970000.	0.15	0.69	0.08
COU	COLUMBIA	MO				11.80	2581244.	757397.	8970000.	0.32	1.85	0.37
JLN	JOPLIN	MO				11.90	488387.	589073.	8970000.	0.32	1.87	0.12
MCI	KANSAS CITY	MO	ASR-8	B C D	H	10.00	72233920.	20337584.	9760000.	47.31	44.28	9.48
SGF	SPRINGFIELD	MO	ASR-7 A		E	11.90	57474384.	2242409.	8970000.	5.70	3.74	6.66
STJ	ST JOSEPH	MO				10.30	146769.	452161.	8970000.	0.08	0.56	0.07
STL	ST LOUIS	MO	ASR-8	B C D	H	11.80	84937440.	50579216.	9760000.	85.12	78.19	13.88
GLH	GREENVILLE	MS				11.39	633505.	445901.	8970000.	0.22	1.53	0.12
GPT	GULFPORT	MS	ASR-4 A		F	14.00	54470672.	728598.	8970000.	8.38	3.64	6.15
JAN	JACKSON	MS	ASR-8 A		F	11.39	65740432.	2241591.	8970000.	15.86	9.29	7.58
BIL	BILLINGS	MT	ASR-7		F	5.70	23192848.	3323883.	8970000.	8.69	8.19	2.96
HLN	HELENA	MT				0.50	26502.	720857.	8970000.	0.22	1.97	0.08

MSO	MISSOULA	MT									8.17	433737.	583426.	8970000.	0.26	2.07	0.11
AVL	ASHEVILLE	NC	ASR-7						F		17.50	80391120.	922692.	8970000.	14.31	4.90	9.07
CLT	CHARLOTTE	NC	ASR-4		B	C	D		F		13.40	74273072.	18754320.	9760000.	54.93	30.61	9.53
FAY	FAYETTEVILLE	NC	ASR-4	A					F		14.01	67274576.	1071535.	8970000.	11.13	4.73	7.62
GSO	GREENSBORO	NC	ASR-4	A					F		13.69	67090448.	6559222.	9760000.	29.84	14.60	7.55
RDU	RALEIGH-DURHAM	NC	ASR-7		B	C	D		F		12.80	60428000.	10390519.	9760000.	33.82	17.36	7.26
ILM	WILMINGTON	NC	ASR-6	A					F		11.10	43137344.	1300504.	8970000.	8.31	4.63	4.95
BIS	BISMARCK	ND									10.60	21830704.	1458466.	8970000.	2.30	6.00	2.60
FAR	FARGO	ND	ASR-7						F		11.90	56746448.	1984326.	8970000.	11.03	5.86	6.55
LNK	LINCOLN	NE	ASR-7						F		9.60	42602144.	5379334.	9760000.	12.28	8.10	4.92
MHT	MANCHESTER	NH									20.40	29622960.	1746333.	8970000.	3.36	1.53	3.50
ACY	ATLANTIC CITY	NJ	ASR-4	A				E			17.40	56458192.	1991378.	8970000.	13.13	4.37	6.52
ABQ	ALBUQUERQUE	NM	ASR-8		B	C	D		F		1.21	6240726.	10330862.	9760000.	7.88	21.22	1.70
FMN	FARMINGTON	NM									2.20	118150.	865549.	8970000.	0.23	2.00	0.11
ROW	ROSWELL	NM									3.89	2474138.	864802.	8970000.	0.31	2.69	0.37
LAS	LAS VEGAS	NV	ASR-8		B	C	D			H	0.20	1237425.	56279760.	9760000.	8.22	55.98	5.89
RNO	RENO	NV	ASR-8	A					F		1.71	7360069.	7930161.	9760000.	9.10	19.39	1.57
ALB	ALBANY	NY	ASR-4		B	C	D		F		11.79	57653040.	3772796.	8970000.	23.22	11.82	6.85
BGM	BINGHAMTON	NY	ASR-4						F		21.60	56480976.	590384.	8970000.	12.59	2.27	6.36
BUF	BUFFALO	NY	ASR-8		B	C	D		F		14.10	97721376.	8975986.	9760000.	42.05	24.30	10.93
ELM	ELMIRA	NY	ASR-4					E			12.99	11642229.	734184.	8970000.	0.59	2.16	1.38
ISP	ISLIP	NY	ASR-8					E			19.80	48288192.	4674562.	9760000.	10.54	2.71	5.43
ROC	ROCHESTER	NY	ASR-4		B	C	D		F		11.40	70338416.	10547773.	9760000.	23.61	14.81	8.29
SYR	SYRACUSE	NY	ASR-8		B	C	D		F		10.80	54880000.	5445114.	9760000.	24.58	14.22	6.18
HPN	WHITE PLAINS	NY	ASR-3	A				E			20.20	36626592.	2983667.	9760000.	12.74	3.33	4.06
CAK	AKRON	OH	ASR-4	A					F		17.71	46172176.	1992156.	8970000.	15.43	5.38	5.37
CLE	CLEVELAND	OH	ASR-8		B	C	D			H	15.10	106458640.	25337616.	9760000.	76.09	48.59	13.50
CMH	COLUMBUS	OH	ASR-8		B	C	D		F		13.40	67378592.	12874864.	9760000.	39.91	20.94	8.22
DAY	DAYTON	OH	ASR-8		B	C	D		F		16.10	87958464.	5421579.	9760000.	38.73	16.23	9.57
MFD	MANSFIELD	OH									17.99	3035652.	590776.	8970000.	0.25	0.86	0.40
TOL	TOLEDO	OH	ASR-4	A					F		14.00	66972608.	1749169.	8970000.	16.17	7.49	7.66
YNG	YOUNGSTOWN	OH	ASR-8						F		20.90	50398560.	1360590.	8970000.	13.46	3.70	5.77
CSM	CLINTON	OK									10.40	378705.	273811.	8970000.	0.11	1.08	0.07
OKC	OKLAHOMA CITY	OK							F		10.40	64493072.	7707210.	9760000.	22.97	14.49	7.40
TUL	TULSA	OK	ASR-4		B	C	D		F		9.01	62944160.	8742465.	9760000.	14.51	13.40	7.34
EUG	EUGENE	OR	ASR-5	A				E			12.10	63850864.	2519438.	8970000.	11.86	5.23	7.40
MFR	MEDFORD	OR									11.99	16596910.	1784790.	8970000.	1.39	1.93	2.05
PDT	PENDLETON	OR									6.80	139991.	373103.	8970000.	0.14	0.72	0.06
PDX	PORTLAND	OR	ASR-8		B	C	D		F		10.99	67808048.	14082728.	9760000.	44.47	30.92	8.39
ABE	ALLENTOWN	PA	ASR-7	A					F		16.41	52811264.	1689818.	8970000.	14.28	4.93	6.08
ERI	ERIE	PA	ASR-7						F		14.20	34455248.	828037.	8970000.	7.58	3.04	3.93
CXY	HARRISBURG	PA	ASR-4	A					F		13.30	17851904.	718117.	8970000.	8.40	2.78	2.07
PHL	PHILADELPHIA	PA	ASR-7		B	C	D			H	15.70	95685424.	42735040.	9760000.	105.77	55.82	14.18
PIT	PITTSBURGH	PA	ASR-8		B	C	D			H	17.09	122570352.	61214368.	9760000.	127.85	80.20	18.83
RDG	READING	PA	ASR-5	A				E			14.50	2559577.	1438574.	8970000.	0.42	0.74	0.45
AVP	WILKES-BARRE/SCRAN	PA	ASR-8	A					F		12.60	40579856.	1160177.	8970000.	4.74	3.20	4.65
IPT	WILLIAMSPORT	PA									13.00	3340351.	695832.	8970000.	0.27	0.73	0.45
CAE	COLUMBIA	SC	ASR-7	A					F		11.60	46209440.	3631410.	8970000.	16.56	8.61	5.56
FLO	FLORENCE	SC									12.21	737253.	436053.	8970000.	0.17	0.67	0.13
GSP	GREER	SC	ASR-4	A					F		12.51	62071520.	803079.	8970000.	10.46	5.02	7.01
FSD	SIOUX FALLS	SD	ASR-7						F		12.50	72070064.	2014363.	8970000.	15.23	8.55	8.26
TUT	PAGO PAGO	SP									2.00	67646.	69197.	8970000.	0.91	1.57	0.02
TRI	BRISTOL/JOHNSON	TN	ASR-8	A					F		10.80	47550192.	1969674.	8970000.	12.49	7.12	5.52
CHA	CHATTANOOGA	TN	ASR-8	A					F		9.50	29519456.	2049864.	8970000.	9.53	5.80	3.52
TYS	KNOXVILLE	TN	ASR-6	A					F		9.51	39545568.	3668694.	8970000.	14.38	9.17	4.82
MEM	MEMPHIS	TN	ASR-8		B	C	D		F		9.39	59375104.	51902944.	9760000.	59.60	57.66	11.40
BNA	NASHVILLE	TN	ASR-8		B	C	D		F		10.20	52464192.	13985926.	9760000.	35.12	24.34	6.81
ABI	ABILENE	TX						E			7.01	11610204.	1095663.	8970000.	1.15	1.97	1.42

AMA	AMARILLO	TX	ASR-4					F		8.11	50452592.	1907006.	8970000.	8.51	6.78	5.84
AUS	AUSTIN	TX		A				F		15.21	92585008.	7385534.	9760000.	28.70	13.30	10.24
BPT	BEAUMONT/PORT ART	TX	ASR-7	A				F		14.30	14596324.	406929.	8970000.	2.05	1.00	1.67
BRO	BROWNSVILLE	TX								11.61	'2168286.	951015.	8970000.	0.38	1.84	0.35
CLL	COLLEGE STATION	TX								15.21	1104261.	715202.	8970000.	0.16	0.64	0.20
CRP	CORPUS CHRISTI	TX	ASR-5	A				F		12.70	54742608.	2261461.	8970000.	14.05	6.90	6.35
DFW	DALLAS-FORT WORTH	TX	ASR-7		B	C	D		G	8.69	54623504.	160226592.	9760000.	74.79	53.59	22.01
ELP	EL PASO	TX	ASR-5		B	C	D	F		1.11	5853736.	8458299.	9760000.	5.90	15.99	1.47
IAH	HOUSTON	TX	ASR-8		B	C	D		H	17.10	120442688.	72932976.	9760000.	113.28	70.55	19.81
GGG	LONGVIEW	TX	ASR-4	A				F		10.90	2377384.	806960.	8970000.	0.19	0.75	0.35
LBB	LUBBOCK	TX	ASR-5	A				F		8.09	49636768.	3083912.	8970000.	10.12	7.46	5.88
MFE	MC ALLEN	TX								11.61	1553074.	1001624.	8970000.	0.34	1.97	0.28
MAF	MIDLAND	TX	ASR-7					F		7.00	40092880.	3706526.	8970000.	0.78	7.13	4.88
SJT	SAN ANGELO	TX								7.19	5132306.	930979.	8970000.	0.41	1.60	0.68
SAT	SAN ANTONIO	TX	ASR-8		B	C	D	F		17.50	109842432.	12262231.	9760000.	43.90	19.89	12.51
TYR	TYLER	TX								13.30	935003.	615780.	8970000.	0.18	0.58	0.17
ACT	WACO	TX	ASR	A						11.00	409850.	431555.	8970000.	0.16	0.58	0.09
SLC.	SALT LAKE CITY	UT	ASR-8		B	C	D	F		5.51	31499040.	26282864.	9760000.	26.79	34.32	5.92
LYH	LYNCHBURG	VA								12.80	27100256.	996132.	8970000.	1.64	3.17	3.13
ORF	NORFOLK	VA	ASR-6		B	C	D	F		13.70	73699264.	8914189.	9760000.	42.62	22.58	8.46
RIC	RICHMOND	VA	ASR-4	A				F		13.30	68296432.	6171992.	9760000.	30.81	15.03	7.63
ROA	ROANOKE	VA	ASR-8	A				F		8.59	47950992.	4218192.	8970000.	15.47	11.61	5.82
BTV	BURLINGTON	VT	ASR-7	A						8.50	34906016.	1718090.	8970000.	9.07	6.28	4.08
MWH	MOSES LAKE	WA								8.60	11343368.	2100228.	8970000.	0.32	1.54	1.50
PSC	PASCO	WA								6.80	28988800.	2014368.	8970000.	1.62	4.50	3.46
SEA	SEATTLE	WA	ASR-8		B	C	D		H	16.31	117237808.	26465696.	9760000.	76.70	52.11	14.72
GEG	SPOKANE	WA	ASR-6	A				F		14.30	94503280.	5156017.	8970000.	26.70	14.07	11.11
YKM	YAKIMA	WA								7.71	31244144.	1829608.	8970000.	1.83	4.28	3.69
GRB	GREEN BAY	WI	ASR-7					F		14.00	74582480.	2414352.	8970000.	18.01	9.10	8.58
LSE	LA CROSSE	WI								20.30	9997087.	878588.	8970000.	0.70	2.38	1.21
MSN	MADISON	WI	ASR-4					F		14.09	59285680.	5683324.	8970000.	21.32	10.12	7.24
MKE	MILWAUKEE	WI	ASR-8		B	C	D	F		14.60	90934352.	19069760.	9760000.	57.07	33.11	11.27
CRW	CHARLESTON	WV	ASR-8					F		22.20	71503296.	2305638.	8970000.	23.81	7.08	8.23
CKB	CLARKSBURG	WV	ASR	A						27.09	1870000.	544178.	8970000.	0.28	0.71	0.27
HTS	HUNTINGTON	WV	ASR-4					F		15.40	55257712.	905829.	8970000.	9.88	3.70	6.26
PKB	PARKERSBURG	WV								16.09	5649189.	720677.	8970000.	0.36	0.90	0.71
CPR	CASPER	WY	ASR-6	A			E			6.70	19289872.	1285149.	8970000.	4.23	3.31	2.29
CYS	CHEYENNE	WY								9.20	6960473.	868846.	8970000.	0.48	2.60	0.87

* RADAR EQUIPMENT AND RADAR SERVICE AS OF SEPTEMBER 30,1981 (SOURCE: REFERENCE 26).
RADAR SERVICE CROSS REFERENCE CODES:
- A = ARTS II
- B = ARTS III
- C = CONFLICT ALERT
- D = MINIMUM SAFE ALTITUDE WARNING
- E = STAGE II EXPANDED RADAR SERVICE
- F = STATE III EXPANDED RADAR SERVICE
- G = TCA GROUP 1
- H = TCA GROUP 2

** IFR WEATHER PREVAILANCE PERCENTAGES WERE TAKEN FROM REFERENCES 7 AND 29.

FIGURE 14D

Summary of Results of Applying Previous and Revised ASR Criteria to all FAA Approach Control Towers[a]

Phase II Benefit/Cost Ratio	Previous Criteria	Revised Criteria
0.00 - 0.34[g] } [h]	32[b]	30[b]
0.35 - 0.74	15[c]	12[b]
0.75 - 0.99	2[d]	3
1.00 - 1.34	2[c]	2[d]
1.35 and above	153[e]	157[f]

a/ Source: Figure 14A. Excludes CIFRR's, CERAP's, RAPCON's and RATCF's and benefits that may be attributable to radar coverage provided to qualified secondary airports, if any, under the "area concept" outlined in Section IV.

b/ As of September 1981, 3 of these locations had radar equipment and service (Reference 26).

c/ As of September 1981, 2 of these locations had radar equipment and/or service (Reference 26).

d/ As of September 1981, 1 of these locations had radar equipment and service (Reference 26).

e/ As of September 1981, 144 of these locations had radar equipment or service (Reference 26).

f/ As of September 1981 145 of these locations had radar equipment or service (Reference 26).

g/ Range of discontinuance criteria under the revised criteria. Of the 30 locations that fall in this range under the revised criteria, 3 had ASR as of September 1981. Tentatively applying the "area concept" criteria discussed in Section IV reduces this to 2 discontinuance candidates.

h/ Range of discontinuance criteria under the previous criteria. Of the 47 locations that fall in this range under the previous criteria, 5 had ASR as of September 1981 and therefore satisfy the previous discontinuance criteria.

SECTION VII - A MANUAL METHOD FOR COMPUTING THE PHASE II ASR ESTABLISHMENT BENEFIT/COST RATIO

In actual practice, candidates found to satisfy Phase I criteria (simplified criteria) will be further screened under Phase II criteria (site-specific benefit/cost analysis) by a computer program. To facilitate understanding of the logic incorporated in the Phase II screening process by program analysts, auditors and others, this section describes in detail a manual method for computing the Phase II ASR establishment benefit/cost ratio. Figures 15 through 24 are designed to serve as worksheets for manually computing the Phase II benefit/cost ratio. Additional copies of Figures 16, 18 and 21 may be required in instances where there exist secondary airports qualified under the "area concept" discussed in Section IV. It may be noted that several of the worksheets include 4-engine turbofans/turbojets. Obviously, terminals that serve these aircraft types are already equipped with and/or served by ASR. Conversely, airports within the range of interest in this report for new radar establishment do not serve these aircraft types. Their inclusion here is without impact and only for completeness of presentation.

The step-by-step methodology outlined in this section is supplemented with an illustration in Figures 25 through 34 for Binghamton Broome County Airport, NY (BGM) (which already has an ASR), including one of its secondary or satellite airports, Endicott Tri-Cities Airport (N17), which for purposes of this illustration is assumed to meet the "area concept" criteria outlined in Section II. 1982 activity forecasts are used. Application of the manual approach to computing the Phase II benefit/cost ratio should be based on site-specific data since these program inputs, if available, should be used for the computerized Phase II benefit/cost screening process. In addition to being specified in the following steps, Appendix F provides a checklist for those program inputs which should be site-specific, for those which are fixed for all candidates, and those for which default values may be used in the absence of site-specific data. The manual computation of the Phase II benefit-cost ratio described in this section quantifies the expected life-cycle benefits by discounting future year benefits using a site-specific compound growth rate. The computerized Phase II benefit/cost screening will rely on official agency traffic forecasts specific to the potential candidate site over fifteen years to derive the present value of the expected life-cycle benefits.

IFR Delay Reduction Benefits

Step 1

Enter the annual number of primary instrument operations by user class in Column A of Figure 15 for the primary airport. In Column A of each copy of Figure 16 for each qualified secondary airport, if any, enter the number of primary instrument operations by user class or the number of secondary instrument operations of the primary airport allocable to the secondary airport, whichever is larger. In the Binghamton/Endicott illustration (Figures 25 and 26), Binghamton (the primary airport) has 42,480 primary instrument operations. Assuming Endicott is its only qualifying secondary airport by satisfying the "area concept" criteria outlined in Section IV, 100 percent of Binghamton's 7,668 secondary instrument operations are allocable to Endicott. Since Endicott generates no primary instrument operations on its own, Endicott's instrument operations total 7,668.

Step 2

In Column B of Figure 15 for the primary airport and Column B of each copy of Figure 16 for each qualified secondary airport, enter the percent of annual instrument operations represented by each user class by dividing the annual instrument operations in Column A by the respective totals. The sum of the percentages should equal 100 or approximate 100 in the event of a rounding effect.

Step 3

Disaggregate each user class by aircraft type in percentage terms and enter the percentages in Column C of Figure 15 for the primary airport and Column C of each copy of Figure 16 for each qualified secondary airport. The sum of the percentages for each user class should equal 100 or approximate 100 in the event of a rounding effect. For purposes of the Binghamton/Endicott illustration (Figures 25 and 26), the distribution of instrument aircraft by aircraft type within the air taxi, general aviation and military user classes are based on national norms, as illustrated in Appendix E-2. For the air carrier user class, the distribution of aircraft by aircraft type is site-specific based on published statistics from References 15 and 16. In the computerized Phase II benefit/cost screening process, only the air carrier user class requires dissaggregation by aircraft type. The aircraft type disaggregation of the other user classes are fixed based on national norms (Appendix E-2).

Step 4

Reference Figure 6 to determine the estimated number of instrument operations during a busy hour at the primary airport and each qualified secondary airport. Enter this (these) values in the space(s) provided in the heading(s) of Column D of Figure 15 for the primary airport and Column D of each copy of Figure 16 for each qualified secondary airport. In the Binghamton/Endicott illustration (Figures 25 and 26), 42,480 annual primary instrument operations equates to 29 instrument operations during a busy hour at Binghamton, the primary airport; for Endicott, the secondary airport, 7,668 annual instrument operations equates to 11 instrument operations during a busy hour.

Step 5

In Figure 15 for the primary airport and each copy of Figure 16 for each qualified secondary airport, find the expected mix of aircraft during a busy IFR hour by multiplying the results from steps 2 (Column B), 3 (Column C) and 4 and dividing the product by 10,000 for each aircraft type. Enter the quotient(s) in Column D.

Step 6

Transcribe the instrument aircraft mix of the primary airport from Column D of Figure 15 to Column A of Figure 17 and from Column D of each copy of Figure 16 to Column A of each copy of Figure 18 for each qualified secondary airport.

Step 7

In Figure 17 for the primary airport and each copy of Figure 18 for each qualified secondary airport, determine the hourly aircraft variable operating cost for each aircraft type mix by multiplying the number of instrument aircraft (Column A) by the respective aircraft hourly variable operating cost (preprinted in Column B). Enter the product(s) in Column C.

Step 8

Enter the average number of passengers for the air carrier and air taxi user classes and the average number of occupants for the general aviation and military user classes for each aircraft type in Column D of Figure 17 for the primary airport and Column D of each copy of Figure 18 for each qualified secondary airport. For purposes of the Binghamton/Endicott illustration (Figures 27 and 28) and the computer-generated Phase II benefit/cost ratios outlined for all FAA approach control towers in Section VI, passenger and occupant load factors are based on national norms, as derived from References 17, 18, 19 and 20. These are illustrated in Appendix C.

Step 9

In Figure 17 for the primary airport and each copy of Figure 18 for each qualified secondary airport, determine the value of passengers'/occupants' time per hour for each aircraft type mix by multiplying the number of aircraft (Column A), the average number of passengers/occupants per aircraft (Column D), and $17.50 (the hourly value of time of aircraft passengers/occupants in 1980 dollars). Enter the product(s) in Column E.

Step 10

In Figure 17 for the primary airport and each copy of Figure 18 for each qualified secondary airport, find the sum of aircraft variable operating costs (Column C) and the value of occupants'/passengers' time (Column E) to arrive at the total hourly operating cost of each aircraft type mix. Enter the sum(s) in Column F. Sum all values in Column F to find the total cost of operating the instrument aircraft mix for one hour.

Step 11

Find the percent of total annual instrument operations represented by the air carrier user class from Column B of Figure 15 for the primary airport and Column B of each copy of Figure 16 for each qualified secondary airport. Round to the nearest 10 percent. If less than 20 percent, round up to 20 percent; if greater than 90 percent, round down to 90 percent. With this (these) percentage(s) and the number(s) of total instrument operations during a busy hour from Column D of Figure 15 for the primary airport and Column D of each copy of Figure 16 for each qualified secondary airport, refer to Figure 5 to find the number of hours saved per aircraft per hour of airport operation. Enter this (these) value(s) in the appropriate space(s) in Row A of Figure 19. Applying Binghamton's 29 instrument operations per busy hour and a 20% air carrier instrument mix (rounded up from 6.6%) to Figure 5, we find an expected savings of 1.931 hours per aircraft per hour of airport operation (Figure 29). Similarly, applying Endicott's 11 instrument operations per busy hour and a 20% air carrier instrument mix (rounded up to lower limit) to Figure 5, we find an expected savings of .021 hours per aircraft per hour of airport operation (Figure 29).

Step 12

Transcribe the total hourly cost of aircraft operation and passengers'/occupants' time from Column F of Figure 17 for the primary airport and Column F of each copy of Figure 18 for each qualified second airport to the appropriate space(s) in Row B of Figure 19.

Step 13

In Figure 19, find the total delay savings per busy IFR hour at the primary airport and each qualified secondary airport per hour of airport operation by multiplying the average delay savings per aircraft per hour of airport operation (Row A) by the total hourly operating cost of the aircraft mix (Row B). Enter the product(s) in Row C.

Step 14

From local statistics or Section VI, find the proportionate hours of the year that instrument approach weather prevails at the primary airport and each qualified secondary airport. Enter the value(s) in the appropriate space(s) of Row D of Figure 19.

Step 15

In Figure 19, find the number of busy IFR hours per year at the primary airport and each qualified secondary airport by multiplying the percentage of time that IFR weather prevails (Column D) by 1,252 hours. The 1,252 value is the annual national norm of IFR weather prevailance based on 4 hours during weekdays and 2 hours during weekends. Enter the product(s) in Row E.

Step 16

In Figure 19, find the value of annual delay savings for the primary airport and each qualified secondary airport by multiplying the total delay savings per busy IFR hour (Row C) by the number of busy IFR hours per year (Row E). Enter the product(s) in Row F.

Step 17

Find the value of total annual delay savings for all airports (primary airport and qualified secondary airports) by summing Row F of Figure 19. Enter the sum in the space provided.

Safety Benefits

Step 18

Enter the number of annual aircraft operations for each user class in Column A of Figure 20 for the primary airport and Column A of each copy of Figure 21 for each qualified secondary airport. Sum the values of the user classes to determine total annual aircraft operations at the primary airport and each qualified secondary airport.

Step 19

Disaggregate each user class by aircraft type in percentage terms and enter the percentages in Column B of Figure 20 for the primary airport and Column B of each copy of Figure 21 for each qualified secondary airport. The sum of the percentages for each user class should equal 100 or approximate 100 in the event of a rounding effect. For purposes of the Binghamton illustration (Figure 30), the distributions of aircraft by aircraft type within the air taxi, general aviation and military user classes are based on national norms, as illustrated in Appendix E-3. For the air carrier user class, the distribution of aircraft by aircraft type is site-specific based on published statistics from References 15 and 16. In the computerized Phase II benefit/cost screening process, only the air carrier user class requires disaggregation by aircraft type. The aircraft type disaggregations of the other user classes are fixed based on national norms (Appendix E-3).

Step 20

In Figure 20 for the primary airport and each copy of Figure 21 for each qualified secondary airport, find the mix of aircraft in all operations by multiplying Column A by Column B and dividing the product by 100 for each aircraft type. Enter the results in Column C. Sum Column(s) C in Figure 20 and any copies of Figure 21.

Step 21

Cross sum the annual operations by aircraft type over the primary and qualified secondary airports in Columns C of Figure 20 and all copies of Figure 21. Enter the sum for each aircraft type in Column A of Figure 22.

Step 22

Enter in Column B of Figure 22 the occupant load factor for each aircraft type within the air carrier and air taxi user classes by making allowances for crews to the passenger load factors used in Columns D of Figures 17 and 18. The occupant load factors for the general aviation and military user classes used in Figures 17 and 18 should be transcribed directly to Column B of Figure 22.

Step 23

In Figure 22 find the expected contributory costs of fatalities and serious injuries per aircraft for each aircraft type by multiplying the aircraft mix (Column A), the number of occupants per aircraft (Column B), the expected costs of fatalities and serious injuries per occupant (preprinted in Column C) and dividing the resultant product by the total aircraft mix. Enter the result for each aircraft type in Column D.

Step 24

In Figure 22 find the expected contributory cost of aircraft damage per aircraft for each aircraft type by multiplying the aircraft mix (Column A) by the expected cost of aircraft damage per aircraft (preprinted in Column E) and dividing the resultant product by the total aircraft mix. Enter the result for each aircraft type in Column F.

Step 25

In Figure 22 sum the expected contributory costs of fatalities and serious injuries (Column D) and the expected contributory cost of aircraft damage per aircraft (Column F) for each aircraft type. Enter the result for each aircraft type in Column G. Sum Column G to determine the expected cost of a midair collision per aircraft.

Step 26

Transcribe the number of total annual aircraft operations from Column A of Figure 22 to both spaces provided in Row A of Figure 23.

Step 27

In Row B of Figure 23, enter the expected number of avertable midair collisions by referring to Figure 10 or by solving the formula outlined in the footnote to Figure 10.

Step 28

Multiply the total expected cost of a midair collision per aircraft in Column G of Figure 22 by the factor "2" (i.e., two aircraft per midair collision). Enter the product in Column C of Figure 23.

Step 29

Refer to Figure 12 to determine the Mode C usage factor. As an approximation of the average factor over the 15-year economic life of an ASR system, use that factor corresponding to the base year plus seven years. Enter the factor in Column D of Figure 23. In the Binghamton/Endicott illustration (Figure 33), the Mode C usage factor is found to be 76%.

Step 30

Find the expected value of annual avertable midair collisions by multiplying the expected number of annual avertable midair collisions

(Column B) by the expected cost of a midair collision (Column C). Enter the product in the space provided in Column E. Find the value of avertable terrain collisions by multiplying the number of total aircraft operations (Column A), the cost of terrain collisions per operation (preprinted in Column C) and the Mode C usage factor (Column D). Enter the product in the space provided in Column E. Find the expected value of all avertable collisions by adding the respective values in Column E. Enter the sum in the space provided.

Benefit/Cost Ratio

Step 31

Transcribe the expected annual value of IFR delay reduction from Row F of Figure 19 to Row A of Figure 24 and the expected annual value of avertable collisions from Column E of Figure 23 to Row B of Figure 24.

Step 32

Add Rows A and B of Figure 24 to arrive at total expected annual quantified benefits of an ASR in the base year. Enter this sum in Row C.

Step 33

Compute the site-specific net discount factor by solving the following formula:

$$\text{NDF} = \left(\frac{1}{(1 + d)^{7.5}}\right) \left(\frac{\text{Projected Total aircraft Opns in "Base Year + 7 years"}}{\text{Actual Total aircraft Opns in "Base Year"}}\right) \left(15\right)$$

where,

NDF = net discount factor
d = OMB-prescribed discount rate of 10 percent

For the Binghamton/Endicott illustration, assume there are 191,000 total aircraft operations in the base year and 224,000 total aircraft operations projected for the seventh year thereafter. The net discount factor is then computed to be:

$$\text{NDF} = \left(\frac{1}{(1.1)^{7.5}}\right) \left(\frac{270,000}{185,000}\right) \left(15\right) = 10.71$$

Enter the result in the space provided in Row D of Figure 24.

This step is only a short-cut method of discounting the total approximate life-cycle benefits over 15 years to their present value. The computerized Phase II screening benefit/cost process is more specific in that each year is addressed separately and independently of the others.

Step 34

Multiply the total annual benefits in Column C of Figure 24 by the net discount factor computed in Step 34. Enter the product in Row D.

Step 35

Enter the site-specific discounted life-cycle cost of an ASR system in Row E of Figure 24 based on the methodology outlined in Figure 1 for a TRACAB configuration or Figure 2 for a TRACON configuration, as appropriate. The criteria for TRACAB/TRACON are outlined in paragraph E of Section II.

Step 36

In Figure 24, find the ASR Phase II benefit/cost ratio by dividing the total discounted life-cycle benefits (Row D) by the discounted life-cycle costs (Row E). Enter the quotient in Row F. As illustrated in Figure 34, Binghamton/Endicott easily qualify for an ASR with a benefit/cost ratio of 6.51. Note how similar this manually computed Phase II benefit/cost ratio is with the computer-generated Phase II benefit/cost ratio of 6.36 computed for Binghamton in Figure 14 of Section VI. The difference can be attributed principally to the fact that the computer-generated benefit/cost ratio was derived for Binghamton only and includes no credit for radar coverage provided to Endicott, while in the benefit/cost ratio computed manually in this section does include Endicott. Also, the computer-generated benefit/cost ratio is based on discounted traffic forecasts specific to Binghamton, while the benefit/cost ratio computed manually in this section is based on a less precise net discount factor concept.

FIGURE 15

Worksheet for Computation of Aircraft Mix During a Busy IFR Hour - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Primary Instrument Operations	(B) Percent of Total Annual Primary Instrument Operations	(C) Percent Aircraft Type of User Class	(D) Number of Aircraft During a Busy IFR Hour ((BxCx)/10,00
Air Carrier				
Turbofan, 4-engine, wide body				
Turbojet, 4-engine				
Turbofan, 4-engine, regular body				
Turbofan, 3-engine, wide body				
Turbofan, 3-engine, regular body				
Turbofan, 2-engine, wide body				
Turbofan, 2-engine, regular body				
Turboprop				
Piston				
Air Taxi (Including Air Commuter)				
Jet				
Turboprop				
Multi-engine piston				
Single-engine piston				
Rotorcraft				
General Aviation (Excluding Air Taxi)				
Jet				
Turboprop				
Multi-engine piston				
Single-engine piston				
Rotorcraft				
Military				
Jet				
Turboprop				
Piston				
Rotorcraft				
TOTAL				

FIGURE 16

Worksheet for Computation of Aircraft Mix During a Busy IFR Hour - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Instrument Operations (See Text)	(B) Percent of Total Annual Instrument Operations	(C) Percent Aircraft Type of User Class	(D) Number of Aircraft During a Busy IFR Hour ((BxCx)/10,000)
Air Carrier				
Turbofan, 4-engine, wide body				
Turbojet, 4-engine				
Turbofan, 4-engine, regular body				
Turbofan, 3-engine, wide body				
Turbofan, 3-engine, regular body				
Turbofan, 2-engine, wide body				
Turbofan, 2-engine, regular body				
Turboprop				
Piston				
Air Taxi (Including Air Commuter)				
Jet				
Turboprop				
Multi-engine piston				
Single-engine piston				
Rotorcraft				
General Aviation (Excluding Air Taxi)				
Jet				
Turboprop				
Multi-engine piston				
Single-engine piston				
Rotorcraft				
Military				
Jet				
Turboprop				
Piston				
Rotorcraft				
TOTAL				

FIGURE 17

Worksheet for Computation of Aircraft Variable Operating Costs and Value of Passengers'/Occupants' Time During a Busy IFR Hour - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Aircraft During a Busy IFR Hour (From Figure 15)	(B) Aircraft Hourly Variable Operating Cost1/	(C) V.O.C. of Aircraft Mix (AxB)	(D) Number of Passengers/ Occupants per Aircraft2/	(E) Value of Passengers'/Occupants' Time (AxDx$17.50 1/)	(F) Hourly Cost of Aircraft Operations and Passengers'/ Occupants' Time of Aircraft Mix (C+E)
Air Carrier						
Turbofan, 4-engine, wide body		$4,767				
Turbojet, 4-engine		2,880				
Turbofan, 4-engine, regular body		2,643				
Turbofan, 3-engine, wide body		3,341				
Turbofan, 3-engine, regular body		1,964				
Turbofan, 2-engine, wide body		2,655				
Turbofan, 2-engine, regular body		1,508				
Turboprop		694				
Piston		139				
Air Taxi (Including Air Commuter)						
Jet		942				
Turboprop		369				
Multi-engine piston		132				
Single-engine piston		56				
Rotorcraft		138				
General Aviation (Excluding Air Taxi)						
Jet		782				
Turboprop		233				
Multi-engine piston		93				
Single-engine piston		30				
Rotorcraft		77				
Military						
Jet		1,333				
Turboprop		360				
Piston		97				
Rotorcraft		113				
TOTAL						

1/Source: Reference 9

2/Passengers for Air Carrier and Air Taxi; Occupants for General Aviation and Military.

FIGURE 18

Worksheet for Computation of Aircraft Variable Operating Costs and Value of Passengers'/Occupants' Time During a Busy IFR Hour - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Aircraft During a Busy IFR Hour (From Figure 16)	(B) Aircraft Hourly Variable Operating Cost1/	(C) V.O.C. of Aircraft Mix (AxB)	(D) Number of Passengers/ Occupants per Aircraft2/	(E) Value of Passengers'/Occupants' Time (AxDx$17.501/)	(F) Hourly Cost of Aircraft Operation and Passengers'/ Occupants' Time of Aircraft Mix (C+E)
Air Carrier						
Turbofan, 4-engine, wide body		$4,767				
Turbojet, 4-engine		2,880				
Turbofan, 4-engine, regular body		2,643				
Turbofan, 3-engine, wide body		3,341				
Turbofan, 3-engine, regular body		1,964				
Turbofan, 2-engine, wide body		2,655				
Turbofan, 2-engine, regular body		1,508				
Turboprop		694				
Piston		139				
Air Taxi (Including Air Commuter)						
Jet		942				
Turboprop		369				
Multi-engine piston		132				
Single-engine piston		56				
Rotorcraft		138				
General Aviation (Excluding Air Taxi)						
Jet		782				
Turboprop		233				
Multi-engine piston		93				
Single-engine piston		30				
Rotorcraft		77				
Military						
Jet		1,333				
Turboprop		360				
Piston		97				
Rotorcraft		113				
TOTAL						

1/Reference 9

2/Passengers for Air Carrier and Air Taxi; Occupants for General Aviation and Military.

FIGURE 19

Worksheet for Computation of Annual Benefits of IFR Delay Reduction at Primary and Secondary Airports

		Primary Airport	"Qualified" Secondary Airports				Total
A	Hours Saved per Aircraft per Hour of Airport Operation						
B	Sum of Aircraft Variable Operating Costs and Value of Passengers'/Occupants' Time						
C	Total Delay Savings per Busy IFR Hour (A x B)						
D	Percent of Time that IFR Weather Prevails						
E	Number of Busy IFR Hours per Year (D x 1,252 Hours)						
F	Annual Benefits of IFR Delay Reduction (C x E)						

FIGURE 20

Worksheet for Computation of Relative Annual Aircraft Mix - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Operations By User Class	(B) Percent Aircraft Type of User Class	(C) Annual Aircraft Mix ((AxB)/100)
Air Carrier			
Turbofan, 4-engine, wide body			
Turbojet, 4-engine			
Turbofan, 4-engine, regular body			
Turbofan, 3-engine, wide body			
Turbofan, 3-engine, regular body			
Turbofan, 2-engine, wide body			
Turbofan, 2-engine, regular body			
Turboprop			
Piston			
Air Taxi (Including Air Commuter)			
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston			
Rotorcraft			
General Aviation (Excluding Air Taxi)			
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston			
Rotorcraft			
Military			
Jet			
Turboprop			
Piston			
Rotorcraft			
TOTAL			

FIGURE 21

Worksheet for Computation of Annual Aircraft Mix - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Operations By User Class	(B) Percent Aircraft Type of User Class	(C) Annual Aircraft Mix ((AxB)/100)
Air Carrier			
Turbofan, 4-engine, wide body			
Turbojet, 4-engine			
Turbofan, 4-engine, regular body			
Turbofan, 3-engine, wide body			
Turbofan, 3-engine, regular body			
Turbofan, 2-engine, wide body			
Turbofan, 2-engine, regular body			
Turboprop			
Piston			
Air Taxi (Including Air Commuter)			
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston			
Rotorcraft			
General Aviation (Excluding Air Taxi)			
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston			
Rotorcraft			
Military			
Jet			
Turboprop			
Piston			
Rotorcraft			
TOTAL			

FIGURE 22

Worksheet for Computation of the Expected Cost of a Midair Collision Per Aircraft

User Class and Aircraft Type	(A) Aircraft Mix	(B) Number of Occupants Per Aircraft	(C) Expected Costs of Fatalities and Serious Injuries Per Occupant*	(D) Expected Contributory Costs of Fatalities and Serious Injuries ((AxBxC/∑ Col A)	(E) Expected Cost of Aircraft Damage Per Aircraft*	(F) Expected Contributory Costs of Aircraft Damage ((AxE)/∑ Col A)	(G) Total Expected Contributory Cost Per Collision Per Aircraft (D+F)
Air Carrier			$249,700				
Turbofan, 4-engine, wide body					$11,389,000		
Turbojet, 4-engine					889,000		
Turbofan, 4-engine, regular body					2,200,000		
Turbofan, 3-engine, wide body					11,420,000		
Turbofan, 3-engine, regular body					2,201,000		
Turbofan, 2-engine, wide body					11,120,000		
Turbofan, 2-engine, regular body					2,860,000		
Turboprop					705,000		
Piston					178,000		
Air Taxi (Including Air Commuter)			216,900				
Jet					814,000		
Turboprop					348,000		
Multi-engine piston					64,000		
Single-engine piston					19,000		
Rotorcraft					71,000		
General Aviation (Excluding Air Taxi)			216,900				
Jet					998,000		
Turboprop					390,000		
Multi-engine piston					64,000		
Single-engine piston					17,000		
Rotorcraft					46,000		
Military			216,900				
Jet					1,344,000		
Turboprop					2,085,000		
Piston					66,000		
Rotorcraft					257,000		
TOTAL							

*Source: Appendix D

FIGURE 23

Worksheet for Computation of the Expected Value of Annual Avertable Collisions

	A	B	C	D	E
Safety Benefit	Annual Aircraft Operations	Expected Number of Avertable Midair Collisions	Expected Cost of a Midair Collision* and Cost of Terrain Coll/Opn.	Mode C Factor	Expected Value of Annual Avertable Collisions
Avertable Midair Collisions					
Avertable Terrain Collisions			$ .587		
Total					

*Total expected cost of a midair collision per aircraft (from Figure 22 Column G) x 2 (i.e., 2 aircraft per midair collision).

FIGURE 24

Worksheet or Computation of Phase II Benefit/Cost Ratio

A	Annual Benefits of IFR Delay Reduction (Base Year)	
B	Annual Benefits of Averted Collisions (Base Year)	
C	Total Annual Base Year Quantified Benefits (A + B)	
D	Annual Benefits (C) x Net Discount Factor of ______	
E	Total Discounted Life-Cycle Costs	
F	Benefit/Cost Ratio (D / E)	

FIGURE 25

Illustrative Computation of Aircraft Mix During a Busy IFR Hour - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Primary Instrument Operations	(B) Percent of Total Annual Primary Instrument Operations	(C) Percent Aircraft Type of User Class	(D) Number of Aircraft During a Busy IFR Hour ((BxCx29)/10,000)
Air Carrier	2,786	6.6		
Turbofan, 4-engine, wide body				
Turbojet, 4-engine				
Turbofan, 4-engine, regular body				
Turbofan, 3-engine, wide body				
Turbofan, 3-engine, regular body				
Turbofan, 2-engine, wide body			5.8	0.11
Turbofan, 2-engine, regular body				
Turboprop			65.3	1.25
Piston			28.9	0.55
Air Taxi (Including Air Commuter)	26,191	61.7		
Jet			4.0	0.72
Turboprop			10.1	1.81
Multi-engine piston			65.9	11.79
Single-engine piston			19.0	3.40
Rotorcraft			1.0	0.18
General Aviation (Excluding Air Taxi)	13,186	31.0		
Jet			3.4	0.31
Turboprop			3.8	0.34
Multi-engine piston			24.7	2.22
Single-engine piston			67.9	6.10
Rotorcraft			0.2	0.02
Military	317	0.7		
Jet			47.0	0.10
Turboprop			9.5	0.02
Piston			5.6	0.01
Rotorcraft			37.9	0.08
TOTAL	42,480	100.0		29.00

FIGURE 26

Illustrative Computation of Aircraft Mix During a Busy IFR Hour - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Instrument Operations (See Text)	(B) Percent of Total Annual Instrument Operations	(C) Percent Aircraft Type of User Class	(D) Number of Aircraft During a Busy IFR Hour ((B×C×11)/10,000)
Air Carrier	0	0.0		
Turbofan, 4-engine, wide body				
Turbojet, 4-engine				
Turbofan, 4-engine, regular body				
Turbofan, 3-engine, wide body				
Turbofan, 3-engine, regular body				
Turbofan, 2-engine, wide body				
Turbofan, 2-engine, regular body				
Turboprop				
Piston				
Air Taxi (Including Air Commuter)	593	7.7		
Jet				
Turboprop				
Multi-engine piston			76.7	0.65
Single-engine piston			22.1	0.19
Rotorcraft			1.2	0.01
General Aviation (Excluding Air Taxi)	7,072	92.2		
Jet				
Turboprop				
Multi-engine piston			26.6	2.70
Single-engine piston			73.2	7.42
Rotorcraft			0.2	0.02
Military	3	0.0		
Jet				
Turboprop				
Piston				
Rotorcraft				
TOTAL	7,668	100.0		11.00

FIGURE 27

Illustrative Computation of Aircraft Variable Operating Costs and Value of Passengers'/Occupants' Time During a Busy IFR Hour - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Aircraft During a Busy IFR Hour (From Figure 25)	(B) Aircraft Hourly Variable Operating Cost 1/	(C) V.O.C. of Aircraft Mix (AxB)	(D) Number of Passengers/ Occupants per Aircraft 2/	(E) Value of Passengers'/Occupants' Time (AxDx$17.50) 1/	(F) Hourly Cost of Aircraft Operation and Passengers'/ Occupants' Time of Aircraft Mix (C+E)
Air Carrier						
Turbofan, 4-engine, wide body		$4,767				
Turbojet, 4-engine		2,880				
Turbofan, 4-engine, regular body		2,643				
Turbofan, 3-engine, wide body		3,341				
Turbofan, 3-engine, regular body	0.11	1,964	$ 216	78.4	$ 151	$ 367
Turbofan, 2-engine, wide body		2,655				
Turbofan, 2-engine, regular body	1.25	1,508	1,885	61.6	1,348	3,233
Turboprop	0.55	694	382	23.5	226	608
Piston		139				
Air Taxi (Including Air Commuter)						
Jet	0.72	942	678	2.3	29	707
Turboprop	1.81	369	668	7.3	231	899
Multi-engine piston	11.79	132	1,556	5.4	1,114	2,670
Single-engine piston	3.40	56	190	2.1	125	315
Rotorcraft	0.18	138	25	1.4	4	29
General Aviation (Excluding Air Taxi)						
Jet	0.31	782	242	4.1	22	264
Turboprop	0.34	233	79	5.6	33	112
Multi-engine piston	2.22	93	206	3.6	140	346
Single-engine piston	6.10	30	183	2.2	235	418
Rotorcraft	0.02	77	2	2.4	1	3
Military						
Jet	0.10	1,333	133	6.0	11	144
Turboprop	0.02	360	7	5.0	2	9
Piston	0.01	97	1	3.0	1	2
Rotorcraft	0.08	113	9	2.0	3	12
TOTAL	29.00					$10,138

1/Source: Reference 9.

2/Passengers for Air Carrier and Air Taxi; Occupants for General Aviation and Military. Sources: References 17, 18, 19 and 20.

FIGURE 28

Illustrative Computation of Aircraft Variable Operating Cost and Value of Passengers'/Occupants' Time During a Busy IFR Hour - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Aircraft During a Busy IFR Hour (From Figure 26)	(B) Aircraft Hourly Variable Operating Cost 1/	(C) V.O.C. of Aircraft Mix (AxB)	(D) Number of Passengers/Occupants per Aircraft 2/	(E) Value of Passengers'/Occupants' Time (AxDx$17.50) 1/	(F) Hourly Cost of Aircraft Operation and Passengers'/Occupants' Time of Aircraft Mix (C+E)
Air Carrier						
Turbofan, 4-engine, wide body		$4,767				
Turbojet, 4-engine		2,880				
Turbofan, 4-engine, regular body		2,643				
Turbofan, 3-engine, wide body		3,341				
Turbofan, 3-engine, regular body		1,964				
Turbofan, 2-engine, wide body		2,655				
Turbofan, 2-engine, regular body		1,508				
Turboprop		694				
Piston		139				
Air Taxi (Including Air Commuter)						
Jet		942				
Turboprop		369				
Multi-engine piston	0.65	132	$ 86	5.4	$ 61	$ 147
Single-engine piston	0.19	56	11	2.1	7	18
Rotorcraft	0.01	138	1	1.4	0	0
General Aviation (Excluding Air Taxi)						
Jet		782				
Turboprop		233				
Multi-engine piston	2.70	93	251	3.6	170	421
Single-engine piston	7.42	30	223	2.2	286	509
Rotorcraft	0.02	77	2	2.4	1	3
Military						
Jet		1,333				
Turboprop		360				
Piston		97				
Rotorcraft		113				
TOTAL	11.00					$1,098

1/Source: Reference 9.

2/Passengers for Air Carrier and Air Taxi; Occupants for General Aviation and Military. Sources: References 17, 18, 19 and 20.

FIGURE 29

Illustrative Computation of Annual Benefits of IFR Delay Reduction at Primary and Secondary [illegible]orts

		Primary Airport	"Qualified" Secondary Airports				
		BGM	N17				Total
A	Hours Saved per Aircraft per Hour of Airport Operation	1,931	0.021				
B	Sum of Aircraft Variable Operating Costs and Value of Passengers'/Occupants' Time	$ 10,138	$1,098				
C	Total Delay Savings per Busy IFR Hour (A x B)	$ 19,576	$ 23				
D	Percent of Time that IFR Weather Prevails	21.6	21.6				
E	Number of Busy IFR Hours per Year (D x 1,252 Hours)	270	270				
F	Annual Benefits of IFR Delay Reduction (C x E)	$5,285,520	$6,210				$5,291,730

FIGURE 30

Illustrative Computation of Relative Annual Aircraft Mix - PRIMARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Operations By User Class	(B) Percent Aircraft Type of User Class	(C) Annual Aircraft Mix ((AxB)/100)
Air Carrier	2,786		
Turbofan, 4-engine, wide body			
Turbojet, 4-engine			
Turbofan, 4-engine, regular body			
Turbofan, 3-engine, wide body			
Turbofan, 3-engine, regular body		5.8	162
Turbofan, 2-engine, wide body			
Turbofan, 2-engine, regular body		65.3	1,819
Turboprop		28.9	805
Piston			
Air Taxi (Including Air Commuter)	30,947		
Jet		3.0	928
Turboprop		12.5	3,868
Multi-engine piston		38.2	11,822
Single-engine piston		27.5	8,510
Rotorcraft		18.8	5,818
General Aviation (Excluding Air Taxi)	33,380		
Jet		3.1	1,035
Turboprop		3.0	1,001
Multi-engine piston		13.0	4,339
Single-engine piston		76.9	25,669
Rotorcraft		4.0	1,335
Military	1,669		
Jet		58.8	981
Turboprop		12.3	205
Piston		6.8	113
Rotorcraft		22.1	369
TOTAL	68,782		68,782

FIGURE 31

Illustrative Computation of Annual Aircraft Mix - QUALIFIED SECONDARY AIRPORT

User Class and Aircraft Type	(A) Number of Annual Operations By User Class	(B) Percent Aircraft Type of User Class	(C) Annual Aircraft Mix ((AxB)/100)
Air Carrier	0		
Turbofan, 4-engine, wide body			
Turbojet, 4-engine			
Turbofan, 4-engine, regular body			
Turbofan, 3-engine, wide body			
Turbofan, 3-engine, regular body			
Turbofan, 2-engine, wide body			
Turbofan, 2-engine, regular body			
Turboprop			
Piston			
Air Taxi (Including Air Commuter)	9,968		
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston		45.2	4,506
Rotorcraft		32.5	3,240
		22.3	2,223
General Aviation (Excluding Air Taxi)	106,109		
Jet			
Turboprop			
Multi-engine piston			
Single-engine piston		13.8	14,643
Rotorcraft		81.9	86,903
		4.3	4,563
Military	300		
Jet			
Turboprop			
Piston			
Rotorcraft		23.5	71
		76.5	230
TOTAL	116,377		116,377

FIGURE 32

Illustrative Computation of the Expected Cost of a Midair Collision Per Aircraft

User Class and Aircraft Type	(A) Aircraft Mix	(B) Number of Occupants Per Aircraft	(C) Expected Costs of Fatalities and Serious Injuries Per Occupant*	(D) Expected Contributory Costs of Fatalities and Serious Injuries ((AxBxC)/185,159)	(E) Expected Cost of Aircraft Damage Per Aircraft*	(F) Expected Contributory Costs of Aircraft Damage ((AxE)/185,159)	(G) Total Expected Contributory Cost Per Collision Per Aircraft (D+F)
Air Carrier			$249,700				
Turbofan, 4-engine, wide body					$11,389,000		
Turbojet, 4-engine					889,000		
Turbofan, 4-engine, regular body					2,200,000		
Turbofan, 3-engine, wide body					11,420,000		
Turbofan, 3-engine, regular body	162	84.4		$ 18,439	2,201,000	$ 1,926	20,365
Turbofan, 2-engine, wide body					11,120,000		
Turbofan, 2-engine, regular body	1,819	66.6		163,373	2,860,000	28,097	191,470
Turboprop	805	26.5		28,768	705,000	3,065	31,833
Piston					178,000		
Air Taxi (Including Air Commuter)			216,900				
Jet	928	4.3		4,674	814,000	4,080	8,754
Turboprop	3,868	9.3		42,139	348,000	7,270	49,409
Multi-engine piston	16,328	7.4		141,540	64,000	5,644	147,184
Single-engine piston	11,750	3.1		42,669	19,000	1,206	43,875
Rotorcraft	8,041	2.4		22,607	71,000	3,083	25,690
General Aviation (Excluding Air Taxi)			216,900				
Jet	1,035	4.1		4,971	998,000	5,579	10,550
Turboprop	1,001	5.6		6,567	390,000	2,108	8,675
Multi-engine piston	18,982	3.6		80,050	64,000	6,561	86,611
Single-engine piston	112,572	2.2		290,113	17,000	10,336	300,449
Rotorcraft	5,898	2.4		16,582	46,000	1,465	18,047
Military			216,900				
Jet	981	6.0		6,895	1,344,000	7,121	14,016
Turboprop	205	5.0		1,201	2,085,000	2,308	3,509
Piston	184	3.0		647	66,000	66	713
Rotorcraft	599	2.0		1,403	257,000	831	2,234
TOTAL	185,159						$963,384

*Source: Appendix D

FIGURE 33

Illustrative Computation of the Expected Value of Annual Avertable Collisions

	A	B	C	D	E
Safety Benefit	Annual Aircraft Operations	Expected Number of Avertable Midair Collisions	Expected Cost of a Midair Collision* and Cost of Terrain Coll/Opn.	Mode C Factor	Expected Value of Annual Avertable Collisions
Avertable Midair Collisions	185,159	.041	$1,926,768		$ 78,9[illegible]
Avertable Terrain Collisions	185,159		$ .587	76%	$ 82,603
Total					$161,600

*Total expected cost of a midair collision per aircraft (from Figure 32, Column G) x 2 (i.e., 2 aircraft per midair collision).

FIGURE 34

Illustrative Computation of Phase II Benefit/Cost Ratio

A	Annual Benefits of IFR Delay Reduction (Base Year)	$ 5,291,730
B	Annual Benefits of Averted Collisions (Base Year)	$ 161,600
C	Total Annual Base Year Quantified Benefits (A + B)	$ 5,453,330
D	Annual Benefits (C) x Net Discount Factor of 10.71	$58,405,164
E	Total Discounted Life-Cycle Costs	$ 8,970,000
F	Benefit/Cost Ratio (D / E)	6.51

SECTION VIII - DEVELOPMENT OF SUPPLEMENTAL CRITERIA

In addition to revising ASR establishment criteria, this report reviews and/or revises the supplemental criteria relative to ASR facilities. This section outlines the development of the ASR supplemental criteria outlined in Section II: discontinuance, improvements, remoted radar bright display scope, establishment of terminal radar approach control in tower cab (TRACAB), establishment of terminal radar approach control (TRACON) and TRACAB to TRACON conversion. Like the establishment criteria, the discontinuance criteria are based on a detailed benefit/cost analysis. The other supplemental criteria, however, are not readily adaptable to rigorous benefit/cost analyses for system-wide application. Rather, they are based on activity levels at which there is expected to exist reasonable relationships between benefits and costs.

A. Discontinuance

Since initial ASR acquisition and installation costs are sunk costs, the only relevant costs when an ASR system is being considered for decommissioning are recurring operations and maintenance costs, ignoring salvage value, relocation costs, etc. An ASR system should be decommissioned if the present value of the life-cycle operating and maintenance costs exceed the present value of the benefits expected over the remaining useful life of the system. Using the life-cycle cost data in Figures 1 and 2 as a basis, it is estimated that this condition is reached whenever a benefit/cost ratio of less than 0.35 is derived when applying the detailed benefit/cost methodology for new radar establishment.

B. Improvements

Existing radar approach control facilities frequently require improvements to satisfy operational requirements and/or facilitate the provision of terminal area radar service. The varying and diverse nature and costs of such improvements prohibit a meaningful and rigorous benefit/cost analysis for system-wide application. However, experience suggests instrument activity ranges where the marginal benefits are expected to exceed costs. This approach was used to derive the revised improvements criteria outlined in Section II.

C. Remoted Radar Bright Display Scope

Remoted radar bright display scopes are occasionally installed in VFR towers of secondary or satellite airports receiving radar service from a primary airport. As with the improvements criteria discussed above, experience can be relied upon to identify an activity level at or above which a remoted radar bright display scope can be expected to be economically justified. In addition to changing the qualifying level of itinerant operations, the revised criteria outlined in Section II eliminate the requirement that the secondary airport be within twenty miles and within microwave link range of the existing surveillance radar system, because microwave link repeaters can be used to extend the range almost indefinitely or digital remoting may be used. Finally, since a FAA control tower which is satellite to a military radar approach control facility can benefit from a remoted radar bright display scope, the previous requirement that the radar approach control facility be an FAA facility has been eliminated.

D. TRACAB and TRACON

Radar service can be configured into either of two housing designs - TRACAB or TRACON. A TRACAB (Terminal Radar Approach Control in Tower CAB) is a facility that provides radar approach control service from positions located in the tower cab, as opposed to a TRACON (Terminal Radar Approach Control) in which radar approach control service is provided from positions located in a separate IFR room.

Historically, the principal technical questions of TRACAB feasibility revolved around the adequacy of the BRITE radar scope display and space congestion in the tower cab. Early difficulties were experience with utilization of the BRITE display in the tower cab due to the high ambient light level. However, with existing improvements in BRITE display performance the consensus currently is that the TRACAB concept is feasible and can work effectively at some maximum level of operations. Currently, the only impact of adding a separate TRACON or IFR room is to relieve congestion in the tower cab. As more radar positions are required due to increased sectorization demanded by growing traffic counts, it becomes impossible to squeeze the physical space required for these radar positions into the tower cab. Without some radical revision of cab design concepts, the physical size of the cab limits the peak hour operations that can be accommodated.

An earlier benefit/cost analysis of the TRACAB concept (Reference 21) found that the major cost savings made possible by the TRACAB was a reduction in controllers required. This reduction is due primarily to eliminating flight data positions in the IFR room. Reduced coordination effort is also an advantage when all radar controllers and cab personnel are co-located. Thus, there is normally a positive cost advantage to utilizing a TRACAB configuration. The cost of converting a TRACAB facility to a TRACON is highly site dependent. In some cases, adequate space may be available close to the tower. In other cases, new construction is required, possibly at some distance from the tower. Thus, each site should be surveyed to determine a reliable cost impact prior to an establishment decision. Typical TRACAB and TRACON cost differentials are outlined in further detail in Section III.

Review of several evaluations of tower cab configurations (References 22 through 24) and Air Traffic Service experience suggests that the current provisions in Airway Planning Standard Number One, Order 7031.2B, are valid operational and economic determinants for determining how a radar approach control facility should initially be established and for determining when a TRACAB should be converted to a TRACON. Therefore, the current provisions of these supplemental criteria, in effect since 8/13/80 by Change 18 to the subject order, remain intact.

SECTION IX - SENSITIVITY ANALYSIS

In the computation of the benefit/cost ratio for ASR, there are a number of constants and variables which are used to quantify benefits. This section addresses the sensitivity of the benefit/cost ratio to variations in those factors which are defined by uncertain or judgmental parameters. These factors include the number of instrument operations during a busy hour, the percentage of time that IFR weather prevails, the value of time of aircraft passengers/occupants, the probability of a midair collision, the cost of a midair collision, the cost of a terrain collision and the value of a statistical life. To get some indication of the sensitivity of these factors on the benefit/cost ratio, sample selected airports with Phase II benefit/cost ratios of 0.56 (ABY), 0.71 (GNV), 0.87 (HUT), 1.21 (LSE), 1.38 (ELM) and 1.50 (MWH) were examined with specific percentage increases and decreases in these variables.

	Airport With B/C Ratio of					
	0.56	0.71	0.87	1.21	1.38	1.50
Number of Instrument Operations During a Busy Hour						
50% decrease	0.05	0.07	0.08	0.28	0.32	0.35
20% decrease	0.10	0.13	0.16	0.39	0.44	0.48
10% decrease	0.22	0.28	0.34	0.65	0.74	0.80
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	1.09	1.39	1.70	1.90	2.17	2.36
20% increase	1.66	2.10	2.58	2.46	2.80	3.04
50% increase	2.34	2.96	3.63	2.82	3.22	3.50
Percentage of Time that IFR Weather Prevails						
50% decrease	0.30	0.38	0.47	0.74	0.84	0.92
20% decrease	0.46	0.58	0.71	1.02	1.17	1.27
10% decrease	0.51	0.65	0.80	1.12	1.27	1.38
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.61	0.78	0.95	1.30	1.49	1.62
20% increase	0.66	0.84	1.03	1.40	1.59	1.73
50% increase	0.82	1.04	1.27	1.68	1.92	2.08
Value of Time of Aircraft Passengers/Occupants						
50% decrease	0.48	0.61	0.75	1.03	1.18	1.28
20% decrease	0.53	0.68	0.83	1.14	1.30	1.41
10% decrease	0.55	0.69	0.85	1.17	1.34	1.46
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.57	0.73	0.89	1.25	1.42	1.54
20% increase	0.59	0.75	0.92	1.28	1.46	1.59
50% increase	0.64	0.81	0.99	1.39	1.58	1.72

	0.56	0.71	0.87	1.21	1.38	1.50
Probability of a Midair Collision						
50% decrease	0.55	0.70	0.86	1.14	1.30	1.41
20% decrease	0.56	0.71	0.87	1.17	1.34	1.46
10% decrease	0.56	0.71	0.87	1.20	1.37	1.49
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.56	0.71	0.87	1.22	1.39	1.51
20% increase	0.56	0.71	0.87	1.25	1.42	1.54
50% increase	0.56	0.71	0.87	1.28	1.46	1.59
Cost of a Midair Collision						
50% decrease	0.55	0.70	0.86	1.14	1.30	1.41
20% decrease	0.56	0.71	0.87	1.17	1.34	1.46
10% decrease	0.56	0.71	0.87	1.20	1.37	1.49
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.56	0.71	0.87	1.22	1.39	1.51
20% increase	0.56	0.71	0.87	1.25	1.42	1.54
50% increase	0.56	0.71	0.87	1.28	1.46	1.59
Cost of a Terrain Collision						
50% decrease	0.55	0.69	0.85	1.15	1.31	1.43
20% decrease	0.55	0.70	0.86	1.19	1.35	1.47
10% decrease	0.56	0.71	0.87	1.20	1.37	1.49
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.56	0.71	0.87	1.22	1.39	1.51
20% increase	0.57	0.72	0.88	1.23	1.41	1.53
50% increase	0.57	0.73	0.89	1.27	1.45	1.57
Value of a Statistical Life						
50% decrease	0.55	0.70	0.86	1.15	1.31	1.43
20% decrease	0.56	0.71	0.87	1.19	1.35	1.47
10% decrease	0.56	0.71	0.87	1.20	1.37	1.49
When computed or standard value used	0.56	0.71	0.87	1.21	1.38	1.50
10% increase	0.56	0.71	0.87	1.22	1.39	1.51
20% increase	0.56	0.71	0.87	1.23	1.41	1.53
50% increase	0.57	0.72	0.88	1.27	1.45	1.57

APPENDIX A - PREVIOUS ASR INVESTMENT CRITERIA

The previous investment criteria for ASR, as outlined in Airway Planning Standard Number One (Reference 1) are reproduced below. Except for the criteria for TRACAB establishment, TRACON establishment and TRACAB to TRACON conversion, these criteria have been superceded by the revised criteria outlined in Section II. The TRACAB establishment, TRACON establishment and TRACAB to TRACON conversion criteria remain unchanged.

"AIRPORT SURVEILLANCE RADAR WITH AIR TRAFFIC CONTROL RADAR BEACON SYSTEM AND BRIGHT DISPLAY SCOPE (ASR/ATCRBS/BDS)

a. Establishment. An FAA approach control tower which records a minimum of 45,000 annual itinerant operations and 4,000 certificated route air carrier operations and records 18,000 instrument operations at the primary and secondary airports is a candidate for ASR/ATCRBS/BDS if it satisfies any combination of the three parameters which equals or exceeds a linear sliding scale defined by the following limits:

(1) 45,000 annual itinerant operations, of which 10,000 are certificated route air carrier operations, and 18,000 instrument operations at the primary and secondary airports; or

(2) 105,000 annual itinerant operations, of which 4,000 are certificated route air carrier operations, and 27,000 instrument operations at the primary and secondary airports.

(3) Numbers of operations required for candidacy... may be determined either by interpolating the sliding scale or by satisfying both of the following equations:

$$N \geq 145,000 - 10AC$$

$$I \geq 33,000 - 1.5AC$$

Where N, AC, and I are the annual numbers of itinerant, air carrier, and primary plus secondary instrument operations, respectively.

b. Discontinuance. An ASR/ATCRBS/BDS at an FAA radar approach control facility is a candidate for decommissioning if the facility records less than 75 percent of the levels specified... above for at least one parameter. In lieu of deriving these levels, discontinuance candidates must satisfy at least one of the following five equations:

$$AC < 3,000$$

$$N < (108,750 - 10AC) \text{ for } 3,000 \leq AC \leq 7,500$$

$$N < 33,750 \text{ for } AC < 7,500$$

$$I < (24,750 - 1.5AC) \text{ for } 3,000 \leq AC \leq 7,500$$

$$I < 13,500 \text{ for } AC > 7,500$$

c. Benefit/Cost Screening. ASR/ATCRBS/BDS candidates identified... above will be screened using the benefit versus cost technique described in Report Number ASP-75-2. FAA Regional Offices shall submit data required for screening purposes as specified in the annual Call for Estimates...

d. Improvements. Existing FAA approach control facilities equipped with ASR/ATCRBS/BDS frequently require improvements. Such improvements are normally made when there exists a reasonable relationship between the operational benefits to be realized and the costs involved in accordance with the following provisions:

(1) An FAA radar approach control facility recording 30,000 or more annual instrument operations qualifies for those improvements that satisfy an operational requirement and/or facilitate the provision of terminal area radar service. This activity level normally assures a cost per operation that is commensurate with the benefit derived from the improvement.

(2) An FAA radar approach control facility recording between 20,000 and 29,000 annual instrument operations may be a candidate for improvements. It qualifies for those improvements that satisfy an operational requirement and/or facilitate the provision of terminal area radar service provided the additional cost does not result in a cost per operation that exceeds the benefit derived from the improvement.

(3) An FAA radar approach control facility recording less than 20,000 annual instrument operations is not a candidate for improvements. At that activity level, the additional cost per operation resulting from the improvement is not commensurate with the benefit derived. Any improvement to terminal radar facilities in this category will be limited to the correction of a critical situation and shall be justified by an individual staff study.

NOTE: Improvements to FAA staffed RAPCON/RATCCs... may be considered on an individual basis but the above criteria for FAA civil facilities shall remain a major determinant in considering them for improvement.

e. Remoted Radar Bright Display Scope. An FAA VFR control tower at an airport, which is a satellite of the primary airport of an FAA radar approach control facility, is a candidate for a remote radar bright display scope in the tower cab when:

(1) At least 35,000 annual itinerant operations are recorded; and

(2) The airport is located within 20 miles and within microwave link range of an existing surveillance radar system.

(3) Operationally adequate low altitude radar coverage is assured at the satellite airport.

f. Terminal Radar Approach Control in Tower Cab.

(1) Establishment. An initial ASR/ATCRBS/BDS installation shall be a TRACAB facility consisting of appropriate displays placed in the tower cab.

(a) If the official agency forecasts indicate an ASR/ATCRBS/BDS candidate location will exceed 125,000 annual itinerant operations or 60,000 annual instrument operations within 2 years of the year of budget submission for the facility, the initial installation should be planned as a TRACON rather than a TRACAB. Instrument operations at secondary airports may be included in this forecast provided radar coverage at these locations is expected to exist at or below initial approach altitude.

(b) If an ASR/ATCRBS/BDS candidate location cannot physically accommodate radar approach control in the tower cab, then individual justification shall be required to go directly to a TRACON facility.

(c) When the complexity of the facility operation warrants, individual justification and consideration shall be given to locating the ASR/ATCRBS/BDS in a TRACON rather than a TRACAB.

(2) Discontinuance. A TRACAB will be discontinued when the ASR/ATCRBS/BDS is decommissioned or when the radar approach control function is transferred to a TRACON.

(3) Conversion to TRACON. A TRACAB location is a TRACON candidate when the facility has at least 125,000 annual itinerant operations or 60,000 annual instrument operations. Instrument operations at secondary airports that receive radar service at or below initial approach altitude may be included in this count. Also, when the complexity of the facility operations warrants, individual justification and consideration should be given to relocating from a TRACAB to a TRACON."

APPENDIX B

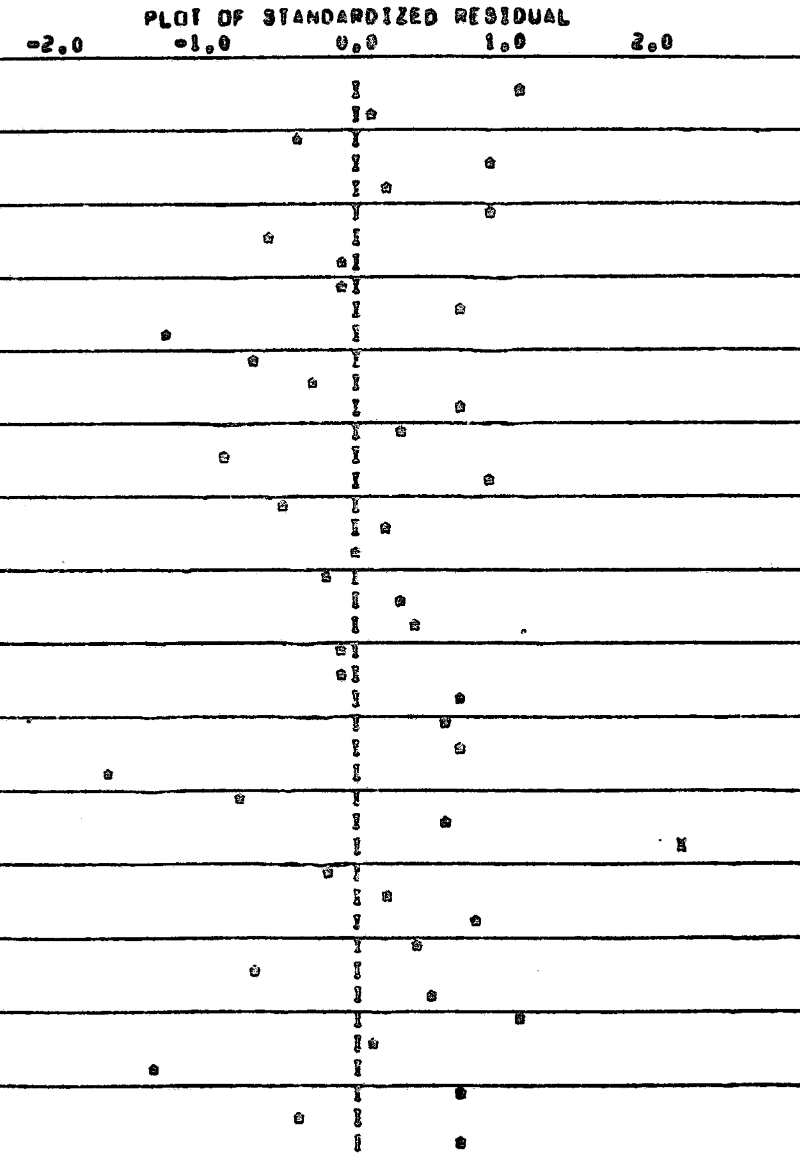
BUSY HOUR REGRESSION

FILE ASR80 (CREATION DATE = 01/07/81)

* M U L T I P L E R E G R E S S I O N * * * * * * * * * * * * * * * * * * *

DEPENDENT VARIABLE: LBUSY FROM VARIABLE LIST 1
REGRESSION LIST 1

SEQNUM	OBSERVED LBUSY	PREDICTED LBUSY	RESIDUAL
1	5.459585	5.134432	0.3251525
2	4.955627	4.931170	0.2445602E-01
3	4.787491	4.919735	-0.1322448
4	5.105945	4.827636	0.2783077
5	4.812184	4.758632	0.5355236E-01
6	4.997211	4.735957	0.2612537
7	4.553877	4.725426	-0.1715499
8	4.672829	4.715522	-0.4269402E-01
9	4.624972	4.642311	-0.1733975E-01
10	4.859812	4.639207	0.2206041
11	4.248495	4.637045	-0.3885506
12	4.430817	4.630789	-0.1999727
13	4.499809	4.602301	-0.1024929
14	4.795790	4.592259	0.2035294
15	4.691347	4.590522	0.1008239
16	4.304065	4.590427	-0.2863635
17	4.828313	4.565838	0.2624745
18	4.382026	4.537405	-0.1553788
19	4.574711	4.515728	0.5898131E-01
20	4.488636	4.493083	-0.4447446E-02
21	4.330733	4.406593	-0.7586110E-01
22	4.499809	4.400428	0.9938019E-01
23	4.477336	4.368225	0.1091102
24	4.317488	4.349149	-0.3166175E-01
25	4.304065	4.342298	-0.3823370E-01
26	4.564347	4.340302	0.2240446
27	4.477336	4.284822	0.1925135
28	4.510859	4.283388	0.2274709
29	3.761200	4.272016	-0.5108167
30	3.988983	4.231898	-0.2429163
31	4.418840	4.221886	0.1969540
32	4.905274	4.217513	0.6877608
33	4.143134	4.197916	-0.5478020E-01
34	4.219507	4.169856	0.4965015E-01
35	4.418840	4.163287	0.2555528
36	4.290459	4.157490	0.1329677
37	3.931825	4.144927	-0.2131028
38	4.290459	4.142968	0.1474903
39	4.465908	4.138915	0.3269917
40	4.143134	4.127513	0.1562076E-01
41	3.688879	4.120576	-0.4316969
42	4.343805	4.115578	0.2282263
43	3.988983	4.114607	-0.1256239
44	4.330733	4.112508	0.2182254



LBUSY = Natural logarithm of busy IFR hour operations
Source = FAA-APO regression analysis of data contained in Reference 8

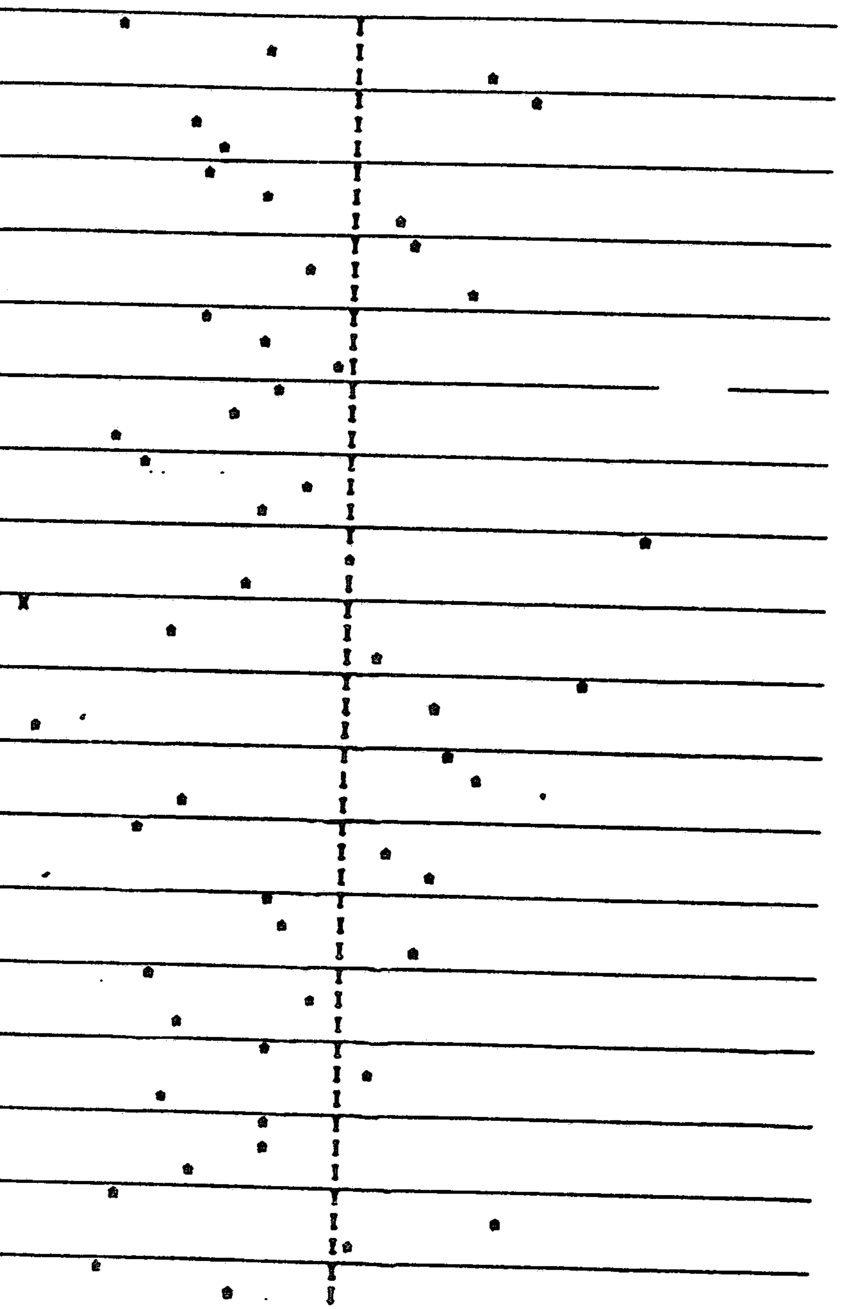
BUSY HOUR REGRESSION

45	4.043051	4.095171	-0.5212089E-01
46	3.871201	4.093073	-0.2218730
47	4.094344	4.081750	0.1259327E-01
48	3.970291	4.075375	-0.1050842
49	4.127134	4.074734	0.5240050E-01
50	4.564347	4.064438	0.4999089
51	4.584967	4.042813	0.5421526
52	4.510859	4.030272	0.4805869
53	3.806662	4.026323	-0.2196621
54	4.189654	4.025174	0.1644799
55	4.043051	4.024415	0.1863530E-01
56	4.330733	4.019780	0.3109527
57	4.762174	4.005869	0.7563041
58	3.871201	4.001813	-0.1306129
59	4.219507	4.001450	0.2180568
60	3.988983	3.992227	-0.3244229E-02
61	3.850147	3.983379	-0.1332327
62	4.077537	3.980295	0.9724069E-01
63	4.418840	3.977426	0.4414146
64	4.077537	3.975506	0.1020298
65	4.127134	3.962878	0.1642554
66	3.912023	3.961599	-0.4957712E-01
67	3.737669	3.954100	-0.2164308
68	3.970291	3.953381	0.1690971E-01
69	4.330733	3.936655	0.3940781
70	4.007333	3.917426	0.8990540E-01
71	3.555347	3.906059	-0.3507122
72	4.276666	3.905984	0.3706811
73	3.663561	3.869698	-0.2061371
74	3.850147	3.868740	-0.1859354E-01
75	3.871201	3.861582	0.9618577E-02
76	3.850147	3.852230	-0.2083559E-02
77	3.970291	3.789657	0.1806343
78	3.988983	3.743488	0.2450945
79	3.806662	3.719025	0.8763677E-01
80	3.891820	3.709485	0.1823344
81	3.555347	3.708632	-0.1532859
82	4.025352	3.702446	0.3229050
83	3.526361	3.683680	-0.1573198
84	3.931825	3.680736	0.2510884
85	3.465735	3.675066	-0.2093313
86	3.912023	3.668112	0.2439102
87	3.496507	3.642108	-0.1456016
88	4.077537	3.619640	0.4578952
89	3.688879	3.615060	0.7381839E-01
90	3.218875	3.596054	-0.3771794
91	2.772588	3.592277	-0.8196895
92	3.583518	3.579678	0.3839757E-02
93	3.496507	3.578897	-0.8239108E-01
94	3.496507	3.568000	-0.7149357E-01
95	3.610917	3.566590	0.4432644E-01
96	3.367295	3.508632	-0.1413365
97	2.833213	3.497623	-0.6644113

APPENDIX B (Cont'd.)

BUSY HOUR REGRESSION

98	2.995731	3.476085	-0.4803537	
99	3.295836	3.473302	-0.1774661	
100	3.737669	3.467757	0.2699112	
101	3.828641	3.456891	0.3717489	
102	3.091042	3.433442	-0.3424013	
103	3.135493	3.426345	-0.2908518	
104	3.091042	3.413095	-0.3220544	
105	3.218875	3.406204	-0.1873293	
106	3.496507	3.394587	0.1019194	
107	3.526361	3.394135	0.1322244	
108	3.258096	3.364103	-0.1060085	
109	3.610917	3.360277	0.2506396	
110	3.044522	3.358972	-0.3144498	
111	3.178053	3.358666	-0.1806138	
112	3.332204	3.355958	-0.2375435E-01	
113	3.178053	3.344924	-0.1668717	
114	3.091042	3.337533	-0.2464916	
115	2.833213	3.334983	-0.5017704	
116	2.890371	3.317318	-0.4269471	
117	3.178053	3.281649	-0.1035957	
118	3.091042	3.276530	-0.1854886	
119	3.871201	3.265938	0.6052622	
120	3.258096	3.254946	0.3149777E-02	
121	3.044522	3.253559	-0.2090372	
122	2.484906	3.251387	-0.7664807	
123	2.890371	3.244238	-0.3538675	
124	3.295836	3.236790	0.5904672E-01	
125	3.713572	3.233388	0.4801827	
126	3.401196	3.231339	0.1698577	
127	2.564949	3.223943	-0.6589942	
128	3.433987	3.223213	0.2107730	
129	3.496507	3.222226	0.2742802	
130	2.890371	3.220523	-0.3301518	
131	2.772588	3.209673	-0.4370859	
132	3.295836	3.189394	0.1064425	
133	3.367295	3.189200	0.1780948	
134	3.044522	3.187283	-0.1427606	
135	3.044522	3.177361	-0.1328396	
136	3.332204	3.172587	0.1596164	
137	2.772588	3.167813	-0.3952264	
138	3.091042	3.156721	-0.6568033E-01	
139	2.833213	3.156374	-0.3231611	
140	2.995731	3.154572	-0.1588411	
141	3.218875	3.148408	0.7046616E-01	
142	2.772588	3.147932	-0.3753443	
143	2.995731	3.147496	-0.1517653	
144	2.995731	3.139705	-0.1439734	
145	2.833213	3.134424	-0.3012114	
146	2.639057	3.104486	-0.4654296	
147	3.401196	3.058493	0.3427037	
148	3.091042	3.050674	0.4036669E-01	
149	2.564949	3.047980	-0.4830314	
150	2.833213	3.046259	-0.2130467	



APPENDIX B (Cont'd.)

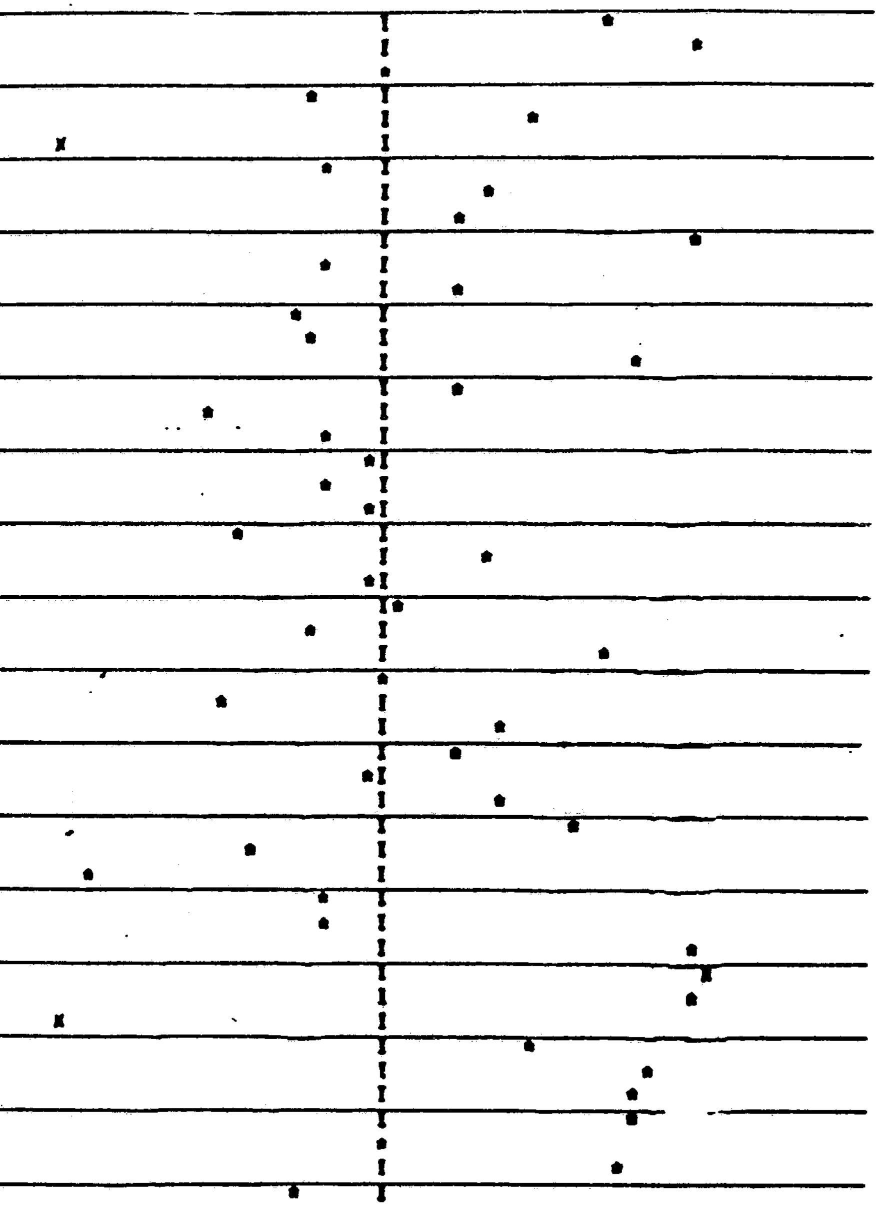
BUSY HOUR REGRESSION

151	2.397895	3.041463	-0.6435683
152	3.465735	3.036027	0.4297079
153	3.465735	3.029882	0.4358525
154	2.944439	3.025793	-0.8135462E-01
155	2.944439	3.016313	-0.7187408E-01
156	2.708050	3.014860	-0.3068113
157	3.178053	3.008754	0.1692985
158	2.639057	3.001336	-0.3622798
159	2.708050	2.990479	-0.2824303
160	2.302585	2.989992	-0.6874081
161	2.995731	2.988474	0.7256664E-02
162	2.890371	2.986081	-0.9570992E-01
163	2.708050	2.985536	-0.2774859
164	3.258096	2.982938	0.2751573
165	2.772588	2.972767	-0.2001800
166	2.772588	2.959091	-0.1865039
167	2.833213	2.959005	-0.1257930
168	3.091042	2.958007	0.1330347
169	3.091042	2.956976	0.1340648
170	2.564949	2.956575	-0.3916267
171	3.555347	2.954624	0.6007229
172	2.995731	2.954366	0.4136547E-01
173	3.295836	2.946230	0.3496064
174	3.044522	2.943776	0.1007460
175	2.484906	2.943395	-0.4584893
176	3.258096	2.937715	0.3203810
177	3.135493	2.934422	0.2010705
178	2.833213	2.931381	-0.9816867E-01
179	3.332204	2.923254	0.4089491
180	3.218875	2.920429	0.2984456
181	3.044522	2.918172	0.1263503
182	3.044522	2.913753	0.1307689
183	2.833213	2.895997	-0.6278467E-01
184	2.995731	2.886754	0.1089765
185	2.639057	2.870315	-0.2312582
186	2.564949	2.857688	-0.2927390
187	2.564949	2.849987	-0.2850381
188	2.708050	2.836633	-0.1285832
189	2.197224	2.823508	-0.6262850
190	3.178053	2.821173	0.3568800
191	2.833213	2.813343	0.1986914E-01
192	2.302585	2.811333	-0.5087485
193	2.708050	2.780755	-0.7270598E-01
194	2.302585	2.780370	-0.4777853
195	2.708050	2.771116	-0.6306732E-01
196	2.833213	2.770019	0.6319356E-01
197	2.772588	2.761398	0.1118890E-01
198	2.639057	2.741427	-0.1023709
199	3.091042	2.737833	0.3532081
200	2.995731	2.726619	0.2691122
201	2.484906	2.713507	-0.2286005
202	2.397895	2.709172	-0.3112773
203	2.890371	2.690163	0.2002081

APPENDIX B (Cont'd.)

BUSY HOUR REGRESSION

204	3.135493	2.660359	0.4751332	
205	3.295836	2.654854	0.6409821	
206	2.639057	2.652369	-0.1331279E-01	
207	2.484906	2.651986	-0.1670803	
208	2.944439	2.638759	0.3056800	
209	1.945910	2.636500	-0.6905915	
210	2.484906	2.616085	-0.1311795	
211	2.890371	2.687010	0.2033611	
212	2.772588	2.610560	0.1620265	
213	3.258096	2.609687	0.6484087	
214	2.484906	2.607367	-0.1224608	
215	2.772588	2.605607	0.1669799	
216	2.397895	2.593832	-0.1959373	
217	2.397895	2.563243	-0.1653481	
218	3.091042	2.560285	0.5307562	
219	2.708050	2.555003	0.1530465	
220	2.197224	2.551550	-0.3543266	
221	2.397895	2.525554	-0.1276593	
222	2.484906	2.514598	-0.2969174E-01	
223	2.397895	2.514054	-0.1161592	
224	2.484906	2.512903	-0.2799746E-01	
225	2.197224	2.510292	-0.3130686	
226	2.708050	2.507547	0.2005028	
227	2.484906	2.500782	-0.1587563E-01	
228	2.484906	2.456486	0.2841963E-01	
229	2.302585	2.441295	-0.1387106	
230	2.890371	2.441091	0.4492810	
231	2.397895	2.409041	-0.1114682E-01	
232	2.079441	2.404329	-0.3248877	
233	2.639057	2.390632	0.2484252	
234	2.484906	2.337349	0.1475576	
235	2.302585	2.323326	-0.2074224E-01	
236	2.484906	2.250124	0.2347820	
237	2.639057	2.230438	0.4086185	
238	1.945910	2.221585	-0.2756760	
239	1.609437	2.221089	-0.6116527	
240	2.079441	2.215008	-0.1355668	
241	2.079441	2.195342	-0.1159015	
242	2.833213	2.184469	0.6487440	
243	2.944439	2.184469	0.7599701	
244	2.833213	2.183095	0.6501175	
245	1.386293	2.133364	-0.7470704	
246	2.397895	2.093640	0.3042546	
247	2.484906	1.920237	0.5646694	
248	2.397895	1.875208	0.5226843	
249	2.302585	1.777573	0.5250111	
250	1.609437	1.594704	0.1473273E-01	
251	1.791759	1.291343	0.5004157	
252	1.098612	1.268003	-0.1693906	



APPENDIX B (Cont'd.)

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R REGRESSION
SR80     (CREATION DATE = 01/07/81)

* * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * *   VARIABLE LIST  1
                                                                                                                REGRESSION LIST 1
T VARIABLE..    LBUSY

(S) ENTERED ON STEP NUMBER  1..   LCOUNT

R             0.92364                    ANALYSIS OF VARIANCE    DF      SUM OF SQUARES      MEAN SQUARE          F
              0.85311                    REGRESSION               1.        136.77724        136.77724       1451.97765
R SQUARE      0.85252                    RESIDUAL               250.         23.55016          0.09420
ERROR         0.30692

--------- VARIABLES IN THE EQUATION -----------------           ------------- VARIABLES NOT IN THE EQUATION ----------
           B            BETA     STD ERROR B        F            VARIABLE      BETA IN      PARTIAL   TOLERANCE         F

    0.5921863        0.92364       0.01554     1451.978
T)  -2.927675

N REGRESSION                                                                  01/07/81      PAGE   5
SR80     (CREATION DATE = 01/07/81)

* * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * *   VARIABLE LIST  1
                                                                                                                REGRESSION LIST 1
T VARIABLE..    LBUSY

                                         SUMMARY TABLE

                                   MULTIPLE R   R SQUARE   RSQ CHANGE   SIMPLE R          B                    BETA

                                    0.92364     0.85311     0.85311     0.92364       0.5921863              0.92364
T)                                                                                   -2.927675

R REGRESSION                                                                  01/07/81      PAGE  12
SR80     (CREATION DATE = 01/07/81)

* * * * * * * * * * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N  * * * * * * * * * * * * * * * * * * * * * * *

ATSON TEST OF RESIDUAL DIFFERENCES COMPARED BY CASE ORDER (SEQNUM).

 LIST  1, REGRESSION LIST  1.    DURBIN-WATSON TEST     1.74256
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APPENDIX B (Cont'd)

BUSY HOUR REGRESSION

FILE ASR80 (CREATION DATE = 01/07/81)

VARIABLE	MEAN	STANDARD DEV	CASES
BUSYHR	38.7659	33.9413	252
COUNT	82367.0516	113813.1850	252
LBUSY	3.3360	0.7992	252
LCOUNT	10.5772	1.2466	252

BUSY HOUR REGRESSION

FILE ASR80 (CREATION DATE = 01/07/81)

CORRELATION COEFFICIENTS

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	BUSYHR	COUNT	LBUSY	LCOUNT
BUSYHR	1.00000	0.91226	0.90913	0.84645
COUNT	0.91226	1.00000	0.78009	0.81432
LBUSY	0.90913	0.78009	1.00000	0.92364
LCOUNT	0.84645	0.81432	0.92364	1.00000

APPENDIX C

DELAY COSTS PER HOUR BY AIRCRAFT TYPE
(1980 Dollars)

User Class and Aircraft Type	(A) Aircraft Variable Operating Costs[1]	(B) Number of Passengers/ Occupants[2]	(C) Value of Passengers'/ Occupants' Time (Column B x $17.50[1])	(D) Total Delay Cost Per Hour (Column A + Column C)
Air Carrier				
Turbofan, 4 engine, wide body[3]	$4,767	235.7	$4,125	$8,892
Turbojet, 4-engine[3]	2,880	92.3	1,615	4,495
Turbofan, 4-engine, regular body[3]	2,643	99.7	1,745	4,388
Turbofan, 3-engine, wide body	3,341	158.5	2,774	6,115
Turbofan, 3-engine, regular body	1,964	78.4	1,372	3,336
Turbofan, 2-engine, wide body	2,655	138.3	2,420	5,075
Turbofan, 2-engine, regular body	1,508	61.6	1,078	2,586
Turboprop	694	23.5	411	1,105
Piston	139	2.2	39	178
Air Taxi (Including Air Commuter)				
Jet	942	2.3	40	982
Turboprop	369	7.3	128	497
Multi-engine piston	132	5.4	95	227
Single-engine piston	56	2.1	37	93
Rotorcraft	138	1.4	25	163
General Aviation (Excluding Air Taxi)				
Jet	782	4.1	72	854
Turboprop	233	5.6	98	331
Multi-engine piston	93	3.6	63	156
Single-engine piston	30	2.2	39	69
Rotorcraft	77	2.4	42	119
Military				
Jet	1,333	6.0	105	1,438
Turboprop	360	5.0	88	448
Piston	97	3.0	53	150
Rotorcraft	113	2.0	35	148

1/ Source: Reference 9

2/ Sources: Reference 17 for air carrier; References 18, 19 and 20 for air taxi and general aviation. Data represents the number of passengers for the air carrier and air taxi user classes, and the number of occupants for the general aviation and military user classes. Passenger load factors, as opposed to occupant load factors, are used for the air carrier and air taxi user classes because the value of time of the crews of these user classes are included in aircraft variable operating costs in the form of salaries and wages.

3/ The NBS DELCAP simulation model did not include these aircraft types. Terminals that serve these aircraft types obviously are already equipped with or served by ASR. Conversely, airports within the range of interest in this report for new radar establishments do not serve these aircraft types. Their inclusion here is without impact and only for completeness of presentation.

APPENDIX D

Midair Collision Costs (Thousands of 1980 Dollars)

	Fatalities and Injuries					Aircraft Damage							
		Fatalities		Serious Injuries		Destroyed			Substantially Damaged				
	No. Occupants[1/]	Prob.[2/]	Cost (@$530[3/])	Prob.[2/]	Cost (@$38[3/])	Prob.[2/]	Replace. Value[3/]	Exp. Cost	Prob.[2/]	Restor. Cost[3/]	Exp. Cost		Total Collision Costs
Air Carrier		.471		.002		.417			.417				
Turbofan, 4-engine, wide body[4/]	251.7		$62,832		$19		20,485	8,542		6,828	2,847		74,24[illegible]
Turbojet, 4-engine[4/]	100.3		25,038		8		1,600	667		533	222		25,935
Turbofan, 4-engine, regular body[4/]	107.7		26,885		8		3,958	1,650		1,319	550		29,[illegible]
Turbofan, 3-engine, wide body	169.5		42,312		13		20,540	8,565		6,847	2,855		53,7[illegible]
Turbofan, 3-engine, regular body	84.4		21,069		6		3,959	1,651		1,320	550		23,276
Turbofan, 2-engine, wide body	148.3		37,020		11		20,000	8,340		6,667	2,780		48,151
Turbofan, 2-engine, regular body	66.6		16,625		5		5,144	2,145		1,715	715		19,490
Turboprop	26.5		6,615		2		1,269	529		423	176		7,322
Piston	4.2		1,048		0		320	133		107	45		1,226
Air Taxi (Including Air Commuter)		.406		.046		.493			.400				
Jet	4.3		925		8		1,300	641		433	173		1,747
Turboprop	9.3		2,001		16		556	274		185	74		2,365
Multi-engine piston	7.4		1,592		13		102	50		34	14		1,669
Single-engine piston	3.1		667		5		31	15		10	4		691
Rotorcraft	2.4		516		4		114	56		38	15		591
General Aviation		.406		.046		.493			.400				
Jet	4.1		882		7		1,594	786		531	212		1,887
Turboprop	5.6		1,205		10		623	307		208	83		1,605
Multi-engine piston	3.6		775		6		102	50		34	14		845
Single-engine piston	2.2		473		4		27	13		9	4		494
Rotorcraft	2.4		516		4		74	36		25	10		566
Military		.406		.046		.493			.400				
Jet	6.0		1,291		10		2,146	1,058		715	286		2,645
Turboprop	5.0		1,076		9		3,328	1,641		1,109	444		3,170
Piston	3.0		646		5		106	52		35	14		717
Rotorcraft	2.0		430		3		410	202		137	55		690

1/ Sources: References 17, 18, 19 and 20.
2/ Sources: References 27 and 28.
3/ Source: Reference 9.
4/ Terminals that serve these aircraft types obviously are already equipped with or served by ASR. Conversely, airports within the range of interest in this report for new radar establishments do not serve these aircraft types. Their inclusion here is without impact and only for completeness of presentation.

APPENDIX E-1

NORMATIVE DISTRIBUTION OF AIR CARRIER AIRCRAFT BY AIRCRAFT TYPE USED IN THE DEVELOPMENT OF DELAY AND MIDAIR COLLISION AVOIDANCE BENEFITS*

Aircraft Type	Percentage Mix
Turbofan, 4 engine, wide body	0.0
Turbojet, 4 engine	0.0
Turbofan, 4 engine, regular body	0.0
Turbofan, 3 engine, wide body	0.0
Turbofan, 3 engine, regular body	8.0
Turbofan, 2 engine, wide body	0.0
Turbofan, 2 engine, regular body	50.0
Turboprop	36.0
Piston	6.0

*Data represents the expected mix of air carrier aircraft at potential candidate airports, based on a subset of airports listed in Section VI applied to References 15 and 16.

APPENDIX E-2

NORMATIVE DISTRIBUTION OF AIR TAXI, GENERAL AVIATION AND MILITARY AIRCRAFT BY AIRCRAFT TYPE USED IN THE DEVELOPMENT OF DELAY BENEFITS

	Estimated Number of Aircraft-1978	Estimated % of Active Aircraft Flown IFR	Expected Number Aircraft Flown IFR	Percent Distribution
Air Taxi (Including Air Commuter)1/				
Jet	170	100.0	170.00	4.0
Turboprop	444	97.5	432.90	10.1
Multi-engine piston	3,314	85.2	2,823.53	65.9
Single-engine piston	2,770	29.4	814.38	19.0
Rotorcraft	1,215	3.6	43.74	1.0
	7,913		4,284.55	100.0
General Aviation (Excluding Air Taxi)1/				
Jet	2,310	100.0	2,310.00	3.4
Turboprop	2,686	97.5	2,618.85	3.8
Multi-engine piston	19,857	85.2	16,918.16	24.7
Single-engine piston	157,881	29.4	46,417.01	67.9
Rotorcraft	4,100	3.6	147.60	0.2
	186,834		68,411.62	100.0
Military2/				
Jet	8,898			47.0
Turboprop	1,794			9.5
Piston	1,056			5.6
Rotorcraft	7,183			37.9
	18,931			100.0

1/Source: Reference 19
2/Source: Reference 29

APPENDIX E-3

NORMATIVE DISTRIBUTION OF AIR TAXI, GENERAL AVIATION AND MILITARY AIRCRAFT BY AIRCRAFT TYPE USED IN THE DEVELOPMENT OF MIDAIR COLLISION AVOIDANCE BENEFITS

	Estimate of Total Hours Flown-1978	Percent Distribution
Air Taxi (Including Air Commuter)1/		
Jet	132,449	3.0
Turboprop	550,288	12.5
Multi-engine piston	1,683,862	38.2
Single-engine piston	1,210,368	27.5
Rotorcraft	828,107	18.8
	4,405,094	100.0
General Aviation (Excluding Air Taxi)1/		
Jet	1,061,797	3.1
Turboprop	1,055,995	3.0
Multi-engine piston	4,502,028	13.0
Single-engine piston	26,646,920	76.9
Rotorcraft	1,399,544	4.0
	34,666,284	100.0
Military2/		
Jet	2,843,000	58.8
Turboprop	595,000	12.3
Piston	328,000	6.8
Rotorcraft	1,071,000	22.1
	4,837,000	100.0

1/Source: Reference 19
2/Source: Reference 29

APPENDIX F - PROGRAM LOGIC OF ASR ESTABLISHMENT AND DISCONTINUANCE CRITERIA

The ASR establishment and discontinuance criteria described in this report will be integrated as a FORTRAN subroutine into the Terminal Area Forecast Data System. This appendix provides a centralized algebraic description of the logic used to compute the Phase I and II benefit/cost ratios (in Section VI), a description and source of variables and constants used in the subroutine, and appropriate default values.

A. Phase I Ratio

$ACEBE = ACPRIM_1/(3{,}400 - (.0013 \times PRIM_1))$*
$ATEBE = ATPRIM_1/(26{,}000 - (.0096 \times PRIM_1))$*
$GAEBE = GAPRIM_1/(53{,}300 - (.0196 \times PRIM_1))$*
$MLEBE = MLPRIM_1/(8{,}600 - (.0032 \times PRIM_1))$*
$ACSBE = ACITN_1/107{,}400$
$ATSBE = ATITN_1/539{,}600$
$GASBE = (GAITN_1 + GALCL_1)/847{,}200$
$MLSBE = (MLITN_1 + MLLCL_1)/376{,}200$

*If the denominator for any user class results in a value equal to or less than zero, disregard all denominators and use all of the following instead. For the air carrier user class: 9,300 - (.0034 x PRIM); for the air taxi user class: 71,200 - (.0262 x PRIM); for the general aviation user class: 146,000 - (.0538 x PRIM); and for the military user class: 23,400 - (.0086 x PRIM).

PHASE I = ACEBE + ATEBE + GAEBE + MLEBE + ACSBE + ATSBE + GASBE + MLSBE

If PHASEI $>$ 1.0, then location satisfies Phase I establishment criteria.

If PHASEI $<$ .35, then location satisfies Phase I discontinuance criteria.

In cases where qualifying radar service is provided by the primary airport to secondary airports, the Phase I ratio value shall be the sum of the airport ratios of the airports comprising the radar service area.

B. Phase II Benefit/Cost Ratio

1. Compute Life-Cycle Benefits

$$DISBEN = \sum_{y=1}^{15} (ANNBEN_y \times 1/(1+d)^{y-0.5})$$

where DISBEN is the life-cycle benefits discounted over 15 years, 'y' is each of 15 years of an ASR's estimated economic life, 'ANNBEN' is the nondiscounted sum in year 'y' of benefits of IFR delay reduction, midair collision avoidance and terrain collision avoidance, and 'd' is the OMB-prescribed discount rate of ten percent. In cases where qualifying radar service is provided by the primary airport to secondary airports, the Phase II benefit/cost ratio shall be the sum of the airport ratios of the airports comprising the radar service area.

a. IFR Delay Reduction Benefits

(1) Compute delay costs (aircraft variable operating costs and value of passengers'/occupants' time) of aircraft mix during an busy IFR hour:

```
                        Aircraft Mix                         Hourly Delay Costs
ACACST = (((ACPRIM/PRIM) x ACAEP x BHIO)/100) x (ACAVOC + (ACAPAX x VALTIM))
ACBCST = (((ACPRIM/PRIM) x ACBEP x BHIO)/100) x (ACBVOC + (ACBPAX x VALTIM))
ACCCST = (((ACPRIM/PRIM) x ACCEP x BHIO)/100) x (ACCVOC + (ACCPAX x VALTIM))
ACDCST = (((ACPRIM/PRIM) x ACDEP x BHIO)/100) x (ACDVOC + (ACDPAX x VALTIM))
ACECST = (((ACPRIM/PRIM) x ACEEP x BHIO)/100) x (ACEVOC + (ACEPAX x VALTIM))
ACFCST = (((ACPRIM/PRIM) x ACFEP x BHIO)/100) x (ACFVOC + (ACFPAX x VALTIM))
ACGCST = (((ACPRIM/PRIM) x ACGEP x BHIO)/100) x (ACGVOC + (ACGPAX x VALTIM))
ACHCST = (((ACPRIM/PRIM) x ACHEP x BHIO)/100) x (ACHVOC + (ACHPAX x VALTIM))
ACICST = (((ACPRIM/PRIM) x ACIEP x BHIO)/100) x (ACIVOC + (ACIPAX x VALTIM))
ATACST = (((ATPRIM/PRIM) x ATAEP x BHIO)/100) x (ATAVOC + (ATAPAX x VALTIM))
ATBCST = (((ATPRIM/PRIM) x ATBEP x BHIO)/100) x (ATBVOC + (ATBPAX x VALTIM))
ATCCST = (((ATPRIM/PRIM) x ATCEP x BHIO)/100) x (ATCVOC + (ATCPAX x VALTIM))
ATDCST = (((ATPRIM/PRIM) x ATDEP x BHIO)/100) x (ATDVOC + (ATDPAX x VALTIM))
ATECST = (((ATPRIM/PRIM) x ATEEP x BHIO)/100) x (ATEVOC + (ATEPAX x VALTIM))
GAACST = (((GAPRIM/PRIM) x GAAEP x BHIO)/100) x (GAAVOC + (GAAOCU x VALTIM))
GABCST = (((GAPRIM/PRIM) x GABEP x BHIO)/100) x (GABVOC + (GABOCU x VALTIM))
GACCST = (((GAPRIM/PRIM) x GACEP x BHIO)/100) x (GACVOC + (GACOCU x VALTIM))
GADCST = (((GAPRIM/PRIM) x GADEP x BHIO)/100) x (GADVOC + (GADOCU x VALTIM))
GAECST = (((GAPRIM/PRIM) x GAEEP x BHIO)/100) x (GAEVOC + (GAEOCU x VALTIM))
MLACST = (((MLPRIM/PRIM) x MLAEP x BHIO)/100) x (MLAVOC + (MLAOCU x VALTIM))
MLBCST = (((MLPRIM/PRIM) x MLBEP x BHIO)/100) x (MLBVOC + (MLBOCU x VALTIM))
MLCCST = (((MLPRIM/PRIM) x MLCEP x BHIO)/100) x (MLCVOC + (MLCOCU x VALTIM))
MLDCST = (((MLPRIM/PRIM) x MLDEP x BHIO)/100) x (MLDVOC + (MLDOCU x VALTIM))
```

TOTCST = $\sum$ of above

(2) Compute IFR Delay Reduction Benefits:

$$DELTOT = \overbrace{TOTCST \times TSAVE}^{DELSPH} \times (PIFR/100) \times BHPY$$

b. <u>Safety Benefits</u>

(1) <u>Midair Collision Avoidance Benefits</u>

(a) Compute Expected Cost of a Midair Collision:

```
         Relative Aircraft Mix               Cost of Fatal and Serious Injuries Per Aircraft      Cost of Aircraft Damage Per Aircraft
ACACCC =          ((ACITN x ACASP)/100)  x  (ACAOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACAREP) + (ACSDP x ACARES))
ACBCCC =          ((ACITN x ACBSP)/100)  x  (ACBOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACBREP) + (ACSDP x ACBRES))
ACCCCC =          ((ACITN x ACCSP)/100)  x  (ACCOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACCREP) + (ACSDP x ACCRES))
ACDCCC =          ((ACITN x ACDSP)/100)  x  (ACDOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACDREP) + (ACSDP x ACDRES))
ACECCC =          ((ACITN x ACESP)/100)  x  (ACEOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACEREP) + (ACSDP x ACERES))
ACFCCC =          ((ACITN x ACFSP)/100)  x  (ACFOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACFREP) + (ACSDP x ACFRES))
ACGCCC =          ((ACITN x ACGSP)/100)  x  (ACGOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACGREP) + (ACSDP x ACGRES))
ACHCCC =          ((ACITN x ACHSP)/100)  x  (ACHOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACHREP) + (ACSDP x ACHRES))
ACICCC =          ((ACITN x ACISP)/100)  x  (ACIOCU x ((ACFPRB x VALLIF) + (ACIPRB x (CSTINJ))) + ((ACDESP x ACIREP) + (ACSDP x ACIRES))
ATACCC =          ((ATITN x ATASP)/100)  x  (ATAOCU x ((ATFPRB x VALLIF) + (ATIPRB x (CSTINJ))) + ((ATDESP x ATAREP) + (ATSDP x ATARES))
ATBCCC =          ((ATITN x ATBSP)/100)  x  (ATBOCU x ((ATFPRB x VALLIF) + (ATIPRB x (CSTINJ))) + ((ATDESP x ATBREP) + (ATSDP x ATBRES))
ATCCCC =          ((ATITN x ATCSP)/100)  x  (ATCOCU x ((ATFPRB x VALLIF) + (ATIPRB x (CSTINJ))) + ((ATDESP x ATCREP) + (ATSDP x ATCRES))
ATDCCC =          ((ATITN x ATDSP)/100)  x  (ATDOCU x ((ATFPRB x VALLIF) + (ATIPRB x (CSTINJ))) + ((ATDESP x ATDREP) + (ATSDP x ATDRES))
ATECCC =          ((ATITN x ATESP)/100)  x  (ATEOCU x ((ATFPRB x VALLIF) + (ATIPRB x (CSTINJ))) + ((ATDESP x ATEREP) + (ATSDP x ATERES))
GAACCC =  ((GAITN + GALCL) x GAASP)/100) x  (GAAOCU x ((GAFPRB x VALLIF) + (GAIPRB x (CSTINJ))) + ((GADESP x GAAREP) + (GASDP x GAARES))
GABCCC =  ((GAITN + GALCL) x GABSP)/100) x  (GABOCU x ((GAFPRB x VALLIF) + (GAIPRB x (CSTINJ))) + ((GADESP x GABREP) + (GASDP x GABRES))
GACCCC =  ((GAITN + GALCL) x GACSP)/100) x  (GACOCU x ((GAFPRB x VALLIF) + (GAIPRB x (CSTINJ))) + ((GADESP x GACREP) + (GASDP x GACRES))
GADCCC =  ((GAITN + GALCL) x GADSP)/100) x  (GADOCU x ((GAFPRB x VALLIF) + (GAIPRB x (CSTINJ))) + ((GADESP x GADREP) + (GASDP x GADRES))
GAECCC =  ((GAITN + GALCL) x GAESP)/100) x  (GAEOCU x ((GAFPRB x VALLIF) + (GAIPRB x (CSTINJ))) + ((GADESP x GAEREP) + (GASDP x GAERES))
MLACCC =  ((MLITN + MLLCL) x MLASP)/100) x  (MLAOCU x ((MLFPRB x VALLIF) + (MLIPRB x (CSTINJ))) + ((MLDESP x MLAREP) + (MLSDP x MLARES))
MLBCCC =  ((MLITN + MLLCL) x MLBSP)/100) x  (MLBOCU x ((MLFPRB x VALLIF) + (MLIPRB x (CSTINJ))) + ((MLDESP x MLBREP) + (MLSDP x MLBRES))
MLCCCC =  ((MLITN + MLLCL) x MLCSP)/100) x  (MLCOCU x ((MLFPRB x VALLIF) + (MLIPRB x (CSTINJ))) + ((MLDESP x MICREP) + (MLSDP x MLCRES))
MLDCCC =  ((MLITN + MLLCL) x MLDSP)/100) x  (MLDOCU x ((MLFPRB x VALLIF) + (MLIPRB x (CSTINJ))) + ((MLDESP x MLDREP) + (MLSDP x MLDRES))
```

EMACCC = $((\sum$ of above$)/\text{OPS}) \times 2$

(b) Compute Annual Midair Collision Avoidance Benefits:

MACTOT = EMACCC x .010 x $(\text{OPS}/100000)^{2.3}$

(2) <u>Terrain Collision Avoidance Benefits</u>

TRCTOT = TERBEN x OPS x MODECP

(3) <u>Compute Total Safety Benefits</u>:

SAFTOT = MACTOT + TRCTOT

c. <u>Compute Total Annual Benefits</u>:

ANNBEN = DELTOT + SAFTOT

2. <u>Compute Phase II Benefit/Cost Ratio</u>

BC = DISBEN/DISCST

If BC $\geq$ 1.0, then location satisfies Phase II establishment criteria.

If BC $<$ .35, then location satisfies Phase II discontinuance criteria.

Variable/Fixed Factor Name	Description	Source	Default Value
ANNBEN	Nondiscounted sum of benefits of IFR delay reduction, midair collision avoidance and terrain collision avoidance in year 'y'.	Computed	
BC	Phase II benefit/cost ratio.	Computed	
BHIO	Number of operations during a busy IFR hour: BHIO = $.05352138 \times (PRIM^{.5921863})$.	Computed	
BHPY	Number of busy hours per year.	Constant of 1,252	
_ _ _CCC	Contributory expected midair collision costs by user class and aircraft type category. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Computed	
_ _ _CST	Contributory aircraft variable operating costs and value of passengers'/occupants' time by user class and aircraft type category during a busy IFR hour. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Computed	
CSTINJ	Cost of a statistical serious injury.	Constant of $38,000	
d	OMB-prescribed discount rate.	Constant of 0.10	
DELSPH	Product of TOTCST and TSAVE	Computed	
DELTOT	Nondiscounted IFR delay reduction benefits in year 'y'.	Computed	
_ _DESP	Probability of an aircraft involved in a midair collision being "destroyed" by user class. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Constants outlined in in Appendix D	
DISBEN	Life-cycle benefits discounted over 15 years.	Computed	

Variable/Fixed Factor Name	Description	Source	Default Value
DISCST	Life-cycle costs discounted over 15 years.	Regional input	Constants outlined in Figures 1 and 2
_ _ BBE	Break-even activity levels by user class (i.e., where efficiency benefits equal cost). Used in Phase I criteria. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Computed	
EMACCC	Total expected cost of a midair collision.	Computed	
_ _ _EP	Percentage dissaggregation of user classes by aircraft type category for purposes of delay benefits. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	For air carrier: Regional input or the Official Airline Guide. For other user classes: Constants outlined in Appendix E-2.	For air carrier: As outlined in Appendix E-1
EXPMAC	Expected annual number of avertable midair collisions: EXPMAC = $.010 \times (OPS/100{,}000)^{2.3}$	Computed	
_ _FPRP	Probability of an occupant being fatally injured in a midair collision by user class. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Constants outlined in Appendix D	
_ _IPRB	Probability of an occupant being seriously injured in a midair collision by user class. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Constants outlined in in Appendix D	
_ _ITN	Itinerant operations of the air carrier and air taxi user classes in year 'y'. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	TAF	

Variable/Fixed Factor Name	Description	Source	Default Value
_ _LCL	Local operations of the general aviation and military user classes in year 'y'. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	TAF	
MACTOT	Nondiscounted midair collision avoidance benefits in year 'y'.	Computed	
MODECF	Percentage of all aircraft which are estimated to be Mode C - equipped in year 'y'.	Constants outlined in Figure 12	
_ _ _OCU	Standard number of occupants (including crew) aboard each aircraft type category of each user class. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Constants outlined in Appendix D	
OPS	Total aircraft operations in year 'y'.	TAF	
_ _ _PAX	Standard number of passengers (other than crew) aboard the various aircraft type categories of the air carrier and air taxi user classes. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Constants outlined in Appendix C	
PHASEI	Phase I benefit/cost ratio.	Computed	
PIFR	Percentage of time that IFR weather prevails.	This report, Reference 5, Reference 29, or regional input.	13.5

Variable/Fixed Factor Name	Description	Source	Default Value
PRIM	Sum of _ _PRIM. _ _ $PRIM_1$ = Sum of _ _ PRIM in year 1. See below.	TAF	
_ _PRIM	Annual primary instrument operations by user class. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix. For a primary airport, this includes only primary instrument operations. For a secondary airport, this includes primary instrument operations of the secondary airport or secondary instrument operations of the primary airport allocable to the secondary airport, whichever is greater. _ _ $PRIM_1$ = Annual primary instrument operations by user class in year 1.	Terminal Area Forecast (TAF) File for instrument operations. To compute allocable secondary instrument operations of the primary airport, regions provide allocation percentages.	
_ _ _REP	Aircraft "replacement" costs by user class and aircraft type category. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Constants outlined in Appendix D	
_ _ _RES	Aircraft "restoration" costs by user class and aircraft type category. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Constants outlined in Appendix D	
SAFTOT	Nondiscounted sum of midair and terrain collision avoidance benefits in year 'y'.	Computed	
_ _SBE	Break-even activity levels by user class (i.e., where safety benefits equal cost). Used in Phase I criteria. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Computed	

Variable/Fixed Factor Name	Description	Source	Default Value
_ _SDP	Probability of an aircraft involved in a midair collision being "substantially-damaged" by user class. The user classes (identified in the first two positions) are cross-referenced at the end of this appendix.	Constants outlined in Appendix D	
_ _ _SP	Percentage dissaggregation of user classes by aircraft type category for purposes of safety benefits. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	For air carrier: Regional input. For other user classes: Constants outlined in Appendix E-3.	For air carrier: As outlined in Appendix E-1.
TERBEN	Benefits of averted terrain collision benefits per operation.	Constant of .587	
TOTCST	Sum of aircraft variable operating costs and value of passengers'/occupants' time during an IFR busy hour for all aircraft type categories of all user classes.	Computed	
TRCTOT	Nondiscounted terrain collision avoidance benefits in year 'y'.	Computed	
TSAVE	Delay time saved (hours) per aircraft per hour of airport operation. Derived from Figure 5 delay time table and supplemented with the following FORTRAN interpolation:	Computed	

```
      IB=BHIO-9.
      IF(BHIO.GE.30.) IB=21
      IF(BHIO.LE.10.) IB=1
      PSLOW=(ATPRIM + GAPRIM + MLPRIM)/PRIM
      TSAVE=0.
      IF(PSLOW.LE..10) TSAVE=T(1,IB)
      IF(PSLOW.GE..80) TSAVE=T(8,IB)
      IF(TSAVE.NE.0.) GO TO 940
      IP=PSLOW*10.
      TSAVE=T(IP,IB)+(PSLOW*10.-FLOAT(IP))*
     &(T(IP+1,IB)-T(IP,IB))
  940 CONTINUE
```

where T(IP,IB) = element of delay time table whose subscripts are calculated, FLOAT(IP) = FORTRAN supplied mathematical function to change an integer (IP) to its real equivalent. This allows us to find the fractional difference between PSLOW*10 and IP.

Variable/Fixed Factor Name	Description	Source	Default Value
	T(IP+1,IB) = Next higher element of delay timetable used to interpolate the stated value of T(IP,IB).		
	PSLOW = Fraction of total primary instrument operations represented by user classes other than air carrier.		
VALLIF	Value of a statistical life.	Constant of $530,000	
VALTIM	Hourly value of time of aircraft passengers/occupants.	Constant of $17.50	
_ _ _VOC	Aircraft variable operating costs per hour by user class and aircraft type category. The user classes (identified in the first two positions) and the aircraft type categories (identified in the third position) are cross-referenced at the end of this appendix.	Constants outlined in Appendix C	
y	A year of an ASR's estimated 15-year economic life.		
	<u>Factors relating to aircraft type categories (third position) within each user class (first two positions)</u>:		
	Air Carrier:		
ACA	Turbofan, 4-engine, wide body		
ACB	Turbojet, 4-engine		
ACC	Turbofan, 4-engine, regular body		
ACD	Turbofan, 3-engine, wide body		
ACE	Turbofan, 3-engine, regular body		
ACF	Turbofan, 2-engine, wide body		
ACG	Turbofan, 2-engine, regular body		
ACH	Turboprop		
ACI	Piston		
	Air Taxi (Including Air Commuter):		
ATA	Jet		
ATB	Turboprop		
ATC	Multi-engine piston		
ATD	Single-engine piston		
ATE	Rotorcraft		
	General Aviation (Excluding Air Taxi):		
GAA	Jet		
GAB	Turboprop		
GAC	Multi-engine piston		
GAD	Single-engine piston		
GAE	Rotorcraft		
	Military:		
MLA	Jet		
MLB	Turboprop		
MLC	Piston		
MLD	Rotorcraft		

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