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PRELIMINARY LIMITED SURVEILLANCE RADAR (LSR) COST/BENEFIT ANALYSIS

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16. Abstract

This report presents the findings of a cost/benefit analysis of the deployment of a new Limited Surveillance Radar (LSR). An LSR is an inexpensive, single channel, short-range (about 20 miles), primary radar for use at approach control facilities which cannot economically justify an Airport Surveillance Radar/Radar Beacon System (ASR/RBS). An LSR can also be used in tower cabs to aid in VFR operation where a BRITE display is not feasible due to coverage limitations dictated by obstructions or distance from the parent radar facility.

The study is preliminary in that it is brief and uses rough estimates and assumptions for both benefits and costs. Its purpose is to give a gross estimate of the current deployment potential of the LSR and to aid in decisions regarding further system analysis, development, and testing.

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PREFACE

This work was performed at the Transportation Systems Center under the sponsorship of the Federal Aviation Administration, Office of Aviation System Plans. The work consists of a cost/benefit analysis of the deployment of a new Limited Surveillance Radar (LSR) for terminal area surveillance.

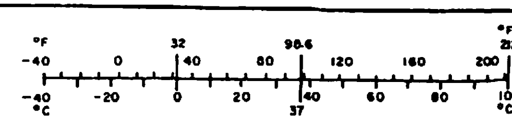
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report presents the findings of a brief cost/benefit analysis performed for a Limited Surveillance Radar (LSR) concept. An LSR is an inexpensive, single channel, short-range (about 20 miles), primary radar for use at approach facilities which cannot economically justify an Airport Surveillance Radar/Radar Beacon System (ASR/RBS). It can also be used in tower cabs to aid in VFR operation where a BRITE display (fed directly from a collocated ASR/RBS or remotely from a parent radar approach control facility) is not feasible. The LSR's annual cost is estimated at about 1/3 that of an ASR/RBS (when used for radar approach control) and about 2-1/2 times that of a BRITE/TML (when used only to aid VFR operation). The purpose of this analysis is to give a gross estimate of the current deployment potential of an LSR to aid in decisions regarding further analysis, development and testing. This study is not considered adequate to support an establishment criterion or a production procurement decision.

The analysis considers an LSR deployment for the year for which the most recent traffic activity data exists, calendar year (CY) 1975. The results indicate that as an upper bound, approximately 15 to 17 LSRs might be deployed. The deployment breakdown is:

a. Of the 146 tower cabs which do not have a BRITE display (because they fail to meet current establishment criteria), approximately 11 to 13 could justify an LSR and its associated bright display on economic grounds (i.e., the benefit/cost ratio is greater than one).

b. Of the 11 to 13 tower cabs which could economically justify an LSR, approximately four to six could economically justify instituting radar approach control with the LSR. These sites currently operate approach control without radar. The LSR at the remaining seven cabs would be used primarily to aid in VFR traffic advisories.

c. Of 79 of the 93 TML sites in operation, perhaps four have sufficient traffic and deficient enough low altitude coverage to justify economically an LSR to aid in VFR traffic advisories. The major assumptions leading to these results are (1) that an LSR would provide benefits equivalent to an ASR/RBS when used for approach control at small facilities at which it might be deployed, and (2) that an LSR driven BRITE display would provide benefits equivalent to a BRITE display driven remotely from an ASR/RBS when used for VFR separation advisories by the local controller.

A sensitivity analysis was made to examine the effect of increased F&E costs. With a 20 percent cost increase, six of the eleven baseline sites using the LSR only for VFR operations failed to qualify. This suggests a minimum deployment of nine to eleven LSRs, approximately half of which would be for radar approach control.

To estimate overall system benefits, an LSR program was hypothesized which would (1) develop the LSR in fiscal year (FY) 1978 and 1979, (2) deploy fifteen LSRs in FY 1980, and (3) operate the units for the next fifteen years. As traffic grew, LSR-equipped airports which qualified for ASR/RBS would be so equipped and the LSR moved to a newly qualified LSR airport. The unit would be easily and cheaply transported. This program would have a present value (base year 1977) cost of $9,444,000 and a present value benefit of $14,619,000 resulting in a benefit/cost ratio of 1.55. If the program start were postponed the benefit/cost ratio would be unchanged but the present value benefit and cost would be divided by 1.1^N, where N is the number of years the program is postponed.

1. INTRODUCTION

1.1 CURRENT SYSTEM DESCRIPTION

The primary purpose of VFR control towers is to prevent a collision between aircraft operating in the immediate area of the airport, and to expedite the flow of traffic. Aircraft are normally radio controlled within ten miles of the airport and visually separated within the airport traffic area. The tower establishes the sequence and clears aircraft to land and take off to provide safe runway utilization. Airborne separation exclusive of runway use (e.g., after takeoff or on the downwind approach leg) is the responsibility of the pilots although the tower does provide a landing sequence and advise users of threatening traffic and potential collisions if they are observed.

During IFR conditions, VFR towers can clear aircraft for take-off and landing using prescribed procedures. However, VFR towers do not provide approach control service. Approach control service is provided by a nearby parent facility such as a TRACON, TRACAB or ARTCC. The VFR tower will intermix VFR traffic operating below ceiling with IFR arrivals, and will report visual acquisition of IFR arrivals to the controlling facility.

The capacity of the ATC system at an airport without its own radar is affected by the radar coverage of its parent approach control facility. If the controlling facility has good low-altitude radar coverage (e.e., no terrain blockage), the capacity can approach that which would occur if the airport did, in fact, have its own radar approach control. However, if the approach control radar is far away or has low-altitude coverage limitations, successive arrivals must be adjusted to compensate for the separation needed to cover the time interval between loss of radar coverage and visual acquisition. This results in a reduction of capacity. Although radar separation in peak conditions can result in 30-40 arrivals per hour on a runway, approach control service provided from a facility without low altitude radar coverage can reduce capacity to 4-5 arrivals per hour.

When instrument operations into an airport with a VFR tower become substantial, and its capacity (due to radar coverage) is low, non-radar approach control authority may be delegated to the tower (or primary tower) for the airport(s) within the area of jurisdiction. In this case the tower will accept transfer of control and handoff from the ARTCC, and will control the arrivals using pilot position reports derived from radio navigational aids. Aircraft can be held and stacked by the tower and routed from the stack to the final approach fix for timed approaches. Capacity will depend on the locations and number of the radio navigation aids (i.e., the stack and approach route) and weather. The FAA has estimated arrival rates of from 6 to 16 arrivals per hour (varying with pilot and controller proficiency levels) for non-radar approach control.[1]

When non-radar approach control cannot satisfy the demand for instrument operations, efficiency is increased by installing an Airport Surveillance Radar/Radar Beacon System (ASR/RBS) and implementing radar approach control. Approach control is either conducted from the cab (TRACAB) with Bright Radar Indicator Equipment (BRITE) displays, or from a separate approach control facility (TRACON). When the TRACON is used, BRITE displays are employed in the cab to aid the local controller in providing VFR service and in coordinating with the TRACON. Safety increases thanks to IFR separation assurance and VFR separation advisories, and IFR delay is reduced thanks to increased capacity associated with radar separation standards. The resulting capacity can be quite high (e.g., 30 arrivals/hour per independent runway) and is generally adequate except at the highest volume airports.

Once radar approach control is established and BRITE displays are furnished to the cab with a direct line from the ASR/RBS, BRITE displays can normally be furnished to other nearby tower cabs (within 20 miles of the ASR/RBS). The equipment used for doing this is the Television Microwave Link (TML), which consists of BRITE equipment and a microwave communication link for transmitting the TV picture to the nearby (staellite) airport. Digital remoting is also currently under test. Safety is increased thanks to VFR separation advisories and improved coordination with the TRACON.

1.2 CURRENT SYSTEM COSTS

The ASR/RBS is a fairly expensive system to install and operate. The estimated costs (based on 1975 report) are summarized in Table 1-1.[1]

TABLE 1-1. ASR/RBS ANNUAL COSTS

Basic establishment costs - $2 million* amortized over 15 years at 10%	$263,000
Operation and Maintenance Costs	141,000
Staffing costs (5 additional controllers for radar approach control)	96,000
	$500,000

*These costs will increase. FY79 F&E costs are estimated at $2.7 million.

These costs assume an installation in a TRACAB mode with service provided from the cab. If space limitations in the cab preclude the installation of the required consoles, radar approach control receives its own separate facility (TRACON), in which case some building expansion may be required. No such costs are included in the above estimate.

The TML is a fairly inexpensive system to install and operate. The costs are estimated in Appendix A and summarized in Table 1-2.

TABLE 1-2. TML ANNUAL COSTS

Basic establishment costs - $163,400 amortized over 15 years at 10%	$21,500
Operation and Maintenance costs	6,800
	$28,300

1.3 PROBLEM

In 1975 there were 233 approach control facilities.[2] Given the location of ASR/RBS systems, it is estimated that of these facilities, 174 are radar approach control and 59 are non-radar approach control unable to qualify for an ASR/RBS. The non-radar approach control sites would not derive benefits which exceed the cost of an ASR/RBS. Appendix B estimates that the 59 non-radar approach control facilities accumulate approximately $8 million per year in delay and accident costs which radar coverage could eliminate. However, the high cost of the ASR/RBS ($29.5 million per year to equip all 59 facilities for radar approach control) makes the realization of these potential savings impractical.

In 1975, there were 146 airport cabs without a BRITE installed or programmed. Based upon the assumptions in this study, these cabs accumulate approximately $9.5 million per year in accident related costs, which could be eliminated by the installation of BRITE displays (see Appendix B). To equip these cabs with BRITE driven via TML would be comparatively inexpensive. This would cost $4 million annually, resulting in an annual net benefit of $5.5 million. However, deployment at these locations has not been practical, due primarily to the remoting range or line of site limitations of the TML.

1.4 LIMITED SURVEILLANCE RADAR (LSR)

The LSR is an inexpensive, all digital, primary radar for use at approach control facilities which do not qualify for an ASR/RBS and at cabs which cannot receive a BRITE display via TML because of inadequate radar coverage or excessive remoting range. Costs can be reduced further (beyond dropping secondary radar) because the radar has only a single channel and reduced range (20 nmi versus 60 nmi for an ASR/RBS), and because of the anticipated simplicity of installation. The current best estimate of basic costs for the LSR are estimated in Appendix A and summarized in Table 1-3.

Relative to the problems cited in Section 1.3, the cost of the LSR seems reasonable. The cost of full deployment to non-radar approach control facilities with radar approach control staff would be $9.5 million, about 20 percent higher than the potential benefits of $8 million. Some cost effective installations could be anticipated. Similarly, the cost of full deployment to

TABLE 1-3. LSR ANNUAL COSTS

Basic establishment costs - $362,000 amortized over 15 years at 10%		$47,500
Operating and Maintenance Costs		18,300
	Sub-total	$65,800
Staffing costs if the LSR is used for radar approach control		96,000
	Total	$161,800

unequipped cabs for VFR use (without radar approach control staff) would be $9.5 million, which is approximately equal to the potential benefits. The question remaining is "Which and how many of the individual cabs and control facilities could support an LSR?"

1.5 STUDY SCOPE AND PURPOSE

This study represents a brief analysis aimed at estimating the current deployment potential for an LSR. The year examined is CY 1975 since traffic data for CY 1976 was not available at the time the report was being developed. The analysis did not make extensive use of present value discounting techniques but did amortize initial costs over 15 years at 10 percent. Present value discounting was used at the end of the study to provide a gross estimate of present value net benefits for a hypothetical LSR development/deployment program. Assumptions made in the analysis are rather gross and tend to favor deployment (e.g., it is assumed that the LSR, a primary only system, will be equivalent to the ASR/RBS in providing separation assurance/advisories). The deployment may therefore be considered an upper bound. The purpose of the study is to develop a preliminary deployment estimate for an LSR so that management can decide if further activity is warranted. The study is not considered adequate to support an establishment criteria or a production procurement decision.

2. ASSUMPTIONS AND APPROACH

This section sets forth the assumptions and approach used in the analysis. A summary of key assumptions and estimates is presented below. The assumptions are discussed in Section 2.1.

a. An LSR and an ASR/RBS would provide equivalent benefits for approach control at the small approach control facilities at which it would be deployed.

b. A BRITE display, driven by either an LSR or a TML from a nearby ASR/RBS, would provide equivalent benefits to the local controller in the cab for providing VFR separation advisories and sequencing.

c. An LSR would only be installed at an airport for approach control if the airport was not already provided radar service (by an ASR/RBS or ARSR).

d. An LSR would only be installed at an airport for cab use by local control if the airport could not be provided with a BRITE via TML from a nearby ASR/RBS.

e. It is estimated that 95 percent of midair collisions occuring at non-radar approach control facilities could be prevented by providing the facility with a BRITE display for local controller use since they involve at least one VFR aircraft in contact with local control and, therefore, would be preventable simply by providing local control with a BRITE display. This is to say that few midair collisions occur between IFR aircraft under non-radar approach control (e.g., only one such accident occurred between January 1964 and December 1971).

2.1 DISCUSSION OF ASSUMPTIONS

All ASR radars now equipped with an RBS have some form of beacon processing (i.e., beacon decoder or ARTS-3). Thus, as a minimum, target enhancement (and in many cases identity) is available for approach control and on BRITE displays for beacon equipped targets. Because of this and the fact that the LSR has no broad band capability, assumptions (a) and (b) may be overly optimistic. If further work is done on the LSR, the differences between its operational parameters and those of an ASR/RBS should be examined more closely.

Assumptions (c) and (d) may result in a deployment estimate on the low side. LSRs may be applicable at existing and planned ASR/RBS sites. However, these sites were not considered in this analysis. In addition, existing and planned sites for BRITE TML equipment may suffer from low altitude surveillance limitations which an LSR would rectify. These sites are not considered in the basic analysis (although treated in a sensitivity analysis is Section 3.4).

Item (e) is an estimate which was made in the following manner:

1. Each midair collision occurring between January 1964 and December 1971 involving ATC services was examined using the accident summaries provided in Reference 3. This represented a total of 50 midair collisions. A breakdown of these collisions is given in Figure 2-1.

2. Those accidents were identified which might have been prevented by the deployment of a new radar/BRITE system. This set excluded accidents involving existing radar approach control, ARTCC control, and tower cab control where the tower and existing ASR were collocated permitting direct BRITE deployment to the cab. Twenty-three accidents were excluded, leaving 27 for further consideration.

3. Of the 27 accidents identified, an estimate was made of which could conceivably have been prevented by the installation of a radar and cab bright display at the airport/terminal facility involved. Examples of accidents conceivably preventable are accidents between VFR aircraft in radio contact with the cab but outside the visual range of the controllers which went undetected or were detected too late for corrective advisories to be given, and accidents between IFR aircraft under non-radar approach control in which instructions were not followed by an aircraft but went

undetected, resulting in a collision. It was estimated that 22 of the 27 accidents were conceivable preventable through estended radar display deployment.

4. Of the conceivably preventable accidents, only one involved non-radar approach control (over the 8-year period examined) whereas 21 involved a cab-controlled VFR aircraft. Thus, it was estimated that 95% of the preventable accidents associated with installing a radar and a BRITE display at the unequipped airports will be realized by use of the BRITE at the local controller position, without instituting radar approach control. Radar approach control will provide safer IFR operation, but few accidents occur under non-radar approach control due to the conservative practices employed. The chief benefit of radar approach control is to increase capacity (reduce delay) while maintaining a safe operation.

It should be noted that while there were no radar displays covering the 22 accidents at the time of the accident, that is no longer the case. Since then, ASR/RBS and TML systems have been deployed. The one accident under non-radar approach control occurred at Asheville NC, which now has an ASR/RBS. The 21 VFR-related accidents occurred at 18 different airports, of which 14 now have a cab BRITE via TML. However, the 95% estimate will be used later in this analysis applied to current non-radar approach control facilities and unequipped tower cabs.

2.2 ANALYSIS APPROACH

The analysis approach taken in this study is shown in Figure 2-2. The analysis begins with the examination of a sample of approximately 100 airport towers consisting primarily of the towers similarly considered in the ASR/RBS Establishment Criteria report.(1) Data used in this preliminary examination are for CY 1973, to be consistent with Reference 1 and to permit using computations already made in that analysis. In addition, the benefits models developed and used in Reference 1 are used in this preliminary analysis. Those models include methods for estimating the costs associated with midair collisions which would be prevented with the installation of an ASR/RBS/BRITE system (i.e., safety benefits) and the costs

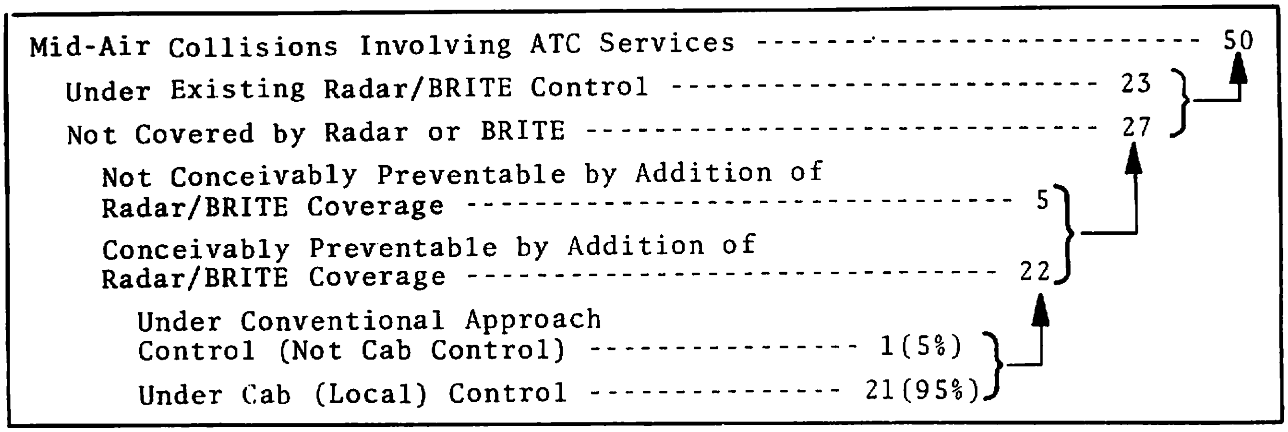

FIGURE 2-1. CLASSES OF MID-AIR COLLISIONS, JANUARY 1964 TO DECEMBER 1971

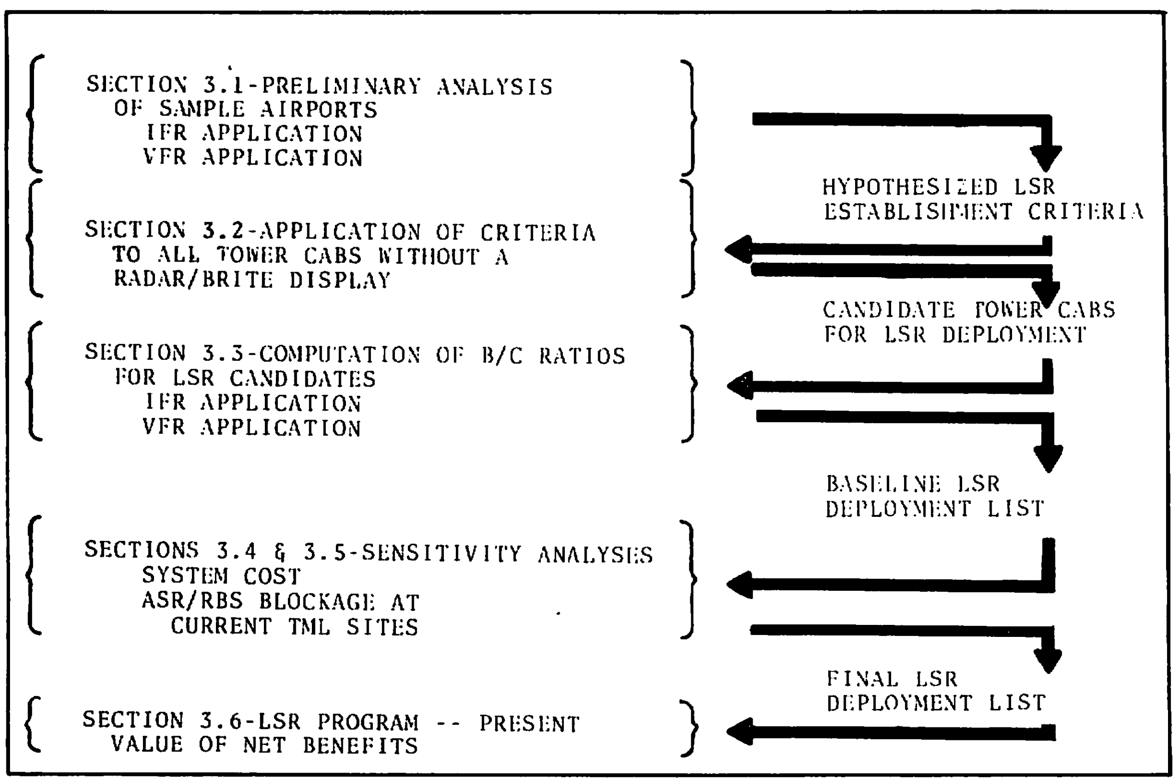

FIGURE 2-2. ANALYSIS APPROACH AND PRODUCTS

associated with IFR operations delay which would be prevented (i.e., delay benefits).

The preliminary analysis considers the deployment of an LSR at unequipped airports in two ways. The first is for radar approach control with a BRITE display (IFR application) and radar approach control staff resulting in an annual system cost of $161,800 (see Table 1-3). The second is to be used as a BRITE display without radar approach control for VFR operations only (VFR application) resulting in an annual system cost of $65,800 (See Table 1-3). Benefit/cost (B/C) ratios are computed for each application at each unequipped airport tower in the sample. Benefits for the LSR in an IFR application are assumed equivalent to those from an ASR/RBS (Assumption (a)) and are simply taken from Reference 1. The benefits for the LSR in a VFR application are computed by using 95 percent of the safety benefits for an ASR/RBS/BRITE (Assumption/estimate (e)) following the model in Reference 1. Based upon the B/C ratios, establishment criteria are hypothesized for the LSR in each application. In addition, since it was a simple addition to the analysis, B/C ratios are computed for the BRITE/TML with the assumption that its benefits are equivalent to those of an LSR in VFR application (Assumption (b)). This permitted examination of the current BRITE/TML extablishment criteria.

The second step in the analysis applies the hypothesized LSR establishment criteria to all towered airports using the most recent air traffic activity data (from CY 1975). But before applying the criteria, towers are eliminated from consideration which have an ASR/RBS on site permitting a BRITE cab display and radar approach control (Assumption (c)) or a cab with a BRITE display via TML (Assumption (d)). The 400 fulltime towers are taken from Reference 2. The existing/programmed ASR/RBS and TML sites were obtained from the ATC Systems Program Division, Terminal Branch, and are listed in Tables 2-1 and 2-2, respectively. The results of the screening establish a strong set of candidates for an LSR.

In the third step of the analysis the B/C ratios are computed for the LSR (in both applications) for the candidates identified by the hypothesized establishment criteria. CY 1975 air traffic activity data are used. The B/C ratios are then employed in a final screening of the candidate airports using the following rules:

a. If the candidate airport is already provided with radar approach control from a parent TRACON or nearby ARTCC, the LSR can only be deployed at that airport for VFR application.

b. If the candidate airport is within range of a TML (i.e., within 20 miles), an LSR is not required.

c. If the B/C ratio is less than one for either application, the candidate airport would not qualify for an LSR for that application.

d. If the B/C for an ASR/RBS is greater than one, the candidate airport would recieve an ASR/BRS and not an LSR.

Based upon the final screening a list of potential LSR sites was drawn up. The analysis concludes with a sensitivity analysis and overall deployment benefits estimate.

TABLE 2-1. ASR/RBS SITES

FACILITY LOCATION/NAME	FACILITY LOCATION/NAME
Abilene TX (Dyess RAPCON)	Daytona Beach FL
Akron-Canton OH	Denver CO
Albany NY	Des Moines IA
Albuquerque NM	Detroit MI
Allentown PA	Dulles-Washington DC
Amarillo TX	Duluth MN
Anchorage AK (Elemendorf RAPCON)	Edwards RAPCON-Palmdale CA
Andrews RAPCON-Washington DC	Elmira NY
Asheville NC	El Paso TX
Atlanta GA	Erie PA
Atlantic City NJ	Evansville IN
Augusta GA	Fairbanks AK
Austin TX	Falmouth MA (Otis RAPCON)
Bakersfield CA	Fargo ND
Balboa CZ	Fayetteville, NC
Baltimore MD	Flint MI
Bangor ME	Fort Lauderdale FL
Baton Rouge LA	Fort Smith AR
Beale AFB-Marysville CA	Fort Wayne IN
Beaumont TX	Fresno CA
Billings MT	Grand Rapids MI
Binghampton NY	Great Falls MT (Malstrom RAPCON)
Birmingham AL	Green Bay WI
Boise ID	Greensboro NC
Boston MA	Greer SC (Greenville)
Bristol TN	Guam
Buffalo NY	Gulfport MS
Burbank CA	Harrisburgh PA
Burlington VT	Hilo HI
Casper WY	Honolulu HI
Cedar Rapids MI	Houston TX
Champaign IL	Huntington WV
Charleston SC	Huntsville AL
Charleston WV	Indianapolis IN
Charlotte NC	Islip NY
Chattanooga TN	Jackson MS
Chicago IL (O'Hare)	Jacksonville FL
Chicago IL (South)	Kahului HI
Cleveland OH	Kalamazoo MI
Colorado Springs CO	Kansas City MO
Columbia SC	Knoxville TN
Columbus GA	Lafayette LA
Columbus OH	Lake Charles LA
Corpus Christi TX	Lansing MI
Covington KY (Cincinnati)	Las Vegas NV
Dallas TX (Addison)	Lexington KY
Dallas TX (Colleyville)	Lincoln NE
Dayton OH (Wright-Pat. RAPCON)	Little Rock AR
	Long Beach CA

TABLE 2-1. ASR/RBS SITES (CONT.)

FACILITY LOCATION/NAME	FACILITY LOCATION/NAME
Longview TX	Saginaw MI
Los Angeles CA (#1)	Salt Lake City UT
Los Angeles CA (#2)	Santa Ana CA (El Toro RAPCON)
Louisville KY	San Antonio TX
Lubbock TX	San Diego CA
Macon GA (Robins RAPCON)	San Juan PR
Madison WI	Santa Barbara CA
Memphis TN	Sarasota FL
Meridian MS	Savannah GA
Miami FL	Seattle WA
Midland TX	Shreveport LA
Milwaukee WI	Sioux City IA
Minneapolis MN	Sioux Falls SD
Mobile AL	South Bend IN
Moffet NAS-San Jose CA	Spokane WA
Moline IL	Springfield IL
Monroe LA	Springfield MO
Monterey CA	St. Louis MO
Montgomery AL	St. Thomas VI
Muskegon MI	Syracuse NY
Nashville TN	Tacoma WA (McChord RAPCON)
Newark NJ	Tallahassee FL
New Orleans LA	Tampa FL
New York (JFK) NY	Toledo OH
Norfolk VA	Tuscon AZ
Oakland CA	Tulsa OK
Oklahoma City OK (Tinker AFB)	Washington DC (National)
Omaha NE	Waterloo IA
Ontario CA (March RAPCON)	West Palm Beach FL
Orlando FL	White Plains NY
Palm Springs CA	Wichita KS
Pensacola FL	Wilkes Barre PA
Peoria IL	Wilmington NC
Philadelphia PA	Windsor Locks CT
Phoenix AZ	Youngstown OH
Pittsburgh PA	
Portland ME	
Portland OR	
Providence RI (Quonset RATCC)	
Pueblo CO	
Raleigh NC	
Reno NV	
Richmond VA	
Roanoke VA	
Rochester, MN	
Rochester NY	
Rockford IL	
Rome NY (Griffis RAPCON)	
Sacramento CA (MeClellan RAPCON)	

TABLE 2-2. TML BRITE SITES (EXISTING AND PROGRAMMED)

AIRPORT LOCATION/NAME	AIRPORT LOCATION/NAME
Austin TX (Mueller)	New Orleans (Lakefront) LA
Abilene TX	Newport News VA
Alton IL	Niagra Falls NY
Anchorage AK (Merrill)	North Philadelphia PA
Arapahoe CO (Denver)	Norwood MA
Beford MA (Hanscolm)	Ogden UT
Beverly MA	Orlando FL (McCoy Jet Port)
Broomfield CO (Jefferson Co.)	Oklahoma City (FAA Academy) OK
Chesterfield MO (Spirit of St. Louis)	Oklahoma City (Wiley Post) OK
Chicago Dupage IL	Oklahoma City (Will Rogers) OK
Chicago Meigs IL	Omaha (Eppley) NE
Cincinnati (Lankin) OH	Opa Locks FL
Cleveland OH (Burke Lakefront)	Oxnard CA
Cleveland OH (Cuyahoga Co.)	Palo Alto CA
Columbus OH (Ohio St.)	Panama City FL
Chino CA	Phoenix AZ (Litchfield)
Carlsbad CA	Pittsburgh PA (Allegheny)
Central Islip NY	Providence RI
Chicago (Dalwaukee) IL	Pompano Beach FL
Dallas (Addison) TX	Riverside CA
Dallas (Redbird) TX	Sacramento (Exec.) CA
Dekalb Peachtree GA	Sacramento (Metro.) CA
Detroit City MI	San Carlos (Oakland) CA
Dothan AL	San Diego (Lindbergh) CA
Detroit MI (Willow Run)	San Diego (Montgomery) CA
Farmingdale NY	San Francisco CA
Ft. Lauderdale (Exec.) FL	San Jose CA
Ft. Worth (Meacham) TX	San Juan PR
Fullerton CA	Santa Ana (Orange Co.) CA
Fulton Co. GA	Santa Monica CA
Fresno (Chandler) CA	Seattle (Boeing) WA
Great Falls MT	Shreveport (Downtown) LA
Greenville SC	Shreveport (Regional) LA
Hartford CT (Brainard)	Spokane WA
Hawthorne CA	San Antonio TX
Hollywood (North Perry) FA	San Jose CA (Reid Hillview)
Hyannis MA (Post)	Spartanburg NC
Jackson (Hawkins) MS	Tamiami FL
Kansas City KS (Fairfax)	Teterboro NJ
Kodiak AK	Torrance CA
Knoxville (Downtown) TN	Troutdale OR (Portland)
La Verne (Brackett) CA	Tuscon AZ
Louisville KY (Bowman)	Tulsa OK (Riverside)
Melbourne FL	Utica NY
Middletown PA	Van Nuys CA
Minneapolis MN (Flying Cloud)	Westfield MA
Montgomery AL (Dannelly Field)	Wilmington DE
Macon GA (Lewis B. Wilson)	Winston Salem NC
New Bedford MA	

3. BENEFITS ANALYSIS

3.1 PRELIMINARY ANALYSIS OF SAMPLE AIRPORTS

3.1.1 LSR for VFR Application and TML

The LSR for VFR application and the TML deployment were considered first in the analysis. The 100 airport sample in Reference 1 was considered and those airports which qualified for an ASR/RBS which did not warrant decommissioning were omitted from further consideration. This represented 55 airports, leaving 45 airports for potential LSR/TML deployment. To these 45 airports, the 15 airports listed in Table 3-1 were added. These airports were selected randomly, to include ones which have either low itinerant operations or high itinerant and low air carrier operations. These classes of airport were not adequately represented in the Reference 1 sample. For the 60 airport sample the B/C ratios for an LSR (VFR application) and TML were computed using 95 percent of the safety benefits obtained from the Reference 1 model and the costs presented in Section 1. The results are given in Table 3-2. The airports marked with an (*) in the TML column have or are programmed for a TML.

In order to derive simple establishment criteria, the data shown in Table 3-2 were plotted in terms of annual itinerant operations and annual air carrier operations in Figure 3-1. In that plot, each data point represents one of the 60 airports in the sample. The distribution of the data points suggests the establishment criteria depicted by the two two-segment curves. Airports with traffic characteristics below the lower curve would receive no surveillance aids. Those with characteristics between the curves would receive a BRITE via TML if within range. And, those airports with characteristics above the upper curve would receive a BRITE via TML if within range but, if a BRITE were not possible, would receive an LSR. The filled-in symbols show the airports for which the B/C computation does not agree with the criteria. In most cases, the B/C correlated quite well with the criteria.

TABLE 3-1. AIRPORTS ADDED TO SAMPLE

AIRPORT IDENTIFIER	AIRPORT LOCATION/NAME	ANNUAL OPERATIONS FOR CY 1973 ITINERANT	INSTRUMENT	BUSY HOUR INSTRUMENT OPERATIONS	% IFR WEATHER 0700-2100
HGL	Wheeling WV	29585	5807	8	-(*)
ROW	Roswell NM	28852	9976	11	10.6
PDT	Pendleton OR	27726	3994	12	6.5
HOB	Hobbs Lea NM	20424	1312	6	5.0
DET	Detroit City MI	27183	43429	21	16.2
SLN	Salina KS	35387	12915	18	7.7
EWB	New Bedford MA	53426	6390	19	-
PMD	Palmdale CA	30849	17015	22	-
HUF	Terra Haute IN	42386	16164	22	12.2
JVL	Janesville WI	43637	6296	14	-
MOD	Modesto CA	64690	3478	10	-
GNV	Gainsville FL	55286	8896	12	-
PIE	St. Petersburg FL	81379	13031	16	-
IAG	Niagara Falls NY	70010	14148	19	15.9
OXR	Oxnard CA	79816	14046	23	-

*Missing weather data not available.(4)

TABLE 3-2. SUMMARY OF SAMPLE RESULTS

AIRPORT IDENTIFIER	AIRPORT LOCATION/NAME	ANNUAL ITINERANT OPERATIONS	EXPECTED SAFETY COST SAVINGS (thousands$)	VFR ONLY APPLICATION LSR B/C RATIO	TML B/C RATIO	IFR APPLICATION LSR B/C RATIO
FSM	Ft. Smith AR	53559	79	1.2	2.8	2.8
PSP	Palmsprings CA	72934	138	2.1	4.9	.9
TXK	Texarkana AR	41910	47	.7	1.6	.9
GJT	Grand Junction CO	39746	66	1.0	2.3	.6
TWD	New Haven CT	80868	78	1.2	2.8	1.6
ILG	Wilmington DE	96488	175	2.7	6.3*	1.2
FMY	Fort Meyers FL	55386	22	.3	.8	1.9
MLB	Melbourne FL	80364	77	1.2	2.8*	.6
MDT	Middleton PA	50801	77	1.2	2.8*	.9
YKM	Yakima WA	62172	54	.8	1.9	1.6
HOT	Hot Springs AR	53554	51	.8	1.9	.6
DAB	Daytona Beach FL	138892	318	4.9	11.4	2.8
PFN	Panama City FL	51665	47	.7	1.6*	.6
ABY	Albany GA	61609	42	.6	1.4	.6
CID	Cedar Rapids IA	53485	72	1.1	2.6	.9
SUX	Sioux City IA	56702	60	.9	2.1	.9
ALO	Waterloo IA	45173	58	.9	2.1	1.2
MLU	Monroe LA	98556	48	.7	1.7	1.6
ORH	Worcester MA	51849	32	.5	1.2	.3
AZO	Kalamazoo MI	79085	107	1.7	3.8	1.2
BIL	Billings MT	68985	176	2.7	6.3	1.9
MSO	Missoula MT	46432	37	.6	1.4	.3
ELM	Elmira NY	50775	55	.9	2.1	.6
UCA	Utica NY	41586	54	.8	1.8*	.6
BIS	Bismark ND	39058	75	1.1	2.6	.9
RAP	Rapid City SD	39068	59	.9	2.1	.6
HTS	Huntington WV	45425	69	1.1	2.6	.9
CPR	Casper WY	38555	72	1.1	2.6	2.8
CYS	Cheyenne WY	44850	48	.7	1.6	.6
DHN	Dothan AL	76152	135	2.1	4.9*	.9
BFL	Bakersfield CA	111287	199	3.1	7.1	2.2
PIH	Pocatello ID	32175	64	.9	2.1	.6
TOP	Topeka KS	83868	115	1.8	4.2	.9
ABE	Allentown PA	84041	149	2.3	5.3	1.9
MKG	Muskegon MI	40936	41	.6	1.4	.6
PHF	Newport News VA	61407	67	1.0	2.3*	.6
KOA	Kona HI	30253	149	2.3	5.3	1.2
IDA	Idaho Falls ID	29042	58	.9	2.1	.6
SCK	Stockton CA	71765	69	1.1	2.5	1.2
MFD	Mansfield OH	45607	41	.6	1.4	.6
LHY	Lynchburg VA	43278	65	1.0	2.1	.6
FAR	Fargo ND	55367	46	.7	1.6	1.2
AVL	Asheville NC	53563	78	1.2	2.8	.9
EUG	Eugene OR	72349	75	1.1	2.6	.9
GSP	Greer SC	43903	101	1.6	3.7	.9
HGL	Wheeling WV	29585	24	.4	.9	-
ROW	Roswell NM	28852	52	.8	1.9	.4
PDT	Pendlton OR	27358	24	.4	.9	.2
HOB	Hobbs Lea NM	20424	40	.6	1.4	.3
DET	Detriot City MI	27183	159	2.4	5.7*	2.3
SLN	Salina KS	35387	41	.6	1.5	.5
EWB	New Bedford MA	53426	35	.5	1.3*	-
PMB	Palmdale CA	30849	44	.7	1.6	-
HUF	Terra Haute IN	42386	23	.3	.8	2.0
JVL	Janesville WI	43637	19	.3	.7	-
MOD	Modesto City	64690	25	.4	.9	-
GNV	Gainsville FL	55286	25	.4	.9	-
PIE	St. Petersburg FL	81379	43	.7	1.5	-
IAG	Niagra FAlls NY	70010	45	.7	1.6*	.7
OXR	Oxnard CA	79816	60	.9	2.1*	-

*Airport has or is programmed for a TML.

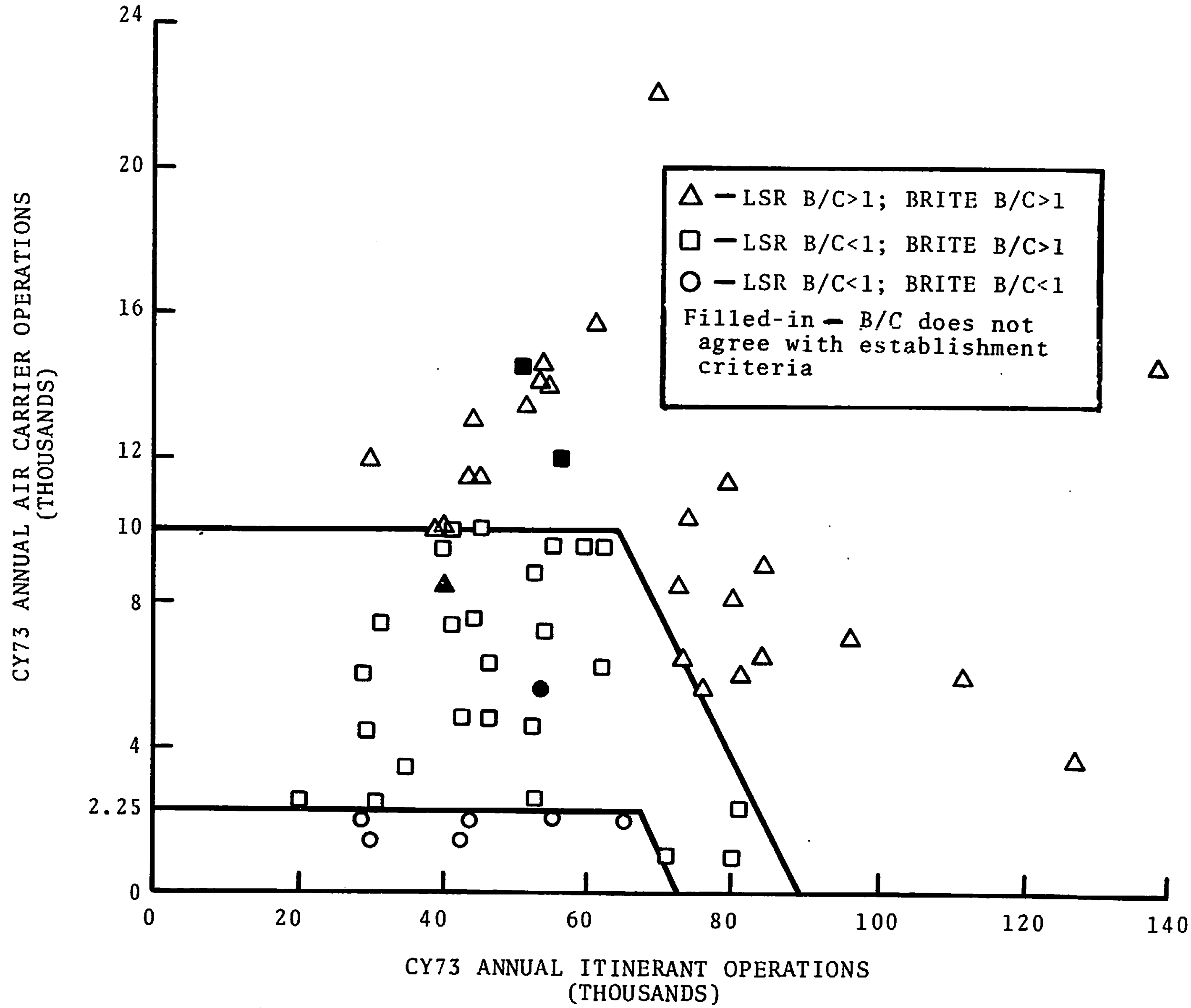

FIGURE 3-1. SAMPLE RESULTS FOR VFR APPLICATION

To rationalize the dependence of the establishment criteria on the two traffic parameters, it is necessary to examine the safety model used. In that model the expected number of preventable midair collisions is a fairly linear function of annual itinerant operations. The more operations there are, the more likely it is that there will be accidents some of which will be preventable. Therefore, annual itinerant operations is one important parameter. Also as part of the model, the average cost per collision is estimated based upon the mix of aircraft (i.e., air carrier, air taxi, general aviation and military) at each airport. Due to the expense of the aircraft and the large number of passengers, the cost of an accident involving an air carrier is much larger than, say, an accident involving a general aviation aircraft (e.g., $4 million versus $200 thousand). Therefore, as the number of preventable accidents decreases (i.e., annual itinerant operations are lower), a certain level of air carrier traffic is required to offset the effect of the reduced accident rate with higher costs per accident. Therefore, air carrier operations is another important parameter.

This preliminary analysis is the only treatment of the B/C for TML in this study. Actual TML deployment is used in the next step of the analysis. However, it seems appropriate to note here that current TML establishment criteria involve only annual itinerant operations, with a required level of 35000 annual itinerant operations.[5] Although this criterion may result in deployment to some general aviation airports for which the benefits are marginal, the overall program benefits should still be quite high. Of some concern is the fact that some airports having a relatively high level of air carrier activity, which should be equipped, may be excluded by this criterion (see Figure 3-1).

3.1.2 LSR For IFR Application

This study considered LSR for IFR application with approach control. As with the VFR application, the ASR/RBS sites were subtracted from the 100 airport sample of Reference 1, leaving 45 airports. To these 45 were added seven of the 15 airports added to the sample for VFR application. Only seven could be added since weather data required in the IFR benefits computation was not available for eight of the airports. The resulting IFR sample contains 52 airports. The B/C ratio for the LSR (IFR application) was then computed using the results and/or models from Reference 1 and the cost estimate from Section 1. The results are given in Table 3-2.

In order to determine simple establishment criteria, the results in Table 3-2 were plotted on a chart of annual instrument operations versus annual air carrier operations as shown in Figure 3-2. In the plot, each data point represents one of the 53 airports in the sample. The distribution of the data points suggests that an establishment criterion based upon only two parameters is not very accurate in the IFR application. Other factors in the model are also important. However, since airports meeting the criteria were to be reexamined using B/C ratio computation, a criterion was chosen that tended to favor selection. The criterion was simply that the airport should handle more than 15,000 annual instrument operations a year.

3.2 APPLICATION OF ESTABLISHMENT CRITERIA

The establishment criteria defined above were applied to all towered airports in CY 1975. Airport towers at which there was an ASR/RBS or a BRITE via TML were first removed from the sample. Table 3-3 lists all towered airports in CY 1975 in rank order of itinerant operations. For each airport, it is noted whether the airport is an ASR/RBS site (A), has a BRITE cab display from an on-site ASR/RBS (B), has a BRITE cab display from a TML (T), or is unequipped and so is a candidate for an LSR (C). ASR/RBS and TML locations were obtained from Tables 2-1 and 2-2. The TML sites include sites for which the equipment is programed, but not yet installed. The BRITE displays from on-site ASR/RBS systems were taken from Reference 3. The list indicates that only 138 of 160 ASR/RBS sited airports have BRITEs in the cab. However, Reference 3 is several years old, and this information should simply be taken to indicate that most towers with an ASR/RBS on site are furnished with a BRITE in the cab.

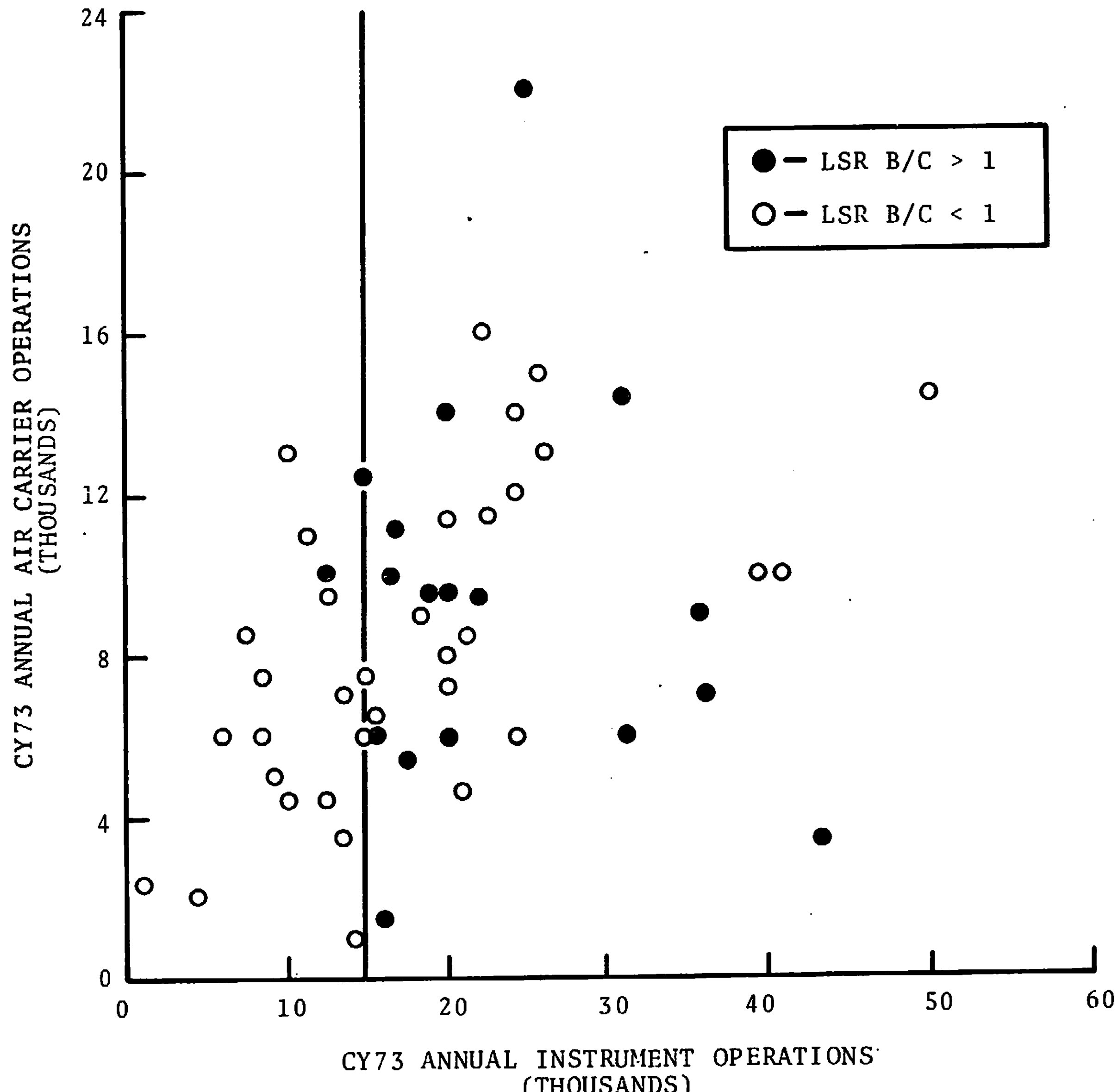

FIGURE 3-2. SAMPLE RESULTS FOR IFR APPLICATION

TABLE 3-3. FAA-OPERATED AIRPORT TRAFFIC CONTROL TOWERS BY RANK ORDER OF ITINERANT AIRCRAFT OPERATIONS WITH EQUIPMENT DISTRIBUTION - CY 1975

TOWER	STATE ABBREV.	EQUIP.*	RANK	NUMBER	TOWER	STATE ABBREV.	EQUIP.	RANK	NUMBER
CHICAGO OHARE INTL	IL	A B	1	668248	BUFFALO INTERNATIONAL	NY	A B	81	127499
ATLANTA INTERNATIONAL	GA	A B	2	463405	SANTA MONICA	CA	T	82	126980
LOS ANGELES INTERNATIONAL	CA	A B	3	446732	RICHMOND BYRD INTL	VA	A B	83	126205
DENVER STAPLETON INTL	CO	A B	4	365883	CINCINNATI GREATER	KY	A B	84	123673
DALLAS FT WORTH REGIONAL	TX	B	5	342116	SAN JOSE REID HILLVIEW	CA	T	85	123347
JOHN F KENNEDY INTL	NY	A B	6	337089	ORLANDO HERNDON	FL	A B	86	123233
PHOENIX SKY HARBOR INTL	AZ	A B	7	332851	ONTARIO	CA	A	87	122232
LA GUARDIA	NY	B	8	328763	DALLAS ADDISON	TX	T	88	120789
SAN FRANCISCO	CA	T	9	326677	ROCHESTER MONROE COUNTY	NY	A B	89	119666
VAN NUYS	CA	T	10	320227	LITTLE ROCK ADAMS FIELD	AR	A B	90	119118
ST LOUIS INTERNATIONAL	MO	A B	11	311582	LAFAYETTE	LA	A B	91	118919
WASHINGTON NATIONAL	DC	A B	12	306302	PROVIDENCE	RI	T	92	117141
SANTA ANA	CA	T	13	304459	SAN DIEGO GILLESPI	CA	C	93	116018
PHILADELPHIA INTL	PA	A B	14	298104	EL PASO INTERNATIONAL	TX	A B	94	115144
LONG BEACH	CA	A B	15	293592	ATLANTA DEKALB PEACHTREE	GA	T	95	115093
MIAMI INTERNATIONAL	FL	A B	16	285463	OKLAHOMA CITY WILL ROGERS	OK	T	96	114990
BOSTON LOGAN	MA	A B	17	282735	AUSTIN	TX	T	97	114872
PITTSBURGH GREATER INTL	PA	A B	18	279249	RENO INTERNATIONAL	NV	A B	98	113656
MEMPHIS INTERNATIONAL	TN	A B	19	274077	PONTIAC	MI	C	99	112693
HONOLULU	HI	A	20	272333	SAN CARLOS	CA	T	100	112651
FORT LAUDERDALE	FL	A B	21	245730	CHICAGO DU PAGE COUNTY	IL	T	101	112447
HOUSTON HOBBY	TX	T	22	237016	BROOMFIELD JEFFERSON CO	CO	T	102	112025
DETROIT METRO WAYNE CO	MI	A B	23	235135	LOUISVILLE STANDIFORD	KY	A B	103	111820
LAS VEGAS MCCARRAN INTL	NV	A B	24	231598	BAKERSFIELD MEADOWS FLD	CA	A	104	111299
MINNEAPOLIS ST PAUL INTL	MN	A B	25	226352	SYRACUSE HANCOCK INTL	NY	A B	105	111210
SAN JOSE MUNICIPAL	CA	T	26	217658	OMAHA	NE	T	106	110842
OPA LOCKA	FL	T	27	206986	FAIRBANKS	AK	A	107	110516
BALTIMORE WASHINGTON INTL	MD	A B	28	204974	LOUISVILLE BOWMAN	KY	T	108	109456
SEATTLE BOEING	WA	T	29	198937	NORFOLK REGIONAL	VA	A B	109	109046
CLEVELAND HOPKINS INTL	OH	A B	30	196627	DETROIT CITY	MI	T	110	108946
SAN JUAN INTERNATIONAL	PR	A	31	194319	GREENSBORO REGIONAL	NC	A B	111	107462
SALT LAKE CITY INTL	UT	A B	32	193493	LA VERNE BRACKETT	CA	T	112	106995
DALLAS LOVE FIELD	TX	A B	33	192218	TAMIAMI	FL	T	113	105982
OAKLAND INTERNATIONAL	CA	A B	34	191012	OXNARD VENTURA COUNTY	CA	T	114	105500
TETERBORO	NJ	T	35	190176	SANTA BARBARA	CA	A	115	105358
NASHVILLE METROPOLITAN	TN	A B	36	189698	NORTH PHILADELPHIA	PA	T	116	105114
INDIANAPOLIS WEIR COOK	IN	A B	37	188059	CHARLESTON AFB MUNICIPAL	SC	A B	117	104354
NEWARK	NJ	A B	38	187302	CAMP SPRINGS ANDREWS AFB	MD	A B	118	103958
HOUSTON INTERCONTINENTAL	TX	A B	39	186034	MADISON	WI	A B	119	103495
CHARLOTTE DOUGLAS	NC	A B	40	185270	GRAND RAPIDS	MI	A B	120	102673
TAMPA INTERNATIONAL	FL	A B	41	184415	NAPA COUNTY	CA	C	121	101430
COLUMBUS INTERNATIONAL	OH	A B	42	180545	FARMINGDALE	NY	T	122	100975
TORRANCE MUNICIPAL	CA	T	43	175966	HARTFORD BRAINARD	CT	T	123	100949
ALBUQUERQUE INTERNATIONAL	NM	A B	44	174686	HAWTHORNE	CA	T	124	100881
MILWAUKEE MITCHELL	WI	A B	45	171849	COLORADO SPRINGS	CO	A	125	100579
SAN ANTONIO INTERNATIONSL	TX	A B	46	169770	KNOXVILLE MCGHEE TYSON	TN	A B	126	99656
WICHITA MID CONTINENT	KS	A B	47	169134	ALBANY COUNTY	NY	A B	127	99327
KANSAS CITY INTERNATIONAL	MO	B	48	169029	NORWOOD	MA	T	128	99323
BURBANK	CA	A B	49	165333	PITTSBURGH ALLEGHENY	PA	T	129	98736
TULSA INTERNATIONAL	OK	A B	50	163827	LANSING	MI	A B	130	98602
CHICAGO MIDWAY	IL	A B	51	163784	ATLANTA FULTON COUNTY	GA	T	131	98299
SEATTLE TACOMA INTL	WA	A B	52	160990	LINCOLN MUNICIPAL	NE	A B	132	97677
PORTLAND INTERNATIONAL	OR	A B	53	160211	CARLSBAD PALOMAR	CA	T	133	97593
FRESNO AIR TERMINAL	CA	A B	54	159526	KANSAS CITY MUNICIPAL	MO	A B	134	96792
ANCHORAGE MERRILL	AK	T	55	159225	EL MONTE	CA	C	135	96518
SAN DIEGO LINDBERG	CA	T	56	158145	WESTFIELD	MA	T	136	96356
HAYWARD	CA	T	57	155514	VERO BEACH	FL	C	137	96023
ISLIP MACARTHUR	NY	A B	58	155359	JACKSONVILLE INTL	FL	A B	138	95200
WEST PALM BEACH	FL	A B	59	154364	MINNEAPOLIS FLYING CLOUD	MN	T	139	94473
SACRAMENTO EXECUTIVE	CA	T	60	152190	ROCKFORD	IL	A	140	93405
DAYTONA BEACH	FL	A B	61	147577	CINCINNATI LUNKEN	OH	T	141	93249
DES MOINES MUNICIPAL	IA	A B	62	143236	BRIDGEPORT	CT	C	142	93200
WHITE PLAINS WESTCHESTER	NY	A B	63	140451	LANCASTER	PA	C	143	93038
ANCHORAGE INTL RAPCON	AK	A	64	139901	CHICAGO PALWAUKEE	IL	T	144	91871
BIRMINGHAM	AL	A B	65	139258	MORRISTOWN	NJ	C	145	91088
TULSA RIVERSIDE	OK	T	66	138000	SPRINGFIELD CAPITAL	IL	A B	146	91060
WASHINGTON DULLES INTL	VA	A B	67	137550	BEVERLY MUNICIPAL 2	MA	T	147	90932
NEW ORLEANS MOISANT	LA	A B	68	136419	ALLENTOWN	PA	A B	148	90627
WINDSOR LOCKS	CT	A B	69	135304	CHARLESTON	WV	A B	149	90599
RALEIGH DURHAM	NC	A B	70	134464	SARASOTA BRADENTON	FL	A	150	89797
BEDFORD	MA	T	71	131630	WILMINGTON GR WILM	DE	A B	151	87824
SAN DIEGO MONTGOMERY	CA	T	72	131545	TRENTON	NJ	C	152	87693
NEW ORLEANS LAKEFRONT	LA	T	73	130762	TOLEDO EXPRESS	OH	A B	153	87540
FULLERTON MUNICIPAL	CA	T	74	130522	SANTA ROSA SONOMA COUNTY	CA	C	154	87466
TUCSON	AZ	T	75	130182	AKRON CANTON REGIONAL	OH	A B	155	87441
BOISE	ID	A B	76	129231	FORT WAYNE	IN	A B	156	86933
DAYTON	OH	A	77	129095	SAN JUAN ISLA GRANDE	PR	T	157	86683
OKLAHOMA CITY WILEY POST	OK	T	78	129022	LEXINGTON	KY	A B	158	85293
CONCORD	CA	C	79	128929	PALO ALTO	CA	T	159	84727
FORT WORTH MEACHAM	TX	T	80	128508	ST THOMAS H S TRUMAN	VI	A	160	84718

*Equipment designations are:

A-ASR/RBS
B-BRITE direct from colocated ASR/RBS
T-TML remote BRITE
C-None of the above-candidate for LSR

TABLE 3-3. FAA-OPERATED AIRPORT TRAFFIC CONTROL TOWERS BY RANK ORDER OF ITINERANT AIRCRAFT OPERATIONS WITH EQUIPMENT DISTRIBUTION - CY 1975 (CONT.)

TOWER	STATE ABBREV.	EQUIP.*	RANK	NUMBER	TOWER	STATE ABBREV.	EQUIP.	RANK	NUMBER
ST PETERSBURG CLEARWATER	FL	C	161	84300	WINSTON SALEM	NC	T	241	59068
DANBURY MUNICIPAL	CT	C	162	84272	GAINESVILLE	FL	C	242	58816
MELBOURNE	FL	T	163	84128	LANCASTER FOX AIRPORT	CA	C	243	58551
READING	PA	C	164	83924	BANGOR INTERNATIONAL	ME	A	244	58486
SPOKANE INTERNATIONAL	WA	T	165	83801	GULFPORT	MS	A B	245	58383
CHATTANOOGA	TN	A B	166	83681	SALINAS MUNICIPAL	CA	C	246	58199
TOPEKA PHILIP BALLARD	KS	C	167	83493	NEW BEDFORD	MA	T	247	57850
COLUMBIA METROPOLITAN	SC	A B	168	82759	GROTON TRUMBULL	CT	C	248	57750
STOCKTON	CA	C	169	82551	FARGO HECTOR FIELD	ND	A B	249	57671
LUBBOCK	TX	A B	170	82127	SALEM MCNARY FIELD	OR	C	250	57372
MIDLAND	TX	A B	171	81701	WILKES BARRE	PA	A B	251	57357
HARRISBURG	PA	A B	172	79932	SPRINGFIELD	MO	A B	252	56897
OLATHE	KS	C	173	79383	WORCESTER	MA	C	253	56333
DENVER ARAPAHOE COUNTY	CO	T	174	79302	MUNCIE DELAWARE COUNTY	IN	C	254	56245
PEORIA	IL	A B	175	79182	FORT SMITH MUNICIPAL	AR	A B	255	55919
ORLANDO JETPORT	FL	T	176	79141	SHREVEPORT	LA	T	256	55293
ROANOKE	VA	A B	177	78909	PASCO TRI CITIES	WA	C	257	54913
MOLINE	IL	A B	178	78233	LONGVIEW	TX	A B	258	54450
LIVERMORE MUNICIPAL	CA	C	179	77488	ALTON CIVIC MEMORIAL	IL	T	259	54337
MONTEREY	CA	A B	180	74731	AMARILLO	TX	A	260	53974
HYANNIS	MA	T	181	74562	DOTHAN	AL	T	261	53904
BILLINGS	MT	A B	182	74095	MILWAUKEE TIMMERMAN	WI	C	262	53740
CHAMPAIGN UNIV OF ILL	IL	A B	183	73960	WATERLOO	IA	A B	263	53503
KALAMAZOO	MI	A	184	73939	ROCHESTER	MN	A	264	53388
ST PAUL	MN	C	185	73932	PENSACOLA	FL	A	265	53378
MEDFORD JACKSON COUNTY	OR	C	186	73850	WILMINGTON NEW HANOVER CO	NC	A B	266	53369
EUGENE	OR	C	187	73467	RENTON	WA	C	267	53166
CORPUS CHRISTI	TX	A B	188	72494	JACKSON REYNOLDS MUNIC	MI	C	268	52929
FORT LAUDERDALE EXECUTIVE	FL	T	189	72110	YOUNGSTOWN	OH	A B	269	52891
NEW HAVEN	CT	C	190	71767	COLUMBUS	GA	A B	270	52834
COLUMBUS OHIO ST	OH	T	191	71541	KANSAS CITY FAIRFAX	KS	T	271	52819
HOLLYWOOD	FL	T	192	71376	CHEYENNE	WY	C	272	52773
EVERETT PAINE FIELD	WA	C	193	71158	AUGUSTA	GA	A B	273	52502
EVANSVILLE	IN	A B	194	70839	JACKSON HAWKINS	MS	T	274	51819
AKRON MUNICIPAL	OH	C	195	70771	GREAT FALLS	MT	T	275	51786
FLINT BISHOP	MI	A B	196	70330	BINGHAMTON BROOME COUNTY	NY	A B	276	51724
NEWPORT NEWS	VA	T	197	70223	SAGINAW TRI CITY	MI	A B	277	51583
SCOTTSDALE	AZ	C	198	70217	SAN ANGELO	TX	C	278	50936
PALM SPRINGS MUNICIPAL	CA	A	199	70216	ST CROIX ALEX HAMILTON	VI	C	279	50787
MANCHESTER	NH	C	200	70202	FARMINGTON	NM	C	280	50695
TALLAHASSEE	FL	A B	201	70136	HUNTINGTON	WV	A B	281	50651
RIVERSIDE MUNICIPAL	CA	T	202	69978	PANAMA CITY BAY COUNTY	FL	T	282	50544
TROUTDALE	OR	T	203	69947	ANN ARBOR MUNICIPAL	MI	C	283	50249
SOUTH BEND	IN	A B	204	69642	ERIE	PA	A B	284	50148
KAHULUI	HI	A	205	68671	SANTA MARIA PUBLIC 2	CA	C	285	50101
MONTGOMERY DANNELLY FIELD	AL	T	206	68588	SAN DIEGO BROWN FIELD	CA	C	286	49884
PORTLAND	ME	A B	207	68587	WACO MUNICIPAL	TX	C	287	49745
CHINO	CA	T	208	68477	DECATUR	IL	C	288	49566
BRISTOL TRI CITY	TN	A B	209	68062	MIDDLETON	PA	T	289	49304
DETROIT WILLOW RUN	MI	T	210	67827	BISMARCK	ND	C	290	49161
SAVANNAH MUNICIPAL	GA	A B	211	67579	GRAND JUNCTION	CO	C	291	48937
ST LOUIS SPIRIT OF ST LOU 2	MO	T	212	67462	LIHUE	HI	C	292	48666
SIOUX FALLS FOSS FLD	SD	A B	213	67250	MANSFIELD LAHM MUNICIPAL	OH	C	293	48627
SACRAMENTO METRO	CA	T	214	66673	ELMIRA	NY	A B	294	48576
MODESTO CITY COUNTY	CA	C	215	66618	LAFAYETT PURDUE UNIVERSITY	IN	C	295	48368
FORT MYERS PAGE FIELD	FL	C	216	66407	ABILENE	TX	T	296	47963
OSHKOSH WITTMAN FIELD	WI	C	217	66389	ST PETERSBURG WHITT	FL	C	297	47773
CLEVELAND CUYAHOGA COUNTY	OH	T	218	66329	ALBANY	GA	C	298	47710
DALLAS REDBIRD	TX	T	219	66146	NANTUCKET MEMORIAL	MA	C	299	47689
MOBILE BATES FIELD	AL	A B	220	65713	CASPER	WY	A B	300	47637
FRESNO CHANDLER	CA	T	221	64915	DULUTH	MN	A B	301	47271
MINNEAPOLIS CRYSTAL	MN	C	222	64262	WILLIAMSPORT	PA	C	302	47248
MONROE	LA	A	223	64142	PUEBLO	CO	A B	303	47232
BURLINGTON INTERNATIONAL	VT	A B	224	63671	GRAND ISLAND	NE	C	304	47043
HILLSBORO	OR	C	225	63236	TERRE HAUTE	IN	C	305	47037
BATON ROUGE RYAN FIELD	LA	A B	226	63234	AURORA MUNICIPAL 2	IL	C	306	46814
YAKIMA AIR TERMINAL	WA	C	227	62714	LEWISTON	ID	C	307	46749
CEDAR RAPIDS	IA	A B	228	62667	PARKERSBURG WOOD COUNTY	WV	C	308	46715
GREENVILLE MUNICIPAL	SC	T	229	62363	LA CROSSE	WI	C	309	46196
POMPANO BEACH AIRPARK	FL	T	230	61992	SALINA	KS	C	310	46183
SPOKANE FELTS FIELD	WA	C	231	61913	ANCHORAGE LAKE HOOD SPR	AK	C	311	45553
HUNTSVILLE MADISON COUNTY	AL	A B	232	61619	MUSKEGON	MI	A B	312	45486
NIAGARA FALLS	NY	T	233	61452	TYLER	TX	C	313	45374
EAST ST LOUIS BI STATE PK	IL	C	234	61307	CRAIG FIELD JACKSONVILLE 2	FL	C	314	45250
CHICAGO MEIGS	IL	T	235	60964	COLLEGE STATION	TX	C	315	45139
JACKSON MUN ARPT	MS	A B	236	60809	CLEVELAND BURKE LAKEFRONT	OH	T	316	44897
SHREVEPORT DOWNTOWN	LA	T	237	60464	RAPID CITY	SD	C	317	44716
BEAUMONT PORT ARTHUR	TX	A B	238	60207	ASHEVILLE	NC	A B	318	44695
SIOUX CITY MUNICIPAL	IA	A B	239	60040	FAYETTEVILLE GRANNIS	NC	A B	319	44637
GREEN BAY AUSTIN STRAUBEL	WI	A B	240	59296	HUTCHINSON	KS	C	320	44351

*Equipment designations are:

A-ASR/RBS
B-BRITE direct from colocated ASR/RBS
T-TML remote BRITE
C-None of the above-candidate for LSR

TABLE 3-3. FAA-OPERATED AIRPORT TRAFFIC CONTROL TOWERS BY RANK ORDER OF ITINERANT AIRCRAFT OPERATIONS WITH EQUIPMENT DISTRIBUTION - CY 1975 (CONT.)

TOWER	STATE ABBREV.	EQUIP.*	RANK	NUMBER
JANESVILLE	WI	C	321	44131
LYNCHBURG	VA	C	322	43512
MORGANTOWN	WV	C	323	43426
MOSES LAKE GRANT	WA	C	324	43108
GREER	SC	A	325	42968
OGDEN MUNICIPAL	UT	T	326	42901
MISSOULA	MT	C	327	42411
KENAI MUNICIPAL	AK	C	328	41310
IMPERIAL	CA	C	329	41052
BLOOMINGTON NORMAL	IL	C	330	40938
HOT SPRINGS MEMORIAL	AR	C	331	40868
MCALLEN	TX	C	332	40697
UTICA	NY	T	333	40522
CLARKSBURG BENEDUM	WV	C	334	40046
GRAND FORKS INTERNATIONAL	ND	C	335	40008
JUNEAU	AK	C	336	39797
TEXARKANA	AR	C	337	39529
GOODYEAR	AZ	C	338	39504
SAN ANTONIO STINSON	TX	T	339	39460
KLAMATH FALLS	OR	C	340	39162
HAGERSTOWN	MD	C	341	38962
PENDLETON	OR	C	342	38576
REDDING	CA	C	343	38502
HILO GENERAL LYMAN FIELD	HI	A	344	38334
CARBONDALE 2	IL	C	345	38208
SPARTANBURG	SC	T	346	38125
TACOMA INDUSTRIAL	WA	A	347	37628
APPLETON	WI	C	348	37548
MACON LEWIS B WILSON	GA	T	349	37359
DUBUQUE	IA	C	350	37312
ATLANTIC CITY	NJ	A	351	36587
TRAVERSE CITY	MI	C	352	36536
OLYMPIA	WA	C	353	36257
IDAHO FALLS FANNING FIELD	ID	C	354	36101
KNOXVILLE DOWNTOWN MUN	TN	T	355	35479
SOUTH LAKE TAHOE	CA	C	356	35147
WHEELING	WV	C	357	34962
BROWNSVILLE INTERNATIONAL	TX	C	358	34515
TUSCALOOSA VAN DE GRAAF	AL	C	359	34441
CHARLOTTESVILLE ALBEMARLE	VA	C	360	34312
LAKE CHARLES	LA	A B	361	34081
MERCED	CA	C	362	34018
POCATELLO	ID	C	363	34001
POUGHKEEPSIE DUTCHESS CO	NY	C	364	33833
MERIDIAN KEY	MS	A	365	33751
PLAINVIEW HALE COUNTY	TX	C	366	33553
ROSWELL	NM	C	367	33216
CAPE GIRARDEAU MUNICIPAL	MO	C	368	32977
PALMDALE	CA	C	369	32950
OWENSBORO DAVIESS CO	KY	C	370	32773
ENID WOODRING MUNICIPAL	OK	C	371	32661
ATHENS CLARKE COUNTY	GA	C	372	32576
BATTLE CREEK	MI	C	373	32473
KONA KE AHOLE	HI	C	374	32033
SANTA FE	NM	C	375	31555
PINE BLUFF GRIDER FIELD	AR	C	376	31533
KEY WEST	FL	C	377	31195
COLUMBIA REGIONAL	MO	C	378	31154
JOPLIN	MO	C	379	31142
ASPEN PITKIN COUNTY	CO	C	380	30994
ITHACA TOMPKINS CO	NY	C	381	30947
PONCE MERCEDITA	PR	C	382	30833
BLOOMINGTON MONROE COUNTY	IN	C	383	30710
GREENVILLE MUNICIPAL	MS	C	384	30682
CHICO 2	CA	C	385	30549
HARLINGEN INDUSTRIAL AP	TX	C	386	30310
ARDMORE MUNICIPAL	OK	C	387	30230
HELENA	MT	C	388	29497
FAYETTEVILLE DRAKE FIELD	AR	C	389	29208
HICKORY	NC	C	390	29019
WALLA WALLA 2	WA	C	391	28169
PADUCAH BARKLEY FIELD	KY	C	392	27019
ST JOSEPH	MO	C	393	26553
BENTON HARBOR ROSS FIELD	MI	C	394	26351
LAWTON MUNICIPAL	OK	C	395	26146
MARYSVILLE YUBA COUNTY	CA	C	396	25488
TWIN FALLS 2	ID	C	397	25220
KING SALMON	AK	C	398	24597
GRAND CANYON MUNICIPAL	AZ	C	399	23822
DANVILLE	IL	C	400	22698
KWAJALEIN AAF	WK	C	401	22521
BRUNSWICK SAINT SIMON	GA	C	402	22394
HOBBS LEA COUNTY	NM	C	403	22293
LEBANON 2	NH	C	404	21221
VALDOSTA MUNICIPAL	GA	C	405	20378
ALEXANDRIA 2	LA	C	406	20200
DEADHORSE 2	AK	C	407	19405
NEW BERN	NC	C	408	18254
DEER VALLEY 2	AZ	C	409	16430
MYRTLE BEACH 2	SC	C	410	15929
MAYAGUEZ	PR	C	411	15771
GALESBURG MUNICIPAL 2	IL	C	412	14495
KINSTON 2	NC	C	413	14079
LEWISBURG GREENBRIER	WV	C	414	13789
VALDEZ 2	AK	C	415	13252
FLORENCE CITY 2	SC	C	416	8924
KODIAK	AK	T	417	7593
FLAGSTAFF 2	AZ	C	418	5017
MARION WILLIAMSON 2	IL	C	419	4180
MIAMI DADE COLLIER	FL	C	420	2951
		GRAND	TOTAL	38041040

*Equipment designations are:

A-ASR/RBS
B-BRITE direct from colocated ASR/RBS
T-TML remote BRITE
C-None of the above-candidate for LSR

1. AIR TRAFFIC HUBS ARE CLASSIFIED AS FOLLOWS:

L LARGE 1.00% (1,984,078 PASSENGERS AND OVER)
M MEDIUM 0.25% TO 0.99% (BETWEEN 496,020 AND 1,984,077 PASSENGERS)
S SMALL 0.05% TO 0.24% (BETWEEN 99,204 AND 496,019 PASSENGERS)
N NONHUB LESS THAN 0.05% (UNDER 99,204 PASSENGERS)

2. LESS THAN FULL YEAR DATA.

CODE INDICATES TYPE OF CHANGE TAKEN PLACE.
C COMMISSIONED

C	TOWER	ST LOUIS SPIRIT OF ST LOU	MO	01-75
C	TOWER	DEADHORSE	AK	01-75
C	TOWER	SANTA MARIA PUBLIC	CA	02-75
C	TOWER	ALEXANDRIA	LA	04-75
C	TOWER	LEBANON	NH	04-75
C	TOWER	KINSTON	NC	04-75
C	TOWER	BEVERLY MUNICIPAL	MA	01-75
C	TOWER	CRAIG FIELD JACKSONVILLE	FL	01-75
C	TOWER	TWIN FALLS	ID	02-75
C	TOWER	WALLA WALLA	WA	01-75
C	TOWER	CARBONDALE	IL	03-75
C	TOWER	CHICO	CA	05-75
C	TOWER	FLORENCE CITY	SC	08-75
C	TOWER	AURORA MUNICIPAL	IL	02-75
C	TOWER	MARION WILLIAMSON	IL	11-75
C	TOWER	FLAGSTAFF	AZ	09-75
C	TOWER	VALDEZ	AK	01-75
C	TOWER	PHOENIX DEER VALLEY	AZ	10-75
C	TOWER	GALESBURG	IL	06-75
C	TOWER	NORTH MYRTLE BEACH	SC	06-75

FULL TIME TOWERS WITH LISTED EQUIPMENT

A = 160 (ASR/RBS)
B = 138 (BRITE)
T = 93 (TML)
C = 146 (LSR CANDIDATES)

From Table 3-3, a list of 146 candidates for LSR deployment is obtained. The application of the establishment criteria to these candidates resulted in the list of 31 potential LSR qualifiers that would require further screening. These sites are shown in Table 3-4 along with the applications(s) for which each might be qualified.

3.3 FINAL SCREENING OF LSR QUALIFIERS

The final screening was applied to the 31 potential qualifiers using the rules set down in Section 2.2. Prior to computing the appropriate B/C ratios, the airports were checked for existing coverage. Two airports, although not programmed for a BRITE via TML, were well within TML range and so LSR B/C ratios were not computed for them. Two others were found to have existing radar approach control from a nearby facility, and LSR B/C ratios were not computed. Three others were provided with radar approach control service but were out of TML range. Since these three airports qualified for both VFR and IFR application, the LSR B/C ratios for VFR application were computed. The type of coverage and parent facility are given for each of these airports in Table 3-4.

The B/C ratios were computed for each VFR application using the Reference 1 model. The ratios for the IFR application posed a problem since the Reference 1 model for delay savings requires weather data which was not available on all airports. To solve this problem, it was necessary to alter the model. An example of how the model was altered is Fort Myers Page Field, Florida. The B/C computations for Fort Myers Page Field are depicted in Table 3-5. The resulting B/C ratio is greater than one, suggesting an LSR deployment for radar approach control. However, in CY 1975, Fort Myers only experienced 211 instrument approaches. This would suggest that for the small airports considered in this study, the estimate of delayed aircraft (item (6) in Table B-5) may be in error. In addition, in that estimate it is assumed that departures are delayed as much as arrivals, which is unlikely. When operating in IFR, lateral separation (i.e. diverging headings) can be applied

TABLE 3-4. FULL-TIME TOWERS QUALIFYING FOR LSR - CY 1975

AIRPORT IDENTIFIER	AIRPORT LOCATION/NAME	APPLICATION FOR WHICH QUALIFIES	CURRENT COVERAGE*	LSR B/C FOR VFR	LSR B/C** FOR IFR
BDR	Bridgeport CT	VFR		1.2†	
MMU	Morristown NJ	VFR		1.0†	
CCR	Concord CA	VFR		1.4†	
SEE	San Diego Gillespi CA	VFR	TML (1)		
APC	Napa County CA	VFR		1.0†	
VRB	Vero Beach FL	VFR		.9	
EMT	El Monte CA	VFR	TML (2)		
LNS	Lancaster PA	VFR		1.2†	
PTK	Pontiac MI	VFR/IFR	TRACON (3)	1.1†	
TTN	Trenton NJ	VFR/IFR	TRACON (4)	1.7†	
SCK	Stockton CA	VFR/IFR		1.9	1.8/1.9†
TOP	Topeka KS	VFR/IFR	ARTCC(5)	1.5†	
MFR	Medford OR	VFR/IFR		1.1	6.1/4.1
EUG	Eugene OR	VFR/IFR		1.4	3.8/2.8†
LIH	Lihue HI	VFR/IFR		2.8†	.2/1.2
KOA	Kona Ke HI	VFR/IFR		2.3†	.0/ .9
RDG≠	Reading PA	IFR			1.5†
MHT	Manchester NH	IFR			.7
PAE	Everett Paine WA	IFR	ARTCC (6)		
FMY	Fort Meyers FL	IFR			.5
SJT	San Angelo TX	IFR			2.6†
CYS	Cheyenne WY	IFR			.4
BIS	Bismarck ND	IFR			.6
DEC	Decatur IL	IFR			.9
IPT	Williamsport PA	IFR			.3
MFD	Mansfield OH	IFR			5.2
LSE	La Crosse WI	IFR			.4
ACT≠	Waco TX	IFR			.4
MGW	Morgantown WV	IFR			.4
CKB	Clarksburg WV	IFR			.3
PMB	Palmdale CA	IFR	RAPCON (7)		

*Potential Coverage from
(1) Mirimar RAPCON
(2) Ontario TRACON
Existing Coverage from
(3) Detriot TRACON
(4) Philadelphis TRACON
(5) Kansas City, ARTCC
(6) Seattle ARTCC
(7) Edwards RAPON

**{Incremental B/C for Adding Approach Control / Overall B/C with Approach Control} If VFR B/C >1

†Airports which are candidates for LSR deployment (not potential ASR/RBS sites).

≠Scheduled for ASR in FY '78.

TABLE 3-5. EXAMPLE, B/C COMPUTATIONS USING ASR ESTABLISHMENT CRITERIA MODELS - FORT MYERS PAGE FIELD, FLORIDA

(1) EXPECTED COST/COLLISION = $1,579,000

USER CLASS	ANNUAL OPERATIONS[a] NUMBER	ANNUAL OPERATIONS[a] FRACTION	AVERAGE COST PER COLLISION (THOUSANDS)[b]	FRACTION USER CLASS X AVG. COST PER COLLISION
Air Carrier	4005	.04	19,822	793
Air Taxi	7196	.08	3,349	268
GA Itin.	54984	.58	625	363
GA Local	28808	.30	517	155
Military	382	.00	3,349	0
	95375	1.00		Total = $1,579 = Average Cost/Collision (Thousands)

(2) EXPECTED PREVENTABLE COLLISIONS/YEAR[c] = .032

(2.1) Annual Itinerant Operations[a] = 66,407

(3) SAFETY BENEFITS = (1) x (2) = $50,500/YEAR

(4) EXPECTED COST/HOUR OF DELAY = $425

USER CLASS	ANNUAL INSTRUM. OPS[a] NUMBER	ANNUAL INSTRUM. OPS[a] FRACTION	AVERAGE HOURLY COSTS/AIRCRAFT[d]	EXPECTED COST/HOUR OF DELAY
Air Carrier	4594	.19	1250	238
Air Taxi	7528	.32	375	120
GA	11330	.48	131	63
Military	189	.01	375	4
				$425

(5) EXPECTED DELAY SAVINGS/AIRCRAFT DELAYED = .183

(5.1) Busy Hour IFR Operations[a] = 21

(6) EXPECTED AIRCRAFT DELAYED/YEAR = (6.1) x (6.2) x (5.1) = 1578

(6.1) Busy Hours/Year = 1252 (4 Hours Weekdays & 2 Hours Weekends)

(6.2) Fraction of Time Instrument Approach Weather Prevails[f] = .06

(7) DELAY BENEFITS = (4) x (5) x (6) = $122,700/YEAR

(8) B/C FOR LSR (IFR APPLICATION) = ((3) + (7))/(8.1) = 1.07

(8.1) LSR Costs (IFR Application) = $161,800

(a) From Reference 2
(b) From Reference 1, Table 5
(c) " " Table 4 based upon item 2.1
(d) " " Table 3
(e) " " Table 6 based upon item 5.1 and fraction of GA from item 4 Table
(f) From Reference 4

to successive departures between widely spaced arrivals, resulting in a higher departure than arrival rate. Because of these factors and the lack of weather data on all airports, the delay benefit model was altered by using the reported annual instrument approaches in place of the estimated aircraft delayed per year. Of the airports with weather data (13 airports), this change affected the deployment results only at Fort Myers. In this instance, with so few reported instrument approaches, the effect appears beneficial. The B/C ratio for Fort Myers with the revised model was .4, which resulted in its being dropped from the deployment list.

The B/C ratios are listed for each airport in Table 3-4. For those airports which qualified for both applications and whose B/C for VFR exceeds one, the marginal B/C resulting from adding radar approach control is also shown. In these cases, the marginal B/C was used to determine deployment. Thus, airports with high safety benefits but little or no IFR weather would not receive radar approach control but would receive a BRITE display for separation advisories and sequencing.

From Section 1, the annual cost of an ASR/RBS is about three times the annual cost of an LSR with radar approach control. Therefore, Table 3-4, two airports having LSR B/C ratios greater than three might warrant an ASR/RBS. These two airports might thus receive an ASR/RBS rather than an LSR and might not be LSR candidates. The LSR deployment, therefore, is reduced to 14 to 16 out of 31 airports, with four to six LSRs installed with radar approach control and 10 LSRs installed for VFR application. The 14 airports (excluding the potential ASR/RBS sites) are marked with a (†) in Table 3-4.

3.4 SENSITIVITY TO BRITE/TML BLOCKAGE PROBLEMS

For the benefits analysis, it was assumed that if an airport had or was programed for a BRITE via TML, it would not be a candidate for an LSR. However, at some airports which may have coverage problems, although a TML provides some assistance, an LSR might be much preferred. This possibility was investigated for terrain shielding using an analysis presented in Reference 6. It is pointed out that this is only a partial analysis, since shielding due to man-made obstructions (e.g., buildings, towers) is not included and may be significant. Also, not all sites were considered.

In Reference 6, 79 of the 93 TML sites in Table 3-3 were addressed. For each airport, topographical maps were used to establish line-of-sight to the parent airport's ASR from a grid of 392 locations at each of 10 altitudes from 0 to 1800 feet in 200-foot increments. For each altitude, the number of grid locations without line-of-sight was determined and the percent of the total (392) locations computed. The results are shown in Figure 3-3 versus percent line-of-sight blockage at 400 feet. Four hundred feet was chosen as the minimum altitude for which coverage would be required. From Figure 3-3, it can be seen that all but nine airports have better than 80 percent coverage. For this study, these nine airprots were considered to have unacceptable coverage and were examined to see if the benefits exceeded the LSR costs.

The nine airports considered are listed in Table 3-6 with their pertinent characteristics. Of the nine, four fail to meet the hypothesized criteria presented in Figure 3-1. All of the remaining five have an LSR B/C ratio which exceeds one, and so would justify an LSR. Of the five, one is San Francisco, with an extremely high B/C ratio. However, until it received its BRITE via TML (in the early 1970s) San Francisco had its own ASR-2. It is unlikely that such a major airport would have given up its radar for the TML if coverage was not adequate. Therefore, San Francisco was not added to the LSR deployment list. The four other airports were added to the list, as shown in Table 3-7. A cost sensitivity analysis was then performed for the airports on the list. It is presented in Section 3.5.

3.5 SENSITIVITY TO COST ESTIMATES

Table 3-7 presents a summary list of the 18 airports which might receive an LSR. The two airports which might warrant an ARS/RBS are not included. Development (R&D) costs have not yet

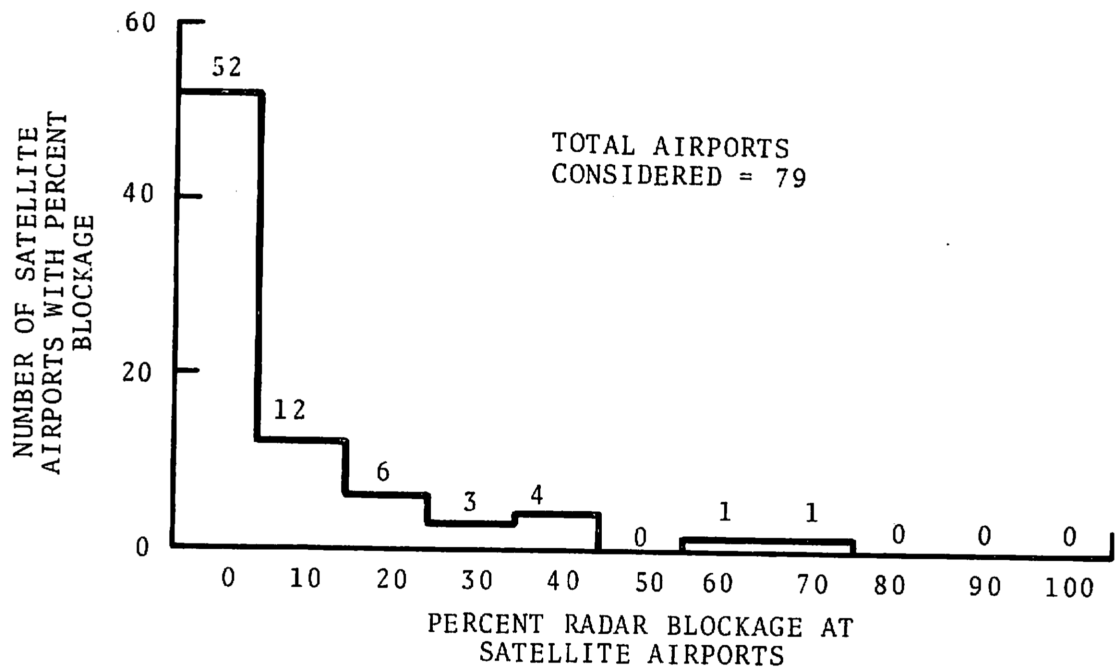

FIGURE 3-3. TML COVERAGE DISTRIBUTION, ALTITUDE 400 FEET

TABLE 3-6. B/C RATIOS FOR TML AIRPORTS WITH LESS THAN 80 PERCENT COVERAGE

AIRPORT LOCATION/NAME	PERCENT COVERAGE	ANNUAL CY 1975 ITINERANT OPERATIONS	ANNUAL CY 1975 AIR CARRIER OPERATIONS	QUALIFY FOR LSR	VFR APPLICATION LSR B/C RATIO
San Francisco CA	70	326667	267627	Yes	43.6
Torrance Muni CA	70	175966	0	Yes	1.5
Tulsa Riverside OK	60	138000	0	Yes	1.3
San Jose Reid CA	70	123347	0	Yes	1.2
Troutdale OR	60	69947	1	No	-
Greenville Muni SC	60	62363	0	No	-
Middleton PA	60	49304	11612	Yes	1.2
Ogden Muni UT	40	42901	55	No	-
Spartanburg SC	30	38125	16	No	-

TABLE 3-7. SUMMARY AND SENSITIVITY TO COST

AIRPORT LOCATION/NAME	BASE CASE LSR B/C RATIO	LSR B/C RATIO > 1 BASE CASE	PLUS R&D COSTS	10 PERCENT	20 PERCENT*
IFR APPLICATION					
Stockton CA	1.9	X	X	X	X
Reading PA	1.5	X	X	X	X
Eugene OR	2.8	X	X	X	X
San Angelo TX	2.6	X	X	X	X
Subtotal		4	4	4	4
VFR APPLICATION					
Topeka KS	1.5	X	X	X	X
Pontiac MI	1.1	X			
Bridgeport CT	1.2	X	X		
Morristown NJ	1.0	X			
Trenton NJ	1.7	X	X	X	X
Lihue HI	2.8	X	X	X	X
Kona Ke HI	2.3	X	X	X	X
Concord CA	1.4	X	X	X	
Napa Co. CA	1.0	X			
Lancaster PA	1.2	X	X		
Torrance Muni CA	1.5	X	X	X	X
Tulsa Riverside OK	1.3	X	X		
San Jose Reid CA	1.2	X	X		
Middleton PA	1.2	X	X		
Subtotal		14	11	6	5
Total Units		18	15	10	9

*Increase in F&E costs. O&M, controller (in IFR application), and R&D costs assumed constant.

been considered in the analysis since it was not known how many systems would share them. R&D costs have been estimated by the Systems Research and Development Service, Detection Systems Branch, to be approximately $1.5 million. If these costs are amortized over 15 years at 10%, and spread over the LSR deployment, three of the LSR candidates drop out. The resulting deployment would be at 15 airports, four of which would be used for radar approach control (see Table 3-7).

Of course, if each unit's share of the R&D costs were offset by a reduction in its F&E costs, all 18 airports could continue to justify an LSR economically. This would be true for increasingly higher R&D costs until even a reduction to zero F&E costs would not offset them. Therefore, there is a range of R&D and F&E costs which will produce an economically justifiable deployment of 18 systems. In fact, there is a range of costs which will produce any of the possible LSR deployments which result as the system costs increase. This is shown in Figure 3-4.

Figure 3-4 permits the estimation of the LSR deployment as a function of total R&D and per unit F&E costs. With R&D costs of $1.5 million, if the nominal F&E costs ($362,000; see Table A-3) were reduced by $83,000 (i.e., $1.5 million/18 units) to $279,000, 18 units could be economically justified. In the figure, the nominal values of $362,000 F&E and $1.5 million R&D are depicted by dashed lines. It can be seen that the deployment to 15 airports is very sensitive to an increase in either R&D or F&E costs. Once to the right of a line, the deployment should drop to the units specified by the next line and the 15 unit airport deployment would drop to 11 units. (Costs would cause the four airports with B/C ratios of 1.2 to fall below 1.0.) Similarly, the nominal deployment is quite insensitive to cost reduction. A reduction in R&D of 90% or a reduction in F&E of 10% will not increase the deployment.

Also from Figure 3-4, it is apparent that as R&D costs increase, the sensitivity to F&E costs increases (i.e., the lines converge). Table 3-7 (using Figure 3-4) shows that for a 20% increase in F&E costs, the LSR deployment falls to nine.

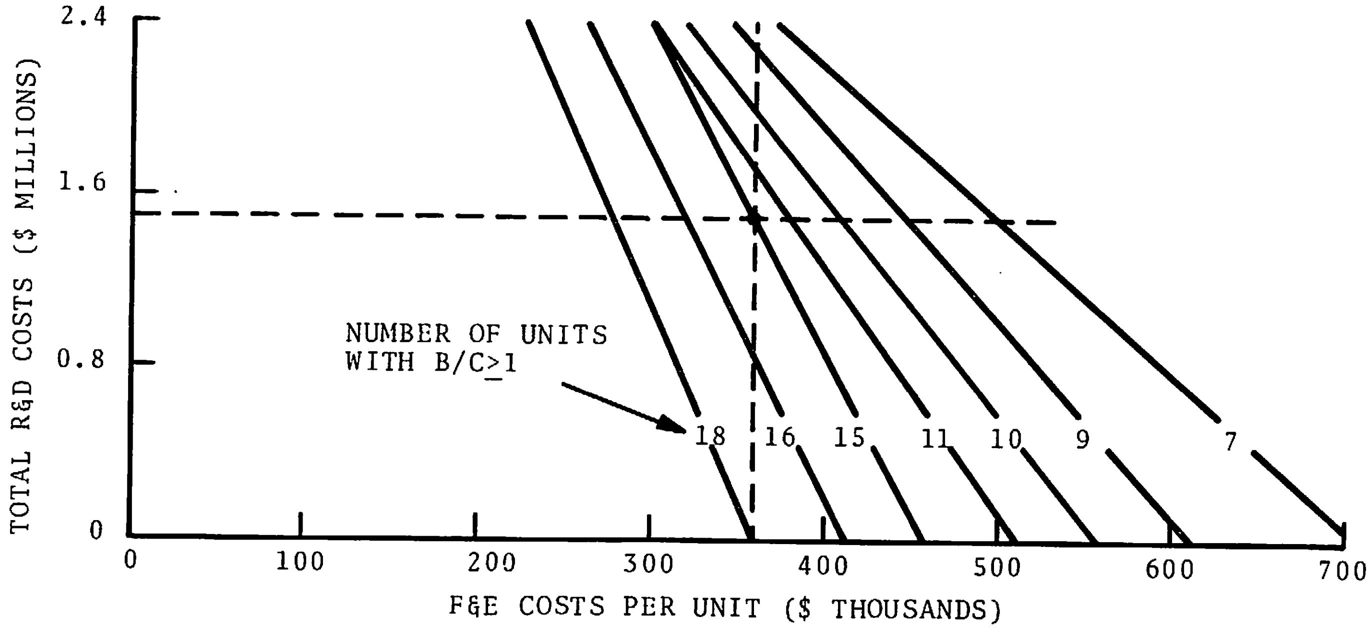

FIGURE 3-4. DEPLOYMENT COST SENSITIVITY

3.6 NET BENEFITS ESTIMATE

Although this study considers only the CY 1975 LSR deployment potential, it is possible to estimate the net benefits of a program which would (1) develop the LSR in FY 1978 and FY 1979, (2) deploy the LSR in FY 1980, and (3) operate the units for the next fifteen years. Based upon the results presented in Table 3-7, fifteen units might be deployed and maintained. As traffic grows, unequipped airports would qualify for LSRs while LSR-equipped airports would qualify for ASRs. It is assumed that LSRs would be moved from the ASR-qualified sites to the new LSR sites, keeping the net number of LSRs at 15. In making the estimate of benefits, it is assumed that the average B/C ratio for the 15 airports will approximate the average B/C ratio of the 15 airports qualifying for the LSR in CY 1975 (See Table 3-7). Costs required to relocate LSRs in this arrangement are taken as the non-radar F&E costs from Table A-3 and are $165,000 per relocation. It is further assumed that there would be one relocation every 2 years, beginning 5 years after the initial deployment.

The benefits estimate is made in Table 3-8. The results indicate that for a present value cost of $9,444,000, a present value benefit of $14,619,000 is accrued over the 15 year period. The program has a present value net benefit of $5,175,000 and a benefit/cost ratio of 1.55. If the program start is delayed, the benefit/cost ratio would remain unchanged. However, the present value (base year 1977) net benefit would be divided by 1.1^N, where N is the number of years the program is postponed.

TABLE 3-8. HYPOTHESIZED LSR PROGRAM BENEFITS ESTIMATE

FISCAL YEAR	YEARLY VALUE[a] R&D COSTS	F&E COSTS	O&M COSTS	STAFF COSTS	TOTAL COSTS	BENEFITS	DISCOUNT FACTOR[b]	PRESENT VALUE[a] COSTS	BENEFITS
1978	750[c]				750		.909	682	0
1979	750				750		.826	620	0
1980		5430[d]			5430		.751	4078	0
1981			275[e]	384[f]	659	2561[g]	.683	450	1749
1982			275	384	659	2561	.621	409	1590
1983			275	384	659	2561	.564	372	1444
1984			275	384	659	2561	.513	338	1313
1985		165[h]	275	384	824	2561	.466	384	1193
1986			275	384	659	2561	.424	279	1085
1987		165	275	384	824	2561	.385	317	986
1988			275	384	659	2561	.350	231	896
1989		165	275	384	824	2561	.318	262	814
1990			275	384	659	2561	.289	190	740
1991		165	275	384	824	2561	.263	217	673
1992			275	384	659	2561	.239	158	612
1993		165	275	384	824	2561	.217	179	556
1994			275	384	659	2561	.198	130	507
1995		165	275	384	824	2561	.180	148	461
Total	1,500	6,420	4,125	5,760	17,805	38,415		9,444	14,619

PRESENT VALUE NET BENEFITS = $5,175,00
BENEFIT/COST RATIO = 1.55

a Thousands of 1976 dollars
b FY77 base year at 10%
c Half the $1.5 million estimate each of two years
d 15 units @ $362,000 per unit
e 15 units @ $18,300 per unit
f 4 units (IFR application) @ $96,000 per unit
g 4 units (IFR application) * 2.2 (Ave. IFR B/C) * $161,000 + 11 units (VFR application) *1.6 (Ave. VFR B/C) *$65,000
h Estimated relocation costs

4. SUMMARY OF RESULTS

The following is a summary of the results from Section 3. The first five items apply to CY 1975, the year for which the study was performed.

1) The CY 1975 analysis suggests a total LSR deployment at approximately 15 to 17 airports (see items (2) through (5) below). Four to six of these would be for radar approach control. Cost increases could lower the potential deployment.

2) Of the 59 non-radar approach control facilities in operation, six appear able to justify economically (with benefit/cost ratios greater than one) radar approach control with an LSR. However, two of these might justify an ASR/RBS and thus may not be LSR candidates.

3) Of the 146 tower cabs without a BRITE display, seven appear to justify economically a BRITE display without radar approach control via an LSR.

4) Of 79 of the 93 TML sites in operation, approximately four have sufficient terrain obstructions and adequate activity to justify an LSR economically.

5) If F&E costs are 20 percent higher than those used in the analysis, six airports which were to receive the LSR for VFR would probably be dropped from the deployment list as no longer cost beneficial.

6) If F&E costs are 20 per cent lower than those used in the analysis, one airport would probably be added to the deployment list for VFR application.

7) A benefit/cost analysis has indicated that if 15 LSRs are deployed in 1980 and operated for the next 15 years, the program (See Section 3.6) would accrue a present value (base year 1977) net benefit of $5,175,000, with a benefit/cost ratio of 1.6.

5. REFERENCES

1. Federal Aviation Administration, "Establishment Criteria for Airport Surveillance Radar (ASR/ATCRBS/BDS)," U.S. Dept. of Transportation, ASP-75-2, December 1975.

2. Federal Aviation Administration, "FAA Air Traffic Activity - Calendar Year 1975," U.S. Dept. of Transportation, ADA 024328, March 1976.

3. Mitre Corporation, "Civil Aviation Midair Collisions Analysis January 1964 - December 1971," prepared for Federal Aviation Administration, FAA-EM-73-8, May 1973.

4. National Climatic Center, Asheville NC, "Ceiling-Visibility Climatological Study and Systems Enhancement Factors," prepared for Federal Aviation Administration, ADA 012105, June 1975.

5. Federal Aviation Administration, "Airway Planning Standard Number One - Terminal Air Navigation Facilities and Air Traffic Control Services," Order 7031.2B, September 1974.

6. Federal Aviation Administration, "FAA ASR Coverage," Draft Final Report, U.S. Dept. of Transportation, FAA-RD-74-103, June 1974.

APPENDIX A

EQUIPMENT COST ESTIMATES

A.1 TELEVISION MICROWAVE LINK (TML)

The TML consists of three major elements. The TML Indicator (TMLI) includes the TV video reciever, antenna, BRITE display and ancillary interface equipment. The TML Transmitter (TMLT) is provided in two classes: a basic single channel unit (Class A) including a PPI, TV camera with a slow decay rate vidicon, a transmitter, and ancillary interface equipment; and a dual channel input (Class B) including two PPIs, two TV cameras, a video mixer, a transmitter, and ancillary equipment. The Class A TMLT provides only radar targets (primary and secondary), while the Class B TMLT provides for alphanumerical data from an ARTS site. The TML repeater (TMLR) is a repeater for use when total transmission range exceeds 10 miles or when line-of-sight transmission is not possible. The TML is a complete turnkey system except for site preparation, which is accomplished by the individual region.

The unit whose costs are estimated here is a standard Class A system with 1 repeater. Data in Reference 6 indicate that the majority of TMLs require a repeater. Basic F&E costs are drawn from the F&E Cost Estimates Summaries Handbook and are presented below.

TABLE A-1. FY76 BRITE-TV REMOTING WITH ONE REPEATER - F&E COSTS

Regional Costs	$43,800
Equipment Costs	119,600
	$163,400

The annual O&M costs are drawn from the data developed under Order 1380.32, Airway Facilities Maintenance Staffing Standard Study, dated November 1975. Average costs are presented below.

TABLE A-2. TML ELEMENT ANNUAL O&M COSTS

TMLT Costs	$3,300
TMLI Costs	1,600
TMLR Costs	1,900
	$6,800

A.2 LIMITED SURVEILLANCE RADAR (LSR)

The primary elements of the LSR are the transmitter/receiver, antenna, signal processor, and display. The signal processor will be digital and will include a new system of clutter rejection called Moving Target Detection (MTD). Due to the digital nature of the target data, an improved (over BRITE) digital display will be possible, as will a convenient telephone line remoting from almost anywhere in the immediate airport area. The following is a list of pertinent features/parameters:

a. Single channel system (not dual channel) MTBF estimated at 500 hours. MTTR estimated at one hour. System availability estimated to be 99.8%.

b. Frequency allocation is with S band (3500-3700 MHz).

c. Coverage is as follows:

   Range = 20 nmi
   Altitude = 10000 ft.
   Minimum Range = 0.5 nmi
   Azimuth = 360 degrees
   Elevation = 1 to 20 degrees.

d. Antenna - 5.5 feet wide, 5 feet high.

Estimates of the F&E and O&M costs are made in Tables A-3 and A-4, respectively.

TABLE A-3. LSR F&E COST ESTIMATE

Radar Procurement costs	
Transmitter/Receiver	$64,000
Antenna/Pedestal	38,000
Signal Processor	30,000
Shelter	5,000
Built-in Test Equipment	10,000
Assembly and Test	20,000
Remoting and Displays	30,000
Total Radar Costs	$197,000
Establishment Cost	
Radar	$197,000
Spares (30%)	59,000
Test Equipment	10,000
MTI Reference Target	1,000
Contractor Turnkey and Shipping	30,000
Installation (Regional related costs)	50,000
Documentation	10,000
Factory Inspection	5,000
Total Establishment Costs	$362,000

TABLE A-4. LSR ANNUAL O&M COST ESTIMATE

Maintenance Costs	
Personnel (0.43 manyear at $19,600)	$8,400
Spares attrition at $100/failure and MTBF = 500 hours	1,700
Equipment Refurbishment	1,000
Maintenance Training	3,000
Utilities (8KW @.05/kwh)	3,500
Test Equipment Replacement and Refurbishment	700
Total Maintenance Cost	$18,300

APPENDIX B
POTENTIAL SAVINGS ESTIMATE

This section uses the results of the sample airport analysis to project potential savings.

B.1 FULL COVERAGE ON RADAR APPROACH CONTROL

There were 233 approach control facilities in CY 1975.[2] Given the location of ASR radars, it is estimated that of these facilities, 174 are radar approach control and 59 are non-radar approach control. In the sample of 52 airports considered in the LSR IFR application analysis, 19 are towers which conduct non-radar approach control. Table B-1 shows the distribution of the 59 facilities, the sample of 19 facilities, and the average B/C ratio for the LSR (under IFR application) for each segment of the distribution. As would be

TABLE B-1. DISTRIBUTION OF CONVENTIONAL APPROACH CONTROL FACILITIES

Annual Instrument Approaches	Number In Total	Number In Sample	Average B/C
0 to 1000	27	4	.78
1000 to 2000	19	8	.86
2000 to 3000	8	6	.93
Over 3000	5	1	.90
	59	19	

expected, the average B/C increases as the volume of instrument approaches increases.

To estimate the overall potential benefits, the average B/C ratio for each segment (based on the sample) was multiplied by the number of actual facilities in each segment, the products combined, and the sum multiplied by the LSR cost estimate. The resulting estimated benefits, assuming full radar approach control, are $8 million per year.

B.2 FULL COVERAGE ON REMOTE BRITE DISPLAYS

As indicated in Table 3-3, there are 146 unequipped cabs which could utilize a BRITE display if remoting were possible (or cost-justified). In the sample of 60 airports considered in the LSR VFR application analysis, 11 have or soon will have a BRITE display via TML. Table B-2 shows the distribution of the 146 unequipped cabs, the sample of 49 unequipped cabs, and the average B/C ratio for the LSR (under VFR application) for each segment of the distribution. As would be

TABLE B-2. DISTRIBUTION OF CABS WITHOUT A BRITE DISPLAY

Annual Itinerant Operations	Number in Total	Number In Sample	Average B/C
0 to 50,000	96	24	.79
50,000 to 100,000	46	23	1.16
100,000 to 150,000	4	2	3.98
Over 150,000	0	0	-
	146	49	

expected, the average B/C increases as the volume of itinerant operations increases. The estimated benefits assuming full BRITE deployment, computed similarly to those for approach control above, are $9.5 million per year.

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