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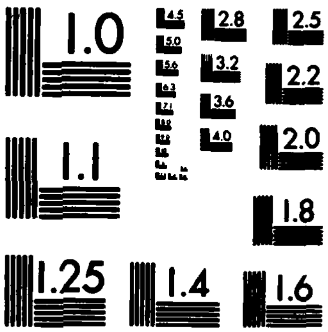

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U.S. Department
of Transportation
Federal Aviation
Administration

An Analysis of the Impacts of the Airport Radar Service Area (ARSA)

Office of Aviation
Policy and Plans

FAA-APO-85-1

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16. Abstract

The Airport Radar Service Area (ARSA) is a new concept in terminal airspace design that has been proposed as a replacement for the Terminal Radar Service Area (TRSA) which has been installed at 137 locations in the U.S. The primary difference between them is that pilots can enter the TRSA without communicating with Air Traffic Control (ATC), while in the ARSA ATC service is mandatory.

This report contains an analysis of data gathered both before and after the implementation of the ARSA at two lead sites. The analysis concludes that the ARSA produces a significant reduction in collision risk at a moderate increase in controller workload with no significant impact on ATC service to the pilots.

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PREFACE

This report was prepared in response to a request by the FAA Air Traffic Service (AAT-200) for an analysis to determine the impact of the new airspace rules that were implemented on a test basis at two locations (Austin, Texas and Columbus, Ohio). The analysis was based on data collected at these sites both before and after the implementation. The results of this analysis indicate that collision risk was substantially reduced, controller workload moderately increased, and there was no appreciable impact on the airspace users (in terms of delay, diversions, or availability of service).

While this analysis was being performed, a survey of pilot and controller reactions was conducted. The results of this survey (described in DOT/FAA/AT-84/2) generally indicate that the perception of the users and controllers confirm the findings of this analysis.

The writer wishes to acknowledge contributions made in the completion of this analysis. Guidance and support were provided by Dick Bardelmeier (APO-120), Marv Olson (APO-100), Bill Hill (AAT-240) and Harvey Safeer (APO-1). Essential technical support and air traffic control expertise was provided by:

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Jan Alsman - Washington National ATCT

Computational support was provided by Bert Katz of Native American Consultants, Inc. and Ursula Shields of Acumenics Research and Technology, Inc., and typing was performed by Pamela McCree.

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Background

The FAA is conducting a one-year confirmation of a new terminal airspace design at two locations: Austin, Texas (implemented on December 22, 1983)* and Columbus, Ohio (implemented on January 19, 1984). If this test is successful, this design could be used to replace the Terminal Radar Service Area (TRSA) at over 100 locations. The new design is called the Airport Radar Service Area (ARSA).

The primary differences between the ARSA and the TRSA are:

1. The ARSA will have (to the maximum extent possible) the same basic shape at all locations: a 5-nm ring centered at the primary airport from the surface up to 1200 feet AGL, and a 10-nm ring from 1200 feet AGL up to 4000 feet above the airport surface. The TRSA configurations vary greatly.

2. All aircraft entering the ARSA must be in radio contact with air traffic control (ATC). In the TRSA, participation is voluntary.

3. With the ARSA, the controller is required to provide advisories to all participating pilots. In the TRSA, the controller provides traffic advisories concerning non-participating VFR aircraft on a workload-permitting basis. However, the required separation between VFR aircraft has been eliminated.

In the ARSA, as with the TRSA, radar service will be provided to VFR pilots who participate out to the limits of the terminal designated airspace, or to the limits of the terminal radar and radio coverage. For the ARSA, this is referred to as the "outer limits."

Specifically, ATC will:

1. Provide the separation currently applied between aircraft operating under IFR.

2. Resolve potential conflictions between aircraft operating under IFR and VFR so that those aircrafts' radar targets do not touch when vertical separation is less than 500 feet.

3. Provide traffic advisory service to all participating aircraft and arrival sequencing at the primary airport.

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* The Austin approach control facility had discontinued TRSA service following the air traffic controllers' strike.

Extensive data were gathered for one week at both test locations by the local facilities before the ARSA was implemented. For the most part, these data are material ordinarily collected and retained temporarily by the facility, such as facility voice communications tapes and flight progress strips. At Columbus, radar data (ARTS Extraction) were also recorded. Similar data were again collected for a one week period several months after ARSA implementation.

Findings

Comparison was made between select portions of the Before and After data. (The selection was made to concentrate on times when high levels of VFR activity were reported.) The principal findings are as follows:

1. A relatively small number of pilots are affected.

At both Columbus and Austin, only about 10 percent of the operations at the primary airport were non-participants* before the ARSA (see Table 1). Thus, the impact of the ARSA could not be expected to be very great. The ARSA had no significant impact on participation by users of other airports in the vicinity of Austin and Columbus.

2. The ARSA produces no measurable impact on delay.

A total of seventeen hours of voice tapes (all control positions) were monitored which included some of the busier hours. No airborne aircraft requesting radar service were denied either Before or After at either location. All of these aircraft were allowed to continue on course while radar contact was being established. Thus, no delay impact due to the ARSA could be determined. However, periods of congestion at the clearance delivery position were noticed at Austin in the After data.

3. Average controller workload per-flight shows a slight increase. Total controller workload also increases due to increased participation.

The workload impact on terminal radar ATC was measured by computing the length of time that the average participating flight receives radar service, and by counting the number of traffic advisories and heading changes (some of which could be for conflict avoidance). The results (see Table 2) show no significant impact on the average per flight except for increased duration of service at Columbus. However, controller workload would be increased due to an increase in participating flights (about 8 percent at Austin and 5 percent at Columbus).

It should be noted that there are other impacts on workload that were not measured, such as position-to-position controller coordination.

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* In Stage III service at Columbus or Stage II service at Austin.

Table 4. EXPECTED NUMBER OF COLLISIONS UNDER HIGH-RISK SCENARIO

(Collisions per million hours)
Columbus International, 15-nm radius, surface to 7,000 feet

Collision Risk for:	Before	After
Candidate ARSA flights 1/	6.58	0.85
All others 2/	0.92	0.92
Total	7.50	1.77

1/ Expected number of collisions per million hours for collisions involving non-participants in to-be ARSA airspace (candidate ARSA flights). In the After scenario, those flights are assumed to be VFR participants.

2/ All other collisions, i.e., collisions outside of the ARSA or not involving pre-ARSA non-participants.

Note: These results should not be extrapolated to form an annual estimate of risk because the results are based on a high-activity, high-risk traffic mix period.

Table 1. ITINERANT TOWER OPERATIONS

(a) Austin

(Based on 7 days reported in each sample)

Type of Operation	Before	After
IFR	2,427 (52.79%)	2,217 (50.5%)
Participating VFR	1,700 (36.9%)	2,172 (49.5%)
Non-participant	474 (10.3%) 1/	0 (0%)
Total	4,601 (100.0%)	4,389 (100.0%)

1/ Essentially all non-participants were GA departures.

(b) Columbus

(Based on 4 days reported in each sample - VMC* only)

Type of Operation	Before	After
IFR	1,269 (62.5%)	1,321 (62.5%)
Participating VFR	594 (29.3%)	794 (37.5%)
Non-participant	167 (8.2%) 2/	0 (0.0%)
Total	2,030 (100.0%)	2,115 (100.0%)

2/ Almost all of the non-participants were GA. About 60% were departures.

* Visual meteorological conditions

Table 2. NUMBER OF TRAFFIC ADVISORIES AND HEADING CHANGES PER FLIGHT 1/

(Based on approximately 100 flights, both Before and After, at each location)

	Before	After
Austin:		
Duration of service (min.)	7.09	7.17
Traffic advisories	0.61	0.50
Heading changes	0.65	0.72
Columbus:		
Duration of service (min.)	8.22	8.71
Traffic advisories	0.53	0.97
Heading changes	0.85	0.85

1/ These are averages weighted by the number of flights of various types, in a typical day. In the samples selected, the radar traffic at Austin was about the same Before and After. At Columbus, the After sample had about 31 percent more activity.

Table 3. VFR RADAR CONTACT ESTABLISHMENT TIMES (minutes per flight) 1/

(Based on more than 20 flights, both Before and After, at each location)

	Before	After
Austin	1.2	1.1
Columbus	1.6	1.4

1/ Weighted averages for various types of GA VFR flights. Non-transponder-equipped aircraft and departures from the primary airport are excluded.

Table 4. EXPECTED NUMBER OF COLLISIONS UNDER HIGH-RISK SCENARIO

(Collisions per million hours)
Columbus International, 15-nm radius, surface to 7,000 feet

Collision Risk for:	Before	After
Candidate ARSA flights 1/	6.58	0.85
All others 2/	0.92	0.92
Total	7.50	1.77

1/ Expected number of collisions per million hours for collisions involving non-participants in to-be ARSA airspace (candidate ARSA flights). In the After scenario, those flights are assumed to be VFR participants.

2/ All other collisions, i.e., collisions outside of the ARSA or not involving pre-ARSA non-participants.

Note: These results should not be extrapolated to form an annual estimate of risk because the results are based on a high-activity, high-risk traffic mix period.

SECTION I

INTRODUCTION

The FAA is conducting a one-year test of a new concept in terminal airspace design at two locations: Austin, Texas and Columbus, Ohio. The new procedures were implemented at Austin on December 22, 1983, and at Columbus on January 19, 1984. If this test is successful, this design could be used to replace over 100 current Terminal Radar Service Areas (TRSAs). (See Reference 1)

A TRSA is the airspace surrounding a designated airport where air traffic control (ATC) provides radar vectoring, sequencing and separation on a full-time basis for all IFR flights and participating VFR flights. Unidentified VFR aircraft can operate within the TRSA without being in communication with ATC. The airspace within five miles (from the surface up to, but not including, 3,000 feet above the elevation of the airport) is the Airport Traffic Area where pilot communication with the airport control tower is mandatory (except when the aircraft is landing or departing from an airport other than the primary airport). (See Reference 2)

ARSA Concept

In April 1982, the National Airspace Review Committee (composed of representatives of many airspace user groups) recommended the adoption of what was referred to as "Model B" as the standard model for a replacement for Level III, IV and V TRSA's (see Reference 3). Model B has now been designated as the "Airport Radar Service Area" (ARSA). The ARSA design consists of two concentric circles 5nm and 10nm around the center of the primary airport. The ARSA consists of the airspace within the inner circle from the surface up to 4,000 feet above the surface of the airport, and within the outer ring, from 1,200 feet above the surface up to 4,000 feet above the surface of the airport. Within the ARSA, communications with ATC will be mandatory and certain other restrictions will apply.

Radar service will also be provided on a voluntary basis outside of the ARSA in what is referred to as the "outer limits area." This is similar to TRSA service. As with the TRSA, arriving aircraft are encouraged to report-in 25 miles out. The outer limits area extends to the boundary of the approach control facility's delegated airspace wherever radar and radio coverage exists.

One of the primary advantages of the ARSA concept is that the same basic simple design will apply at all airports to the extent practical. The TRSA designs are unique at each airport and many are very complex. Some modifications to the basic ARSA design must be made to accommodate site-specific considerations such as terrain features and existing airspace design features, but the variations will be kept to a minimum.

The features of the ARSA and TRSA are summarized in Table 1-1. Note that inside the ARSA, ATC responsibility extends to all aircraft, but TRSA separation requirements between IFR and VFR aircraft and between VFR aircraft have been modified in the ARSA. Additional information about the ARSA and TRSA is contained in Reference 1 and section 105 of Reference 2.

Table 1-1 TRSA and ARSA COMPARISON

	TRSA	ARSA
AIRSPACE	o Non-Regulatory o Non-Standard Design	o Regulatory o Basic Standard Design - Minor Adjustments for Site Sensitivity
EQUIPMENT REQUIREMENTS	o 2-Way radio if landing at a towered airport within the TRSA	o 2-Way radio
PILOT REQUIREMENTS	o Student Pilots - ok	o Student Pilots - ok
PARTICIPATION	o Voluntary	o Mandatory within ARSA, Voluntary outside
SERVICE	o Stage III service: Separation between all <u>Participating Aircraft</u> - 3 miles between IFR aircraft at the same altitude (1000 feet or less separation) - 1.5 miles between IFR and VFR aircraft or between VFR aircraft with less than 500 feet vertical separation o Sequencing of participating arriving aircraft.	o Within the ARSA: - Sequencing of all arriving aircraft - Std. IFR separation between IFR aircraft - Between IFR and VFR aircraft - Traffic Advisories and conflict resolution so that targets do not touch at the same altitude. - Between VFR Aircraft - Traffic Advisories o Outside of the ARSA: Same as above to all participating aircraft which establish 2-way communications and radar contact within the approach control's delegated airspace.

Lead Sites

Both Austin and Columbus have a primary airport with a moderate amount of traffic with a fair percentage of air carrier jet operations. Austin Robert Mueller (AUS) conducts an average of 464 itinerant operations (flights arriving or departing the airport area) per day. About 21 percent of these are air carrier operations. Port Columbus International (CMH) conducts an average of about 535 itinerant operations per day. About 26 percent of these are air carrier operations.

Both Austin and Columbus radar approach control serve a number of secondary airports. Austin approach control serves Bergstrom AFB which performs about 100 operations a day; most of these are F-4 fighters on IFR flight. It also serves a number of very small general aviation (GA) airports, none of which have an FAA tower. The Austin ARSA is shown in Figure 1-1.

Columbus approach control serves Ohio State University Airport (OSU), the third busiest airport in Ohio, which has an FAA tower; Bolton Municipal (2I4), which has a privately-operated tower; Rickenbacker Air National Guard Base (LCK), which has a military tower; and several other small non-towered airports. The Columbus ARSA is shown in Figure 1-2. The Columbus ARSA is very similar in dimensions to the TRSA it replaced.

Analysis of Test Results

This paper contains a detailed analysis of the impacts of the ARSA at both Austin and Columbus. This analysis was performed at the request of, and with the support of, the FAA Air Traffic Service; specifically, the Airspace Rules and Aeronautical Information Division (AAT-200) and the Procedures Division (AAT-300). The methodology used in this analysis is based on experience gained through a before/after analysis of the San Diego Terminal Control Area performed during 1980 and 1981. (The results of that analysis were not published.)

The concepts supporting the analysis are discussed in Section II. The analysis is summarized in Section III and the findings are presented in Section IV.

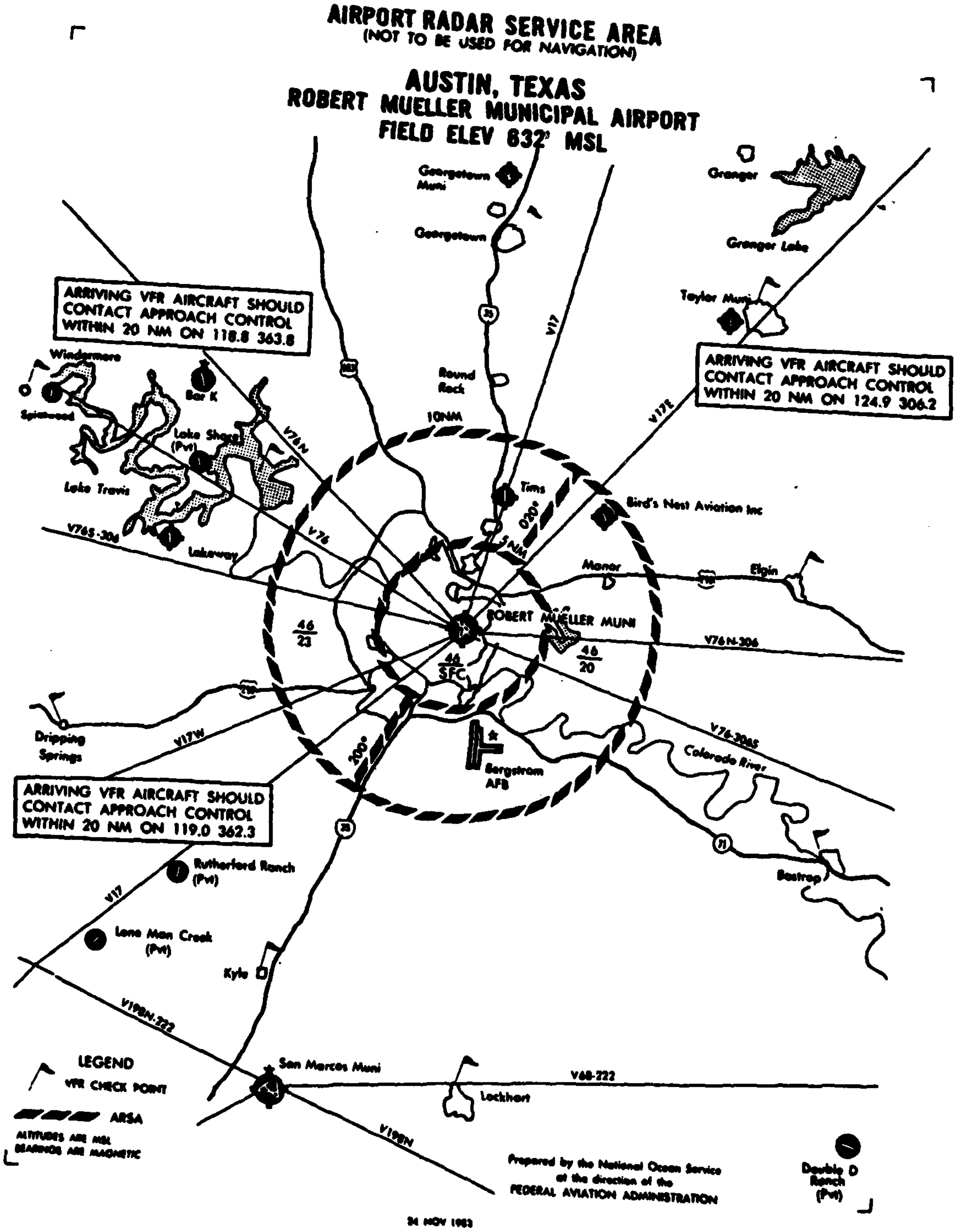
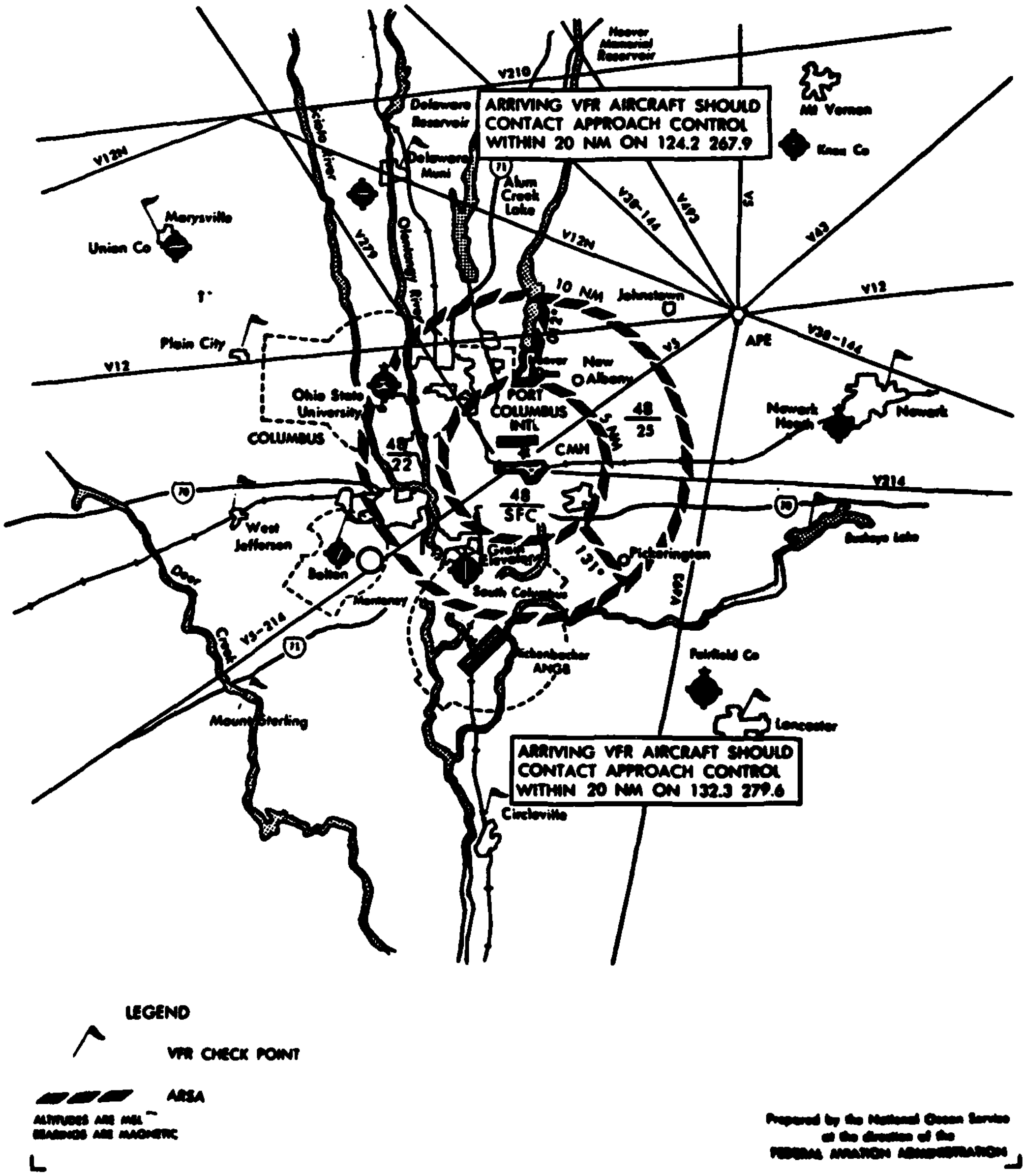


Figure 1-1 ARSA at Austin, Texas



AIRPORT RADAR SERVICE AREA
(NOT TO BE USED FOR NAVIGATION)
PORT COLUMBUS INTL. AIRPORT
COLUMBUS, OHIO
FIELD ELEV. 816 MSL

Figure 1-2 ARSA a Columbus, Ohio

SECTION II

ANALYSIS PLAN

The purpose of the ARSA is to increase safety, particularly for users of the primary airport, by requiring all traffic in the ARSA to be in radio contact with air traffic control (ATC). This contact could produce additional workload on the controllers because some users who would not otherwise do so, are required to communicate with ATC in the ARSA. Arrivals are not permitted to enter the airspace unless two-way communication has been established. Departures are not allowed to take-off without radar departure control clearance. This could produce delays to aircraft because of additional workload on the controllers.

This analysis plan discusses the purpose of the analysis, the scope, and the data sources.

Purpose of the Analysis

The purpose of this analysis is to assess the impact of the ARSA on the number of aircraft receiving ATC service (participating), controller workload, collision risk, delay to aircraft, and the availability of ATC service.

Participation and Workload

In the course of this investigation several questions will be addressed, such as:

1. What percentage of aircraft that entered the area previously and did not participate now participate, and what percentage now avoid the area?

2. How much impact does the ARSA have on controller workload from former participants and new participants, respectively?

3. Does the ARSA increase or decrease controller workload per flight?

Collision Risk

Collision risk occurs primarily where high density routes cross in space. There is always some chance that a collision can occur on a seldom used path, but the risk on any such path is very small compared to the risk on the dominant routes, where risk is already very low. In any case, a before/after comparison of risks where the risk is highest, can be used as a surrogate for a comparison of all possible risk, which would be impossible.

It is expected that the installation of regulatory airspace could change the routes of travel, particularly for non-participating aircraft. Therefore, the principal intersections before the ARSA might not be exactly the same as the principal intersections after the ARSA. Particular attention must be given to the areas immediately around, under and over the ARSA.

Because the purpose of the analysis is to compare two alternative sets of rules affecting the handling of VFR aircraft in the terminal radar area, the analysis will be confined to that area and the will be based on conditions of fairly heavy VFR activity. Only daytime VFR conditions will be considered; low traffic activity and anti-collision lights make night collision risk very low, although other types of accidents might be more likely.

Delay

Congestion-related delay can be defined as the time the flight took minus the time that it would have taken in the absence of aircraft congestion. The impact of congestion can take the form of delayed ATC clearances, either to provide separation, or due to frequency congestion or controller workload.

A before/after delay comparison must also consider if the primary routes of travel have been elongated or shortened as a result of the changed procedures.

Availability of Radar Service

Airborne aircraft desiring radar service must be identified by the radar controller. This process can be deferred or delayed by the controller if he is busy with other traffic. Since participation is mandatory in the ARSA, the controller must not allow aircraft to enter the ARSA until he is able to work the traffic. This is indicated by instructions to "remain clear of the ARSA."

Scope

This analysis is concentrated primarily on Columbus for the following reasons:

1. Collision risk requires the availability of recorded radar data. These recordings were made at Columbus through ARTS III-A Extraction. The Austin facility does not have this capability.

2. TRSA (Stage III) services were not performed at Austin prior to ARSA implementation, having been suspended as a result of the air traffic controllers' strike. Austin was providing Stage II service. The situation at Columbus was more typical of what is being proposed--namely, going from a TRSA to an ARSA. In the future, some Stage II terminal radar facilities may go directly to an ARSA, but the great majority of cases will be TRSA to ARSA conversions.

The analysis of the impact at Austin is similar to the analysis at Columbus, except that no collision risk impact is estimated.

Data

Detailed data were collected during two one-week test periods: one period prior to the ARSA implementation and one following the implementation. The exact dates were left to the local TRACON personnel to determine based on weather conditions and other pertinent local factors in an attempt to obtain comparable, relatively high VFR traffic activity levels within a time frame constrained by the needs of the analysis. The test periods selected were:

AUSTIN

Pre-ARSA: Nov. 16, 1983 - Nov. 22, 1983, incl.
Post-ARSA: Mar. 21, 1984 - Mar. 27, 1984, incl.

COLUMBUS

Pre-ARSA: Nov. 7, 1983 - Nov. 13, 1983, incl.
Post-ARSA: Mar. 30, 1984 - Apr. 5, 1984, incl.

The following data were collected during the test periods:

1. Tower and TRACON

   a. Facility recordings (pilot/controller voice tapes): Austin Mueller (AUS), Port Columbus (CMH), and Ohio State University Airport (OSU) towers
   b. Radar data from ARTS-IIIA (Continuous Data Record Target Reports) on computer disc packs 1/: Columbus
   c. Flight progress strips: All FAA facilities
   d. Hourly traffic counts: Austin, Bergstrom AFB (BSM), Port Columbus, Bolton, Rickenbacker (LCK) and CSU towers; Austin and Columbus approach control
   e. Facility operations logs (FAA Form 7230-4): Austin and Columbus approach control

2. FSS

Flight plan records (FAA Form 7233-1): Austin and Columbus FSS.

3. Weather Bureau

Hourly surface weather observations (NOAA form AF1-10A): Austin and Columbus.

During the selected periods at Austin, the weather and traffic conditions were remarkably good and comparable. On 10 out of 14 test days, the tower count of itinerant operations exceeded 600. The records submitted by the AUS Tower (FAA Form 7230-1) during 1983 showed only 92 days when this count was 600 or greater. Thus, the Before/After comparison at AUS is based on heavy, but not peak traffic conditions.

1/ The disc packs were converted to magnetic tape by the FAA Air Traffic Service at the FAA Technical Center (AAT-460 and AAT-350). The data were then used to produce target plots showing all beacon target reports, including beacon code and altitude data, for selected time periods.

During the Columbus test periods activity levels were only slightly above average. Both Before and After test periods included bad weather days which precluded use of the data in analysis. Further complications include runway closures and bad radar recordings. However, enough good data were obtained for an analysis.

SECTION III

ANALYSIS

This section contains an analysis of the impact of the ARSA on participation, controller workload, service availability and collision risk. It is based on the plan and data described in Section II.

Impact of the ARSA on Participation

The Austin Before and After test periods both contain seven days of moderate or good VFR conditions with few operational problems. Hence, a comparison can be made using the entire test period.

Table 3-1 shows the total AUS tower count of itinerant operations in both the Before and After weeks. Before the ARSA, about 10.3% (474 out of 4601) of the operations were non-participants. This is a high estimate, based on general aviation (GA) activity that is well above average. All of the non-participants were GA departures. Some of the same aircraft were observed as participating VFR (Stage II) arrivals and some as IFR arrivals. In the After sample, total GA activity is 10 percent lower (2,827 operations compared to 3,146). The increase in GA VFR participants (from 1,456 Before to 1,967 After) is larger than the number of Before non-participants. It appears that some of this increase is from former IFR flights.

Table 3-2 compares the total count of Austin radar operations for the Before and After test periods. The increase in AUS participating flights was largely offset by a decrease from other sources. There was an 8.2 percent decrease in participating flights other than Bergstrom AFB (BSM) and Austin Mueller (AUS) (909 Before compared to 834 After), which is about the same as the 10.1 percent decline in AUS GA itinerant operations (3,146 Before compared to 2,827 After). This suggests that the ARSA had little, if any, impact on participation by flights other than AUS arrivals and departures.

If the same levels of activity had occured Before and After, but with required participation (i.e., with the 5801 former participants plus the 474 AUS tower non-participants participating), there would have been an 8.2 percent increase (6275 compared to 5801) in the radar count. This is an estimate of total impact on radar participation, neglecting a possible slight increase in participation by flights other than arrivals and departures at AUS.

Table 3-3 compares the Port Columbus (CMH) itinerant tower count over four good VFR days in the Before test period to a similar four days in the After test period. Before the ARSA, 8.2 percent of all the flights (167 out of 2030) did not participate. Table 3-4 shows the radar count for the same periods. Before the ARSA, 19.2 percent (594) of the 3,097 radar operations were CMH VFR flights. If all of the CMH flights had participated, this would have resulted in an increase in the CMH radar count by 167 and thus increased the total radar count by 5.4 percent (3,264 compared to 3,097).

The radar count from other sources (both IFR and VFR) is lower in the After sample than in the Before sample, even though the count from CMH is considerably increased.

TABLE 3-1

BEFORE/AFTER ITINERANT OPERATIONS-AUSTIN TOWER

(One Week Total)

(a) By type of participation and user

Category	Before		After	
IFR				
Air Carrier	1025		1137	
Air Taxi	141		176	
GA	1216		860	
Military	45		44	
Total	2427	(52.8%)	2217	(50.5%)
Participating VFR				
Air Taxi	87		103	
GA	1456		1967	
Military	157		102	
Total	1700	(36.9%)	2172	(49.5%)
Non-participant*				
GA	474	(10.3%)	0	(0.0%)
Tower Total	4601	(100.0%)	4389	(100.0%)

* Based on a sample, all of the non-participants were departures. Some of these aircraft arrived as IFR flights.

(b) By type of user

Category	Before	After	Percent change
Air Carrier	1025	1137	+ 10.9
Air Taxi	228	279	+ 22.4
Military	202	146	- 27.7
GA	3146	2827	- 10.1
Total	4601	4389	- 4.6

TABLE 3-2

BEFORE/AFTER COMPARISON OF AUSTIN RADAR OPERATIONS

(One Week Total)

(a) By type of service and airport

Category	Before		After	
Austin IFR	2427		2217	
Bergstrom IFR	765		630	
Other IFR	419		364	
Total IFR	3611	(62.2%)	3211	(54.9%)
Austin VFR	1700		2172	
Other VFR	490		470	
Total VFR	2190	(37.8%)	2642	(45.1%)
Radar Total	5801	(100.0%)	5853	(100.0%)

(b) By airport

	Before	After	Percent Change
Austin	4127	4389	+ 6.3
Bergstrom IFR	765	630	- 17.6
Other	909	834	- 8.2
Total	5801	5853	+ 0.9

TABLE 3-3

BEFORE/AFTER ITINERANT OPERATIONS (FOUR-DAY 1/ TOTALS) - COLUMBUS TOWER

(a) By type of participation

Category	Before	After
IFR		
Air Carrier	535	547
Air Taxi	434	449
GA	284	320
Military	16	5
Total	1269 (62.5%)	1321 (62.5%)
Participating VFR		
Air Taxi	56	40
GA	532	745
Military	6	9
Total	594 (29.3%)	794 (37.5%)
Non-participant 2/		
Air Taxi	7	0
GA	154	0
Military	6	0
Total	167 (8.2%)	0 (0.0%)
Tower Total	2030 (100.0%)	2115 (100.0%)

1/ Four selected days in each sample (VMC only)

2/ About 60 percent of the non-participants were departures

(b) By type of user

Category	Before	After	Percent Change
Air Carrier	535	547	+ 2.2
Air Taxi	497	489	- 1.6
GA	970	1065	+ 9.8
Military	28	14	- 50.0
Total	2030	2115	+ 4.2

TABLE 3-4

BEFORE/AFTER COMPARISON OF COLUMBUS RADAR OPERATIONS (FOUR-DAY TOTALS)

(a) By type of service and airport

		Before		After	
Port Columbus	IFR	1269	(41.0%)	1321	(41.5%)
Other	IFR	748	(24.1%)	623	(19.6%)
Port Columbus	VFR	594	(19.2%)	794	(25.0%)
Other	VFR	486	(15.7%)	443	(13.9%)
TOTAL		3097	(100.0%)	3181	(100.0%)

(b) By airport

	Before	After	Percent Change
Port Columbus	1863	2115	+ 13.5
Other	1234	1066	- 13.6
Total	3097	3181	+ 2.7

Table 3-3(b) shows CMH GA activity up 9.8 percent and Table 3-4(b) shows radar operations from other airports down 13.6 percent. At the same time, itinerant tower operations at OSU increased from 953 to 1025 and at Bolton remained the same at 336 (not shown in the tables). This suggests that participation from other sources decreased.

In conclusion, the ARSA is estimated to increase the number of aircraft handled by the radar approach control by 8 percent (on a heavy VFR traffic day) at Austin and by 5 percent (on a slightly above average VFR traffic day) at Columbus. The change in both cases is due to mandatory participation at the primary airport, only.

Impact of the ARSA on Controller Workload

Tables 3-5 and 3-6 show average values of the following measures of workload per flight:

1. The duration of time that the aircraft is handled by radar control (from first report-in to final handoff) in minutes per flight.

2. The number of heading changes (or speed reductions) given to each flight (some of which could be for conflict resolution).

3. The number of traffic advisories given to each flight.

The average is shown for a number of dominant types of flight. A weighting factor, based on the relative number of each type of flight on a typical day, is also shown. These weighting factors were used to obtain an overall weighted average.

At Austin, where the number of aircraft handled per hour was about the same in both Before and After samples, the duration of flight and the number of heading changes per flight are unchanged. There appears to be a decrease in the average number of traffic advisories per flight. This could be due to increased participation allowing the controller to avoid unnecessary traffic calls concerning non-participating aircraft that are not really a threat.

At Columbus, the number of heading changes per flight was unchanged (almost all appeared to be for other than conflict resolution) but the duration of flight and the number of traffic advisories per flight increased significantly. Columbus controllers indicated that they had changed their procedures to terminate radar service for VFR aircraft at 20 miles out. This could explain the increase of 3 minutes in duration for CMH GA VFR departures. The increase in traffic calls could be due to an increase in traffic density and not due to the ARSA.

It should be noted that these measures are not the only impacts on controller workload. Increased participation also means a proportionate increase in clearances, radar identification, and controller coordination. Conflict resolution is frequently performed by altitude restrictions, rather than heading changes. The altitude restrictions are difficult to identify and were not tabulated.

Table 3-5 CONTROLLER WORKLOAD MEASURES - AUSTIN RADAR
(Averages per flight - see notes)

Type of Flight	Weight	Duration Before	Duration After	Headings Before	Headings After	Traffic Before	Traffic After	Observations Before	Observations After
AUS Air Carrier Arr.	0.124	7.35	6.70	1.40	1.23	0.20	0.62	10	13
AUS Air Carrier Dep.	0.124	3.17	2.06	0.42	0.46	0.17	0.23	12	13
AUS GA IFR Arr.	0.094	10.34	10.27	1.17	1.33	0.75	0.67	12	9
AUS GA IFR Dep.	0.094	3.26	3.46	0.50	0.67	0.13	0.00	8	6
AUS GA VFR Arr.	0.214	8.92	9.02	1.15	1.13	0.89	0.92	27	24
AUS GA VFR Dep.	0.214	9.12	9.42	0.00	0.00	1.00	0.56	6	16
BSM Military IFR	0.136	4.74	6.23	0.18	0.57	0.55	0.14	11	11
Total	1.000	--	--	--	--	--	--	86	92
Overall Weighted Avg.	--	7.09	7.17	0.65	0.72	0.61	0.50	--	--

Notes:

1. "Duration" is the length of time the aircraft was in contact with the TRACON in minutes per flight.
2. "Headings" is the number of heading changes and speed reductions issued per flight.
3. "Traffic" is the number of traffic advisories issued per flight.
4. "Weight" is a weighting factor reflecting the relative frequency of occurence of each type of flight.
5. "Observations" is the number of flights used in the sample mean.
6. The above statistics are based on all flights completed during 2 sample hours Before and 2 sample hours After. The TRACON traffic density was about 6 percent heavier in the After sample than in the Before sample.

Table 3-6 CONTROLLER WORKLOAD MEASURES - COLUMBUS RADAR
(Averages per flight - see notes)

		Duration		Headings		Traffic		Observations	
Type of Flight	Weight	Before	After	Before	After	Before	After	Before	After
CMH Air Carrier Arr.	0.112	6.48	7.22	1.00	1.00	0.64	1.58	14	12
CMH Air Carrier Dep.	0.112	2.60	2.51	0.76	1.00	0.18	0.50	17	10
CMH Air Taxi Arr.	0.103	9.64	7.61	0.71	0.75	0.29	1.75	7	4
CMH Air Taxi Dep.	0.103	10.38	8.46	0.71	0.25	0.29	0.25	7	4
CMH GA IFR Arr.	0.033	11.42	17.56	0.83	2.00	0.67	0.60	6	5
CMH GA IFR Dep.	0.033	5.06	5.78	0.33	0.25	0.66	0.25	3	4
CMH GA VFR Arr.	0.145	6.17	6.50	1.07	0.86	0.36	0.57	28	22
CMH GA VFR Dep.	0.145	6.30	9.35	0.77	0.83	0.48	0.88	22	25
OSU IFR Arr.	0.027	12.56	11.32	1.25	1.67	1.00	0.67	8	3
OSU IFR Dep.	0.027	12.37	8.64	1.00	0.75	0.33	1.50	3	4
OSU VFR Arr.	0.040	6.90	11.01	1.29	0.33	0.14	0.56	7	6
GA IFR other	0.048	15.42	18.80	0.80	0.00	0.80	0.86	16	7
GA VFR other	0.072	15.21	14.26	0.70	0.30	1.05	1.80	20	15
Total	1.000	--	--	--	--	--	--	158	121
Overall Weighted Avg.	--	8.22	8.71	0.85	0.85	0.53	0.97	--	--

Notes:

1. "Duration" is the length of time the aircraft was in contact with the TRACON in minutes per flight.
2. "Headings" is the number of heading changes and speed reductions issued per flight.
3. "Traffic" is the number of traffic advisories issued per flight.
4. "Weight" is a weighting factor reflecting the relative frequency of occurence of each type of flight.
5. "Observations" is the number of flights used in the sample mean.
6. These statistics are based on all completed flights that obtained radar service during a 4.0 hour Before sample and a 2.5 hour After sample. The average per-hour radar traffic count in the After sample was 31 percent higher than the Before sample.

The Impact of the ARSA on Radar Service Availability

No airborne aircraft requesting radar service were denied or delayed at either location in the selected time periods monitored, either Before or After. (The only exception to this was that service was denied to a banner-tow aircraft over a football stadium in the Before sample.)

All aircraft (except those few that did not have transponders and had to make turns for identification) were allowed to continue on course while radar contact was being established. Almost all arrivals at the primary airport report-in well beyond the ARSA, many 40 miles out, or more. One case was noted of a CMH arrival in the After sample that reported-in 5 miles out. It was identified and handed-off to the tower, all within 53 seconds.

In order to have some measurable comparison of radar service availability, the time was measured between pilot requests for radar service and controller confirmation of radar contact. IFR flights and VFR departures were excluded from this comparison because the beacon code is pre-assigned and radar contact is almost instantaneous. Non-transponder equipped aircraft were also excluded. The results are shown in Table 3-7. There appears to be no significant difference in radar contact times due to the ARSA at either Austin or Columbus, on average. There does appear to be an increase in time for some flight categories and a decrease for others.

All aircraft departing the primary airport must contact the clearance delivery controller who prepares a flight progress strip and assigns a discrete beacon code. This created a considerable increase in workload at Austin. Several hours of Austin clearance delivery were monitored when an average of 24 calls per hour were handled. Many were delayed. This problem might be solved by an additional controller position.

Collision Risk Analysis

Assumptions

The assumptions upon which this analysis are based are:

1. Aircraft are constrained to follow the paths observed in the sample data. Given a sufficient sample size, collected under constant operational parameters (e.g., runway use configurations, air traffic rules, weather and traffic mix), the resulting collection of paths should approximate those used anytime under similar situations.

2. The generic type of aircraft observed on the path is the only type to use the path (air carrier jet, IFR business jet, VFR GA propellor, etc.)

3. All aircraft enter their respective paths at a randomly-selected time.

TABLE 3-7 TIME REQUIRED TO ESTABLISH RADAR CONTACT
Mean, Standard Deviation, and Size of samples
(VFR, Transponder-equipped aircraft only)

Flight category	Before			After			Statistical inference *
	Mean	Std. Dev.	S	Mean	Std. Dev.	S	
Austin:							
AUS GA Arrivals	1.24	0.69	26	1.13	0.91	23	same
Columbus:							
CMH GA Arrivals	1.46	1.21	20	0.76	0.48	19	different
OSU GA Arrivals	1.05	0.48	6	1.80	1.08	6	different
GA Overflight	0.94	0.48	14	1.10	0.78	12	same
Overall Avg.	1.6	--	--	1.4	--	--	--

* "Different" means that there is better than a 50 percent probability that the population averages are greater or less, as indicated by the sample means. "Same" means that there is less than a 50 percent probability that the sample difference is significant. (See Reference 5)

4. Conflicts occur when the aircraft on two different paths come within a specified distance, R, in the horizontal plane and a specified distance, Y, in the vertical direction. If R and Y are set to values that would result in physical contact, the conflict is a collision. Collision distances are specified in Table 3-8.

5. Because of arrival sequencing and inherent spacing between departures, the chance of conflict between two aircraft arriving at the same airport or departing from the same airport is negligible.

6. In order to restrict consideration of collision risk to the terminal radar airspace in and around the ARSA, conflicts are of interest only if they are no more than 15nm from the radar site (located near the center of CMH) and at or below 7,000 feet (6,200 feet above the airport surface). The conflict must also be either 4nm from the center or 3,000 feet above the surface of any airport. Conflicts become relatively unlikely beyond 15nm because of dispersal of aircraft in altitude and azimuth. Therefore, the risk out to 15nm is a reasonable approximation of the total risk in the terminal radar airspace.

7. Altitudes for non-mode C aircraft paths can be inferred from flight progess strips and/or recorded ATC clearances for participating aircraft. Altitudes for non-participating, non-mode C aircraft can be inferred from other similar tracks made by mode C VFR aircraft.

8. At the time this analysis was performed it was not clear how the ARSA rules would affect services provided outside the ARSA. It is assumed that there is no change in risk to aircraft outside the ARSA, before vs. after the ARSA implementation, due to changed ATC procedures alone.

As a result of comparing a large number of tracks generated for east and west operations*, it was noted that:

1. East operations afford more opportunity for conflicts than west operations.

2. The paths of the pre-ARSA flights were not changed as the result of the ARSA.

3. No more diversion around, under or over the primary airport occurs after ARSA implementation than before.

Therefore, it was concluded that there is no significant compression of non-participants around, over and below the ARSA. The only significant impact of the ARSA is mandatory participation by VFR aircraft within the ARSA.

In order to have completely comparable Before/After data sets, the same flight tracks, and the same aircraft mix and densities were used in both Before and After scenarios. This was based on 2.6 hours of heavy, multi-airport

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* East operations is defined as the predominant use of runways 10L and 10R at Port Columbus, and West operations as the use of runways 28L and 28R.

Table 3-8 COLLISION DISTANCES (Nautical Miles)

R = horizontal, Y = vertical

Combination of Aircraft types

Aircraft Type	Air Carrier	Commuter	GA or helicopter	Military	Business jet
Air Carrier	R = .025 Y = .006				
Commuter	R = .018 Y = .005	R = .010 Y = .004			
GA or Helicopter	R = .016 Y = .004	R = .008 Y = .003	R = .006 Y = .002		
Military (fixed-wing)	R = .023 Y = .007	R = .016 Y = .005	R = .014 Y = .004	R = .021 Y = .007	
Business Jet	R = .017 Y = .005	R = .009 Y = .004	R = .007 Y = .003	R = .015 Y = .007	R = .008 Y = .004

Note: The distances represent the maximum separation between aircraft centers that would allow physical contact. They are based on wing span and overall height of typical aircraft of that type operating in the Columbus area.

activity, during east operations, in the Before data. The only difference is that in the After scenario all Before non-participants are assumed to be VFR participants when within the ARSA.

A set of 146 typical flight tracks which could possibly interact with other tracks in the area of interest were identified. A profile of the number of tracks by various categorizations are shown in Tables 3-9 and 3-10.

Conflict Risk

The expected number of conflicts per hour, N, on any two intersecting paths is given by:

$$N = P_{ATC} \times P_{SA} \times C_{BF}$$

Where:

C_{BF} = The expected number of conflicts per hour, assuming that no speed or path deviation is made to avoid the conflicts (blind flying). This is a complex function of the geometry of the paths and the aircraft speed and densities. See Reference 6.

P_{SA} = The probability that neither of the pilots will detect the conflict and effect a successful avoidance maneuver (see and avoid) independent of ATC support. See Table 3-11.

P_{ATC} = The probability that an air traffic controller would not alert either or both pilots and/or direct a course change in time to avoid the conflict. See Table 3-12.

There are no hard data available for the ATC risk factor, P_{ATC}. No data exist on how many times an ATC traffic advisory or course correction made the difference in preventing a collision. It can be expected that because collisions involving participating aircraft are extremely rare, that P_{ATC} should be very small.

Table 3-12 contains judgemental values data for P_{ATC} that are based on controller comments and the less detailed values derived from Reference 10. Comparison of predictions based on these values to observed collision rates suggest that these values understate the effectiveness of ATC. This means that the results of this analysis will understate the benefits of the ARSA. P_{ATC} is a function of the type of air traffic control service of both aircraft. For example, if both aircraft are non-participants, the value is 1 (no risk mitigation). If both aircraft are IFR, the value is 0.01 (all but 1 out of 100 collisions that would otherwise occur are avoided).

Analysis of all combinations of the 146 paths produced 26 intersections with collision potential (the paths come within collision distance).* Nine of these intersections involved at least one non-participant and were in (to be)

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* It is assumed that, while a larger base of experience would produce more intersections, these 26 are typical of those where the most significant risk occurs. A larger sample would spread the flights into the larger number of intersections for a numerically similar estimate of total risk.

Table 3-9 BREAKOUT OF SAMPLE FLIGHT TRACKS BY ORIGIN/DESTINATION

Airport	Arrival	Departure	Other	Total
Port Columbus	35	30	-	65
Ohio State University	17	16	-	33
Bolton	5	5	-	10
Rickenbaker	1	2	-	3
South Columbus	2	0	-	2
Lancaster	1	3	-	4
Mount Vernon	2	0	-	2
Inter-airport flight	-	-	7	7
other (overflight)	-	-	20	20
Total	63	56	27	146

Table 3-10 BREAKOUT OF SAMPLE FLIGHT TRACKS BY TYPE OF AIRCRAFT AND TYPE OF ATC SERVICE

Type of Aircraft	IFR	VFR participant	Non-participant	Total
Air Carrier (jet)	21	0	0	21
Commuter (prop.)	14	3	0	17
General Aviation (prop.)	24	36	33	93
Military (fixed-wing)	4	0	0	4
Helicopter	1	1	2	4
Business Jet	7	0	0	7
Total	71	40	35	146

Table 3-11 SEE AND AVOID RISK FACTOR, P_{SA}

(Probability that neither pilot would detect and avoid a collision)

V = closing rate (knots)	P_{SA}
$0 < V \leq 100$	0.05
$100 < V \leq 200$	0.03
$200 < V \leq 300$	0.12
$300 < V \leq 400$	0.25
$400 < V$	0.52

Note: These values were derived from data in Reference 7

Table 3-12 ATC RISK FACTOR, P_{ATC}

(Probability that ATC would not prevent a collision)

Type of ATC Service	Type of ATC Service - Aircraft 1		
Aircraft 2	IFR	Participating VFR	Non-participant
IFR	0.01	0.02	0.04
Participating VFR	0.02	0.04	0.10
Non-participant	0.04	0.10	1.00

ARSA airspace. This is a relatively large number of intersections, considering that so few non-participating tracks entered this airspace. It reflects the fact that the non-participating aircraft flew at high-traffic density altitudes (mostly 2,500 feet) in very congested airspace.

Table 3-13 shows the computation of collision risk for each of the nine intersections that would be affected by the ARSA mandatory participation. Risk is given in terms of expected number of collisions per million hours of time during which similar conditions exist.

For example, the first intersection involves two GA aircraft. One is a VFR participant departing CMH and the other is non-participating OSU arrival. The intersection is located 6.5nm from the radar site at 2,500 feet. If the aircraft flew blind (and this level of activity, mix of aircraft, and traffic flow continued indefinitely) there would be, on average, 30.8 collisions every million hours. This is one collision every 32,468 hours.

Fortunately, in all but 3 out of 100 cases the pilots would see and avoid the threat. In the TRSA scenario, because one of the aircraft is a VFR participant, the ATC advisory would prevent the collision in 9 out of 10 of those three cases. The result is an estimated 0.092 collisions in a million hours. This is one collision in 10.8 million hours at that (representative) intersection alone.

The sum taken over the nine intersections is 6.578 collisions per million hours. The total taken over the 17 other intersections is 0.916 collisions per million hours, making a total of 7.494 per million hours.

For the ARSA scenario, the non-participants in the nine cases are assumed to be VFR participants. New values of P_{ATC} are used, resulting in new values of N. The net total is 0.849 collisions per million hours. The risk at the other intersections remains at 0.916. The total collision risk is 1.765 per million hours, a 76 percent reduction.

Note that the blind flying risk at the nine ARSA-affected intersections is 30.3 per million hours, slightly less than the total for the other intersections (45.4), but the net risk, N, is much greater for the nine intersections shown than the others for the TRSA scenario. This is because the other intersections involve a higher degree of participation, on average, including many IFR aircraft. In the ARSA case, total participation at the nine intersections restores the balance.

One should not extrapolate these collision estimates to an annual basis because these results are for a high traffic volume, a high-risk traffic mix, and a comparatively high risk direction of flow situation. However, the relative risk between the Before vs. After ARSA implementation cases probably holds on an annual basis.

Near Midair Collisions

The procedure used for estimating the number of collisions was used to estimate the number of near midair collisions. For this analysis, a near midair collision is defined as follows: 1) for interactions involving one or more air carrier aircraft, a horizontal separation of 1,000 feet (0.165 nm) or

Table 3-13 COLLISION RISK COMPUTATION - High Risk Scenario

(Collisions within 15nm of CMH center and altitude of 7,000 feet or less)
(Nine intersections affected by the change are shown separately)

Aircraft 1			Aircraft 2			dist.	alt.			TRSA*		ARSA	
Class	Cnt.	CMH dep.	Class	Cnt.	Flight	(nm)	(100 ft)	C_{BF}	P_{SA}	P_{ATC}	N	P_{ATC}	N
GA	V	CMH dep.	GA	N	OSU arr.	6.5	25	30.8	.03	0.10	0.092	0.04	0.037
GA	N	SCOL arr.	GA	N	OSU arr.	8.0	35	32.0	.12	1.00	3.829	0.04	0.153
GA	V	CMH m.a.	GA	N	CMH arr.	6.0	25	102.3	.12	0.10	1.228	0.04	0.491
GA	V	CMH m.a.	GA	N	CMH dep.	7.5	25	17.2	.03	0.10	0.051	0.04	0.021
GA	N	CMH-SCOL	GA	N	SCOL arr	5.0	25	37.6	.03	1.00	1.126	0.04	0.045
GA	V	OSU arr.	GA	N	SCOL arr	6.5	25	22.9	.03	0.10	0.069	0.04	0.028
GA	N	CMH dep.	GA	V	OSU dep.	4.9	25	24.4	.03	0.10	0.073	0.04	0.029
GA	N	CMH dep.	GA	V	CMH arr.	9.5	26	17.3	.05	0.10	0.087	0.04	0.035
GA	N	CMH dep.	AT	I	CMH arr.	4.0	28	18.4	.03	0.04	0.022	0.02	0.011
					Subtotal			30.3			6.578		0.849
					All others			45.4			0.916		0.916
					Total			75.7			7.494		1.765

* Separation minimums between VFR aircraft and between VFR and IFR aircraft exist in the TRSA but not in the ARSA. This is assumed to produce no increase in risk in this analysis, i.e., safe separations are provided in either case.

Note:

Cnt. = Type of participation: I=IFR, V=VFR participant, N=non-participant
C_{BF} = Blind flying collisions per million hours.
P_{SA} = See-and-avoid factor
P_{ATC} = Air traffic control factor
N = Expected number of collisions in one million hours
ARR. = Arrival, dep. = departure, m.a. = missed approach, CMH - SCOL = CMH to South Columbus Airport
GA = General Aviation (propellor), AT = commuter (propellor)

less and a vertical separation of 250 feet (0.0410 nm) or less; 2) for other interactions, a horizontal separation of 500 feet or less and a vertical separation of 250 feet or less.

Note that by this definition, collisions are included as near midairs.

There are 66 intersections with near midair potential (including the 26 with collision potential). The risk of a near midair (or collision), assuming TRSA conditions, was found to be 211 per million hours, and for the ARSA, 118 per million hours. Of those, 5.2 for the TRSA and 4.9 for the ARSA involved an air carrier aircraft. For the TRSA, 134 involved two non-participating aircraft, and for the ARSA, 63 involved two non-participating aircraft (those of the 134 that were in the outer limits).

This suggests that the ARSA produces a 44 percent reduction in the risk of a near midair.

Reduced Separation Requirements

As mentioned in Section 1, the ARSA rules provide two significant changes from the TRSA: 1) universal participation in the ARSA, which has been shown to produce a signicant reduction in collision risk; and 2) elimination of the required 1.5nm separation between VFR aircraft, which could produce an increase in risk.

The ARSA rules require no specified separation between VFR aircraft, and only enough separation between an IFR and VFR aircraft so that their primary target returns on the radar scope "do not touch" when the aircraft have less than 500 feet vertical separation. The diameter of the target display depends upon range, signal strength, etc., but is typically about 600 feet. This means that the new rules allow 600 feet separation in situations where neither pilot has acknowledged sighting the other aircraft. A separation of 1.5nm allows aircraft converging at 180 knots only 30 seconds to avoid a collision. A separation of 600 feet allows aircraft closing at only 25 knots to collide in the time it takes for three radar scans (14.1 seconds), which is probably the minimum time required for the controller to detect the movement.

The primary intent of the controller in handling participating VFR aircraft is to insure that one or both pilots visually acquire the other aircraft and to let them provide their own separation. In both the ARSA and the TRSA, traffic advisories are provided well in advance of 1.5nm closure, and heading changes or altitude restrictions are employed if visual sighting is not forthcoming. The pilot can also request vectors to provide controller separation of unacquired aircraft. Safety advisories are issued in emergencies in either case.

How much the reduction in separation requirements increases risk is impossible to prejudge because it leaves the actual separation standard employed up to the individual controller. The results already presented assume that the controller will continue to provide equally safe separations in the ARSA as in the TRSA. In this subsection, the worst case will be assumed--that the controller provides traffic advisories only, but no separation service for VFR interactions.

Traffic advisories put the pilots into a "directed search" mode. Studies performed by the Lincoln Laboratory as part of the Traffic Alert and Collision Avoidance System (TCAS) evaluation study (Reference 8) suggest that TCAS advisories make the pilots between six and nine times more likely to locate a threat aircraft and make a successful avoidance maneuver if they had not been alerted. The advisories from an air traffic controller are thought to be slightly less effective.

In keeping with these general guidelines, collision risk for the ARSA was computed using a new set of P_{ATC} factors, as follows:

1) IFR/IFR = 0.01
2) IFR/VFR participant = 0.04
3) both VFR participants = 0.06
4) IFR/non-participant = 0.15
5) VFR/non-participant = 0.20
6) both non-participants = 1.00

This equates to a benefit from air traffic control of improving the likelihood of a participating pilot seeing and avoiding the threat (posed by an intruding VFR aircraft) by a little better than a factor of 4 for VFR participants and 6 for IFR aircraft.* Under these assumptions the risk was computed to be 7.49 collisions per million hours for the TRSA and 2.83 for the ARSA; i.e., even under these pessimistic assumptions, the ARSA is expected to be 2.6 times as safe as the TRSA. This is equivalent to a 62 percent reduction in collision risk. This can be compared to the 75 percent reduction obtained by assuming that the elimination of required separation standards has no impact on risk.

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* The P_{ATC} factor here becomes the probability that neither aircraft receives ATC assistance that makes the difference in the pilots seeing and avoiding the conflict. This is given by:

$$P_{ATC} = 1 - (P_1 + P_2 - P_1 \times P_2)$$

Where P_1 is the probability that effective assistance given to aircraft 1 and P_2 is the same for aircraft 2. For participating VFR aircraft $P = 0.75$, i.e., 1 out of 4 times effective assistance is not given. For IFR aircraft, $P = 0.85$, i.e., 1 out of 6.7 times effective assistance is not given. Again, these values were selected as conservative estimates of ATC benefits.

SECTION IV

FINDINGS AND CONCLUSIONS

Findings

The principle findings of this analysis are the following:

Participation

Before ARSA implementation, about 10 percent of the flights in and out of Austin Mueller and about 8 percent of the flights at Port Columbus (on a typical VFR day) did not participate. Mandatory participation by arrivals and departures at the primary airport, as required by the ARSA, would increase the aircraft handled by the radar controller by 8 percent at Austin and 5 percent at Columbus. There was evidence of a slight decrease in participation by other flights at Austin and Columbus, but this was small compared to the increase at the primary airport.

Controller Workload

The workload imposed per flight was computed by considering: 1) the length of time the flight received radar service; 2) the number of heading changes issued; and 3) the number of traffic advisories issued. On average, the duration of radar service increased at Columbus but was unchanged at Austin. The number of heading changes was unchanged at both locations. The number of traffic advisories decreased at Austin but increased at Columbus. Traffic activity was considerably greater in the After sample than the Before sample at Columbus. This might explain some of the increase in traffic advisories.

While there were only minor differences in workload per flight, the increase in the number of participating flights would definitely produce an increase in workload. There are other workload impacts that were not investigated, such as coordination between controllers within the facility.

Delay

There were no delays to aircraft movement due to controller workload observed in the sample data at either location (neither Before or After). The sample data included traffic activity levels that were above average at Columbus and well above average at Austin. However, there was congestion noticed at the clearance delivery position at Austin during busy periods in the After sample.

Radar Service Availability

Radar service was never denied or delayed during the observed periods. The time required for a VFR airborne aircraft to receive radar service after reporting-in was, if anything, reduced slightly.

Collision Risk

Assuming that the change in separation standards between the ARSA and TRSA has no impact on collision risk, in TRACON airspace the risk should be reduced by 75 percent (one fourth of the Before ARSA value). On the other hand, assuming that the changes in separation standards completely eliminate the effectiveness of controller-initiated avoidance maneuvers and the pilot has only the benefit of traffic advisories (which is obviously pessimistic), the ARSA still provides a 62 percent reduction in risk compared to the TRSA. The reduction in risk is due entirely to universal participation in the ARSA core. There is no evidence of increased compression around or under the ARSA that would produce a greater risk to non-participants not using the primary airport.

The estimated reduction in collision risk due to the ARSA can be considered conservative for the following reasons:

1. The factors used to represent the air traffic controller's contribution in reducing risk are conservative estimates. Since the effect of the ARSA is to increase the proportion of aircraft receiving ATC service, less conservative estimates would reduce the estimated risk both before and after, but would increase the relative difference in risk in favor of the ARSA.

2. In computing the impact of the ARSA on risk reduction, it was assumed that pre-ARSA non-participants would become participating VFR flights only within the ARSA. In practice, they would probably obtain or maintain radar service well beyond the ARSA if they were required to obtain the service anyway. The analysis of service duration times suggests that duration of service actually increased, on average, for those participating after ARSA implementation.

Conclusions

The ARSA was found to produce a significant decrease in collision risk with no significant impact on delay or service availability to the user. There is some increase in controller workload.

These conclusions are based on findings at Columbus and Austin. (The collision risk finding is based on Columbus only.) The same results cannot necessarily be expected if the ARSA is implemented at other locations.

The finding of no impact on delay and service availability is based on two locations where participation was already 90 percent and there was sufficient excess controller workload capacity to accommodate the additional traffic. This might not be the case at all locations.

The collision risk finding included the observation that, at Columbus, the ARSA produced no compression of traffic around, over and under the ARSA, because prior to ARSA implementation, traffic (other than arrivals and departures at the primary airport) avoided penetrating the airspace that was to become the ARSA. This might not be the case at other locations. If a proposed ARSA location has an appreciable amount of non-participating overflights penetrating the proposed ARSA, compression could occur; however, the removal of non-participating overflights from the ARSA would probably have a considerable safety benefit that would more than offset any increase in risk from compression.

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AD-A150 954 AN ANALYSIS OF THE IMPACTS OF THE AIRPORT RADAR SERVICE AREA (ARSA)(U) FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE OF AVIATION POLICY AND PLANS 2/2

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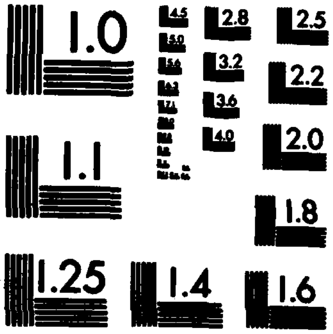

MICROCOPY RESOLUTION TEST CHART
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SUPPLEMENTARY

INFORMATION

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Extensive data were gathered for one week at both test locations by the local facilities before the ARSA was implemented. For the most part, these data are material ordinarily collected and retained temporarily by the facility, such as facility voice communications tapes and flight progress strips. At Columbus, radar data (ARTS Extraction) were also recorded. Similar data were again collected for a one week period several months after ARSA implementation.

Findings

Comparison was made between select portions of the Before and After data. (The selection was made to concentrate on times when high levels of VFR activity were reported.) The principal findings are as follows:

1. A relatively small number of pilots are affected.

At both Columbus and Austin, only about 10 percent of the operations at the primary airport were non-participants* before the ARSA (see Table 1). Thus the impact of the ARSA could not be expected to be very great. The ARSA had no significant impact on participation by users of other airports in the vicinity of Austin and Columbus.

2. The ARSA produces no measurable impact on delay.

A total of seventeen hours of voice tapes (all control positions) were monitored which included some of the busier hours. No airborne aircraft requesting radar service were denied either Before or After at either location. All of these aircraft were allowed to continue on course while radar contact was being established. Thus no delay impact due to the ARSA could be determined. However, periods of congestion at the clearance delivery position were noticed at Austin in the After data.

3. Average controller workload per-flight shows a slight increase. Total controller workload also increases due to increased participation.

The workload impact on terminal radar ATC was measured by computing the length of time that the average participating flight receives radar service, and by counting the number of traffic advisories and heading changes (some of which could be for conflict avoidance). The results (see Table 2) show no significant impact on the average per flight except for increased duration of service at Columbus. However, controller workload would be increased due to an increase in participating flights (about 8 percent at Austin and 5 percent at Columbus).

It should be noted that there are other impacts on workload that were not measured, such as position-to-position controller coordination.

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* In Stage III service at Columbus or Stage II service at Austin.

4. Radar service availability is not affected.

The impact on radar service availability was measured by computing the time between when a VFR pilot requested radar service and the time radar contact was established by the controller. (IFR flights and VFR departures from the primary airport were not considered because the beacon code is pre-assigned and contact is almost instantaneous.) The results (see Table 3) show, if anything, a slight decrease in time required after the ARSA implementation.

5. Collision risk is substantially reduced.

Collision risk for aircraft in the ARSA is decreased because all aircraft are receiving radar service. Aircraft operating immediately outside of the ARSA could be exposed to greater risk if there is a compression of non-participating aircraft around and under the ARSA.

About 6.3 hours of Columbus radar data from the Before sample and 3.2 hours from the After sample were reproduced on analog plots. No evidence of compression or diversion of aircraft around and under the ARSA could be detected. Therefore, it was concluded that the only impact of the ARSA is the benefit of increased radar participation within the ARSA.

In order to estimate the benefit of increased participation with otherwise exactly comparable data, the same tracks and activity levels were used for both Before and After, but all aircraft operating within the ARSA were "given" the benefit of radar protection (assumed to be VFR participants). The common scenario was based on 2.6 hours of heavy activity during east operations in the Before sample.

The results are shown in Table 4. Under this scenario, the ARSA is expected to reduce collision risk by over 75 percent. The reason for such a large impact is that the pre-ARSA non-participants are exposed to a comparatively greater risk. They tend to operate close-in to the airport, in level flight at heavy-use altitudes. Providing radar service to these aircraft has a disproportionate impact on risk reduction.

The above results are based on the assumption that the changes in required aircraft separation between ARSA and TRSA do not effect safety. An alternate set of computations were made with the worst case assumption that ARSA radar service provides only traffic advisories and no effective separation service. Even then, the ARSA is estimated to reduce collision risk by 63 percent.

Conclusion

In conclusion, the ARSA has been shown to produce a significant reduction in risk at little or no inconvenience to the user, but with some increase in controller workload.