# WEB-BASED FORECASTING: SMALL AIRCRAFT TRANSPORTATION SYSTEM

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I am going to talk about the part of aviation that hasn't been mentioned so far—the general aviation (GA) world—and in particular the Small Aircraft Transportation System (SATS) [since renamed the Smart Aircraft Transportation System]. It is a current initiative that follows the GA revitalization effort that was started several years ago. The Piston Engine Aircraft Revitalization Committee (PEARC) Study by the General Aviation Manufacturers Association (GAMA) was an important early initiative. Its purpose was to determine the customer requirements for learning how to fly GA aircraft and to project the market demand for small aircraft based upon meeting the customer requirements. The PEARC Study is useful today because it provides a baseline for the SATS program data analysis effort.

The SATS website at http://sats.nasa.gov contains information about the program, so I'm not going to talk in depth about the defining characteristics of SATS or the impact of SATS on the future of our nation. Rather, I am going to talk about forecasting customer demand and customer acceptance by collecting actual responses from SATS customers to survey questions presented to them.

On the SATS site, you will find the information shown in Figure 1. Note in these statements the phrases "affordable infrastructure," "significant economic development," "significant economic impact," and "affordable means." These words imply to estimators and forecasters that data have to be gathered to further quantify these phrases. So my effort has been focused on collecting data from the future customers of SATS that will determine the impact of SATS on the transportation infrastructure and the economic development of our states.

NASA, in partnership with FAA, the states, and industry, leads the National General Aviation Roadmap strategy, which guides national investments toward an "InterState Skyway" capability. These investments take the form of focused and base research and technology programs. The SATS program provides for investments in showcase demonstrations of key technologies for vehicles and airports/airspace infrastructure. There are two major emphases in SATS. One is on the key technologies that will enable air vehicles to meet a goal of portal-to-portal transportation at four times highway speeds, and the other is on the air transportation infrastructure required to meet this portal-to-portal goal.

The investigation into the required air transportation infrastructure at the state level is just beginning. Two initial SATS states have been designated—Florida and Virginia. In addition, there is a list of other states that are now beginning to discuss ways that they might develop their transportation infrastructures to support this new system.

The investigation into the key vehicle-related technologies required to meet the SATS goal was launched in 1994 by the Advanced General Aviation Transport Experiments (AGATE) consortium and the General Aviation Propulsion (GAP) program, and a great deal of information has been derived from these initiatives. The investigation that I'm going to discuss today—the vehicle- and engine-related initiatives of AGATE and GAP, as described in Figure 2—will play a key role in the development and deployment of SATS.

AGATE is managed by an alliance consisting of NASA, FAA, research universities, and selected GA industry partners, and it is headquartered at the NASA Langley Research Center. The alliance is charged with defining vehicles and flight training specifications that would fit within the system and support the needs of the traveling public. The GAP program, located at NASA's Glenn Research Center, develops engine technologies that will meet the reliability, efficiency, quietness, speed, and cost goals of the program. These two initiatives are providing the leadership and resources to define the technology roadmap to meet the vehicle, engine, and training requirements of SATS.

The goals of AGATE, those related to vehicles, are quite aggressive. To meet them, the work was divided into technical work packages aligned with the systems of the aircraft. Two additional work package teams, Program Analysis and Systems Assurance, have broad interactions throughout the technical AGATE work packages. I work with the Program Analysis Work Package team (Figure 3). The Program Analysis Technical Council (PATC) directs and leverages the program investments in market analyses, metrics database development, program impact analyses, and portfolio analyses. Their principal products are the volume forecasts for use by the AGATE management team for modeling GA aircraft systems and for trying to reach the volume-driven cost goals. The PATC members listed in Figure 3 are responsible for the results that I am going to present this morning. Their marketing experience and skills were a tremendous help in the definition and construction of a web-based survey that we are using to collect customer information for AGATE and the GAP program.

PATC developed two data collection efforts—a large-scale effort and a small-scale effort. The latter effort is the personal presentation of the AGATE cockpit concept demonstrator to a small, but representative sample of the total GA market. Personal interaction during the presentation allows for evaluation of the advantages and disadvantages of the proposed AGATE initiatives. In addition, individual written assessments of the program are collected through the personal administration of the same survey instrument used in the large-scale data collection effort. The small-scale data collection initiative gathers information that is used to improve both the survey instrument and the analysis of the large survey data set.

The large-scale data collection effort is the main focus of the program analysis activity. It uses the resources of the World Wide Web (the Internet) to gather data from both the existing and latent GA markets. Data are collected by an interactive, dynamic survey instrument located on a server at the National Institute of Aviation Research (NIAR) on the campus of Wichita State University, Wichita, Kansas.

The survey can be accessed from multiple websites by an active link to the NIAR server from each of the cooperating sites. A new Internet domain was created to house the survey and related information on the NIAR server. The site name, Advanced Personal Air Transportation System, at http://apats.org, was chosen to convey to the user a new direction in GA. A link to the AGATE home page was established and it provides a source of valuable information about AGATE to all visitors to the new site. A link to the survey site is also on the AGATE home page, and it provides a valuable source for Internet users with interest in GA activities.

Multiple additional websites, with an active link to the NIAR server, encourage visitors to their site to complete the survey. Because of the large number of sites linked to the NIAR server survey, and the exploding use of the Internet, a large number of surveys have been completed. The surveys provide important information about both the existing GA market and the additional market provided by an increasing demand for travel.

There are several advantages to web-based applications, as shown in Figure 4. The survey was rapidly developed and deployed on the web. In six weeks, we had six iterations of the survey reviewed by PATC, with each version better than the previous one. Because the survey was online, the peer review by Research Triangle Institute was completed very quickly, letting us activate the survey on the web just three months after the start of the project. I should note that we did use key questions from the PEARC survey so that we can compare the web-based survey results with the results obtained by traditional survey methods. This will help us uncover any bias in the web-based survey.

It is a dynamic survey, so branching to succeeding questions is determined in real time by the answers provided by the respondent to current questions. This is not visible to the respondent; it is happening seamlessly in the program code of the survey. Another big advantage to the web-based survey is that it is threaded. We know attention spans on surveys are limited and attention spans on the web are very limited. We developed this survey so that nobody spends more than 10 minutes completing it. In the survey itself, there are over 100 questions, so how is this accomplished? Well, again, using the technology of the web, when you enter the survey, you are assigned two random numbers. These random numbers determine sets of questions that you receive. The survey contains cost questions that have three different cost values associated with each question, but you will only see one from this collection of questions. We reduce the set of questions per user from literally 115 to 120 down to no more than about 30, yet from the volume of survey traffic that we get on the Internet, we still build a statistically valid sample for each question.

Finally, the survey is updateable in real time. If we determine that we are asking a question that needs to be changed, we can immediately change it in the survey, and the survey is ready for the next participant. Each survey is automatically given a date stamp with the day, hour, and minute it was completed so we know from each survey response date which set of questions was being answered. This allows for the data analysis of both the old and new questions.

I want to present some of the information contained in the survey data, but before we get to survey results, let's look at the survey activity to date. I will just point out a few things illustrated by Figure 5. These data were compiled on September 5, 1999. The number of users to date is 43,109, which tells us how many people have been on the survey site. If someone visits the site, he or she doesn't have to take the survey, but I can tell you that about 4,300 surveys have been completed. This says that we have a survey completion rate of about 10 percent, which is phenomenal when compared with the completion rate of paper surveys mailed to a randomly selected sample of participants.

Also note that the traffic is not only from the domestic market in the United States, but it is in fact truly international in scope with almost 10 percent of the visitors to the site coming from outside the United States. The average time spent on the site is almost 7 minutes. This is a long time, for an average, if you are looking at it from a web perspective, because the attention span there is very short for many people.

Now let's look at some of the preliminary observations that are coming from the AGATE survey. Figure 6 shows the survey activity over time. Initially, we were hooking up to search engines and we were getting all the links from other sites—Embry Riddle, for example, has a link to the survey site; the travel agents site has a link; AOPA; and various other sites. The first bump is when AOPA introduced the site to their members via a link. Activity slowed down over the holiday season but then picked up dramatically when AVWEB published an article about our site and survey. The article generated tremendous response from the owners and pilots of GA aircraft. This was very beneficial to our data collection effort because the AGATE survey focuses on the vehicle. It has vehicle-related questions and we need people who are familiar with airplane system technology and the associated cost of that technology. We have been able to sustain an increase in the number of surveys, and we now have approximately 4,300 surveys completed.

Let's look at the distribution of people who have taken the survey and their interest in piloting an aircraft. Figure 7 shows that the "would like to become a pilot" sector of the latent market is 11 percent of the total sample. The remainder of the latent market are those who chose to travel in an advanced light aircraft, but not to become a pilot. These people are captured in the "not interested in piloting a plane" sector and make up 2 percent of the total. Note that former pilots make up 4 percent of the total respondents, and the remainder, 83 percent, are current pilots.

One of the cost demand curves that we generate on a regular basis is shown in Figure 8. The values have been removed from the cost axis and the identification of the marked data points has been removed from the curve because the data are proprietary to AGATE. However, the graph does illustrate a typical reasonable cost curve generated by the survey data. The favorable responses at each cost value are shown on the vertical axis. Note that percentage in agreement with the reasonableness of the cost decreases with the increase in the cost of the airplane feature. This information is useful to the manufacturers of equipment related to the AGATE airplane features to show them what they can expect in terms of market acceptance for each cost value.

In the ranking of the benefits of the AGATE airplane by the current and former pilot population, the pilots were asked to indicate the most important benefit of the AGATE aircraft (their first choice), the second most important benefit, and the third most important benefit. This ranking showed that the most important benefits are affordability, increased safety, and increased reliability. These three benefits must accrue before GA will revitalize itself as an industry. Airplanes must become more affordable, safer, and more reliable. Speed is next in the pilots' ranking, followed by ease of use, utility, and cabin comfort. The weighted score is calculated by the formula in Figure 9, where F indicates a first choice, S is a second choice, and T is a third choice of the benefit.

Which feature of the AGATE airplanes that we are considering is the most important to the pilots? Figure 9 shows the overall winner—the graphical pilot interface. Note that a graphical pilot interface makes the aircraft safer and more reliable to fly in more environments. The graphical pilot interface is followed by advanced turbine engines, advanced piston engines, datalink communications, free flight, crashworthiness, etc.

One important result that has emerged from this study is that not only do people travel frequently today, but also there is a large pent-up demand for additional travel. This conclusion is drawn from the responses to three questions that ask how many additional trips of more than 2 hours' travel time by automobile and less than 1000 miles the survey participant would take if they were (a) cheaper, (b) faster, or (c) cheaper and faster than commercial air travel. Pent-up demand for travel exists no matter how the data are grouped. The charts in Figures 10-13 represent the responses of people who are frequent travelers, not pilots, but who would be willing to travel in advanced light aircraft—in other words, the traveling latent market.

One further note before the charts are presented. Because the survey is threaded, a latent market survey participant will only receive one of the three questions listed above.

Figure 10 gives the response to the number of additional trips survey participants would take if they were cheaper than commercial air travel. Only 1 percent of the survey respondents would not take any additional trips under this condition, but 62 percent say they would take at least 6 extra trips, with 28 percent saying they would take more than 10 extra trips.

Figure 11 shows the information gleaned from responses to the question, "How many extra trips would you take if they were three times faster than by automobile?" Again, 1 percent of the population would take no extra trips if they were three times faster than travel by automobile. But now fully 50 percent of the respondents say that they would take more than 10 such extra trips. This is consistent throughout the data sectors that we have analyzed—people want to travel faster. They want to go portal-to-portal faster than we can travel today. So cost is a factor in determining the number of extra trips a person would take, but not as big a factor as increasing the speed of taking the trip.

Now, one-third of the latent market who completed the survey were asked, "How many additional trips (more than 2 hours but less than 1000 miles away) would you make each year if you could travel three times faster than by automobile and it were less expensive than a commercial flight?" You see the data are consistent with the previous chart—51 percent say they would take six or more such trips a year and 49 percent say they would take more than 10 such extra trips (Figure 12).

The large number of extra trips that people would take if they were cheaper than commercial air travel and three times faster than travel by automobile bodes well for the economic viability of SATS. One should remember that this pent-up demand for travel is dependent upon achieving the benefits of the AGATE aircraft: affordable, safe, reliable, fast, and comfortable transportation that is easy to use. Also note that in Figure 12 there is widespread acceptance by the latent market of travelling in an advanced light aircraft, not necessarily piloting, in order to satisfy the pent-up demand for travel.

Figure 13 is my last chart and I chose it because it represents a shift in survey responses from the results in the PEARC Study relative to the benefits of flying. The PEARC Study asked survey participants to rank the benefits of flying. In the PEARC Study, the majority of the respondents said that "enjoyment" was the reason they wanted to fly in a GA airplane. In the current survey, the majority of the survey participants say that the greatest benefit of learning how to fly is the ability to travel. This reinforces the point that I made earlier about the pent-up demand for travel within the latent market.

In the SATS program we are expanding the AGATE survey to include SATS-related questions. The level of difficulty of the SATS effort is an order of magnitude larger than the AGATE work because it represents an expansion of the vehicle analysis to the system that will contain the vehicle as one part.

Potential customer input is important to the success of any new system because it drives the market analysis, which then yields an estimate of the return on investment and the economic viability of the system. So if you have not taken the AGATE survey yet, I encourage you to go to the site and complete it.

**SATS is:**

- **An integrated transportation system approach to safety for small aircraft, underutilized airspace, and small landing facilities.**
- **Affordable infrastructure for highly accurate instrument approaches to virtually all runway ends and helipads in the nation.**
- **Scheduled as well as on-demand point-to-point air transportation services (including very small economical jets) between 5,400 public use landing facilities.**
- **Safe accessibility by air to 90% more destinations throughout the nation.**
- **Economic development for suburban, rural, and remote America, enabled by the SATS transportation innovation.**
- **An exportable transportation innovation of significant economic impact for the nation's balance of trade.**
- **An affordable means to close the 21st century gap between transportation demand and supply.**

**FIGURE 1 SATS goals.**

## Developing Vehicle Technologies

Two major partnerships, AGATE and GAP, were developed by NASA and the FAA to explore the future role of aviation in personal transportation systems.

The Advanced General Aviation Transport Experiments (AGATE) Consortium is a government- industry-university partnership that supports the revitalization of the U.S. general aviation industry. It was founded in 1994 to produce the industry standards and certification methods for aircraft, flight training systems, and airspace infrastructure for next generation single pilot, 4-6 place, near all-weather light planes.

The General Aviation Propulsion (GAP) program was established by NASA in partnership with the FAA and the U.S. aviation industry to develop technologies and manufacturing processes for revolutionary, low-cost, environmentally-compliant propulsion systems and to flight-demonstrate these propulsion systems on advanced light aircraft.

**FIGURE 2 AGATE and GAP.**

## AGATE Program Analysis Technical Council

**Bruce Holmes, NASA, Chairperson**

**Members:**

James Coyne, NATA

Paul Fiduccia, SAMA

Bob Gavinsky, Stoddard-Hamilton Aircraft

Charles R. Lynch, Executive Jet

James Griswold, Aerospace Consultant

Tom Shea, Cirrus Design

Bruce Landsberg, AOPA

Alan Goodnight, Cessna Aircraft Company

Robin Sova, FAA

Ron Wilkinson, Teledyne Continental Motors

Mike Humphreys, Kestrel Aircraft

Chris Ode, Kestrel Aircraft

Lance Neibauer, Lancair

Michael R. Smith, Global Aircraft

Robert J. Stewart, Global Aircraft

George Rourk, Williams International

Ron Swanda, GAMA

Robert A. Wright, FAA

Russ Smith, Rayethon Aircraft

Mike Wolf, Lycoming

Dave Ellis, Wichita State University

Bill Hammers, Optimal Solutions, Inc.

**FIGURE 3 Program analysis team.**

## Survey Instrument

### Survey Development:

- Constructed by the Program Analysis Technical Council
- Improved through five iterations of the draft survey
- Peer review of site and survey by Research Triangle Institute
- Activated on the Web on June 1, 1998
- Benchmarked with PEARC 1995 survey questions

### Web Based Survey Characteristics:

- Rapid Development and Distribution
- Dynamic
- Threaded
- Updateable

**FIGURE 4 Data collection instrument.**

### Survey Site (http://apats.org) Statistics

| | |
|---|---|
| This Report was Generated | Monday September 06, 1999 |
| Timeframe | 05/15/98 - 09/05/99 |
| Number of Hits for Home Page | 25,446 |
| Number of Successful Hits for Entire Site | 557,205 |
| Number of User Sessions | 43,109 |
| User Sessions from United States | 57. 18% |
| International User Sessions | 9.6% |
| User Sessions of Unknown Origin | 33.19% |
| Average Number of Hits Per Day | 1,163 |
| Average Number of User Sessions Per Day | 89 |
| Average User Session Length | 00:06:51 |

**FIGURE 5 Survey activity to date.**

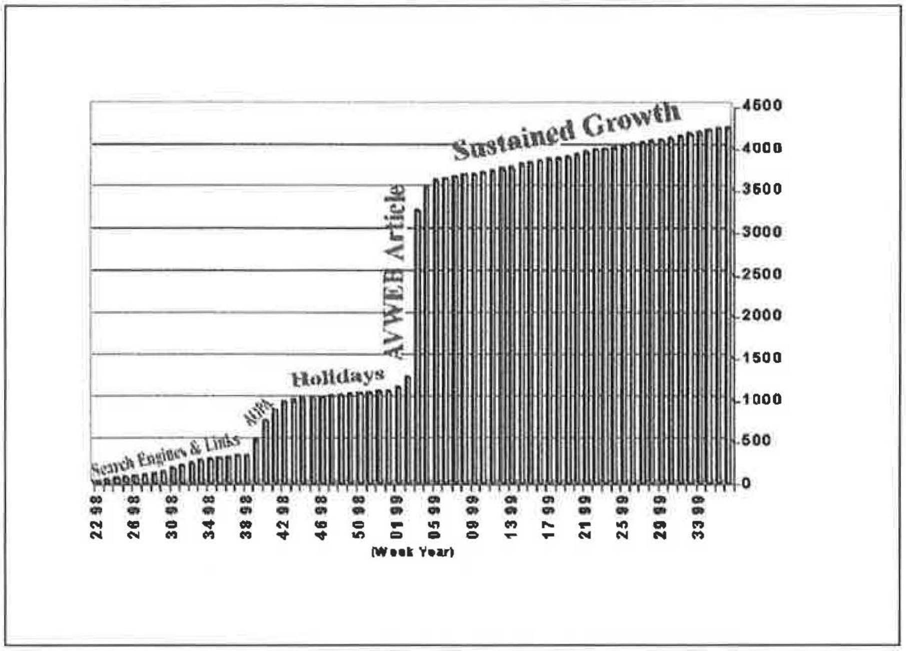


**FIGURE 6 Survey activity: cumulative number of surveys.**

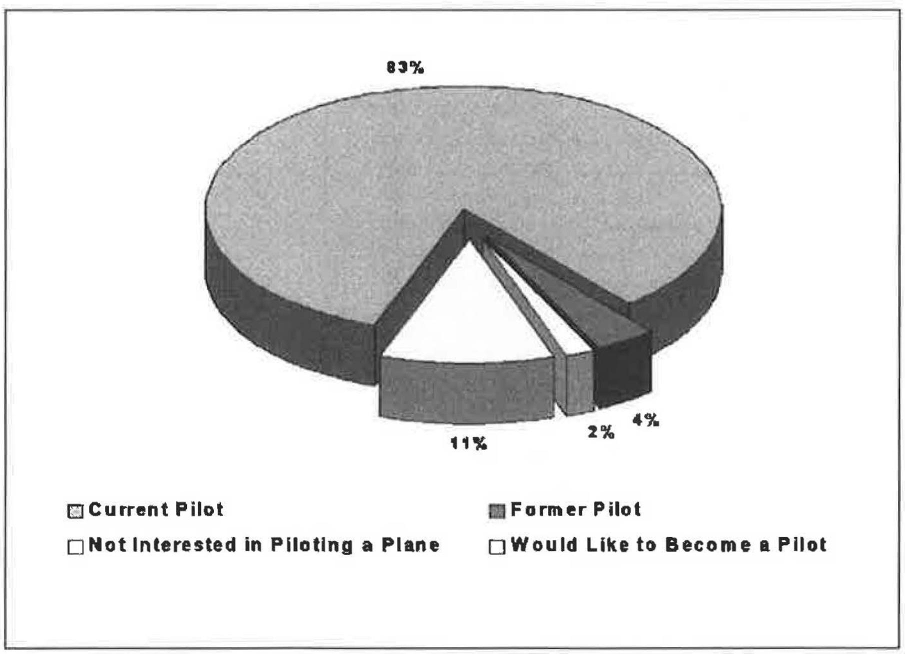


**FIGURE 7 Pilot demographics: pilot status.**

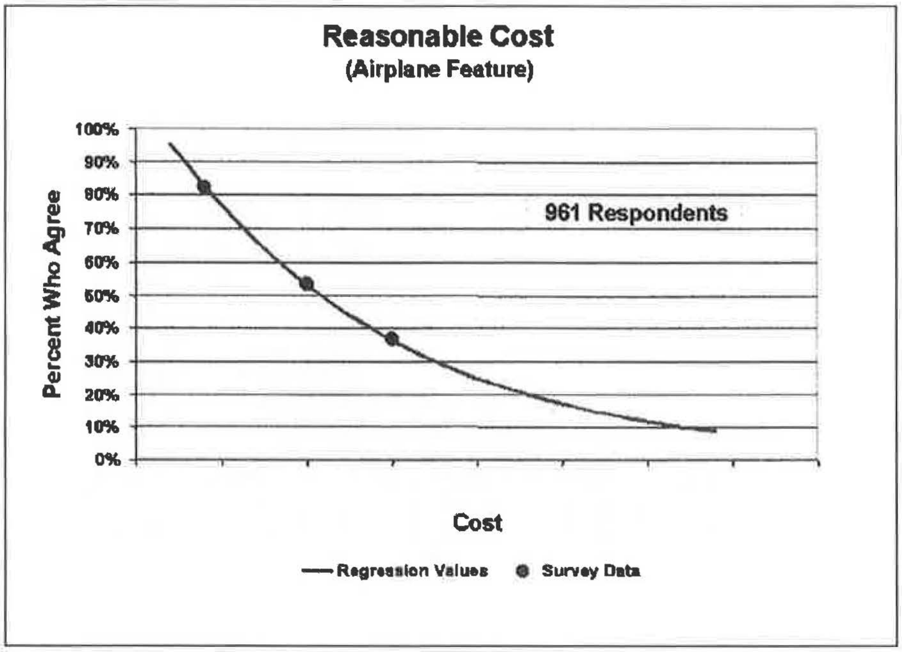


**FIGURE 8 Cost curve.**

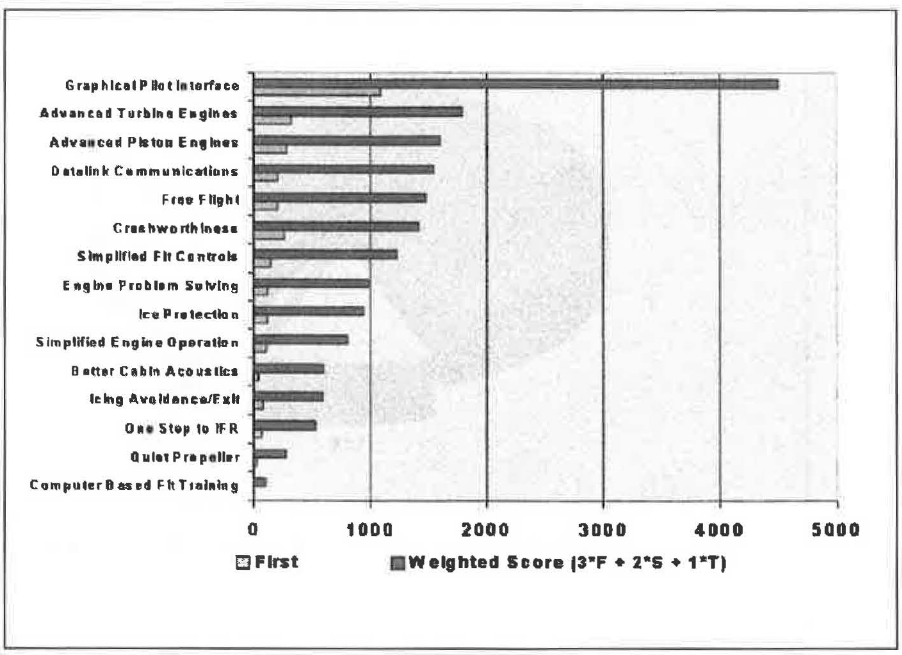


**FIGURE 9 Features ranking: pilot ranking of AGATE features.**

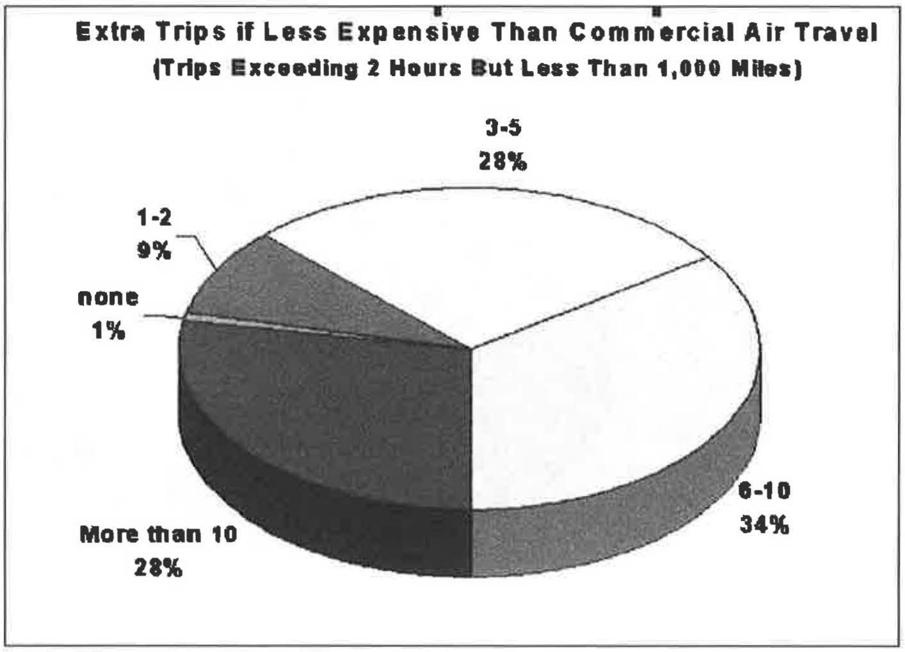


**FIGURE 10 Number of extra trips survey participants would take if they were less expensive than commercial air travel.**

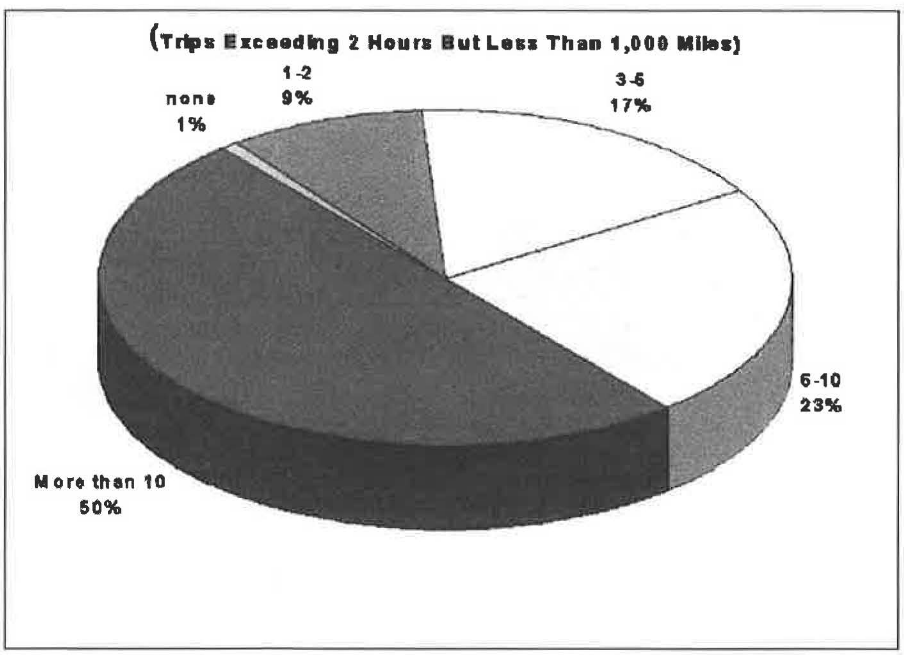


**FIGURE 11 Number of extra trips survey participants would take if they were three times faster than by automobile.**

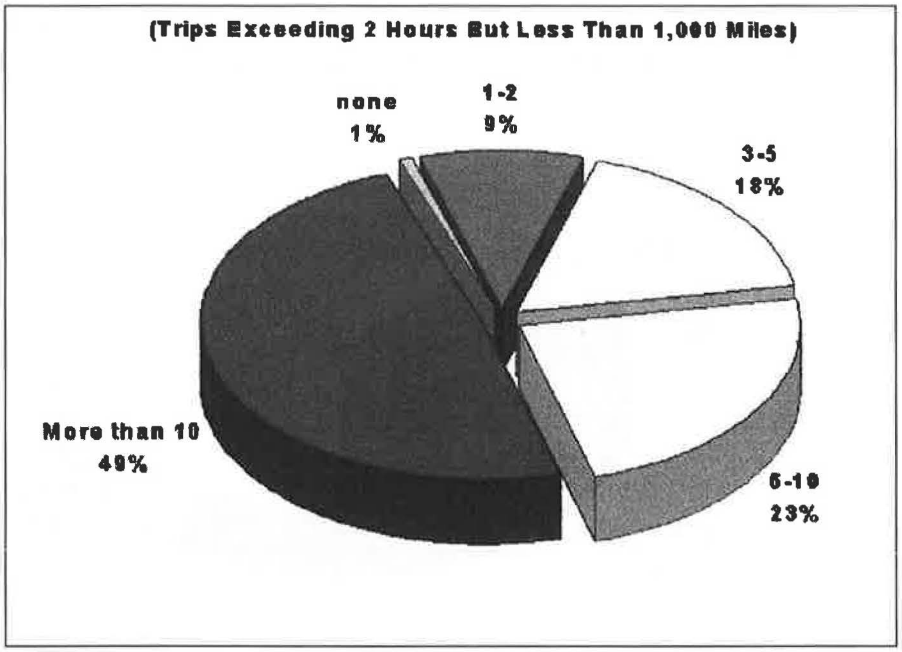


**FIGURE 12 Number of extra trips survey participants would take if they were three times faster than by automobile travel and less expensive than commercial air travel.**

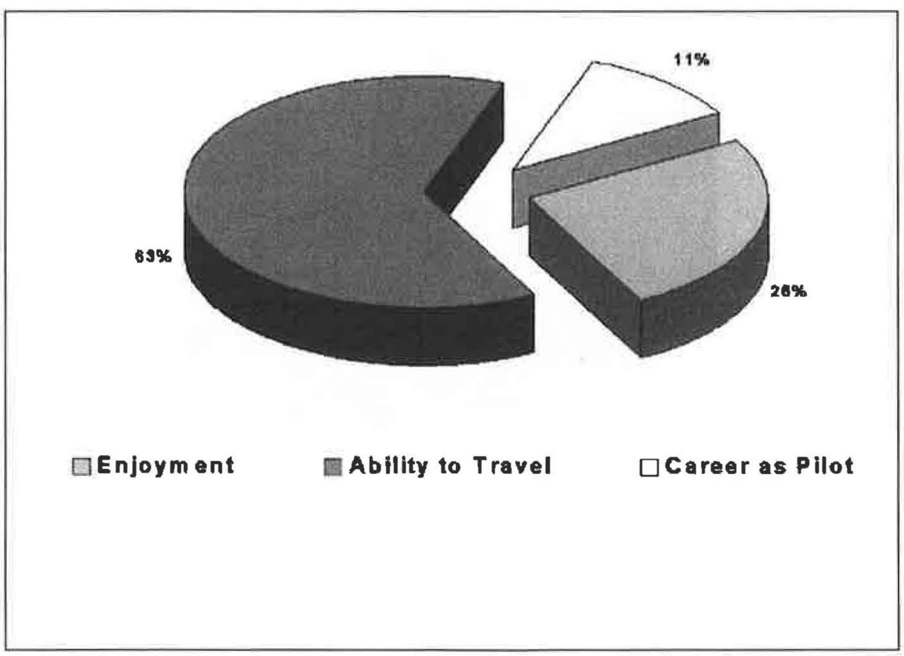


**FIGURE 13 Reasons for flying (potential pilots).**