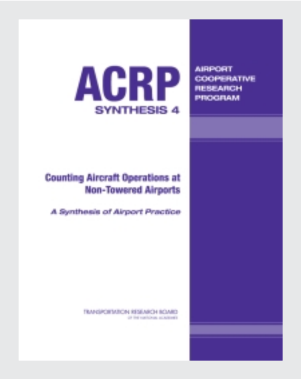

Counting Aircraft Operations at Non-Towered Airports

DETAILS

33 pages | | PAPERBACK
ISBN 978-0-309-42397-7 | DOI 10.17226/23241

AUTHORS

AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP SYNTHESIS 4

Counting Aircraft Operations at Non-Towered Airports

A Synthesis of Airport Practice

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SUBJECT AREAS

Aviation

Research Sponsored by the Federal Aviation Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.

2007

www.TRB.org

AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100–Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI–NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

ACRP SYNTHESIS 4

Project 11-03, Topic 10-01
ISSN 1935-9187
ISBN 978-0-309-09790-1
Library of Congress Control Number 2007931659

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AIRPORT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

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http://www.national-academies.org/trb/bookstore

Printed in the United States of America

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FOREWORD

By Staff
Transportation Research Board

Airport administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the airport industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire airport community, the Airport Cooperative Research Program authorized the Transportation Research Board to undertake a continuing project. This project, ACRP Project 11-03, "Synthesis of Information Related to Airport Practices," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an ACRP report series, *Synthesis of Airport Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis project identifies and evaluates the different methods used by states, airports, and metropolitan planning agencies (MPOs), of counting and estimating aircraft operations at non-towered airports with the goal of identifying best practices. Also identified are any new technologies that can be used for these counts and estimates.

Information used in this study was acquired through a literature review; a survey distributed to all 50 state aviation agencies, and selected airports and MPOs; contacts with manufacturers of counting equipment and aviation trade organizations; and follow-up telephone interviews and e-mail correspondence, where appropriate.

Maria Muia, Aerofinity, Inc., Indianapolis, Indiana, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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COUNTING AIRCRAFT OPERATIONS AT NON-TOWERED AIRPORTS

SUMMARY

Annual aircraft operations estimates are used in aviation system planning, airport master planning, environmental studies, aviation forecasts, and to determine funding and design criteria for the nation's airports. At airports with air traffic control towers, aircraft operations are tracked and recorded by the air traffic controller. Most airports in the United States, however, do not have air traffic control towers. These airports are generally known as non-towered airports, and they make up the vast majority of the airports open to the public for business. Accordingly, unlike with larger towered airports, these non-towered airports do not have readily available records on aircraft activity. Consequently, many state aviation agencies and some airports and metropolitan planning organizations (MPOs) have developed aircraft traffic counting programs to track airport activity at their airports. However, many have not. For airports without air traffic control towers and/or with part-time towers, the number and type of operations may be based on the best guess of the airport manager or on prior-year counts, factored for assumed growth. It would be desirable to know and use the most accurate means of counting and estimating actual operations at these smaller airports. The corresponding operations data collected could then be included on FAA Airport Master Record Form 5010, because this form is often used as a source for these data in the system planning, master planning, forecasting, and funding operations.

This synthesis project determines the practices for counting and estimating aircraft operations at non-towered airports. A literature review was conducted to establish previous research and findings on counting and estimating aircraft operations at these airports. Additionally, questionnaires were sent to all 50 state aviation agencies and selected airports and MPOs that were known to have traffic counting programs to determine their methods of counting and estimating aircraft operations at non-towered airports. A total of 61 questionnaires were sent and 51 were returned, an 84% response rate. Crossover technology was researched and traffic counting manufacturers and aviation trade organizations were also contacted. This was done to help determine current and potential technology for counting and estimating aircraft operations and also to help obtain previous research completed on the topic.

Through this synthesis report it was revealed that a variety of methods are being used across the country to count and estimate aircraft operations, and these methods vary in accuracy. These methods are:

- Count traffic year-round,
- Sample traffic and extrapolate annual operations,
- Multiply a predetermined number of operations per based aircraft by the total aircraft based at the airport,
- Perform regression analysis, and
- Ask the airport manager or personnel associated with the airport.

The most common method used by the respondents to this study's questionnaire is also the most inaccurate of the methods currently in use, which is simply asking the airport

manager or other related airport personnel what they believe the annual aircraft operations are for their airport. The Texas Department of Transportation's *1994 Aircraft Activity Counter Report* found that an airport's operations can be as much as doubled when estimated by the airport manager as opposed to sampling traffic with an acoustical counter and extrapolating the sample into an annual estimate. The most accurate method currently in use is to deploy an aircraft traffic counter(s) at an airport year-round, which in theory counts all traffic at the airport. Seven respondents used this method, four of which were airports.

Another method believed to be accurate is to sample traffic with some type of aircraft counter for two weeks in each of the four seasons and to expand that sample into an annual count. The method relies on a valid extrapolation from the sample to annual operations. However, only 6 of the remaining 12 respondents that sampled traffic actually did so for two weeks in each of the four seasons. The final six did not sample in all four seasons, making their results less accurate than those that sampled during all seasons or year-round.

The method used to expand the sample count to an annual estimate was most often done with a seasonal or monthly adjustment factor. How the adjustment factor was determined for each respondent was not covered in this study's questionnaire and is recommended for further study. Previous research indicated that towered airports were not a valid way to develop adjustment factors for non-towered airports partially because of the availability of more instrument approaches at towered airports, which supposedly made them accessible during inclement weather. This may have been the case more than 20 years ago, but more and more non-towered airports have instrument approaches today.

There are currently six different methods being used to sample aircraft traffic:

- Acoustical,
- Airport guest logs,
- Fuel sales,
- Pneumatic,
- Video image detection, and
- Visual.

Use of airport guest logs and fuel sales, although helpful, will not track all traffic because not all pilots sign a guest log and because not all aircraft purchase fuel with each flight. Additionally, neither of these methods will account for touch-and-go operations. Of the equipment currently being used to sample traffic, the acoustical (including the sound-level meter and computerized acoustical) and video image detection systems offer acceptable levels of accuracy in detecting aircraft, both estimated by the manufacturers to be in the 90% range. The acoustical systems are generally less expensive than the video systems, although the video systems offer more information such as aircraft tail numbers. Visual sampling of traffic by a human observer is very accurate, but also very costly and time-consuming.

In summary, it is believed that the most accurate and cost-effective way to estimate aircraft operations at a non-towered airport is to sample traffic for two weeks for each of the four seasons and extrapolate that sample into an annual estimate. This would be considered the best practice if year-round counts are not feasible. As stated earlier, the acoustical counter provides a cost-effective, efficient, and accurate way to collect the sample, whereas the video image detection system, although more costly, adds additional information that may be useful to the airport. Pneumatic counters and inductance loop counters have several serious limitations and would only be useful at airports that have a most simple configuration of one runway and one entry taxiway. Airport guest logs and fuel sales are also not recommended as a way to count traffic.

The information received by the states, airports, and MPOs from their aircraft traffic counting programs is being used for a variety of purposes, including justification for airport improvement projects, justification for air traffic control towers, airport environmental documentation, forecasting, economic impact statements, performance measures, FAA Airport Master Record Form 5010 reporting, system planning, justification for navigational aids, and airport planning studies. Because the most common method for estimating aircraft operations (asking the airport manager or other airport personnel) may not be accurate, the information being used for these purposes may also be assumed not to be accurate. Additionally, because the methods being used to count and estimate aircraft operations at non-towered airports vary in accuracy, the results are not comparable among the airports.

As stated earlier, airport operations data are being used on FAA Airport Master Record 5010 forms. Each airport has an Airport Master Record that is produced under the guidelines of the FAA Airport Safety Data Program. The information on the Airport Master Record is made available to the general public to use at their discretion. The FAA Order directs the airport inspector to record the total number of general aviation operations that occur at the airport. It further stipulates that the inspector is to use "FAA tower counts where available. If not available from FAA sources, use estimates based on discussion with airport management and/or the fixed base operators." State aviation agencies and the FAA should coordinate the collection and reporting of accurate airport operations data. This can be accomplished by: (1) encouraging widespread use of appropriate practices identified in the synthesis; (2) when such practices are used, including information in the Airport Master Record Form 5010; and (3) considering changing the format of Form 5010 to identify the counting practices used.

CHAPTER ONE

INTRODUCTION

STATEMENT OF PROBLEM

Annual aircraft operations estimates are used in aviation system planning, airport master planning, environmental studies, aviation forecasts, and to determine funding and design criteria for the nation's airports. At airports with air traffic control towers, aircraft operations are tracked and recorded by the air traffic controller; however, most airports in the United States do not have air traffic control towers (*1*). Such airports are generally known as non-towered, and they comprise the vast majority of the airports open to the public. Accordingly, unlike the larger towered airports, these non-towered airports do not have readily available records on aircraft activity. Consequently, many state aviation agencies and some airports and metropolitan planning organizations (MPOs) have developed aircraft traffic counting programs to track airport activity at their airports, although many have not. For airports without air traffic control towers or with part-time towers, the number and type of operations may be based on the best guess of the airport manager or on prior-year counts, adjusted for assumed growth. Knowledge of the most accurate means of counting and estimating actual operations at these smaller airports would be desirable. The corresponding operations data collected could then be included on FAA Airport Master Record Form 5010, because this form is often used as a source for these data in system planning, master planning, forecasting, and funding.

PURPOSE OF STUDY

This synthesis project identifies and evaluates the different methods of counting and estimating aircraft operations at non-towered airports being used by the states, airports, and MPOs. It also identifies any new technology that could be used to count and estimate aircraft operations.

RESEARCH METHODOLOGY

In *Practical Research: Planning and Design,* Leedy states that the qualitative approach is a logical methodology for research in business (*2*). This study follows Leedy's rationale and uses predominantly a qualitative approach where data are gathered by means of a questionnaire, telephone interviews (where necessary), e-mail correspondence, and published studies and texts.

On November 28, 2006, the survey questionnaires were distributed by e-mail by NASAO to all state aviation agencies. The survey was also sent to a few airports and MPOs known by the topic panel members to have aircraft traffic counting programs, in addition to any revealed by state aviation agencies when they responded to the questionnaire. Those agencies that did not respond were contacted directly. The questionnaire included 16 questions about the respondent's method(s) for estimating aircraft operations at non-towered airports. If equipment was used to sample traffic, the questionnaire asked about the type of equipment, the cost, and the number of runways it covered. The questionnaire also asked about the time it took to use the respondent's method, the strengths and limitations of the method, and what each respondent used the resulting operations data for.

In addition, a comprehensive review of the literature related to aircraft traffic counting and estimating of operations at non-towered airports was undertaken. Transportation Research Information Services (TRIS) Online, hosted by the National Transportation Library, was included in this search, in addition to Internet searches using various search engines.

Various aviation industry trade organizations were also contacted for any information they might have on this subject. Potential crossover technology was also investigated to determine if there was any other technology that could count aircraft as a spin-off use from its intended purpose.

QUESTIONNAIRE RESPONSE RATE

Questionnaires were sent to the 50 state aviation agencies of the United States, 7 airports, and 4 metropolitan or regional planning organizations to ascertain the methods they use to count and estimate aircraft operations at non-towered airports. Two states (Idaho and Oregon) each completed two questionnaires. Idaho completed one questionnaire for its state-managed airports and one for the rest; both responses are included. Oregon returned responses from a current employee and a former employee familiar with their aircraft traffic counting program. Its responses were consolidated into one. Of the 51 questionnaires returned (an 84% response rate), 45 were from state aviation agencies, 5 from airports, and 1 from an MPO. Of the 50 states aviation agencies, 44 were represented; 88% of the states.

DEFINITION OF TERMS

- Advisory circular (AC)—advisory circulars are published by the FAA to inform the public in a systematic way of nonregulatory material. They are issued to provide guidance and information in a designated area or to demonstrate an acceptable manner for complying with a related Federal Aviation Regulation (*3*). Compliance with FAA Advisory Circulars is mandatory for obligated airports.
- Distance measuring equipment (DME)—equipment (airborne and ground) that measures the slant range distance of an aircraft from the DME navigation aid in nautical miles (*4*).
- Federal Aviation Regulations (FAR)—a set of regulations (Chapter I of Title 14 of the Code of Federal Regulations) established to promote the safety of civil aviation both domestically and internationally (*5*).
- Fixed base operator—a business operation at an airport that provides, but is not limited to, such services as aircraft sales, aircraft maintenance, flight instruction, and charter flights (*5*).
- General aviation—all aviation other than military and commercial common carriage, including business flying, flight instruction, personal flying, and commercial flying such as agricultural pesticide spraying and aerial photography (*5*).
- Operation—a takeoff or a landing at an airport (*6*).
- Magnetometer—an instrument used to measure the intensity and direction of a magnetic field (*7*). In traffic counting, the detector measures the difference in the level of the earth's magnetic forces that occurs when a vehicle passes near its sensor and a count is recorded.
- Acoustical—of or relating to sound, the sense of hearing, or the science of sound (*7*). In traffic counting, a detector monitors acoustic signals and records a count when the signal matches an aircraft takeoff.
- Pneumatic—of or relating to air or other gases (*7*). In traffic counting, a tube is installed across a taxiway and when an aircraft travels over the tube a pulse of air activates the counter to record the movement.

CHAPTER TWO

LITERATURE REVIEW

INTRODUCTION

A literature review was conducted for this synthesis project that consisted of performing searches on the TRIS database, which is the largest and most comprehensive resource of published transportation material. Internet searches were also done using various search engines.

Additionally, material suggested by the TRB project committee was also reviewed. The bibliographies from the literature from all of these sources were also reviewed for any potential sources that could be included in this literature review.

This review generally found that previously published literature on this topic was minimal and most of it was dated. A detailed review the literature is included as Appendix C. Where detailed statistical analysis was performed, it was included in the review.

CONCLUSIONS FROM LITERATURE REVIEW

As determined by the selected review of the literature, the preferred method to sample aircraft traffic is by the use of acoustical counters. Although it is the method used most often in the reviewed studies, the acoustical counter's ability to accurately record helicopter operations appears questionable (*8*, p. 1; *9*, p. 42).

Most researchers agreed that stratified cluster samples of two-week periods during each season are the most statistically acceptable form of sampling. One study developed a model based on only a one-week count. The accuracy of this method could not truly be calculated because observed operations were not available (*10*, p. 29).

The studies reviewed generally concluded that weather was not a good predictor of aircraft operations. There was no consensus however on the use of fuel sales to predict operations. Furthermore, there are also contradictions as to whether operations at towered airports can be used as an estimator of operations at non-towered airports (*11*, p. 22).

Another conclusion resulting from this selected review is that there are different methods being used throughout the states to count and estimate aircraft operations at non-towered airports. Because there are different methods being used and because those methods vary in accuracy, the results can be called into question, in addition to not being comparable among airports. Because information on airport operations has been used for so many purposes (planning and programming of airport development projects, assessing the environmental impact of those projects, evaluating the need for air traffic control towers, determining airport fueling and staffing needs, evaluating airport capacity, and assessing the economic impact of an airport on a particular community), it is imperative that the information be as accurate as possible. Without accurate information on aircraft operations at non-towered airports, the managerial, operational, and financial decisions being made based on these data may come into question. Therefore, the need for an accurate method of counting and estimating aircraft operations at non-towered airports is important.

The literature review also revealed that the FAA has provided funding to states for aircraft traffic counting programs. However, this information was not always used on the FAA's Airport Master Record 5010 Form (*12*).

In the following chapter, the methods being used by state aviation agencies and selected airports across the country to count and estimate airport operations for accuracy, efficiency, and cost-effectiveness will be identified and evaluated.

CHAPTER THREE

RESEARCH FINDINGS

INTRODUCTION

This chapter reviews the type of equipment that was found to be used to count aircraft traffic. It also covers crossover technology and its potential for counting aircraft traffic. Finally, this chapter reviews the specific findings as derived from the responses to the survey questionnaire sent to states and selected airports and MPOs.

AIRCRAFT TRAFFIC COUNTING TECHNOLOGY

Aircraft traffic counters have developed over time in response to the need for information about activity levels at non-towered airports; however, there are a limited number of manufacturers producing this equipment. The first devices used to count aircraft operations, pneumatic counters, were based on the technology used to count vehicles. The pneumatic tube counter uses a tube installed across the taxiway surface to record each aircraft as it travels over the tube. On contact with the tube, a pulse of air is triggered that activates a counter to record a movement. These counters cannot distinguish between types of aircraft, between aircraft and vehicles, and do not count touch-and-go operations.

The inductance loop counter is another type of counter that transitioned from counting vehicles to counting aircraft. Unlike the portable pneumatic tube, the inductance loop is a wire embedded in the pavement of the runway. Operations are counted as aircraft pass over or fly within a few feet of the surface of the loop. As with pneumatic tubes, inductance loop counters do not distinguish between aircraft and vehicles and will not record most touch-and-go operations.

Another type of counter developed specifically for use at airports was the tape recorder acoustical counter. A doppler shift triggers the equipment to record the sound of aircraft takeoffs. Landings do not trigger the recording equipment. The tape is audited to determine total takeoffs. For every takeoff there is an assumed landing, so the count is doubled to determine total operations for the sampled time. This counter is labor intensive in that it requires the cassette tapes to be audited (listened to) to determine total operations. No known manufacturers were found that still make this equipment.

A third type of counter, also acoustical, was developed specifically for aircraft traffic counting. The equipment is deployed within approximately 50 yards of the runway and operates by monitoring acoustic signals and recording only those that match those of an aircraft takeoff. This is a computerized unit similar to the tape recorder acoustical counter. It requires downloading data onto a laptop computer and subsequent review of the data to delete any false counts. The time to perform this function is minimal because it is computerized. (This counter will hereafter be referred to as the automated acoustical counter.) This equipment has extremely low power requirements and can be operated with a battery and solar power unit for recharging, allowing it to be left in the field for months at a time. It is rugged and operates in all weather conditions. The software is designed to detect aircraft takeoffs; therefore, the count is doubled to determine total operations for the sampled time. It cannot distinguish between aircraft type, but will detect touch-and-go operations. A video system can be added to this equipment to record images.

A fourth type of counter (also acoustical) employed to record aircraft operations uses sound-level meter technology originally designed for environmental noise monitoring. (This counter will hereafter be referred to as the sound-level meter acoustical counter.) As a by-product of measuring noise, this meter is able to differentiate aircraft noise from other noise through software and thereby count aircraft operations. This system uses existing sound-level meters currently on the market and software designed to detect aircraft takeoffs. It also requires the downloading of the stored data onto a laptop computer and subsequent review to delete any false counts. These systems are rugged, use low power, operate in all weather conditions, and can be left in the field for approximately a month at a time.

Another type of aircraft counter in use is a video image detection system that records video of aircraft movement by means of cameras. This equipment was originally developed for security purposes and a spin-off use is for counting aircraft traffic. The camera/recorder is event-driven and is triggered by motion or by a light-to-dark transition in the screen and records the movement to a hard drive. Depending on the system chosen, the video can then be audited by airport staff or the service provider to identify tail numbers and count traffic. It is labor intensive if airport staff have to review the images and determine operations. This equipment does allow for identification of aircraft tail numbers and subsequent determination of aircraft make and model. As a result, an airport's critical aircraft and subsequent airport reference code can be determined. If a service provider is used, time involved is minimal, but costs increase.

POTENTIAL CROSSOVER TECHNOLOGY

The magnetometer has been researched as a way to count aircraft operations. Magnetometer technology is currently used at airport security checkpoints to detect metal devices on travelers. Magnetometers are also used in roadway applications to count vehicles passing over the road surface, but was unsuccessful for recording aircraft because of the limited amount of metal in the aircraft and the limitations on the narrow physical area the magnetometer can cover. Taxiways and runways vary in width from 50 ft to 150 ft. The aircraft fuselage and landing gear width can be significantly smaller. Because the aircraft can vary its route over the entire width of the taxiway or runway, the magnetometer's range of detection is too small to reliably detect the aircraft.

Radar has been used to count vehicular traffic on roadways. It can detect distant objects and determine their position, as in aircraft radar used for air traffic control. The system works by directing a high-frequency radio wave at the road surface and timing its return signal (*13*). The ability to count aircraft technically appears feasible; however, the location and range of the sensor in relation to a runway would require extensive testing to determine its potential as an effective counting method. Research on the use of this technology to count aircraft has been conducted by the Iowa Department of Transportation; however, no conclusions have been reached as to its accuracy or cost-efficiency.

Aircraft navigational systems currently in place may have the ability to count aircraft traffic. Discussions with a manufacturer of navigational equipment worldwide indicated that no known research had been done in this area; however, the use of distance measuring equipment (DME) was a possibility, but it also had some inherent problems that would need to be overcome. DME works on an ultra high frequency, where the aircraft DME equipment transmits an interrogation signal to a ground station that transmits a signal back. The aircraft's distance is measured based on the time it takes for this signal exchange. Research would be needed to determine how the ground station could count the interrogation signals, uniquely identify them to an aircraft, and determine if it landed.

Automatic Dependent Surveillance—Broadcast (ADS-B) is a surveillance concept whereby an airborne or ground vehicle broadcasts its position and the position is received by another application. For example, an aircraft broadcasts its latitude, longitude, altitude, and velocity and other aircraft or systems receive this information for use in a wide variety of applications. ADS-B is an enabling technology for many new applications that are being developed to improve airborne and airport safety and capacity (*14*). This technology provides an accurate, low-cost way to gather position information, and one potential application is counting an airport's operations.

INDUSTRY TRADE ORGANIZATIONS CONTACTED

As part of this research project, several aviation organizations were contacted to determine if they had conducted any research on aircraft traffic counting methods. The AAAE, Airports Consultants Council, Helicopter Association International, National Business Aviation Association (NBAA), and ACI–NA all indicated that they had not performed any such research, nor did they have any information on methods to count aircraft operations at non-towered airports.

METHODS USED TO COUNT AND ESTIMATE AIRPORT OPERATIONS

One of the primary functions of the questionnaire was to determine the method used by each of the respondents to count and estimate aircraft operations at non-towered airports. The responses are shown in Table 1.

The questionnaire results indicated that the most popular method used to count and estimate operations is by simply asking the airport manager, FBO, or other personnel associated with the airport (21 respondents use this method). The next most popular method is to extrapolate a sample count into an annual estimate (19 respondents use this method). The third most popular method is to multiply a predetermined number of operations per based aircraft. Of the 13 respondents that use this method, 2 supplied their predetermined numbers: Louisiana used 500 local and 250 itinerant operations per based aircraft and Washington used 250 (low), 350 (medium), and 450 (high) operations per based aircraft, depending on the activity of the airport. Nine respondents indicated that they used more than one method to count and estimate operations; therefore, when categorized, some respondents are recorded under multiple methods, which is why the results in Table 1 add up to more than the total number of questionnaires distributed.

As stated earlier, 19 respondents take sample counts of operations at non-towered airports. The type of equipment used to take these samples varied. A breakdown of the types of equipment is shown in Table 2. Of these 19 respondents, 3 indicated that they used more than one method, which is why the results add up to more than 19.

The most common method used by the survey respondents to sample operations is acoustical counters. Sixteen respondents used this method. There are three types of acoustical counters currently being used: the computerized acoustical counter, tape recorder acoustical counter, and sound-level meter acoustical counter. Eight respondents currently use the computerized model, two use the tape recorder model, and six use the sound-level meter model.

Of the respondents that take samples by the means identified in Table 2, the lengths of the samples vary. Table 3 summarizes the length of samples taken by each respondent.

TABLE 1
METHOD USED TO COUNT AND ESTIMATE AIRCRAFT OPERATIONS

Ask Airport Manager, FBO, or Other Personnel Associated with the Airport	Multiply a Predetermined Number of OPSBA	Take Sample Count	Other	Do Not Track This Information	Multiple Methods (listed elsewhere in this exhibit)	Did Not Respond
21	13	19	6	3	9	10
Alabama	Colorado	California	Arizona	Flagler County Airport[c]	Colorado	Alaska
Arkansas	Florida	DVRPC	Colorado	Missouri	Kansas	Connecticut
Colorado[a]	Georgia[b]	Idaho: state-owned airports	New Hampshire	Nevada[d]	Maryland	Delaware
Idaho: non-state-owned airports	Iowa	Illinois	New York		New Hampshire	Denver Regional Council of Governments
Kansas	Kansas	Indiana	Utah[e]		New York	Hawaii
Louisiana[g]	Maryland	Maryland	Virginia		Pennsylvania[f]	Kentucky
Maine	Pennsylvania: non-DVRPC-counted airports	Michigan[h]			Utah	Massachusetts
Minnesota	Rhode Island	Nevada[d]			Washington	Metropolitan Transportation Commission of San Francisco Bay Area
Mississippi	South Carolina	New Mexico			Wisconsin	New Jersey
Montana	Tennessee	New York[i]				Southern California Association of Governments
Nebraska	Texas	Oregon				
New Hampshire	Washington	Reno Stead Airport				
North Carolina	Wisconsin	Taos Regional Airport				
North Dakota		Upshur County Regional Airport				
Ohio		Utah[e]				
Oklahoma[j]		Vermont				
Pennsylvania: non-DVRPC-counted airports		Visalia Airport				
South Dakota[k]		Watsonville Airport				
Washington		Wyoming[l]				
W. Virginia						
Wisconsin						

Notes: OPSBA = operations per based aircraft; DVRPC = Delaware Valley Regional Planning Commission; FBO = fixed base operator.
[a]Colorado estimates from airport managers, using OPSBA to help validate. They also track fuel sales, which they feel gives them a good gauge of activity.
[b]Georgia adjusts the count seasonally by usage type (agricultural operations, flight schools, etc.).
[c]Flagler County Airport has the ability to count traffic with its video detection system, but does not use it for this purpose.
[d]Nevada expanded sample counts in the past, but is no longer tracking this information.
[e]Utah uses a statistical model for non-sampled airports.
[f]Pennsylvania uses OPSBA for master and system planning, but asks the airport manager for the FAA Master Record Form 5010.
[g]Louisiana asks the airport manager, who may use OPSBA or guest logs or fuel sales.
[h]Michigan is no longer performing traffic counts owing to budget constraints as of 2007.
[i]New York does not presently conduct a counting program, but did in the past with acoustical counters. For airports not sampled, the airport managers or owners estimated average weekday and weekend day landings during the peak season, and these figures were multiplied by modifiers that considered various factors (including paved versus turf runway).
[j]Oklahoma asks the airport manager. Approximately eight of their airports keep traffic logs.
[k]South Dakota asks the airport manager, who may use visual counts and/or airport guest logs to answer the FAA Master Record 5010 Form.
[l]Wyoming does not use equipment to take sample counts. The airport managers co unt or guest logs are used.

Seven of the 19 respondents count traffic all year round or during the operational seasons of the airport; therefore, theoretically, they count all the operations rather than take a sample. Six of the 19 respondents that sample airport traffic take samples in all four seasons and use a seasonal or monthly adjustment factor to extrapolate the sample into an annual count. In addition, two respondents sample in three seasons and four sample in two or fewer seasons.

ACCURACY AND EFFICIENCY

The survey also included accuracy and efficiency questions related to the aircraft operations counting devices. For those respondents that did not sample traffic, the accuracy was generally unknown. Also, for those respondents that did not sample traffic, time expended was negligible (i.e., the time it took to ask airport personnel what their annual traffic was or to multiply total based aircraft by a set number of operations per based aircraft), except for those that estimated annual airport operations through an airport master plan or system planning process. Generally, the video image detection, sound-level meter, and computerized acoustical counters were reported to be the most accurate systems, usually reporting 80% to 100% accuracy.

The most labor-intensive method to count and estimate aircraft operations is through visual observation. The tape

TABLE 2
EQUIPMENT USED TO TAKE SAMPLE COUNTS

Computerized Acoustical Counter	Tape Recorder Acoustical Counter	Sound-Level Meter Acoustical Counter	Pneumatic Tube Counter	Video Image Detection	Visual	Airport Guest Logs
8	2	6	2	1	2	1
Idaho: state-managed airports Indiana Nevada[d] New Mexico Reno Stead Airport Taos Regional Airport Utah[e] Vermont	Oregon New York[b]	California DVRPC Maryland Utah[e] Visalia Airport Watsonville Airport	Illinois Michigan[c]	Upshur County Regional Airport	Illinois Wyoming[a]	Wyoming[a]

Notes: DVRPC = Delaware Valley Regional Planning Commission.
[a]Wyoming does not use equipment to take sample counts. The airport managers' count or guest logs are used.
[b]New York does not presently conduct a counting program, but did in the past with acoustical counters.
[c]Michigan is no longer performing traffic counts owing to budget constraints as of 2007, but used visual and pneumatic in the past.
[d]Nevada expanded sample counts in the past, but is no longer tracking this information.
[e]Utah uses two types of counters and a statistical model for non-sampled airports.

TABLE 3
SAMPLE LENGTHS AND SEASONS

Respondent	Sample Period and Season	Extrapolation Method
California	6 weeks; 2 weeks per three seasons (July–October, November–February, March–June)	Seasonal or monthly adjustment factor
Delaware Valley Regional Planning Commission	8 weeks; 2 weeks per season	Seasonal or monthly adjustment factor
Idaho: state-managed airports (turf strips)	All months that the airports operate (approximately April–October)	N/A
Illinois	One monthly for pneumatic counters; visual counts for five consecutive 12-h days including a weekend; do not sample more than one season	Seasonal or monthly adjustment factor
Indiana	5 weeks; do not sample more than one season	Seasonal or monthly adjustment factor
Maryland	8 weeks; 2 weeks per season	Seasonal or monthly adjustment factor
Michigan[a]	1.5 months; spring and summer	Seasonal or monthly adjustment factor
Nevada[b]	2 months; do not sample more than 1 season	Seasonal or monthly adjustment factor
New Mexico	2–4 weeks per season	Seasonal or monthly adjustment factor
New York[c]	2 weeks per season	Seasonal or monthly adjustment factor
Oregon	6–9 weeks; winter, spring, and summer	Seasonal or monthly adjustment factor
Reno Stead Airport	All year	N/A
Taos Regional Airport	All year	N/A
Upshur County Regional Airport	All year	N/A
Utah[d]	4 months; one month per season	Seasonal or monthly adjustment factor
Vermont	All year	N/A
Visalia Airport	4 months; one month per season	Seasonal or monthly adjustment factor
Watsonville Airport	All year	N/A
Wyoming[e]	All year	N/A

Notes: N/A = not available.
[a]Michigan is no longer performing traffic counts owing to budget constraints as of 2007, but used visual and pneumatic in the past.
[b]Nevada expanded sample counts in the past, but is no longer tracking this information.
[c]New York does not presently conduct a counting program, but did in the past with acoustical counters.
[d]Utah uses two types of counters and a statistical model for non-sampled airports.
[e]Wyoming does not use equipment to take sample counts. The airport managers' count or guest logs are used.

recorder acoustical counter method is also labor-intensive because the tapes must be audited to determine total operations. The video image detection system used by Upshur Country Regional Airport required one-half hour every two to three days to review the images. If a system is chosen that uses a service provider, the images are communicated by means of the Internet to a central location where they are analyzed, stored, and communicated back to the airport. Accordingly, there is no effort expended by the airport to determine its aircraft operations. The remaining methods to sample traffic typically took less than 2 h per counter deployment. Table 4 summarizes the accuracy and time involved by each respondent who sampled aircraft traffic.

The method used to expand the sample count to an annual estimate was most often done with a seasonal or monthly adjustment factor. How the adjustment factor was determined for each respondent was not covered in this study's questionnaire and is recommended as a subject for further study. Previous research indicated that towered airports were not a valid way to develop adjustment factors for non-towered airports partially because of the availability of more instrument approaches at towered airports, which supposedly made them accessible during inclement weather. This may have been the case more than 20 years ago; however, an increasing number of non-towered airports now have instrument approaches.

TABLE 4
ACCURACY AND TIME INVOLVED FOR RESPONDENTS THAT SAMPLED TRAFFIC

Respondent	Accuracy	Accuracy Test	Approximate Hours Per Count (excluding travel time to airport)
Sound-Level Meter			
California	80%–100%	Yes	Greater than or equal to 2, but less than 4
DVRPC	80%–100%	Yes	Less than 2
Maryland	80%–100%	Yes	Less than 2
Utah[a]	80%–90%	No	Less than 2
Visalia Airport	70%–80%	Yes	Less than 2
Watsonville Airport	70%–80%	Yes	Less than 2
Computerized Acoustical Counter			
Idaho: state-managed airports (turf strips)	80%–100%	Yes	Less than 2
Indiana	80%–100%	Yes	Less than 2
Nevada[b]	80%–100%	Yes	Less than 2
New Mexico	80%–100%	Yes	Less than 2
Reno Stead Airport	80%–100%	Yes	Less than 2
Taos Regional Airport	80%–100%	No	Less than 2
Utah[a]	80%–90%	No	Less than 2
Vermont	70%–80%	No	Greater than or equal to 2, but less than 4
Tape Recorder Acoustical Counter			
New York[c]	Unknown	N/A	Unknown
Oregon	<60%	No	16
Video Image Detection Counter			
Upshur County Regional Airport	80%–100%	Yes	½ hr every 2–3 days
Pneumatic Tube Counter and Visual			
Michigan[d] (pneumatic tube counter)	60%–70%	Yes	Less than 2
Illinois (pneumatic tube counter and visual)	Unknown	N/A	Less than 2 for pneumatic; Greater than 60 for visual
Visual and Airport Guest Logs			
Wyoming[e] (visual and airport guest logs)	Unknown	N/A	Less than 2

Note: Approximate hours per count includes the answers from Question 10 on the questionnaire, which included person-hours required to perform a traffic count at the airport excluding travel time to the facility. DVRPC = Delaware Valley Regional Planning Commission; N/A = not available.
[a]Utah uses two types of counters and a statistical model for non-sampled airports.
[b]Nevada expanded sample counts in the past, but is no longer tracking this information.
[c]New York does not presently conduct a counting program, but did in the past with acoustical counters.
[d]Michigan is no longer performing traffic counts owing to budget constraints as of 2007, but used visual and pneumatic in the past.
[e]Wyoming does not use equipment to take sample counts. The airport managers' count or guest logs are used.

TABLE 5
USES OF OPERATIONS DATA

Respondent	Justification for Airport Development Projects	Justification for Airport Control Towers	Environmental Assessment or Impact Documentation	Aviation Forecasts	Economic Impact Statements	Measure of Performance	Airport Master Record (5010 Form)	Other	N/A
	28	5	8	25	17	11	39	11	3
Alabama	√						√		
Arizona								√	
Arkansas				√	√	√	√		
California	√	√		√			√	√	
Colorado							√		
DVRPC	√		√	√	√	√	√	√	
Flagler County Airport[a]									√
Florida	√			√			√	√	
Georgia							√		
Idaho—Statewide Program							√		
Idaho—30 State-Managed Airports	√				√	√			
Illinois	√			√			√	√	
Indiana	√						√		
Iowa	√			√	√		√		
Kansas							√		
Louisiana								√	
Maine							√		
Maryland				√	√		√		
Michigan[b]	√			√	√				
Minnesota							√		
Mississippi							√		
Missouri									√
Montana	√						√		
Nebraska	√		√	√			√		
Nevada[c]	√								
New Hampshire	√		√	√	√		√		
New Mexico	√	√		√			√		
New York[d]								√	
North Carolina	√	√	√	√	√	√	√		
North Dakota	√			√	√	√	√	√	
Ohio	√								
Oklahoma							√		
Oregon	√	√		√			√	√	
Pennsylvania							√		
Rhode Island	√			√			√		
Reno Stead Airport	√			√	√		√		
South Carolina	√		√	√	√		√		
South Dakota							√		
Taos Regional Airport	√			√		√	√		
Tennessee							√		
Texas									√
Upshur County Regional Airport	√			√	√	√	√		
Utah		√	√	√			√		
Vermont	√		√	√	√	√	√		
Virginia	√			√	√	√			
Visalia Airport	√			√	√	√	√		
Washington								√	
Watsonville Airport	√			√	√	√	√	√	
West Virginia							√		
Wisconsin							√		
Wyoming	√		√	√	√		√		

Notes: DVRPC = Delaware Valley Regional Planning Commission; N/A = not available.
[a]Flagler County Airport is able to track operations counts with their video image detection system, but they do not use their system for this purpose.
[b]Michigan is no longer performing traffic counts owing to budget constraints.
[c]Nevada expanded sample counts in the past, but is no longer tracking this information.
[d]New York does not presently conduct a counting program, but did in the past.

TABLE 6
OTHER USES OF OPERATIONS DATA

Respondent	Other Use
Arizona	Airport master plans
California	Airport master plans
DVRPC	Regional airport system planning
Florida	System plan
Illinois	Inventory report
Louisiana	None
New York	System plan eligibility; FAA Reliever Designation for Privately Owned Airports
North Dakota	GPS and AWOS site justification; local–itinerant operations split; percentage of aerial spray operations; percentage of air taxi operations; percentage of military operations
Oregon	Justification to keep airport open
Washington	System planning; master planning
Watsonville Airport	Political: value of airport to city officials to counter anti-airport groups

Notes: DVRPC = Delaware Valley Regional Planning Commission; GPS = global positioning system; AWOS = aviation weather observing system.

COSTS

The cost associated with estimating aircraft operations at non-towered airports varies depending on the method employed. Costs include equipment (capital purchase and installation) and operating (maintenance, data collection, and analysis) costs. This section looks only at equipment costs. If operations estimates are obtained simply by asking airport staff what their operations are, then the cost is negligible and there are no equipment costs.

If sample counts are taken, the cost of the equipment varies depending on the approach taken. The sound-level meters and computerized acoustical counting equipment costs range from approximately $4,500 to $5,600 per counter. Owing to the nature of the equipment, one acoustical counter can usually count only one runway. If the runway is exceptionally long, more than one counter may be needed for one runway.

Video image detection equipment costs vary depending on the runway configuration. Minimally, approximately $20,000 would be required to count a one-runway airport.

If pneumatic counters are used, the equipment costs vary depending on the complexity of the airport layout. One counter is needed for each entry and exit to the runway. If a runway has four exits, then four counters could be needed. The cost of each counter is approximately $400.

Visual counts have no associated mechanical equipment, but are the most expensive because this method is labor intensive, requiring hours of visual survey. Volunteers could be used to perform this function, but quality control could be an issue.

USES OF DATA

Respondents were also requested to report on their uses of the aircraft traffic data they collected. The most common use of the data was to include it on the FAA Airport Master Record Form 5010 (39 respondents did this). The next most common use of the data was for justification for airport development projects (28 respondents did this), followed closely by use in aviation forecasts (25 respondents did this). Seventeen respondents use the data in economic impact studies, 11 as a measure of performance (i.e., is the airport being utilized to an acceptable level for its given capacity), and 8 for environmental studies. Additionally, five respondents indicated that they had used it to justify air traffic control towers. The uses are detailed in Table 5 by respondent.

The other uses for the data, as provided by the respondents, are shown in Table 6.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

This synthesis report has documented practices that are in use by some state aviation agencies, airports, and metropolitan planning organizations to count and estimate airport operations at non-towered airports. This study revealed that the following methods are being used across the United States and that these methods vary in accuracy:

- Count traffic year-round,
- Sample traffic and extrapolate annual operations,
- Multiply a predetermined number of operations per based aircraft by the total aircraft based at the airport,
- Perform regression analysis, and
- Ask the airport manager or personnel associated with the airport.

The most common method used by the respondents to this study's survey questionnaire is also the most inaccurate of the methods currently in use; simply asking the airport manager or other related airport personnel what they believe the airport's annual aircraft operations are. The Texas Department of Transportation's *1994 Aircraft Activity Counter Report* found that an airport's operations can be as much as doubled when estimated by the airport manager, as opposed to using the sampling traffic with an acoustical counter and extrapolating the sample into an annual estimate. Currently, the most accurate method is to deploy an aircraft traffic counter(s) at an airport year-round, which in theory counts all the traffic at the airport. Seven respondents did this, four of which were airports.

It is believed that the next most accurate method to count and estimate operations is to sample traffic with some type of aircraft counter for two weeks in each of the four seasons and to expand that sample into an annual count. One study, when this method was used with the tape recorder acoustical counter, produced results with 9% to 21% margins of error. However, only 6 of the remaining 12 respondents that sampled traffic actually did so for two weeks in each of the four seasons. The other six did not sample in all four seasons, making their results less accurate than those that sampled during all seasons or year-round. Determination of accuracy assumes that the technique used to extrapolate from sample to annual operations is appropriate in characterizing the airport's operating environment.

There are currently six different methods being used to sample aircraft traffic:

- Acoustical,
- Airport guest logs,
- Fuel sales,
- Pneumatic,
- Video image detection, and
- Visual.

The use of airport guest logs and fuel sales, although helpful, will not track all traffic during the sample period because not all pilots sign into a guest log and not all aircraft purchase fuel with each flight. Additionally, neither of these methods will account for touch-and-go operations. Of the equipment currently being used to sample traffic, the acoustical (including the sound-level meter and computerized acoustical) and video image detection systems offer acceptable levels of accuracy in detecting aircraft; both are estimated by their manufacturers to be in the 90% range. The acoustical systems are generally less expensive than the video systems, whereas the video systems offer more information, such as aircraft tail numbers. Visual sampling of traffic by a human observer is very accurate, but also very costly and time-consuming.

It is believed that the most accurate and cost-effective way to estimate aircraft operations at a non-towered airport is to sample traffic for two weeks for each of the four seasons and extrapolate that sample into an annual estimate. This can be considered most preferable if year-round counts are not feasible, providing that a valid extrapolation is used to expand from seasonal counts to annual operations. As stated previously, the acoustical counter provides a cost-effective, efficient, and accurate way to collect the sample, whereas the video image detection system, although more costly, adds additional information that may be useful to the airport. Pneumatic counters and inductance loop counters have serious limitations and would only be useful at airports that have a most simple configuration such as one runway and one entry taxiway, and are not recommended for such activities. Airport guest logs and fuel sales are also not recommended as a way to count traffic.

The information received by the states, airports, and metropolitan planning organizations from their aircraft traffic counting programs is being used for a variety of purposes, including justification for airport improvement projects, justification for air traffic control towers, airport environmental documentation, forecasting, economic impact statements, performance measures, FAA Airport Master Record Form 5010 reporting, system planning, justification for navigational aids, and airport planning studies. Because the most common method for estimating aircraft operations (asking the airport manager or other airport personnel) may not be accurate, the information being used for these purposes may also be assumed not to be accurate. Additionally, because the methods being used to count and estimate aircraft operations at non-towered airports vary in accuracy, the results are not comparable among the airports.

As stated earlier, airport operations data are being used on the FAA Airport Master Record 5010 forms. Each airport has an Airport Master Record that is produced under the guidelines of the FAA Airport Safety Data Program. The information on the Airport Master Record is made available to the general public to use at their discretion. The FAA Order directs the airport inspector to record the total number of general aviation operations that occur at the airport. It further stipulates that the inspector is to use "FAA tower counts where available. If not available from FAA sources, use estimates based on discussion with airport management and/or the fixed base operators." Coordination of the collection and reporting of accurate airport operations data between state aviation agencies and the FAA is desirable. This can be accomplished by implementing the following: (1) encourage widespread use of appropriate practices identified in this synthesis; (2) when such practices are used, include this information in the Airport Master Record 5010; (3) consider changing the format of the 5010 form to identify the counting practices used.

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APPENDIX A

Manufacturer Information

Current or Historic User	Type of Equipment Used	Manufacturer	Website
California Delaware Valley Regional Planning Commission Utah Visalia Airport Watsonville Airport	Sound level meter	Larson Davis	www.larsondavis.com
Maryland	Sound level meter	Scantek–Rion sound level meters (claims 95% accuracy)	www.scantekinc.com/releases/pr050506.htm
Flagler County (Florida)[a]	Video image detection	TTI	http://www.ttiwireless.com/
Idaho[b] Indiana Nevada New Mexico Vermont Reno Stead Airport Taos Regional Airport Utah	Computerized acoustical	Wilderness Systems Technologies (claims 90% accuracy)	www.wildernesstechnologies.com
Upshur County Regional Airport	Video image detection	Vicon dome camera and tape deck	
Oregon	Tape recorder acoustical	RENS	No longer being manufactured
Illinois	Pneumatic tube	Manufacturer was not given	There are various manufacturers of this type of road traffic counter
Michigan[c]	Computerized acoustical	ATR Enterprises Aircraft Takeoff Counters	www.aircrafttakeoffcounters.com

[a]Does not use system to count traffic, but equipment has this capability.
[b]State-managed airports (turf strips).
[c]Proprietary field testing stage.

APPENDIX B

Questionnaire

TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

November 28, 2006

Dear State Aviation Director:

On behalf of the Transportation Research Board, I want to thank you in advance for taking the time to read and respond to this questionnaire. I know you are all very busy, but I truly believe the information I am collecting will be of benefit to all of us. The Airport Cooperative Research Program Synthesis Project (ACRP), under the Transportation Research Board, was developed to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current airport practices. The main focus of this ACRP Synthesis is **Aircraft Operations Counts for Small and Non-towered Airports**.

The enclosed questionnaire is designed to identify and evaluate the various methods used to count and estimate aircraft traffic at non-towered airports among the states. Please fill it out or direct it to the appropriate staff member. If you currently use more than one method to count or estimate aircraft operations, *please fill out a questionnaire for each method.*

Additionally, if you have produced any reports on your aircraft traffic counting program or conducted any research or accuracy tests, I would appreciate receiving a copy of these items (email, fax, or regular mail is fine). If you are aware of any airports in your state that are conducting their own aircraft traffic counting program, please provide that information also.

Please answer all applicable questions to the very best of your knowledge. If you would like to make comments on any of the questions, please feel free to do so in the comments section located at the end of the questionnaire. Thank you again for taking the time to assist in this research project.

Sincerely,

Maria J. Muia, Ph.D.
Director, Aerofinity
51 S. New Jersey St.
Indianapolis, IN 46204

Enclosures

Questionnaire

COUNTING AND ESTIMATING AIRCRAFT OPERATIONS AT NON-TOWERED AIRPORTS QUESTIONNAIRE

1. What method of estimating aircraft operations at non-towered airports is used in your state or at your airport? (This is the number of operations used in the airport master record form, system planning, master planning, forecasting, and for other managerial uses.)

   A) Expand a sample count using seasonal or monthly adjustment factors ____
   B) Multiply a predetermined number of operations per based aircraft by the number of aircraft based at the airport ____
   C) Statistical model ____
   D) Other (please specify below): ____

2. If you answered statistical model, please indicate the type of statistical model you employ to estimate aircraft operations. ____

3. If you estimate from a sample count, what method do you use to collect the sample data?

   A) Acoustical counters ____
   B) Pneumatic counters ____
   C) Visual counts ____
   D) Airport guest logs ____
   E) Other (please specify the method below): ______________________________

4. If you estimate from a sample count, how long does the sample count last at an individual airport over a year?

   A) Week(s) (specify number of below) ____
   B) Month (specify number of below) ____
   C) Year ____
   D) Other (please specify below): _________________________________

5. Do you sample traffic at an airport in more than one season?

   A) Yes (please specify which seasons below) _____________________________
   B) No ____

6. If you use equipment to sample data, what is the approximate cost of the equipment per unit?

   A) Less than $2,000 ____
   B) $2,000 up to but not including $4,000 ____
   C) $4,000 up to but not including $8,000 ____
   D) More that $8,000 ____

   Please specify the name and manufacturer of the equipment. _________________

7. How many runways will one unit cover?

A) Less than 1 runway ____
B) 1 runway ____
C) 2 runways ____
D) 3 or more runways ____
E) Other (please specify below): ____

8. What is the accuracy of this method? (100% indicates all operations were accounted for, none were omitted, and none were erroneously included.)

A) 80%–100% ____
B) 70%–80% ____
C) 60%–70% ____
D) Less than 60% ____
E) Don't know ____

9. Did you answer Question 8 based on your opinion/hunch or did you actually perform some type of accuracy tests (either formal or informal)?

A) Hunch/opinion ____
B) Formal or informal accuracy tests ____

10. Approximately how many person-hours does it take to perform a traffic count at an airport using this method (excluding travel time to the airport)?

A) Less than 2 hours ____
B) 2 hours up to but not including 4 hours ____
C) 4 hours up to but not including 6 hours ____
D) 6 hours up to but not including 8 hours ____
E) Other (please specify below): ____

11. What are the strengths and limitations of this method? ______________________
____

12. How long have you been using this method to collect and estimate aircraft operations at non-towered airports?

A) Less than 5 years ____
B) 5 years up to but not including 10 years ____
C) 10 years up to but not including 15 years ____
D) 15 years up to but not including 20 years ____
E) More than 20 years ____

13. Why, specifically, do you collect these data? (Circle all that apply.)

A) Justification for airport development projects
B) Justification for airport control towers
C) Use in airport environmental assessment or impact documentation
D) Forecasts
E) Economic Impact Statements
F) Measure of Performance
G) Include in Airport Master Record— (5010 Form)

H) Other

14. If you answered other to Question 13, please indicate what other uses you have for these data. ____

15. What state agency, airport, or MPO are you from? ____________________

16. Include any comments you would like to make here:
____
____
____
____
____

Your name and phone number are optional; however, this information would be very helpful to me if I have any questions regarding your responses and in the tallying of the results.

Name: ____
Title: ____
Phone: ____

A GENTLE REMINDER: If you have any of the following items, please include them with your questionnaire.

1) Traffic counting reports
2) Formula examples
3) Research reports
4) Accuracy tests
5) Any other examples of programs in your state

THANK YOU FOR YOUR ASSISTANCE IN THIS RESEARCH. WITHOUT YOUR DEDICATION, THIS PROJECT COULD NOT BE POSSIBLE.

Please return your questionnaire by January 15, 2007, by mail, fax, or e-mail to:

Transportation Research Board, Airport Cooperative Research Program
C/O Maria Muia, Aerofinity, Inc.
51 S. New Jersey Street, Indianapolis, IN 46201

APPENDIX C

Literature Review

The following literature was reviewed for this research project and is provided here in no particular order.

LOUISIANA DEPARTMENT OF TRANSPORTATION

Information on airport operations was used by the state of Louisiana in 1985 to determine fuel requirements and fuel storage capacity needs for fuel sales to aircraft and to determine space requirements for terminal buildings (*1*, p. 4-1). The *Louisiana Airports Activity Study*, completed during 1984 and 1985, was reviewed and it was concluded that activity data need to be continually updated for efficient planning by airport management. The goals of the study were to determine the "value and reliability of airport activity counting as an input into the process of determining priorities for the allocation of both state and federal airport development funding" (*1*, p. 1-1) and to establish a traffic counting program that would estimate aircraft operations at several of the state's non-towered airports (*1*, p. 4-1).

The data collection process for the 1985 Louisiana study utilized tape recorder acoustical aircraft activity counters. The units were placed close to the edge of the runway at approximately midpoint, where they recorded aircraft departures on a regular magnetic cassette tape. The counters were battery powered and remained at the airports for varying amounts of time, during which the airport operated on a normal schedule. As such, the researchers experienced some problems with maintenance personnel damaging the counters during their normal mowing duties. Additionally, because the counters were battery driven and were exposed to all weather conditions, the researchers experienced some difficulties in keeping the batteries charged. Even with these problems, however, they conceded that downtime was acceptable. Airport personnel at each facility were used to monitor and maintain the counting equipment. The study concluded that "the counts themselves can provide the very best input when the level of activity is going to be a factor in a funding decision" (*1*, p. 1-4). The study also determined that it was necessary to count aircraft for six to eight weeks to ensure that an adequate sample was taken (*1*, p. 5-1).

The researchers in the Louisiana study sampled aircraft traffic and then used known data on annual fuel sales to expand that sample to an annual estimate of aircraft operations. They then proceeded to determine if there was a correlation between monthly fuel sales and monthly operations. A correlation analysis is a statistical procedure that determines if there is a relationship between two variables (*2*, p. 474). In this case, the variables were fuel and monthly operations. They concluded that the correlational analysis between fuel sales and operations produced an *r*-value of approximately 0.91 (*1*, p. 2-2), which indicates a fairly strong positive correlation, because the *r*-value is close to 1.0 (*3*, p. 297).

The 1985 Louisiana study also investigated whether or not a relationship existed between based aircraft and operations. An inventory of based aircraft was taken during the same time the operations were being sampled at the airports. After annual activity was calculated using the fuel sales data, statistical analysis was done and the researchers concluded that the relationship between based aircraft and operations was not statistically significant (*1*, p. 4-2). It should be noted that the Louisiana study did not address either the costs or the efficiency of their counting and estimating method (*1*).

DELAWARE VALLEY REGION

According to the 1988 article "Estimation of Aircraft Operations at Non-towered Airports in the Delaware Valley Region," estimates of airport operations were being used for managerial and operational decisions, for the provision of daily services at the airport, and for forecasting future activities. This study used a sampling methodology that utilized tape recorder acoustical aircraft traffic counters, the same type of counters used in the Louisiana study. The researcher (Zakaria) sampled 11 airports for 2 weeks during each of the four seasons. The budget for the entire program was $50,000. Zakaria stated that "the greater the precision desired in the estimate, the larger the sample size and cost " (*4*, p. 37). Tests of the model to calculate the annual estimates were only conducted on two towered airports and produced margins of error of ±10% and ±11%. The margins of error for the 11 airports where operations were estimated ranged from 9% to 21%.

During the study, Zakaria discovered that "the placement of the microphone with respect to the runway had a significant impact on the quality of the sounds recorded" (*4*, p. 41). There was also a problem discerning helicopter activity on the aircraft traffic counter (*4*, p. 42).

The Delaware Valley study concluded that eight-week, stratified cluster samples using an acoustical aircraft traffic counter produced "adequate estimates for airport operations" (*4*, p. 46). The cost for estimating operations at an airport using this method was estimated to be approximately $5,000 per airport (in 1986 dollars).

INDIANA STATE UNIVERSITY

Indiana has been involved in counting and estimating aircraft operations at non-towered airports for some time. In July 1985, Indiana State University (ISU) conducted a study to investigate the most feasible method of counting aircraft in the state (*5*).

The ISU study was limited to airports in Indiana and did not survey all other states on their procedures. It also made recommendations based on the use of mechanical counters, which are no longer used at airports in Indiana. Although informative, the ISU study did not undertake any real research; it simply used information already contained in *Statistical Sampling of Aircraft Operations at Non-Towered Airports* (*6*), which is reviewed in this report.

INDIANA DEPARTMENT OF TRANSPORTATION

Further research done by the Indiana Department of Transportation (INDOT) on counting aircraft traffic at non-towered airports resulted in the 1989 report, *A Study of Aircraft Operations at Indianapolis Reliever Status Airports* (*7*). This study tested the accuracy of two different methods of sampling aircraft operations at five non-towered airports in the Indianapolis area. Tape recorder acoustical counters and mechanical counters were tested against visual counts for one week at each airport. The outcome of the tests at Eagle Creek Airpark, Indianapolis, Indiana, for the acoustical counter resulted in an accuracy rate of almost 92%, whereas the mechanical pneumatic counters resulted in only a 64% accuracy rate (47% accuracy with a touch-and-go factor included) (*7*, Appendix A). The mechanical pneumatic counters continually recorded non-aircraft traffic (i.e., aircraft towing equipment, airport vehicles, taxiing aircraft), which was responsible for most of the inaccuracy of the machines. Two service areas were located on both sides of the runway at this particular airport that resulted in consistent non-aircraft traffic between the buildings and, therefore, the excessive count. Another inaccuracy found with the mechanical counter was that it failed to count touch-and-go operations, which, if included, would inflate the estimated operations even further (*7*, p. 2).

At the Metropolitan Airport, Indianapolis, Indiana, the tests resulted in a 95% accuracy level for the acoustical counter, but only a 36% accuracy level for the mechanical counter (27% accuracy with a touch-and-go factor included) (*7*, Appendix A). Again, the reason for the highly inaccurate count from the mechanical counter was the result of continuous recording of non-aircraft traffic. At Mount Comfort Airport, Indianapolis, Indiana, the accuracy levels of the two counting methods was closer. The acoustical counter tested as 97% accurate, whereas the mechanical counter was 90% accurate (39% accuracy with a touch-and-go factor included) (*7*, Appendix A). The service areas on this airport were all located in the same general location; therefore, very little non-aircraft traffic was recorded. However, touch-and-go operations were still not counted (*7*, p. 10).

At Terry Airport, Indianapolis, Indiana, the outcome of the tests resulted in accuracy levels of 67% for the acoustical counter and 34% for the mechanical pneumatic counter (43% accuracy with a touch-and-go factor included) (*7*, Appendix A). Neither method was particularly accurate because of the high volume of glider activity at the airport; neither counter recorded these operations. The results of the study at the Greenwood Municipal Airport, Greenwood, Indiana, produced accuracy levels for the acoustical counter of 94% and for the mechanical pneumatic counters of 45% (57% accuracy with a touch-and-go factor included) (*7*, Appendix A).

The INDOT study concluded that airport layout and ground traffic are critical factors when using mechanical pneumatic type traffic counters that depend on the aircraft to roll over their associated equipment to be recorded. If there is a large amount of non-aircraft traffic rolling over the counters, an exceedingly high estimation of aircraft operations is produced. Additionally, because mechanical counters fail to record touch-and-go operations can intensify their inaccuracy (*7*, p. 20).

Although the tape recorder acoustical counter may indeed record non-aircraft activity, these erroneous recordings can be edited out during the tape audit process (*7*, p. 20). This is not the case with the mechanical tube counters. Although the INDOT study tested the accuracy of two different sampling devices, it did not evaluate the method used to expand the sample into an annual estimate (*7*).

TEXAS DEPARTMENT OF TRANSPORTATION

The airport development projects across the United States compete with each other for funding, and many states use airport operations as a factor in allocating funds for these development projects. According to a 1994 study completed by the Texas DOT, "accurate aircraft activity is valuable information for planning and development of individual airports and for the entire airport system" (*8*, p. 1). This study, the *1994 Aircraft Activity Counter Report*, was financed in part by the FAA. According to this study, statistical sampling of aircraft operations with tape recorder acoustical counters is more reliable than operation estimates "derived from recollections of annual activity" or "estimates based on the number of based aircraft" (*8*, p. 1). The actual data collection process for the Texas study was done by several district offices of the Texas DOT, thus reducing travel costs to and from the airports to maintain and move the counters. Additionally, they enlisted the help of the individual airport personnel to assist with the daily maintenance of the machines. The use of the tape recorder acoustical counters was chosen "because of their accuracy and low maintenance costs" (*8*, p. 4).

In the Texas study, the researchers used a statistical method that "generally mirrored that of the one developed by the Oregon Department of Transportation" (*8*, p. 1). Their study procedure involved taking samples in clusters of 7 to 14 consecutive days to account for daily variations in traffic. Additionally, they sampled in each season of the year to account for seasonal variations. The summer and winter seasons were sampled for two weeks each, whereas the fall and spring samples lasted for one week each. This differentiation was the result of the researchers' belief that the fall and spring seasons had comparable weather conditions and therefore could be grouped together as one season that they called spring/fall. As a result, there were really only three seasons in their counting program: spring/fall, summer, and winter (*8*, p. 4).

The estimating procedure was comprised of determining each airport's total weekly operations for each of the three seasons and then calculating what the average operations were. From there, they determined the percentage of daily operations that occurred in each season. The next step consisted of multiplying the daily average by the number of days in the season and finally adding them all together for an annual estimate (*8*, p. 7).

The researchers in the Texas study were able to use the variations calculated for each day, week, and season "to determine the precision or range of the estimates of annual operations" (*8*, p. 1). They concluded with a 95% confidence level that their sampling error was on average 27%. The highest error was 53% and the lowest was 10%. The larger the sample, the more accurate it is likely to be (*9*, p. 205). Sampling for the extra week in the spring and fall seasons would have increased their sample size by 33%. The decision to sample for only one week in the spring and one week in the fall may have contributed to their 27% average sample error (*8*, p. 10).

The Texas study also compared its results from the tape recorder acoustical counters and statistical sampling with the results received from the FAA Airport Master Record Form 5010 reports. The estimates for aircraft operations on the FAA Form 5010 reports for Texas airports was determined by asking each airport's manager what they believed the annual operations to be, which is a method used by several states. The results of this comparison showed an average deviation of 15% between the two methods. The highest difference was 179%, whereas the lowest was a negative 2%. One airport's operations were almost double when estimated by the airport manager, as opposed to using the acoustical/statistical method (*8*, p. 11).

As previously mentioned in the Delaware Valley study, the Texas study also determined that helicopter operations were difficult to count. The researchers concluded they could not be estimated from the samples because the tape recorder counter will "activate again and again by the constant whirring of the helicopter" blades (*8*, p. 5).

The Texas study concluded that statistical sampling by use of the tape recorder acoustical counter provided reasonably accurate estimates. The researcher believed "the acoustical method of counting aircraft activity at airports" to be "the most accurate within the limits of the available technology and budget restraints" (*8*, p. 19). This research was undertaken because information could be used on traffic at non-towered airports for the planning and development of their airports (*8*, p. 1). The Texas DOT no longer uses this method regardless of the accuracy.

VIRGINIA DEPARTMENT OF AVIATION

According to the study, *1998 Virginia Department of Aviation On-Site Air Activity Survey* (*10*), the Virginia Department of Aviation (DOAV) used aircraft activity data to "examine the needs for development at General Aviation airports across the Commonwealth." This study was undertaken in cooperation with the Metropolitan Washington Council of Governments (COG), Virginia Civil Air Patrol, Information Systems Research Institute of the Virginia Commonwealth University, and the FAA. Review of this study revealed that the DOAV had been performing on-site surveys at their non-towered airports for 20 years. For this particular study, the Virginia Civil Air Patrol did the data collection for seven consecutive 12-h days at 22 non-towered airports. Information on the type of aircraft operation, weather, and purpose of the flight was collected and used in a model that expands the sample into an annual count. The model was developed by COG and is discussed later in this section.

The Virginia report indicated that the raw data were reviewed for accuracy; however, it did not elaborate on the method used to check the accuracy or the level of the accuracy. The model used the raw data to provide an "expanded picture (weighted) of the preliminary data in terms of an annualized figure" (*10*, p. 2).

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

The COG study elaborated on the accuracy of the model used in the DOAV on-site air activity survey. In December 1995, COG published the *General Aviation Activity Mode* (*11*). Under contract with the DOAV, COG developed a model to estimate annual operations from one-week operation samples taken by the Virginia Wing of the Civil Air Patrol on behalf of the DOAV. COG began by collecting operations data from state and local airport authorities in Maryland, North Carolina, and Pennsylvania, and expanding these data to "yearly estimates using standard statistical expansion techniques"

(*11*, p. vii). The intent was to "investigate whether or not a stable summer-to-yearly general aviation operations ratio exists across states and, if possible, to develop a model relating the ratio, or absolute summer and yearly operations, to an independent variable, such as based aircraft" (*11*, p. vi). COG used regression analysis to determine that there was a positive correlation between based aircraft and general aviation operations; however, the correlation was not strong enough to actually forecast operations (*11*, p. vii).

COG then modified their approach to simply "expanding summer general aviation counts to annualized estimates" (*11*, p. viii). Basically, the technique used was to expand 12-h counts to 24-h counts, daily counts to weekly counts, and so on until annual counts were obtained. Expansion curves for the daily operations were developed from counts at 28 general aviation airports in Maryland using the tape recorder acoustical counter, as were the weekly curves. Month-to-year distributions were developed from six towered airports in Maryland, North Carolina, and Virginia (*11*, p. ix).

The problems with the COG study were that there were no data for general aviation airports with which to compare the results with to determine the model's accuracy. "A comparison of estimated results to observed data is normally sought to measure a model's performance. Since there was no observed annual GA [general aviation] operations data for airports in Virginia, no such tests were possible" (*11*, p. ix). As such, the accuracy of the model is in question.

Additionally, the COG model uses tower operations data as the basis to expand a sample count to an annual count at non-towered airports, a questionable technique. The study completed by Ford and Shirack in 1983 (*12*), reviewed next in this report, concluded that "tower operations data should not be expected to provide reliable estimates for operations at non-towered airports."

FORD AND SHIRACK STUDY

Review of *Statistical Sampling of Aircraft Operations at Non-Towered Airports* revealed that the researchers believed "investment decisions can be made with more confidence if benefit-cost analysis is based on accurate information about use of the facility (airport)" (*6*, p. 1). The 1983 study that resulted in this publication was entitled *Estimating Aircraft Activity at Non-Towered Airports: Results of the Aircraft Activity Counter Demonstration Project* (*12*). Three different independent measures, operations at towered airports, weather data, and fuel sales, were analyzed to determine if they could be used to estimate annual aircraft operations from sampled operations at non-towered airports (*12*, p. 1).

Tape recorder acoustical aircraft activity counters were used to collect the samples for a full year each at 23 non-towered airports in Idaho, Oregon, and Washington State. These non-towered airports were paired with similar towered airports, and the data were compared for seasonal variations. This analysis revealed that the variations in operations at towered airports throughout the year were not similar to the variations at non-towered airports. "Therefore, tower operations data should not be expected to provide reliable estimates for operations at non-towered airports" (*12*, p. 8). The researchers determined that this lack of similarity between towered and non-towered operations data was partially the result of towered airports having instrument approaches that make them accessible during inclement weather, whereas non-towered airports did not. This may have been the case in 1983; however, an increasing number of non-towered airports have instrument approaches. The use of global positioning systems has made instrument approaches possible for any airport with clear approaches.

The Ford and Shirack study also compared operations data from the 23 non-towered airports with weather data and determined that "if daily weather data for a sampled airport were available, it would be expected to help provide an estimate of variation in operations so that the size of the sample of operations could be reduced" (*12*, p. 12). However, these data were often not available or not thorough enough to be useful, and it could not account for all the variations that influence aircraft operations at a particular airport (*12*, p. 12).

The Ford and Shirack study compared fuel sales data with aircraft operations to determine if there was a correlation and if it could be used to estimate operations. Although there was a relationship, "wide errors could result if fuel data were used to expand a single weekly count to an annual total" (*12*, p. 13). Additionally, there were significant differences in the ratio of operations to fuel sales among the airports, and there were questions concerning how much fuel was sold or used by private individuals that were not reported (*12*, pp. 13–14). It is common for some proportion of fuel sales to go unreported because some aircraft owners operate their own private tanks. For these reasons, the Ford and Shirack study recommended further study be done to determine if fuel sales can predict airport operations.

The researchers recommended using systematic cluster samples to estimate aircraft operations at non-towered airports when accurate independent factors are not available or need to be verified for reliability. Their formula required taking samples during two 7-day clusters in each season. They indicated this was required to adequately determine seasonal and annual estimates. They reported that use of the tape recorder acoustical counter was a cost-effective way to take this sample (*12*, p. 16).

This study, however, was conducted during an economic downturn in 1981, which affected the aviation industry. The degree of impact this downturn had on aircraft activity by aircraft type, airport type, or region is not known. Additionally, the national air traffic controllers' strike occurred in August 1981 during the course of this study. The impact of this now historic event on the aviation industry was substantial and could have affected the outcome of this study, which assumed that neither the economic downturn nor the air traffic controller strike affected the results of the research (*12*, p. 21).

Additionally, the Ford and Shirack study was completed in 1983. Many factors have changed in the aviation environment that make this study outdated. For instance, there have been advancements in technology since 1983 that have made general aviation, non-towered airports more accessible during inclement weather. Also, the avionics equipment in general aviation aircraft has advanced technologically since 1983, making aircraft more suitable for all-weather flying. More pilots are also being trained to fly in instrument conditions. An instrument rating allows a pilot to fly in inclement weather. When the Oregon study began in 1980, 42% of all active pilots were instrument rated (*13*). Twenty-one years later, the percentage of instrument-rated pilots increased to 52% of all active pilots (*14*).

These factors alone bring towered and non-towered airports closer in similarity in their ability to conduct all-weather operations. These factors make the Ford and Shirack study conclusions regarding similarity in operations questionable in today's environment.

MUIA STUDY

In 2000, Maria J. Muia completed a study entitled *An Analysis of the Methods Used to Calculate Customer Operations at Non-Towered Airports and of the Associated Managerial Uses of Operations Information* (*15*). This study surveyed all state aviation agencies on the different methods of counting and estimating general aviation operations at non-towered airports. This research revealed that the methods used differ from state to state and all varied in accuracy, efficiency, and cost-effectiveness. The accuracy of the sound level meter acoustical counter was reported to range from 60% to 95%, whereas the tape recorder acoustical counter accuracy was reported to range from 66% to 99%. Accordingly, the report concluded that the results were determined not to be comparable among airports across the nation.

This study revealed that each state counts and estimates aircraft operations at non-towered airports for a variety of reasons, the most common being for use on FAA Airport Master Record Form 5010. Other uses of the data were for justification for funding airport projects and air traffic control towers. The data were also used in airport environmental documentation, forecasts, and economic impact statements.

Of all the methods being used by the states, the respondents in this 2000 research project believed that statistical sampling was the most accurate method for counting and estimating annual airport operations. Asking airport management what they believed their operations were was thought to be the most inaccurate method, as it was reported to possibly double an airport's actual operations. Further study was recommended on the use of acoustical counters as a means to obtain the sample, whereas pneumatic counters could be highly inaccurate depending on the airport's layout.

DELAWARE VALLEY REGIONAL PLANNING COMMISSION—NEW JERSEY

In June 1997, the Delaware Valley Regional Planning Commission (DVRPC) published the *New Jersey Aircraft Counting Program: 1996/97 Seasonal and Annual Operations Count for Twenty-Four Non-Towered New Jersey Airports* (*16*). The Planning Commission was contracted by the New Jersey DOT to count and estimate aircraft operations at 24 non-towered airports in the state. They employed a computerized noise measuring acoustic aircraft counter to collect the sample data for the study. At the time, they had used this same methodology for more than a decade and claimed their "experience shows statistically acceptable margin of errors generally between ten to twenty-five percent at ninety-five percent confidence for its results" (*16*, p. 1). As with the Texas DOT study, the DVRPC concluded that helicopter operations were difficult to count. The helicopters were not recorded properly at the airports included in the Delaware Valley study, because they occurred too far away from the counter. Therefore, they relied on the individual airports to report their estimated number of helicopter operations (*16*, p. 1).

IOWA STATE UNIVERSITY

The Center for Transportation Research and Education at Iowa State University published *Acceptable Methods of Counting Aircraft Operations at Non-Towered Airports* in 1996 (*17*). This study compared three counting methods: visual, pneumatic tubes and inductance loops, and acoustical counters. These methods were compared for their accuracy, cost, and major advantages/disadvantages. This report recommended use of pneumatic tubes at airports of relatively stable aircraft activity even though they were the least accurate method. Although the acoustical counters were more accurate, it recommended use of these counters only as necessary, on a case-by-case basis, because they were more expensive. This study recommended counting four weeks during each of the four seasons, for a total of 16 weeks.

For projecting annual operations, this study recommended applying monthly adjustment factors for each month counted. These adjustment factors were to be specific to an airport's region.

FEDERAL AVIATION ADMINISTRATION

Hoekstra Study

In April 2000, Mark Hoekstra authored *Model for Estimating General Aviation Operations at Non-Towered Airports* (*18*) for the FAA Office of Aviation Policy and Plans. This research used regression analysis in two stages to estimate operations at non-towered airports as a function of airport characteristics. In the first stage, equations were estimated for a group of small towered airports. In the second stage, these equations were applied to a group of non-towered airports to produce operations estimates. The results for the non-towered airports were compared with annual operations estimates made by 9 states at 129 non-towered airports that used primarily a sampling-based counting and extrapolation process. The analysis resulted in the selection of a model for non-towered airports that uses operations per based aircraft as the dependent variable and dummy variables for airport size and airport region as the independent variables.

The Hoekstra model produced generally higher annual operations than those made by the nine states.

GRA Study

The Hoekstra study was followed by another study in July 2001, by GRA, Inc., on estimating general aviation operations, which was also completed for the Statistics and Forecast Branch, Office of Aviation Policy and Plans, of the FAA. This study, *Model for Estimating General Aviation Operations at Non-Towered Airports Using Towered and Non-Towered Airport Data* (*19*), built on the Hoekstra report. The GRA report developed a model that uses a combined data set for small towered and non-towered general aviation airports. By incorporating a dummy variable to distinguish towered and non-towered airports, the model quantifies the impact a tower may have on aviation activity. The new model also added local factors including population, airport regional prominence, and certificated flight schools. The estimates produced by the GRA model for operations at non-towered airports were unbiased relative to the state estimates based primarily on counter and survey estimation procedures.

The selection of the models in the Hoekstra and GRA studies was based in whole or in part on testing model accuracy for small towered airports. Although the GRA model resulted in producing unbiased annual estimates relative to the state estimates at non-towered airports, the accuracy of the models for estimating operations at non-towered airports in both studies was not verified. This was the case because the accuracy of the historical state estimates for the non-towered airports could not be verified.

FAA Order 1050.1E

Additional FAA literature reviewed indicates that airport operations information is being used for studies related to environmental concerns. FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures* (*20*), identifies airport development projects that do not require a noise analysis. Specifically, no noise analysis is needed for certain projects whose operations do not exceed 90,000 annual propeller operations or 700 jet operations.

FAR Part 170

In addition to determining if a noise analysis is required, information on the total aircraft activity of an airport can also be used to justify an aircraft control tower. Control towers provide for the safe, orderly, and expeditious movement of air traffic at an airport [*Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures*; includes Change 1 effective August 3, 2006] (*21*). To qualify for a federally funded air traffic control tower, the airport must meet the benefit–cost ratio criteria. The benefit–cost ratio formula includes a variable for annual aircraft traffic counts (FAR Part 170.13(a)(5)) (*22*). Knowing accurate data on aircraft operations allows management to justify the need for an air traffic control tower at the airport and, therefore, improve the safety of the facility.

Procedures for Handling Airspace Matters

Further FAA literature reviewed indicates that the FAA uses annual operations data in the evaluation of tall structures. The FAA is responsible for ensuring that aircraft are safe from obstructions while navigating in U.S. airspace. In evaluating if an object will present a hazardous situation to navigating aircraft, the FAA must determine if a significant volume of aeronautical operations will be affected (*23*).

Airport Master Plans, Advisory Circular 150/5070-6B

Chapter 6, “Existing Conditions,” of the FAA’s Advisory Circular on *Airport Master Plans* (AC 150/5070-6B) (*24*) states that, “The planning agency should use appropriate statistical techniques to estimate activity where actual operations counts are not available.” Chapter 7, “Aviation Forecasts,” of this same Advisory Circular states that estimating current activity at non-towered airports can be difficult. Page 44 and Page 45 specifically reads as follows (*24*):

> The traditional method of using operations data from a similar towered airport to estimate the activity at a non-towered airport has been found to be unreliable. Records of fuel sales at the non-towered airport may be a more reliable indicator. However, the most reliable method has been found to be using a relatively inexpensive acoustical aircraft activity counter to obtain a series of cluster samples systematically drawn throughout the year and estimating the annual activity from these samples. The samples not only provide information on total annual operations, but also on the seasonal variability and peaking characteristics of the activity. For further information on this subject, see *Transportation Research Record 958*, Ford–Shirack Study, “Estimating Aircraft Activity at Non-towered Airports: Results of the Aircraft Activity Counter Demonstration Project.” The characteristics of operations at a non-towered airport, such as whether the operations are local or itinerant and what type of aircraft are using the airport, are as important as the number of operations. Visual surveys to determine these and other observable characteristics

can be expensive. A statistical sample can greatly reduce the cost. In 1987, the Oregon Department of Transportation published the results of a study in which the characteristics of operations at non-towered airports were determined through statistical sampling. See *Statistical Sampling and Estimating Procedure for Aircraft Activity Characteristics*, Oregon Aeronautics Division, Oregon Department of Transportation, April 1987 (*24*).

Airport Design, Advisory Circular 150/5300-13

Appendix 5 of the FAA's Advisory Circular on *Airport Design* (*25*) provides guidance on designing small airport buildings, airplane parking, and tiedowns. To determine the amount of space needed for apron parking, the Advisory Circular recommends a method that includes a factor for total annual airport operations. Where specific data are not available, the Advisory Circular recommends using 538 operations per based aircraft for non-NPIAS (National Plan of Integrated Airport Systems), public use airports; 492 operations per based aircraft for reliever airports; 637 operations per based aircraft for other general aviation airports; and 700 operations per based aircraft for primary airports. This could be problematic for an airport that has no based aircraft.

Aviation System Planning, Advisory Circular 150/5070-7

The FAA also provides guidance on computing operations for use in forecasting in their Advisory Circular on *Aviation System Planning* (*26*). This Advisory Circular advises that the accuracy of baseline master plan forecasts for non-towered airports may be improved through aircraft counting programs, but that these counts may not be cost–beneficial for airports with fewer than 100,000 annual operations, where a more exact count would not affect the airport's development requirements. When counts cannot be taken, it advises using the regression model outlined in *Model for Estimating General Aviation Operations at Non-Towered Airports Using Towered and Non-Towered Airport Data* (*19*), discussed earlier, for estimating general aviation operations at non-towered airports.

FAA Order 5090.3C "Field Formulation of the National Plan of Integrated Airport Systems"

All airports that receive federal funds must be in the NPIAS. What role the airport plays in the NPIAS is determined by the airport's annual operations. For example, to be classified as a reliever, the airport must have 25,000 annual itinerant operations. The field formulation guide advises that when forecast data of aircraft operations are not available, the method of operations per based aircraft can be used. A general guideline is 250 operations per based aircraft for rural general aviation airports with little itinerant traffic, 350 operations per based aircraft for busier general aviation airports with more itinerant traffic, and 450 operations per based aircraft for busy reliever airports. In unusual circumstances, such as a busy reliever airport with a large number of itinerant operations, the number of operations per based aircraft may be as high as 750. The field formulation guide also advises that an effort should be made to refine such estimates by comparing them with activity levels at similar airports or by conducting an activity survey.

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Abbreviations used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation