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Cost-Benefit Analysis: Substituting Ground Transportation for Subsidized Essential Air Services

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Final Report
December 2015

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16. Abstract

Since the Airline Deregulation Act of 1978, the U.S. Department of Transportation (DOT) has been subsidizing air service to small rural communities through the Essential Air Service (EAS) program. The original intent of the program was to maintain some level of air service to rural communities that would otherwise not have any. The Rural Survival Act of 1996 established the permanence of the EAS program; the act was fueled by the idea that reliable air services are vital to local rural economies. This idea has been somewhat challenged in recent studies that found little to no economic impacts of air traffic.

This project entertained the theory that intercity traffic volume, and not air traffic volume alone, is what affects the economic outcomes of certain geographical areas. A cost-benefit analysis of substituting subsidized air service with a subsidized ground service is presented and concludes that an intercity ground service network can create substantial cost savings on both a per round trip basis and a round trip-seat basis.

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COST-BENEFIT ANALYSIS: SUBSTITUTING GROUND TRANSPORTATION FOR SUBSIDIZED ESSENTIAL AIR SERVICES

Final Report
December 2015

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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EXECUTIVE SUMMARY

Since the Airline Deregulation Act of 1978, the U.S. Department of Transportation (DOT) has been subsidizing air service to small rural communities through the Essential Air Service (EAS) program. The original intent of the program was to maintain some level of air service to rural communities that would otherwise not have any. The Rural Survival Act of 1996 established the permanence of the EAS program; the act was fueled by the idea that reliable air services are vital to local rural economies. This idea has been challenged somewhat in recent studies that found little to no economic impacts of air traffic.

This report entertains the theory that intercity traffic volume, and not just air traffic volume alone, is what affects the economic outcomes of certain geographical areas. A cost-benefit analysis of substituting subsidized air service with a subsidized ground service is presented and concludes that an intercity ground service network can create substantial cost savings on both a per round trip basis and a round trip-seat basis.

INTRODUCTION

Since the Airline Deregulation Act of 1978, the U.S. Department of Transportation (DOT) has been subsidizing air service to small rural communities through the Essential Air Service (EAS) program. Prior to this act, airlines were required by the Civil Aeronautics Board (CAB) to provide two round trips per day to these communities (U.S. DOT 2015a). It was argued that deregulating the air service would result in certificated air carriers shifting operations away from small communities and toward more profitable routes, leaving these small rural communities entirely without access to the national air transportation network.

This argument was further supported by the fact that, initially, a community was only eligible for EAS subsidies if it had lost its last certificated air carrier (U.S. Congress Office of Technology Assessment 1982). Because of this concern, the EAS was established to provide two to four subsidized round trips per day from outlying communities to major airport hubs. The original legislation incorporated a sunset provision that set the expiration for the EAS subsidies at 10 years, with the assumption that air traffic would eventually become self-sustaining, similar to what happened with the "internal" subsidies for air service to rural areas provided by the CAB between the end of World War II and the late 1950s.

These internal subsidies worked by allowing airlines to set prices that allowed a higher profit margin at the more trafficked routes but also required them to operate in unprofitable rural areas. In that way, the rural areas were having air service "subsidized" by air passengers who traveled the more popular routes.

The EAS was reauthorized by Congress for another 10 years in 1988, and was made permanent in 1996 under the Rural Survival Act. The rationale for doing so was that the EAS program was essential for the smaller communities to maintain commercial air service.

Over time, as these communities and surrounding areas have developed, the EAS has increasingly become outdated. New roads and highway systems have been built to better connect rural areas, coupled with better ground transportation technologies. Thus, rural communities now have better ground transportation alternatives, such as a bus or a shuttle, and four large Interstate-type highways to connect them to the national air transportation network. Furthermore, a growing number of residents at these EAS-eligible communities are already choosing to drive directly to a primary airport, which may have lower fares and a greater variety of service options, rather than utilizing their local EAS (U.S. Congress Transportation and Infrastructure Committee Subcommittee on Aviation 2007b, statement of Michael W. Reynolds, Deputy Assistant Secretary for Aviation and International Affairs, U.S. Department of Transportation).

Additionally, many communities can be grouped such that they can all be served with just one ground route instead of multiple air routes because many current EAS communities are sufficiently close to one another. Trying to serve multiple communities with one air route would not be practical because it is much more costly for a plane to take off and land at three separate airports than it is for a ground vehicle to make extra stops.

Figure 1 shows all of the EAS communities and their serviced hubs as of November 2014.

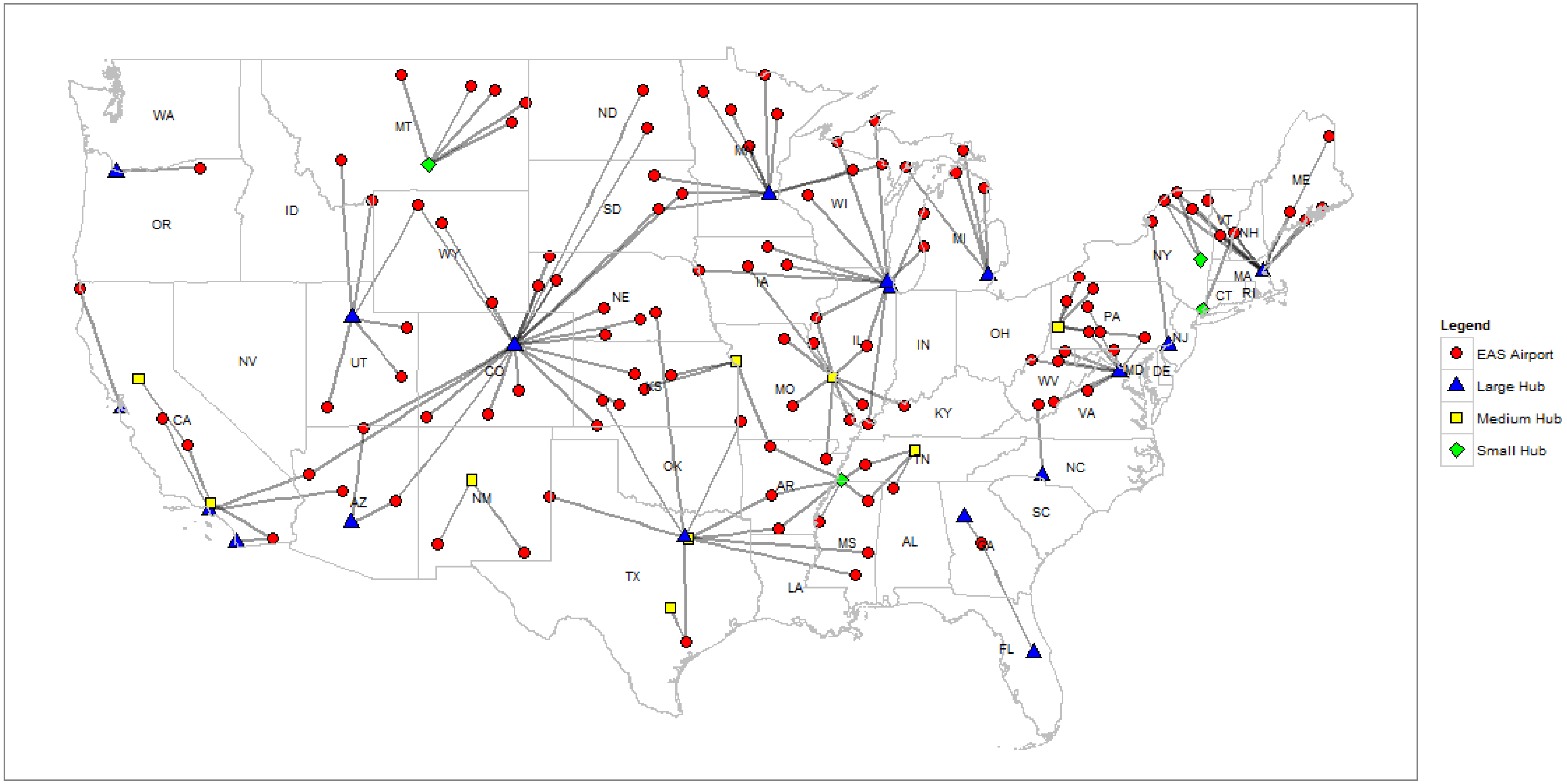


Figure 1. Map of EAS communities and routes to hubs

Ironically, some routes do not even fly to the closest hub; however, while this is a waste of taxpayer resources, this study does not directly examine eliminating the inefficiency related to the close proximity of some EAS communities with others. The topic of service redundancies has already been extensively covered in Grubesic et al. (2013), and other topics related to operational inefficiencies are tackled in Matisziw et al. (2012).

The EAS is no longer efficient in fulfilling its original purpose of connecting rural communities to the national air service network. A ground transportation system would have the potential to reach a larger group of people and would more effectively benefit many communities currently being served by the EAS. Furthermore, the process for selecting a qualified certificated air carrier to operate at these rural communities is cumbersome. Early contract terminations are not uncommon among the EAS communities, and the process of finding a new eligible carrier can take months. (For a more detailed explanation of the air carrier selection process, refer to Appendix C.)

The hypothesis of this study is that a ground service network would be able to connect the EAS communities to not only the national air system, but to all the amenities of a larger urban area, including the public ground transportation system of that area, for a much lower cost. Therefore, this study proposes that the EAS subsidy be altered from an airline subsidy to an intercity transportation subsidy so that communities can decide at the local level which mode of service best fits their collective needs.

The purpose of this study is to examine the viability of substituting a bus or shuttle system for the current EAS in the continental US. The results from this analysis will aid EAS community leaders in deciding how to meet their communities' transportation needs.

This report proceeds with a literature review that details how public opinion has evolved in regards to the EAS and cites some empirical research that attempts to support some of these arguments. The two subsequent chapters highlight the cost and convenience advantages of substituting the EAS with a ground transportation system.

Following these chapters is a cost-benefit analysis and a discussion of the self-sufficiency potential of the ground transportation service. The final chapter summarizes the conclusions and policy implications of the findings.

The three appendices include the main tables and figures from the final analysis and technical details, which may be useful to some readers.

LITERATURE REVIEW

The original intent of the EAS was to protect certain rural communities from losing air service due to the unprofitability of servicing those communities. This argument was largely supported by the fact that a carrier needed to first demonstrate that they could not serve the EAS community without incurring a loss in order to be eligible for a subsidy (U.S. Congress Transportation and Infrastructure Committee Subcommittee on Aviation 2007a, statement of Gerald Dillingham, Director of Physical Infrastructure Issues, Government Accountability Office). Airlines were required to give an estimate of the difference between ticket revenue and the costs plus five percent profit, and the government reimbursed that difference (Frank 2007).

The original legislation included a sunset provision that set the end date for the subsidies at 10 years, with the hope that the market would eventually find a way to make rural air operations sustainable. However, not only has this goal not been realized, but the average air service subsidies per community have continued to increase significantly. These facts led many to believe that the EAS was necessary to maintain air service to these rural communities and helped justify the passing of the Rural Survival Act of 1996, which ended the sunset provision.

Since 1979, the total subsidy appropriations per community have increased by about 181% in real terms according to EAS subsidy data from the U.S. DOT (2015b) Historical Fiscal Year Appropriations and Number of Points Receiving Service and the U.S. Department of Labor Bureau of Labor Statistics consumer price index (CPI) data. At the same time, the average cost of providing scheduled air passenger service increased by about 183.1%, in real terms, from 1980 to 2013, while the average airfare, in real terms, actually decreased by about 18% from 1980 to 2012 (U.S. Department of Labor Bureau of Labor Statistics 2014). Based on these figures, it is clear that there is a need for government subsidies in order to maintain air service at many of the EAS communities.

Of course, some exceptions to this generality exist. Topeka, Kansas, for example, lost its EAS subsidies in May 2003, and the level of outbound passengers grew from 2,977 in 2003 to 3,985 in 2013, an increase of about 34% over 10 years (U.S. DOT Office of Aviation Analysis 2015a). In 2014, the level of outbound passengers climbed to as high as 13,815. This is partially due to the $950,000 Small Community Air Service Development Program (SCASDP) grant to the Topeka Regional Airport in 2012, which allowed for airport improvements to be made (U.S. DOT 2013).

Surprisingly, 10 out of the 34 EAS communities that have had their EAS subsidies terminated in 1993 or after have experienced a major increase in their outbound passenger levels. All communities that saw an increase in air traffic after the EAS termination had an average increase of about 1,500%, while those that saw a decrease in air traffic almost always saw a decrease to zero. This unusually large increase in air traffic after termination for a few communities can partially be explained by the SCASDP grants and other various changes either in airport infrastructure or community characteristics.

The low level of aircraft ridership is often advanced as support for the termination of the entire EAS program. As evidenced by the 2014 passenger data from the U.S. DOT Office of the Assistant Secretary for Research and Technology (USDOT/OST-R) Bureau of Transportation Statistics (BTS), 61% of current EAS communities fail to maintain an average ridership equal to 50% of aircraft capacity (USDOT/OST-R BTS 2015a). (Refer to Figures 8 through 10 in Appendix B for distributive plots.) In light of the growing costs associated with maintaining air service and the low level of ridership at these EAS communities, it is natural to question the necessity of having subsidized commercial air passenger service to these communities. How important is it to connect these EAS communities to a large or medium airport via aircraft? Many constituents at EAS communities highlight the importance of the subsidized air service on the local economy. Global industries and tourism rely heavily on fast and convenient transportation, and they are among some of the major proponents of the continuation of the EAS (Richardson 2015).

Many studies have looked into the effects of airline traffic on various economic performance measures such as income and employment. In general, the results have shown that airline traffic does have a positive effect on local economic outcomes. A study by Brueckner (2003) used data from 91 US metropolitan areas covering a wide range of population levels for the year 1996. The author used a two-stage least squares regression analysis, and the two structural equations are shown in Equations (1) and (2).

$$GDSEMP_i = f(T_i , X_i \, ; \, \theta) + u \tag{1}$$

$$SVCEMP_i = f(T_i , X_i \, ; \, \theta) + u \tag{2}$$

Where *GDSEMP* and *SVCEMP* represent total nonfarm employment in the goods-related industry and the service-related industry, respectively; subscript *i* represents individual metropolitan areas; T is the total 1996 passenger enplanements in the metropolitan area and is the variable of interest; X is a vector of exogenous variables that influence employment; and θ is a parameter vector. The list of exogenous variables that are in X include the 1990 population, shares of the 1996 population that are 14 years old or younger, shares of the 1996 population that are 65 years old or older, the average temperature for the metropolitan area over the 1971–2000 period, the percentage of college graduates in the 1990 population, a dummy variable that equals one if the metropolitan area is within a state with a “right-to-work” law, the maximum marginal rate for the state’s personal income tax (1996), and the maximum marginal rate for the state’s corporate tax (1996).

The models have many advantages that allow them to be applicable even in the smaller EAS communities. Brueckner (2003) first selected a wide range of metropolitan statistical areas (MSAs) with varying population levels. By doing this, the study is more representative and allowed the study to examine effects across the whole population range and control for differences in population. However, this study never mentioned how the MSAs were selected into the sample, which raises a concern regarding selection bias. There are also inherent endogeneity issues with the air passenger traffic variable. Refer to Appendix C for more technical details and an explanation of endogeneity.

The results of the study by Brueckner (2003) show that air passenger traffic has no effect on goods-related industry employment but is positively related to service industry employment. According to the study, a 1% increase in air passenger traffic leads to a 0.11% increase in total employment in the service sector. It is worth noting that there is only a one percentage point difference between the model that controls for endogeneity and the one that does not. This suggests either that there is little reason to worry about endogeneity issues or that the instruments that were used are inadequate in controlling for the endogeneity issue even though they meet the instrumental variable criteria. At the same time, the insignificance of the coefficient for the college graduate variable raises additional suspicion about the results of this study. Taking these criticisms and the date at which the data were collected into consideration leads to the conclusion that the only contribution that this study makes is to provide an analytical framework for future research.

A study by Bilotkach (2015) used 17 year panel data covering all US metropolitan areas for the years 1993–2009 and ran a two-stage least squares two-way fixed effects estimation and a generalized method of moments (GMM) estimation separately for comparison. Bilotkach (2015) approached the issue of endogeneity a bit differently than Brueckner (2003). Not only does Bilotkach’s (2015) data span across time, but the study also lagged all independent variables by one and used the second lag as instrumental variables. This study aimed to measure the effects of three airport-level variables (total passengers, total number of flights, and the number of flight destinations offered at each MSA) on three economic variables (total employment, total number of establishments, and real weekly wage rate). The three equations can be summarized as one:

$$\ln(Y_{it}) = \alpha_i + \sum \beta_t I_t + \gamma_1 \ln\left(T_{i_{t-1}}\right) + \gamma_2 \ln\left(D_{i_{t-1}}\right) + \delta X_{i_{t-1}} + \varepsilon_{it} \qquad \textbf{(3)}$$

Where Y_{it} is one of the three economic development indicators in metropolitan area *i* at time *t*; α_i and β_t represent MSA fixed effects and yearly fixed effects, respectively; $T_{i_{t-1}}$ is the air traffic level measured by either passenger volume or number of flights; $D_{i_{t-1}}$ is the number of unique destinations; subscript *t* denotes the value from the current year, so *t-1* denotes the value from the previous year; and $X_{i_{t-1}}$ is a vector of independent control variables lagged one period: natural log of area population, unemployment rate, airport-level concentration, average airfare, and airlines’ market shares at the airport(s).

A notable weakness of this model is that it does not control for the varying levels of human capital as measured by educational experience. The results were taken from the GMM estimators and show that a 1% increase in the number of air passengers leads to a 0.02% increase in the average wage per week and a 0.006% increase in total employment. The figures from this more sophisticated estimation show that there is a much smaller effect between air passenger traffic and wages than Brueckner (2003) found, which suggests that a significant portion of the positive effects are attributed to idiosyncratic factors at the MSA level. As with the previous example of Topeka, Kansas, the area experienced a 34% increase in outbound passenger air traffic after losing its EAS, its real per capita income increased 8% and employment levels increased 38% over the same time period between 2003 and 2013 (U.S. Bureau of Economic Analysis 2014 and U.S. Bureau of Labor Statistics 2014).

The Topeka case coupled with the results from the previous research does suggest that air passenger traffic positively affects local economic outcomes, however small. This finding fits well with urban economic theory, which states that urban areas can potentially experience a net benefit from agglomeration, either in an industry or in general, due to better labor markets, sharing of ideas and/or skills, and sharing input markets. Agglomeration is defined as the geographic clustering of individuals and or businesses. Hence, if there is a high level of air passenger traffic, the agglomeration benefits can be shared across cities, resulting in intercity agglomeration benefits. Therefore, it may be the case that intercity travel is the ultimate source of the economic benefit derived from intercity agglomeration.

Because none of the aforementioned studies incorporate intercity travel through other modes of transportation, their estimators likely suffer from omitted variable bias. Furthermore, the previous studies used enplanement data collected using Federal Aviation Administration (FAA) Form 1800-31, Airport Activity Survey, which adds up both scheduled and nonscheduled revenue passengers (U.S. FAA n.d.). This means there is potential measurement error because the enplanement data do not separate out the commercial aviation passengers from the general aviation passengers if both generate revenue for the reporting airport. However, while urban economic theory strongly supports the claim that there is a positive effect between intercity travel and economic outcomes, it would be wrong to assume that this effect exists only for air travel or that the effects from air traffic are always going to be the strongest.

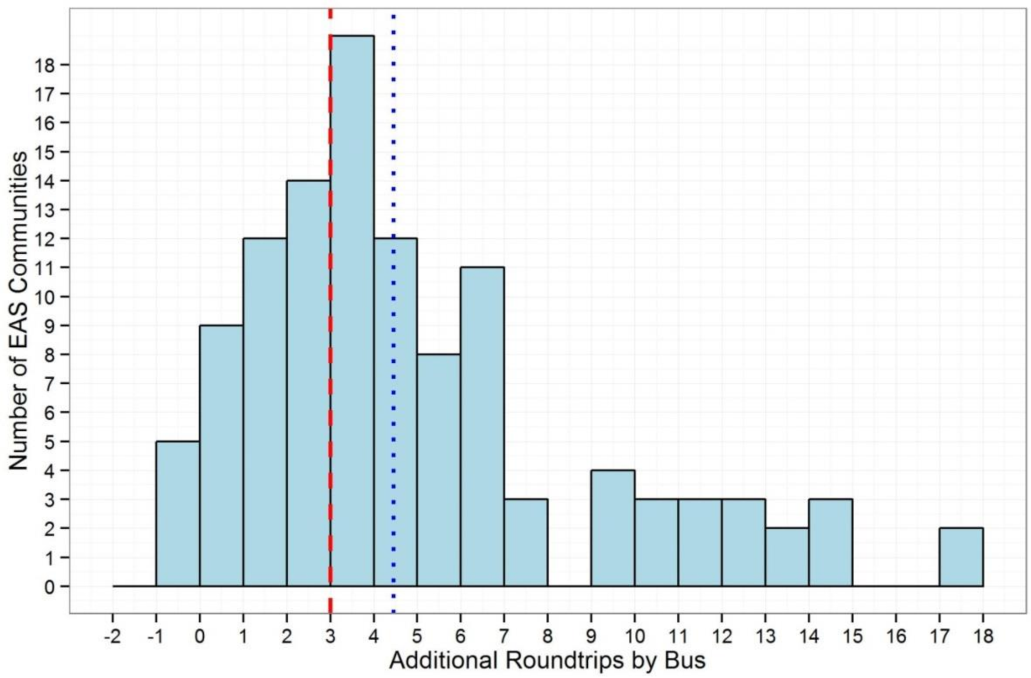
Finally, it is safe to assume that as the cost of transportation decreases, the realized intercity agglomeration benefits increase. If the cost of transportation is determined by more than just money (such as time, comfort, and convenience), it stands to reason that ground travel may not always be the dominant choice and that air transportation can be the more attractive option. Thus, the decision in regards to the mode for intercity travel is simultaneously determined by the comparative direct accounting cost, the comparative trip times, and the comparative convenience of the two alternatives.

COMPARABLE ROUND TRIPS ANALYSIS

For this report, convenience is measured by the variety in trip schedules. This means that if the available departure times at any community increase, then the convenience factor increases as well. This increase in available departure times can be accomplished by increasing the number of available round trips. One round trip is defined as starting from point A, going to point B, and then returning back to point A.

By holding the current subsidy amount to each community constant, the number of alternative round trips that can be made with a bus or shuttle can be calculated and compared. A per mile cost of $2.71 per mile and $2 per mile were used for the bus and shuttle, respectively. The cost per mile figure is the median value of a cost range that was estimated by Lowell et al. (2011).The U.S. DOT sets a minimum required number of round trips per weekday for each carrier at each community. This is determined with the help of the respective local community leaders. The per weekday measure means that for any given week, the number of round trips made during the seven-day week divided by five (for the five weekdays in a week) must equal the minimum number of round trips per weekday.

On average, switching over to a subsidized bus service would allow an additional five round trips per weekday on top of the current minimum EAS trips without increasing subsidy costs to the government. Furthermore, by restricting the ground transportation substitute to only the most feasible communities—for instance, the 15 communities with the shortest drive times to their nearest hubs—this average number of additional round trips per weekday increases to 10 for buses and 16 for shuttles. In Figure 2, the bars show the additional bus trips per weekday.

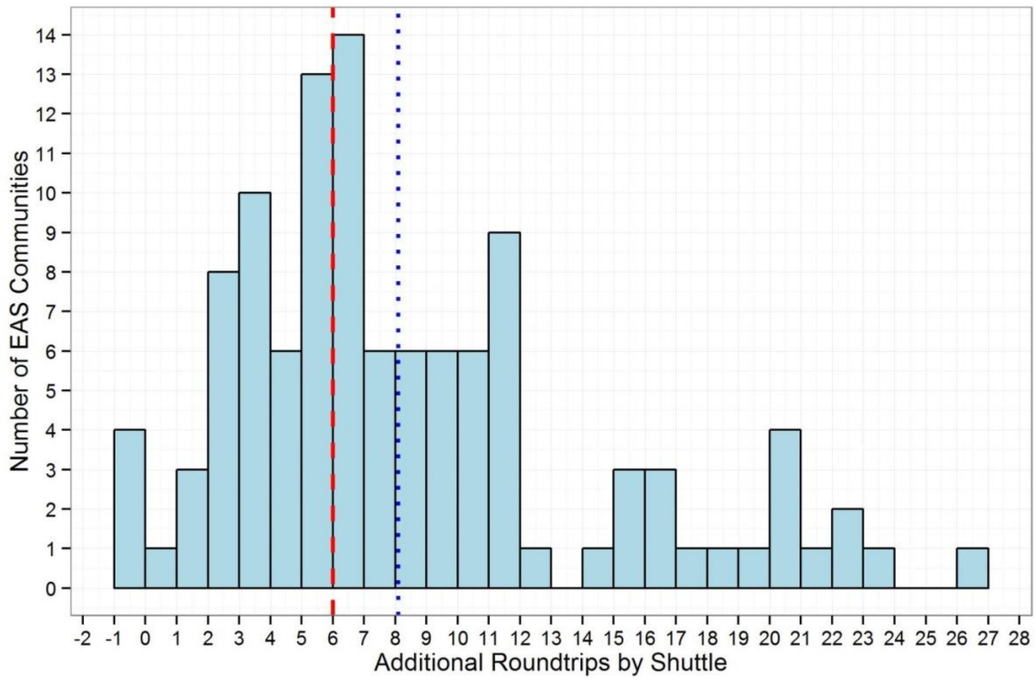


Note: EAS communities that were excluded from this analysis due to early air service termination: Kingman and Prescott, Arizona; Macon, Georgia, and Moab and Vernal, Utah.

Figure 2. Comparative round trips by bus

About 40% of all EAS communities would gain two to four round trips per weekday in addition to the number of current round trips made through air service. Figure 2 also shows the distribution of communities with respect to the number of additional round trips made with a bus. The red dashed line shows the median additional round trips that would be made by bus if all communities were to switch. The blue dotted line shows the average additional round trips that would be made by bus if all communities were to switch. The x-axis includes negative numbers because there are some communities whose members would have to drive so far that switching over to ground transportation would cause a decrease in the number of available round trips per weekday, holding subsidy dollars constant.

Similarly, analyzing the additional available round trips from switching over to shuttle service gives even more favorable numbers, as shown in Figure 3.



Note: EAS communities that were excluded from this analysis due to early air service termination: Kingman and Prescott, Arizona; Macon, Georgia, and Moab and Vernal, Utah.

Figure 3. Comparative round trips by shuttle

For instance, on average, switching to a shuttle system can provide about nine additional round trips per weekday compared to the minimum EAS trips. As before, the red dashed line is the median and the blue dotted line is the average. The distribution is much more level for the shuttle service, which makes sense because the cost per mile of a shuttle bus is much lower than that of the traditional bus. This distribution would allow communities with greater driving distances to still be able to make additional round trips. Thus, the shuttle service is more beneficial over longer distances compared to the traditional bus.

The figures for the number of round trips that can be made per weekday by plane, bus, and shuttle are displayed in Table 11 in Appendix A.

COMPARABLE COST PER MILE ANALYSIS

One way of examining the comparative direct accounting costs is by looking at the costs in terms of a per mile basis. The cost per mile comparison focuses on how much more the cost per mile of a subsidized flight is compared to the cost per mile of a bus and/or shuttle. There are two methods of calculating the cost per flight mile: one is based on the recorded direct costs, and the other is based on aircraft cost specifications from various online sources. In Equation (4), the airfare is included because the costs per mile for bus and shuttle already incorporate a 20% profit margin.

$$Cost\ per\ Mile_i = \frac{Annual\ EAS\ Subsidy_i + (Cost\ of\ Plane\ Ticket_i \times Annual\ Roundtrip\ Passengers_i)}{Annual\ Flight\ Miles_i} \quad \textbf{(4)}$$

Where i is the individual EAS communities' route and j is the specific aircraft used to fly route i.

Because the actual cost per mile of flight is unknown, this study assumes that the air passenger revenue plus the EAS subsidies are enough to cover air costs plus profit. Note that the air cost and ground cost are not forced to have the same profit margin because in reality this is likely to be the case. In Equation (5), the cost per block hour is assumed to be the cost before profit because a few of the sources for that variable are airport records, and so it is multiplied by 1.2 to account for the profit margin.

$$Cost\ per\ Mile_i = \left[\frac{Cost\ Per\ Block\ Hour_{ij} \times Flight\ Time_i}{Distance\ Flown_i}\right] \times 1.2 \quad \textbf{(5)}$$

On average, the cost per mile of flight is higher than that of a bus by a factor of 4.50 and higher than that of a shuttle by a factor of 6.61 using Equation (4). Note that the minimum airfare is used to calculate Equation (4) to obtain a more conservative estimate. Calculating the per mile cost of an EAS flight with Equation (5), which uses cost figures for specific aircrafts in operation for each EAS route, yields much lower costs per flight mile. The average cost per flight mile from Equation (5) is higher than the cost per bus mile by a factor of 3.10 and higher than the cost per shuttle mile by a factor of 4.56. This suggests that the cost per flight mile is higher than the cost per bus mile by a factor that is likely to fall between 3.10 and 4.50. Likewise, the range for the shuttle is between 4.56 and 6.61. It is useful to mention that more confidence is placed on the upper bound estimate because the data used to calculate Equation (4) are more reliable.

It is obvious that the shuttle is the least expensive ground transportation alternative, and, based on the previous analyses, it is reasonable to ask why anyone would ever consider the bus substitute. The answer to this is that a bus has a much higher seating capacity than a shuttle, and if a community requires additional seating for larger groups, such as during major peak needs for a large university, conference center, or tourist event, then it makes sense for that community to consider the bus. Therefore, the cost per seat mile gives a better indication of relative costs because it shows the costs of transporting one passenger one mile.

This study assumes that the seating capacity for a shuttle and a bus is 12 and 55, respectively, while the seating capacity for each aircraft is taken from online sources. On average, the cost per seat mile of an EAS flight is higher than the cost per seat mile of a bus by a factor between 8.30 and 11.63. If we look only at the 15 communities with the shortest drive times, that range becomes 11.17 and 14.82. Similarly, the cost per seat mile of an EAS flight is, on average, higher than the cost per seat mile of a shuttle by a factor between 2.66 and 3.73. For the communities with the shortest drive times, this range is 3.58 and 4.75. This finding suggests that the bus is the most economical choice for higher trafficked EAS communities.

This study does not assume that any particular community is best served by either a bus or shuttle. Instead, both bus and shuttle are analyzed in the cost-benefit analysis for the purpose of meeting a whole range of EAS communities' needs.

COST-BENEFIT ANALYSIS

The cost-benefit analysis is done individually for each community and explores both the bus and shuttle alternatives. The communities of interest here are only those within the continental US, which means that communities in Alaska and Hawaii are excluded from this study. The analysis uses EAS data taken from the US Subsidized EAS Report for November 2014 (U.S. DOT EAS and Domestic Analysis Division 2014).

This study attempts to measure the total monetary effects of switching over from EAS to either a bus or shuttle service network for each community. The relevant variables can be broken into two main groups: direct accounting costs and nonpecuniary costs. The direct accounting cost is the actual cost to run each service network. The nonpecuniary costs consist of the monetary loss of having additional travel time and the social costs of emissions.

The impact on local economic outcomes is not directly estimated due to the possibility that it is intercity travel in general that positively impacts local economic outcomes and not strictly intercity travel by air. Therefore, the impact on the local economy of a ground transportation substitution is unknown, and the impact assumed to be unaffected as long as intercity travel is maintained.

It is also important to note that the following cost-benefit analysis only looks at a snapshot in time and does not extrapolate the costs and benefits over time, which thus avoids the need for any net present value calculations. Another important note is that there are 21 communities within the EAS program that have more than one hub destination. To keep the analysis simple, only one of these hubs were chosen to compare costs with the bus and shuttle.

The EAS destination hubs were chosen based on the authors' opinion of attractiveness. If flight times between the two hubs were similar, then the cheapest destination was used. If there was a slight difference in price but a large difference in flight times, then the hub with the shorter time was chosen. In addition, the driving destinations may be different than the EAS destinations if there is a closer hub of the same class than the current EAS destination. Finally, note that the driving routes in the cost-benefit comparisons are from one airport to another to keep the analysis relatively simple. Most likely, in reality this will not be the case. The methodologies of quantifying all relevant variables are each given their own separate subsection below.

Direct Costs

The direct cost comparison compares the cost of running each transportation network on a round trip basis. This is done because each community may not want to adopt only one transportation option and may instead have a combination of air, bus, and/or shuttle. Thus, comparing direct round trip cost and the direct round trip cost per seat would most benefit these communities in their decision making process. The calculations for the direct round trip costs are as follows:

$$\text{RT Air Cost per Seat}_i = \frac{Annual\ EAS\ Subsidy_i + (CY\ 2014\ Passengers \times Airfare_i)}{Minimum\ RTs\ per\ Year_i \times Aircraft\ Seat\ Capacity_i} \quad \textbf{(6)}$$

$$\text{RT Bus Cost per Seat}_i = \frac{Drive\ Miles_i \times Bus\ Cost\ per\ Mile \times 2}{Bus\ Seat\ Capacity} \quad \textbf{(7)}$$

$$\text{RT Shuttle Cost per Seat}_i = \frac{Drive\ Miles_i \times Shuttle\ Cost\ per\ Mile \times 2}{Shuttle\ Seat\ Capacity} \quad \textbf{(8)}$$

Note that the emissions costs have not yet been added to the round trip cost calculations. To calculate only the cost per round trip, the same equations are used, except the cost is not divided by seating capacity. The subscript *i* means that that value is specific for community *i*, and RT stands for round trip. Equation (6) uses revenue passenger data, and it is assumed that all those who utilize the EAS require a round trip service. Passenger data were taken from the U.S. DOT's *Air Carriers: T-100 Domestic Market (All Carriers)* table for the year 2014 (USDOT/OST-R BTS 2015b). The minimum airfare is also used for Equation (6) in hopes of obtaining a more conservative estimate. The airfare numbers were taken three months in advance for the month of October, but some communities had an established EAS termination date before then, in which case the price from the last available day of service was taken. If that was not available, the community was dropped from the analysis altogether.

Again, the bus cost per mile of $2.71 per mile was taken from a similar cost-benefit study done by Lowell et al. (2011). The authors reported a range of possible values for the bus cost per mile, from $2.61 to $3.27 per mile. The values are based on gas prices between $3.77 and $3.99 per gallon. These values already incorporate a 30% profit margin, yet this study instead uses a more realistic 20% profit margin. Taking the middle value in the cost range, the cost per bus mile used is $2.71 per mile. Equations (7) and (8) are multiplied by 2 to get the round trip values.

The shuttle cost per mile used is $2 per mile, which may be considered a high cost for airport shuttle service. However, a larger passenger shuttle is typically used for these types of services and drivers are typically employees, so the fully allocated cost and profit are covered by this higher estimate (Mundy 2015).

Travel Time

When choosing a form of transportation, travelers are strongly influenced not only by the price, but also by the amount of time the various modes take. Changing from air to ground transportation means that travelers take more time to arrive at their destination. Therefore, this section of the cost-benefit analysis attempts to monetize travel time in order to reflect travelers' preferences to use less time getting to their final destination. It should be noted, however, that the lower direct costs of ground transportation could lead to more arrival times at the hub airport, which may also significantly reduce the time travelers wait before the air trip to their final destinations. The same may also be true for returning trips.

In order to measure the cost to travelers for this additional time spent, a model was created to predict the amount of additional time spent when traveling by ground as opposed to air. This model was designed after a similar model in Lowell et al. (2011). The present study assumes that everyone who leaves the EAS community will return, and therefore the time comparisons are measured on a round trip basis for the same reasons as those cited in the direct cost comparisons. For a detailed explanation of the calculations throughout the rest of this section, see Appendix C.

For the EAS flights, the total trip time was determined as depicted in Figure 4.

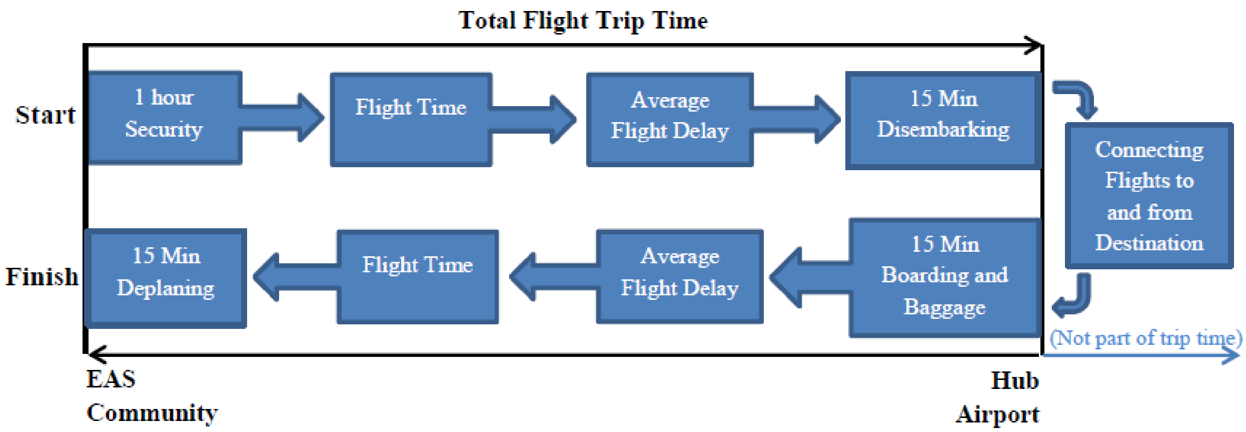


Figure 4. Trip time by air

In recent years, airlines have begun to incorporate the time for operations other than just flight as well as "fluff" time to improve on-time performance goals. This means that the reported flight times are the times from one gate to the other (Frank 2013). Thus, we assume that the flight time portion includes taxi/idle in and taxi/idle out times as well. On the return portion of the trip, the same flight time and delay time were used as the outgoing trip. The flight times were taken from the Expedia website, with supplemental data from the Priceline website and Google Flights if prices were not available on Expedia. The average flight delay was calculated using Equation (9), which is based on performance data for each airline providing flights to each EAS community.

$$Avg. Flight\ Delay = (probablity\ of\ flight\ delay)(avg. delay\ when\ delays\ occur) \qquad \textbf{(9)}$$

Data for the small regional airlines came from the FlightStats.com website, while data for American Airlines, Delta Airlines, and SkyWest Airlines were taken from Airline On-Time Statistics and Delay Causes from the BTS website (USDOT/OST-R BTS 2015c).

For the bus or shuttle, the total trip time was determined as depicted in Figure 5.

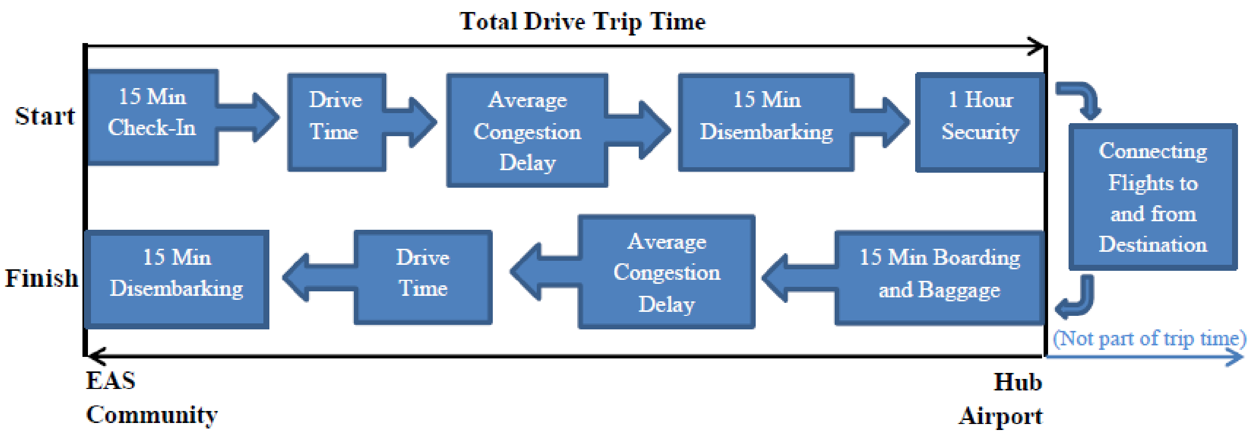


Figure 5. Trip time by bus or shuttle

On the return portion of the trip, the same drive time and delay time were used as the outgoing trip. The average congestion delay for each community was calculated using Equation (10), and data were collected for the Travel Time Index and the number of rush hours for each urban area from the 2012 Annual Urban Mobility Report (Texas A&M Transportation Institute (TTI) 2012). The Travel Time Index is the ratio of travel time during peak congestion times to travel time when no congestion exists and thus measures the intensity of the congestion. The number of rush hours is the number of hours per day that congestion is present in the urban area, which helps determine the probability of hitting congestion.

$$Avg. Congestion\ Delay = (congestion\ intensity)(.6)(prob. of\ hitting\ congestion) \quad \textbf{(10)}$$

Once the total times for ground and air services are calculated for each EAS community, the bus total travel time is subtracted from the air total travel time to yield the time lost per trip when traveling by ground instead of air. In order to monetize this time, several steps are taken. According to the U.S. DOT, 59.6% of intercity air traffic is personal and 40.4% is business, and people value time saved while traveling at 70% of their income for personal travel and 100% for business travel (U.S. DOT Office of the Secretary of Transportation 2014). Therefore, to discern the monetary value of the time difference spent traveling, the 2013 median annual income of each EAS community was collected from the American Community Survey and converted to an hourly income (U.S. Census Bureau 2014). The number of round trip passengers was taken from the same place as before. Equation (11) is used to produce the total monetary value of the annual time difference between traveling by ground transportation as opposed to traveling by EAS flight, measured in U.S. dollars per year.

$$Value\ of\ Time\ Lost\ Per\ Trip = (hourly\ income)(time\ diff.)(enplanements)[(1)(.404) + (.7)(.596)] \quad \textbf{(11)}$$

From these calculations, it is estimated that switching every EAS community in the continental US from air service to ground service in 2013 would have cost EAS travelers a total of 341,837 hours, which is valued at $85,129,406. This averages to $72 for each enplanement in 2013.

Emissions

To calculate aircraft emissions for one flight, many variables are necessary. First, each route serviced for any EAS community has a reported aircraft that is used by the contracted air carrier and is reported on the U.S. DOT's website under US Subsidized EAS Report for April 2015 (U.S. DOT Office of Aviation Analysis 2015b). All the reported aircraft fall under one of three engine categories: turboprop, turbofan, and piston. Due to the unavailability of aircraft-specific emissions data, this report uses emissions data from engines that are similar to the ones used by the aircraft of interest. Turboprop engine emissions data were taken from the U.S. Environmental Protection Agency's (EPA's) *Final Technical Report: Collection and Assessment of Aircraft Emissions Base-Line Data Turboprop Engines* (Vaught et al. 1971) in conjunction with the National Aeronautics and Space Administration's (NASA) *Stratospheric Emissions Effects Database Development* (Baughcum et al. 1994). Within the turboprop category there are different values depending on whether NASA classifies the aircraft as large, medium, or small based on seating capacity. Without any clear guideline from NASA as to how it classified aircraft size, the present study classifies any turboprop aircraft with a seating capacity of 30 or more as large, between 14 to 30 as medium, and 10 or less as small. All three size categories have their unique emissions indexes. However, the report from NASA only reported the averages of each pollutant (Baughcum et al. 1994). The estimated emissions index for each pollutant and each phase of flight is calculated by first calculating the average emissions index for each pollutant from the EPA report (Vaught et al. 1971). Then, the emissions index for each pollutant and each phase of flight is divided by the average emissions index over all phases. This value is then multiplied by the average emissions index in the NASA report (Baughcum et al. 1994) to obtain the estimated value for any particular phase of flight. This is done because the EPA report (Vaught et al. 1971) is 20 years older than the NASA report (Baughcum et al. 1994), and the EPA's emissions data are likely to suffer from measurement error and the sample aircraft are likely to not be representative.

The emissions data for turbofan engines were taken from the International Civil Aviation Organization's (ICAO) emissions databank (United Nations 2015). This databank does not have the specific engine models of interest on record but contains other models from all of the different engine manufacturers. To circumvent this issue, the average of all models from each relevant manufacturer was used. The data for the piston-type engines were taken from the Federal Office of Civil Aviation (FOCA) of Switzerland (Switzerland n.d.). The piston emissions data are the only data specific to the aircraft of interest.

An emissions index is defined as the grams of pollutant per kilogram of fuel used and varies depending on the power setting, which differs depending on the mode of flight. Therefore, the total level of emissions was calculated separately for each aircraft, route, and mode of flight. Other variables used in the calculation of emissions were the typical cruise altitude, average taxi time, maximum rate of climb for each aircraft, and the fuel used (in kilograms per second) for each mode of flight. The variable for the amount of fuel used is reported with the emissions data. A detailed table of all aircraft variables and their respective sources can be found in Appendix A Table 12. The typical cruise altitude was taken from "flightaware.com," which tracks all live flights and is route specific (FlightAware n.d.). However, while the cruise altitude may change considerably depending on wind direction and speed, for the purposes of this study it is sufficient to use the one value taken from a specific date and treat it as a constant. Average taxi times were taken from the U.S. DOT Research and Innovative Technology Administration (RITA), Bureau of Transportation Statistics (BTS), Airline On-Time Performance Database, and T100 Domestic and International Segment Databases. The maximum rate of climb data was taken from various online websites. Once the total amount of fuel needed (in kilograms) was estimated for each phase of the flight, it was then multiplied by the emissions index for nitrogen oxide (NO_X), carbon monoxide (CO), and hydrocarbons (HC, sometimes called volatile organic compounds or VOCs). No aircraft emissions databank had an emissions index for carbon dioxide (CO_2), so this emission was left out of the analysis of bus transport as well.

This report follows the guidelines laid out by the U.S. DOT Transportation Investment Generating Economic Recovery (TIGER) *TIGER Benefit-Cost Analysis (BCA) Resource Guide* (U.S. DOT 2014). This guide provides a methodology to monetize the negative social impacts of certain pollutants. According to the guide, one short ton (2,000 lbs) of VOCs that are emitted costs society $1,813, and one short ton of NO_X costs $7,147. The CO emissions were monetized according to calculations by the Victoria Transport Policy Institute (2013). The emission values for CO were originally reported in 1989 and for this study were converted to 2015 dollars, yielding a value of $5,223 per short ton of CO emissions (Victoria Transport Policy Institute 2013).

Calculating the emissions for ground transportation does not involve as many steps. Because the miles per gallon estimate of the respective vehicles is the only difference between the bus and shuttle emissions calculations, the two were evaluated at the same time. The data for the emissions index (grams per mile driven) are collected and multiplied by the total miles driven per round trip for each EAS community. The data for NO_X, CO, and VOCs were taken from Table 7.1.1 of the H-258 document on the EPA website (U.S. EPA n.d.). The values are based on a 2001 heavy duty diesel-powered vehicle with 50,000 miles on the odometer. Although data were found for CO_2 and particulate matter (PM) for ground transportation, these figures were left out of the study in order to more accurately compare the air and ground emission costs. Once the emissions emitted per round trip are calculated, the amounts are monetized. Each type of emission is converted from grams per mile into U.S. dollars per ton. This yields the dollar cost placed upon the emissions emitted per round trip for every EAS community. The ground transportation emissions are monetized using the same calculations as those used for the aircraft emissions. The emission types are then summed by community to produce the total emissions dollar value for each EAS community.

The results show that within the EAS program, the service that has the highest emissions cost on society is to Devil's Lake, North Dakota, where one round trip made by the EAS costs about $2,438.50 in social costs due to emissions versus $93.33 per round trip by bus. This example is not unusual. On average, the emissions cost from an EAS round trip flight is 16 times more costly than the emissions cost from one round trip by bus. And because a bus's seating capacity is the same, if not higher, than any aircraft used for the EAS, the analysis of the emissions cost per seat shows a similar but more pronounced pattern. A pivotal assumption here is that if some portion of the EAS is substituted by ground transportation, then the aircraft is idle and not used for any other service. This in turn allows the emissions cost-benefit to be calculated by taking the total aircraft emissions (per round trip) minus the total ground transportation emissions (per round trip). However, if this assumption does not hold, then it cannot be reasonably assumed that substituting any round trip EAS flight would actually result in a lower social cost due to emissions.

RESULTS

The results do not include Kingman, Arizona; Prescott, Arizona; Macon, Georgia; Moab, Utah; and Vernal, Utah because the air carriers at these communities terminated their EAS contracts early, which resulted in the researchers' inability to gather the flight data for these communities. Table 1 shows the round trip cost-benefit results per seat of substituting the EAS with a bus transportation service.

Table 1. Round trip cost benefit per seat of a bus substitution

State	EAS Community	Drive Miles	RT Bus Cost Benefit	RT Shuttle Cost Benefit
MI	Sault Ste. Marie	337	$15,289.55	$16,717.58
NE	Grand Island	154	$15,205.77	$15,858.34
MI	Pellston	289	$14,502.24	$15,726.87
KS	Garden City	340	$14,212.67	$15,653.40
IA	Sioux City	88.7	$14,086.43	$14,462.29
MO	Joplin	166	$13,123.43	$13,826.85
KY	Paducah	150	$11,672.29	$12,307.91
MS	Meridian	208	$ 9,800.81	$10,682.20
NY	Watertown	334	$ 9,712.26	$11,127.57
WI	Eau Claire	91.4	$ 9,648.92	$10,036.23
MS	Laurel/Hattiesburg	132	$ 9,610.49	$10,169.84
MI	Escanaba	300	$ 9,591.12	$10,862.35
IA	Waterloo	190	$ 9,396.47	$10,201.58
MN	Chisholm/Hibbing	214	$ 7,375.08	$ 8,281.89
WI	Rhinelander	238	$ 7,193.75	$ 8,202.27
MN	Bemidji	233	$ 7,053.98	$ 8,041.31
WV	Greenbrier/White Sulphur Springs	247	$ 6,901.81	$ 7,948.46
ND	Jamestown	340	$ 6,840.03	$ 8,280.76
MT	Butte	423	$ 6,798.10	$ 8,590.54
ND	Devils Lake	415	$ 6,714.79	$ 8,473.34

This is a table of the 20 EAS communities that show the highest benefits of substituting one round trip through the EAS with one round trip through a bus service.

As shown in Table 1, the round trip bus and shuttle benefits are very close together in value, with the shuttle benefits being just slightly larger. This result seems reasonable, considering that there is only a 71 cent difference between the costs per mile of the two modes. It may be striking for some that there are communities in Table 1 with drive miles as high as 423 miles. This is due to the fact that the regions' median income from 2013 may not be very high, and if a community also happens to have a low level of passenger traffic, then the net monetary effects per round trip of having a longer travel time will be very low. The numbers from Table 1 can be interpreted as being the net benefit from each round trip when the EAS is substituted by either ground transportation mode. These net benefits per round trip may seem exaggerated. This is because the number of round trips used for the calculation is the minimum number of round trips imposed by the U.S. DOT. This means that if a community has a high enough traffic volume, then its actual number of round trips made in year would be well above the minimum and would thus inflate the benefits per round trip calculation. The benefit per round trip is a valuable measure for communities that experience a low level of intercity travel because they will most likely have low ridership. As such, these low-trafficked communities do not need to consider the added benefit of being able to transport more seats per dollar.

Table 2 shows the 20 EAS communities with the highest round trip benefits per seat from substituting the EAS with a bus service network.

Table 2. EAS communities with the highest round trip benefits per seat from a bus substitution

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost Benefit per Seat
ME	Bar Harbor	BHB	271	$ 607.22
MT	Glendive	GDV	225	$ 591.30
MT	Wolf Point	OLF	315	$ 589.31
MT	Glasgow	GGW	278	$ 565.24
MT	Havre	HVR	254	$ 545.36
NM	Clovis	CVN	233	$ 482.80
MT	Sidney	SDY	272	$ 472.66
PA	Lancaster	LNS	83.2	$ 460.48
NY	Saranac Lake/Lake Placid	SLK	323	$ 448.78
NY	Massena	MSS	161	$ 442.17
NY	Ogdensburg	OGS	123	$ 436.61
NY	Jamestown	JHW	183	$ 427.22
MO	Fort Leonard Wood	TBN	139	$ 421.98
MO	Kirksville	IRK	175	$ 387.98
KY	Owensboro	OWB	140	$ 380.70
MD	Hagerstown	HGR	73.7	$ 365.65
MI/WI	Ironwood/Ashland	IWD	230	$ 341.11
ME	Augusta/Waterville	AUG	162	$ 338.22
VT	Rutland	RUT	159	$ 337.51
CA	Merced	MCE	132	$ 317.98

These values can be interpreted as the net round trip benefit of transporting one seat by bus instead of through the EAS program. This perspective allows communities with high intercity traffic to interpret the per seat costs as per passenger costs; this measure can lead to additional savings by allowing communities to choose the alternative with the higher total cost but higher seat capacity.

Table 3 shows the 20 EAS communities with the highest round trip benefits per seat from substituting the EAS with a shuttle service.

Table 3. EAS communities with the highest round trip benefits per seat from a shuttle substitution

State	EAS Community	EAS Airport Code	Drive Miles	RT Shuttle Cost Benefit per Seat
ME	Bar Harbor	BHB	271	$ 539.62
MT	Glendive	GDV	225	$ 535.18
MT	Wolf Point	OLF	315	$ 510.74
MT	Glasgow	GGW	278	$ 495.90
MT	Havre	HVR	254	$ 482.00
NM	Clovis	CVN	233	$ 424.69
MT	Sidney	SDY	272	$ 404.81
PA	Lancaster	LNS	83.2	$ 439.73
NY	Saranac Lake/Lake Placid	SLK	323	$ 368.21
NY	Massena	MSS	161	$ 402.01
NY	Ogdensburg	OGS	123	$ 405.93
NY	Jamestown	JHW	183	$ 381.57
MO	Fort Leonard Wood	TBN	139	$ 387.30
MO	Kirksville	IRK	175	$ 344.33
KY	Owensboro	OWB	140	$ 345.78
MD	Hagerstown	HGR	73.7	$ 347.27
MI/WI	Ironwood/Ashland	IWD	230	$ 283.74
ME	Augusta/Waterville	AUG	162	$ 297.81
VT	Rutland	RUT	159	$ 297.85
CA	Merced	MCE	132	$ 285.06

Note that these round trip benefit values are lower than the round trip benefits per seat from a bus substitution. This is because the difference in seating capacity between EAS and shuttle is much greater than the difference in the cost per mile figures used.

The communities in both Table 2 and Table 3 are the top 20 candidates for substituting EAS with a ground transportation service network based on the round trip benefits per substituted seat. The main results tables can be found in Table 8 in Appendix A.

POTENTIAL SELF-SUFFICIENCY

The potential for the ground transportation service to reach a level of self-sufficiency rests on the ability for a community to meet the minimum level of bus or shuttle ridership at the maximum price level. The maximum price level is determined in Equation (12).

$$Price\ Airfare_i - VTTS_i = Maximum\ Bus\ \div\ Shuttle\ Price_i \tag{12}$$

The idea is that the maximum bus price has to be less than the price of a plane ticket, all else being equal. This is because the price of the bus ticket has to be set such that it successfully compensates the consumer for the longer travel time associated with the ground alternative. The level of compensation then depends on how much the community "suffers" as a result of the extra travel time, or, in other words, its value of travel time saved (VTTS). Only the VTTS data for business travelers were used because the VTTS is highest for business travelers. This restriction gives the least upper bound on price and provides a justification for the assumption that both personal and business travelers would use the ground service because the maximum price for business travelers is lower than for personal travelers.

For Equation (13), the analysis assumes that the total cost of driving either a bus or shuttle (which includes a profit margin) for any particular route is equal to the minimum level of revenue required for the ground service to be profitably maintained. Therefore, the minimum required revenue (which is the total driving cost) divided by the maximum price results in the minimum level of ridership.

$$\text{Minimum Ridership} = \frac{Total\ Drive\ Cost_i}{Maximum\ Bus \div Shuttle\ Price_i} \tag{13}$$

Equation (13) can be combined with Equation (12) and can be expressed as an inequality that provides better insight into the logic that engendered these equations.

$$\begin{matrix} Total\ Drive\ Cost_i \\ (Minimum\ Revenue_i) \end{matrix} \leq Minimum\ Ridership_i\ x\ (Price\ Airfare_i - VTTS_i) \tag{14}$$

The minimum bus ridership calculation results can be seen in Appendix A, Table 10. Table 4 shows the 20 communities with the highest sustainability potential with regards to the bus substitution, while Table 5 shows the 20 communities with the highest sustainability potential with regards to the shuttle substitution.

Table 4. Communities with the highest sustainability potential for bus

State	EAS Community	Drive	Drive	Min Bus
IA	Sioux City	OMA	88.7	2
CO	Pueblo	DEN	131	2
MS	Laurel/Hattiesburg	MSY	132	2
WI	Eau Claire	MSP	91.4	3
NE	Grand Island	OMA	154	3
PA	Lancaster	PHL	83.2	3
TN	Jackson	MEM	82.6	3
WV	Morgantown	PIT	89.3	4
MO	Joplin	MCI	166	4
AR	Jonesboro	MEM	76.9	4
MS	Meridian	MSY	208	4
IA	Mason City	MSP	129	4
WV	Clarksburg/Fairmont	PIT	107	5
KY	Paducah	BNA	150	5
CO	Alamosa	ABQ	204	5
AZ	Show Low	PHX	174	5
PA	Johnstown	PIT	90.4	5
IA	Waterloo	MSP	190	6
MI	Sault Ste. Marie	DTW	337	6
WV/OH	Parkersburg/Marietta	PIT	145	6

Table 5. Communities with the highest sustainability potential for shuttle

State	EAS Community	Drive	Drive	Min Shuttle
IA	Sioux City	OMA	88.7	1
CO	Pueblo	DEN	131	1
MS	Laurel/Hattiesburg	MSY	132	2
WI	Eau Claire	MSP	91.4	2
NE	Grand Island	OMA	154	2
PA	Lancaster	PHL	83.2	3
TN	Jackson	MEM	82.6	3
WV	Morgantown	PIT	89.3	3
MO	Joplin	MCI	166	3
AR	Jonesboro	MEM	76.9	3
MS	Meridian	MSY	208	3
IA	Mason City	MSP	129	3
WV	Clarksburg/Fairmont	PIT	107	4
KY	Paducah	BNA	150	4
CO	Alamosa	ABQ	204	4
AZ	Show Low	PHX	174	4
PA	Johnstown	PIT	90.4	4
IA	Waterloo	MSP	190	4
MI	Sault Ste. Marie	DTW	337	5

Tables 4 and 5 show the 20 EAS communities with the lowest estimated minimum ridership required for the ground transportation to operate without the need for subsidy dollars. The driving destination columns are expressed as the three-letter airport codes. Remember that the cost of transportation has multiple dimensions: price, time, convenience, and comfort. Therefore, these minimum ridership estimates are most likely biased downwards because they only incorporate the compensation for increased travel time. This study has also made the assumption that ground transportation out competes the EAS in the convenience dimension because more round trips can be made with the ground service network. However, the comparative round trips analysis is an either-or comparison. In other words, it compares the possible number of additional round trips that can be made with each mode if all the resources were only used for that mode. It does not account for the possibility that a community can have a combination of air, bus, and shuttle. Unless it is assumed that if and when a community adopts a ground transportation alternative they use only that alternative, it is not certain that the ground transportation service will outcompete the EAS on the convenience factor. The comfort factor is ambiguous because it is the most subjective. For example, a very tall person may find that a coach bus is exponentially more comfortable than a packed nine-seat Cessna airplane. Or if someone is more susceptible to colder temperatures, this person may find ground transportation to be much more comfortable because small regional airline fleets do not always have ideal cabin temperatures.

The estimates in Table 5 may also suffer from a downward bias for similar reasons as the estimates for the bus. In fact, the shuttle estimates may be even more biased downwards than the bus estimates due to the fact that shuttles do not have restrooms built into them. This will cause the shuttle to be inferior to EAS with respect to the comfort factor. This relative discomfort will only increase as the driving distance and travel time increases.

Regardless of the likely downward bias, the communities that are listed in both Tables 4 and 5 are the most likely to be able to maintain intercity ground services without the need for government subsidies.

CONCLUSIONS AND POLICY IMPLICATIONS

The aim of the recommendations provided in this chapter is to provide the most useful information to the individual communities that are part of the EAS program so they can decide how to optimize their intercity transportation subsidy dollars. Figures 6 and 7 show all of the EAS communities and their serviced routes.

The shading on the scale indicates the different levels of round trip benefits per seat for bus in Figure 6 and shuttle in Figure 7. The summary of round trip benefits per seat of substituting EAS with ground transportation forms the basis of the recommendation for substitution. This summary allows each community to use these figures in a meaningful way regardless of its local demand for intercity transport and decide how to best allocate its transportation subsidy dollars across a variety of transportation modes.

Note that in Figure 6 and 7 the line segments are only shaded to show the varying levels of benefits through ground substitution. This shading does not mean that the ground substitution should be used for that particular route. Instead, it means that if the community substituted EAS with ground transportation to the closest hub of a similar size as their current one, then the level of benefits is indicated on the maps.

There are two reasons why the benefits of substitution would be inflated. The first is that the subsidized air services are reimbursed on a per flight basis, which means that the subsidy dollar amount in the U.S. DOT report is the dollar value that is set aside to be disbursed later in the year. Thus, the appropriated subsidy amount that is reported is not the actual subsidy amount that is received by the air carrier, which leads to an overestimation of the cost of providing subsidized air service. Second, the number of round trips per weekday reported by the U.S. DOT is only the minimum number of round trips required of the air carriers. If a community has a high level of traffic, then it is very likely that the community will make more round trips than the reported number. This would then lead to a higher estimated EAS cost per round trip.

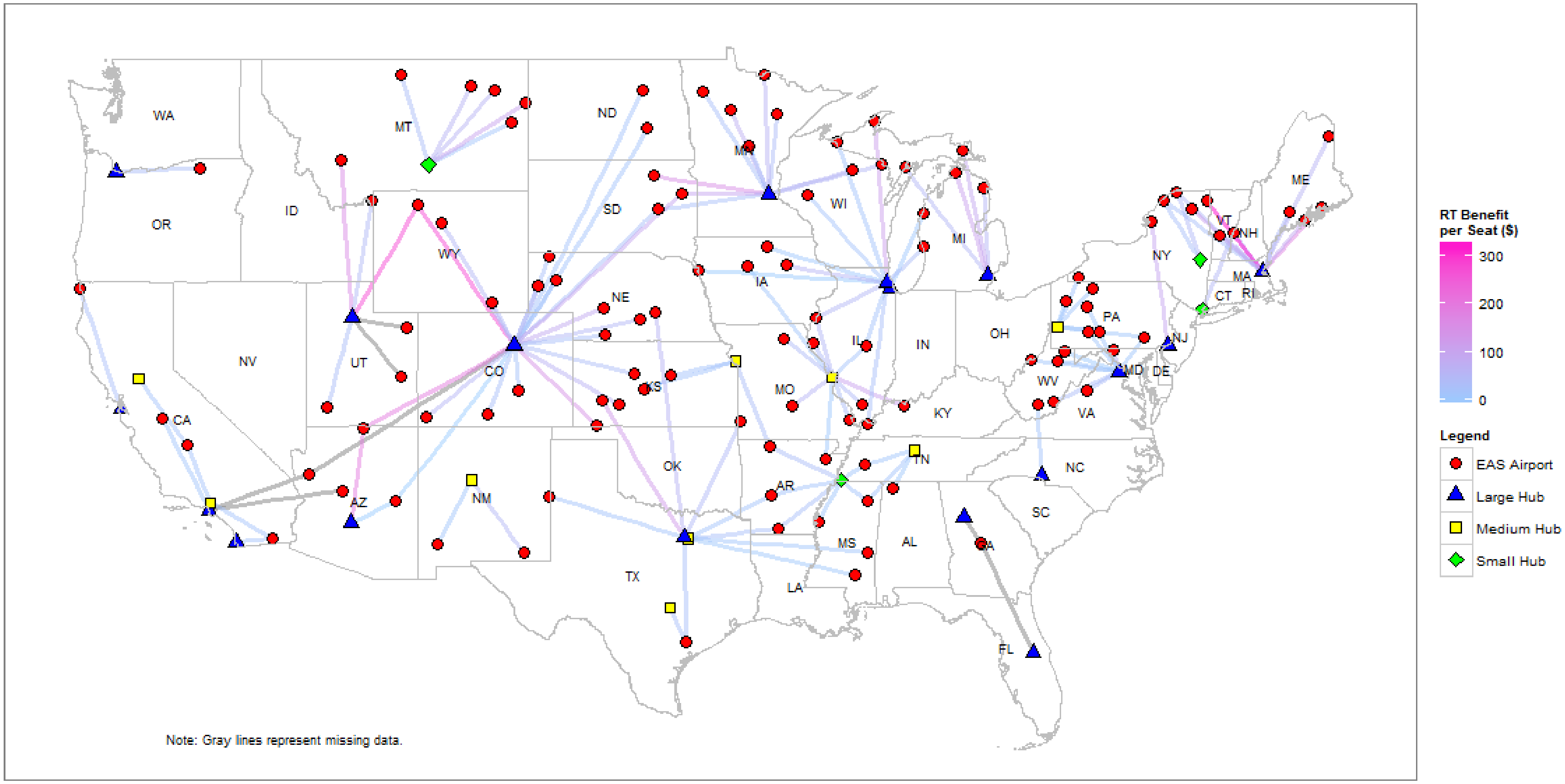


Figure 6. Round trip benefit per seat of bus substitution

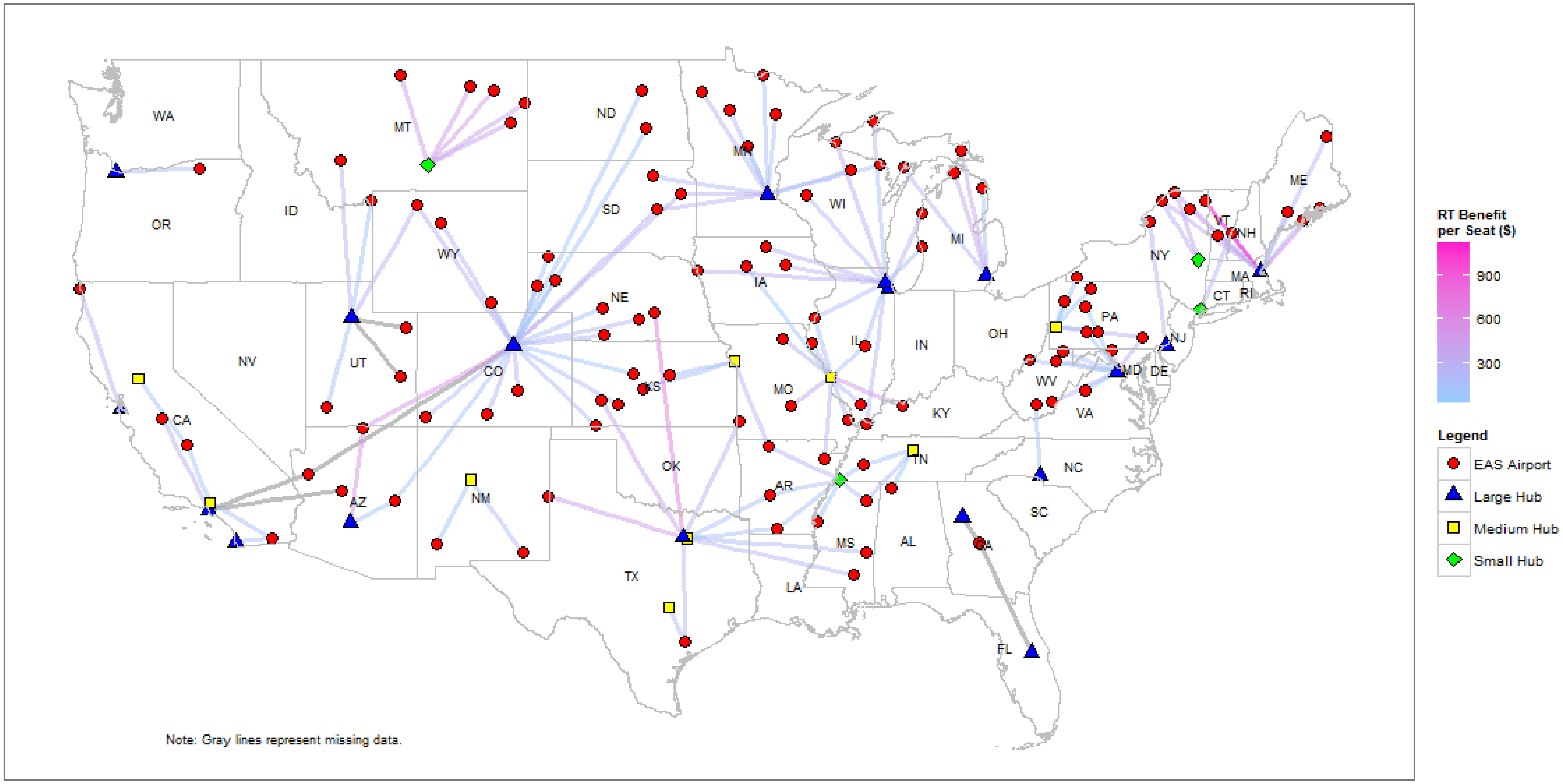


Figure 7. Round trip benefit per seat of shuttle substitution

There is also the issue of knowing the costs and benefits of substituting EAS with ground transportation after taking into consideration the final destinations of the EAS users. After taking the final destinations of EAS users into consideration, the benefits of ground transportation are magnified.

This is based on the fact that if there is a delay during the flight from the final destination to the connecting hub, then the connecting flight back to the EAS community may be missed. This would result in a much longer layover because those passengers would need to wait for the next flight, which may be as many as six hours later. However, if ground transportation is used instead, the layover may only be another two hours due to the ability of the ground transportation to make more round trips per day. An example of this cost-benefit analysis through entire journeys with presumed final destinations is presented in Table 6.

Table 6. Cost-benefit analysis with final destinations

EAS Community			Johnstown, PA
Aircarrier			Silver
Drive Miles			90.4
Drive Time			132.00
EAS Airport Code			JST
Estimated Bus Price			$ 40.83
Estimated Shuttle Price			$ 90.41
Hubs as of April 2015			IAD
Final Destinations	Final Destination	Variables of Interest	Values (1 week fares)
	LAX	CB Bus	$ 142.17
		CB Shuttle	$ 92.60
		Travel Time Diff	160
	SFO	CB Bus	$ 346.47
		CB Shuttle	$ 296.90
		Travel Time Diff	-271
	DEN	CB Bus	$ 116.49
		CB Shuttle	$ 66.92
		Travel Time Diff	85
	ATL	CB Bus	$ 195.77
		CB Shuttle	$ 146.20
		Travel Time Diff	78
	ORD	CB Bus	$ 209.07
		CB Shuttle	$ 159.50
		Travel Time Diff	78

Note: CB is the cost benefit to the individual consumer.

The final destinations are in descending order based on percent of traffic volume. With data from the BTS Air Carriers: T-100 Segment (US Carriers Only) database (USDOT/OST-R BTS

2015d), it is possible to find the level of passenger traffic at each connecting hub that is specific to each outbound destination. This, in turn, allows the ability to find the top five destinations travelled for each major hub as a percent of total enplanements. If we assume that the same percentage of EAS users travel to the same top five destinations as at the connecting hub, then it is possible to calculate the costs and benefits of the entire travel route. In contrast to a cost-benefit analysis that spans only from the community to the connecting hub, this broader analysis goes further and analyzes the costs and benefits up to the final destination and back. In the interest of time, this analysis is only done for Johnstown, Pennsylvania, which was chosen based on the availability of flight information and the driving distance, which is close to the 75 highway mile EAS eligibility threshold imposed by the U.S. DOT.

Johnstown's connecting hub is Washington Dulles International Airport, whose top five destinations are Los Angeles, San Francisco, Denver, Atlanta, and O'Hare International Airport in Chicago. The CB in Table 6 stands for cost benefit. All values are calculated by taking the values that correspond to air travel minus the values that correspond to either bus or shuttle. Table 6 gives a clear indication that in almost every instance there is a net dollar benefit from substituting EAS with ground transportation, given that the EAS users travel to any of these five destinations. However, the ground substitution would result in longer travel times in all five instances. Travel time is the time spent in transport (or motion) and should not be mistaken with the total time to reach one's final destination, which includes wait and delay times.

With the previous findings at hand, it is no surprise that a ground transportation network has serious potential as a better alternative to connect rural communities to the vast national air service network. As such, the recommendation in this regard is to restructure the EAS program such that the subsidies are issued to communities that can then decide for themselves how to allocate their resources to best fit their collective intercity transport needs. The procedure would be to require each qualifying community to submit a cost-benefit analysis of having air, bus, and shuttle service in order to receive its intercity transport subsidies. In this way, subsidized air service may be phased out gradually and naturally.

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APPENDIX A

This appendix includes all tables referenced in the report or used for analysis.

Table 7. Number of round trips per weekday, holding the current subsidy constant

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
AL	Muscle Shoals	MSL	13	19	4
AR	El Dorado/Camden	ELD	4	7	4
AR	Harrison	HRO	5	8	3
AR	Hot Springs	HOT	5	7	3
AR	Jonesboro	JBR	16	24	3
AZ	Kingman	IGM	8	12	2
AZ	Page	PGA	5	8	3
AZ	Prescott	PRC	13	19	3
AZ	Show Low	SOW	6	9	3
CA	Crescent City	CEC	4	6	2
CA	El Centro	IPL	10	15	4
CA	Merced	MCE	13	20	2
CA	Visalia	VIS	8	11	4
CO	Alamosa	ALS	7	10	3
CO	Cortez	CEZ	5	8	3
CO	Pueblo	PUB	8	12	2
GA	Macon	MCN	14	22	2
IA	Burlington	BRL	6	9	4
IA	Fort Dodge	FOD	7	10	4
IA	Mason City	MCW	21	31	4
IA	Sioux City	SUX	4	6	2
IA	Waterloo	ALO	3	4	2
IL	Decatur	DEC	11	17	6
IL	Marion/Herrin	MWA	10	15	6
IL/MO	Quincy/Hannibal	UIN	9	14	6
KS	Dodge City	DDC	4	6	3
KS	Garden City	GCK	2	4	2
KS	Great Bend	GBD	3	5	2
KS	Hays	HYS	5	7	2
KS/OK	Liberal/Guymon	LBL	4	5	3
KS	Salina	SLN	5	7	3
KY	Owensboro	OWB	7	10	3
KY	Paducah	PAH	8	13	2
MD	Hagerstown	HGR	15	23	4
ME	Augusta/Waterville	AUG	7	10	4
ME	Bar Harbor	BHB	3	5	3
ME	Presque Isle/Houlton	PQI	7	11	3
ME	Rockland	RKD	6	9	6
MI	Alpena	APN	5	8	2

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
MI	Escanaba	ESC	6	9	2
MI	Hancock/Houghton	CMX	1	1	2
MI	Iron Mountain/Kingsford	IMT	5	8	2
MI/WI	Ironwood/Ashland	IWD	10	14	3
MI	Manistee/Ludington	MBL	5	8	2
MI	Muskegon	MKG	4	7	2
MI	Pellston	PLN	2	3	2
MI	Sault Ste. Marie	CIU	3	5	2
MN	Bemidji	BJI	3	4	2
MN	Brainerd	BRD	6	9	2
MN	Chisholm/Hibbing	HIB	7	11	2
MN	International Falls	INL	2	3	2
MN	Thief River Falls	TVF	5	7	2
MO	Cape Girardeau/Sikeston	CGI	8	12	4
MO	Fort Leonard Wood	TBN	13	20	4
MO	Joplin	JLN	1	1	2
MO	Kirksville	IRK	6	9	3
MS	Greenville	GLH	16	23	3
MS	Laurel/Hattiesburg	PIB	19	28	2
MS	Meridian	MEI	12	18	2
MS	Tupelo	TUP	17	25	5
MT	Butte	BTM	1	1	2
MT	Glasgow	GGW	4	7	2
MT	Glendive	GDV	5	8	2
MT	Havre	HVR	5	7	2
MT	Sidney	SDY	9	13	5
MT	West Yellowstone	WYS	1	1	2
MT	Wolf Point	OLF	4	6	2
ND	Devils Lake	DVL	5	7	2
ND	Jamestown	JMS	6	8	2
NE	Alliance	AIA	3	5	2
NE	Chadron	CDR	2	4	2
NE	Grand Island	GRI	7	11	2
NE	Kearney	EAR	6	9	3
NE	McCook	MCK	5	8	2
NE	North Platte	LBF	4	6	3
NE	Scottsbluff	BFF	4	6	3
NH/VT	Lebanon/White River Junction	LEB	12	17	6
NM	Carlsbad	CNM	3	4	2
NM	Clovis	CVN	8	13	3
NM	Silver City/Hurley/Deming	SVC	5	7	4
NY	Jamestown	JHW	7	10	4
NY	Massena	MSS	8	12	3
NY	Ogdensburg	OGS	9	13	3
NY	Plattsburgh	PBG	11	17	2
NY	Saranac Lake/Lake Placid	SLK	3	5	3

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
NY	Watertown	ART	6	9	2
OR	Pendleton	PDT	5	8	3
PA	Altoona	AOO	10	15	4
PA	Bradford	BFD	7	10	4
PA	DuBois	DUJ	10	15	3
PA	Franklin/Oil City	FKL	9	14	3
PA	Johnstown	JST	17	25	3
PA	Lancaster	LNS	19	28	5
SD	Aberdeen	ABR	2	3	2
SD	Huron	HON	5	8	2
SD	Watertown	ATY	9	13	3
TN	Jackson	MKL	8	12	3
TX	Victoria	VCT	12	17	2
UT	Cedar City	CDC	8	12	2
UT	Moab	CNY	6	10	2
UT	Vernal	VEL	5	7	2
VA	Staunton	SHD	9	14	3
VT	Rutland	RUT	5	8	3
WI	Eau Claire	EAU	11	16	2
WI	Rhinelander	RHI	4	6	2
WV	Beckley	BKW	7	11	2
WV	Clarksburg/Fairmont	CKB	14	20	3
WV	Greenbrier/White Sulphur Springs	LWB	9	13	2
WV	Morgantown	MGW	17	25	3
WV/OH	Parkersburg/Marietta	PKB	15	23	3
WY	Cody	COD	1	2	2
WY	Laramie	LAR	7	10	2
WY	Worland	WRL	3	5	2

Table 8. Round trip cost-benefit per seat

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost per seat ($)	RT Shuttle Cost per seat ($)	RT Air Cost per Seat ($)	Value of Time Difference/ RT/Seat ($)	RT Bus Cost Benefit per Seat ($)	RT Shuttle Cost Benefit per Seat ($)
AL	Muscle Shoals	MSL	128	12.61	42.67	72.46	2.56	59.85	29.80
AR	El Dorado/Camden	ELD	268	26.41	89.33	153.05	12.93	126.64	63.72
AR	Harrison	HRO	259	25.52	86.33	258.50	28.38	232.97	172.16
AR	Hot Springs	HOT	203	20.00	67.67	157.37	5.80	137.36	89.70
AR	Jonesboro	JBR	76.9	7.58	25.63	222.60	(0.65)	215.02	196.96
AZ	Page	PGA	277	27.30	92.33	229.86	20.27	202.56	137.53
AZ	Show Low	SOW	174	17.15	58.00	135.51	(4.90)	118.37	77.51
CA	Crescent City	CEC	340	33.51	113.33	274.01	25.63	240.51	160.68
CA	El Centro	IPL	120	11.83	40.00	146.77	13.03	134.94	106.77
CA	Merced	MCE	132	13.01	44.00	329.21	7.93	316.20	285.21
CA	Visalia	VIS	172	16.95	57.33	128.31	14.48	111.36	70.97
CO	Alamosa	ALS	204	20.10	68.00	231.66	14.26	211.56	163.66
CO	Cortez	CEZ	252	24.83	84.00	218.99	24.90	194.15	134.99
CO	Pueblo	PUB	131	12.91	43.67	228.97	11.25	216.07	185.31
IA	Burlington	BRL	202	19.91	67.33	191.34	47.13	171.43	124.00
IA	Fort Dodge	FOD	167	16.46	55.67	96.71	0.20	80.26	41.05
IA	Mason City	MCW	129	12.71	43.00	301.61	0.33	288.90	258.61
IA	Waterloo	ALO	190	18.72	63.33	256.16	58.04	237.43	192.82
IA	Sioux City	SUX	88.7	8.74	29.57	270.09	(6.12)	261.35	240.52
IL	Decatur	DEC	147	14.49	49.00	161.44	13.40	146.95	112.44
IL	Marion/Herrin	MWA	132	13.01	44.00	206.17	34.31	193.16	162.17
IL/MO	Quincy/Hannibal	UIN	130	12.81	43.33	206.11	35.70	193.30	162.78
KS	Dodge City	DDC	343	33.80	114.33	211.66	34.04	177.86	97.33
KS	Garden City	GCK	340	33.51	113.33	441.67	133.42	408.17	328.34
KS	Great Bend	GBD	268	26.41	89.33	197.49	0.51	171.08	108.16
KS	Hays	HYS	276	27.20	92.00	133.80	19.76	106.60	41.80
KS/OK	Liberal/Guymon	LBL	363	35.77	121.00	207.63	44.73	171.86	86.63
KS	Salina	SLN	193	19.02	64.33	149.96	10.40	130.94	85.63
KY	Owensboro	OWB	140	13.80	46.67	269.71	18.02	255.92	223.05
KY	Paducah	PAH	150	14.78	50.00	236.80	22.39	222.02	186.80

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost per seat ($)	RT Shuttle Cost per seat ($)	RT Air Cost per Seat ($)	Value of Time Difference/ RT/Seat ($)	RT Bus Cost Benefit per Seat ($)	RT Shuttle Cost Benefit per Seat ($)
MD	Hagerstown	HGR	73.7	7.26	24.57	261.51	6.47	254.25	236.95
ME	Augusta/Waterville	AUG	162	15.96	54.00	260.13	30.38	244.16	206.13
ME	Bar Harbor	BHB	271	26.71	90.33	624.96	148.23	598.26	534.63
ME	Presque Isle/Houlton	PQI	395	38.93	131.67	256.96	59.66	218.03	125.29
ME	Rockland	RKD	188	18.53	62.67	246.86	36.75	228.33	184.19
MI	Alpena	APN	251	24.73	83.67	127.04	23.53	102.30	43.37
MI	Escanaba	ESC	300	29.56	100.00	248.69	55.33	219.12	148.69
MI	Hancock/Houghton	CMX	375	36.95	125.00	200.38	98.88	163.43	75.38
MI	Iron Mountain/Kingsford	IMT	294	28.97	98.00	170.86	41.05	141.89	72.86
MI/WI	Ironwood/Ashland	IWD	230	22.67	76.67	358.01	11.15	335.35	281.34
MI	Manistee/Ludington	MBL	260	25.62	86.67	295.53	34.74	269.91	208.87
MI	Muskegon	MKG	190	18.72	63.33	139.30	24.34	120.57	75.96
MI	Pellston	PLN	289	28.48	96.33	397.46	106.30	368.98	301.12
MI	Sault Ste. Marie	CIU	337	33.21	112.33	395.87	85.44	362.66	283.53
MN	Bemidji	BJI	233	22.96	77.67	207.53	68.49	184.57	129.86
MN	Brainerd	BRD	142	13.99	47.33	136.21	26.33	122.22	88.88
MN	Chisholm/Hibbing	HIB	214	21.09	71.33	179.71	30.90	158.62	108.38
MN	International Falls	INL	303	29.86	101.00	182.64	49.54	152.79	81.64
MN	Thief River Falls	TVF	305	30.06	101.67	266.87	4.14	236.82	165.21
MO	Cape Girardeau/Sikeston	CGI	130	12.81	43.33	238.39	27.70	225.58	195.06
MO	Fort Leonard Wood	TBN	139	13.70	46.33	386.43	51.26	372.73	340.10
MO	Joplin	JLN	166	16.36	55.33	309.88	44.10	293.52	254.54
MO	Kirksville	IRK	175	17.25	58.33	314.19	34.41	296.95	255.86
MS	Greenville	GLH	142	13.99	47.33	129.54	2.19	115.55	82.21
MS	Laurel/Hattiesburg	PIB	132	13.01	44.00	166.45	0.47	153.45	122.45
MS	Meridian	MEI	208	20.50	69.33	174.84	3.21	154.34	105.51
MS	Tupelo	TUP	94.2	9.28	31.40	140.78	1.39	131.50	109.38
MT	Butte	BTM	423	41.68	141.00	301.83	155.25	260.14	160.83
MT	Glasgow	GGW	278	27.40	92.67	521.08	103.97	493.69	428.42
MT	Glendive	GDV	225	22.17	75.00	469.20	34.41	447.02	394.20
MT	Havre	HVR	254	25.03	84.67	487.50	59.02	462.47	402.83

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost per seat ($)	RT Shuttle Cost per seat ($)	RT Air Cost per Seat ($)	Value of Time Difference/ RT/Seat ($)	RT Bus Cost Benefit per Seat ($)	RT Shuttle Cost Benefit per Seat ($)
MT	Sidney	SDY	272	26.80	90.67	418.59	106.90	391.78	327.92
MT	West Yellowstone	WYS	325	32.03	108.33	125.83	45.91	93.80	17.50
MT	Wolf Point	OLF	315	31.04	105.00	541.71	84.65	510.67	436.71
ND	Devils Lake	DVL	415	40.90	138.33	139.20	9.19	98.31	0.87
ND	Jamestown	JMS	340	33.51	113.33	143.01	16.70	109.51	29.68
NE	Alliance	AIA	244	24.05	81.33	150.59	4.29	126.55	69.26
NE	Chadron	CDR	292	28.78	97.33	158.56	7.39	129.79	61.23
NE	Grand Island	GRI	154	15.18	51.33	329.80	23.13	314.63	278.47
NE	Kearney	EAR	187	18.43	62.33	255.87	31.38	237.44	193.54
NE	McCook	MCK	258	25.42	86.00	249.18	4.99	223.75	163.18
NE	North Platte	LBF	258	25.42	86.00	176.99	33.10	151.57	90.99
NE	Scottsbluff	BFF	198	19.51	66.00	156.15	21.66	136.63	90.15
NH/VT	Lebanon/White River Junction	LEB	127	12.52	42.33	262.88	44.25	250.37	220.55
NM	Carlsbad	CNM	291	28.68	97.00	223.05	30.80	194.38	126.05
NM	Clovis	CVN	233	22.96	77.67	505.55	16.68	482.59	427.89
NM	Silver City/Hurley/Deming	SVC	264	26.02	88.00	119.88	4.94	93.87	31.88
NY	Jamestown	JHW	183	18.03	61.00	283.11	1.92	265.07	222.11
NY	Massena	MSS	161	15.87	53.67	378.43	39.11	362.56	324.76
NY	Ogdensburg	OGS	123	12.12	41.00	339.41	24.24	327.29	298.41
NY	Plattsburgh	PBG	151	14.88	50.33	202.40	17.86	187.52	152.07
NY	Saranac Lake/Lake Placid	SLK	323	31.83	107.67	402.42	92.69	370.59	294.75
NY	Watertown	ART	334	32.91	111.33	268.67	65.49	235.75	157.34
OR	Pendleton	PDT	204	20.10	68.00	218.71	30.71	198.61	150.71
PA	Altoona	AOO	123	12.12	41.00	57.89	4.92	45.77	16.89
PA	Bradford	BFD	181	17.84	60.33	109.22	5.35	91.39	48.89
PA	DuBois	DUJ	144	14.19	48.00	86.98	1.10	72.79	38.98
PA	Franklin/Oil City	FKL	85	8.38	28.33	96.12	1.96	87.74	67.78
PA	Johnstown	JST	90.4	8.91	30.13	107.54	4.85	98.63	77.41
PA	Lancaster	LNS	83.2	8.20	27.73	308.69	3.91	300.49	280.95
SD	Aberdeen	ABR	280	27.59	93.33	254.67	158.72	227.08	161.34
SD	Huron	HON	287	28.28	95.67	334.08	24.97	305.80	238.41

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost per seat ($)	RT Shuttle Cost per seat ($)	RT Air Cost per Seat ($)	Value of Time Difference/ RT/Seat ($)	RT Bus Cost Benefit per Seat ($)	RT Shuttle Cost Benefit per Seat ($)
SD	Watertown	ATY	205	20.20	68.33	223.80	7.50	203.60	155.47
TN	Jackson	MKL	82.6	8.14	27.53	127.88	4.09	119.74	100.35
TX	Victoria	VCT	123	12.12	41.00	234.21	1.77	222.09	193.21
UT	Cedar City	CDC	179	17.64	59.67	148.43	29.65	130.79	88.77
VA	Staunton	SHD	132	13.01	44.00	107.89	15.43	94.88	63.89
VT	Rutland	RUT	159	15.67	53.00	303.94	61.46	288.27	250.94
WI	Eau Claire	EAU	91.4	9.01	30.47	184.29	12.49	175.28	153.82
WI	Rhinelander	RHI	238	23.45	79.33	205.49	59.50	182.03	126.15
WV	Beckley	BKW	214	21.09	71.33	172.02	10.10	150.94	100.69
WV	Clarksburg/Fairmont	CKB	107	10.54	35.67	108.73	4.00	98.18	73.06
WV	Greenbrier/White Sulphur Springs	LWB	247	24.34	82.33	252.72	30.04	228.38	170.39
WV	Morgantown	MGW	89.3	8.80	29.77	124.16	(1.59)	115.36	94.40
WV/OH	Parkersburg/Marietta	PKB	145	14.29	48.33	131.76	1.34	117.47	83.43
WY	Cody	COD	455	44.84	151.67	312.35	281.11	267.51	160.68
WY	Laramie	LAR	155	15.27	51.67	187.55	36.51	172.27	135.88
WY	Worland	WRL	408	40.21	136.00	276.70	18.47	236.49	140.70
							Total	23,150.01	17,719.27

Table 9. Round trip cost-benefit

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost Benefit	RT Shuttle Cost Benefit
AL	Muscle Shoals	MSL	128	$ 1,902.85	$ 2,084.61
AR	Jonesboro	JBR	76.9	$ 2,889.53	$ 2,998.73
AR	Harrison	HRO	259	$ 1,947.69	$ 2,315.47
AR	Hot Springs	HOT	203	$ 1,155.99	$ 1,444.25
AR	El Dorado/Camden	ELD	268	$ 651.58	$ 1,032.14
AZ	Page	PGA	277	$ 2,482.21	$ 2,875.55
AZ	Show Low	SOW	174	$ 1,812.39	$ 2,059.47
CA	Merced	MCE	132	$ 5,222.44	$ 5,409.88
CA	Crescent City	CEC	340	$ 6,045.55	$ 6,528.35
CA	El Centro	IPL	120	$ 1,304.48	$ 1,474.88
CA	Visalia	VIS	172	$ 1,212.18	$ 1,456.42
CO	Pueblo	PUB	131	$ 6,156.56	$ 6,342.58
CO	Alamosa	ALS	204	$ 2,901.42	$ 3,191.10
CO	Cortez	CEZ	252	$ 2,215.45	$ 2,573.29
IA	Mason City	MCW	129	$ 3,696.84	$ 3,880.02
IA	Sioux City	SUX	88.7	$ 14,086.43	$ 14,212.38
IA	Waterloo	ALO	190	$ 9,396.47	$ 9,666.27
IA	Burlington	BRL	202	$ 1,046.80	$ 1,333.64
IA	Fort Dodge	FOD	167	$ 1,008.29	$ 1,245.43
IL	Marion/Herrin	MWA	132	$ 1,670.19	$ 1,857.63
IL/MO	Quincy/Hannibal	UIN	130	$ 1,623.71	$ 1,808.31
IL	Decatur	DEC	147	$ 1,374.60	$ 1,583.34
KS	Garden City	GCK	340	$ 14,212.67	$ 14,695.47
KS	Great Bend	GBD	268	$ 1,421.63	$ 1,802.19
KS	Dodge City	DDC	343	$ 1,425.15	$ 1,912.21
KS/OK	Liberal/Guymon	LBL	363	$ 1,056.18	$ 1,571.64
KS	Salina	SLN	193	$ 1,019.08	$ 1,293.14
KS	Hays	HYS	276	$ 5,606.42	$ 5,998.34
KY	Owensboro	OWB	140	$ 2,765.34	$ 2,964.14
KY	Paducah	PAH	150	$ 11,672.29	$ 11,885.29
MD	Hagerstown	HGR	73.7	$ 2,196.48	$ 2,301.13
ME	Bar Harbor	BHB	271	$ 4,185.54	$ 4,570.36
ME	Augusta/Waterville	AUG	162	$ 2,279.14	$ 2,509.18
ME	Rockland	RKD	188	$ 1,939.88	$ 2,206.84
ME	Presque Isle/Houlton	PQI	395	$ 5,065.62	$ 5,626.52
MI/WI	Ironwood/Ashland	IWD	230	$ 3,807.71	$ 4,134.31
MI	Sault Ste. Marie	CIU	337	$ 15,289.55	$ 15,768.09
MI	Pellston	PLN	289	$ 14,502.24	$ 14,912.62
MI	Manistee/Ludington	MBL	260	$ 3,614.25	$ 3,983.45
MI	Escanaba	ESC	300	$ 9,591.12	$ 10,017.12
MI	Iron Mountain/Kingsford	IMT	294	$ 6,402.89	$ 6,820.37
MI	Muskegon	MKG	190	$ 5,649.92	$ 5,919.72
MI	Alpena	APN	251	$ 4,967.42	$ 5,323.84
MI	Hancock/Houghton	CMX	375	$ 4,774.28	$ 5,306.78

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost Benefit	RT Shuttle Cost Benefit
MN	Thief River Falls	TVF	305	$ 3,156.87	$ 3,589.97
MN	Chisholm/Hibbing	HIB	214	$ 7,375.08	$ 7,678.96
MN	Bemidji	BJI	233	$ 7,053.98	$ 7,384.84
MN	International Falls	INL	303	$ 6,301.83	$ 6,732.09
MN	Brainerd	BRD	142	$ 6,003.49	$ 6,205.13
MO	Fort Leonard Wood	TBN	139	$ 3,141.54	$ 3,338.92
MO	Kirksville	IRK	175	$ 2,665.64	$ 2,914.14
MO	Cape Girardeau/Sikeston	CGI	130	$ 2,091.43	$ 2,276.03
MO	Joplin	JLN	166	$ 13,123.43	$ 13,359.15
MS	Meridian	MEI	208	$ 9,800.81	$ 10,096.17
MS	Laurel/Hattiesburg	PIB	132	$ 9,610.49	$ 9,797.93
MS	Tupelo	TUP	94.2	$ 1,521.43	$ 1,655.19
MS	Greenville	GLH	142	$ 3,899.67	$ 4,101.31
MT	Glendive	GDV	225	$ 4,259.43	$ 4,578.93
MT	Wolf Point	OLF	315	$ 3,816.66	$ 4,263.96
MT	Glasgow	GGW	278	$ 3,774.68	$ 4,169.44
MT	Havre	HVR	254	$ 3,709.03	$ 4,069.71
MT	Sidney	SDY	272	$ 2,969.75	$ 3,355.99
MT	Butte	BTM	423	$ 6,798.10	$ 7,398.76
MT	West Yellowstone	WYS	325	$ 1,970.21	$ 2,431.71
ND	Jamestown	JMS	340	$ 6,840.03	$ 7,322.83
ND	Devils Lake	DVL	415	$ 6,714.79	$ 7,304.09
NE	Grand Island	GRI	154	$ 15,205.77	$ 15,424.45
NE	McCook	MCK	258	$ 3,078.57	$ 3,444.93
NE	Kearney	EAR	187	$ 3,176.83	$ 3,442.37
NE	Chadron	CDR	292	$ 1,209.52	$ 1,624.16
NE	Alliance	AIA	244	$ 1,364.65	$ 1,711.13
NE	North Platte	LBF	258	$ 1,300.53	$ 1,666.89
NE	Scottsbluff	BFF	198	$ 1,436.40	$ 1,717.56
NH/VT	Lebanon/White River Junction	LEB	127	$ 2,100.95	$ 2,281.29
NM	Clovis	CVN	233	$ 3,245.21	$ 3,576.07
NM	Carlsbad	CNM	291	$ 1,196.18	$ 1,609.40
NM	Silver City/Hurley/Deming	SVC	264	$ 682.90	$ 1,057.78
NY	Saranac Lake/Lake Placid	SLK	323	$ 2,514.05	$ 2,972.71
NY	Massena	MSS	161	$ 3,219.46	$ 3,448.08
NY	Ogdensburg	OGS	123	$ 3,348.75	$ 3,523.41
NY	Jamestown	JHW	183	$ 2,089.00	$ 2,348.86
NY	Watertown	ART	334	$ 9,712.26	$ 10,186.54
NY	Plattsburgh	PBG	151	$ 5,993.55	$ 6,207.97
OR	Pendleton	PDT	204	$ 1,636.66	$ 1,926.34
PA	Lancaster	LNS	83.2	$ 2,813.50	$ 2,931.65
PA	Franklin/Oil City	FKL	85	$ 2,097.83	$ 2,218.53
PA	Johnstown	JST	90.4	$ 3,303.74	$ 3,432.11
PA	Bradford	BFD	181	$ 963.29	$ 1,220.31
PA	DuBois	DUJ	144	$ 2,430.41	$ 2,634.89
PA	Altoona	AOO	123	$ 1,332.35	$ 1,507.01

State	EAS Community	EAS Airport Code	Drive Miles	RT Bus Cost Benefit	RT Shuttle Cost Benefit
SD	Huron	HON	287	$ 4,120.35	$ 4,527.89
SD	Watertown	ATY	205	$ 2,995.82	$ 3,286.92
SD	Aberdeen	ABR	280	$ 4,591.18	$ 4,988.78
TN	Jackson	MKL	82.6	$ 1,360.96	$ 1,478.26
TX	Victoria	VCT	123	$ 3,821.59	$ 3,996.25
UT	Cedar City	CDC	179	$ 6,122.58	$ 6,376.76
VA	Staunton	SHD	132	$ 2,705.90	$ 2,893.34
VT	Rutland	RUT	159	$ 2,286.97	$ 2,512.75
WI	Eau Claire	EAU	91.4	$ 9,648.92	$ 9,778.71
WI	Rhinelander	RHI	238	$ 7,193.75	$ 7,531.71
WV	Greenbrier/White Sulphur Springs	LWB	247	$ 6,901.81	$ 7,252.55
WV	Beckley	BKW	214	$ 4,834.18	$ 5,138.06
WV	Morgantown	MGW	89.3	$ 4,252.22	$ 4,379.02
WV/OH	Parkersburg/Marietta	PKB	145	$ 4,039.11	$ 4,245.01
WV	Clarksburg/Fairmont	CKB	107	$ 3,322.21	$ 3,474.15
WY	Worland	WRL	408	$ 2,560.47	$ 3,139.83
WY	Laramie	LAR	155	$ 3,794.45	$ 4,014.55
WY	Cody	COD	455	$ 700.47	$ 1,346.57

Table 10. Complete results for minimum ridership

State	EAS Community	Drive Destination(s)	Drive Miles	Min Bus Ridership (based on price)	Min Shuttle Ridership (based on price)
AL	Muscle Shoals	BNA	128	NA	NA
AR	El Dorado/Camden	DAL	268	73	54
AR	Harrison	MCI	259	35	26
AR	Hot Springs	MEM	203	57	42
AR	Jonesboro	MEM	76.9	4	3
AZ	Page	PHX	277	10	7
AZ	Show Low	PHX	174	5	4
CA	Crescent City	PDX	340	15	11
CA	El Centro	SAN	120	NA	NA
CA	Merced	SFO	132	7	5
CA	Visalia	BUR	172	NA	NA
CO	Alamosa	ABQ	204	5	4
CO	Cortez	ABQ	252	14	10
CO	Pueblo	DEN	131	2	1
IA	Burlington	STL	202	107	79
IA	Fort Dodge	OMA	167	12	9
IA	Mason City	MSP	129	4	3
IA	Sioux City	OMA	88.7	2	1
IA	Waterloo	MSP	190	6	4
IL	Decatur	STL	147	9	7
IL	Marion/Herrin	STL	132	29	22
IL/MO	Quincy/Hannibal	STL	130	20	14
KS	Dodge City	MCI	343	98	72
KS	Garden City	DEN	340	8	6
KS	Great Bend	MCI	268	NA	NA
KS	Hays	MCI	276	14	10
KS/OK	Liberal/Guymon	DEN	363	NA	NA
KS	Salina	MCI	193	132	98
KY	Owensboro	BNA	140	13	10
KY	Paducah	BNA	150	5	4
MD	Hagerstown	IAD	73.7	10	7
ME	Augusta/Waterville	BOS	162	17	12
ME	Bar Harbor	BOS	271	8	6
ME	Presque Isle/Houlton	BOS	395	56	41
ME	Rockland	BOS	188	7	5
MI	Alpena	DTW	251	25	18
MI	Escanaba	ORD	300	15	11
MI	Hancock/Houghton	MSP	375	32	24
MI	Iron Mountain/Kingsford	ORD	294	24	18
MI/WI	Ironwood/Ashland	MSP	230	15	11
MI	Manistee/Ludington	DTW	260	26	19
MI	Muskegon	DTW	190	10	7

State	EAS Community	Drive Destination(s)	Drive Miles	Min Bus Ridership (based on price)	Min Shuttle Ridership (based on price)
MI	Pellston	DTW	289	7	5
MI	Sault Ste. Marie	DTW	337	6	5
MN	Bemidji	MSP	233	13	10
MN	Brainerd	MSP	142	9	7
MN	Chisholm/Hibbing	MSP	214	10	7
MN	International Falls	MSP	303	10	8
MN	Thief River Falls	MSP	305	25	18
MO	Cape Girardeau/Sikeston	STL	130	13	10
MO	Fort Leonard Wood	STL	139	37	27
MO	Joplin	MCI	166	4	3
MO	Kirksville	MCI	175	19	14
MS	Greenville	MEM	142	28	21
MS	Laurel/Hattiesburg	MSY	132	2	2
MS	Meridian	MSY	208	4	3
MS	Tupelo	MEM	94.2	14	10
MT	Butte	SLC	423	28	21
MT	Glasgow	BIL	278	NA	NA
MT	Glendive	BIL	225	50	37
MT	Havre	BIL	254	NA	NA
MT	Sidney	BIL	272	NA	NA
MT	West Yellowstone	SLC	325	17	13
MT	Wolf Point	BIL	315	NA	NA
ND	Devils Lake	MSP	415	24	18
ND	Jamestown	MSP	340	28	21
NE	Alliance	DEN	244	12	8
NE	Chadron	DEN	292	13	10
NE	Grand Island	OMA	154	3	2
NE	Kearney	OMA	187	6	5
NE	McCook	DEN	258	22	16
NE	North Platte	DEN	258	24	17
NE	Scottsbluff	DEN	198	11	8
NH/VT	Lebanon/White River Junction	BOS	127	12	9
NM	Carlsbad	ABQ	291	NA	NA
NM	Clovis	ABQ	233	10	8
NM	Silver City/Hurley/Deming	ABQ	264	45	33
NY	Jamestown	PIT	183	NA	NA
NY	Massena	SYR	161	17	12
NY	Ogdensburg	SYR	123	7	5
NY	Plattsburgh	ALB	151	10	7
NY	Saranac Lake/Lake Placid	BOS	323	42	31
NY	Watertown	PHL	334	15	11
OR	Pendleton	PDX	204	33	24
PA	Altoona	PIT	123	NA	NA
PA	Bradford	PIT	181	NA	NA
PA	DuBois	PIT	144	7	5

State	EAS Community	Drive Destination(s)	Drive Miles	Min Bus Ridership (based on price)	Min Shuttle Ridership (based on price)
PA	Franklin/Oil City	PIT	85	19	14
PA	Johnstown	PIT	90.4	5	4
PA	Lancaster	PHL	83.2	3	3
SD	Aberdeen	MSP	280	68	50
SD	Huron	MSP	287	9	7
SD	Watertown	MSP	205	12	9
TN	Jackson	MEM	82.6	3	3
TX	Victoria	AUS	123	18	14
UT	Cedar City	LAS	179	21	15
VA	Staunton	IAD	132	13	9
VT	Rutland	BOS	159	18	14
WI	Eau Claire	MSP	91.4	3	2
WI	Rhinelander	MSP	238	13	10
WV	Beckley	CLT	214	7	5
WV	Clarksburg/Fairmont	PIT	107	5	4
WV	Greenbrier/White Sulphur Springs	IAD	247	20	15
WV	Morgantown	PIT	89.3	4	3
WV/OH	Parkersburg/Marietta	PIT	145	6	5
WY	Cody	SLC	455	NA	NA
WY	Laramie	DEN	155	20	15
WY	Worland	SLC	408	42	31

Table 11. Number of round trips per weekday, holding the current subsidy constant

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
AL	Muscle Shoals	MSL	13	19	4
AR	El Dorado/Camden	ELD	4	7	4
AR	Harrison	HRO	5	8	3
AR	Hot Springs	HOT	5	7	3
AR	Jonesboro	JBR	16	24	3
AZ	Kingman	IGM	8	12	2
AZ	Page	PGA	5	8	3
AZ	Prescott	PRC	13	19	3
AZ	Show Low	SOW	6	9	3
CA	Crescent City	CEC	4	6	2
CA	El Centro	IPL	10	15	4
CA	Merced	MCE	13	20	2
CA	Visalia	VIS	8	11	4
CO	Alamosa	ALS	7	10	3
CO	Cortez	CEZ	5	8	3
CO	Pueblo	PUB	8	12	2
GA	Macon	MCN	14	22	2
IA	Burlington	BRL	6	9	4
IA	Fort Dodge	FOD	7	10	4
IA	Mason City	MCW	21	31	4
IA	Sioux City	SUX	4	6	2
IA	Waterloo	ALO	3	4	2
IL	Decatur	DEC	11	17	6
IL	Marion/Herrin	MWA	10	15	6
IL/MO	Quincy/Hannibal	UIN	9	14	6
KS	Dodge City	DDC	4	6	3
KS	Garden City	GCK	2	4	2
KS	Great Bend	GBD	3	5	2
KS	Hays	HYS	5	7	2
KS/OK	Liberal/Guymon	LBL	4	5	3
KS	Salina	SLN	5	7	3
KY	Owensboro	OWB	7	10	3
KY	Paducah	PAH	8	13	2
MD	Hagerstown	HGR	15	23	4
ME	Augusta/Waterville	AUG	7	10	4
ME	Bar Harbor	BHB	3	5	3
ME	Presque Isle/Houlton	PQI	7	11	3
ME	Rockland	RKD	6	9	6
MI	Alpena	APN	5	8	2
MI	Escanaba	ESC	6	9	2
MI	Hancock/Houghton	CMX	1	1	2
MI	Iron Mountain/Kingsford	IMT	5	8	2
MI/WI	Ironwood/Ashland	IWD	10	14	3
MI	Manistee/Ludington	MBL	5	8	2

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
MI	Muskegon	MKG	4	7	2
MI	Pellston	PLN	2	3	2
MI	Sault Ste. Marie	CIU	3	5	2
MN	Bemidji	BJI	3	4	2
MN	Brainerd	BRD	6	9	2
MN	Chisholm/Hibbing	HIB	7	11	2
MN	International Falls	INL	2	3	2
MN	Thief River Falls	TVF	5	7	2
MO	Cape Girardeau/Sikeston	CGI	8	12	4
MO	Fort Leonard Wood	TBN	13	20	4
MO	Joplin	JLN	1	1	2
MO	Kirksville	IRK	6	9	3
MS	Greenville	GLH	16	23	3
MS	Laurel/Hattiesburg	PIB	19	28	2
MS	Meridian	MEI	12	18	2
MS	Tupelo	TUP	17	25	5
MT	Butte	BTM	1	1	2
MT	Glasgow	GGW	4	7	2
MT	Glendive	GDV	5	8	2
MT	Havre	HVR	5	7	2
MT	Sidney	SDY	9	13	5
MT	West Yellowstone	WYS	1	1	2
MT	Wolf Point	OLF	4	6	2
ND	Devils Lake	DVL	5	7	2
ND	Jamestown	JMS	6	8	2
NE	Alliance	AIA	3	5	2
NE	Chadron	CDR	2	4	2
NE	Grand Island	GRI	7	11	2
NE	Kearney	EAR	6	9	3
NE	McCook	MCK	5	8	2
NE	North Platte	LBF	4	6	3
NE	Scottsbluff	BFF	4	6	3
NH/VT	Lebanon/White River Junction	LEB	12	17	6
NM	Carlsbad	CNM	3	4	2
NM	Clovis	CVN	8	13	3
NM	Silver City/Hurley/Deming	SVC	5	7	4
NY	Jamestown	JHW	7	10	4
NY	Massena	MSS	8	12	3
NY	Ogdensburg	OGS	9	13	3
NY	Plattsburgh	PBG	11	17	2
NY	Saranac Lake/Lake Placid	SLK	3	5	3
NY	Watertown	ART	6	9	2
OR	Pendleton	PDT	5	8	3
PA	Altoona	AOO	10	15	4
PA	Bradford	BFD	7	10	4
PA	DuBois	DUJ	10	15	3

State	EAS Community	EAS Airport Code	Trips By Bus	Trips By Shuttle	Trips By Plane
PA	Franklin/Oil City	FKL	9	14	3
PA	Johnstown	JST	17	25	3
PA	Lancaster	LNS	19	28	5
SD	Aberdeen	ABR	2	3	2
SD	Huron	HON	5	8	2
SD	Watertown	ATY	9	13	3
TN	Jackson	MKL	8	12	3
TX	Victoria	VCT	12	17	2
UT	Cedar City	CDC	8	12	2
UT	Moab	CNY	6	10	2
UT	Vernal	VEL	5	7	2
VA	Staunton	SHD	9	14	3
VT	Rutland	RUT	5	8	3
WI	Eau Claire	EAU	11	16	2
WI	Rhinelander	RHI	4	6	2
WV	Beckley	BKW	7	11	2
WV	Clarksburg/Fairmont	CKB	14	20	3
WV	Greenbrier/White Sulphur Springs.	LWB	9	13	2
WV	Morgantown	MGW	17	25	3
WV/OH	Parkersburg/Marietta	PKB	15	23	3
WY	Cody	COD	1	2	2
WY	Laramie	LAR	7	10	2
WY	Worland	WRL	3	5	2

Table 12. Aircraft specific variables and sources

		Variables					
Aircraft	Engine Type	Cost per Block Hour		Number of Seats		Max Rate of Climb (ft/min)	
		Value	Source	Value	Source	Value	Source
B-1900	Turbprob	$1,148.55	ARGUS International, Inc. OPERATING COSTS - HAWKER BEECHCRAFT Beechcraft 1900D Executive. Rep. N.p	18	"Air Canada Seat Maps." SeatGuru Seat Map Air Canada Beechcraft 1900D. Tripadvisor, n.d.	2625	Raytheon Aircraft. 2001 Beech 1900D Airliner Performance / Specifications. Rep. N.p.
C-402	Piston	$ 624.00	Conklin & de Decker Aviation Information: Aircraft Cost Evaluator. N.d. Raw data. Orleans, MA.	9	Cape Air - Cessna 402C Aircraft Configuration Information. N.p.: Cape Air, n.d. PDF.	1600	"Aircraft Performance Data: Cessna 402-A Turbocharged Performance Information." RisingUp Aviation. N.p., n.d. Web. July 20, 2015.
Caravan	Turbprob	$ 982.53	Aircraft Cost Calculator. Cessna Caravan EX Report.	14	"Cessna 208B - Grand Caravan." - AOPA. N.p.	975	"Cessna Grand Caravan Specifications." Cessna Grand Caravan Specifications. PilotFriend, n.d.
Chieftain	HO Piston	$ 639.00	Conklin & de Decker Aviation Information: Aircraft Cost Evaluator. N.d. Raw data. PO Box 1142, Orleans, MA.	7	"Piper Chieftain PA-31-350." AirCraft24.com. Web. July 13, 2015.	1200	"The Piper PA-31 Chieftain/Mojave/T-1020/T-1040." Airliners.net. N.p., n.d. Web. July 2, 2015.
CRJ-200	Turbfan	$1,786.00	Hazel, Bob. Air Service Incentives and Air Service Development. Rep. N.p.: Oliver Wyman, 2011. Print.	50	"United Seat Maps Bombardier CRJ-200 V2." SeatGuru. Tripadvisor. Web. November 20, 2015.	2500	Tomas, C., L. Kolin, J. Warner, and S. Widmer. *Bombardier CRJ-200ER Aircraft Operations Manual*. N.p.: Global Virtual Airlines Group, May 3, 2014. PDF.
EMB-120	Turbprob	$2,077.00	Conklin & de Decker Aviation Information: Aircraft Cost Evaluator. N.d. Raw data. Orleans, MA.	30	"The Embraer EMB120 Brasilia." Airliners.net. N.p., n.d. Web. July 2, 2015.	2120	"The Embraer EMB120 Brasilia." Airliners.net. N.p., n.d. Web. July 2, 2015.
ERJ	Turbofan	$3,503.70	"Aircraft Operating Series – Aircraft Operating Expenses." OPShotsnet Cyberhub to Cleveland Aviation and the World. N.p., n.d. Web. June 20, 2015.	50	"United Seat Maps Embraer ERJ-145 V1." SeatGuru. Web. July 20, 2015.	2560	"Embraer ERJ 145." Axlegeeks. N.p., n.d. Web. July 2, 2015.

		Variables					
Aircraft	**Engine Type**	**Cost per Block Hour**		**Number of Seats**		**Max Rate of Climb (ft/min)**	
		Value	**Source**	**Value**	**Source**	**Value**	**Source**
Jetstream 32	Turbprop	$1,587.00	Conklin & de Decker Aviation Information: Aircraft Cost Evaluator. N.d. Raw data. Orleans, MA.	19	"BAe Jetstream 31/32." Airlines Inform. Web. July 20, 2015.	2000	"BRITISH AEROSPACE Jetstream 32." SKYbrary Aviation Safety. Web. June 25, 2015.
PC-12	Turbprop	$ 905.00	Conklin & de Decker Aviation Information: Aircraft Cost Evaluator. N.d. Raw data. Orleans, MA.	9	"The Most Wanted Single Exceeding Expectations Everywhere." Pilatus. Web. July 2, 2015.	1680	"PILATUS PC-12 Eagle." SKYbrary Aviation Safety. Web. July 2, 2015.
Saab 340	Turbprob	$1,094.00	Aviation Daily: Aircraft Operating Costs. July 1, 2013. Raw data. N.p.	36	"The Saab 340." Saab 340. Airliners.net, n.d. Web. July 20, 2015.	1800	Flight Safety Foundation (FSF) Editorial Staff. Icing, Inadequate Airspeed Trigger Loss of Control of Saab 340. *Flight Safety Foundation Accident Prevention*. Vol. 58. No. 10. October 2001

APPENDIX B

This appendix contains all figures referenced in the report or used for analysis.

Figure 8 charts the distribution of all EAS communities for 2014.

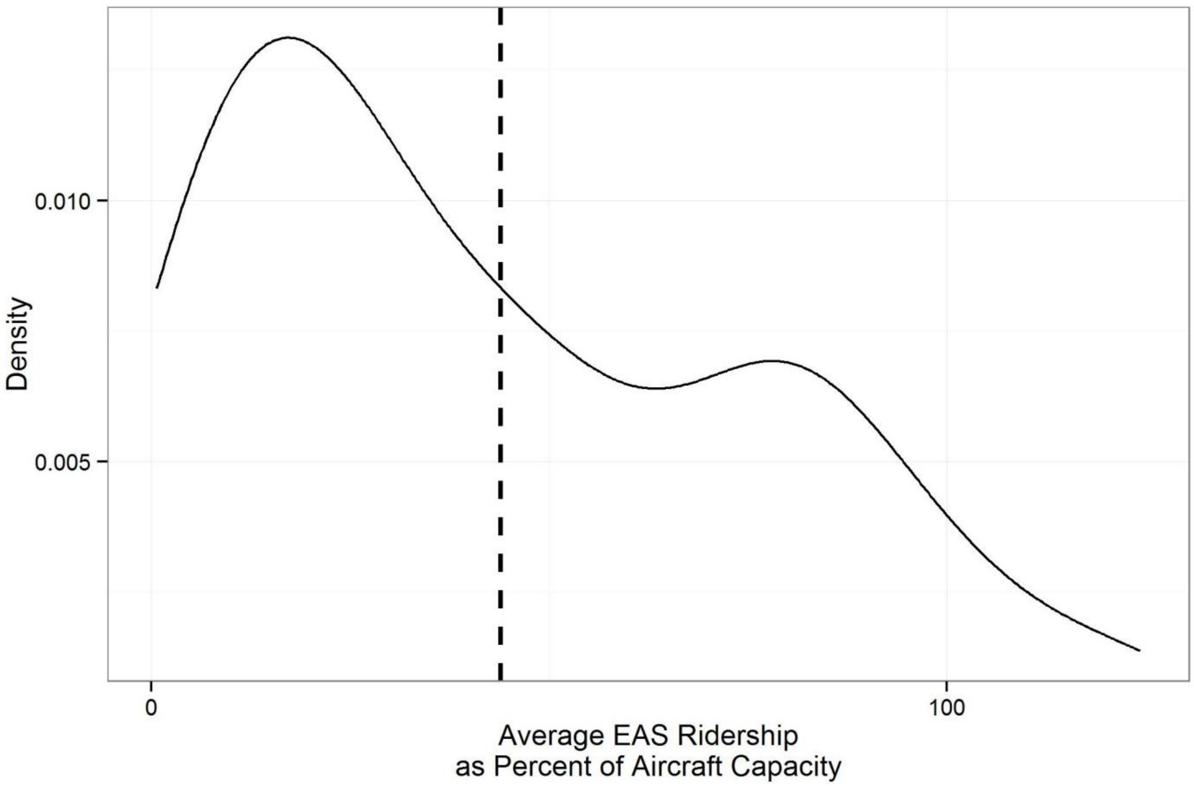

Figure 8. Average EAS ridership – percent of aircraft capacity

The dashed lines in the figures is the mean. Figure 9 removes all values that are greater than 100%.

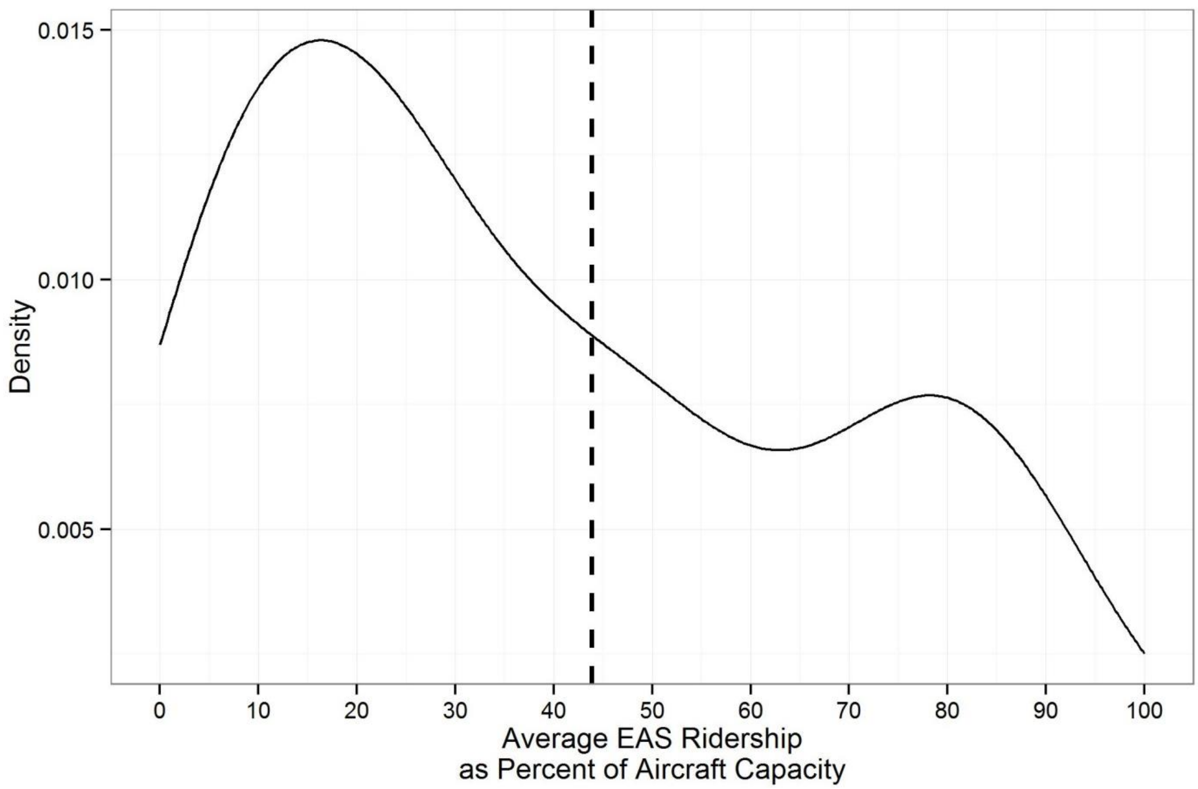

Figure 9. EAS utilization density plot

Values can exceed 100% of aircraft capacity because the minimum round trips per weekday required by the U.S. DOT were used in calculating the average EAS ridership as a percent of aircraft capacity. Thus, it is possible for the subsidized air carriers to run more than the required amount of round trips if the traffic is high enough. The detailed calculation is as follows:

$$Avg.\ EAS\ Ridership\ as\ a\ Percent\ of\ Aircraft\ Capacity =$$

$$\left[\frac{2014\ Passenger\ Level}{(Min\ Rountrips\ per\ Year) \times (Aircraft\ Capacity)}\right] \qquad \textbf{(15)}$$

Note that density plots show the probability of an observation having some specified value for the given variable of interest, which, in this case, is the average EAS ridership as a percent of aircraft capacity. Figure 10 shows a bar chart of EAS utilization.

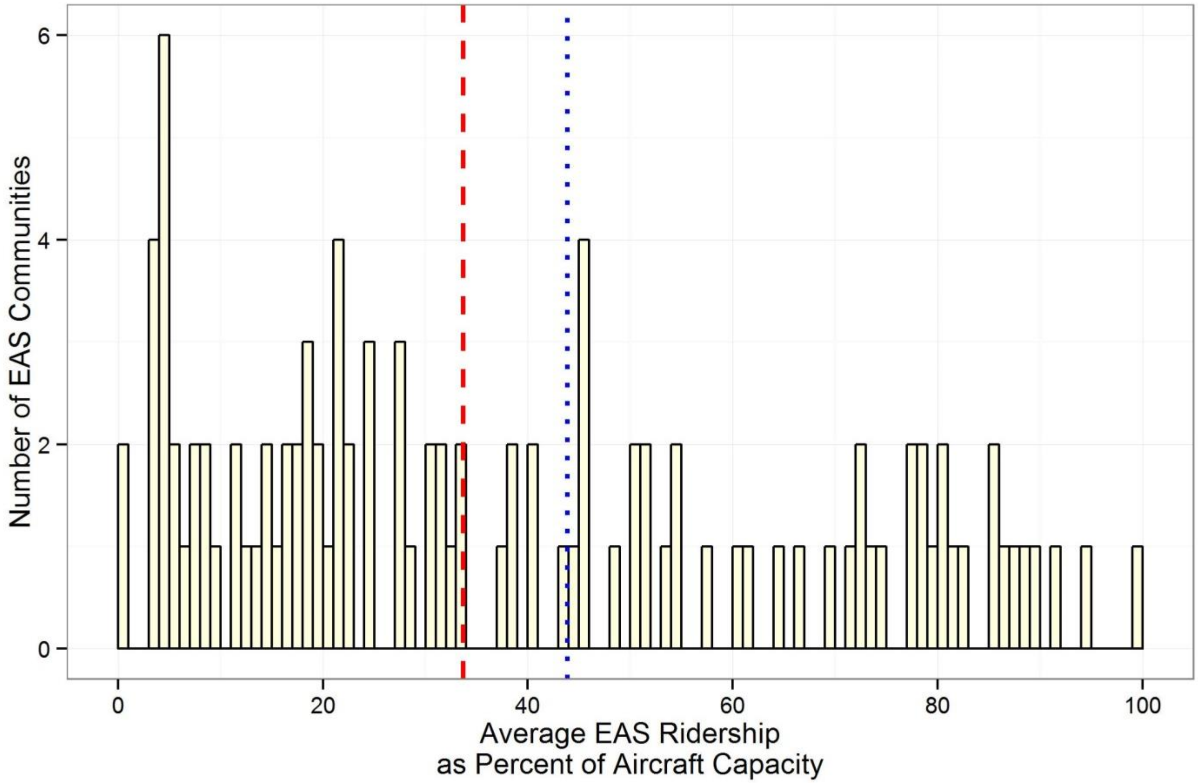

Figure 10. EAS utilization histogram

APPENDIX C

This appendix includes an elaboration of the methodology summarized in the report.

The selection process for subsidies is as follows:

- The governing statutes require the U.S. DOT to consider four carrier selection criteria, and subsidy is not one. Nonetheless, the U.S. DOT may consider the relative subsidy requirements of the various options, and it has done so since the inception of the program. In selecting a carrier, the law directs the U.S. DOT to consider four factors: (1) service reliability, (2) contractual and marketing arrangements with a larger carrier at the hub, (3) interline arrangements with a larger carrier at the hub, and (4) community views.
- After the U.S. DOT receives proposals, it formally solicits the views of the communities as to which carrier and option the community prefers. After receiving the communities' views, the U.S. DOT issues a decision designating the successful air carrier and specifying the specific service pattern (routing, frequency, and aircraft type), subsidy rate, and effective period of the rate. It is possible to change the terms of the contract during the two-year period if the carrier and community agree and the carrier agrees to the same or lower subsidy rate.
- This information is taken directly from the U.S. DOT's website under the EAS tab (U.S. DOT 2015a).

The endogeneity problem arises when there is a correlation between any independent or control variable(s) and the error term. In regression analysis, the error term is the predicted value of Y minus the observed value of Y or the unexplained portion of the variation in the dependent variable around its mean. A more intuitive explanation of endogeneity is that it arises when any one of the Xs (right-hand side variables) is actually a function of Y (left-hand side variable) and Y may also be a function of the endogenous X. In other words, one of the Xs is not an independent variable but does have an effect on Y. This can be shown mathematically:

$$Y(X,T) = \beta_0 + \beta_1 X(Y,\theta) + \beta_2 T + \epsilon \qquad \textbf{(16)}$$

Where X is a function of both Y and parameter θ and Y is a function of X and T.

To control for endogeneity issues between total enplanements and total employment, Brueckner (2003) uses four instrumental variables. The first is a variable that indicates whether the metropolitan area has a hub airport, and in cases where the area has more than one airport, this variable takes on the value equal to the share of that hub airport's enplanements out of the total enplanements for all airports in the metropolitan area. The second instrument is a dummy variable that equals one for metropolitan areas that are not in the top 26 areas with the highest enplanements and that are also within 150 miles of one of the top 26 areas. This variable tries to capture the effects of the proximity to a large hub. The third instrument is set equal to the share of enplanements from an airport that has slot controls. The last instrument is equal to one for Las Vegas and Orlando only because they have special leisure attractions.

The value of time calculations is as follows:

$$Total\ Roundtrip\ Flight\ Time_i\ (min) = Avg.Delay_{RT_j} + SFT_{RT_i} + 75 + 30 \quad (17)$$

$$Avg.(Flight)\ Delay_{RT_j} = Avg.Duration\ of\ Delay_j * PCFD_j \quad (18)$$

Where SFT_{RT_i} is the scheduled round trip flight time at community *i* and $PCFD_j$ is the percent of completed flights that are delayed for each airline j.

For the EAS flights, the total trip time was determined by taking the scheduled flight time (SFT_{RT_i}) for each community and adding one hour for getting through security at the EAS community airport and 15 minutes for disembarking, which makes a total of 75 additional minutes. The other 30 minutes added were for the enplanement and deplanement times for the return trip back to the EAS airport. The percentage of all completed flights in 2014 that were delayed is the probability that any given flight would be delayed and is given by $PCFD_j$. This was multiplied by the average delay experienced for each air carrier as reported by FlightStats.com and the BTS. This calculation would then yield the average flight delay for each community. Once these individual calculations were added, the result was the total time per round trip by air for each community.

$$Avg.Congestion\ Delay_{RT_i} = \left(TTI_{k,i}\right)(.6)(PC_k)(2) \quad \mathbf{(19)}$$

$$PC_k = \frac{Number\ of\ Rush\ Hours_k}{15} \quad \mathbf{(20)}$$

$$Total\ Roundtrip\ Drive\ Time_i = Drive\ Time_{RT_{i,k}} + Avg.Congestion\ Delay_{RT_i} + 1.5 + .5 \quad \mathbf{(21)}$$

Where $TTI_{k,i}$ is the travel time index for city *k*, where *k* is the closest city to EAS community *i* with a large or medium hub. It is calculated by taking the average time to commute at city *k* at peak congestion divided by the average time to commute with no congestion. This measures the intensity of congestion.

PC_k is the probability of encountering congestion at city *k*.

$Drive\ Time_{RT_{i,k}}$ is the estimated time spent driving from *i* to *k* as reported by Google Maps with no congestion.

For the bus or shuttle, the total trip time was determined by taking the drive time for each community as reported by Google Maps and adding (1) 15 minutes for check-in for the bus, (2) time for congestion delays, (3) 15 minutes for disembarking, and (4) one hour for getting through security at the hub airport. On the return trip, the total trip time is determined by taking the same drive time and congestion delay as for the outgoing trip and adding 30 minutes for getting baggage from the connecting flight and boarding and disembarking the bus. To calculate the average congestion delay for each community, it is assumed that congestion will occur in a 30 mile radius of the major hub and that within those 30 miles the average speed without congestion is 50 miles per hour. This means that without congestion the urban portion of the trip would take 0.6 hours (or 36 minutes).

The number of rush hours is the number of hours per day that congestion is present in the urban area. Because the buses or shuttles would not all be in the urban area during peak congestion times, the number of rush hours is divided by the number of hours the ground service would run per day (15 hours) to produce the probability that the bus or shuttle would encounter congestion on any given route.